DIVERSITY AND DISTRIBUTION OF BIRDS ALONG AN ELEVATION GRADIENT IN MAKAWANPUR DISTRICT, NEPAL

Hari Sharan Giri

T.U. Registration No: 5-2-242-686-2014

T.U Examination Roll No: 713/2075

Batch: 2075/2076

A Thesis submitted in partial fulfillment of the requirements for the award of degree of the Masters 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

August 2022

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 authors.

Date: August 23, 2022
07/05/2079

Hari Sharan Giri

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U., Kirtipur

RECOMMENDATION

This is to recommend that the thesis entitled "**Diversity and Distribution of birds along an elevation gradient in Makawanpur District, Nepal**" has been carried out by Mr. Hari Sharan Giri for partial fulfillment of the requirement for Master's Degree in Zoology with the special paper of Ecology. This is his original work and has been carried out under my supervision. To the best of my knowledge, this work has not been submitted for any other degree in any institutions.

Date: 07/05/2079 August 23, 2022

....

Supervisor

Asst. Prof. Bishnu P. Bhattarai, PhD

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

Central Department of Zoology T.U. Kirtipur

LETTER OF APPROVAL

On the recommendation of supervisor Dr. Bishnu P. Bhattarai, Central Department of Zoology, Tribhuvan University, the thesis submitted by Mr. Hari Sharan Giri entitled " **Diversity and Distribution of birds along an elevation gradient in Makawanpur District, Nepal**" is approved for the examination in partial fulfillment of the requirement for the Master's Degree of Science in Zoology with special paper Ecology and Environment.

Date: August 28, 2022
12/05/2079

....

Prof. Dr. Tej Bahadur Thapa
Head of Department
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

त्रिभुवन विश्वविद्यालय
TRIBHUVAN UNIVERSITY
प्राणी शास्त्र केन्द्रीय विभाग
CENTRAL DEPARTMENT OF ZOOLOGY
कीर्तिपुर, काठमाडौं, नेपाल ।
Kirtipur, Kathmandu, Nepal.

०१-४३३१८९६
01-4331896
Email: info@cdztu.edu.np
URL: www.cdztu.edu.np

पत्र संख्या :-
च.नं. Ref.No.:-

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Hari Sharan Giri "**Diversity and Distribution of birds along an elevation gradient in Makawanpur District, Nepal**" has been accepted as a partial fulfillment for the requirement of Master's Degree of Science in Zoology with special paper Ecology.

EVALUATION COMMITTEE

....	....
Supervisor	**Head of Department**
Bishnu P. Bhattarai, PhD	Prof. Dr. Tej Bahadur Thapa
Asst. Professor	Head of Department
Central Department of Zoology	Central Department of Zoology
Tribhuvan University	Tribhuvan University
Kirtipur, Nepal	Kirtipur, Nepal
....	....
External Examiner	**Internal Examiner**
Dr. Hem Sagar Baral	Dr. Laxman Khanal
Zoological Society of London	Associate Professor
Nepal Office	Central Department of Zoology
	Tribhuvan University

Date of Examination: September 15, 2022
31/05/2079

ACKNOWLEDGEMENTS

Foremost, I would like to express my heartfelt gratitude and indebtedness to my honorable supervisor Asst Prof. Bishnu P. Bhattarai, PhD, Central Department of Zoology (Ecology) for his guidance, immense help, valuable suggestions, information and knowledge regarding the subject matters. This thesis would not have taken its present shape and quality without his untiring efforts.

My sincere thanks and gratitude are due to Prof. Tej Bahadur Thapa, PhD, Head of the Central Department of Zoology for providing administrative support and facilities. I am highly obliged and extend my thanks to all of my respected teachers and staffs of the Central Department of Zoology, TU, Kirtipur.

I am thankful to my friends Sachet Timilsina, Sourabh Sigdel, and Dipesh Karki for their immense help and assistance during field data collection. I am also grateful to Dr. Hem Bahadur Katuwal sir and my seniors Juna Neupane, Nabina Kunwar, Naresh Pandey for guiding and suggesting me during the time of research design, data analysis and writing of this thesis.

I too extend my heartfelt gratitude to my guardians who supported me economically, and encouraged me throughout the time and during field work. I am very much grateful to all people who encouraged for my study and all my friends for their direct and indirect help in completing this work.

Hari Sharan Giri

Examination Roll No.: 713/075

ABSTRACT

The purpose of this research was to investigate the variety, distribution, and associated characteristics along an elevation gradient of the Makawanpur District, Nepal. The field survey was conducted throughout the winter season (December–February, 2021). For every 100 m elevation gain, the point count method (radius=50 m) was used. Bird abundance, bird species, and environmental variables were evaluated, and diversity indices were computed. The generalized linear model was used to investigate the role of environmental factors in shaping the species richness pattern. Within the study area, 22 sampling plots were established ranging in elevation from 431 m (Hetauda) to 2503 m (Simbhanjyang). Data on variables such as the number of fruiting trees as a proxy for resource availability, distance to road, and distance to the village as proxies for disturbance, and habitat types were gathered and analyzed. A total of 1824 birds from 172 species were counted. The Shannon diversity index (H'=4.553) and the evenness index (e=0.551) indicated a diverse assemblage of avian fauna in the study area. The order Passeriformes and the Muscicapidae family have the highest species richness. The majority of the 172 bird species were residents (74%), followed by winter migrants (21%), and the remaining 5% were summer migrants. Bird species were more diversified in Riverbank areas than in agricultural and Forest habitats. The quantity of fruiting trees and the gradient of altitude had a substantial impact on the richness of bird species. The richness of large range resident bird species was favorably connected with the quantity of fruiting trees and forest environment, although it decreased with increasing distance to road and altitude. However, small-ranged and insectivorous birds were strong influence by Elevation gradients only. The research that diversified bird species and their associations with many factors require a more detailed survey to investigate more species as well as other patterns and processes throughout the elevational gradient.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
Asl	Above sea level
BCN	Bird Conservation Nepal
C	Carnivorous
EN	Endangered
F	Frugivorous
G	Granivores
GLM	Generalized Linear Model
IUCN	International Union for Conservation of Nature and Natural resources
I	Insectivorous
LB	Invertebrates Biome
LC	Land Cover
m	meter
MDE	Mid Domain Effect
N	Nectarivores
NT	Near Threatened
O	Omnivorous
R	Resident
SP	Seasonal Precipitation
S	Species richness
STR	Seasonal temperature range
SV	Summer visitor
VU	Vulnerable
WV	Winter visitor

1. INTRODUCTION

1.1 Background

There are almost 10000 species of birds worldwide (Jetz et al. 2012). Among them, the diversified ecosystem of Nepal supports approximately 887 species of birds, of which 168 (68 critically endangered, 38 endangered, and 62 vulnerable) are classified as nationally threatened, 62 are considered Near Threatened, and 22 are Data Deficient (Grimmett et al. 2016, Inskipp et al. 2016, Inskipp et al. 2017). 550 of Nepal's 886 bird species are seasonal altitudinal migrants (Inskipp et al. 2016). In the summer, they reproduce at higher heights in the mountain region, and in the winter, they descend to lower elevations (Inskipp et al. 2016). The sole endemic bird to Nepal is the Spiny Babbler (*Turdoides nipalensis*). According to Nepal's National Park and Wildlife Conservation Act (NPWC) 2029, nine species of birds are protected, including the Himalayan Monal (*Lophophorus impejanus*), Cheer Pheasant (*Catreus wallichii*), Satyr Tragopan (*Tragopan satyra*), Bengal Florican (*Houbaropsis bengalensis*), Lesser Florican (*Sypheotides indicus*), Great Hornbill (*Buceros bicornis*), Sarus Crane (*Grus antigone*), Black Stork (*Ciconia nigra*) and White Stork (*Ciconia ciconia*).

As lying in a series of Hindukush Himalayan regions, the elevation range of this country varies from 60 m altitude to the highest elevation range of 8,849 m of altitude (mount. Everest). Elevation plays an important role in governing temperature, precipitation, distribution of species, and natural vegetation within the area. Understanding diversity patterns along elevation gradients and their underlying causes are important for conserving biodiversity. Because the highest richness does not always occur in the most natural habitats but can occur in moderately disrupted ones, monotonic decrease and mid-domain peak are found to be the most commonly seen patterns in elevation gradients (Rahbek 1995, McCain 2009). Some researchers found a monotonic reduction in species richness with elevation, whereas others found the unimodal or hump-shaped relationship, with a peak in species richness at intermediate elevations between 1500 and 3250 m (Bhattarai & Vetaas 2006, Grau et al. 2007, Baniya et al. 2010, Acharya et al. 2011, Katuwal et al. 2016, He et al. 2019, Pandey et al. 2020, Ghimire et al. 2021). This could be because mid-elevation has a variety of weather and diversity. The fall in species richness at higher altitudes is caused by a decrease in primary productivity rather than an elevation gradient (Rahbek 1997). The differences in species diversity and composition along these gradients have long been a topic of interest in ecology (Lomolino 2001). In terms of habitat preferences and elevation constraints, bird species have received more attention than any other taxonomic group (Both et al. 2006). Although less well studied than the latitudinal gradient, elevational gradients still offer similarly impressive patterns in variety as major abiotic and biotic alterations take place across relatively limited spatial extents (McCain 2010).

The geographic location of Nepal at the meeting point of the Palearctic and Oriental realms boosts diversity, and the variety of climatic conditions encourages high biodiversity. The Eastern Nepal is a global hotspot for biodiversity (Mittermeier et al. 1999). Apart from the elevation effect, there are so many factors that affect the distribution and diversity of Avifauna. For instance; seasonal variation in temperature, climatic factors, habitat type, conservation status, and human disturbance metrics are some factors that shape the avian species diversity and distribution. Vegetation structure and composition of the habitat determine the food and cover requirement of bird species within the area (Waterhouse et al. 2003). Thus bird's community structure is strongly influenced by the size of the forest, forest density, composition and structure (Zellweger et al. 2016), habitat heterogeneity, density and dimension of snag trees (Gibbs et al. 1993), and mature trees (DeWalt et al. 2003). Vegetation structure, composition, distribution, and biotic interaction of a specific area are mainly affected by elevation and slope (Hofer et al. 1999, Waterhouse et al. 2003). Human activity can lead to a change in vegetation structure that alter the quality of food, shelter, nesting sites, and water which may harm the diversity, abundance, and distribution of birds in particular habitats (Mengesha et al. 2011). There are conflict information about the distribution of avian species across different elevation zones of the Himalayan. In the Himalayan, high climatic variability occurs within a short distance (Paudel & Šipoš 2014).

Birds are one of the important agents of an ecosystem because they play a significant role in seed dispersal through pollination, nutrient cycle, and control of harmful insects (Tesfahunegny et al. 2016). They are considered the indicator of habitat quality and in many countries, they support the economic growth of that country as an important factor in the tourism industry (Areaya et al. 2013). To understand the variables influencing the variety and distribution of birds in different forest types in Nepal, it is crucial to investigate avian dispersion. So, the knowledge about the diversity and composition of bird communities helps to determine the health status of the local ecosystem or regional landscapes as well (Sethy et al. 2015). The current study examines the patterns of variety and distribution of bird fauna in the Makawanpur area of Nepal as well as the influences on them. Due to insufficient research, it is hard to find out any study about bird diversity along elevation gradient in the Makawanpur District. So, the study is most important for the exploration management and conservation of bird species in the study area.

1.2 Objectives

The general objective of the study was to explore the altitudinal diversity and distribution of birds in Makawanpur, Nepal.

The specific objectives were:

- To determine the species diversity of birds along the elevation gradient in Makawanpur District.
- To examine the factors affecting bird species distribution in the study area.

1.3 Rationale

Only a few countable research have been done on the diversity and species richness of Nepalese birds along the elevation gradient. (Paudel & Šipoš 2014). Understanding the diversity of bird species across a large area is crucial for conservation efforts (Mittelbach et al. 2001). The current state of rapid development in many areas makes it vital to research the diversity of the region to support the conservation efforts for those specific taxa. There is a great deal of habitat loss and fragmentation, thus it is crucial to research their distribution patterns and the variables that influence them. Diversity and distribution of bird species are well studied in the National Park and protected areas but when comes to community forests or non-protected areas, it is very rare to find studies on these topics. Less research has been done on the bird species of the Makawanpur along the elevation gradient; the most recent avian fauna survey was conducted by Basnet et al. (2016) from Palung valley to Simbhanjyang. Therefore, it is necessary to update the status of birds in the Makawanpur District. It can offer suggestions for the conservation of birds. This study intends to explain the patterns of species richness along elevational bands in the Makawanpur District, as well as the variables influencing the distribution of the bird species. The checklist for the overall bird species of this District also has not been published yet. So, this study also might be helpful to make a Checklist of the species which may provide ideas for bird conservation. The conservation efforts of the species of those birds will be aided by knowledge of their status and patterns of distribution.

2. LITERATURE REVIEW

2.1 Avian species richness and diversity along elevation

Studying bird species diversity along the elevation gradient at the global level displayed 4 distinct diversity patterns in nearly equal frequency on mountains: decreasing diversity, low-elevation plateaus, low-elevation plateaus with mid-peaks, and unimodal mid-elevation peaks (McCain 2009). Acharya et al. (2011) studied on Elevational Gradients in Bird Diversity in the Eastern Himalaya and found that species richness of birds is highest at intermediate elevations; birds' species richness increased to approximately 2000 m, then declined and the ranges of most bird species were narrow along the elevation gradient . Katuwal et al. (2016) in their study in central Himalaya, Nepal, observed 3,642 individuals of birds belonging to 178 species, and these data showed a peak species diversity at the 3000 m a.s.l elevation band, however, the average number of migratory species was consistently low across the studied elevational gradient. Montaño-Centellas et al. (2020) through their study on functional and phylogenetic diversity to infer avian community assembly along elevational gradients across the globe concluded that bird species displayed eight different patterns of functional and phylogenetic diversity across elevations. Mountain species are more closely related to each other at any given elevation and birds' diversity strongly declines with increased elevation on tropical mountains. Pan et al. (2019) observed a hump-shaped patterns along the elevational gradient by recording a total of 296 species. Overall, bird species richness reached its peak at 1600-1900 m. The maximum diversity of endemic species peaked: at 2500-2800 m higher than Non-endemic species: at 1300-1600 m. The mid-elevation climate is neither too cold nor too dry, which results in maximum species richness and the results are consistent (Kluge et al. 2017). Pandey et al. (2020) studied the Mardi Himal in Annapurna Conservation Area and recorded 673 bird individuals of 112 species (13 orders and 35 families) from a total of 21 point-count sites during the summer and winter seasons and found avian richness peaked at around 1900 m asl. Likewise, the lowest species richness was found in lower elevations and the lesser avian diversity was found above 2500 m. Basnet et al. (2016) studied the Central Himalayas, Nepal, and recorded 146 bird species from the elevation of 950-2760 m with the help of the point count method. They concluded high bird species diversity at low altitudes by observing 26 bird species at 1400 m of altitude. A similar observation has been reported by Santhakumar et al. (2018) in the Sutlej River basin, western Himalayas, India. Here, bird species richness was significantly higher at the lower elevation than at mid and high elevations, showing monotonic decline with increasing elevation. As, altogether, 203 bird species from elevations ranging from 498 to 3700 m were recorded. The Highest species richness was found at around 700 m elevation. Neupane et al. (2020) recorded a total of 120 species of 33 families from the Kaligandaki River basin and by recording maximum species at the altitude of 850, they explained that bird diversity decreases with increasing elevation. Alvarez-Alvarez et al. (2020) studied on Southern Mexican Highland from the elevation of 1600 to 2200 observed the highest species richness at the altitude of 2200 m of altitude and concluded that bird diversity increases with increasing elevation later it was supported by Shah & Sharma (2022) through recording maximum species richness at the altitude of 1500 m from the range of 800 m to 1600 m.

2.2 Factors affecting the richness and diversity of birds

Due to their sensitivity to environmental variables and ability to detect changes in their habitat, birds have been utilized as indicators of environmental change (Moning & Müller 2008). So, for the protection of Biodiversity and Ecosystem, their value must be considered. Elevational diversity patterns are shaped by a variety of factors, including geographical area, geometric restrictions, climate, food supply, and productivity (Colwell et al. 2004, McCain 2009, Price et al. 2014). Kim et al. (2007) studied on the topic of "Identify the factors affecting bird diversity in green areas in an urban landscape of Seoul, South Korea" and found that the cumulative bird diversity was greater in subclass 1-10 ha than in < 1 ha or in > 10 ha. The number of bird species was significantly correlated with the number of insect species in studied patches but was not correlated with the size of green areas or the distance to roads. No evidence of geometric constraints influencing the pattern of bird species richness was found by Acharya et al. (2011) in their study of factors underlying bird diversity in the Eastern Himalaya; instead, actual evapotranspiration, plant species richness pattern, shrub density, basal area of trees, primary productivity, and factors related to habitat accounted for the majority of the variation in avian species richness. In the Hengduan highlands, Wu et al. (2013) explained the species richness of birds along a subtropical elevational gradient and discovered that temperature and energy parameters, as well as seasonality and productivity, had a strong correlation with the richness pattern of birds. Katuwal et al. (2016) observed a minor effect of seasons on bird diversity, but the number of insectivorous birds increased strongly from pre-monsoon to post-monsoon seasons. Basnet et al. (2016) found that slope and space have a vast effect on bird diversity and concludes that Species richness increased with increasing slope and increasing heterogeneity positively affects omnivorous birds whereas increasing altitude negatively affects frugivorous and insectivorous bird species. According to the study by Kim et al. (2019), analysis of environmental factors for determining species richness in Jirisan National Park, South Korea, species range size distribution had a negative relationship with climatic variables and habitat heterogeneity and a positive relationship with primary productivity.

Adhikari et al. (2019) studied factors affecting the diversity and distribution of globally threatened birds and found that the presence of livestock and people caused significant negative effects on species richness and abundance of birds and also the distance from roads and villages harmed the bird species richness. He et al. (2019) observed land area(La), seasonal temperature range (STR), invertebrate biomass (IB), and seasonal precipitation (SP) as important factors of bird diversity. He found that STR negatively affects small range and large range bird species whereas IB affects small range species and mid domain effect positively affects large range species**.** Neupane et al. (2020) observed a positive correlation between bird diversity and the availability of fruiting trees and a negative correlation with road or human settlement. Pandey et al. (2020) explained that increasing area, distance to settlement, precipitation and temperature affect bird diversity during the summer season whereas in winter all of these factors except distance to settlement affect diversity. Ghimire et al. (2021) recorded high bird diversity on a north-facing slope and mentioned high bird diversity in shrub areas and tree cover areas in comparison to grassland and settlement places.

3. MATERIALS AND METHODS

3.1 Study area

Makawanpur District covers an area of approximately 2,426 km^2. This District as an important border of Parsa National Park and Chitwan National Park in the southern part provides a buffer zone as well as path for many wildlife animals and in the northern zone, it connects with the Capital city of Nepal, Kathmandu which also contains Shivapuri Nagarjun National Park. Makwanpur District has an elevation distribution of fewer than 300 m up to 2530 m. The climate of this District varies with the seasons. Winter starts in September and continues to the end of February. December and January are the coldest months, with the temperature falling to freezing point at high altitudes in the area. It constitutes tropical to temperate climatic physiography. There are many communities and government-managed forest areas that as a habitat support many birds as well as wild animals and also help as a corridor for migratory birds moving south to north. But, increasing human interference has a significant negative impact on forests across all of the study areas (Joshi et al. 2009). Tribhuvan Highway is one of the oldest highways that connect Kathmandu with the Indian border. This highway contains the lowest altitude of 450 m in Hetauda to the highest altitude of 2530 m in Simbhanjyang. Forest areas in this way ranged from tropical forests to temperate forests. Lower areas on the highway sides are tropical forests (up to 100 m) dominated by sal (*Shorea robusta)* forest along with predominating species such as *Dalbergia sissoo, Acacia catechu, Terminalia belliraca, T. chebula, Dillenia pentagyna*. Sub-tropical forests range from 1000 to 2000 m in altitude. *Schima-Castanopsis,* Chirr pine, alder, *Rhododendron Arboreum,* and *Castanopsis indica,* forests make up the majority of the subtropical vegetation. while in upper altitudes nearer to Simbhanjyang the broad-leaved species of the genus Quercus predominate in the lower temperate mixed broad-leaved forest, which also contains a large number of laurel trees (*Lidera neesina* and *Litsea cubiba*). *Jasminum, Rubus, Viburnum, Eurya, Mahonia,* and *Arundinaria faLCata* are the predominant shrub genera (Chaudhary 1998). Thus connected by these three National Parks, it is hard to find any papers or information on avian faunal diversity along elevation in the Makawanpur. Thus, the study area has been chosen to explore the patterns of Bird species diversity along the elevation gradient in Makawanpur District, Nepal.

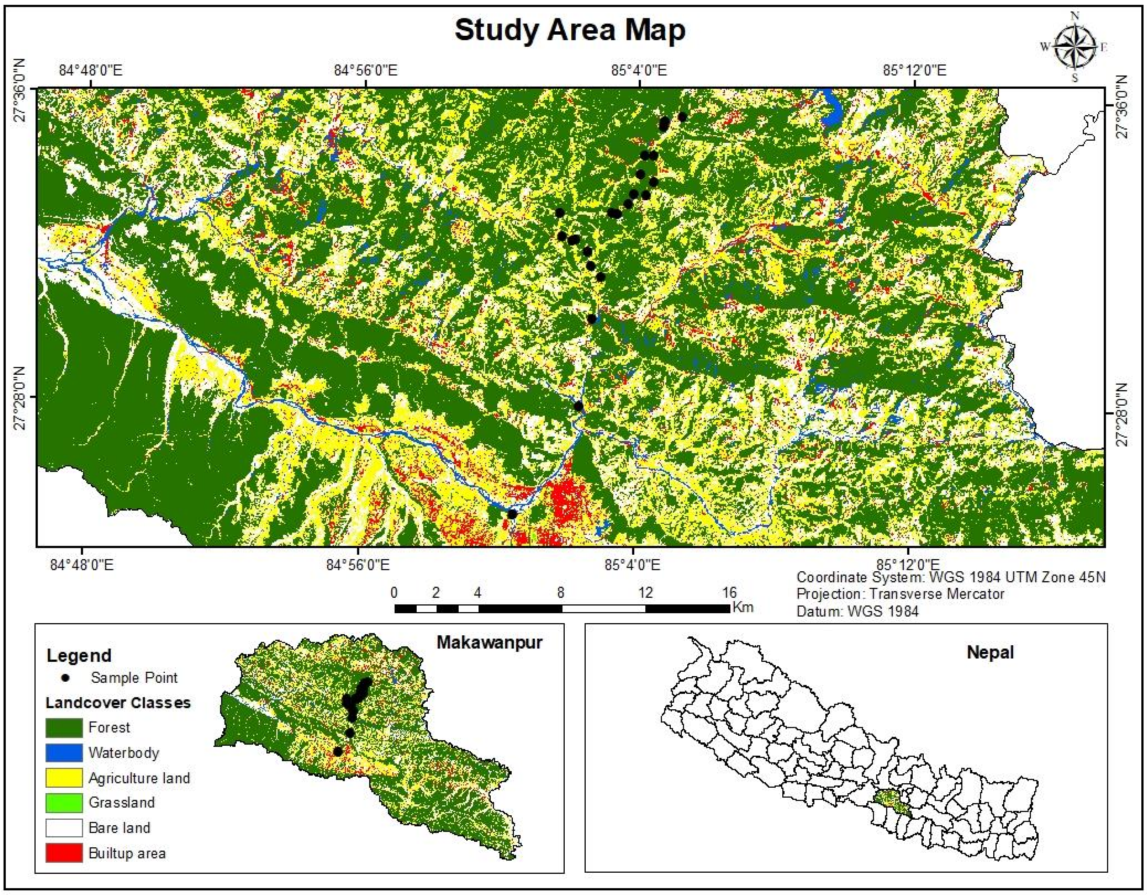


Figure 1: Map of the Makawanpur District displaying locations of the sample at various altitudes.

3.2 Materials

- GPS (Garmin eTrex® 10)
- Camera (Nikon D3400 with 300 mm zoom lens)
- Binocular
- Measuring tape
- Field stationery
- Digital range finder
- Field guide book, Birds of Nepal (Grimmett et al. 2016)

3.3 Data collection

3.3.1 Research Design

The survey's lower elevational limit (431 m asl) was established by the Rapti riverbank in Hetauda, while its upper elevational limit (2503 m asl) was established in the Simbhanjyang. Bird field surveys were carried out in 2021 during the winter (December–February) seasons. The elevation changes were measured by the Garmin Etrex 10 GPS and the point count sites were placed roughly every 100 m of elevation change. Distance between the closest settlement is an approximation of the distance between the nearest settlement and the point count site. The term "distance from the nearest water source" was used to describe numerically how far away from the point count location water bodies like rivers, ponds, and streams were. Distance from the road was used as an approximation of the distance between the nearest vehicle's road and the point count site. All of these variables were estimated in the field and confirmed by aerial distance using Google Earth. Due to the topographic feature and slope of the land, it was difficult to make more plots and points at the higher elevation. So, only one point at each elevation was established. All together 22 points were established at different elevations.

3.3.2 Bird observation

Direct observation is one of the most reliable sources of getting information about bird diversity and for this point count method was used to estimate the population status of birds (Bibby et al. 2000, Dieni & Jones 2002, Sarkar et al. 2009). This method is useful to estimate or evaluate habitat preference, population densities, and population trends of the bird species. From a fixed point in the center, bird observations and sounds within a 50 m radius were recorded (Bötsch et al. 2018, Pandey et al. 2020). The estimated radius of 50 m was caLCulated using a digital range finder. The length of time spent observing a point varied depending on the habitat in which it was located, ranging from 15 minutes in an open space like a field to 25 minutes in a deep forest to find rare and unseen species (Dos Anjos & Bocon 1999). Bushnell FaLCon 1050 wide-angle binoculars were used to monitor the birds, and a Nikon D3400 camera along with a 70-300 mm zoom lens was used to take pictures for identification and documentation. For bird identification, generic traits including size and shape, plumage color and pattern, and habitat type were carefully examined. As much as possible, similar features such as combinations of head/bill form, wing shape, neck length, leg length, tail shape, and foot shape were studied. For those birds with similar shapes and sizes, more characters were taken into consideration for identification (Beaman & Madge 2010, Svensson 2010). The field book, Birds of Nepal (Grimmett et al. 2016) was used for the identification of bird species. Data collection was carried out in the morning time from 7 am to 11:30 am and in the evening time 3 pm to 5 pm. The study area was repeated 3 times and the presence of new species was recorded while the presence of species or individuals of already recorded species were ignored.

3.3.3 Environmental variables

During the survey bird species were recorded from different habitats. Altogether three different habitats were recorded from 22 sampling sites. These habitats were categorized as riverbanks, forests, and agricultural land. The WorldClim database (https://www.worldclim.org/bioclim) was used to extract climate data with a resolution of 1 km x 1 km on mean annual precipitation and mean annual temperature for the coordinates of bird-count locations. Slope of each observation point was recorded or estimated by using digital elevation model to investigate the impact of the area on avian species richness. Canopy cover of the study area (in percentage), the numbers of identified trees in each plot were counted and fruiting trees from these trees were also recorded as the feeding resource availability.

3.4 Data Analysis

Bird species were classified into six feeding guilds and three residential statuses based on the (Grimmett et al. 2016). The feeding guild was classified as Insectivores (feeding on insect, larva, worms, spider, mollusks etc.), Carnivores (feeding on fishes, amphibians, reptiles, birds and mammals), Omnivores (feeding on plants as well as animals), Granivores (feeding on seed and grains), Fruigivores (feeding on fruits, berries and drupes) and Nectarivores (feeding on liquid or juice of flowers). The Residential status was classified on the basis of movement of bird species during season and categorized as summer visitor, winter visitor, and resident (common). The biodiversity index (H') was calculated by using the Shannon-Wiener Diversity Index (Shannon & Weaver 1949) in the PAST v4.11. The Shannon- Wiener Index assumes that individuals are drawn at random from a large, independent population, with each species represented in the sample. The Shannon- Wiener diversity index is frequently used to compare diversity between different habitats and even between different historical periods. Shannon-Wiener diversity index was obtained by using the following formula:

$H' = -\Sigma\ Pi(\ln Pi)$

Where Σ represents the sum of Pi(lnPi)

H'= Index of species diversity,

Pi = the proportion of individuals in the i^{th} species, Pi= n_i/N

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

N= Total importance value (total number of individuals)

The diversity of species also rises as habitat complexity rises. Both species richness and species evenness are taken into account in this species diversity.

Species richness simply indicates the overall number of species present in a specific location. And it can be calculated as follows:

S= total number of species recorded. Where S= Species Richness

The richness of an area is measured by its evenness, which is a measure of the relative abundance of various species. This evenness, which expresses the distribution of individuals evenly among the many species, is a crucial part of diversity indices. Thus, Pielou’s evenness (Pielou 1966) was used to determine if the species are distributed equally throughout the various point count stations and it is calculated as,

$E = H' / H'_{max}$

Where, H' = Shannon-Wiener diversity index.

H'_{max} = maximum possible value of H' if every species is equally likely and equal to ln(S).

S= Species richness is the total number of species.

To assess the effect of the elevation range size of species on the species richness pattern, we divided the overall species into two categories. Those species with an elevation range equal to or above the median size (287 m) were named as "large range species" and those species with an elevation range lower than the median size (287 m) were named as "lower range species" (Wu et al. 2013, Pan et al. 2019, Pandey et al. 2020).

To comprehend the variables influencing the diversity and abundance of birds, generalized linear models (GLM) using the 'lme4' software on R-studio was done (Bates et al. 2014, Katuwal et al. 2022). The overall environmental factors (Annual mean temperature, precipitation, area slope, habitat, canopy cover), anthropogenic factors (distance to nearest road, distance to the village), and resource availability (distance to the water source, numbers of fruiting trees available on the observation plot) were all examined for multicollinearity. Precipitation, elevation area slope, and distance to water source had a strong positive association among predictor variables (r > 0.9 between elevation and precipitation, r > 0.7 between elevation with area slope and, distance to the water source), elevation and temperature of the area had a strong negative correlation with r > 0.9, hence we only utilized elevation for further research. Similarly, the number of fruiting trees in the area had a strong correlation with canopy cover in (%) (r > 7), so we only took the number of fruiting trees for further study. This study took into account the elevation, distance to the road, distance to the nearest village, fruiting trees, and habitat type for GLM. Before the generalized linear model (GLM), this study checked if the response variables were dispersed or not by using "overdisp_fun (model)". Occurrences of bird species of the study area were highly dispersed with P< 0.05. So, bird species richness as a response variable was used for further GLM and poison regression was performed .

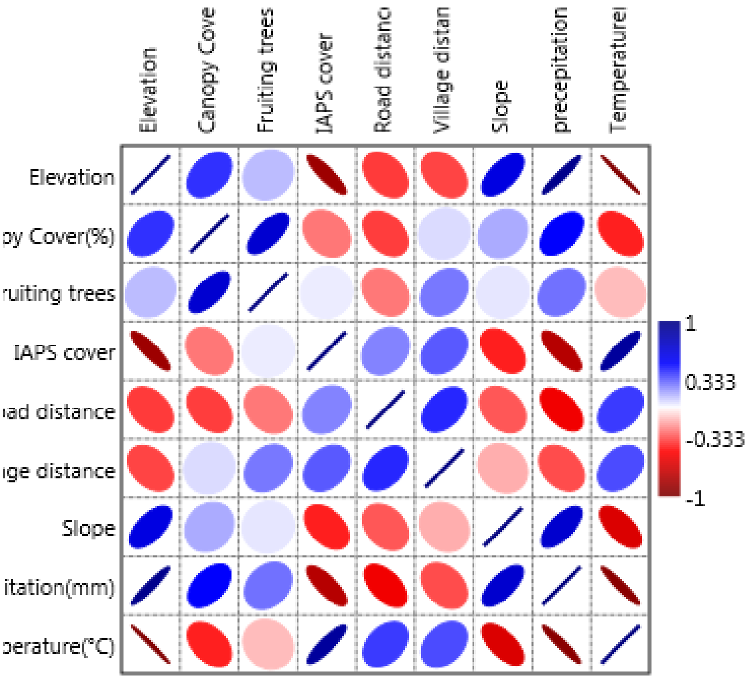


Figure 2: Correlation test of Different Independent variables

4. RESULTS

4.1 Bird diversity along the elevation gradient

A total of 1,824 individuals of 172 bird species from 14 orders and 51 families were recorded by the point count method from the study area. This study observed that order Passeriformes contains the highest number of bird species (125) followed by order Acciptiformes (9) and Columbiformes (7). The last bird species were from the order Apodiformes, Bucerotiformes, Charadriiformes, and FaLConiformes with each containing 1 bird species (Figure 2). Among 51 families recorded, the highest number of species found was of family Muscicapidae (27) followed by Accipitridae (9), Leiothrichidae (8), and Columbidae (7).

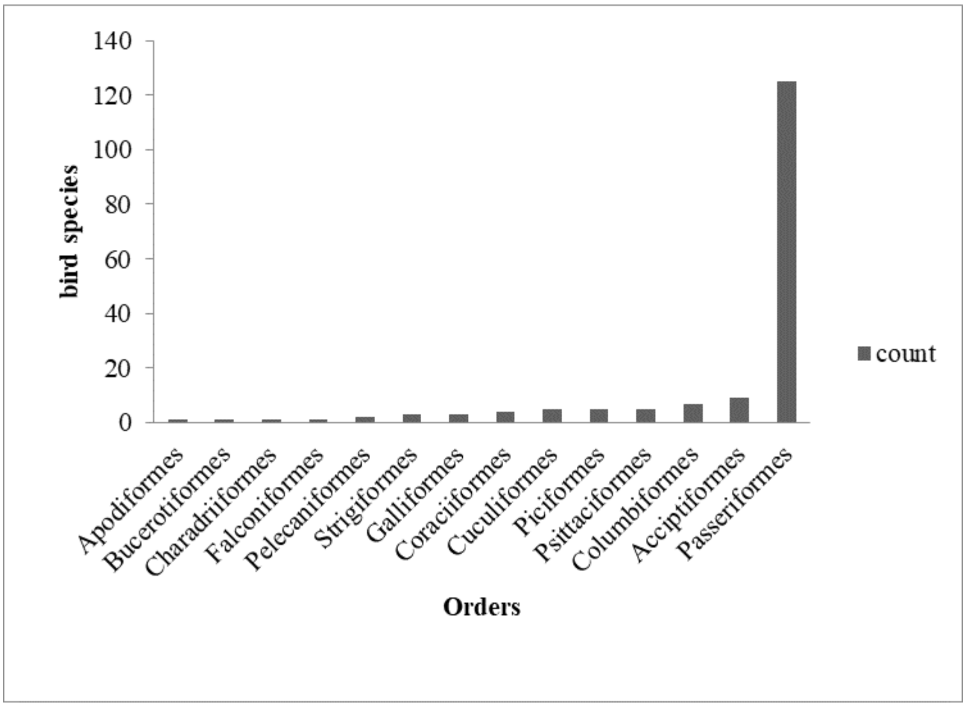


Figure 3: Number of bird species in different orders.

The highest Shannon and Weaver diversity index of the study regions was recorded at the elevation of 1295 m of altitude which was 3.615, followed by 3.16 at the altitude of 1400 m. and the lowest diversity was recorded as 2.137 at the altitude of 2503 m. The overall diversity index (H) was 4.35, Simpsons index (0.982) and the evenness index (e) was 0.84 which indicates that the Makawanpur District is rich in bird diversity (Shannon and Weaver, 1949) (Table 1).

Table 1. The 22-point count stations along the elevation gradient of the Makawanpur District with avian diversity indices.

Site, Elevation	Species richness	Shannon-Wiener Index	Simpson Index	Evenness Index
p1, 431	30	3.29	0.958	0.8946
p2, 512	32	2.93	0.89	0.585
p3, 622	33	3.381	0.96	0.891
p4, 724	35	3.425	0.96	0.877
p5, 801	29	3.279	0.957	0.915
p6, 925	28	3.33	0.961	0.997
p7, 1025	31	3.554	0.975	1
p8, 1108	31	3.423	0.965	0.989
p9, 1216	33	3.583	0.975	1
p10, 1295	34	3.615	0.974	1
p11, 1420	38	3.61	0.971	0.972
p12, 1505	29	3.373	0.963	1
p13, 1625	21	3.105	0.956	1
p14, 1718	28	3.322	0.962	0.989
p15, 1800	26	3.264	0.962	1
p16, 1912	23	2.703	0.847	0.648
p17, 2000	25	3.23	0.959	1.01
p18, 2140	22	2.989	0.936	0.902
p19, 2200	21	3.023	0.948	0.978
P20, 2303	20	2.957	0.944	0.962
p20, 2410	18	2.807	0.926	0.919
p21, 2503	14	2.137	0.799	0.605

Analysis of the observed data based on feeding guild from the study area revealed that half of the total bird species were Insectivores with 88 species followed by Omnivores, Carnivores, Granivores and Frugivores. Nectarivores were to have the least species richness of 4 species (figure 4). This shows that Insectivores bird species contribute more to the overall bird species of the area.

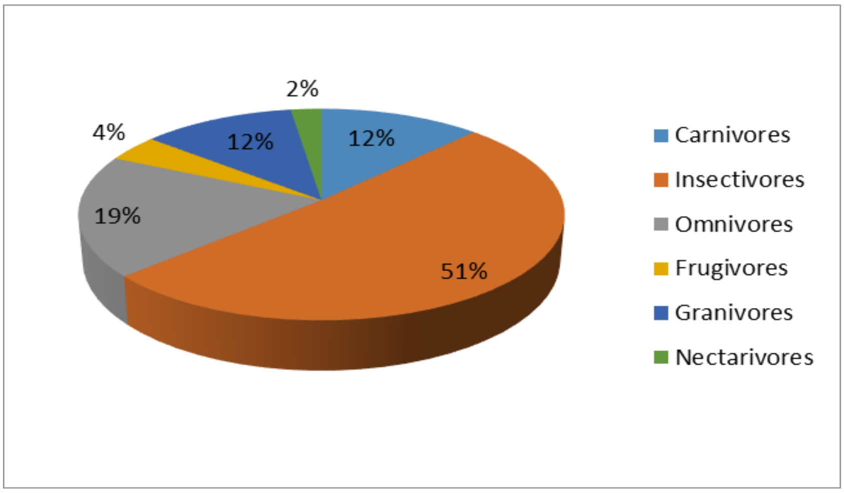


Figure 4. Species richness in different feeding guilds.

Among the observed bird species Steppe eagle is Endangered (EN), Alexandrine Parakeet, Himalayan Griffon, and Red-breasted Parakeet are Near Threatened (NT) under the category of the IUCN Red List. Apart from these 4 species Yellow-eyed Babbler and Yellow-bellied Prinia are Near Threatened (NT) and Grey-sided Laughingthrush, White-gorgeted Flycatcher are Vulnerable (VU) under the National Red Data Book (Table 2).

Table 2: List of Threatened bird species recorded in Makawanpur, Nepal. Status based on IUCN red list category and Nepal red list category 2021

Name	Scientific Name	order	Family	IUCN	NRDB
Himalayan Griffon	*Gyps himalayensis*	Accipitriformes	Accipitridae	NT	VU
Steppe Eagle	*Aquila nepalensis*	Accipitriformes	Accipitridae	EN	VU
Yellow-bellied Prinia	*Prinia flaviventris*	Passeriformes	Cisticolidae	LC	NT
Grey-sided laughingthrush	*Garrulax caerulatus*	Passeriformes	Leiothrichidae	LC	VU
White-gorgeted Flycatcher	*Anthipes monileger*	Passeriformes	Muscicapidae	LC	VU
Yellow-eyed Babbler	*Chrysomma sinense*	Passeriformes	Paradoxornithidae	LC	NT
Alexandrine Parakeet	*Psittacula eupatria*	Psittaciformes	Psittaculidae	NT	NT
Red-breasted Parakeet	*Psittacula alexandri*	Psittaciformes	Psittaculidae	NT	VU

Analysis of observed data from the field revealed that out of 172 bird species from the study area, majority were residents species followed by winter visitors and the least were were summer visitors (figure 5).

The most populated species in the study area was the Himalayan Bulbu (*Pycnonotus leucogenys)* (113) followed by the Red-vented Bulbul (*Pycnonotus cafer)* (92), Green-backed Tit *(Parus monticolus)* (56), Rock Dove (*Columba livia)* (53), Long-tailed Minivet *(Pericrocotus ethologus)* (49), Rufous Sibia (*Heterophasia capistrata)* (45), Grey-hooded Warbler (*Phylloscopus xanthoschistos)* (44), Plum-headed Parakeet (*Psittacula roseate)* (43), Black-lored Tit (*Parus xanthogenys)* (42), Common Myna (*Acridotheres tristis)* (42), House Crow (*Corvus splendens)* (37), House Sparrow (*Passer domesticus*) (37), Buff-barred Warbler (*Phylloscopus puLCher)* (37), Bronzed Drongo (*Dicrurus aeneus)* (32), Black-throated Tit (*Aegithalos concinnus)* (32), Common Wood-pigeon (*Columba palumbus)* (27) Plain Mountain-finch (*Leucosticte nemoricola)* (29), Great Barbet (*Psilopogon virens)* (29) and Grey Treepie (*Dendrocitta formosae)* (28)

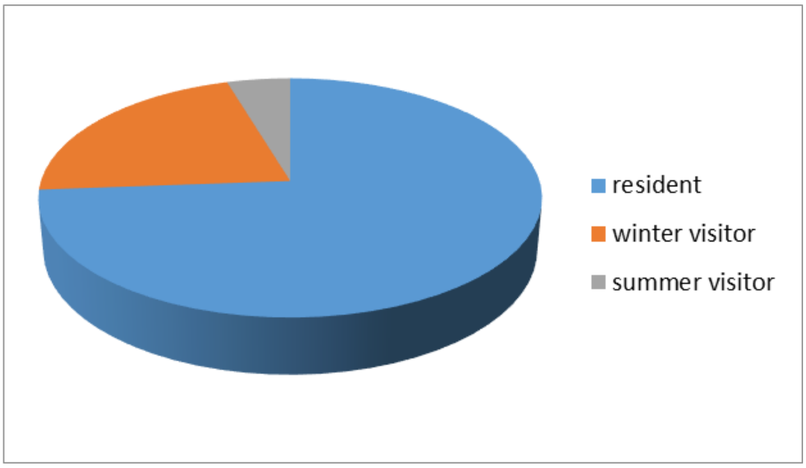


Figure 5: Residential status of birds in the study area**.**

We divided these residential bird species into two categories and found that out of 127 bird species 67 bird species were large range species with elevation range equal to or above 287 m and 60 bird species were small range species with elevation range below 287 m.

4.2 Factors affecting bird species

Table 3: Using generalized linear models with Poisson distribution, a summary of the factors influencing the number of bird species in the Makawanpur District is provided. This study took into account elevation (m), distance to the nearest road (m), distance to the closest settlement (m), the number of fruiting trees present, and habitat categories (riverbank, agricultural land, and forest area).

Overall species richness

Parameters	Estimate	Std. Error	z value	P
Intercept	3.67	0.193	18.979	**< 2e-16**
elevation	-0.00032	0.00009	-3.502	**0.0004**
Distance to road	-0.00073	0.00086	-0.853	0.393
Distance to village	-0.00015	0.00036	-0.433	0.665
No. of Fruiting tree	0.0156	0.0079	1.972	**0.0485**
Habitat (Forest)	-0.0847	0.111	-0.765	0.444
Habitat (riverbank)	-0.00186	0.193	-0.01	0.992
Large range species richness				
Intercept	3.2456	0.2515	12.902	**<2e-16**
elevation	-0.0002	0.00012	-2.272	**0.0231**
Distance to road	-0.0022	0.0012	-1.9	0.057
Distance to village	-0.00039	0.00048	-0.81	0.4179
No. of Fruiting tree	0.0217	0.01057	2.059	**0.0395**
Habitat (Forest)	-0.3377	0.1453	-2.324	**0.0201**
Habitat (riverbank)	0.0309	0.2575	0.12	0.9044
Small range species richness				
Intercept	1.8644	0.46178	4.038	**0.00005**
elevation	-0.0005	0.0002	-2.839	**0.0045**
Distance to road	0.0019	0.0017	1.1	0.271
Distance to village	0.00055	0.00079	0.707	0.479
No. of Fruiting tree	0.00608	0.0175	0.347	0.728
Habitat (Forest)	0.3964	0.2652	1.495	0.135
Habitat (riverbank)	0.18714	0.41308	0.453	0.65

In the study area, the average number of fruiting trees was 15 ± 6 (range from 3 to 32), and the average elevation of 1463.4 ± 645.18 (range from 431 to 2503 m). The nearest distance to the village is 250.22 ± 132.48 (range from 70 m to 525 m), and the road is 70.18 ± 67.14 (range from 8 m to 270 m).

The generalized linear model (GLM) indicated the environmental variables varying relationships with avian species richness. The amount of fruiting trees positively affected the species richness whereas elevation negatively affected bird species richness. The amount of fruiting trees showed positive effect but the elevation, distance to the road and forest environment all negatively influenced the richness of large range resident species (n=67) while for small-ranged resident species (n = 60), only elevation demonstrated a negative influence (Table 4, figure 8). Elevation and the quantity of fruiting trees among the feeding guilds demonstrated a significant role to the insectivores. Elevation showed negative association and numbers of fruiting trees showed positive influence towards insectivores richness. Carnivores had a crucial part in the habitat of the forest. The richness of omnivorous and herbivorous bird species, however, did not appear to be significantly influenced by any of these environmental variables (table 3,4: figure 6).

Table 4: Using GLM (Poisson distribution), a summary of the factors influencing the feeding guild of bird species in the Makawanpur District is provided.

Insectivores richness				
Parameters	Estimate	Std. Error	z value	P value
Intercept	2.77	0.2728	10.152	<2e-16
Elevation	-0.0003	0.00012	-2.407	**0.0161**
Distance to _road	-0.001	0.00126	-0.832	0.4055
Distance to village	-0.0001	0.0005	-0.199	0.8426
No. of Fruiting tree	0.0253	0.01049	2.418	**0.0156**
Habitat (Forest)	0.05703	0.1549	0.368	0.7128
Habitat (riverbank)	-0.0546	0.2825	-0.194	0.8465
Omnivores richness				
Intercept	2.21	0.4	5.454	4.92e-08
elevation	-0.0003	0.00019	-1.536	0.125
Distance to road	-0.00007	0.0017	-0.041	0.967
Distance to village	-0.00005	0.0007	-0.076	0.94
No. of Fruiting tree	0.0139	0.0169	0.825	0.409
Habitat (Forest)	-0.24	0.228	-1.052	0.293
Habitat (riverbank)	-0.106	0.4	-0.263	0.793
Herbivores richness				
Intercept	2.34088	0.4742	4.936	7.97e-07
elevation	-0.00035	0.00023	-1.502	0.133
Distance to road	-0.00047	0.002	-0.23	0.818
Distance to village	-0.00035	0.0009	-0.363	0.717
No. of Fruiting tree	-0.01858	0.0216	-0.859	0.39
Habitat (Forest)	-0.007	0.2851	-0.025	0.98
Habitat (riverbank)	-0.0555	0.4625	-0.12	0.904
Carnivores richness				
Intercept	1.8071	0.626	2.886	0.0039
Elevation	-0.00048	0.0003	-1.433	0.1518
Distance to road	-0.00068	0.0024	-0.275	0.7833
Distance to village	0.011102	0.028	0.396	0.6917
No. of Fruiting tree	-0.00031	0.0011	-0.27	0.7872
Habitat (Forest)	-0.60644	0.3677	-1.649	0.0991
Habitat (riverbank)	0.2455	0.5721	0.429	0.6678

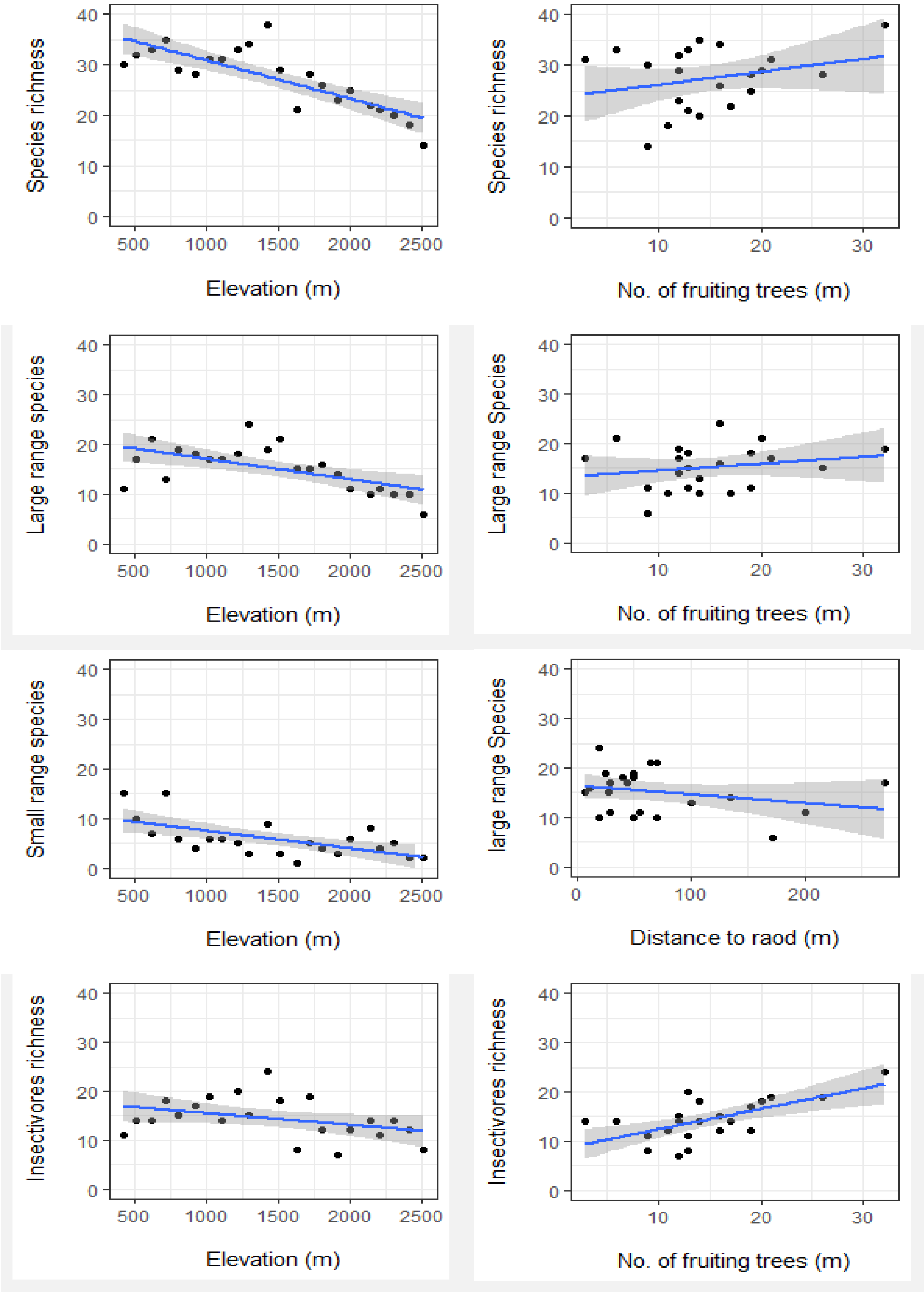


Figure 6: Relationship between bird species richness and environmental factors (elevation, number of fruiting trees, and distance to road) along the side of the Makawanpur, Nepal**.**

5. DISCUSSION

5.1 Bird diversity along the elevation gradient

The majority of species exhibit a monotonic fall in species richness with increasing elevation, however, Growing evidence indicates that mid-elevation peaks in species richness for a wide range of taxa may be increasingly widespread (Rahbek 1995). This research revealed a decrease in species richness with increasing elevation with peak in the richness of bird species at the altitude of 1420 m which is almost similar to the study of (Katuwal et al. (2016), He et al. (2019), Pan et al. (2019), Pandey et al. (2020)). This may be due to dispersed productivity caused by variation in climatic factors, and Anthropogenic factors. Geographic patterns in species richness were primarily based on large-ranged species because of their larger number of distribution records, which had a disproportionate contribution to the species richness counts. In this study, we also discovered that in the data sets of all species large-ranged species contributed more to the overall richness pattern than small-ranged species which is similar to the study by (Fu et al. 2006, Brehm et al. 2007). The presence of most Passeriformes birds in the study region may be caused by migrating birds or the residential behavior of the bird of that order (Shah & Sharma 2022). We found that the feeding guild with the greatest diversity of species is the insectivorous form, which is consistent with much other research on birds (Katuwal et al. 2016, Neupane et al. 2020, Pandey et al. 2020, Shah & Sharma 2022). In this study 26% (45 out of the 172) bird species that have been recorded are migratory, which is nearly similar to the observation made by Pandey et al. (2020) along the Mardi Himal in the Annapurna Conservation Area of Central Nepali but with a smaller proportion. From the total of 172 bird species, we recorded 37 bird species as winter visitors and 8 bird species as summer visitors. Data collection was done from late November to early February (in the winter season). This is the reason for the observation of many winter visitor bird species in comparison to summer visitors. Among the 45 migratory bird species, 30 species were insectivorous. Seasonal defoliation of plants during the winter might encourage the growth of numerous foliage insects, which causes the presence of many insectivorous birds (Katuwal et al. 2018). Some nationally vulnerable bird species, such as the Steppe eagle which is considered to be critically endangered), Himalayan Griffon (which is considered to be Near Threatened globally), Grey-sided laughing thrush, White gorged flycatcher, Red-breasted parakeet (which is considered to be Near Threatened globally) and near-threatened species, such as the

Alexandrine Parakeet, Yellow-bellied Prinia, and Yellow-eyed Babbler also be found in this region. Their population has been steadily falling over the past few years, most likely as a result of habitat loss or fragmentation making them vulnerable. The habitat, structure, and composition of species are generally impacted by changes in land use (Brawn et al. 2001).

5.3 Factors affecting bird species

The richness of bird species in Makawanpur, Nepal, was strongly correlated with elevation and fruiting trees. According to this research, the species richness pattern of large-ranged birds was more strongly influenced by elevation, the quantity of fruiting trees, the forest environment, and the distance to the road than by small-ranged species, which were solely affected by elevation. The earlier study on birds from Nepal (Paudel & Šipoš 2014, Katuwal et al. 2016, Neupane et al. 2020, Pandey et al. 2020) and around the world (McCain 2009) found a sizable difference in bird species richness along the elevation gradient. The decline in bird species richness with increasing altitude is closely related to the decrease in temperature, vegetation (which serves as a source of food and nesting places), and rise in slope and precipitation (Kattan & Franco 2004, Herzog et al. 2005, Basnet et al. 2016, Katuwal et al. 2016). According to our analysis and some earlier studies (Kattan & Franco 2004, McCain 2009, Ferger et al. 2014), altitude is highly related to not only species richness but also the distribution of various feeding guilds and the makeup of bird communities. Particularly, our study found that the proportion of frugivorous, herbivorous, and omnivorous bird species hadn't shown any significant relation with the elevation, while the proportion of insectivorous birds showed a slightly unimodal relation with elevation. This might be due to the reason that insectivores bird contribute more to the overall species richness.

According to Wu et al. (2013) and Pan et al. (2016), one of the key factors restricting bird diversity and abundance is the availability of food. So, as a proxy for resource availability in the research area, the richness of bird species and also the large range of resident species revealed a positive correlation with the number of fruiting trees. Whereas, small range species didn't show any significant relation with the numbers of fruiting trees. Those areas with more energy available can support more species. In addition, more trees provide more food supplies and places to rest and build nests for the majority of forest birds. These findings are in line with earlier research that supported the energy (resource)-diversity theory (Hurlbert & Haskell 2003, Pan et al. 2016, Neupane et al. 2020).

Additionally, fruiting trees with flowers, fruits, and seeds assist insectivores by drawing a variety of insects, which increases the diversity of species overall. In the eastern woods of North America, there was a substantial correlation between assemblages of bird species and assemblages of tree species (Lee & Rotenberry 2005). The species richness of insectivorous feeding guilds was linked to vegetation structure and invertebrate biomass, while the species richness of frugivores was linked to fruit abundance, both of which were supported by the forest stand and cover (Ferger et al. 2014). The different factors that have contributed to the relative richness of bird fauna species include habitat kinds that make up the area, probably for refuge and foraging opportunities (Girma et al. 2017) A substantial link between the habitat categories (forest, riverbanks, and agricultural land) and the richness of bird species was only seen for the large-ranging bird species. This study recorded negative influence of forest habitat on bird diversity in comparison to riverbank and agricultural land. This might be due to the reason that Species with low elevation range, small size and forest dependent species prefer forest habitat (Lindell et al. 2004), whereas large range species prefer riverbank and agricultural land for feeding, and they easily can be observed in this type of open habitat. Riverbank also serve as a path for the movement of bird species. The availability of resources within the riverbank area may be complementary in comparison to other types of land use (Sinha et al. 2019).

The effects of roads on wildlife populations are significant and well-documented World wildly (Fahrig & Rytwinski 2009). By evaluating the relationship between species richness with distance to the road and distance to the village area, this study observed a high negative correlation between large range bird richness and distance to the road (meaning an increase in species richness near the road and vice versa. Many studies on birds have found a positive correlation between roads and bird abundance, occurrence, and species richness, with greater losses near high-traffic roads than near low-traffic roads (Peris & Pescador 2004, Griffith et al. 2010). In Makawnapur, Nepal, low traffic and scarce human settlements and movements may be the primary causes of the higher large range resident bird richness along highways. High species richness along the road may also be caused by increased observer detection and the birds' potential preference for open environments.

6. CONCLUSION AND RECOMMENDATIONS

According to the results of the current study from Makawanpur District, Nepal, this study concluded that there are high diversity of bird species with differences in number and composition and dominated by Passeriformes. Along the elevational gradient, the assemblage of bird species in the study showed decrease in species richness with increasing elevation. In the research area, the majority of the bird species were common while the minority were unusual. The diversity and richness of bird species are positively impacted by the quantity of fruiting trees and negatively affected by Elevation and distance to road . This study conclude that the combined effects of many environmental parameters including elevation, resource availability, and disturbance dictate the avian diversity and richness.

Following are my recommendations for more research, which are based on my study:

- It is recommend to conduct seasonal bird surveys.
- It is recommend to conduct studies based on the elevational distribution of birds in the Makawanpur District, via several potential routes.
- In addition to creating bird checklists, it is strongly advised that future research that will support increased conservation efforts focus on the patterns and processes affecting species and diversity of avian fauna in more expansive gradients and habitat types.

7. REFERENCES

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. https://doi.org/10.1371/journal.pone.0029097.

Adhikari, J. N., Bhattarai, B. P. and Thapa, T. B. 2019. Factors affecting diversity and distribution of threatened birds in Chitwan National Park, Nepal. Journal of Threatened Taxa **11**(5):13511-13522. https://doi.org/10.11609/jott.4137.11.5.13511-13522.

Alvarez-Alvarez, E. A., Rodríguez-Godínez, R., Sierra-Morales, P., Medina-Valdivia, S. A., Vázquez-Salgado, E., Brito-Millán, M., et al. 2020. Patterns of bird diversity and endemism along an elevational gradient in the southern Mexican highlands. Zoological studies **59**.

Areaya, H., Yonas, M. and Haileselasie, T. H. 2013. Community composition and abundance of residential birds in selected church forests, Tigray Region, Northern Ethiopia. Scientific Research and Essays **8**(22):1038-1047.

Baniya, C. B., Solhøy, T., Gauslaa, Y. and Palmer, M. W. 2010. The elevation gradient of lichen species richness in Nepal. The Lichenologist **42**(1):83-96.

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. 11. Pp:e0150498.

Bates, D., Mächler, M., Bolker, B. and Walker, S. 2014. Fitting linear mixed-effects models using lme4. arXiv preprint arXiv:1406.5823.

Beaman, M. and Madge, S. 2010. *The handbook of bird identification: for Europe and the western Palearctic*. A&C Black. p.

Bhattarai, K. R. and Vetaas, O. R. 2006. Can Rapoport's rule explain tree species richness along the Himalayan elevation gradient, Nepal? Diversity and distributions **12**(4):373-378.

Bibby, C. J., Burgess, N. D., Hillis, D. M., Hill, D. A. and Mustoe, S. 2000. *Bird census techniques*. Elsevier. p.

Both, C., Bouwhuis, S., Lessells, C. and Visser, M. E. 2006. Climate change and population declines in a long-distance migratory bird. Nature **441**(7089):81-83.

Bötsch, Y., Tablado, Z., Scherl, D., Kéry, M., Graf, R. F. and Jenni, L. 2018. Effect of recreational trails on forest birds: human presence matters. Frontiers in Ecology and Evolution **6**:175.

Brawn, J. D., Robinson, S. K. and Thompson III, F. R. 2001. The role of disturbance in the ecology and conservation of birds. Annual review of Ecology and Systematics:251-276.

Brehm, G., Colwell, R. K. and Kluge, J. 2007. The role of environment and mid-domain effect on moth species richness along a tropical elevational gradient. Global Ecology and Biogeography **16**(2):205-219.

Chaudhary, R. P. 1998. *Biodiversity in Nepal: Status and Conservation: a Most Recent, Profusely Illustrated Pioneer Book with Up-to-date Information and Pertinent References*. S. Devi. p.

Colwell, R. K., Rahbek, C. and Gotelli, N. J. 2004. The mid-domain effect and species richness patterns: what have we learned so far? The American Naturalist **163**(3):E1-E23.

DeWalt, S. J., Maliakal, S. K. and Denslow, J. S. 2003. Changes in vegetation structure and composition along a tropical forest chronosequence: implications for wildlife. Forest Ecology and Management **182**(1-3):139-151.

Dieni, J. S. and Jones, S. L. 2002. A Field Test of the Area Search Method for Measuring Breeding Bird Populations (Una prueba de campo del metodo de" búsqueda de área" para medir poblaciones de aves reproductivas). Journal of Field Ornithology:253-257.

Dos Anjos, L. and Bocon, R. 1999. Bird communities in natural forest patches in southern Brazil. The Wilson Bulletin:397-414.

Fahrig, L. and Rytwinski, T. 2009. Effects of roads on animal abundance: an empirical review and synthesis. Ecology and society **14**(1).

Ferger, S. W., Schleuning, M., Hemp, A., Howell, K. M. and Böhning-Gaese, K. 2014. Food resources and vegetation structure mediate climatic effects on species richness of birds. Global Ecology and Biogeography **23**(5):541-549.

Fu, C., Hua, X., Li, J., Chang, Z., Pu, Z. and Chen, J. 2006. Elevational patterns of frog species richness and endemic richness in the Hengduan Mountains, China: geometric constraints, area and climate effects. Ecography **29**(6):919-927.

Ghimire, A., Rokaya, M. B., Timsina, B., Bílá, K., Shrestha, U. B., Chalise, M. K., et al. 2021. Diversity of birds recorded at different altitudes in central Nepal Himalayas. Ecological Indicators **127**:107730.

Gibbs, J. P., Hunter Jr, M. L. and Melvin, S. M. 1993. Snag availability and communities of cavity nesting birds in tropical versus temperate forests. Biotropica:236-241.

Girma, Z., Mengesha, G. and Asfaw, T. 2017. Diversity, relative abundance and distribution of Avian fauna in and around Wondo Genet forest, South-Central Ethiopia. Research Journal of Forestry **11**(1):1-12.

Grau, O., Grytnes, J. A. and Birks, H. 2007. A comparison of altitudinal species richness patterns of bryophytes with other plant groups in Nepal, Central Himalaya. Journal of Biogeography **34**(11):1907-1915.

Griffith, E. H., Sauer, J. R. and Royle, J. A. 2010. Traffic effects on bird counts on North American Breeding Bird Survey routes. The Auk **127**(2):387-393.

Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H. S. 2016. *Birds of Nepal*. Bloomsbury Publishing. p.

He, X., Wang, X., DuBay, S., Reeve, A. H., Alström, P., Ran, J., et al. 2019. Elevational patterns of bird species richness on the eastern slope of Mt. Gongga, Sichuan Province, China. Avian Research **10**(1):1-12.

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.

Hofer, U., Bersier, L.-F. and Borcard, D. 1999. Spatial organization of a herpetofauna on an elevational gradient revealed by null model tests. Ecology **80**(3):976-988.

Hurlbert, A. H. and Haskell, J. P. 2003. The effect of energy and seasonality on avian species richness and community composition. The American Naturalist **161**(1):83-97.

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. Nepalâ€™ s National Red List of Birds. Journal of Threatened Taxa **9**(1):9700-9722.

Jetz, W., Thomas, G. H., Joy, J. B., Hartmann, K. and Mooers, A. O. 2012. The global diversity of birds in space and time. Nature **491**(7424):444-448.

Joshi, D., Chaudhary, R., Paudel, K. and Koirala, S. 2009. Nepal fourth national report to the convention on biological diversity.

Kattan, G. H. and Franco, P. 2004. Bird diversity along elevational gradients in the Andes of Colombia: area and mass effects. Global Ecology and Biogeography **13**(5):451-458.

Katuwal, H., Sharma, H., Shaner, P., Gurung, R., Thapa, V., Magar, T., et al. 2018. Updating spatial information of 27 mammal species in Nepal. JAPS: Journal of Animal & Plant Sciences **28**(6).

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., Rai, J., Tomlinson, K., Rimal, B., Sharma, H. P., Baral, H. S., et al. 2022. Seasonal variation and crop diversity shape the composition of bird communities in agricultural landscapes in Nepal. Agriculture, Ecosystems & Environment **333**:107973.

Kim, J.-Y., Seo, C., Hong, S., Lee, S. and Eo, S. H. 2019. Altitudinal range-size distribution of breeding birds and environmental factors for the determination of species richness: An empirical test of altitudinal Rapoport's rule and non-directional rescue effect on a local scale. PLoS One **14**(1):e0203511.

Kim, J., Chae, J. and Koo, T.-H. 2007. Variation in bird diversity in relation to habitat size in the urban landscape of Seoul, South Korea. Acta Ornithologica **42**(1):39-44.

Kluge, J., Worm, S., Lange, S., Long, D., Boehner, J., Yangzom, R., et al. 2017. Elevational seed plants richness patterns in Bhutan, Eastern Himalaya. Journal of Biogeography **44**(8):1711-1722.

Lee, P. Y. and Rotenberry, J. T. 2005. Relationships between bird species and tree species assemblages in forested habitats of eastern North America. Journal of Biogeography **32**(7):1139-1150.

Lindell, C. A., Chomentowski, W. H. and Zook, J. R. 2004. Characteristics of bird species using forest and agricultural land covers in southern Costa Rica. Biodiversity & Conservation **13**(13):2419-2441.

Lomolino, M. V. 2001. Elevation gradients of species-density: historical and prospective views. Global Ecology and Biogeography **10**(1):3-13.

McCain, C. M. 2009. Global analysis of bird elevational diversity. Global Ecology and Biogeography **18**(3):346-360.

McCain, C. M. 2010. Global analysis of reptile elevational diversity. Global Ecology and Biogeography **19**(4):541-553.

Mengesha, G., Mamo, Y. and Bekele, A. 2011. A comparison of terrestrial bird community structure in the undisturbed and disturbed areas of the Abijata Shalla lakes national park, Ethiopia. International Journal of Biodiversity and conservation **3**(9):389-404.

Mittelbach, G. G., Steiner, C. F., Scheiner, S. M., Gross, K. L., Reynolds, H. L., Waide, R. B., et al. 2001. What is the observed relationship between species richness and productivity? Ecology **82**(9):2381-2396.

Mittermeier, R. A., Myers, N., Mittermeier, C. G. and Robles Gil, P. 1999. *Hotspots: Earth's biologically richest and most endangered terrestrial ecoregions*. CEMEX, SA, Agrupación Sierra Madre, SC. p.

Moning, C. and Müller, J. 2008. Environmental key factors and their thresholds for the avifauna of temperate montane forests. Forest Ecology and Management **256**(5):1198-1208.

Montaño-Centellas, F. A., McCain, C. and Loiselle, B. A. 2020. Using functional and phylogenetic diversity to infer avian community assembly along elevational gradients. Global Ecology and Biogeography **29**(2):232-245.

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. https://doi.org/10.11609/jott.5815.12.14.16927-16943.

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.

Pan, X., Liang, D., Zeng, W., Hu, Y., Liang, J., Wang, X., et al. 2019. Climate, human disturbance and geometric constraints drive the elevational richness pattern of birds in a biodiversity hotspot in southwest China. Global Ecology and Conservation **18**:e00630.

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). https://doi.org/10.1186/s40657-020-00217-6.

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.

Peris, S. and Pescador, M. 2004. Effects of traffic noise on paserine populations in Mediterranean wooded pastures. Applied acoustics **65**(4):357-366.

Pielou, E. C. 1966. The measurement of diversity in different types of biological collections. Journal of theoretical biology **13**:131-144.

Price, T. D., Hooper, D. M., Buchanan, C. D., Johansson, U. S., Tietze, D. T., Alström, P., et al. 2014. Niche filling slows the diversification of Himalayan songbirds. Nature **509**(7499):222-225.

Rahbek, C. 1995. The elevational gradient of species richness: a uniform pattern? Ecography:200-205.

Rahbek, C. 1997. The relationship among area, elevation, and regional species richness in neotropical birds. The American Naturalist **149**(5):875-902.

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.

Sarkar, N. J., Sultana, D., Jaman, M. F. and Rahman, M. K. 2009. Diversity and population of avifauna of two urban sites in Dhaka, Bangladesh. Ecoprint: An International Journal of Ecology **16**:1-7.

Sethy, J., Samal, D., Sethi, S., Baral, B., Jena, S., Payra, A., et al. 2015. Species diversity and abundance of birds in and around North Orissa University, Takatpur, Baripada, Mayurbhanj, Odisha. Species Diversity **4**(2).

Shah, S. B. and Sharma, H. P. 2022. Bird diversity and factors affecting bird abundance at Dullu Municipality, Dailekh, Nepal. Biodiversitas Journal of Biological Diversity **23**(3).

Shannon, C. E. and Weaver, W. 1949. The mathematical theory of communication. University of Illinois. Urbana **117**.

Sinha, A., Hariharan, H., Adhikari, B. S. and Krishnamurthy, R. 2019. Bird diversity along riverine areas in the Bhagirathi Valley, Uttarakhand, India. Biodiversity Data Journal **7**.

Svensson, L. 2010. *Collins bird guide*. HarperCollins ebooks. p.

Tesfahunegny, W., Fekensa, T. and Mulualem, G. 2016. Avifauna diversity in Kafa Biosphere Reserve: Knowledge and perception of villagers in Southwest Ethiopia. Ecology and Evolutionary Biology **1**(2):7-13.

Waterhouse, F. L., Mather, M. H. and Seip, D. 2003. Distribution and abundance of birds relative to elevation and biogeoclimatic zones in coastal old-growth forests in southern British Columbia. Journal of Ecosystems and Management **2**(2).

Wu, Y., Colwell, R. K., Rahbek, C., Zhang, C., Quan, Q., Wang, C., et al. 2013. Explaining the species richness of birds along a subtropical elevational gradient in the Hengduan Mountains. Journal of Biogeography **40**(12):2310-2323.

Zellweger, F., Baltensweiler, A., Ginzler, C., Roth, T., Braunisch, V., Bugmann, H., et al. 2016. Environmental predictors of species richness in forest landscapes: abiotic factors versus vegetation structure. Journal of Biogeography **43**(6):1080-1090.

Annex I: The checklist of bird species recorded from the Makawanpur District, Nepal

SN	Common Name	Scientific name	Order	Family	IUCN Status	NRDB status	R. status	types
1	Black kite	*Milvus migrans*	Accipitriformes	Accipitridae	LC	LC	R	C
2	Black-winged Kite	*Elanus caeruleus*	Accipitriformes	Accipitridae	LC	LC	R	C
3	Booted Eagle	*Hieraaetus pennatus*	Accipitriformes	Accipitridae	LC	LC	WV	C
4	Himalayan Buzzard	*Buteo refectus*	Accipitriformes	Accipitridae	LC	LC	WV	C
5	Himalayan Griffon	*Gyps himalayensis*	Accipitriformes	Accipitridae	NT	VU	WV	C
6	Long-legged Buzzard	*Buteo rufinus*	Accipitriformes	Accipitridae	LC	LC	WV	C
7	Oriental Honey-buzzard	*Pernis ptilorhynchus*	Accipitriformes	Accipitridae	LC	LC	R	C
8	Shikra	*Accipiter badius*	Accipitriformes	Accipitridae	LC	LC	R	C
9	Steppe Eagle	*Aquila nepalensis*	Accipitriformes	Accipitridae	EN	VU	WV	C
10	House Swift	*Apus nipalensis*	Apodiformes	Apodidae	LC	LC	R	I
11	Common Hoopoe	*Upupa epops*	Bucerotiformes	Upupidae	LC	LC	R	I
12	Common Sandpiper	*Actitis hypoleucos*	Charadriiformes	Scolopacidae	LC	LC	WV	I
13	Common Woodpigeon	*Columba palumbus*	Columbiformes	Columbidae	LC	LC	WV	G
14	Grey-capped Emerald-dove	*Chalcophaps indica*	Columbiformes	Columbidae	LC	LC	R	G
15	Eurasian Collared-dove	*Streptopelia decaocto*	Columbiformes	Columbidae	LC	LC	R	G
16	Oriental turtle-dove	*Streptopelia orientalis*	Columbiformes	Columbidae	LC	LC	R	G
17	Red Turtle-dove	*Streptopelia tranquebarica*	Columbiformes	Columbidae	LC	LC	R	G
18	Rock Dove	*Columba livia*	Columbiformes	Columbidae	LC	LC	R	G
19	Western Spotted Dove	*Spilopelia suratensis*	Columbiformes	Columbidae	LC	LC	R	G
20	Common Kingfisher	*ALCedo atthis*	Coraciiformes	Alcedinidae	LC	LC	R	C
21	White-breasted Kingfisher	*Halcyon smyrnensis*	Coraciiformes	Alcedinidae	LC	LC	R	C

22	Indian Roller	*Coracias benghalensis*	Coraciiformes	Coraciidae	LC	LC	R	C
23	Asian Green Bee-eater	*Merops orientalis*	Coraciiformes	Meropidae	LC	LC	R	I
24	Banded Bay Cuckoo	*Cacomamtis sonneratii*	Cuculiformes	Cuculidae	LC	LC	SV	I
25	Common Hawk-cuckoo	*Hierococcyx varius*	Cuculiformes	Cuculidae	LC	LC	R	I
26	Greater Coucal	*Centropus sinensis*	Cuculiformes	Cuculidae	LC	LC	R	C
27	Green-billed Malkoha	*Phaenicophaeus tristis*	Cuculiformes	Cuculidae	LC	LC	SV	I
28	Western Koel	*Eudynamya scolopaceus*	Cuculiformes	Cuculidae	LC	LC	SV	O
29	Common Kestrel	*Falco tinnunculus*	Falconiformes	Falconidae	LC	LC	R	C
30	Black Francolin	*Francolinus francolinus*	Galliformes	Phasianidae	LC	LC	R	O
31	Kalij Pheasant	*Lophura leucomelanos*	Galliformes	Phasianidae	LC	LC	R	O
32	Red Junglefowl	*Gallus gallus*	Galliformes	Phasianidae	LC	LC	R	O
33	Thick-billed Warbler	*Arundinax aedon*	Passeriformes	Acrocephalidae	LC	LC	WV	I
34	Black-throated Tit	*Aegithalos concinnus*	Passeriformes	Aegithalidae	LC	LC	R	I
35	Common Iora	*Aegithina tiphia*	Passeriformes	Aegithinidae	LC	LC	R	I
36	Cattle Egret	*Bubulcus ibis*	Passeriformes	Ardeidae	LC	LC	R	I
37	Ashy Woodswallow	*Artamus fuscus*	Passeriformes	Artamidae	LC	LC	R	I
38	Black-winged Cuckooshrike	*Lalage melaschistos*	Passeriformes	Campephagidae	LC	LC	R	I
39	Large Cuckooshrike	*Coracina javensis*	Passeriformes	Campephagidae	LC	LC	R	I
40	Long-tailed Minivet	*Pericrocotus ethologus*	Passeriformes	Campephagidae	LC	LC	WV	I
41	Scarlet Minivet	*Pericrocotus flammeus*	Passeriformes	Campephagidae	LC	LC	R	I
42	Rusty-flanked Treecreeper	*Certhia nipalensis*	Passeriformes	Certhiidae	LC	LC	R	I
43	Aberant Busch-warbler	*Horornis flavolivaceus*	Passeriformes	Cettiidae	LC	LC	WV	I
44	Orange-bellied Leafbird	*Chloropsis hardwickii*	Passeriformes	Chloropseidae	LC	LC	R	N
45	Common Tailorbird	*Orthotomus sutorius*	Passeriformes	Cisticolidae	LC	LC	R	I
46	Grey-breasted Prinia	*Prinia hodgsonii*	Passeriformes	Cisticolidae	LC	LC	R	O
47	Himalayan Prinia	*Prinia crinigera*	Passeriformes	Cisticolidae	LC	LC	R	I

48	Yellow-bellied Prinia	*Prinia flaviventris*	Passeriformes	Cisticolidae	LC	NT	R	O
49	Eurasian Jay	*Garrulus glandarius*	Passeriformes	Corvidae	LC	LC	WV	O
50	Grey Treepie	*Dendrocitta formosae*	Passeriformes	Corvidae	LC	LC	R	O
51	House Crow	*Corvus splendens*	Passeriformes	Corvidae	LC	LC	R	O
52	Large-billed Crow	*Corvus macrorhynchos*	Passeriformes	Corvidae	LC	LC	R	O
53	Red-billed Blue Magpie	*Urocissa erythroryncha*	Passeriformes	Corvidae	LC	LC	R	O
54	Rufous Treepie	*Dendrocitta vagabunda*	Passeriformes	Corvidae	LC	LC	R	O
55	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	Passeriformes	Dicaeidae	LC	LC	R	F
56	Ashy Drongo	*Dicrurus leucophaeus*	Passeriformes	Dicruridae	LC	LC	WV	I
57	Black Drongo	*Dicrurus macrocercus*	Passeriformes	Dicruridae	LC	LC	R	I
58	Bronzed Drongo	*Dicrurus aeneus*	Passeriformes	Dicruridae	LC	LC	R	I
59	Lesser Racquet-tailed Drongo	*Dicrurus remifer*	Passeriformes	Dicruridae	LC	LC	R	I
60	Spangled Drongo	*Dicrurus bracteatus*	Passeriformes	Dicruridae	LC	LC	R	I
61	Scaly-breasted Munia	*Lonchura punctulate*	Passeriformes	Estrildidae	LC	LC	R	G
62	Tricoloured Munia	*Lonchura malacca*	Passeriformes	Estrildidae	LC	LC	R	G
63	White-rumped Munia	*Lonchura striata*	Passeriformes	Estrildidae	LC	LC	R	G
64	Brown Bullfinch	*Pyrrhula nipalensis*	Passeriformes	Fringillidae	LC	LC	R	G
65	Dark-breasted Rose-finch	*Procarduelis nipalensis*	Passeriformes	Fringillidae	LC	LC	WV	I
66	Plain Mountain-finch	*Leucosticte nemoricola*	Passeriformes	Fringillidae	LC	LC	WV	G
67	Yellow-breasted Greenfinch	*Chloris spinoides*	Passeriformes	Fringillidae	LC	LC	WV	G
68	Barn Swallow	*Hirundo rustica*	Passeriformes	Hirundinidae	LC	LC	SV	I
69	Nepal House Martin	*Delichon nipalense*	Passeriformes	Hirundinidae	LC	LC	R	I
70	Asian Plain Martin	*Riparia chinensis*	Passeriformes	Hirundinidae	LC	LC	R	I
71	Red-rumped Swallow	*Cecropis daurica*	Passeriformes	Hirundinidae	LC	LC	R	I
72	Brown Shrike	*Lanius cristatus*	Passeriformes	Laniidae	LC	LC	WV	I
73	Grey-backed Shrike	*Lanius tephronotus*	Passeriformes	Laniidae	LC	LC	WV	I

74	Long-tailed Shrike	*Lanius schach*	Passeriformes	Laniidae	LC	LC	R	C
75	Blue-winged Minla	*Siva cyanouroptera*	Passeriformes	Leiothrichidae	LC	LC	R	I
76	Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	Passeriformes	Leiothrichidae	LC	LC	R	I
77	Grey-sided Laughingthrush	*Garrulax caerulatus*	Passeriformes	Leiothrichidae	LC	VU	R	I
78	Jungle Babbler	*Argya striata*	Passeriformes	Leiothrichidae	LC	LC	R	O
79	Rufous Sibia	*Heterophasia capistrata*	Passeriformes	Leiothrichidae	LC	LC	R	F
80	Striated Laughingthrush	*Grammatoptila striata*	Passeriformes	Leiothrichidae	LC	LC	R	I
81	Streaked Laughingthrush	*Trochalopteron lineatum*	Passeriformes	Leiothrichidae	LC	LC	R	I
82	White-throated Laughingthrush	*Garrulax albogularis*	Passeriformes	Leiothrichidae	LC	LC	R	I
83	Grey Wagtail	*Motacilla cinerea*	Passeriformes	Motacillidae	LC	LC	WV	I
84	Olive-backed Pipit	*Anthus hodgsoni*	Passeriformes	Motacillidae	LC	LC	WV	I
85	White-browed Wagtail	*Motacilla maderaspatensis*	Passeriformes	Motacillidae	LC	LC	R	I
86	White Wagtail	*Motacilla alba*	Passeriformes	Motacillidae	LC	LC	WV	I
87	Black-backed Forktail	*Enicurus immaculatus*	Passeriformes	Muscicapidae	LC	LC	R	I
88	Blue-capped Redstart	*Phoenicurus coeruleocephala*	Passeriformes	Muscicapidae	LC	LC	WV	I
89	Blue-capped Rock-thrush	*Monticola cinclorhynchus*	Passeriformes	Muscicapidae	LC	LC	SV	I
90	Blue-fronted Redstart	*Phoenicurus frontails*	Passeriformes	Muscicapidae	LC	LC	WV	O
91	Blue Rock-thrush	*Monticola solitarius*	Passeriformes	Muscicapidae	LC	LC	WV	C
92	Blue whistling-thrush	*Myophonus caeruleus*	Passeriformes	Muscicapidae	LC	LC	R	I
93	Chestnut-bellied Rock-thrush	*Monticola rufiventris*	Passeriformes	Muscicapidae	LC	LC	R	I
94	Dark-sided Flycatcher	*Muscicapa sibirica*	Passeriformes	Muscicapidae	LC	LC	SV	O
95	Grey Bushchat	*Saxicola ferreus*	Passeriformes	Muscicapidae	LC	LC	R	I
96	Himalayan Bush-robin	*Tarsiger rufilatus*	Passeriformes	Muscicapidae	LC	LC	R	I
97	Himalayan Rubythroat	*Calliope pectoralis*	Passeriformes	Muscicapidae	LC	LC	WV	I
98	Hodgson's Redstart	*Phoenicurus hodgsoni*	Passeriformes	Muscicapidae	LC	LC	WV	I

99	Little pied Flycatcher	*Ficedula westermanni*	Passeriformes	Muscicapidae	LC	LC	SV	I
100	Oriental magpie-robin	*Copsychus saularis*	Passeriformes	Muscicapidae	LC	LC	R	I
101	Pied Bushchat	*Saxicola caprata*	Passeriformes	Muscicapidae	LC	LC	R	I
102	Plumbeous Water-redstart	*Phoenicurus fuliginosus*	Passeriformes	Muscicapidae	LC	LC	R	O
103	Rufous-bellied Niltava	*Niltava sundara*	Passeriformes	Muscicapidae	LC	LC	WV	I
104	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	Passeriformes	Muscicapidae	LC	LC	R	I
105	Siberian Rubythroat	*Calliope calliope*	Passeriformes	Muscicapidae	LC	LC	WV	I
106	Common Stonechat	*Saxicola torquatus*	Passeriformes	Muscicapidae	LC	LC	R	I
107	Slaty-blue flycatcher	*Ficedula tricolor*	Passeriformes	Muscicapidae	LC	LC	WV	I
108	Small Niltava	*Niltava macgrigoriae*	Passeriformes	Muscicapidae	LC	LC	R	I
109	Spotted Forktail	*Enicurus maculatus*	Passeriformes	Muscicapidae	LC	LC	R	I
110	Red-throated Flycatcher	*Ficedula albicilla*	Passeriformes	Muscicapidae	LC	LC	WV	I
111	Verditer Flycatcher	*Eumyias thalassinus*	Passeriformes	Muscicapidae	LC	LC	WV	I
112	White-capped water-redstart	*Phoenicurcus leucocephalus*	Passeriformes	Muscicapidae	LC	LC	R	I
113	White-gorgeted Flycatcher	*Anthipes monileger*	Passeriformes	Muscicapidae	LC	VU	R	I
114	Crimson Sunbird	*Aethopyga siparaja*	Passeriformes	Nectariniidae	LC	LC	R	N
115	Green-tailed Sunbird	*Aethopyga nipalensis*	Passeriformes	Nectariniidae	LC	LC	R	N
116	Purple Sunbird	*Cinnyris asiaticus*	Passeriformes	Nectariniidae	LC	LC	R	N
117	Ethiopian Black-headed Oriole	*Oriolus monachal*	Passeriformes	Oriolidae	LC	LC	R	O
118	Indian Golden Oriole	*Oriolus kundoo*	Passeriformes	Oriolidae	LC	LC	SV	O
119	Maroon Oriole	*Oriolus traillii*	Passeriformes	Oriolidae	LC	LC	R	O
120	White-browed Fulvetta	*Fulvetta vinipectus*	Passeriformes	Paradoxornithidae	LC	LC	R	I
121	Yellow-eyed Babbler	*Chrysomma sinense*	Passeriformes	Paradoxornithidae	LC	NT	R	I
122	Cinereous Tit	*Parus cinereus*	Passeriformes	Paridae	LC	LC	R	I
123	Green-backed Tit	*Parus monticolus*	Passeriformes	Paridae	LC	LC	R	I
124	Black-lored Tit	*Parus xanthogenys*	Passeriformes	Paridae	LC	LC	R	I

125	House Sparrow	*Passer domesticus*	Passeriformes	Passeridae	LC	LC	R	G
126	Russet Sparrow	*Passer cinnamomeus*	Passeriformes	Passeridae	LC	LC	R	O
127	Eurasian Tree Sparrow	*Passer montanus*	Passeriformes	Passeridae	LC	LC	R	G
128	Puff-throated Babbler	*pellorneum ruficeps*	Passeriformes	Pellorneidae	LC	LC	R	I
129	Buff-barred Warbler	*Phylloscopus pulcher*	Passeriformes	Phylloscopidae	LC	LC	WV	I
130	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	Passeriformes	Phylloscopidae	LC	LC	R	I
131	Hume's leaf-warbler	*Phylloscopus humei*	Passeriformes	Phylloscopidae	LC	LC	WV	I
132	Tickell's Leaf-warbler	*Phylloscopus affinis*	Passeriformes	Phylloscopidae	LC	LC	WV	I
133	Ashy Bulbul	*Hemixos flavala*	Passeriformes	Pycnonotidae	LC	LC	R	F
134	Black Bulbul	*Hypsipetes leucocephalus*	Passeriformes	Pycnonotidae	LC	LC	R	O
135	Himalayan Bulbul	*Pycnonotus leucogenys*	Passeriformes	Pycnonotidae	LC	LC	R	O
136	Mountain Bulbul	*Ixos mcclellandii*	Passeriformes	Pycnonotidae	LC	LC	R	F
137	Red-vented Bulbul	*Pycnonotus cafer*	Passeriformes	Pycnonotidae	LC	LC	R	O
138	White-throated Fantail	*Rhipidura albicollis*	Passeriformes	Rhipiduridae	LC	LC	R	I
139	Chestnut-bellied Nuthatch	*Sitta cinnamoventris*	Passeriformes	Sittidae	LC	LC	R	O
140	Velvet-fronted Nuthatch	*Sitta frontalis*	Passeriformes	Sittidae	LC	LC	R	I
141	White-tailed Nuthatch	*Sitta himalayensis*	Passeriformes	Sittidae	LC	LC	R	I
142	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	Passeriformes	Stenostiridae	LC	LC	WV	I
143	Yellow-bellied Fairy-fantail	*Chelidorhynx hypoxanthus*	Passeriformes	Stenostiridae	LC	LC	WV	I
144	Chestnut-bellied Starling	*Lamprotornis pulcher*	Passeriformes	Sturnidae	LC	LC	R	F
145	Common Myna	*Acridotheres tristis*	Passeriformes	Sturnidae	LC	LC	R	O
146	Common Hill Myna	*Gracula religiosa*	Passeriformes	Sturnidae	LC	LC	R	I
147	Jungle Myna	*Acridotheres fuscus*	Passeriformes	Sturnidae	LC	LC	R	O
148	Black-chinned Babbler	*Cyanoderma pyrrhops*	Passeriformes	Timaliidae	LC	LC	R	I
149	Rusty-cheeked Scimitar-babbler	*Erythrogenys erythrogenys*	Passeriformes	Timaliidae	LC	LC	R	I
150	Alpine Thrush	*Zoothera mollissima*	Passeriformes	Turdidae	LC	LC	R	I

151	Black-throated Thrush	*Turdus atrogularis*	Passeriformes	Turdidae	LC	LC	WV	I
152	Grey-winged Blackbird	*Turdus boulboul*	Passeriformes	Turdidae	LC	LC	R	O
153	White-collared Blackbird	*Turdus albocinctus*	Passeriformes	Turdidae	LC	LC	R	I
154	White-bellied Erpornis	*Erpornis zantholeuca*	Passeriformes	Vireonidae	LC	LC	R	O
155	Indian White-eye	*Zosterops palpebrosus*	Passeriformes	Zosteropidae	LC	LC	R	O
156	Stripe-throated Yuhina	*Yuhina gularis*	Passeriformes	Zosteropidae	LC	LC	R	I
157	Whiskered Yuhina	*Yuhina flavicollis*	Passeriformes	Zosteropidae	LC	LC	R	O
158	Indian Pond-heron	*Ardeola grayii*	Pelecaniformes	Ardeidae	LC	LC	R	C
159	Little Egret	*Egretta garzetta*	Pelecaniformes	Ardeidae	LC	LC	R	C
160	Blue-throated Barbet	*Psilopogon asiaticus*	Piciformes	Megalaimidae	LC	LC	R	F
161	Great Barbet	*Psilopogon virens*	Piciformes	Megalaimidae	LC	LC	R	F
162	Fulvous-breasted Woodpecker	*Dendrocopos macei*	Piciformes	Picidae	LC	LC	R	I
163	Black-rumped Flameback	*Dinopium benghalense*	Piciformes	Picidae	LC	LC	R	O
164	Crimson-breasted Woodpecker	*Dryobates cathpharius*	Piciformes	Picidae	LC	LC	WV	O
165	Alexandrine Parakeet	*Psittacula eupatria*	Psittaciformes	Psittaculidae	NT	NT	R	G
166	Plum-headed Parakeet	*Psittacula cyanocephala*	Psittaciformes	Psittaculidae	LC	LC	R	G
167	Red-breasted Parakeet	*Psittacula alexandri*	Psittaciformes	Psittaculidae	NT	VU	R	G
168	Rose-ringed Parakeet	*Psittacula krameria*	Psittaciformes	Psittaculidae	LC	LC	R	G
169	Slaty-headed Parakeet	*Psittacula himalayana*	Psittaciformes	Psittaculidae	LC	LC	R	G
170	Asian Barred Owlet	*Glaucidium cuculoides*	Strigiformes	Sturnidae	LC	LC	R	C
171	Collared Owlet	*Glaucidium brodiei*	Strigiformes	Sturnidae	LC	LC	R	C
172	Spotted Owlet	*Athene brama*	Strigiformes	Strigidae	LC	LC	R	C

Annex II: Photo plates:


Black kite


Black-winged kite


Booted Eagle


Himalayan Buzzard


Himalayan Griffon


Long-legged Buzzard


Oriental Honey-buzzard


Steppe Eagle


Common Hoopoe


Common Woodpigeon


Grey-capped Emerald-dove


Oriental Turtle-dove


Western Spotted Dove


Common Kingfisher


White-breasted Kingfisher


Indian Roller


Green Bee-eater


Banded Bay Cuckoo


Green-billed Malkoha


Western Koel


Greater Coucal


Common Kestrel


Black Frnacolin


Kalij Pheasant


Thick-billed Warbler


Black-throated Tit


Cattle Egret


Ashy Wood-swallow


Large Cuckooshrike


Long-tailed Minivet


Rusty-flanket Treecreeper


Orange-bellied Leafbird

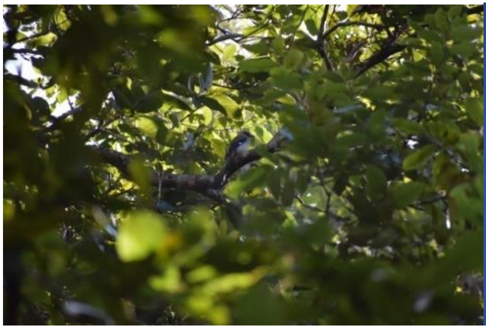

Common Tailorbird


Himalayan Prinia


Yellow-bellied Prinia


Grey-breasted Prinia


Eurasian Jay


Gray Treepie


Large-billed Crow


Red-billed Blue Magpie


Rufous Treepie


Fire-breasted Flowerpecker


Ashy Drongo


Black Drongo


Bronzed Drongo


Spangled Drongo


Scaly-breasted Munia


White-rumped Munia


Dark-breasted Rosefinch


Plain Mountainfinch


Yellow-breasted Greenfinch


Barn Swallow


Red-rumped Swallow


Asian Plain Martin


Brown Shrike


Grey-backed Shrike


Long-tailed Shrike


Chestnut-crowned Laughingthrush


Jungle Babbler


Rufous Sibia


Striated Laughingthrush


White-throated Laughingthrush


Grey Wagtail


Olive-backed Pipit


White-browed Wagtail


White Wagtail


Blue-capped Redstart


Blue Rock-thrush


Blue-fronted Redstart


Hodgson's Redstart


Himalayan Bush-robin


Himalayan Rubythroat


Little pied Flycatcher (female)


Oriental Magpie-robin


Black-backed Forktail


Plumbous Redstart


Rufous-billed Niltava


Rufous-gorgeted Flycatcher


Siberian Rubythroat


Common Stonechat

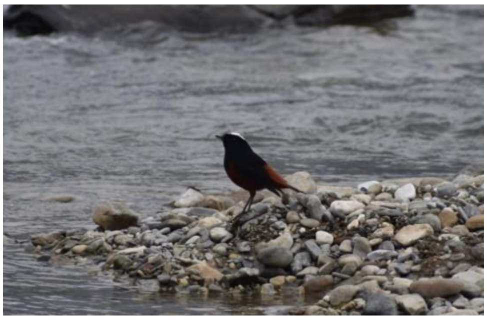

Slaty-blue flycatcher


Small Niltava


Spotted Forktail


Taiga Flycatcher

Verditer Flycatcher


White-capped water-redstart


Maroon Oriole


Green-tailed Sunbird


Crimson Sunbird


Ethiopian Black-headed Oriole


Indian Golden Oriole


Purple Sunbird


Yellow-eyed Babbler


Green-tailed Sunbird


Cinereous Tit


Black-lored Tit


House Sparrow


Buff-barred Warbler


Grey-hooded Warbler


Hume's leaf-warbler


Ashy Bulbul


Black Bulbul


Himalayan Bulbul


Mountain Bulbul


Red-vented Bulbul


Chestnut-bellied Nuthatch


Velvet-fronted Nuthatch


Grey-headed Canary-flycatcher


Yellow-bellied Fairy-fantail


Common Myna


Common Hill Myna


Jungle Myna


Alpine Thrush


Black-throated Thrush


Grey-winged Blackbird


White-collared Blackbird


White-bellied Erpornis


Indian White-eye


Stripe-throated Yuhina


Whiskered Yuhina


Indian Pond-heron


Little Egret


Blue-throated Barbet


Great Barbet


Fulvous-breasted Woodpecker


Black-rumped Flameback


Crimson-breasted Woodpecker


Alexandrine Parakeet


Plum-headed Parakeet


Red-breasted Parakeet


Roes Ring Parakeet


Asian Barred Owlet


Collared Owlet


Spotted Owlet


Blue-capped Rock-thrush


Common Sandpiper


Eurasian Collared-Dove


Red Turtle-dove


Paid Buschat


Grey Buschat


Rock Dove


House Crow


Blue Whistling-thrush


Chestnut-bellied Rock-thrush


Rusty-cheeked Scimitar Babbler