

**BIRD DIVERSITY ALONG THE ELEVATION GRADIENT IN THE  
ALITAL AREA, DADELDHURA, NEPAL**



Entry 42  
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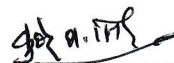
A thesis submitted in partial fulfillment of the requirement for the award  
of the degree of Master of Science in Zoology with special paper  
Ecology and Environment

**Submitted to**

Central Department of Zoology  
Institute of Science and Technology  
Tribhuvan University  
Kirtipur, Kathmandu  
Nepal  
April, 2023

## 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 of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).



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**RECOMMENDATION**

This is to recommend that the thesis entitled “**Bird diversity along the elevation gradient in the Alital area, Dadeldhura, Nepal**” has been carried out by Mr. Kuber Bahadur Singh for the partial fulfilment of the degree of Master 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 institutions.

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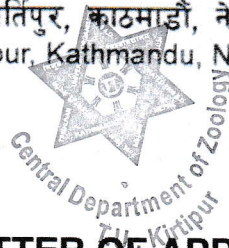
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### LETTER OF APPROVAL

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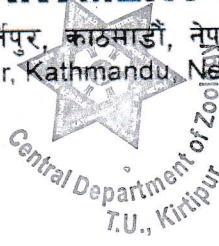
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**CERTIFICATE OF ACCEPTANCE**

This thesis work submitted by Mr. Kuber Bahadur Singh entitled "Bird diversity along the elevation gradient in the Alital area, Dadeldhura, Nepal" has been accepted as a partial fulfilment for the requirements of the degree of Master of Science in Zoology with special paper Ecology and Environment.

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## LIST OF ABBREVIATIONS

<b>Abbreviated form</b>	<b>Details of Abbreviations</b>
DBH	Diameter at Breast Height
DTA	Distance to agriculture
DTR	Distance to road
DTS	Distance to settlement
DTW	Distance to a water source
EN	Endangered
GPS	Global Positioning System
GLM	Generalized Linear Model
IUCN	International Union for Conservation of Nature
LC	Least Concerned
NT	Near Threatened
QGIS	Quantum Geographic Information System
VU	Vulnerable

## ABSTRACT

Nepal supports large number birds and other biota over a wide elevation range. However mid-elevation consists of higher species richness in Nepal. The aim of the study was to explore the avian diversity along elevation gradient in Alital area, Dadeldhura, Nepal. The study was carried out in 16 sampling station ranging from 500 m to 2,000 m elevation above sea level with interval of 100 m each. Fixed point count method in 40 m circular radius was used for bird sampling. Various environmental factors like canopy cover, distance to settlement, distance to water source, distance to agriculture area, distance to road, distance to forest and number of fruiting trees were measured to evaluate their effects on species richness of birds along the elevation gradients. A quadrat of 10 m × 10 m was used for counting trees inside the circular bird counting plot in each elevation gradient. DBH > 1.3 m was considered as tree. Canopy cover was measured by using densiometer. Distances from centre of the circular counting plot to variables; distance to water source, forest, settlement and road were measured in study area map by using QGIS tool. A total of 2,204 individuals of 114 species from 47 families of 14 orders were recorded. The Shannon - Weinner index revealed that the diversified bird population ( $H' = 2.498$ ). The Muscicapidae family had higher abundance than other families. Similarly, species richness was observed with a decreasing trend with increased elevations. Insectivorous bird species were recorded in higher species number with decreasing pattern along the elevation gradient. To observe relationship of different factors like canopy cover, distance to water source, distance to agriculture area, distance to settlement, distance to forest and fruiting trees with species richness, the GLM (Generalized Linear Model) with poisson distribution was used. Species richness showed the significant relationship with distance to a water source, distance to agriculture area. Likewise, insectivorous and carnivorous species richness showed significant relationship with distance to agriculture area. Granivorous species richness had only showed significant relationship with canopy cover, whereas omnivorous and frugivorous species richness had not showed any significant relationship with any of the variables.

# 1. INTRODUCTION

## 1.1. General Background

One of the most typical bio-geographical patterns is a decline in species richness from the equator to the poles due to temperature and humidity variations. (Quintero & Jetz 2018). Comparable trends in the decreasing of species richness are observed with rising elevation gradients, with higher bird species abundance at lower elevations than at higher elevational gradients (Hawkins 1999, Acharya et al. 2011, Zizka & Antonelli 2018, Neupane et al. 2020), where a latitudinal gradient and an elevational gradient frequently overlap a number of climatic traits (Quintero & Jetz 2018). Studies, however, also demonstrate that there is a hump-shaped link between elevation and species richness, with species richness being higher at mid-elevation than at low- and high-elevation (Patterson et al. 1998, Acharya et al. 2011, Joshi 2012, Gómez et al. 2015). Elevational gradients support a variety of species that belong to various feeding guilds such as carnivorous, insectivorous, omnivorous, granivorous and insectivorous in addition to supporting species richness due to presence of heterogeneous habitat (Basnet et al. 2016, Barcante et al. 2017, Walther et al. 2017, Kunwar et al. 2023).

Different factors affects the avian species richness pattern with elevation, some factors might be climate and habitat factors (Acharya et al. 2011), bird species abundance is also influenced by geography and resource availability (Neupane et al. 2020) and also the key factors that determine the species richness of birds along elevation are temperature and precipitation (Kunwar et al. 2023). Due to overlap between two sizable regional species pools, namely lowland and highland, there is a higher species richness at mid elevation (Herzog et al. 2005). High-rise immigrants are more likely to share a diversification signal with close relatives who live in climates similar to their own than with those from lower elevations because of the notable differences in flora between elevation zones (Quintero & Jetz 2018). Similarly, species richness of several groups is adversely affected by forest modification and land use (Waltert et al. 2005). Any variations in the makeup of a community from one elevation to another reflect a variety of factors that have an impact on the patterns of distribution of certain species (Blake & Loiselle 2000). Several bird species exhibit abundance in two or more habitats and migrate from geographical locations that are less suitable in terms of food supply, threats, breeding, habitat, and climatic conditions to those that are more suitable (Inskipp & Baral 2010). Finding and protecting the regions that are important to birds can help ensure that biodiversity is still

there. The variety and endemism of birds suggest the presence of other groups as well (Patterson et al. 1998).

Time programmes are adaptations that help organisms to deal effectively with dynamic conditions (Helm & Gwinner 1999), birds' annual cycles necessitate a careful blending of behaviors, which must all occur at the proper time and location. (Helm et al. 2006). The distribution of different bird species is impacted by seasonal variations, and birds adapt to these surroundings through two main strategies: migration to more hospitable climates and permanent residence (Swanson 2010). Due to habitat loss brought on by different anthropological development activities and agricultural expansion, large-scale migrations are being gradually cut off on a worldwide basis (Berger 2004). Birds can be harmed by human disturbance in a variety of ways, such as by interfering with feeding or social behavior, increasing nesting predation, altering parent-offspring and pair relationships and decreasing the likelihood of survival of nestlings (Marcum 2005, Chaves et al. 2015). As compared to other vertebrate groups, birds have been especially widely researched because to their omnipresence, frequent visibility and audibility, diversity and structural uniformity, inspirational numbers and behavior, and general appeal for study (Bennett & Owens 2002).

For biodiversity conservation, understanding diversity patterns along altitudinal gradients and their underlying causes are crucial (Paudel & Šipoš 2014). Nepal supports well distribution of birds and other biota over a wide elevation range (Hunter & Yonzon 1993), consist varieties of habitat along wider elevation gradient which suits for endemic as well as migratory birds causing the assemblance of 878 bird species in Nepal (Inskipp et al. 2017) and recently 886 species of birds have been recorded in Nepal, which are about 9% comparing total world bird species. Among them 42 species are globally threatened and 35 globally near threatened. Further 167 species are nationally threatened(BCN). Many studies on avian species carried out in Nepal reinforce the trend of ongoing investigations to contribute more information and also reveal significant conservation significance (Acharya et al. 2011). But many regions of the country are relatively unexplored for avifaunal surveys in Nepal (Baral 2018). Thus, this study had attempted to explore the avian diversity along elevation gradient at unexplored area.

## **1.2 Objectives**

### **1.2.1 General Objective**

The main objective of the study was to explore the bird richness and diversity along the gradient of elevation in Alital area, Dadeldhura District, Nepal.

### **1.2.2 Specific Objectives**

- To analyze the bird richness and diversity along elevation gradient.
- To examine the factors influencing bird species richness in the study area.

## **1.3 Significance of the Study**

Various studies had been done in different regions of Nepal on the avian fauna. Studies are done either in a specific area excluding elevation ranges or along the elevation of the Himalayas and hills. Thus, these studies had provided necessary data on the abundance of bird species, species richness, species diversity, and different factors that affect the species diversity and richness of the birds. Still, various regions are under research for avian fauna, in which our study area might be included as previous research was lacking. Thus, this study explored and analyzed the avian diversity along the elevation gradient in the Alital area and also identified the factors affecting the distribution of bird species in the study area. The research on bird diversity in the study region helped determine the species richness of birds in the area, which will aid concerned authorities in bird conservation and habitat management. Further, this study will support the development of policies to sustain the species conservation.

## 2. LITERATURE REVIEW

### 2.1 Avian Diversity and Richness

Avian distribution pattern varies in different habitat of different regions with time period (Jetz et al. 2014, Pan et al. 2016, Archer et al. 2019). There is not any fixed pattern of species richness due to frequent mobility of birds (Acharya et al. 2011, Barcante et al. 2017). Migratory behaviour due to seasonal change, landscape changes and anthropological disturbances causes the variation in distribution pattern (Hawkins 1999, Davies et al. 2007). With a few special circumstances, research on elevational diversity gradients are limited to either low, mid, or high elevation, effectively covering only a small part of the elevation, or on a smaller mountain with restricted elevational spacing (Acharya et al. 2011). However, various studies demonstrated declining pattern of avian species richness pattern with increased altitude, where lower elevation had higher number of species (Hunter & Yonzon 1993, Basnet et al. 2016, Neupane et al. 2020, Kunwar et al. 2023). Similarly, studies had also shown a hump-shaped pattern of species richness with elevation, i.e., species richness increases till mid-elevation and then declines with increased elevation (Able & Noon 1976, Acharya et al. 2011, Pan et al. 2016, Pandey et al. 2020).

It is simple to identify elevational gradients in species richness in immobile beings like plants but difficult to define with sharp borders for mobile creatures like birds, and the elevational packaging remains hazy (Renner 2011). High species richness in medium altitudes may be a sign that many species from low and high elevations have elevational ranges that only slightly overlap in the mid-elevations (Renner 2011, Pan et al. 2016). Lower altitude have adequate resources which causes the higher abundance of avifauna (Quintero & Jetz 2018), along the gradient, a systematic shift in the fairness of the bird communities occur, having inhabitants at higher altitudes displaying a greater degree of dominance (Able & Noon 1976). Higher elevation has decreased temperature and vegetation with harsh climatic condition which leads to limitation of resources causing less abundant of avian fauna resulting isolated occurrence of an endemic avian species (Chaves et al. 2015). The avian species diversity increases with increase in tree density providing habitat complexity and nesting sites to birds and also forest attracts both forest and farmland birds (Jakobsson & Lindborg 2017). The high species diversity present in forest habitats may be limited in agricultural or ecological areas, but such values cannot be greater than those present in undisturbed forest ecosystems (Pagaduan & Afuang

2012). Comparatively few bird species live in urban environments as opposed to rural ones (Katuwal et al. 2018) with lowest species richness in urban areas (Lepczyk et al. 2017). Thus, it is important to take into account that residential areas with trees and forest fragments might be used by a range of species (Archer et al. 2019).

Various migratory birds migrates from Northern Hemisphere to Southern Hemisphere in non-breeding season i.e. winter and Southern Hemisphere to Northern Hemisphere in breeding season, i.e. summer season due to seasonal change (Viana et al. 2016). The migratory status of migratory bird is affected by individual factors including age and sexuality. The behavior of each type would be chosen based on the proportional rewards and costs of either being a migrant or a resident (Lundberg 1988). Partial migration and full migration behavior of the avifauna causes variation in the diversity pattern of the avian community at the resident area and migrated area (Lundberg 1988, Berruti et al. 1994).

### **2.3 Factors Affecting Avian Diversity and Richness**

Avian fauna are globally distributed (Jetz et al. 2014, Quintero & Jetz 2018), in different habitat which are influenced by different environmental variable like altitude, time, temperature, rainfall, productivity and humidity (Santhakumar et al. 2018, Santillán et al. 2019). Most of the avian species are sensitive to the disturbance in their habitat types (Montano-Centellas & Garitano-Zavala 2015) which causes variation in community makeup from one elevation to another (Blake & Loiselle 2000). Decrease in species richness might be influenced by temperature and climatic variables and precipitation along the elevational gradient as it creates unfavorable environment to the avian species (Pan et al. 2016, Santhakumar et al. 2018). Lack of fruit, large insects, and flower nectar during winter resulting the migration of birds from higher altitude to lower altitudes having adequate resources (Price et al. 2011). Most elevational gradients have an approximately stable moisture zone (cloud zone) at a particular threshold, which is particularly noticeable in the tropics and creates favorable conditions for some taxa (Rahbek 1995).

Large open ecosystems may eventually support a greater variety of species due to within-regime speciation (Price et al. 2011), likewise environmental factors like warm, wet climates supports most species of mountains (Pan et al. 2016). Food resources flourished

during dry and warm summer season in which birds are allowed to move freely along the habitat for foraging which might results to high avian species richness during summer (Pagaduan & Afuang 2012). The Himalayas and other tropical mountains' avifaunal populations are also negatively impacted by global climate change, which causes certain bird species to alter their distribution ranges, nesting and migration habits, and breeding seasons in order to access the best food supplies for existence (Kandel et al. 2018). Forest are the major resources and habitat of the forest birds, the phylogenetic richness, divergence, and structure of the remaining forest birds are significantly altered by deforestation (Morante- Filho et al. 2018). Also forest age determines the abundance of avifauna in the forest, sensitive and closed canopy forest dependent bird species prefers to show their abundance in old-growth forests (Arnold et al. 2021).

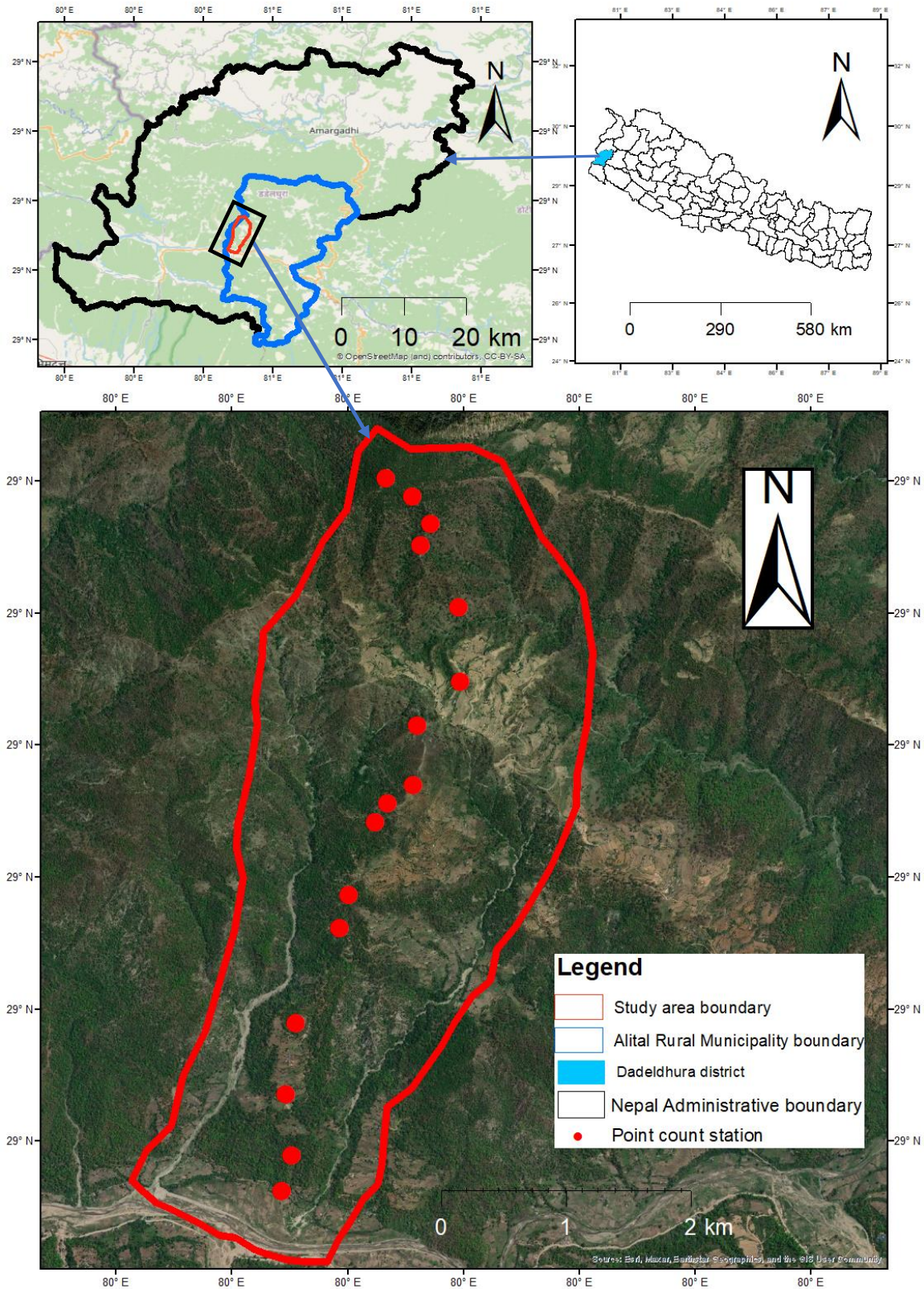
Patterns of species richness, abundance, and species composition for birds were influenced by various environmental variables like species-area relationship, ecotone and habitat heterogeneity in addition to altitude (Grytnes & McCain 2007, Ghimire et al. 2021). However, bird species richness might be affected by factors like distance to forest, distance to settlement, distance to a water sources, canopy cover, etc. (Neupane et al. 2020, Kunwar et al. 2023). In addition, occurrence of birds nearer to road might decreases the chances of predation (Pescador & Peris 2007, Shochat et al. 2010, Downing et al. 2015) and also the chances of availability of grains, fruits, and other types of food obtained from human movements that might provide foods to different feeding guild bird species (Lu et al. 2007, Shochat et al. 2010, Francis et al. 2019, Bastola et al. 2022, Penjor et al. 2022).

Previous research in the Far Western region on avian fauna suggests diversified species of birds along the elevations of the mid-hills (Poudyal 2012, Joshi 2014, Joshi et al. 2015, Baral 2018, Bhusal et al. 2021) and in the lowland of the Terai regions (Basnet 2019, Bhusal et al. 2020, Dangaura et al. 2020). However, studies had only covered some portion of the Far Western region and recommended a further study on avian fauna.

### 3. MATERIALS AND METHODS

#### 3.1 Study Area

The study was conducted in the Alital Rural Municipality of the western part of Nepal (29<sup>0</sup> 07' to 29<sup>0</sup> 09' N and 80<sup>0</sup> 26' to 80<sup>0</sup> 27' E) (Figure 1). Elevation in the Alital Rural Municipality ranges from 350 m to above 2,000 m above sea level. Both climate (tropical to sub-tropical climate) and vegetation type (tropical forest to sub-tropical forest) vary with elevation within a distance of ~3.80 km. Major flora of the Alital Rural Municipality are *Shorea robusta*, *Pinus roxburghii*, *Quercus leucotrichophora*, *Rhododendron arboretum*, *Semecarpus anacardium*, *Acacia catechu* and *Ficus* sps. Similarly, major mammal fauna includes Bengal Fox (*Vulpes bengalensis*), Himalayan Goral (*Naemorhedus goral*), Wild Boar (*Sus scrofa*), etc. The aquatic fauna found in this area are Nepalese Minnow (*Psilorhynchus pseudecheneis*), Nepalese Snow Trout (*Schizothorax macrophthalmus*) and catfish species. Avian fauna like Common Myna (*Acridotheres tristis*), House Sparrow (*Passer domesticus*), Red-vented Bulbul (*Pycnonotus cafer*), Blue Whistling Thrush (*Myophonus caeruleus*) and Red-billed Blue Magpie (*Urocissa erythroryncha*). Throughout the year, average of 1398.8mm (55.1") of rain is accumulated and wettest month as July with the most rainfall with average of 329.2 mm (13") of accumulated precipitation. January month is considered as coldest month with an average low of 5°C and high of 13°C and May as hottest month with an average high of 26°C and low of 18°C. (weatherspark.com).



**Figure 1.** Location of study area in Alital Rural Municipality of Dadeldhura

### **3.2 Materials**

- Garmin Etrex 10 GPS
- Camera: Nikon D5600
- 70-300mm telescopic lens.
- Binoculars
- Densiometer
- Measuring tape
- Working sheets

### **3.3 Research Design**

Preliminary survey was conducted on 10 September 2022 to gather the information about study area. By using land cover map (ICIMOD 2013) of Alital Rural Municipality in QGIS (QGIS Development Team 2019), the field design was constructed. Bird sampling was done in 16 sampling station from 500 m to 2,000 m elevation placing with interval of 100 m elevation distance from each station in available habitat as was decided after preliminary survey. Data was collected in winter season (25 October 2021- 6 February 2022) for a total of 21 days. Each site was re-visited for three times (i.e. each time seven days were spent) during the course of survey. A 10 m × 10 m size quadrat was used in each study site for enumeration of trees to observe their relationship with species richness. Each plot's closest distance to the forest, agricultural area, road, residence, and water source was recorded. The closest distance to these sources was measured using measuring tape; however, the distance > 100 m was measured by using land cover map of 2010 (ICIMOD 2013) of the study area using QGIS (QGIS Development Team 2019).

### **3.4 Methods**

#### **3.4.1 Bird Survey**

Birds counting stations were made between 500 m to 2,000 m with an interval of 100 m elevation distance. Sampling was carried out by the fixed-point count method within a circular plot of radius 40 m (Volpato et al. 2009) in each station along 16 different elevational gradients. Birds seen was observed for 20 minutes with minimum of accessible time interval within a circular plot of 40m radius in each point count station in different habitat types. Similarly, began from 7:20 AM to 11:20 AM during morning time and from 2:30 PM to 4:30 PM at afternoon (i.e. two visit per day in each station) in order to prevent biases brought on by birds departing or arriving at roosting places, also as these time periods are active hours for birds in the winter season. 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. Through careful surveillance of the activities of previously recorded individuals, duplicate counting was avoided. The number of field visits was divided into three sessions, each lasting seven days, for an overall duration of 21 days spent in the field. Altogether, 42 visits were done in the study area. Weather conditions known to impair bird behavior, such as rain and wind, were avoided during censusing periods. Only birds seen during recording periods were recorded. Field guide "Birds of Nepal"(Grimmett et al. 2016) was used to identify the birds seen inside the circular point count. Unidentified birds were photographed and identified later with experts' consultation after completion of survey and by comparing with reference. The global and National threatened categories of each species were categorized using the IUCN red list (IUCN 2022) and National Red List of Nepal birds (Inskipp et al. 2017) respectively. In addition, the bird species were categorized into five feeding guilds i.e. omnivorous, insectivorous, frugivorous, carnivorous, and granivorous (Inskipp et al. 2016).

#### **3.4.2 Habitat Measurements**

A 10 m × 10 m size quadrat was placed randomly inside circular bird counting plot of radius 40 m for enumeration of trees (Joshi et al. 2012). Plants with DBH (Diameter at breast height) >1.3m was considered as trees (Pandey & Pokhrel 2021). Canopy cover was measured by using spherical densiometer. By counting the number of squares (or quarters of squares) that the picture of the canopy covered, it was employed while being

held at breast height (Korhonen et al. 2006). Each plot's elevation was measured by using altimeter whereas, latitude and longitude were recorded using Garmin Etrex 10 GPS device. In addition, each plot's closest distance to the forest, agricultural area, road, residence, and water source was recorded by using land cover map 2010 (ICIMOD 2013) of the study area using QGIS (QGIS Development Team 2019).

### 3.4.3 Habitat Types

Study had recorded different types of habitats such as agriculture, Sal Forest, mixed forest, shrub land, grassland, Pine Forest and Oak forest along the elevation in the Alital

**Table 1.** Details of the stations laid along the elevation gradients in the Alital area.

area.

<b>Station</b>	<b>Elevation (m)</b>	<b>Habitat types</b>	<b>Major vegetation</b>
S1	500	Agriculture	Wheat cultivation
S2	600	Sal Forest	Tropical forest
S3	700	Agriculture	Wheat cultivation
S4	800	Sal Forest	Tropical forest
S5	900	Sal Forest	Tropical forest
S6	1000	Mixed Forest	Subtropical forest
S7	1100	Shrub land	Subtropical forest
S8	1200	Agriculture	Wheat and mustard cultivation
S9	1300	Grassland	Subtropical grassland
S10	1400	Grassland	Subtropical grassland
S11	1500	Agriculture	Wheat and mustard cultivation
S12	1600	Pine Forest	Subtropical Forest
S13	1700	Pine Forest	Subtropical Forest
S14	1800	Mixed Forest	Lower Temperate Forest
S15	1900	Mixed Forest	Lower Temperate Forest
S16	2000	Oak Forest	Lower Temperate Forest

### 3.4.3 Data Analysis

The Shannon-Weiner index was used to calculate the avian diversity in Alital area.

Shannon – Weiner equation:  $H' = -\sum p_i (\ln p_i)$  (Shannon and Weaver, 1949).

Where  $H'$  = Shannon's diversity index

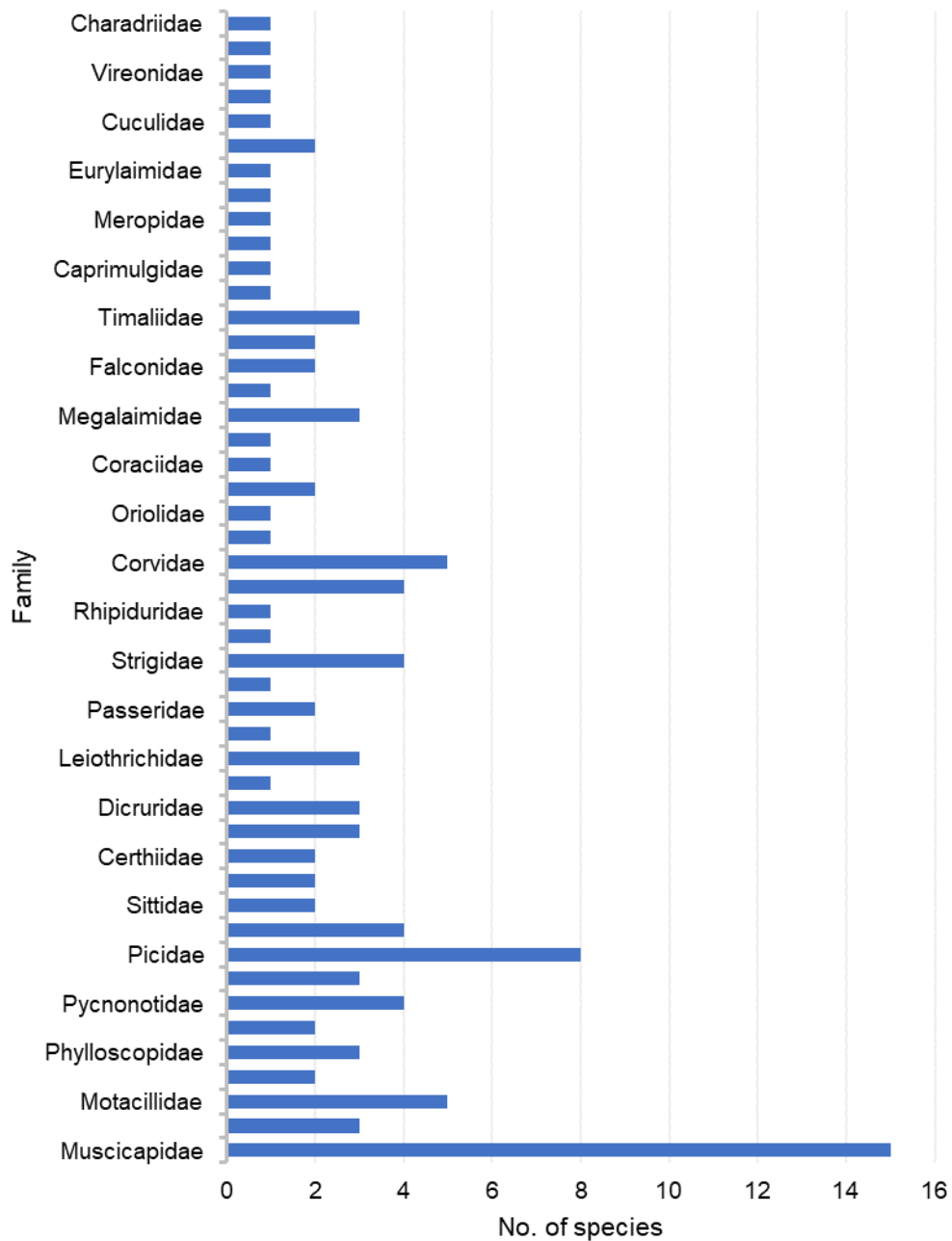
$P_i$  = Proportion of the  $i^{\text{th}}$  species

The GLM (Generalized Linear Model) with a Poisson distribution (Ladet et al. 2018) was used in R software (Team 2016) to assess the relationship between bird species richness and different variables such as canopy cover, distance to road (m), distance to settlement (m), and distance to a water source (m), distance to forest (m), distance to agriculture area (m) and number of fruiting trees along elevation gradients. First, the data tables were imported into the R software (Team 2016). Then, the Shapiro test was employed to examine the normality of the response variable's distribution in the parameter. Statistical significance was set at a level of 0.05, where response variable had shown (P-value = 0.046). Then, the correlation was tested between the explanatory variables before building the regression model to preserve against the models' multiple correlations. The variables showing correlation ( $r > 0.7$ ) were considered to be highly correlated. Among them only one was selected as their representative variable. QGIS (QGIS Development Team 2019) was used to produce the research map layout.

## 4. RESULTS

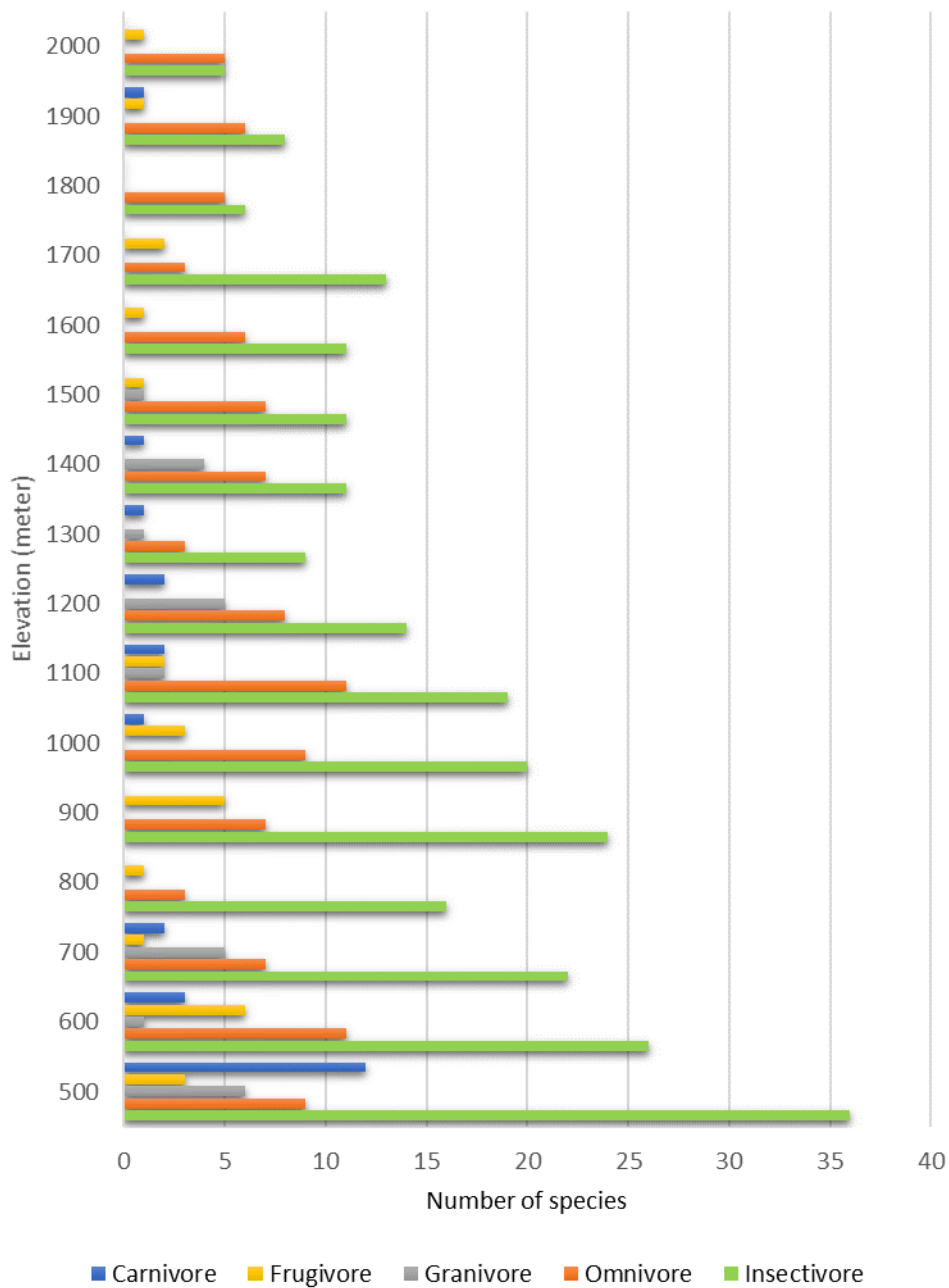
### 4.1 Avian diversity and richness

A total of 2,204 individuals of 114 species from 47 families of 14 orders were recorded. Among 47 families, the Muscicapidae family (15 species) had been the most diverse than other family followed by Picidae, Corvidae and others. Second most diverse family was Picidae with eight species. About 21 families were recorded with abundance of only one species each per family (Figure 2).



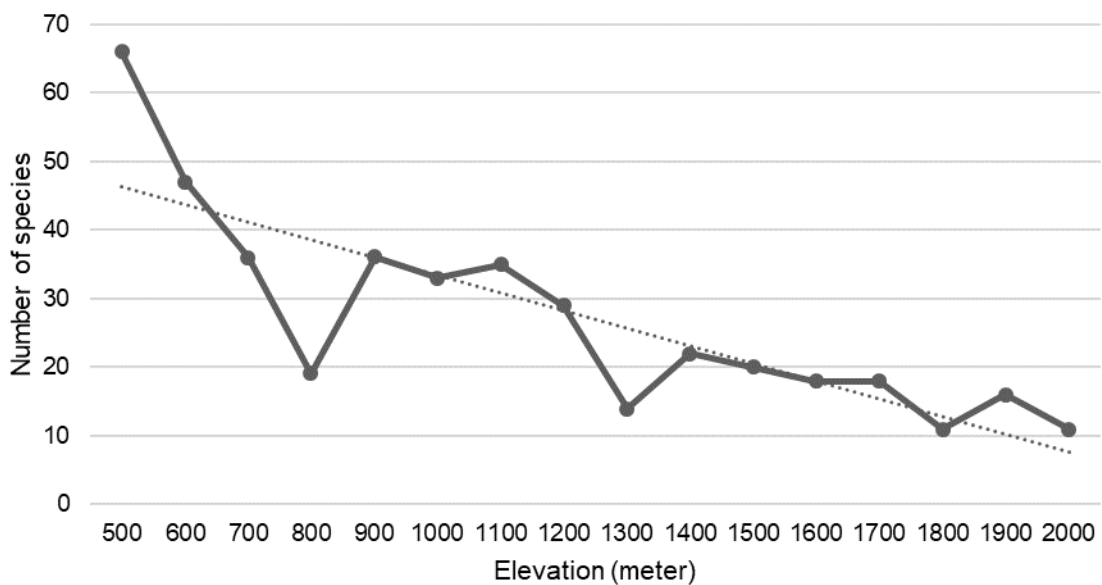
**Figure 2.** Number of bird species in different families.

According to the feeding guild evaluation along elevational gradients, insectivores recorded a higher number of species with a decreasing trend in species richness with rising elevations, followed by omnivores, carnivores, frugivores, and granivores. From 800 to 1,000 m and above 1,600 m elevation, no granivorous species were recorded. Likewise, frugivores were not observed from 1,200 to 1,400 meters of elevation and even at 1,800 meters i.e. high abundance at lower altitudes. At elevations of 2,000 m, 1,500 m to 1,800 m, and 800 m to 900 m, carnivorous species were not observed (Figure 3).



**Figure 3.** Species richness of birds among different feeding guilds along elevational gradients in the Alital area.

With respect to the distribution of bird species along elevation, a decline in species richness was seen as elevation increased (Figure 4). Lower elevations were found to have higher bird species richness. In terms of general abundance, birds were most numerous at an elevation of 500 meters, while they were least numerous between 1,800 meters and 2,000 meters. However, species richness had been observed to decline monotonically until reaching 800 m elevation and then increase at 900 m elevation. As compared to their adjacent elevations, the species richness dropped at elevations of 1,300 m and 1,800 m as well (Figure 4). From avian diversity calculation, Shannon Wiener Index ( $H' = 2.498$ ) was observed in Alital area.



**Figure 4.** Avian species richness along elevational gradients in the Alital area.

Among the observed species, Steppe eagle (*Aquila nipalensis*) falls under the Endangered (EN), Cheer pheasant (*Catreus wallichii*) as Vulnerable (VU) and Alexandrine Parakeet (*Palaeornis eupatria*) falls under the Near Threatened (NT) category of the IUCN Red List ([iucnredlist.org](http://iucnredlist.org)). Three species, Steppe eagle (*Aquila nipalensis*), Black stork (*Ciconia nigra*), Brown fish owl (*Ketupa zeylonensis*) are nationally Vulnerable (VU) species. Three species Collared Falconet (*Microhierax caerulescens*), Whitebrowed scimitar babbler (*Pomatorhinus schisticeps*) and Alexandrine Parakeet (*Psittacula eupatria*) were under the Near Threatened (NT) category of National Red list, and Cheer Pheasant (*Catreus wallichii*) and Blue-eared Kingfisher (*Alcedo meninting*) are under nationally Endangered (EN) species (Table 2).

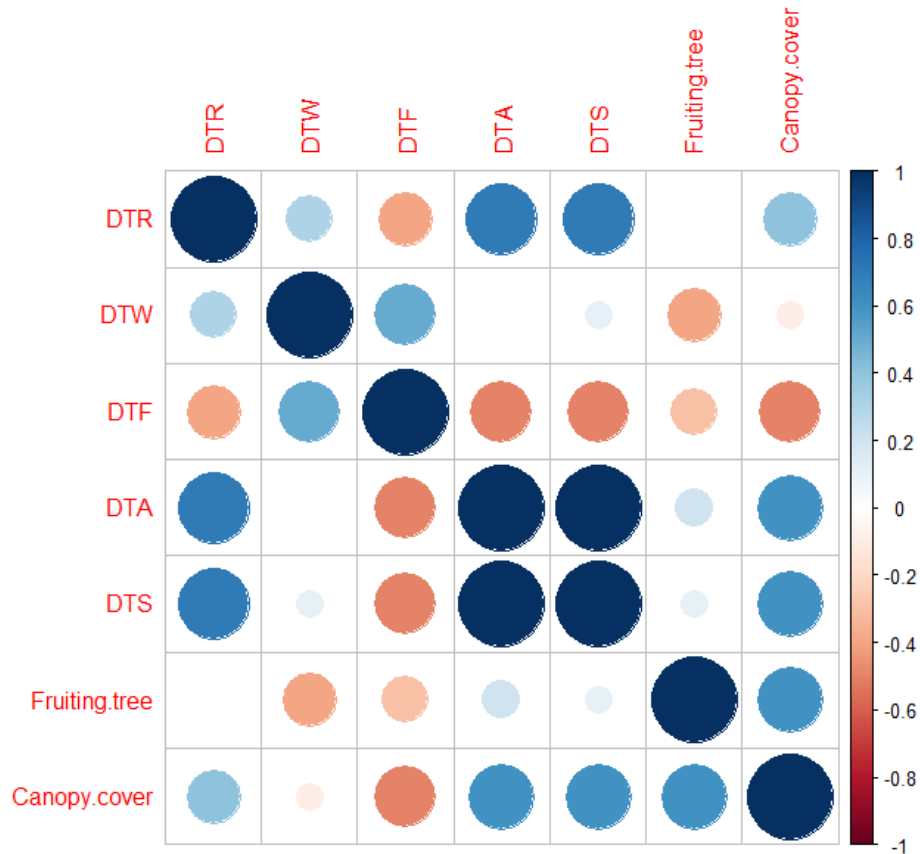
**Table 2.** Threatened status of bird in the Alital area, Dadeldhura, Nepal. Status based on IUCN Red List category (iucnredlist.org) and Nepal's National Red List of Birds

Name of bird	Scientific name	Habitat	Feeding guild	IUCN category	National red list category
Alexandrine Parakeet	<i>Psittacula eupatria</i>	F/Ag	Omnivore	NT	NT
Black Stork	<i>Ciconia nigra</i>	Ag	Carnivore	LC	VU
Blue-eared Kingfisher	<i>Alcedo meninting</i>	Ag	Carnivore	LC	EN
Brown Fish Owl	<i>Ketupa zeylonensis</i>	F	Carnivore	LC	VU
Cheer Pheasant	<i>Catreus wallichii</i>	F	Omnivore	VU	EN
Collared Falconet	<i>Microhierax caerulescens</i>	Ag	Carnivore	LC	NT
Steppe Eagle	<i>Aquila nipalensis</i>	F	Carnivore	EN	VU
White-browed Scimitar Babbler	<i>Pomatorhinus schisticeps</i>	F	Insectivore	LC	NT

**Note:** NT: Near Threatened, LC: Least Concerned, EN: Endangered, VU: Vulnerable, F: Forest, and Ag: Agriculture.

#### 4.2 Factors affecting avian richness

The correlation matrix was created to predict the correlation between the explanatory variables. Among the explanatory variables, distance to agriculture area was highly correlated with distance to settlement ( $r = 0.986$ ) and distance to road ( $r = 0.724$ ) by exceeding the prescribed threshold of 0.7 ( $r > 0.7$ ) (Figure 6). As a result, just the distance to the agricultural area was included in the model considering that the distance to settlements and roads are also reflected in the interpretation of this variable because the majority of bird species' primary feeding sources are agricultural areas (Ladet et al. 2018).



**Figure 5.** Correlation matrix between explanatory variables to estimate factors influencing the avian species richness in Alital area, where DTR = distance to road, DTW = distance to a water source, DTF = distance to forest, DTA = distance to agriculture area and DTS = distance to settlement.

The generalized linear model (GLM), revealed that the richness of avian species was significant with distance to agricultural area ( $P < 0.01$ ) and water sources ( $P = 0.014$ ) but not with canopy cover ( $P = 0.54$ ), distance to forest ( $P = 0.48$ ) and fruiting trees ( $P = 0.84$ ) (Table 3). Similarly, insectivore species richness was significant with distance to agriculture area ( $P < 0.01$ ) but was independent with canopy cover ( $P = 0.72$ ), distance to forest ( $P = 0.24$ ), distance to a water source ( $P = 0.12$ ), and fruiting trees ( $P = 0.47$ ). Only canopy cover ( $P = 0.03$ ) exhibited a significant link with granivore species, while all other factors were independent to them. Only the distance to agriculture area ( $P = 0.01$ ) showed significant with carnivorous species richness; all other correlations were negligible. Whereas, the abundance of omnivore and frugivore species did not significantly correlate with any of the factors.

**Table 3.** Generalized linear model (GLM) with Poisson distribution showing the effects of different variables on avian richness pattern. Values in bold are statistically significant at  $P < 0.05$  (Std. Error = Standard Error, DTR = distance to road, DTW = distance to a water sources, DTF = distance to forest, DTA = distance to agriculture area, DTS = distance to settlement).

	<b>Variables</b>	<b>Estimate</b>	<b>Std. Error</b>	<b>z value</b>	<b>P value</b>
<b>Total species</b>	(Intercept)	3.91	0.13	29.30	$< 2.00e^{-16}$
	Canopy cover	0.002	0.003	0.61	0.54
	DTW	-0.001	0.0003	-2.46	<b>0.014</b>
	DTF	-0.0006	0.001	-0.7	0.48
	DTA	-0.0007	0.0001	-5.51	<b>3.49e<sup>-08</sup></b>
	Fruiting tree	0.015	0.077	0.2	0.84
<b>Insectivore</b>	(Intercept)	3.32	0.18	18.52	$< 2.00e^{-16}$
	Canopy cover	0.001	0.004	0.35	0.72
	DTW	-0.0007	0.0005	-1.52	0.12
	DTF	-0.001	0.001	-1.15	0.24
	DTA	-0.0008	0.0001	-4.43	<b>9.33e<sup>-06</sup></b>
	Fruiting tree	0.07	0.1	0.71	0.473
<b>Granivore</b>	(Intercept)	1.29	0.56	2.285	0.02
	Canopy cover	-0.08	0.04	-2.11	<b>0.03</b>
	DTW	-0.001	0.0015	-1.14	0.25
	DTF	0.003	0.003	1.25	0.23
	DTA	-0.001	0.001	-0.43	0.66
	Fruiting tree	1.22	0.76	1.59	0.11
	(Intercept)	2.28	0.46	4.95	$7.31e^{-07}$
	Canopy cover	-0.01	0.01	-0.66	0.50

<b>Carnivore</b>	DTW	-0.003	0.001	-1.91	0.05
	DTF	-0.0008	0.004	-0.18	0.85
	DTA	-0.002	0.001	-2.35	<b>0.01</b>
	Fruiting tree	0.16	0.41	0.4	0.68
<b>Omnivore</b>	(Intercept)	2.21	0.27	8.06	7.50e <sup>-16</sup>
	Canopy cover	0.005	0.006	0.93	0.35
	DTW	-0.0005	0.0007	-0.65	0.51
	DTF	0.0002	0.001	0.11	0.91
	DTA	-0.0004	0.0002	-1.51	0.13
	Fruiting tree	-0.15	0.156	-0.996	0.32
<b>Frugivore</b>	(Intercept)	1.30	0.7	1.871	0.06
	Canopy cover	0.01	0.01	1.14	0.25
	DTW	-0.001	0.001	-1.02	0.30
	DTF	-0.01	0.007	-1.26	0.2
	DTA	-0.001	0.0005	-1.91	0.05
	Fruiting tree	-0.08	0.29	-0.291	0.77

## 5. DISCUSSION

### 5.1 Avian diversity and richness

A portion of the lowland (Bhattarai 2014, Basnet 2019, Bhusal et al. 2020, Dangaura et al. 2020) and hilly regions (Poudyal 2012, Joshi 2014, Joshi et al. 2015, Baral 2018, Bhusal et al. 2021, Basnet et al. 2023) was explored in earlier research throughout the Far western region of Nepal to evaluate the bird communities. After reviewing previous researches that demonstrated the avian communities' data of Far western region, this might be the first study along an elevation gradient (500-2,000 m) in the Alital area, Dadeldhura that represent the distribution pattern of bird species. This study added the information about avifaunal structural pattern of the study area.

This study recorded diverse community of avian fauna along the elevational gradients of Alital area. Study found the decreasing pattern of the species richness with increased elevation, such type of pattern is commonly in birds (Santhakumar et al. 2018), Birds species of Muscicapidae family were observed with a high occurrence with comparison to other family's species might be related to most of the species being common and widely distributed residents throughout Nepal at the elevation range of the research area (Grimmett et al. 2016). Likewise, species of Picidae family being second most abundant in the study area might be due to high abundance of tall and old trees of *Shorea robusta* species which provides higher probability of food sources and nesting sites for them (Kumar et al. 2014, Engstrom et al. 2020).

Avian species richness along the elevational gradient in the Alital area showed a decreased pattern with an increase in elevation which might be due to sloppy topographic structure, decreased in temperature, precipitation, and vegetation with increasing elevation that reflects the variation in community makeup (Hunter & Yonzon 1993, Jankowski et al. 2013, Santhakumar et al. 2018, Hořák et al. 2019, Neupane et al. 2020, Ghimire et al. 2021, Kunwar et al. 2023). Lower elevations had a higher abundance of bird species than higher elevations, which might be due to increased temperature, the high presence of water sources, food availability, suitable climatic conditions, heterogeneous habitat, and more floral groups (McCain 2009, McGrann & Furnas 2016, Santhakumar et al. 2018). Thus, the likelihood of certain resources being available may decrease as elevation rises (Barcante et al. 2017, He et al. 2022). This might also be linked to higher

abundance of migratory birds at lower altitudes (Katuwal et al. 2016) as lower elevation are warmer than higher elevation in winter (McGrann & Furnas 2016).

Lower species richness at 800 m elevation in comparison with its adjacent elevational gradients might be due to the occurrence of thinner forest at the sampling site due to increasing deforestation and also having active human movements (Lees & Peres 2006, Negret et al. 2021). Similarly, as the elevation arose, there was also a decline in species richness at 1,300 m, which may have resulted from the emergence of barren terrain resulting from the harvesting of the seasonal grasses that had been grown there (Roth 1976, Larkin et al. 2001). The lowest number of species was observed at 1,800 m and 2,000 m elevation which might be due to the less availability of resources and colder climatic condition which results in competition between the species for limited resources (He et al. 2022).

Species of insectivorous feeding guild were recorded numerically higher which correlates with highly abundance of different types of pest and pathogens that feeds on live plants invading forests and agricultural areas of Nepal which supports foraging for such birds in different habitats (Bhatta et al. 2015, Subedi et al. 2021). Also insectivorous avian species were recorded in lesser number at higher altitudes (Katuwal et al. 2016), that relates with the decreasing pattern of insects like ants with increase in elevation due to decreased temperature and vegetation (Malla 2008, Subedi et al. 2021). Furthermore, omnivorous species were recorded in each elevational gradient, as they are proficient in making use of a variety of resources and are capable of dealing with a variety of food sources (Basnet et al. 2016). At higher elevations (1600 m – 2000 m) and from 800 m to 1,000 m elevation, no granivorous species were found, which might be due to the increase in distance to agricultural land areas, leading to the reduced availability of resources, resulting in an adverse effect on their abundance at higher regions of the study area (Waltert et al. 2005, Mulwa et al. 2021). Also, compared to forest, agricultural landscapes have an equal or higher species richness and bird numbers in the winter and play a major role in preserving a significant portion of the winter bird population present in forest (Söderström et al. 2003, Elsen et al. 2017, Mulwa et al. 2021). Likewise, frugivores were not observed from 1,200 to 1,400 meters of elevation, and even at 1,800 meters, frugivores were not recorded, which might be due to the presence of either barren land or grassland or a lesser abundance of fruiting trees that might have resulted in the less availability of necessary food sources (Herrera 1985, Hasui et al. 2007), and being higher abundance at lower

elevations possibly due to availability of fruits like papaya (*Carica papaya*), bananas (*Musa* spp.), and other fruits throughout the winter in human habitation at lower elevations (Tellería et al. 2005, Lu et al. 2007, Rey 2011). There were no any carnivorous species to be found at an elevation of 2,000 m, 1,500 m to 1,800 m, and 800 m to 900 m which might be due to less abundance of prey species due to landscape changes (Haslem & Bennett 2008) or due to anthropological disturbances (Marcum 2005, Pandey et al. 2021).

## **5.2 Factors affecting avian richness**

Study area supports different avian communities in different habitats along elevation gradients in the Alital area. Thus, study provides the initial investigation into how disturbances along the elevational gradient affect avifauna in such a complicated habit. The bird community has been significantly impacted by canopy cover, distance to a water source, and agricultural area in the context of environmental variables and their relationship to avian richness. These components had been observed as major factors contributing to the Alital region's high bird diversity in its numerous habitats.

### **5.2.1 Canopy cover**

Forest birds are more abundant at highly denser vegetation as they might be safer from predation or limited to the habitat by various activities (Thiollay 1999). In certain instances, open canopy habitat had higher abundance of birds which might be due to the vegetative growth remained stronger and light penetration remained greater (Tilghman 1987). The study observed granivorous species significantly depends with inverse relationship with the canopy cover of the habitat types, the reason might be occurrence of granivorous species in open habitat like in agricultural fields, grasslands, etc. due to higher chances of availability of seeds and also for breeding (Franklin et al. 2000, Chettri et al. 2005, Ding et al. 2019). Likewise, gaining accessibility to the open environment may improve foraging effectiveness by lowering the physiological costs of foraging in dense foliage, which is both more humid and challenging to move through (Moorcroft et al. 2002). Another fact is that granivorous species had to frequently consume the grains to complete their dietary activity which had been accomplished in agricultural land, shrub land and near to human settlements (Franklin et al. 2000, Sekercioglu 2012, Wiens et al. 2012).

### **5.2.2 Distance to a water source**

Bird species are linked with the distance towards the water source (Whittaker et al. 2007, Schneider & Griesser 2009), abundance of bird species are more nearer to water sources as it saves energy in searching of water for drinking and bathing behavior (Tryjanowski et al. 2022). Study showed the higher dependency with negative influence of birds species richness with distance to a water sources; mostly birds show restriction to primary sources of water during the summer season as there will be higher chances of availability of other sources of water in their habitats, whereas due to a lower percentage of secondary sources availability during winter season, they are highly dependent on primary sources of water (Schneider & Griesser 2009). The species that must routinely drink due to their dietary needs or physiological demands will be drawn to or stay nearest to water, especially granivorous and insectivorous species (MacMillen & Hinds 1998). Also, the variety of bird species and overall bird population might be higher in the habitats with streams running through them or other water sources nearby because these features might added to the potential microhabitats which can provide suitable nesting and foraging sites for some terrestrial and wetland birds (Tilghman 1987). In addition, water sources for some species might be required as sources of food contents rather than for drinking purposes, e.g., aquatic larvae might be a good foraging source for insectivore and omnivore species. (Tanner et al. 2017).

### **5.2.3 Distance to agriculture area**

The study had observed the dependency of the total number of species, including insectivorous species and carnivorous species, with distance to agricultural areas with a negative influence. Habitat that supports foraging of birds might also supports for nesting sites (Chalfoun et al. 2002), thus habitats that helps in adaptability might had the higher abundances of bird species (Duckworth & Altwegg 2021). Agriculture area connected to adjacent habitat influences the distribution of birds, e.g. agriculture area connected to nearest forest might had accessibility of forest birds (Atkinson et al. 2002). Forest habitat might tended to have a greater variety of microhabitats that could attract a multitude of species (Tilghman 1987), However, agricultural areas are also good sources of food and nesting sites, so it could be that birds visit fields in search of food and to breed. (Chalfoun et al. 2002, Kirinde et al. 2017). On contest with species of the Columbidae and Passeridae families, they had the potential to be impacted by changes in agricultural

availability since these families are heavily reliant on farmland for foraging (Murphy 2003, Haslem & Bennett 2008).

Likewise, carnivorous species also showed their preference in the crop fields by either staying on nearby trees or dwelling on the fields in search of food. (Ripple et al. 1997, Chettri et al. 2005). In agricultural areas where there are higher numbers of species, predator birds are drawn there as well which may lead to an increase in nest and bird predation (Chalfoun et al. 2002). Insectivorous and granivorous bird species are more abundant in agricultural land as they might be more dependent in this area for foraging and breeding purposes (Pringle et al. 2019). Cattle grazing in farmland might causes disturbances in agricultural habitat but insects, beetles and parasites occurring on the body or the periphery of cattle attracts insectivorous bird species (Mastrangelo & Gavin 2012).

## **6. CONCLUSION AND RECOMMENDATIONS**

### **6.1 Conclusion**

This study came to the conclusion that there were a variety of bird species in the Alital area throughout the winter, with abundance in various diverse habitats. The study also reveals that canopy cover, distance to a water source, and distance to an agricultural area are the primary factors impacting avian species richness in the Alital area. This study clearly shows that the bird community fluctuates with elevational variation, demonstrating a declining trend of avian species richness with increasing elevation. Abundance of nationally and globally threatened species suggest the initiations of conservation programs in Alital region.

### **6.2 Recommendations**

The following recommendations are underlined based on the findings and observations of the entire study:

- The study had only recorded winter seasonal bird species, hence seasonal observation is recommended to record additional data of avian species in Alital area.
- Further extensive research is needed to detect the elevational patterns of bird species because the study is only limited to 2,000 m above sea level.

## REFERENCES

- Able, K. and Noon, B. 1976. Avian community structure along elevational gradients in the northeastern United States. *Oecologia* **26**:275-294.
- Acharya, B. K., Sanders, N. J., Vijayan, L. and Chettri, B. 2011. Elevational gradients in bird diversity in the Eastern Himalaya: an evaluation of distribution patterns and their underlying mechanisms. *PLoS One* **6**(12):e29097.
- Archer, J.-M. J., Hostetler, M. E., Acomb, G. and Blair, R. 2019. A systematic review of forest bird occurrence in North American forest fragments and the built environment. *Landscape and Urban Planning* **185**:1-23.
- Arnold, H., Deacon, A. E., Hulme, M. F., Sansom, A., Jaggernauth, D. and Magurran, A. E. 2021. Contrasting trends in biodiversity of birds and trees during succession following cacao agroforest abandonment. *Journal of Applied Ecology* **58**(6):1248-1260.
- Atkinson, P. W., Fuller, R. J. and Vickery, J. A. 2002. Large- scale patterns of summer and winter bird distribution in relation to farmland type in England and Wales. *Ecography* **25**(4):466-480.
- Baral, R. 2018. A short note on birds of Bajhang district, far-western Nepal.
- Barcante, L., M. Vale, M. and S. Alves, M. A. 2017. Altitudinal migration by birds: a review of the literature and a comprehensive list of species. *Journal of Field Ornithology* **88**(4):321-335.
- Basnet, H., Poudyal, L. P., Shah, G., Thakuri, D. C. and Inskipp, C. 2023. Cheer Pheasant *Catreus wallichii* distribution in Far-Western Nepal with notes on threats. *Ornithological Science* **22**(1):57-65.
- Basnet, H. T., Deelip Chand Bhetwal, Kuldeep Joshi, Devraj Poudyal, Laxman Prasad. 2019. Recent records of threatened birds in the Sukilaphanta Grassland, Suklaphanta National Park, Nepal, with particular focus on White-throated Bushchat (*Saxicola insignis*) and Finn's Weaver (*Ploceus megarhynchus*). *BirdingAsia*. 93-96

- Basnet, T. B., Rokaya, M. B., Bhattarai, B. P. and Munzbergova, Z. 2016. Heterogeneous Landscapes on Steep Slopes at Low Altitudes as Hotspots of Bird Diversity in a Hilly Region of Nepal in the Central Himalayas. *PLoS One* **11**(3):e0150498.
- Bastola, S. C., Adhikari, J. N., Dhakal, H. and Bhattarai, B. P. 2022. Influence of environmental factors on bird diversity in and around Kahundanda Hillscape, Pokhara, Nepal. *Nepalese Journal of Zoology* **6**(2):1-16.
- Bennett, P. M. and Owens, I. P. 2002. Evolutionary ecology of birds: life histories, mating systems and extinction. p.
- Berger, J. 2004. The last mile: how to sustain long- distance migration in mammals. *Conservation Biology* **18**(2):320-331.
- Berruti, A., Harrison, J. and Navarro, R. 1994. Seasonal migration of terrestrial birds along the southern and eastern coasts of southern Africa. *Ostrich* **65**(2):54-65.
- Bhatta, L. D., van Oort, B. E. H., Stork, N. E. and Baral, H. 2015. Ecosystem services and livelihoods in a changing climate: Understanding local adaptations in the Upper Koshi, Nepal. *International Journal of Biodiversity Science, Ecosystem Services & Management* **11**(2):145-155.
- Bhattarai, S. 2014. A preliminary checklist of birds of sati karnali community forest, Kailali, Far-West Nepal. Conservation initiatives for coral reef ecosystem in marine national park, Gulf of Kachchh, Gujarat, India **41**(3).
- Bhusal, K. P., Chand, D. B., Pandey, N. and Dangaura, H. L. 2020. Avian richness of the Basanta Protected Forest, far-western lowland Nepal: Implication for conservation. *Nepalese Journal of Zoology* **4**(2):68-84.
- Bhusal, K. P., Dangaura, H. L. and McClure, C. J. 2021. Population levels and productivity of the Himalayan Griffon (*Gyps himalayensis*) in Baitadi District, Nepal. *Environmental Challenges* **5**:100318.
- Blake, J. G. and Loiselle, B. A. 2000. Diversity of birds along an elevational gradient in the Cordillera Central, Costa Rica. *The Auk* **117**(3):663-686.
- Chalfoun, A. D., Thompson III, F. R. and Ratnaswamy, M. J. 2002. Nest predators and fragmentation: a review and meta- analysis. *Conservation Biology* **16**(2):306-318.

- Chaves, A. V., Freitas, G. H., Vasconcelos, M. F. and Santos, F. R. 2015. Biogeographic patterns, origin and speciation of the endemic birds from eastern Brazilian mountaintops: a review. *Systematics and Biodiversity* **13**(1):1-16.
- Chettri, N., Deb, D. C., Sharma, E. and Jackson, R. 2005. The relationship between bird communities and habitat. *Mountain Research and Development* **25**(3):235-243.
- Dangaura, H. L., Pandey, N., Chand, D. B. and Bhusal, K. P. 2020. Avian richness of the Basanta Protected Forest, far-western lowland Nepal: Implication for conservation. *Nepalese Journal of Zoology* **4**(2):68-84.
- Davies, R. G., Orme, C. D. L., Storch, D., Olson, V. A., Thomas, G. H., Ross, S. G., et al. 2007. Topography, energy and the global distribution of bird species richness. *Proceedings of the Royal Society B: Biological Sciences* **274**(1614):1189-1197.
- Ding, Z., Liang, J., Hu, Y., Zhou, Z., Sun, H., Liu, L., et al. 2019. Different responses of avian feeding guilds to spatial and environmental factors across an elevation gradient in the central Himalaya. *Ecology and Evolution* **9**(7):4116-4128.
- Downing, R. J., Rytwinski, T. and Fahrig, L. 2015. Positive effects of roads on small mammals: a test of the predation release hypothesis. *Ecological Research* **30**:651-662.
- Duckworth, G. D. and Altwegg, R. 2021. Why a landscape view is important: nearby urban and agricultural land affects bird abundances in protected areas. *PeerJ* **9**:e10719.
- Elsen, P. R., Kalyanaraman, R., Ramesh, K. and Wilcove, D. S. 2017. The importance of agricultural lands for Himalayan birds in winter. *Conservation Biology* **31**(2):416-426.
- Engstrom, R. T., Edenius, L., Thapa, T. B., Bidari, B., Gurung, A. and Mikusiński, G. 2020. Bird communities of two forest types in Chitwan Valley, Nepal. *Ornithological Science* **19**(1):29-40.
- Francis, M., Dami, F., Kambai, C. and Habila, M. 2019. Birds Species Abundance, Richness and Diversity in Federal College of Forestry, Jos, Plateau State, Nigeria. *African journal of natural sciences (AJNS) ISSN 1119-1104* **20**.

- Franklin, D. C., Woinarski, J. C. and Noske, R. A. 2000. Geographical patterning of species richness among granivorous birds in Australia. *Journal of Biogeography* **27**(4):829-842.
- Ghimire, A., Rokaya, M. B., Timsina, B., BÍl, K., Shrestha, U. B., Chalise, M. K., et al. 2021. Diversity of birds recorded at different altitudes in central Nepal Himalayas. *Ecological Indicators* **127**.
- Gomez, C., Gomez-Bahamon, V., Cardenas-Ortız, L. and Bayly, N. J. 2015. Distribution of Nearctic-Neotropical migratory birds along a South American elevation gradient during spring migration. *The Wilson journal of ornithology* **127**(1):72-86.
- Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H. S. 2016. *Birds of Nepal*. Bloomsbury Publishing. p.
- Grytnes, J.-A. and McCain, C. M. 2007. Elevational trends in biodiversity. *Encyclopedia of biodiversity* **2**:1-8.
- Haslem, A. and Bennett, A. F. 2008. Birds in agricultural mosaics: the influence of landscape pattern and countryside heterogeneity. *Ecological Applications* **18**(1):185-196.
- Hasui, .., Gomes, V. S. d. M. and Silva, W. R. 2007. Effects of vegetation traits on habitat preferences of frugivorous birds in Atlantic rain forest. *Biotropica* **39**(4):502-509.
- Hawkins, A. 1999. Altitudinal and latitudinal distribution of east Malagasy forest bird communities. *Journal of Biogeography* **26**(3):447-458.
- He, X., DuBay, S., Zhangshang, M., Cheng, Y., Liu, Z., Li, D., et al. 2022. Seasonal elevational patterns and the underlying mechanisms of avian diversity and community structure on the eastern slope of Mt. Gongga. *Diversity and Distributions* **28**(12):2459-2474.
- Helm, B. and Gwinner, E. 1999. Timing of postjuvenile molt in African (*Saxicola torquata axillaris*) and European (*Saxicola torquata rubicola*) stonechats: effects of genetic and environmental factors. *The Auk* **116**(3):589-603.
- Helm, B., Piersma, T. and Van der Jeugd, H. 2006. Sociable schedules: interplay between avian seasonal and social behaviour. *Animal Behaviour* **72**(2):245-262.

- Herrera, C. M. 1985. Chapter'11 Habitat-Consumer Interactions in Frugivorous Birds. Habitat selection in birds:341.
- Herzog, S. K., Kessler, M. and Bach, K. 2005. The elevational gradient in Andean bird species richness at the local scale: a foothill peak and a high- elevation plateau. *Ecography* **28**(2):209-222.
- Hořák, D., Ferenc, M., Sedláček, O., Motombi, F. N., Svoboda, M., Altman, J., et al. 2019. Forest structure determines spatial changes in avian communities along an elevational gradient in tropical Africa. *Journal of Biogeography* **46**(11):2466-2478.
- Hunter, M. L. and Yonzon, P. 1993. Altitudinal distributions of birds, mammals, people, forests, and parks in Nepal. *Conservation Biology* **7**(2):420-423.
- Inskipp, C. and Baral, H. 2010. Potential impacts of agriculture on Nepal birds. *Our Nature* **8**(1):270-312.
- ICIMOD. 2013. Land cover of Nepal 2010. <https://rds.icimod.org/home/datadetail?metadataid=9224>. accessed on 12 November, 2021.
- Inskipp, C., Baral, H., Phuyal, S., Bhatt, T., Khatiwada, M., Inskipp, T., et al. 2016. The status of Nepal's Birds: The national red list series. Zoological Society of London, UK **628**.
- Inskipp, C., Baral, H. S., Inskipp, T., Khatiwada, A. P., Khatiwada, M. P., Poudyal, L. P., et al. 2017. Nepal's National Red List of Birds. *Journal of Threatened Taxa* **9**(1):9700-9722.
- IUCN. 2022. The IUCN Red List of Threatened Species. Version 2022-2. <https://www.iucnredlist.org>. accessed on 26 July, 2022.
- Jakobsson, S. and Lindborg, R. 2017. The importance of trees for woody pasture bird diversity and effects of the European Union's tree density policy. *Journal of Applied Ecology* **54**(6):1638-1647.
- Jankowski, J. E., Merkord, C. L., Rios, W. F., Cabrera, K. G., Revilla, N. S. and Silman, M. R. 2013. The relationship of tropical bird communities to tree species

- composition and vegetation structure along an Andean elevational gradient. *Journal of Biogeography* **40**(5):950-962.
- Jetz, W., Thomas, G. H., Joy, J. B., Redding, D. W., Hartmann, K. and Mooers, A. O. 2014. Global distribution and conservation of evolutionary distinctness in birds. *Current biology* **24**(9):919-930.
- Joshi, K. K. 2012. Avian diversity and its association with vegetation structure in different elevational zones of Nainital district (Western Himalayan) of Uttarakhand. *International Journal of Biodiversity and Conservation* **4**(11).
- Joshi, K. K., Bhatt, D. and Thapliyal, A. 2012. Avian diversity and its association with vegetation structure in different elevational zones of Nainital district (Western Himalayan) of Uttarakhand. *International Journal of Biodiversity and Conservation* **4**(11):364-370.
- Joshi, M. K. 2014. Population Status and Breeding Success of Himalayan Griffon (*Gyps himalayensis* Hume, 1869) and Threats: A Case Study from Khodpe, Baitadi District, Far West Nepal. Department of Zoology.
- Joshi, M. K., Chalise, M. K., Chaudhary, A. and Katuwal, H. B. 2015. Himalayan Vultures in Khodpe, far-west Nepal: is there any threat? *Journal of Threatened Taxa* **7**(14):8128-8133.
- Kandel, P., Thapa, I., Chettri, N., Pradhan, R. and Sharma, E. 2018. Birds of the Kangchenjunga Landscape, the Eastern Himalaya: status, threats and implications for conservation. *Avian Research* **9**(1).
- Katuwal, H. B., Basnet, K., Khanal, B., Devkota, S., Rai, S. K., Gajurel, J. P., et al. 2016. Seasonal changes in bird species and feeding guilds along elevational gradients of the Central Himalayas, Nepal. *PLoS One* **11**(7):e0158362.
- Katuwal, H. B., Pradhan, N. M. B., Thakuri, J. J., Bhusal, K. P., Aryal, P. C. and Thapa, I. 2018. Effect of urbanization and seasonality in bird communities of Kathmandu Valley, Nepal. *Proceedings of the Zoological Society, Springer*.
- Kirinde, G., Dayawansa, N. and Mowjood, M. 2017. Water regimes and ecosystem in lowland paddy field: a case study in Awlegama, Kurunegala, Sri Lanka.

- Korhonen, L., Korhonen, K. T., Rautiainen, M. and Stenberg, P. 2006. Estimation of forest canopy cover: a comparison of field measurement techniques.
- Kumar, R., Shahabuddin, G. and Kumar, A. 2014. Habitat determinants of woodpecker abundance and species richness in sub-Himalayan dipterocarp forests of north-west India. *Acta ornithologica* **49**(2):243-256.
- Kunwar, N., Pandey, N., Singh, K. D. and Bhattarai, B. P. 2023. Bird diversity along an elevational gradient in Shivapuri Nagarjun National Park, Nepal. *Our Nature* **21**(1):1-15.
- Ladet, S., Sheeren, D., Herrault, P. A. and Fauvel, M. 2018. Assessing the Influence of Landscape on Biodiversity Using the QGIS Plugin LecoS. *QGIS and Applications in Territorial Planning* **3**:239-264.
- Larkin, J. L., Barnes, T. G., DePoy-Smith, M. and Maehr, D. S. 2001. A comparison of avian communities occupying native and exotic grasslands in Kentucky: a preliminary study. *Proceedings of the North American Prairie Conference*.
- Lees, A. C. and Peres, C. A. 2006. Rapid avifaunal collapse along the Amazonian deforestation frontier. *Biological Conservation* **133**(2):198-211.
- Lepczyk, C. A., La Sorte, F. A., Aronson, M. F., Goddard, M. A., MacGregor-Fors, I., Nilon, C. H., et al. 2017. Global patterns and drivers of urban bird diversity. *Ecology and conservation of birds in urban environments*:13-33.
- Lu, X., Zhang, L. Y. and Zeng, X. H. 2007. Comparisons of the alpine bird communities across habitats and between autumn and winter in the mid- Yalong Zangbo River valley, Tibet. *Journal of Natural History* **41**(37-40):2511-2527.
- Lundberg, P. 1988. The evolution of partial migration in birds. *Trends in ecology & evolution* **3**(7):172-175.
- MacMillen, R. E. and Hinds, D. S. 1998. Water economy of granivorous birds: California house finches. *The Condor* **100**(3):493-503.
- Malla, G. 2008. Climate change and its impact on Nepalese agriculture. *Journal of agriculture and environment* **9**:62-71.

- Marcum, H. A. 2005. The effects of human disturbance on birds in Bastrop State Park. Texas A&M University. p.
- Mastrangelo, M. E. and Gavin, M. C. 2012. Trade- offs between cattle production and bird conservation in an agricultural frontier of the Gran Chaco of Argentina. *Conservation Biology* **26**(6):1040-1051.
- McCain, C. M. 2009. Global analysis of bird elevational diversity. *Global Ecology and Biogeography* **18**(3):346-360.
- McGrann, M. C. and Furnas, B. J. 2016. Divergent species richness and vocal behavior in avian migratory guilds along an elevational gradient. *Ecosphere* **7**(8):e01419.
- Montano-Centellas, F. A. and Garitano-Zavala, Á. 2015. Andean bird responses to human disturbances along an elevational gradient. *Acta Oecologica* **65**:51-60.
- Moorcroft, D., Whittingham, M., Bradbury, R. and Wilson, J. 2002. The selection of stubble fields by wintering granivorous birds reflects vegetation cover and food abundance. *Journal of Applied Ecology*:535-547.
- Morante- Filho, J. C., Arroyo- Rodríguez, V., de Andrade, E. R., Santos, B. A., Cazetta, E. and Faria, D. 2018. Compensatory dynamics maintain bird phylogenetic diversity in fragmented tropical landscapes. *Journal of Applied Ecology* **55**(1):256-266.
- Mulwa, M., Teucher, M., Ulrich, W. and Habel, J. C. 2021. Bird communities in a degraded forest biodiversity hotspot of East Africa. *Biodiversity and Conservation* **30**(8-9):2305-2318.
- Murphy, M. T. 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. *The Auk* **120**(1):20-34.
- Negret, P. J., Maron, M., Fuller, R. A., Possingham, H. P., Watson, J. E. and Simmonds, J. S. 2021. Deforestation and bird habitat loss in Colombia. *Biological Conservation* **257**:109044.
- Neupane, J., Khanal, L., Gyawali, B. and Chalise, M. K. 2020. Elevational pattern and seasonality of avian diversity in Kaligandaki River Basin, central Himalaya. *Journal of Threatened Taxa* **12**(14):16927-16943.

- Pagaduan, D. C. and Afuang, L. E. 2012. Understorey bird species diversity along elevational gradients on the northeastern slope of Mt. Makiling, Luzon, Philippines. *Asia Life Sciences Journal* **21**(2):585-607.
- Pan, X., Ding, Z., Hu, Y., Liang, J., Wu, Y., Si, X., et al. 2016. Elevational pattern of bird species richness and its causes along a central Himalaya gradient, China. *PeerJ* **4**:e2636.
- Pandey, H. P. and Pokhrel, S. 2021. Stocking density and DBH distribution of community forests in Nepal. *Small-scale Forestry* **20**(1):145-159.
- Pandey, N., Khanal, L. and Chalise, M. K. 2020. Correlates of avifaunal diversity along the elevational gradient of Mardi Himal in Annapurna Conservation Area, Central Nepal. *Avian Research* **11**(1).
- Pandey, N., Khanal, L., Chapagain, N., Singh, K. D., Bhattarai, B. P. and Chalise, M. K. 2021. Bird community structure as a function of habitat heterogeneity: A case of Mardi Himal, Central Nepal. *Biodiversitas Journal of Biological Diversity* **22**(1).
- Patterson, B. D., Stotz, D. F., Solari, S., Fitzpatrick, J. W. and Pacheco, V. 1998. Contrasting patterns of elevational zonation for birds and mammals in the Andes of southeastern Peru. *Journal of Biogeography* **25**(3):593-607.
- Paudel, P. K. and Šipoš, J. 2014. Conservation status affects elevational gradient in bird diversity in the Himalaya: A new perspective. *Global Ecology and Conservation* **2**:338-348.
- Penjor, U., Jamtsho, R. and Sherub, S. 2022. Anthropogenic land- use change shapes bird diversity along the eastern Himalayan altitudinal gradient. *Journal of Applied Ecology* **59**(3):847-859.
- Pescador, M. and Peris, S. 2007. Influence of roads on bird nest predation: An experimental study in the Iberian Peninsula. *Landscape and Urban Planning* **82**(1-2):66-71.
- Poudyal, L. P. 2012. Broadcasting a Radio Programme Conserving Globally Threatened Birds in Far Western Nepal. <https://www.researchgate.net/publication/314088125>. accessed on 10 May, 2022.

- Price, T. D., Mohan, D., Tietze, D. T., Hooper, D. M., Orme, C. D. and Rasmussen, P. C. 2011. Determinants of northerly range limits along the Himalayan bird diversity gradient. *Am Nat* **178 Suppl 1**:S97-108.
- Pringle, S., Chiweshe, N., Steward, P. R., Mundy, P. J. and Dallimer, M. 2019. Rapid redistribution of agricultural land alters avian richness, abundance, and functional diversity. *Ecology and Evolution* **9**(21):12259-12271.
- QGIS Development Team, A. 2019. QGIS geographic information system. Open source geospatial foundation project:504-507.
- Quintero, I. and Jetz, W. 2018. Global elevational diversity and diversification of birds. *Nature* **555**(7695):246-250.
- Rahbek, C. 1995. The elevational gradient of species richness: a uniform pattern? *Ecography*:200-205.
- Renner, S. C. 2011. Bird Species-Richness Pattern in the Greater Himalayan Mountains—A General Introduction. *Ornithological Monographs* **70**(1):1-9.
- Rey, P. J. 2011. Preserving frugivorous birds in agro- ecosystems: lessons from Spanish olive orchards. *Journal of Applied Ecology* **48**(1):228-237.
- Ripple, W. J., Lattin, P. D., Hershey, K., Wagner, F. F. and Meslow, E. C. 1997. Landscape composition and pattern around northern spotted owl nest sites in southwest Oregon. *The Journal of Wildlife Management*:151-158.
- Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. *Ecology* **57**(4):773-782.
- Santhakumar, B., Arun, P. R., Sony, R. K., Murugesan, M. and Ramesh, C. 2018. The pattern of bird distribution along the elevation gradient of the Sutlej River basin, western Himalaya, India. *Journal of Threatened Taxa* **10**(13):12715-12725.
- Santillán, V., Quitián, M., Tinoco, B. A., Zárate, E., Schleuning, M., Böhning-Gaese, K., et al. 2019. Different responses of taxonomic and functional bird diversity to forest fragmentation across an elevational gradient. *Oecologia* **189**(4):863-873.

- Schneider, N. A. and Griesser, M. 2009. Influence and value of different water regimes on avian species richness in arid inland Australia. *Biodiversity and Conservation* **18**:457-471.
- Sekercioglu, C. H. 2012. Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. *Journal of Ornithology* **153**(Suppl 1):153-161.
- Shochat, E., Lerman, S. and Fernández-Juricic, E. 2010. Birds in urban ecosystems: population dynamics, community structure, biodiversity, and conservation. *Urban ecosystem ecology* **55**:75-86.
- Söderström, B., Kiema, S. and Reid, R. S. 2003. Intensified agricultural land-use and bird conservation in Burkina Faso. *Agriculture, Ecosystems & Environment* **99**(1-3):113-124.
- Subedi, I. P., Budha, P. B., Kunwar, R. M., Charmakar, S., Ulak, S., Pradhan, D. K., et al. 2021. Diversity and distribution of forest ants (Hymenoptera: Formicidae) in Nepal: implications for sustainable forest management. *Insects* **12**(12):1128.
- Swanson, D. L. 2010. Seasonal metabolic variation in birds: functional and mechanistic correlates. In: (Eds) *Current Ornithology Volume 17*. Springer. pp 75-129.
- Tanner, E. P., Elmore, R. D., Davis, C. A. and Fuhlendorf, S. D. 2017. Wintering bird responses to the presence of artificial surface water in a semi- arid rangeland. *Wildlife Biology* **2017**(1):1-10.
- Team, R. C. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [http://www. R-project.org/](http://www.R-project.org/). accessed on 26 June, 2022.
- Tellería, J. L., Ramírez, Á. and Pérez-Tris, J. 2005. Conservation of seed-dispersing migrant birds in Mediterranean habitats: shedding light on patterns to preserve processes. *Biological Conservation* **124**(4):493-502.
- Thiollay, J.-M. 1999. Frequency of mixed species flocking in tropical forest birds and correlates of predation risk: an intertropical comparison. *Journal of Avian Biology*:282-294.

- Tilghman, N. G. 1987. Characteristics of urban woodlands affecting breeding bird diversity and abundance. *Landscape and Urban Planning* **14**:481-495.
- Tilghman, N. G. 1987. Characteristics of urban woodlands affecting winter bird diversity and abundance. *Forest Ecology and Management* **21**(3-4):163-175.
- Tryjanowski, P., Jankowiak, Ł., Czechowski, P., Dulisz, B., Golawski, A., Grzywaczewski, G., et al. 2022. Summer water sources for temperate birds: use, importance, and threats. *The European Zoological Journal* **89**(1):913-926.
- Viana, D. S., Santamaría, L. and Figuerola, J. 2016. Migratory birds as global dispersal vectors. *Trends in ecology & evolution* **31**(10):763-775.
- Waltert, M., Bobo, K. S., Sainge, N. M., Fermon, H. and Mühlenberg, M. 2005. From forest to farmland: habitat effects on Afrotropical forest bird diversity. *Ecological Applications* **15**(4):1351-1366.
- Walther, B. A., Chen, J. R.-J., Lin, H.-S. and Sun, Y.-H. 2017. The effects of rainfall, temperature, and wind on a community of montane birds in Shei-Pa National Park, Taiwan. *Zoological studies* **56**.
- Weatherspark. 2022. Average weather in Dadeldhura Nepal year round. <https://weatherspark.com/y/110272>. accessed on 23 April, 2022.
- Whittaker, R. J., Nogués- Bravo, D. and Araújo, M. B. 2007. Geographical gradients of species richness: a test of the water- energy conjecture of Hawkins et al.(2003) using European data for five taxa. *Global Ecology and Biogeography* **16**(1):76-89.
- Wiens, J., Johnston, R., Pinowski, J. and Kendeigh, S. 2012. Adaptive correlates of granivory in birds. *Granivorous Birds in Ecosystems: Their Evolution, Populations, Energetics, Adaptations, Impact and Control.*,(Eds J. Pinowski and SC Kendeigh.) pp:301-340.
- Zizka, A. and Antonelli, A.2018. Mountains of diversity. Nature Publishing Group.

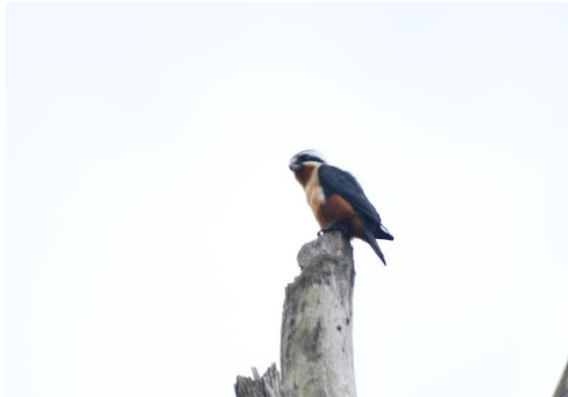
## PHOTOGRAPHS



**Photograph 1.** Brown Fish Owl was spotted sitting on a branch in a forest at 600 m elevation.



**Photograph 2.** Alexandrine Parakeets were spotted sitting on top of the dead tree at 700 m elevation.



**Photograph 3.** Collared Falconet was spotted sitting on top of the dead tree at 500 m elevation.



**Photograph 4.** Black Stork was spotted on the river bank at 500 m elevation.



**Photograph 5.** White-browed Scimitar Babbler was spotted at 1,000 m elevation.



**Photograph 6.** Blue-eared Kingfisher was spotted on the river bank at 500 m elevation.



**Photograph 7.** Crested Serpent Eagle was spotted sitting on the tree top at 500 m elevation.



**Photograph 8.** Grey Nightjar was spotted resting at 500 m elevation.



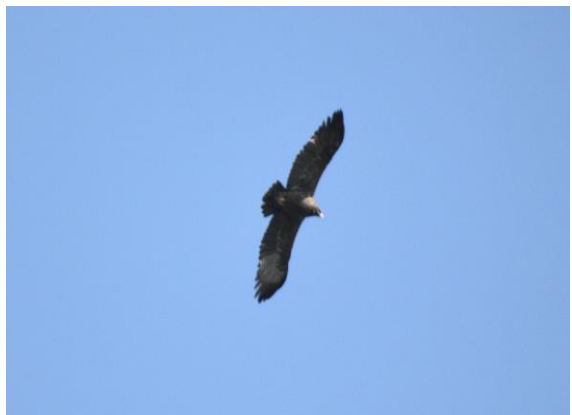
**Photograph 9.** The Eurasian Sparrow Hawk was spotted resting on the ground with its injured right leg.



**Photograph 10.** Common Green Magpie sitting on the branch at 600 m elevation.



**Photograph 11.** Russet Sparrows were spotted flying over the bushes.



**Photograph 12.** Steppe Eagle was spotted flying over at 1,200 m elevation.

## APPENDIX

### Checklist of birds

Family/Common name	Scientific Name	Order	F.G.	N.S.	G.S.
<b>Accipitridae</b>					
Crested Serpent Eagle	<i>Spilornis cheela</i> Latham, 1790	Accipitriformes	C	LC	LC
Eurasian Sparrowhawk	<i>Accipiter nisus</i> (Linnaeus, 1758)	Accipitriformes	C	LC	LC
Griffon Vulture	<i>Gyps fulvus</i> (Hablizl, 1783)	Accipitriformes	C	DD	LC
Steppe Eagle	<i>Aquila nipalensis</i> Hodgson, 1833	Accipitriformes	C	VU	EN
<b>Aegithalidae</b>					
Black-throated Tit	<i>Aegithalos concinnus</i> (Gould, 1855)	Passeriformes	C	LC	LC
<b>Alcedinidae</b>					
Blue-eared Kingfisher	<i>Alcedo meninting</i> Horsfield, 1821	Coraciiformes	C	EN	LC
White-throated Kingfisher	<i>Halcyon smyrnensis</i> (Linnaeus, 1758)	Coraciiformes	C	LC	LC
<b>Campephagidae</b>					
Long-tailed Minivet	<i>Pericrocotus ethologus</i> Bangs & Phillips, 1914	Passeriformes	I	LC	LC
Scarlet Minivet	<i>Pericrocotus speciosus</i> (Latham, 1790)	Passeriformes	I	LC	LC
<b>Caprimulgidae</b>					
Grey Nightjar	<i>Caprimulgus jotaka</i> Temminck & Schlegel, 1844	Caprimulgiformes	I	LC	LC
<b>Certhiidae</b>					
Bar-tailed Treecreeper	<i>Certhia himalayana</i> Vigors, 1832	Passeriformes	I	LC	LC
Rusty-flanked Treecreeper	<i>Certhia nipalensis</i> Blyth, 1845	Passeriformes	I	LC	LC

<b>Charadriidae</b>					
Red-wattled Lapwing	<i>Vanellus indicus indicus</i> (Boddaert, 1783)	Charadriiformes	I	LC	LC
<b>Chloropseidae</b>					
Golden-fronted Leafbird	<i>Chloropsis aurifrons</i> (Temminck, 1829)	Passeriformes	I	LC	LC
Orange-bellied Leafbird	<i>Chloropsis hardwickii</i> Jardine & Selby, 1830	Passeriformes	I	LC	LC
<b>Ciconiidae</b>					
Black Stork	<i>Ciconia nigra</i> (Linnaeus, 1758)	Ciconiiformes	C	VU	LC
<b>Cisticolidae</b>					
Common Tailorbird	<i>Orthotomus sutorius</i> (Pennant, 1769)	Passeriformes	I	LC	LC
Jungle Prinia	<i>Prinia sylvatica</i> Jerdon, 1840	Passeriformes	I	LC	LC
Plain Prinia	<i>Prinia inornata</i> Sykes, 1832	Passeriformes	I	LC	LC
<b>Columbidae</b>					
Common Pigeon	<i>Columba livia</i> ("Gmelin, JF", 1788)	Columbiformes	G	LC	LC
Eurasian Collared Dove	<i>Streptopelia decaocto</i> (Frivaldszky, 1838)	Columbiformes	G	LC	LC
Oriental Turtle Dove	<i>Streptopelia orientalis</i> (Latham, 1790)	Columbiformes	G	LC	LC
Spotted Dove	<i>Spilopelia chinensis</i> (Scopoli, 1768)	Columbiformes	G	LC	LC
<b>Coraciidae</b>					
Indian Roller	<i>Coracias benghalensis</i> Linnaeus, 1758	Coraciiformes	C	LC	LC
<b>Corvidae</b>					
Common Green Magpie	<i>Cissa chinensis</i> (Boddaert, 1783)	Passeriformes	O	LC	LC
Grey Treepie	<i>Dendrocitta formosae</i> Swinhoe, 1863	Passeriformes	O	LC	LC
Indian Jungle Crow	<i>Corvus culminatus</i> Sykes, 1832	Passeriformes	O	LC	LC

Red-billed Blue Magpie	<i>Urocissa erythroryncha</i> (Boddaert, 1783)	Passeriformes	O	LC	LC
Rufous Treepie	<i>Dendrocitta vagabunda</i> (Latham, 1790)	Passeriformes	O	LC	LC
<b>Cuculidae</b>					
Greater Coucal	<i>Centropus sinensis</i> (Stephens, 1815)	Cuculiformes	O	LC	LC
<b>Dicruridae</b>					
Black Drongo	<i>Dicrurus macrocercus</i> Vieillot, 1817	Passeriformes	I	LC	LC
Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i> (Temminck, 1823)	Passeriformes	I	LC	LC
Spangled Drongo	<i>Dicrurus bracteatus</i> Gould, 1843	Passeriformes	I	LC	LC
<b>Emberizidae</b>					
Crested Bunting	<i>Emberiza lathamii</i> ("Gray, JE", 1831)	Passeriformes	O	LC	LC
<b>Estrildidae</b>					
Scaly-breasted Munia	<i>Lonchura punctulata</i> (Linnaeus, 1758)	Passeriformes	G	LC	LC
<b>Eurylaimidae</b>					
Long-tailed Broadbill	<i>Psarisomus dalhousiae</i> (Jameson, 1835)	Passeriformes	I	LC	LC
<b>Falconidae</b>					
Collared Falconet	<i>Microhierax caerulescens</i> (Linnaeus, 1758)	Falconiformes	C	NT	LC
Eurasian Kestrel	<i>Falco tinnunculus</i> Linnaeus, 1758	Falconiformes	C	LC	LC
<b>Hirundinidae</b>					
Barn Swallow	<i>Hirundo rustica</i> Linnaeus, 1758	Passeriformes	I	LC	LC
<b>Laniidae</b>					
Brown Shrike	<i>Lanius cristatus</i> Linnaeus, 1758	Passeriformes	C	LC	LC
Grey-backed Shrike	<i>Lanius tephronotus</i> Vigors, 1831	Passeriformes	C	LC	LC
Long-tailed Shrike	<i>Lanius schach erythronotus</i> (Vigors,	Passeriformes	C	LC	LC

	1831)				
<b>Leiothrichidae</b>					
Jungle Babbler	<i>Turdoides striata</i> Dumont, 1823	Passeriformes	I	LC	LC
Rufous Sibia	<i>Heterophasia capistrata</i> (Vigors, 1831)	Passeriformes	O	LC	LC
White-crested Laughingthrush	<i>Garrulax leucolophus</i> Hardwicke, 1816	Passeriformes	I	LC	LC
<b>Megalaimidae</b>					
Blue-throated Barbet	<i>Psilopogon asiaticus</i> (Latham, 1790)	Piciformes	F	LC	LC
Brown-headed Barbet	<i>Megalaima zeylanica</i> ("Gmelin, JF", 1788)	Piciformes	F	LC	LC
Great Barbet	<i>Psilopogon virens</i> (Boddaert, 1783)	Piciformes	F	LC	LC
<b>Meropidae</b>					
Blue-bearded Bee-eater	<i>Nyctyornis athertoni</i> (Jardine & Selby, 1830)	Coraciiformes	I	LC	LC
<b>Motacillidae</b>					
Grey Wagtail	<i>Motacilla cinerea</i> Tunstall, 1771	Passeriformes	I	LC	LC
Olive-backed Pipit	<i>Anthus hodgsoni</i> Richmond, 1907	Passeriformes	I	LC	LC
Paddyfield Pipit	<i>Anthus rufulus</i> Vieillot, 1818	Passeriformes	I	LC	LC
White Wagtail	<i>Motacilla alba</i> Linnaeus, 1758	Passeriformes	I	LC	LC
White-browed Wagtail	<i>Motacilla maderaspatensis</i> Gmelin, JF 1789	Passeriformes	I	LC	LC
<b>Muscicapidae</b>					
Asian Brown Flycatcher	<i>Muscicapa dauurica</i> Pallas, 1811	Passeriformes	I	LC	LC
Blue Whistling Thrush	<i>Myophonus caeruleus</i> (Scopoli, 1786)	Passeriformes	O	LC	LC
Blue-capped Redstart	<i>Phoenicurus coeruleocephala</i> Vigors, 1831	Passeriformes	I	LC	LC
Chestnut-bellied Rock Thrush	<i>Monticola rufiventris</i> (Jardine & Selby, 1833)	Passeriformes	I	LC	LC

Common Stonechat	<i>Saxicola torquatus</i> (Linnaeus, 1766)	Passeriformes	I	LC	LC
Grey Bushchat	<i>Saxicola ferreus</i> "Gray, JE & Gray, GR", 1847	Passeriformes	I	LC	LC
Plumbeous Water Redstart	<i>Phoenicurus fuliginosus</i> Vigors, 1831	Passeriformes	I	LC	LC
Rufous-breasted Bush Robin	<i>Tarsiger hyperythrus</i> (Blyth, 1847)	Passeriformes	I	LC	LC
Siberian Rubythroat	<i>Luscinia calliope</i> (Pallas, 1776)	Passeriformes	I	LC	LC
Slaty-blue Flycatcher	<i>Ficedula tricolor</i> (Hodgson, 1845)	Passeriformes	I	LC	LC
Small Niltava	<i>Niltava macgrigoriae</i> ("Burton, E", 1836)	Passeriformes	I	LC	LC
Verditer Flycatcher	<i>Eumyias thalassinus</i> (Swainson, 1838)	Passeriformes	I	LC	LC
White-browed Shortwing	<i>Brachypteryx montana</i> Horsfield, 1821	Passeriformes	I	LC	LC
White-capped Redstart	<i>Phoenicurus leucocephalus</i> Vigors, 1831	Passeriformes	I	LC	LC
White-tailed Stonechat	<i>Saxicola leucurus</i> (Blyth, 1847)	Passeriformes	I	LC	LC
<b>Nectariniidae</b>					
Fire-tailed Sunbird	<i>Aethopyga ignicauda</i> (Hodgson, 1837)	Passeriformes	F	LC	LC
Green-tailed Sunbird	<i>Aethopyga nipalensis</i> (Hodgson, 1837)	Passeriformes	F	LC	LC
Mrs Gould's Sunbird	<i>Aethopyga gouldiae</i> (Vigors, 1831)	Passeriformes	F	LC	LC
<b>Oriolidae</b>					
Black-hooded Oriole	<i>Oriolus xanthornus</i> (Linnaeus, 1758)	Passeriformes	O	LC	LC
<b>Paridae</b>					
Black-lored Tit	<i>Parus xanthogenys</i> Vigors, 1831	Passeriformes	I	LC	LC

Great Tit	<i>Parus major</i> Linnaeus, 1758	Passeriformes	I	LC	LC
<b>Passeridae</b>					
House Sparrow	<i>Passer domesticus</i> Linnaeus, 1758	Passeriformes	G	LC	LC
Russet Sparrow	<i>Passer cinnamomeus</i> (Gould, 1836)	Passeriformes	O	LC	LC
<b>Phasianidae</b>					
Cheer Pheasant	<i>Catreus wallichii</i> (Hardwicke, 1827)	Galliformes	O	EN	VU
Kalij Pheasant	<i>Lophura leucomelanos hamiltoni</i> (J.E. Gray, 1829)	Galliformes	O	LC	LC
<b>Phylloscopidae</b>					
Grey-hooded Warbler	<i>Phylloscopus xanthoschistos albosuperciliaris</i> (J. E. Gray & G. R. Gray, 1847)	Passeriformes	I	LC	LC
Hume's Leaf Warbler	<i>Phylloscopus humei</i> ("Brooks, WE", 1878)	Passeriformes	I	LC	LC
Tickell's Leaf Warbler	<i>Phylloscopus affinis</i> (Tickell, 1833)	Passeriformes	I	LC	LC
<b>Picidae</b>					
Darjeeling Woodpecker	<i>Dendrocopos darjellensis</i> (Blyth, 1845)	Piciformes	I	LC	LC
Greater Goldenback	<i>Chrysocolaptes lucidus</i> (Scopoli, 1786)	Piciformes	I	LC	LC
Greater Yellownappe	<i>Chrysophlegma flavinucha</i> (Gould, 1834)	Piciformes	I	LC	LC
Grey-capped Pygmy Woodpecker	<i>Yungipicus canicapillus</i> Blyth, 1845	Piciformes	I	LC	LC
Grey-headed Woodpecker	<i>Picus canus sanguiniceps</i> Baker, ECS, 1926	Piciformes	I	LC	LC
Rufous Woodpecker	<i>Celeus spectabilis</i> Sclater & Salvin, 1880	Piciformes	I	LC	LC
Speckled Piculet	<i>Picumnus innominatus</i> "Burton, E", 1836	Piciformes	I	LC	LC

White-naped Woodpecker	<i>Chrysocolaptes festivus</i> (Boddaert, 1783)	Piciformes	I	LC	LC
<b>Psittaculidae</b>					
Alexandrine Parakeet	<i>Psittacula eupatria</i> (Linnaeus, 1766)	Psittaciformes	O	NT	NT
Slaty-headed Parakeet	<i>Psittacula himalayana</i> (Lesson, 1832)	Psittaciformes	O	LC	LC
<b>Pycnonotidae</b>					
Ashy Bulbul	<i>Hemixos flavala</i> Blyth, 1845	Passeriformes	O	LC	LC
Black Bulbul	<i>Hypsipetes leucocephalus</i> (Gmelin, 1789)	Passeriformes	O	LC	LC
Himalayan Bulbul	<i>Pycnonotus leucogenys</i> ("Gray, JE", 1835)	Passeriformes	I	LC	LC
Red-vented Bulbul	<i>Pycnonotus cafer</i> (Linnaeus, 1766)	Passeriformes	I	LC	LC
<b>Rallidae</b>					
White-breasted Waterhen	<i>Amaurornis phoenicurus</i> (Pennant, 1769)	Gruiformes	C	LC	LC
<b>Rhipiduridae</b>					
White-throated Fantail	<i>Rhipidura albicollis</i> (Vieillot, 1818)	Passeriformes	I	LC	LC
<b>Sittidae</b>					
Chestnut-bellied Nuthatch	<i>Sitta cinnamoventris</i> Blyth, 1842	Passeriformes	O	LC	LC
Velvet-fronted Nuthatch	<i>Sitta frontalis</i> Swainson, 1820	Passeriformes	O	LC	LC
<b>Stenostiridae</b>					
Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i> (Swainson, 1820)	Passeriformes	I	LC	LC
<b>Strigidae</b>					
Asian Barred Owlet	<i>Glaucidium cuculoides</i> (Vigors, 1831)	Strigiformes	C	LC	LC
Brown Fish Owl	<i>Ketupa zeylonensis</i> ("Gmelin, JF",	Strigiformes	C	VU	LC

	1788)				
Jungle Owlet	<i>Glaucidium radiatum</i> (Tickell, 1833)	Strigiformes	C	LC	LC
Spotted Owlet	<i>Athene brama</i> (Temminck, 1821)	Strigiformes	C	LC	LC
<b>Sturnidae</b>					
Common Myna	<i>Acridotheres tristis</i> (Linnaeus, 1766)	Passeriformes	O	LC	LC
Sylviidae					
Lesser Whitethroat	<i>Sylvia curruca</i> (Linnaeus, 1758)	Passeriformes	I	LC	LC
<b>Tichodromidae</b>					
Wallcreeper	<i>Tichodroma muraria</i> (Linnaeus, 1766)	Passeriformes	O	LC	LC
<b>Timaliidae</b>					
Black-chinned Babbler	<i>Stachyris pyrrhops</i> Blyth, 1844	Passeriformes	I	LC	LC
Rusty-cheeked Scimitar Babbler	<i>Erythrogonys erythrogonys</i> (Vigors, 1832)	Passeriformes	I	LC	LC
White-browed Scimitar Babbler	<i>Pomatorhinus schisticeps</i> Hodgson, 1836	Passeriformes	I	NT	LC
<b>Turdidae</b>					
Grey-winged Blackbird	<i>Turdus boulboul</i> (Latham, 1790)	Passeriformes	I	LC	LC
<b>Vireonidae</b>					
Himalayan Shrike Babbler	<i>Pteruthius rileyi</i> Biswas, 1960	Passeriformes	I	LC	LC
<b>Zosteropidae</b>					
Oriental White-eye	<i>Zosterops palpebrosus</i> (Temminck, 1824)	Passeriformes	O	LC	LC

**Note:** I: Insectivore, G: Granivore, O: Omnivore, C: Carnivore, F: Frugivore, LC: Least Concerned, EN: Endangered, NT: Nearly Threatened, VU: Vulnerable and DD: Data Deficient.