DIVERSITY OF BIRDS ALONG AN ELEVATION GRADIENT AND SEASONAL VARIATION IN KALIGANDAKI RIVER BASIN, WESTERN NEPAL

JUNA NEUPANE

T.U. Registration No: 5-2-37-178-2012

T.U Examination Roll No: 422/2073

Batch: 2073/2074

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

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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: 2076/05/22

Juna Neupane

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RECOMMENDATION

This is to recommend that the thesis entitled " **Diversity of birds along an elevation gradient and seasonal variation in Kaligandaki River basin, Western Nepal**" has been carried out by Ms. Juna Neupane for partial fulfillment of therequirement for Master's Degree in Zoology with the special paper of Ecology and Environment. This is her 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.

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LETTER OF APPROVAL

On the recommendation of supervisor Prof. Dr. Mukesh kumar Chalise, Central Department of Zoology, Tribhuvan University, the thesis submitted by Ms. Juna Neupane entitled " **Diversity of birds along an elevation gradient and seasonal variation in Kaligandaki River basin, Western 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.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Ms. Juna Neupane entitled "" **Diversity of birds along an elevation gradient and seasonal variation in Kaligandaki River basin, Western Nepal** " has been accepted as a partial fulfillment for the requirement of Master's Degree of Science in Zoology with special paper Ecology.

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Juna Neupane

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
ACA	Annapurna Conservation Area
AICc	Akaike Information Criterion (corrected)
ANOVA	Analysis of Variance
Asl	Above sea level
BCN	Bird Conservation Nepal
GLM	Generalized Linear Model
IUCN	International Union for Conservation of Nature and Natural Resources
m	Meter
MCA	Manaslu Conservation Area
MDE	Mid Domain Effect
NDVI	Normalized Difference Vegetation Index
NPWC	National Park and Wildlife Conservation
SNNP	Shivapuri Nagarjun National Park
SSI	Sorenson’s Similarity Index

ABSTRACT

Demonstrating the patterns and the underlying mechanism of diversity along elevational gradient has been a powerful test system for understanding and studying biodiversity including the avian fauna. This study aimed to explore the bird diversity, seasonal variation and associated factors along elevation gradient in Kaligandaki River basin in two districts, Myagdi and Mustang of Annapurna Conservation Area. Field survey was carried out in two seasons, winter (Jan and Feb, 2019) and summer (May and June, 2019). Point count method was used for bird survey within three circular plots (radius=30m) in each 100m rise in elevation. A total of 90 sampling plots were set up from elevation of 800m (Beni) to 3800 m (Muktinath) within the study area. Data on variables like number of fruiting trees as a proxy of resource availability, distance to road as a proxy of disturbance, and habitat types were collected, and influence was assessed. All the data were analyzed by using Microsoft excel 2016, R software and CANOCO 4.5. Shannon diversity index (H'=4.134) and the evenness index (e= 0.5205) indicated the diverse assemblage of the avian fauna in the study area, whereas one -way ANOVA (Fstat= 0.48, $p>0.05$) revealed no significant variation in species richness in two seasons within the study period. Monotonic decline in species richness along elevation was illustrated as a pattern of diversity. GLM illustrated that both the species richness and species diversity were negatively associated with elevation. Similarly, distance to road as a predictor variable of disturbance showed reverse association with species richness. However, number of trees analyzed as a variable for resource availability showed positive relationship with species richness and diversity, that means, higher the number of trees, higher the observed avian richness. Likewise, Canonical Correspondence analysis (Monte Carlo significance test with 499 permutations) showed that among different habitat types the species distribution and richness was strongly associated with forest and shrubland habitat. The diverse avian fauna within the study area and their association with different factors needs furthermore detailed and extensive survey to explore more species and other patterns and processes along the elevational gradient.

1. INTRODUCTION

1.1 Background

Elevational gradients are a powerful test system for studying and understanding biodiversity across the world (McCain 2009) and the changes in diversity and composition of species along these gradients have long been the topic of interest in ecology (Lomolino 2001). Uncovering the spatial and temporal aspects of species diversity and mechanisms responsible for these variation along the environmental gradient is one of the central aims and a key challenge for ecologist and conservationists (Gaston 2000). Global latitudinal diversity is one of the well-known patterns where species richness peaks in the tropics and declines towards the poles, i.e., the decline in richness with increasing distance from the equator (Rosenzweig 1992, Hillebrad 2004). Though elevational gradients have not been studied as intensively as the latitudinal gradient but this provide equally striking patterns in diversity as dramatic abiotic and biotic changes occur across relatively small spatial extents (McCain 2010).

Many studies have demonstrated patterns in diversity along elevational gradients and have attempted to describe underlying mechanism, still the consent on the overview of pattern and processes is a topic of discussion (Sanders et al. 2012). In general species richness along elevation gradients has been reported to follow one of the four main diversity patterns; decreasing with elevation, low plateau, low plateau with a mid- elevational peak and mid-elevational peaks, among which mid elevational peaks are the most common richness patterns among vertebrates (McCain & Grytes 2010). These patterns are well explained by several drivers that includes spatial drivers (area, mid domain effect) and environmental drivers (temperature, precipitation, productivity and habitat heterogeneity) (Colwell, Rahbek & Gotelli, 2004, Wu et al. 2013).

Numerous hypotheses have been proposed to explain relationships between species richness and altitude associated with several drivers, such as species- area relationship, Mid-domain effect, climate-richness relationship and productivity- richness relationship. Species- area relationship describe the trend that the larger area tend to support higher number of species because of differential speciation and extinction rates that can be different with area at regional and global scales (Rosenzweig 1995). Another hypothesis of Mid-domain effect (MDE) shows that the spatial boundaries would create greater overlaps in ranges of the species toward the center of an area and result higher diversity at the mid elevation of a mountain region (Colwell & Lees 2000). Similarly, association between richness and the environment can be explained by both the climate-richness relationship and productivity-richness relationship (McCain 2010, McCain & Grytnes 2010). Temperature and precipitation can have direct influence on species richness in respect with physiological tolerances and food resource availability (McCain 2009). Productivity, an estimate of Normalized Difference Vegetation Index (NDVI), also has significant influence in species richness as higher the productivity, greater the number of individuals supported within a community (MacArthur and MacArthur 1961, Sanders and Rahbek 2012, Price et al. 2014).

Birds are excellent model system for examining and understanding most of the biodiversity patterns and drivers as they are present in almost all climatic conditions and habitat types around the globe (McCain 2009). They are a key part of food chains and ecosystem and play a functional role in flower pollination and seed dispersal (Nason 1992). Birds are good environmental indicators as they respond to different habitat structure (MacArthur and MacArthur 1961) and thus can guide management at regional and landscape levels (Canterbury et al. 2000). In Nepal, biodiversity strength is well reflected with high number of bird species representing about 9% of the world's known bird species (Inskipp *et al*. 2016).The high avian diversity is enhanced by the location of Nepal at the border of Palearctic and Oriental realm supporting tropical to alpine bio-climatic regions with altitudinal variation from 67 m asl to 8848m asl (Inskipp et. al. 2016). So far, 887 species of birds have been recorded in Nepal, among them 42 species are globally threatened and 35 globally near threatened (IUCN 2018). Spiny Babbler (*Turdoides nipalensis)* is the only endemic bird of Nepal. Nine species; 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*) are protected birds of Nepal by National Park and Wildlife Conservation Act (NPWC) 2029.

Variations in species richness of birds along elevation are among the most commonly considered aspects of bird community structure (Stevens 1992), because elevation affects the condition of the physical environment and the types and amount of resources available for breeding and foraging activities, thus the composition and structure of bird communities may change along these gradients (Rahbek 2005, McCain 2009, Mengesha et al. 2011,). It has been documented that as elevation increases the availability of resources for birds decreases reflecting differences in forest stand structure, site productivity, vegetation species composition and available land area (Rahbek 2005). Birds in mountain environments are sensitive to seasonal variation in climate, due to resource bottlenecks for food and water availability and to temperature regulation requirements (Herzog et al. 2005) Seasonality also plays a significant role in determining food and cover availability of avian population which ultimately influence breeding success and survival of the bird species (Mengesha and Bekele 2008). The seasonal variation in the amount of rainfall and temperature and other spatial and temporal microhabitat conditions are prime factors to affect the availability of various food items for birds. Such distributions of food and cover resources determine the richness, abundance and habitat use of bird species (Mengesha et al. 2011, Waterhouse, Mather & Seip, 2002). Vegetation structure partly determines prey availability and seasonal migration of birds, ultimately determining the bird community structure (Lincolin et al. 1998).

In Nepal, seasonal migration of birds is associated with changes between dry and monsoon season where summer migration starts between March and May (Pre-monsoon season) which is also extended sometimes to monsoon season in June and July, while winter migration starts during the post monsoon season in September (Grimmett et al. 2000, 2011). About 150 species migrate from northern side in winter and 30-40 species migrate from the southern side in summer to Nepal (Inskipp and Inskipp 1991). Around 650 species of birds are residential in Nepal, many of which are seasonal altitudinal migrant (Grimmett et al. 2016).

Mountain environment are characterized by considerable variation in geology, topography, climate and land cover along elevational gradients (Becker et al. 2007) and are known to feature large number of species, also implies to avian fauna, offering an ideal condition for exploring variation in species diversity over short spatial distances (Korner 2007). These areas are also known to be a global hotspot for bird species (Renner 2011, Inskipp et al. 2010). Studying and understanding the association between species richness and elevation gradients is essential as it provides insights into the observed patterns and processes responsible for the relation, which in turn supports conservation efforts (Stevens 1992, Raman et al. 2005, Acharya et al. 2011).

1.2 Rationale of the study

Nepal is a country with high diversity of bird species, with a total of 887 species recorded which represents over eight percent of the world's known bird species (IUCN 2018). Diversity and species richness along elevation gradient in birds of Nepal are less explored and studies related to these are very insufficient (Paudel and Sipos 2014). Likewise, mountain environment is very fragile with complex topography and hence biodiversity of Himalaya is poorly explored (Baniya et al. 2010). This study aimed to understand the trends of species richness variation along elevation gradients along Kaligandaki river basin, western Nepal covering two districts within Annapurna Conservation Area (ACA). Although the checklist for overall bird species of ACA has been published (Inskipp and Inskipp 2003, Baral 2018) but the study focusing bird's diversity, elevation and associated factors has not been conducted yet within the study. Studying diversity pattern of the avian fauna not only helps to determine the species present in the area but later it will also assist in determining the factors affecting the distribution of birds in different altitudes. This study will be helpful in providing a checklist of bird species in the study area along Kaligandaki river basin which will assist as a basis for monitoring of birds' species in future and has implication of conservation efforts.

1.3 Objectives of the Study

General Objective

To explore the altitudinal diversity of birds in Kaligandaki River Basin, Western Nepal.

Specific Objectives

- To determine species richness, abundance and diversity of birds along elevation gradient in Kaligandaki River Basin.
- To find out seasonal variation in diversity of birds.
- To explore the factors affecting bird diversity within the study area.

2. LITERATURE REVIEW

2.1 Avian species richness, abundance and diversity along elevation

Birds displayed four distinct diversity patterns along elevation band on montane environment; decreasing diversity, low elevation plateau, low elevation plateau with mid-peaks and unimodal mid elevation peaks (McCain 2009). For this result different climatic as well as geographic variables were responsible. Grytnes and Vetass (2002) discussed that species richness showed a unimodal response to elevation in the Nepalese Himalaya. Some other studies have found monotonic decline in species richness with elevation (Bhattarai and Vetaas 2006, Rahbek 2005, Grytnes et al. 2006). Similarly, the mid elevation peak has been known to occur wordwide in different taxa including vascular plants in Norway (Grytnes 2003), lichens in Nepalese Himalayas (Baniya et al. 2010), ants in Colorado (Sanders 2002), small mammals in Costa Rica (McCain 2004), birds in the Andes (Khattan and Franco 2004) and in the Himalayas (Acharya et al. 2011).

Williams et al. (2009) reported a hump-shaped relationship between elevation and species richness in neotropical birds and Australian wet tropical birds respectively. A total of 203 bird species including 147 residents and 56 non-residents were recorded along the elevation gradient in Sutlej river basin, West Himalaya, India across 16 elevation bands where the species distribution showed a monotonic decrease in species richness with increasing elevation (Santhakumar et al. 2018). Pan et al. (2016) recorded a total of 169 breeding birds in the Gyirong valley, belonging to 11 orders, 41 families and 100 genera, where the interpolated species richness showed hump-shaped patterns along the elevation gradient. Similarly, Katuwal et al. (2013) in the study of birds along central Himalaya, Nepal observed 3642 individuals of birds belonging to 178 species, where average number of bird species per plot and the number of species classified as resident both showed a peak at the 3000 m a.s.l elevation band, however, average number of migratory species was consistently low across the studied elevational gradient. Wu et al. (2013) recorded 738 breeding birds for each 100 m elevational band along a gradient in a Hengduan mountains, where the elevation pattern in species richness, for all breeding birds was hump-shaped, with a peak at 800-1800 m elevation. Another study on birds of Himalaya recorded a total of 182 bird species belonging to 12 orders, 43 families and 105 genera which included 169 breeding birds and richness showed a hump shaped pattern along elevation gradient with a peak occurring at 2400-3000 m a.s.l. Overall bird richness and guild richness displayed hump-shaped elevational trends but their richness peaks differed in different elevation band in the study of birds in central Himalaya (Ding et al. 2019).

2.2 Species richness and seasonal variation

Seasonal variation in several environmental factors and variation of availability of food has direct impact on bird species richness. Seasonality not only affects the structure and functions of ecosystem but also has direct influence on species richness of birds including food and cover availability (Mengesha and Bekele 2008). In the forest region, seasonal variation in species diversity occur due to the change in foraging behavior of the species (Robertson and Hackwell, 1995). Seasonal variation in rainfall, temperature and food resources brings changes in species occurrence and abundance of birds (Gatson et al. 2000). Fluctuations in weather patterns have direct influence upon the several activities of birds and have direct impact upon the species richness and community structure of avian fauna (Humphrey 2004).

Ghimire (2009) reported higher species richness in spring than in autumn in a study conducted in Barandabhar Corridor forest. Malla (2006) found higher species richness in winter and spring than other seasons in Nagarjun forest, Kathmandu. Rimal (2006) recorded the highest number of species in spring and lowest in monsoon in Shivapuri National Park (SNP). One hundred and fifty-two species of bird were recorded from lower Mai valley area and highest numbers of species were observed during winter season (Basnet and Sapkota, 2006). Similarly, Chhetry (2006) studied wetland birds around the Koshi barrage area and found 98 species of birds of 60 genera belonging to 18 families of which 41 were winter visitors and 4 were summer visitors, 14 occasional visitors and 39 were residential. Giri and Chalise (2008) studied the seasonal diversity of water bird in Fewa Lake and 39 species was recorded. Among of which highest species of birds (31) was found in winter and 17 species of birds in summer season. Chaudhari et al. (2009) studied the avifaunal diversity of Khata corridor forest and found 141 bird species belonging to 12 orders and 43 families. Species richness was highest in Early winter (102), followed by summer (96), spring (90), late winter (85) and lowest (55) in the late monsoon. A total of 100 species of water birds were recorded in and around of Koshi Tappu wildlife Reserve and highest species of birds were recorded in winter season (Chhetry and Pal 2011). Similarly, Aryal et al. (2012) recorded a total of 96 species of birds from northern Barandabhar forest corridor. The study on birds of Biratnagar sub-Metropolis was performed by Jha and Subba (2012) and found 72 species of birds. Seventy-seven bird species belonging to eight orders and 31 families were observed in Jagdispur reservoir, of which 40 species were resident and 37 were migrants. Highest number of bird species was observed in winter and least in summer (Thapa and Saund 2012). Likewise, Dahal and Chhetry (2013), studied diversity and population status on wetland birds in and around Budhi and Tengra rivers and recorded 15 species of wetland birds. More species of birds were found on January and least species were recorded in July and August. Similarly, Parajuli (2016) studied the diversity and relative abundance of birds of Karra River and found a total of 153 species of birds. In the same study, higher number of birds was found in winter (130) and fewer birds were found in summer season (74). Thakuri (2013) recorded high number of birds in April-May than in December in Manaslu Conservation Area (MCA). Katwal (2013) recorded high species richness of birds in post monsoon season and low in the pre-monsoon season in Manaslu conservation area. BCN (2012) recorded 191 species in winter and 189 species in spring season in Api-Nampa Conservation area.

Cueto and deCasenave (2000) found highest bird diversity during spring and lowest during autumn season in the coastal woodland of the reserve 'EI Destino', Buenos Aires Province, Argentina. Murgui (2007) found that the bird richness was found higher during breeding period that is in spring and summer than in the winter season due to the unfavorable climatic conditions, shortage of food and predation in winter season. Padhye et al. (2007) studied the changes in avifauna community across seasons and landscape elements in Tamhini, northern Western Ghats and found maximum species in spring season (49) followed by early winter (41) and then summer (39). Likewise, in another study 109 species of birds belonging to 34 families were recorded during the rehabilitation stage of Chimdi Lake, of which 28 were resident, 27 winter visitor and 17 were summer visitors whereas 37 were occasional visitors (Surana et al. 2007). Harisha and Hosetti (2009) studied the diversity of birds in Lakkavali range forest, Bhadra wildlife sanctuary, Western Ghat, India and found a total of 132 species of birds belonging to 34 families under 11 orders. A total of 76 species of birds were recorded within moist high-altitude grassland in eastern South Africa. Higher species were recorded during summer followed by autumn and then winter while spring had the least species richness (Maphisa et al. 2016). Collins and Edward (2014) found that bird diversity was higher in wet season than in dry season in wetlands, northern region (Ghana). Acharya et al. (2010) found species richness and abundance maximum in monsoon in Shingba Rhododendron Wildlife sanctuaries, Sikkim, Eastern Himalayan, India.

2.3 Factors affecting richness and diversity of birds

Birds have been used as indicators of environmental changes due to their sensitivity to environmental changes due to their sensitivity to environmental variables and the populations of many species of birds have been monitored to indicate changes in their habitats (Moning & Muller 2008). Numerous factors have been implicated as underlying mechanisms for shaping elevational diversity patterns such as land area, geometric constraints, climate, food availability and productivity (Colwell et al. 2004, McCain 2009, Koh et al. 2006, Sanders and Rahbek 2012, Price et al. 2014).

Acharya et al. (2011) studied factors underlying in bird diversity in the Eastern Himalaya and found no evidence that geometric constraints influenced the bird species richness pattern, however, actual evapotranspiration, plant species richness pattern, shrub density, basal area of trees, primary productivity and factors associated with habitat accounted for most of the variation in avian species richness. Basnet et al. (2016) identified main determinants of bird diversity and species composition of the bird communities in a Hilly region of Nepal in the central Himalayas and found that slope and habitat characteristics such as presence of forest edges and shrubs as important factors in driving species composition. Adhikari et al. (2019) studied factors affecting diversity and distribution of globally threatened birds and found that the presence of livestock and people caused significantly negative effects on species richness and abundance of birds and also the distance from road and village had a negative effect on the bird species richness.

Wu et al. (2013) explained the species richness of birds along a subtropical elevational gradient in the Hengduan mountains and found that climate and energy factors correlated well with the richness pattern of birds along with seasonality and productivity. Another study of avian communities in urban parks across Beijing showed that the vegetation structure and foliage height diversity was the most important factor influencing avian species diversity than park area (Xie et al. 2016). Pan et al. (2016) studied elevational pattern of bird species richness and its causes along a central Himalaya gradient, China and examined the relative importance of six variables: area, mid domain effect, temperature, precipitation, productivity and habitat heterogeneity, where area and precipitation were not crucial factors in determining the species richness along the gradient. However, mid domain effect, temperature and productivity and habitat heterogeneity were strong explanatory factors. Similarly, Rompre et al. (2007) found that plant species richness, precipitation, forest age and topography strongly affected avian diversity in lowland, Panama rain forests. Study of avian diversity and its association with vegetation structure in different zones of Nainital district of Uttarakhand revealed that plant species diversity and foliage height diversity seemed to be key features which influences the avian species at local level (Joshi et al. 2012). Environmental factors for the determination of species richness in Jirisan National Park, South Korea (Kim et al. 2018), showed that species range size distribution showed a negative relationship with climatic variables and habitat heterogeneity and a positive relationship with primary productivity. Study of elevational patterns of bird species richness on the eastern slope of Mt Gongga, China, showed that suite of factors like Mid-domain effect, Invertebrate biomass, seasonal temperature range played important but varying roles in shaping the elevational richness patterns of different birds' species (XingCheng et al. 2019). Santhakumar et al. (2018), tested the roles of explanatory variables such as temperature, precipitation, area, mid domain effect and NDVI for bird species richness along the elevation gradient of the Sutlej River basin, Western Himalayan, India and found that the climatic conditions and vegetation are the major contributors for determining species richness. Another study found that the climatic factors (temperature and precipitation) were closely related to temporal fluctuations than local resource availability in southern Ecuador (Santillan et al. 2018). Also, the temperature had significant positive effects on the abundance of birds at mid and high elevations, whereas precipitation negatively affected bird abundance at low and mid elevation. Similarly, Ding et al. (2019) studied different responses of avian feeding guilds to spatial and environmental factors across an elevational gradient in the central Himalaya and examined the effects of spatial (area and mid domain effect) and environmental factors (Climate, productivity and plant species richness). Result showed that NDVI and habitat heterogeneity were important factors in explaining overall bird richness.

2. MATERIALS AND METHODS

3.1 Study area

Kaligandaki River basin in Western Nepal is a major tributary of the Ganges River Basin with a catchment area of approximately 11,830 km². It is an important sub basin of the Narayani basin in Nepal located between 27°43´ N to 29°19´N and 82°53´E to 84°26´E. This area has a marked topographic variation with elevations varying from 183m to 8143m. The climate in Kaligandaki River Basin is usually dry with strong winds and intense sunlight and receives less than 300 millimeters rainfall annually. The area is one of the important sites for bird diversity. The Kaligandaki valley is a migration corridor for birds moving south to winter in India. About 40 bird species have been recorded migrating along the valley, including Demoiselle Crane and nearly 20 raptors. In addition, larger numbers of birds of prey, thousands each autumn, most of which of Steppe Eagles, migrate west through the ACA just south of the main Himalayan chain (de Roder 1989). The upper region of the Kaligandaki Basin is characterized by high altitudes, low temperatures, and some glacier coverage. Permanent snow covers about 33% of the basin, while over 50% of this snow cover occurs above 5200 m (Mishra et al. 2014). The middle region of the basin is mostly hilly with high altitude terrain; the plains in the south have a sub-tropical climate and high precipitation. The study area covers two districts namely Myagdi and Mustang, along Kaligandaki river, Annapurna Conservation Area. An elevational gradient from 800 m (Beni) to 3800 m (Muktinath) was surveyed for bird observation. The area has not been explored for avian fauna regarding elevation gradient, patterns and processes of diversity. Thus, the area has been chosen to uncover pattern of avian diversity along part of Kaligandaki River Basin, western Nepal.

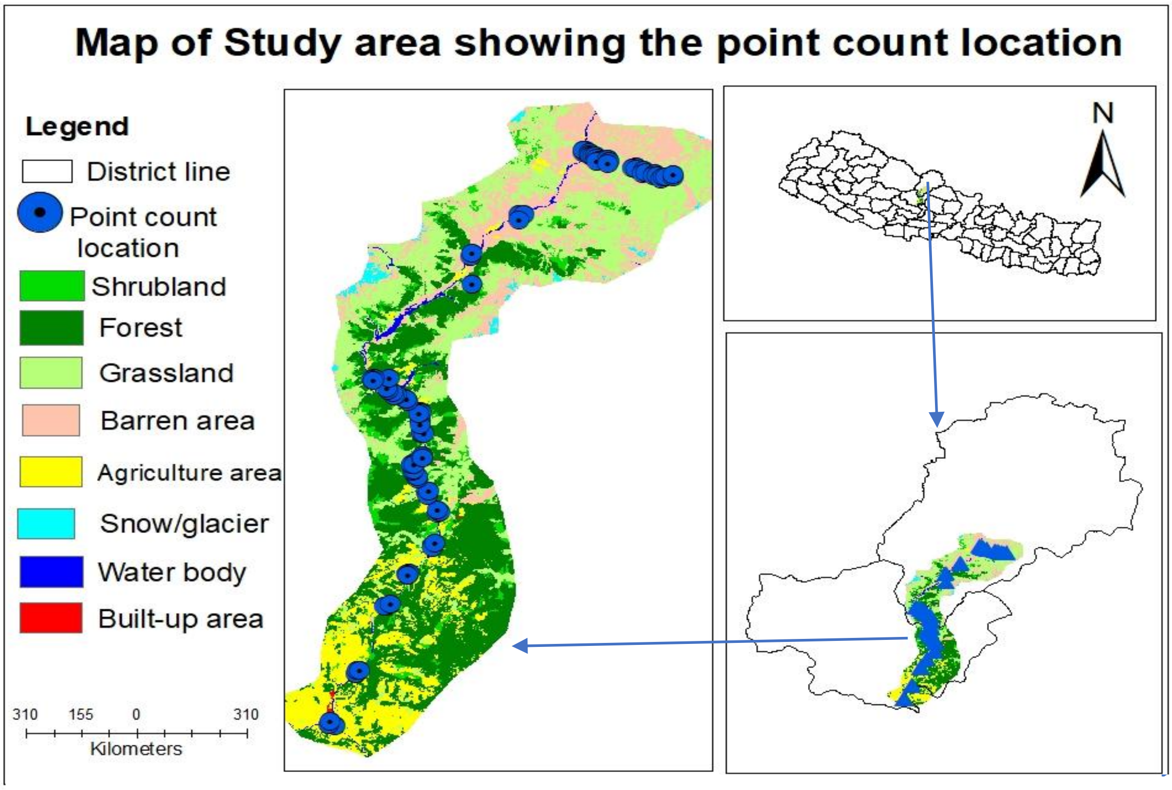


Figure 1: Map showing study area with point count locations

3.2 Materials

- GPS (Garmin eTrex® 10)
- Camera (Nikon D5300)
- Binocular (12×42 Kylietech)
- Measuring tape
- Field stationary
- Field guide book, Birds of Nepal (Grimett et al. 2016)

3.3 Data collection

3.3.1 Birds survey

3.3.1.2 Point count method

Point count method was used to count the number of birds in the study area. This method is used to estimate population densities, defining population trends, assessing habitat preferences, mostly in avian fauna. This method is undertaken from a fixed location for a fixed time and can be conducted at any time of the year (Sutherland 2006). Point count occurs at intervals along the route and for a given duration at each point.

The plots were set up with every 100 meters rise in elevation, which was recorded using GPS. Three fixed-point count plots or the replicates were set up at every sampling site along the elevational gradient. Birds were recorded from 800 m to an elevation of 3800 m within two districts of Annapurna Conservation Area, Myagdi and Mustang along Kaligandaki river basin. A total of 90 sampling replicates were set up within 30 elevational points within the study area. At each plot, birds were recorded within a circle of 30 m radius from the fixed point in a center, for 15 minutes. The birds were observed directly using binoculars and photographs were taken whenever possible. For the identification of birds, field book, Birds of Nepal (Grimmett et al. 2016) was used. The birds were observed in the plot during the active time period of 6 am to 11 am in the morning and 3pm to 5pm in the evening. Data were collected in two seasons, winter (January and February), 2019 and summer (May and June).

3.3.1.3 Call count method

This approach is used for recording birds, which are difficult to see or capture in their preferred habitat. Those species which are shy and cryptic can be rarely observed even in the open habitat. Similarly, in the dense habitat it is impossible to observe the birds in distance. Thus, call count method is the approach of listening the sound and noise produced by the birds and recording them. Thus, in the present study call count method was also employed for the identification of some birds that clearly produced sound and are familiar to the researcher.

3.3.2 Environmental variables

Habitats were categorized into seven types in ninety different point count sampling sites as forests, riverbanks, agricultural area, shrubland, grassland, scrubland and barren area. As a proxy of resources availability for species richness and diversity, number of fruiting trees were counted within the circular plot of 30 m radius.

3.3.3 Disturbance variable

Another predictor variable, distance to road was taken as a proxy of human disturbance within the study area. Distance to nearest road for each sampling points were estimated in the field and confirmed by Google Earth.

3.3.4 Feeding guild classification

Feeding guild were assessed by reviewing field guide book 'Birds of Nepal' (Grimmett et al. 2016) and categorized into five types on the basis of food as insectivores (feeding predominantly on insects, larva, worms, spiders, crustaceans, mollusks etc.), omnivores (feeding on both plants and animals), frugivores (feeding on fruits, berries, figs and drupes and nectars), carnivore (feeding on fishes, amphibians, reptiles, birds and mammals), granivore (feeding on seeds, grains, acorns).

3.4 Data Analysis

All the collected data from the survey of field were first entered in excel data sheet and then analyzed by using different statistical tools.

3.4.1 Shannon-Wiener Diversity Index

Biodiversity index(H') was calculated by using Shannon and Wiener Function. Shannon-Wiener Index assumes that individuals are randomly sampled from an independent large population and all the species are represented in the sample. It is very usually used for comparing diversity between various habitats and between different time periods. Shannon-Wiener diversity index was used to find the alpha (α) diversity of bird species of the study area across seasons and across point stations. It is calculated as,

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

Where, Σ represents 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)

3.4.2 Species Richness and Evenness index

When the complexity of the habitat increases, species diversity also increases. This species diversity considers both the species richness and species evenness.

Species Richness simply gives the presence of total number of species at a particular area. And it is simply calculated as, S= total number of species recorded. Where, S= Species Richness

Evenness is a measure of the relative abundance of different species making up the richness of an area. This evenness is an important component of diversity indices and expresses even distribution of the individuals among different species. Thus, to calculate whether the species are evenly distributed among the different point count stations and among the different seasons, Evenness index was used. 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.

3.4.3 Abundance

Abundance was calculated by using following formula,

Abundance= Frequency of occurrence of species in each plot.

3.4.4 Sorenson Similarity Index

Sorenson's similarity index was used to find the beta diversity of birds which represents the unshared species, by finding the similarity between bird species composition across seasons. As Sorenson similarity index can be used for both qualitative and quantitative data, here this index was used for the qualitative data (presence/absence). Sorenson's Index of similarity was calculated as;

SSI= 2C/ (A+B) *100 %

Where,

SSI is the similarity index and the value ranges from 0 to 100 in percent. Value of '0 %' refers for the no similarity between the communities/seasons whereas value of '100 %' refers for the complete similarity between communities/seasons. Value near to 100 percent represents more similarity whereas value near to zero percent represents less similarity between the communities/seasons.

C= Common number of species shared by two community (two seasons)

A= Number of species found in one community (one season)

B= Number of species found in another community (another season)

3.4.5 Analysis of Variance

One-way ANOVA was used to find out whether there is significant variation in species richness of birds in two seasons among point count stations. The following null hypothesis was assumed.

H_0= There is no significant variation in species richness of birds between summer and winter seasons.

3.4.6 Generalized Linear Model

Generalized linear model was used to assess how the bird species richness and diversity changes along the elevation gradient as well as to assess the influence of resource availability (number of fruiting trees) and human disturbance (distance to road) on species diversity and richness. A total of 90 data points, three points in each 100 m elevation band ranging between 800 m and 3800 m were surveyed. Each data point consists of 30 m radius and response variable (species richness and diversity) was calculated at this scale. Predictor variables for this analysis included elevation (measured in msl at the centroid of 30 m circular radius), resource availability (number of fruiting tree within 30m radius) and human disturbance (distance from nearest road). Since species richness was count data, plausible Generalized Linear Models (GLMs) with Poisson error distribution and log link function was run. To assess influence of predictor variables on species diversity, multiple linear regression was used since the response variable was continuous. Six priori set of models, including the null model were defined. The models were then ranked using the Akaike Information Criterion adjusted for small samples (AICc) (Burnham and Anderson 2002). The beta-coefficient (slope) of covariates was examined to test the significance of their effect on response variable (species richness and species diversity). Confidence intervals that included zero indicated no significant effect of the predictor variables on response variables. All analyses were carried out in R 3.1.2 (R Core Team, 2016).

3.4.7 Canonical Correspondence Analysis

Canonical correspondence analysis (CCA) was used to illustrate the species response to different environment variables (habitat types) in Kaligandaki river basin. The significance of the predictors was tested by using a Monte Carlo permutation test in CANOCO 4.52 with 499 permutations.

4. RESULTS

4.1 Species Richness, Diversity and Abundance

A total of 1,036 individuals of 120 bird species from 33 families of 8 orders were recorded by point count method during the study period in Kaligandaki River basin (Annex I). Out of 8 orders, order Passeriformes had the highest species richness (98 species, 25 families), followed by the order Piciformes (seven species from two families), Columbiformes (five species from one families), Cuculiformes and Accipitriformes (three species each from two families), Galliformes (two species form one family), Ciconiformes and Falconiformes has single species in each family (Figure 2). Among 33 families recorded, family Muscicapidae has the highest number of bird species (17 species), followed by Sylviidae (11 species), Corvidae(Nine species), Fringillidae (Seven species), Motacillidae and Nectarinidae (six species), Turdidae, Paridae and Columbidae (Five species), Picidae (Four species) whereas, Cuculidae, Accipitridae, Dicruridae, Sittidae, Pycnonotidae, Passeridae and Megalaimidae were represented by equal number of species (Three species). Similarly, two species were observed each from five families (Camphephagidae, Cisticolidae, Phasianidae, Rhiphiduridae and Timallidae), whereas single species was recorded each from nine families (Aegithalidae, Certhiidae, Cinclidae, Emberizidae, Falconidae, Hirundidae, Scolopacidae, Sturdinae, Zosteropidae) (Figure 3).

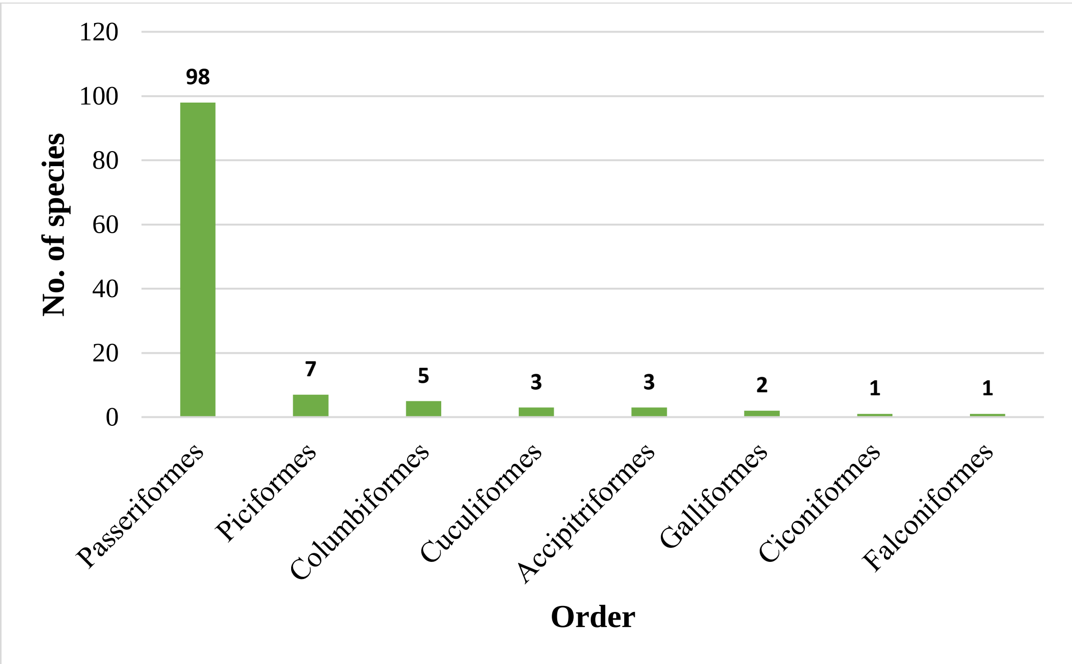


Figure 2: Number of bird species in different orders.

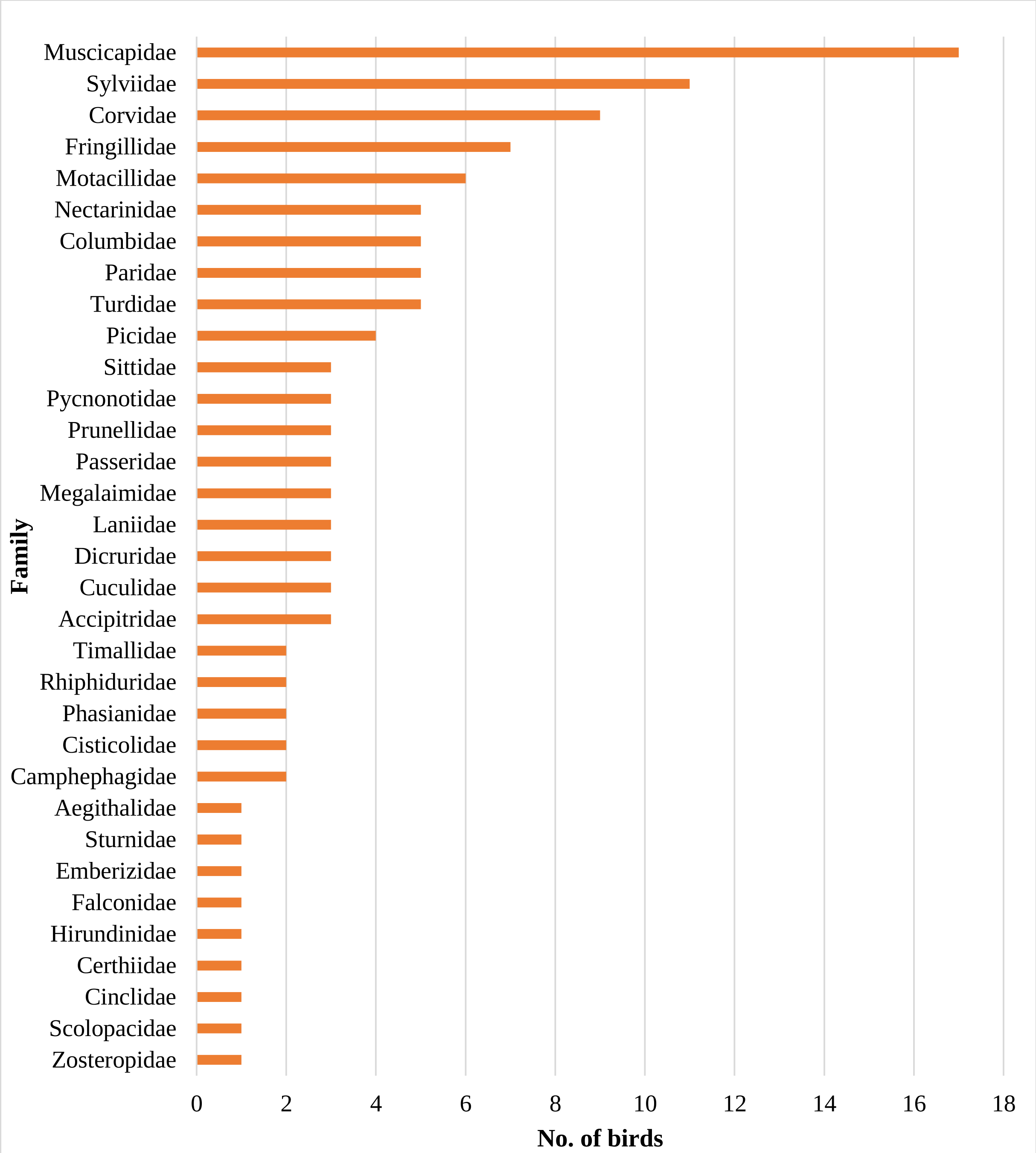


Figure 3: Number of bird species in different families

Analysis of data on food guild structure of birds of Kaligandaki River basin revealed that half of the total bird species were insectivores (60 species, 50%) followed by omnivores (31 species, 25.84%), frugivores (14 species, 11.67%) and granivores (eight species, 6.67%). Carnivores were recorded to have the least species richness of seven species (5.84%) (Figure 4).

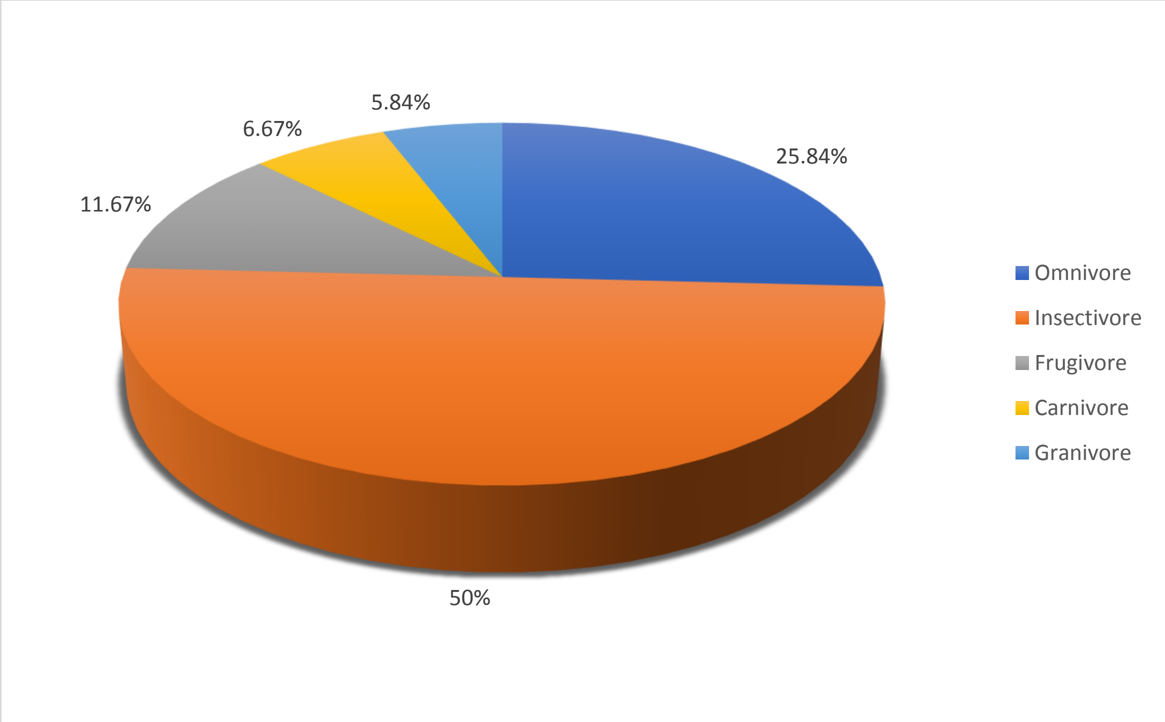


Figure 4. Species richness in different feeding guilds.

Based on point count survey of birds in different sampling sites in Kaligandaki River basin, Large-billed crow (*Corvus macrorhynchos*) (Fq=40), followed by Black Bulbul (*Hypsipetes leucocephalus*), Ashy Drongo (*Dicrurus leucophaeus*) and Grey-hooded Warbler (*Phylloscopus xanthoschistos*) (Fq= 23.34), Long-tailed Shrike (*Lanius schach*) and Eurasian tree Sparrow (*Passer montanus*) (Fq= 22.23), Blue Whistling Thrush (*Myophonus caeruleus*) (Fq= 21.12), Green-backed Tit (*Parus monticolus*) (Fq= 16.67), Great Barbet (*Megalaima virens*) (Fq= 15.56), Oriental turtle Dove (*Streptopelia orientalis*) and Plumbeous water Redstart (*Rhyacornis fuliginosa*) (Fq= 14.45), House Sparrow (*Passer domesticus*) (12.23), Red-vented Bulbul (*Pycnonotus cafer*) and Black-lored Tit *(Parus xanthogenys*) (Fq= 11.12) and Black Drongo (*Dicrurus macrocercus*) (Fq= 8.89) were the most frequently observed bird species (Figure 5).

However, the population of Black Bulbul (*Hypsipetes leucocephalus)* (57 individuals) was the highest followed by Himalayan Bulbul (*Pycnonotus leucogenys*) (49 individuals), Eurasian tree Sparrow (*Passer montanus*) (47 individuals), Grey hooded Warbler (*Phylloscopus xanthoschistos)* (39 individuals), Green-backed tit (*Parus monticolus)* (34 individuals) and Blue whistling Thrush (*Myophonus caeruleus)* (35 individuals) (Figure 6, Appendix 1). Among the total species recorded, species like Hume's leaf Warbler (*Phylloscopus humei*), Himalayan Bluetail, Greenish Warbler (*Phylloscopus trochiloides*), Green Sandpiper (*Tringa ochropus*), Fire-breasted Flowerpecker (*Dicaeum cruentatum*), Brown-throated Tree creeper (*Certhia discolor*) etc. were observed very less during study period with single individual.

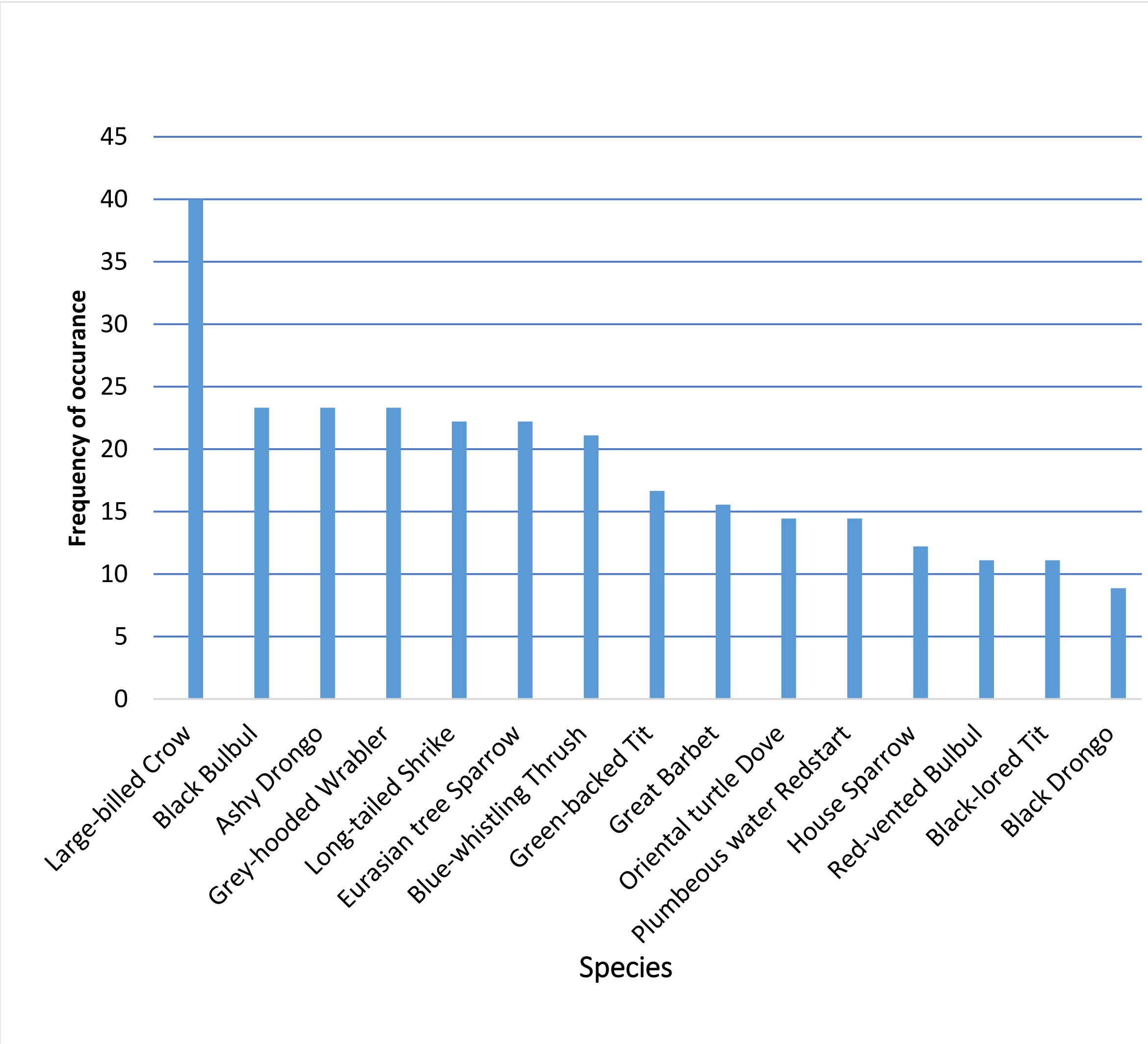


Figure 5. Most frequently observed species of birds in the study area

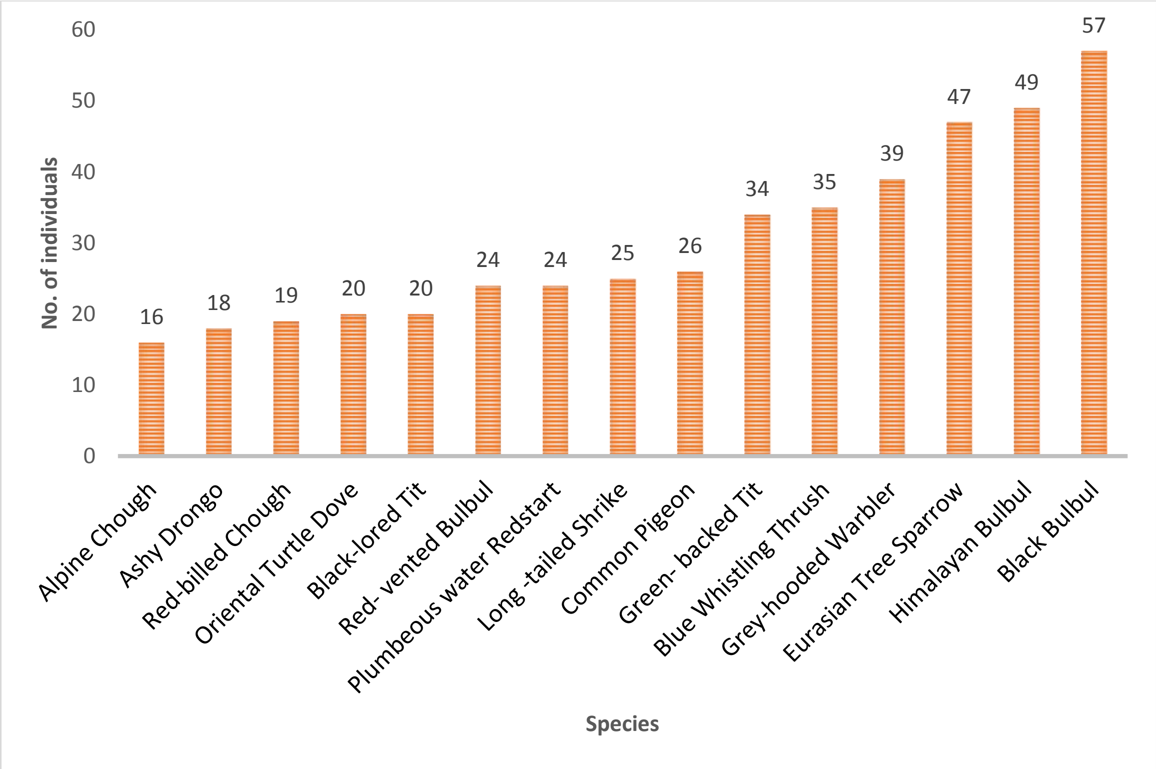


Figure 6. Most populated birds in the study area.

The overall diversity index (H) was 4.134 and the evenness index (e) was 0.5205 which indicates that Kaligandaki river basin is rich in bird diversity (Shannon and Weaver, 1949).

4.2 Seasonal variation

4.2.1 Variation in species richness and diversity

A total of 459 individuals of 81 species of seven orders belonging to 27 families were recorded from point count locations in winter season and 577 individuals of 95 species of six orders belonging to 29 families were recorded from summer season. Fifty-six species of birds were found in both summer and winter season (Table 1).

Shannon Wiener diversity index (H') for winter season (January and February) was H'=3.93 whereas the summer season (May and June) had the diversity index of H'=4.006 indicating slightly diverse bird assemblage in summer season in comparison to winter season. The evenness index was found to be higher in winter (e=0.6287) than in summer season (e=0.5784) and late monsoon season. Thus, evenness index revealed that birds were slightly more evenly distributed in winter season than in summer season (Table 1).

Table 1: Status of birds in two seasons.

Seasons	Orders	Families	Species richness	Common species	Number of individuals	Shannon's Index(H')	Evenness Index(E)
Summer	6	29	95	56	577	4.006	0.5784
Winter	7	27	81		459	3.93	0.6287

Sorenson's similarity index (SSI) of species composition was observed to be 63% between summer and winter season which showed that bird communities were more similar in these two different seasons.

Also, it was found that for species richness in two different seasons, the critical (tabulated) value of F (v_1=1, v_2=175) degree of freedom at 5% level of significance is 3.89. Since the calculated value of the test statistics F= 0.487241 is less than the tabulated value (Table 2) and (P= 0.486071> 0.05), null hypothesis is accepted i.e., there is no any significant variation in species richness of birds between two seasons in different point count locations.

Table 2: ANOVA Table between species richness of birds in two different seasons.

Source of Variation	**D*f***	**SS**	**MSS**	**P-value**	**F Statistics**	**F Critical**
Between Seasons	1	2.688889	2.688889	0.486071	0.487241	3.89
Within Seasons	175	982.3111	5.518602			
Total	176	985				

Similarly, for abundance of birds, the ANOVA table showed the critical (tabulated) value of F (v_1=1, v_2=175) degree of freedom at 5% level of significance is 3.89. Since the calculated value of the test statistics F= 2.903787 is less than the tabulated value (Table 3) and (P= 0.090117> 0.05), null hypothesis is accepted i.e., there is no any significant variation in abundance of birds between two seasons in different point count locations

Table 3: ANOVA Table between abundance of birds in two different seasons.

Source of Variation	***Df***	**SS**	**MSS**	**P-value**	**F Statistics**	**F Critical**
Between Seasons	1	54.45	54.45	0.090117	2.903787	3.89
Within Seasons	175	3357.74	18.75137			
Total	176	3392.1945				

4.2.2 Variation in community structure

Analysis of bird data on residential status revealed that out of 120 species recorded from the study area, 86 species (71.67%) were resident, 18 (15%) were summer visitors and 16 (13.34%) were winter visitors (Figure 7).

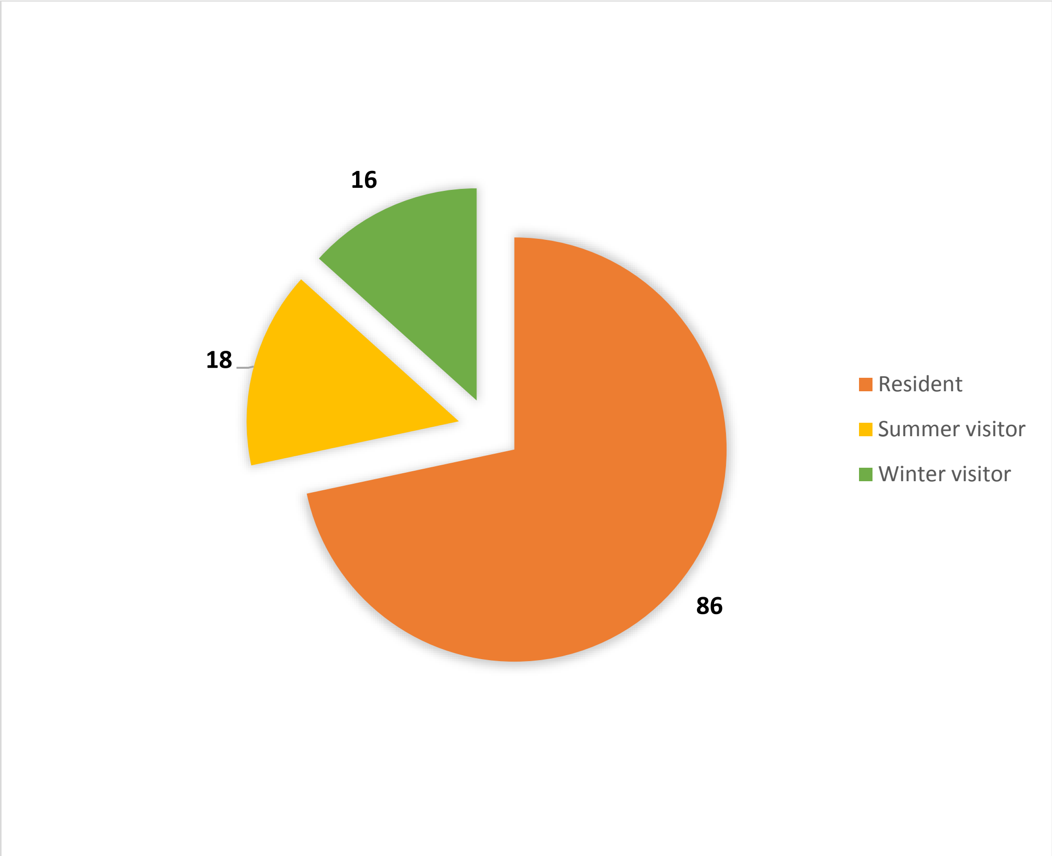


Figure 7. Residential status of birds of the study area.

4.3 Factors affecting bird diversity

The model selection results showed that elevation consistently had negative influence on species richness and diversity, as the elevation increased the species richness decreased significantly (Figure 8). Both species richness and diversity were positively associated with number of fruiting trees as a proxy of resource availability (Figure 9). Distance to road as a predictor of human disturbance also had negative influence on species richness and diversity (Figure 10). As the distance to road increased, the species richness decreased significantly and vice versa. The beta-coefficient or slope of elevation was ($\beta_{elevation}$ = -0.48 (SE=0.05)) and distance to road was ($\beta_{distance\ to\ road}$ = -0.22 (SE=0.05)). The slope estimates of number fruiting tree for species richness analysis was ($\beta_{fruiting\ trees}$ = 0.14 (SE=0.002)). Since the 95 % confidence interval of the beta-coefficients didn't overlapped with zero, the effects of these variables are significant.

For both species' richness and diversity analysis, AIC based model selection showed that the elevation model as the most plausible model in candidate model set (Table 3 and 4). Since the elevation model has the least AIC, it is the best model to describe variation in species richness and diversity in the candidate model set.

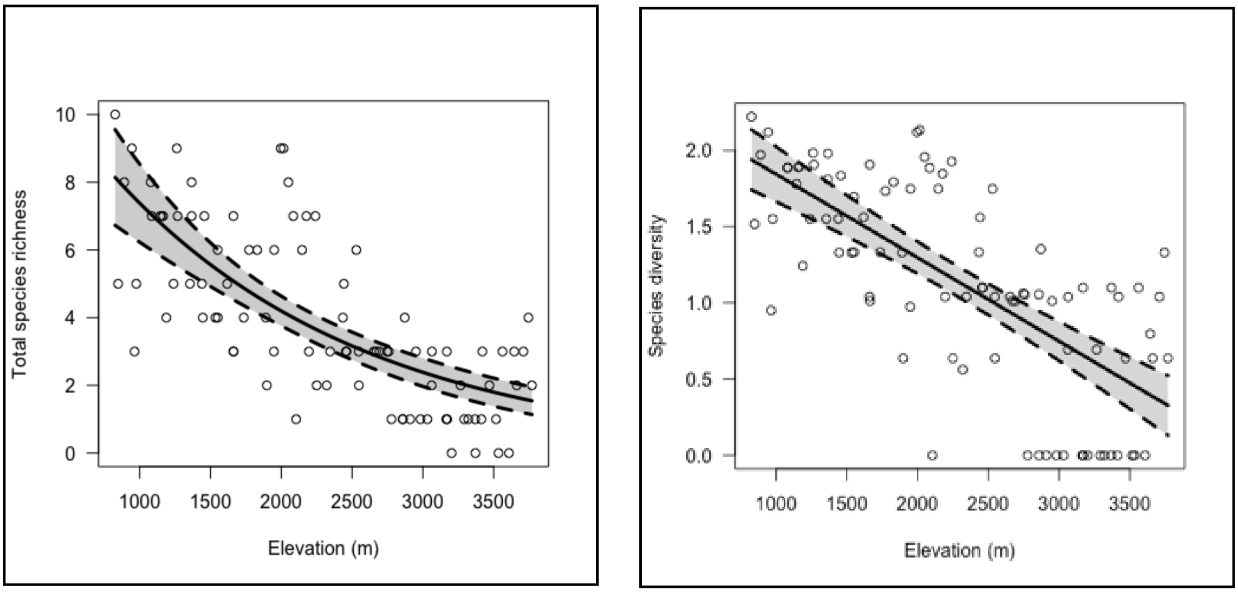


Figure 8. Relationship between bird species richness/ diversity and elevation along an elevation gradient in Kaligandaki river basin.

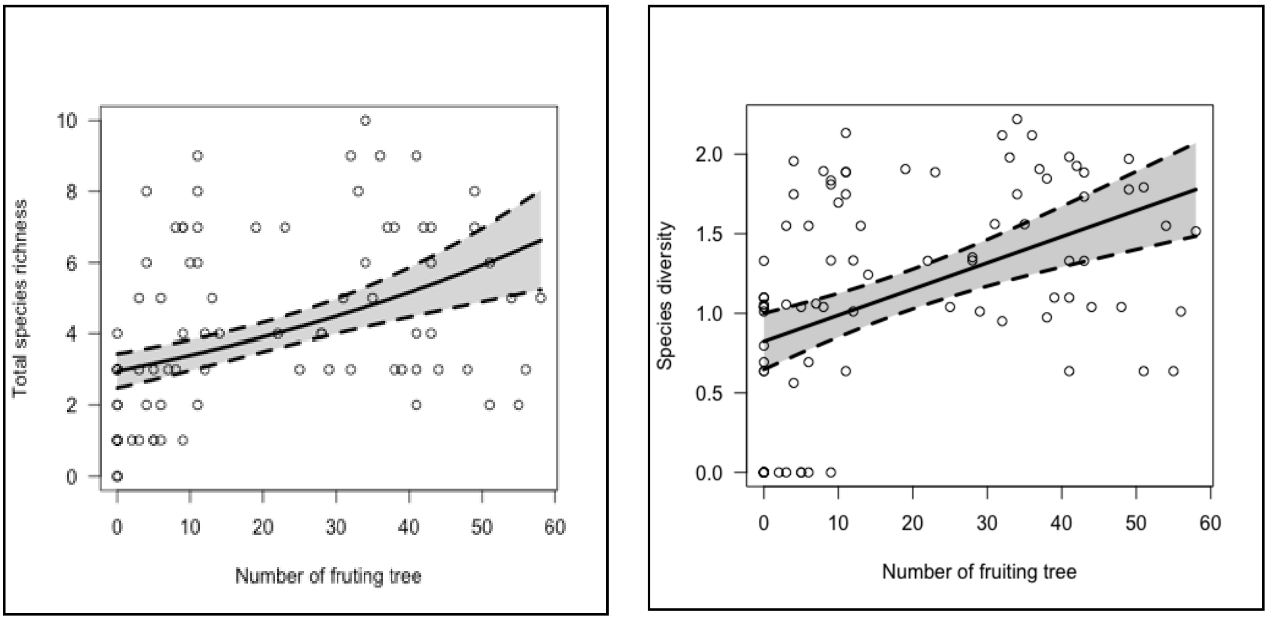


Figure 9. Relationship between bird species richness/ diversity and number of fruiting trees along an elevation gradient in Kaligandaki river basin.

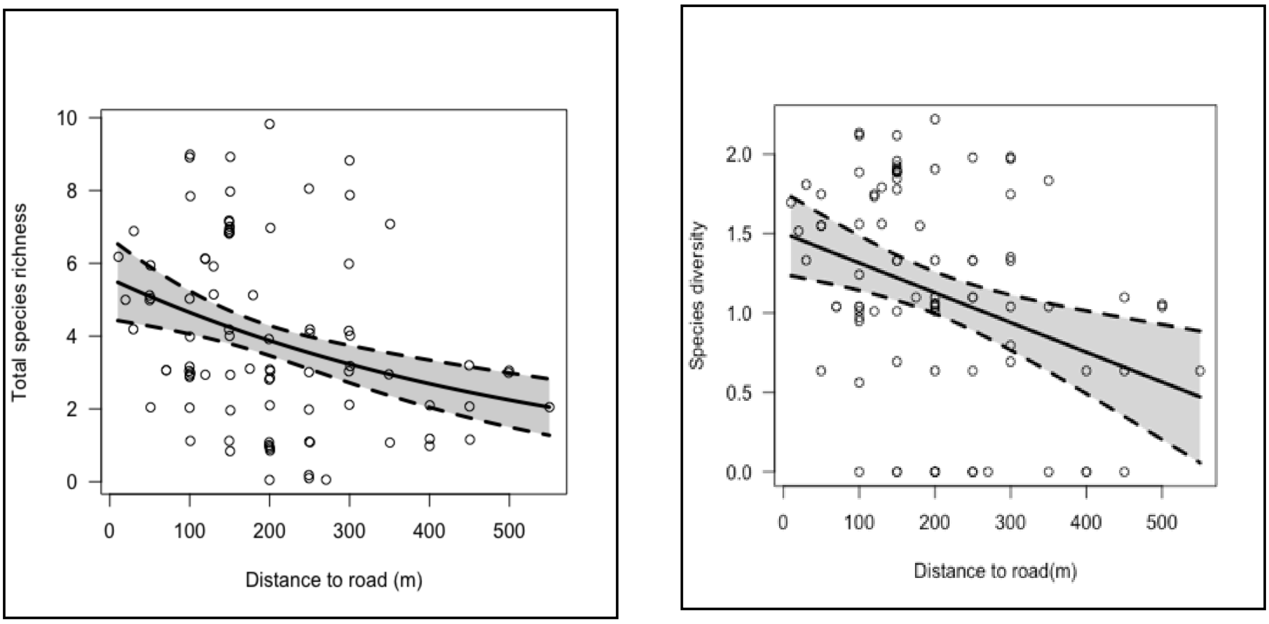


Figure 10. Relationship between bird species richness/ diversity and distance to road along an elevation gradient in Kaligandaki river basin.

Table 4: Poisson regression models describing the bird species richness along the elevational gradient in Kaligandaki river basin, ranked according to the Akaike Information Criterion adjusted for small sample size (AICc).

Model	AICc	delta	Weight	logLik	Df
Elevation	351.58	0.00	0.46	-173.72	2
Elevation+Distance to road	352.63	1.05	0.27	-173.17	3
Elevation+No. of fruiting trees	353.56	1.98	0.17	-173.64	3
Elevation+No. of fruiting trees+Distance to road	354.65	3.07	0.10	-173.09	4
No. of fruiting trees+Distance to road	402.02	50.44	0.00	-197.87	3
No. of fruiting trees	404.69	53.11	0.00	-200.28	2
Distance to road	415.80	64.22	0.00	-205.83	2
Intercept only	428.13	76.55	0.00	-213.04	1

Table 5: Multiple linear regression models describing the bird species diversity along the elevational gradient in Kaligandaki river basin, ranked according to the Akaike Information Criterion adjusted for small sample size (AICc).

Model	AICc	delta	weight	Df	logLik
Elevation	127.95	0.00	0.42	3.00	-60.84
Elevation+Distance to road	128.85	0.89	0.27	4.00	-60.19
Elevation+No. of fruiting trees	129.62	1.67	0.18	4.00	-60.58
Elevation+No. of fruiting trees+Distance to road	130.50	2.55	0.12	5.00	-59.89
No. of fruiting trees+Distance to road	167.01	39.06	0.00	4.00	-79.27
No. of fruiting trees	168.60	40.65	0.00	3.00	-81.16
Distance to road	179.09	51.14	0.00	3.00	-86.41
Intercept only	187.30	59.35	0.00	2.00	-91.58

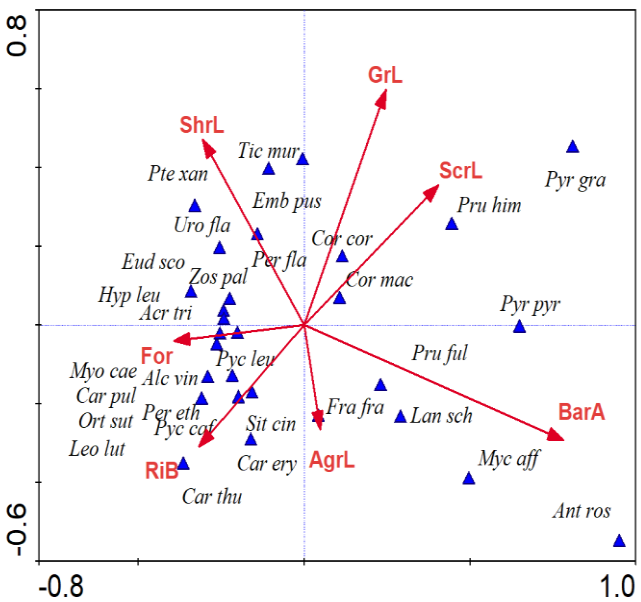
The habitat variables that were selected to find the relationship between environmental variables and species were Forest habitat, Riverbank, Agricultural area, Shrubland, Grassland, Scrubland and Barren area. The upright triangles in graph represent the species while the arrows represent selected environmental variables. The environmental variables with long arrowhead had more impact on species distribution. The angle between an arrow and each axis represents the degree of correlation with that axis. The species that were closest or nearer to the arrow were strongly affected by the factor and the species that were far away were less influenced. The distance between the points reflects the degree of association between different species within same quadrat. If in a quadrat, at the same point, multiple species were present than it means that they had same abundance value and influenced by particular factor in same way.

For omnivores, the Monte-Carlo permutation test of significance of all canonical axes showed a significant relationship between the species and habitat variables. Species like Oriental white eye (*Zosterops palpebrosos*), Black Bulbul (*Hypsipetes leucocephalus*), Asian Koel (*Eudynamys scolopacea*), Scarlet Minivet (*Pericrocotus flammens*), Yellow-billed Blue Magpie (*Urocissa flavirostris*), Green shrike Babbler (*Pteruthius xanthochlorus*) were associated with shrubland habitat. Similarly, bird species such as Common Tailor Bird *(Orthotomus sutorius*), Himalayan Bulbul (*Pycnonotus leucogenys*), Red-billed Leothrix (*Leothrix luteo*), Beautiful Rosefinch (*Carpodacus pulcherrimus*), White-browed Fulvetta (*Alcippe vinipectus*) etc showed significant association with forest habitats. Very few species in comparison to forest and shrubland habitats, showed association with other habitat variables such as scrubland, barren area and grassland habitat. However, these variables have strong impact on species distribution in terms of length of arrowhead. Species richness in response to agricultural land as a habitat variable revealed very weak association in Canonical Correspondence Analysis (Figure 11(a)).

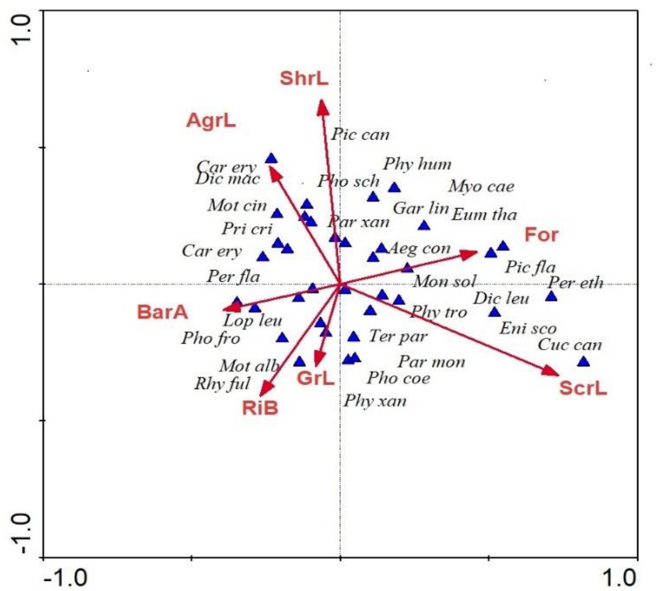
Species of insectivore feeding guild showed strong association with Shrubland and Scrubland habitat, whereas Grassland habitat showed less impact in the distribution of insectivore bird species. Most of the bird species were associated with forest habitat including Black-throated Tit (*Aegithalos concinnus*), Greater Yellownape (*Picus flavinucha*), Verditer Flycatcher (*Eumyias thalassinus*), Black-lored tit (*Parus* *xanthogenys*), Grey-headed Woodpecker (*Picus canus*), Streaked laughing Thrush (*Garrulax lineatus*) (Figure 11 (b)).

For frugivore species, Shrubland habitat followed by Riverbank and Grassland habitat had more significant impact on species distribution. Red-billed blue Magpie (*Urocissa erythrorhyncha*), Blue-throated Barbet (*Megalaima franklinii*), Grey treepie (*Dendrocitta formosae*), Black- throated Sunbird (*Aethopyga saturate*) showed strong association with shrubland habitat. Barbet species like Great Barbet (*Megalaima virens*) and Golden-throated Barbet (*Megalaima franklinii*) were associated with agricultural area. Similarly, species like White-winged Grosbeak (*Mycerobas carnipes*) and Crimson Sunbird (*Aethopyga siparaja*) were associated with forest habitat (Figure 11(c)).

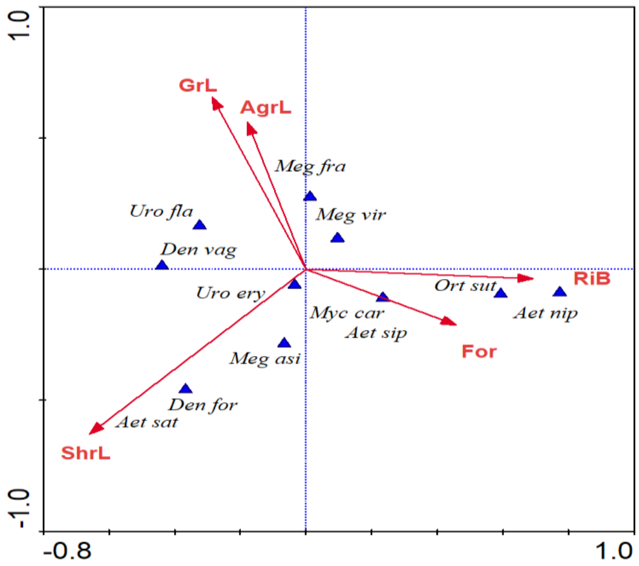
The significance of environmental variables for feeding guilds (Granivore, P-value=0.828) and Omnivore, P= 0.718) were not significant i.e. P>0.05. This may be because of least number of species recorded in these feeding guilds (Figure 11 (d) & (e)).



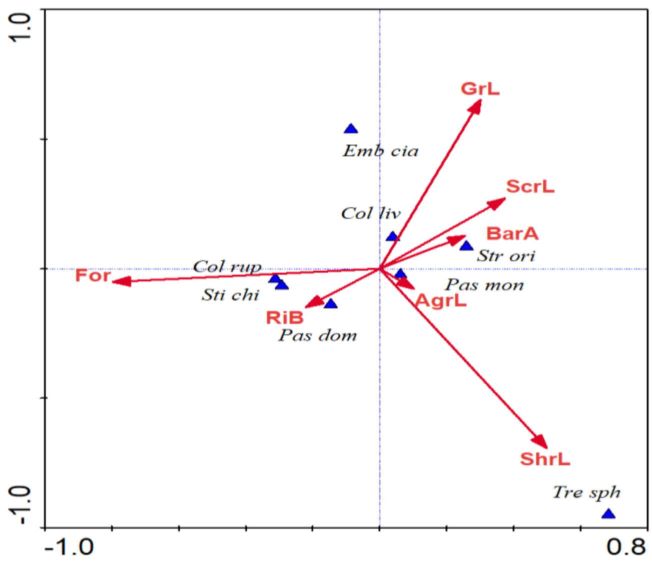
a) Omnivores response with habitat variables
Trace= 0.948
F-ratio= 1.351
P-value= 0.006



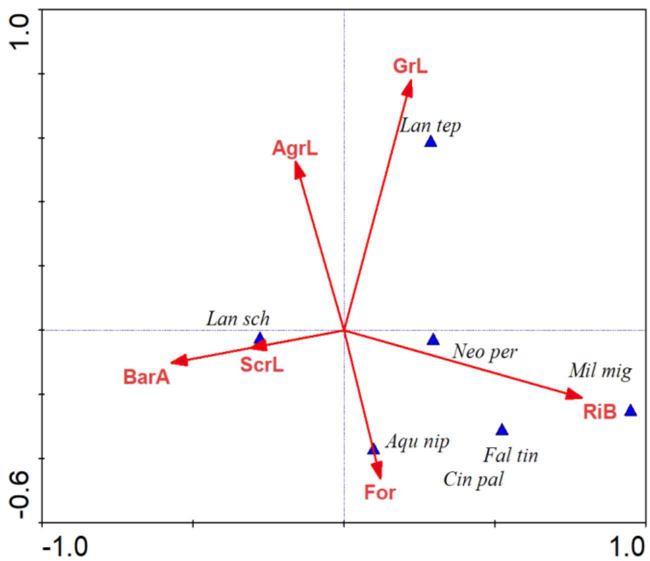
b) Insectivores response with habitat variables
Trace= 0.843
F-ratio= 1.351
P-value= 0.003



a) Frugivores response with habitat variables
Trace= 0.362
F-ratio= 0.125
P-value= 0.034



d) Granivores response with habitat variables
Trace= 0.459
F-ratio= 0.744
P-value= 0.828



e) Carnivores response with habitat variables
Trace= 0.459
F-ratio= 0.744
P-value= 0.828

Figure 11. CCA ordination diagram showing species response to different habitat types in the study area. (Monte Carlo permutation test of significance of all canonical with 499 permutations). (For= Forest habitat, RiB= River Bank, ShrL= Shrubland, GrL= Grassland, AgrL= Agricultural area, BarA= Barren area, ScrL=Scrubland). Triangle represents the species. Arrow indicates each of habitat variables plotted pointing in the direction of maximum change in the explanatory variables. Species code is given in Annex II.

5. DISCUSSION

5.1 Avian species richness, Abundance and Diversity along elevation

A total of 120 species of birds belonging to 8 orders and 33 families were recorded during the study period. Although bird surveys were carried out within short time period, higher species richness was found along the basin of Kaligandaki river in Myagdi and Mustang district, Annapurna Conservation Area. The high species richness might be attributed to diverse habitat types along an elevation gradient comprising riverine *Alnus nipalensis* forest, *Schima wallichi* forest, Mixed forest with *Tooni ciliata* and *Bombyx ceiba*, *Pinus roxburghii* forest, *Pinus wallichiana* forest, *Betula utilis* forest including agricultural land, human settlement area, shrubberies, grassland and scrublands. The study area covered an elevation range of 800 to 3800 m asl from sub-tropical to sub-alpine habitats for diverse avian fauna. At the lowest levels of the study area there were subtropical forests of broadleaved *Schima wallichii, Castanopsis indica, Pinus roxburghii* on dry slopes, as well as Alder *Alnus nepalensis,* which mainly occurred along rivers and streams. Higher up, these were replaced by temperate forests of mixed broadleaves and oaks *Quercus lamellosa, Q. lanata* and *Q. semecarpifolia* with rhododendron species. In the wettest places, in the upper grow bamboo jungles of *Arundinaria* species. Coniferous forests, mainly of fir *Abies spectabilis,* blue pine *Pinus wallichiana* and hemlock *Tsuga dumosa* grow on the dry ridges and slopes. Above the temperate zone lie the subalpine forests of birch *Betula utilis*, blue pine and juniper species. Finally, rhododendron and juniper scrub grow in the alpine zone (Inskipp and Inskipp 2003). Rivers and streams supported a good variety of birds' dependent on this habitat within the study area, notably Crested Kingfisher, four forktail species, Brown Dipper, White-capped Water Redstart and Plumbeous Water Redstart. The combination of highly varied topography, climate and wide altitudinal range has resulted in a large number of habitat types and associated rich bird species diversity within the study area. This study has been conducted only in two seasons, summer season and winter season hence there is more chance in increase in species richness of birds of this area which needs more detailed study in future, covering all seasons and more wide gradients.

5.2 Species richness and seasonal variation

Avian assemblages in any area or habitat types is not static and changes seasonally (Avery et al. 1989). Hence there might be changes in the number and species of birds with season due to changes in several microclimatic and environmental factors like temperature, humidity, rainfall, vegetation, food availability etc. Seasons have direct influence on the food availability and to avoid unfavorable environmental conditions bird migrate from north to south in winter season and for breeding most of birds arrive to Nepal in summer season. In this study there is slight difference in species richness of birds in between seasons, summer (95 species) and winter (81 species), however statistically the result showed no significant variation in species richness between two seasons. This variation may be due to climatic and biotic factors which varied in different seasons. Shoo et al. (2005) discussed that the temperature and climate change according to seasons ultimately affected the diversity and distribution of birds. The low species richness in winter may be accredited to the amount of energy available in a system, often measured as primary productivity, one of the prime determinant of species richness, which used to be lower in winter season (Bailey et al. 2004). In winter, food availability may be a particular constraint on birds diversity (Marra and Holberton 1998, Wang et al. 2013), because the food supply usually is at its lowest level (Moen 1976). A slightly smaller number of species in winter season in this study may be because of harsh climatic condition and snowfall up to 2000m in the study area during winter season which negatively affect richness and abundance. Aryal (2013) also found less species during winter season in Ghunsa valley of Kanchanjunga Conservation Area because the landscapes above 3000m were covered by snow in winter season and less species were recorded due to inaccessibility. However, Cueto and Casenave (2000) stated that only the bird density would vary but the richness of species remained unchanged throughout all seasons.

Another reason for low number of species recorded in winter may be because of a smaller number of winter migrants in the study area. Of total species recorded in Nepal, around 650 species are resident, more than 150 species are winter visitors and more than 60 are summer visitors (Grimmett et al. 2016). Higher number of species are altitudinal migrants in Nepal; they migrate from lower altitudes to higher in summer and vice versa in winter. So, this might have accentuated the higher species richness of birds in summer season in the study area, primarily due to altitudinal migrants. In contrast to these findings study on avian fauna in different parts of Nepal by Thapa and Saud (2013), Thakuri (2009 & 2011), Giri and Chalise (2008), Kafle (2005) found biodiversity index higher in winter than in summer. Katuwal et al. (2016) also revealed that species richness significantly increased from pre-monsoon to the monsoon and post-monsoon seasons signifying that the precipitation regime driven by monsoon has a robust impact on the seasonal distribution and species richness of birds in this part of the Central Himalayas. The seasonal changes in bird species richness can therefore be taken largely as a response to a resource bottleneck for food during the pre-monsoon season and winter followed by improved and better food availability in the monsoon and post-monsoon seasons.

As a result of one-way Anova and Sorenson's similarity index there is no significant variation in species richness and most of the species are similar between summer and winter season. This may be because of the presence of more resident species within the study area common to both summer and winter seasons and very less summer and winter migrants.

5.3 Factors affecting bird species richness and diversity

The present study revealed that species richness of birds decreased monotonically with increasing elevation. The monotonic decline in species richness along the elevation gradient has been reported in several other taxa and regions (Rahbek 1995, 2005, Paterson et al. 1998). In contrast, a few studies in the Himalaya revealed high species richness at middle elevation than higher and lower elevations (Acharya et al. 2011, Joshi et al. 2012, Joshi and Rautela 2014, Joshi and Bhat 2015), although they found very little indication for the Mid-domain effect (MDE) (Acharya et al. 2011). Lack of mid-elevation peak in species richness indicates that geometric constraints have a relatively low impact on the bird species richness pattern in the western Himalaya. A significant decline of bird richness at the highest elevation, which even persevered when accounting for declines in bird abundance was observed in the present study. This result is in line with previous studies showing a decline of species richness along elevational gradients (McCain 2009), which has been attributed to limiting abiotic and biotic factors, such as harsh climatic conditions or reduced resource availability at high elevations, similar to the findings of this study. As the elevation increases, the vegetation types and land topography gradually change from lower sub-tropical to sub-alpine resulting less forest cover, low productivity scarce vegetation with scrubs and meadows which subsequently decreases species richness. However, the observed species richness was higher at the elevation of 850m and 2000m within the study area. At the elevation 850 m, the dense, well-structured sub-tropical forest of *Schima wallichii*, *Alnus nepalensis, Bombyx ceiba* and *Tooni ciliata* harbored high number of species. Similarly, the riverine area and cultivated land with human settlement at this elevation supported more avian fauna than in the higher altitudes. In general, richness peaks at intermediate elevations appear to correspond closely to transition zones between different vegetation types (Lomolino 2001) As moving upward at 2000m in and around the Ghasa forest, the transition zone between the sub-tropical forest and temperate forest predominately with *Pinus wallichiana* might have contributed richness peak seen in this region. The gradual decline of species richness above 2000m might suggest abrupt change in some factors or suite of factors that limit avian richness including poor vegetation and climatic condition. As moving upward with elevation, the stature of the forest decreased dramatically, and the climatic conditions became increasingly severe with heavy winds during summer and snowfall in winter. Such harsh and unproductive environment at higher altitudes cause decline in abundance and distribution of invertebrates' resources and scarcity of food items for birds and favors very small number of species (Blake and Loiselle 2000). Besides this, trees were replaced by bushes, shrubs and Rocky Mountains, which negatively affected the avian fauna in this region.

This study revealed that bird species richness and species diversity along elevation gradient showed positive correlation with number of fruiting trees taken as proxy of resource availability within the study area. Food availability is considered one of the most important factors limiting bird populations (Strong and Sherry 2000). As the number of fruiting trees increased, species richness was also higher illustrating positive impact of forest resources to avian diversity. This might be particularly case for frugivore species, and the reason why overall species richness is positively correlated with number of fruiting trees may be because frugivore species constitutes substantial pool of overall species richness. It is not the largest guild in term of species richness still there is positive correlation. This could be because fruiting trees with flowers, fruits and seeds attract number of insects and hence overall species richness increases. Increase in number of trees provides food resources, roosting and nesting sites to most of forest birds, which might be the possible reasons for positive association of species richness with tree numbers. The result shows similarity with other studies where resource availability influenced species richness. There was a significant relationship between bird species assemblages and tree species assemblages in the eastern forests of North America. The significant correlation between axes of separate DCA ordinations from bird data and tree data suggested that the change in bird species composition over a large spatial extent was correlated with a change in tree species composition (Lee and Rotenberry 2005). The distribution and abundance of many bird species are determined by the configuration and composition of the vegetation (trees species and number) that comprises a major element of their habitat (Morrison et al. 1992, Block and Brennan, 1993). As number of trees stands changes along geographical and environmental gradients, any particular bird species may appear, increase in abundance, decrease, and fade as habitat becomes more or less suitable for its existence. In farmland in central Uganda, richness of forest- dependent bird species showed a positive relationship with the number of native tree species (Douglas et al. 2014) similar to this study. Other studies also found forest cover as the most significant variable determining forest bird species richness (Pidgeon et al. 2007).

The impacts of roads on wildlife populations are extensive and well documented around the globe (Fahrig & Rytwinski 2009). Distance to road as a representation of disturbance variable with species richness and diversity was tested and strong negative correlation was found, revealing increase in species richness near road and vice versa. In the case of birds, many studies have shown contrasting findings of negative association that abundance, occurrence and species richness of birds is reduced near roads, with larger reductions near high-traffic roads than near lower traffic roads (Reijnen et al. 1995, Brotons and Herrando 2001, Fuller et al. 2001, Burton et al. 2002, Rheindt 2003, Peris and Pescador 2004, Pocock and Lawrence 2005, Palomino and Carrascal 2007, Griffith, Sauer and Royle 2010). Similar findings with road distance and species richness was discussed where empirical findings showed that there was a negative impact of roads and settlements on threatened birds of Chitwan National Park, Nepal (Adhikari et al. 2019). In accordance to the result of present study, it can be assumed that the main cause of the responses of birds near roads may due to low traffic and human presence within the study area and the open habitats near roads with less dense forest area as preferred by birds.

Canonical correspondence analysis showed that most of the feeding guilds including insectivores, omnivores and frugivores were associated with forest, shrubland and agricultural area. The observed bird species preferred forest habitat in comparison to other habitat types within the study area. Main reason for such preference could be available resources supplement by forest area in comparison other land use types. Forests provide the indispensable resources required for the accomplishment of life cycles of birds, including food for adults and nestlings and the nesting sites. Avian fauna occurs on several trophic heights in forests from primary consumers to vertebrate predators, as well as omnivores and scavengers. Birds get nutrients from nectar, fruits, seeds and vegetative tissues including roots, shoots and leaves. Birds that consume the vegetative parts of plants may also supplement their diet with other sources of protein such as invertebrates found in different strata in forest habitat, supporting insectivore species. These findings are supported by many studies that explained increased structural complexity of vegetation is associated with increased avian species richness (MacArthur and MacArthur 1961, MacArthur et al. 1962, Orians and Wittenberger 1991, MacArthur, et al. 1966). One degree of forest structure is foliage height diversity and is defined by the variation in the layers of a forest which positively supports species richness. Increasing foliage height diversity is associated with increasing avian diversity, particularly insectivores, (MacArthur and MacArthur 1961; MacArthur et al. 1962) with increasing foraging sites and increased niches available to exploit (MacArthur et al. 1966). In present study low number of species in scrubland and barren area in higher altitude (above 2600m) could be attributed to scarce vegetation and low productivity due to climatic constraints. Significant association of species with river bank area can be explained by the presence of aquatic avian fauna dwelling near and around streams and rivers such as Brown Dipper, Blue whistling Thrush, Plumbeous water Redstart, White-capped Redstart, Forktails, Wagtails etc. depending mostly on aquatic invertebrates in or under the water, river banks and riverine vegetation. Similar result was showed that the species richness of overall birds was positively correlated with forest habitat, productivity and habitat heterogeneity, indicating that the existing primary forest in the valley is important for avian conservation (Pan et al. 2016).

6. CONCLUSION AND RECOMMENDATIONS

Diversity of birds, seasonal variation and related factors were studied with an observation of a total of 1,036 individuals of 120 species belonging to eight orders and 33 families during study period. Order Passeriformes was found to be dominating order comprising of 98 species and Muscicapidae as a dominant family with 17 species. Overall diversity index showed that the area is highly diverse for avian fauna. Insectivores species richness was higher among feeding guilds. Resident bird species were recorded higher (86 species) in the study area. Shannon Wiener diversity index was found slightly higher in summer season with slightly higher species richness in comparison winter season. However, one-way ANOVA revealed that there is not any significant difference in species richness among seasons.

Species richness pattern along the elevation gradient in the study area revealed monotonic decline with elevation accredited to restrictive abiotic and biotic factors, such as harsh climatic conditions or reduced resource availability at high elevations. Analysis of the influence of resource availability (number of fruiting trees) and human disturbance (distance to road) on species diversity and richness showed that elevation and distance to road as a proxy of human disturbance consistently had negative influence on species richness and diversity, whereas both species richness and diversity were positively associated with number of fruiting trees as a proxy of resource availability. Forest habitat followed by shrubland and riverbank had strong effect on species distribution. The effect of habitat variables showed that comparatively less species was associated with grassland, scrubland and barren area at high altitudes and demonstrated weak effect of agricultural land on species richness on different feeding guilds.

The following are some of the recommendations drawn from the study which will be helpful in conservation of avian fauna within the study area.

1. Survey of birds in two seasons from present study showed highly diverse avian fauna, however, this study has not covered all the seasons. Therefore, extensive study covering all seasons is recommended in future to explore more avian species within the area.

2. Apart from developing checklists of birds, the patterns and processes affecting species and diversity of avian fauna in more wide gradients and habitat types in other parts of the conservation area, besides Kaligandaki River basin is highly recommended for future studies that will assist in further implication of conservation efforts.

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Annex I Bird list with scientific name, orders, family, feeding guilds and migratory status

Order, Family, Common Name	Scientific Name	Feeding Guilds	Migratory Status
GALLIFORMES			
Phasianidae			
Black Frankolin	*Francolinus francolinus*	Omnivore	Resident
Kalij Pheasant	*Lophura leucomelanos*	Insectivore	Resident
PICIFORMES			
Megalaimidae			
Blue-throated Barbet	*Megalaima asiatica*	Frugivore	Resident
Golden-throated Barbet	*Megalaima franklinii*	Frugivore	Resident
Great Barbet	*Megalaima virens*	Frugivore	Resident
Picidae			
Greater Yellownape	*Picus flavinucha*	Insectivore	Resident
Grey-headed Woodpecker	*Picus canus*	Insectivore	Resident
Fulvous- breasted Woodpecker	*Dendrocopos macei*	Insectivore	Resident
Speckled Piculet	*Picumnus innominatus*	Insectivore	Resident
CUCULIFORMES			
Cuculidae			
Eurasian Cuckoo	*Cuculus canorus*	Insectivore	Summer visitor
Lesser Cuckoo	*Cuculus poliocephalus*	Insectivore	Summer visitor
Asian Koel	*Eudynamys scolopacea*	Omnivore	Resident
COLUMBIFORMES			
Columbidae			
Common Pigeon	*Columba livia*	Granivore	Resident
Hill Pigeon	*Columba rupestris*	Granivore	Resident
Oriental Turtle Dove	*Streptopelia orientalis*	Granivore	Summer visitor
Spotted Dove	*Stigmatopelia chinensis*	Granivore	Resident
Wedge-tailed green Pigeon	*Treron sphenurus*	Granivore	Resident
CICONIFORMES			
Scolopacidae			
Green Sandpiper	*Tringa ochropus*	Insectivore	Winter visitor
ACCIPITRIFORMES			
Accipitridae			
Black Kite	*Milvus migrans*	Carnivore	Winter visitor
Steppe Eagle	*Aquila nipalensis*	Carnivore	Winter visitor
FALCONIFORMES			
Falconidae			
Common Kestrel	*Mycerobas affinis*	Carnivore	Winter visitor
PASSERIFORMES			
Prunellidae			
Alpine Accentor	*Prunella collaris*	Omnivore	Resident
Altai Accentor	*Prunella himalayana*	Omnivore	Winter visitor
Brown Accentor	*Phylloscopus reguloides*	Omnivore	Winter visitor
Corvidae			

Alpine Chough	*Pyrrhocorax graculus*	Omnivore	Resident
Grey -hooded Warbler	*Phylloscopus xanthoschistos*	Insectivore	Resident
House Crow	*Corvus splendens*	Omnivore	Resident
Large-billed Crow	*Corvus macrorhynchos*	Omnivore	Resident
Northern Raven	*Corvus corax*	Omnivore	Resident
Red-billed Blue Magpie	*Urocissa flavirostris*	Frugivore	Resident
Red-billed Chough	*Pyrrhocorax pyrrhocorax*	Omnivores	Resident
Rufous Treepie	*Dendrocitta vagabunda*	Frugivore	Resident
Yellow-billed Blue Magpie	*Urocissa flavirostris*	Frugivore	Resident
Dicruridae			
Ashy Drongo	*Dicrurus leucophaeus*	Insectivore	Summer visitor
Black Drongo	*Dicrurus macrocercus*	Insectivore	Resident
Spangled Drongo	*Dicrurus hottentottus*	Insectivore	Resident
Muscicapidae			
Asian Paradise Flycatcher	*Terpsiphone paradise*	Insectivore	Summer visitor
Blue-capped Redstart	*Phoenicurus coeruleocephala*	Insectivore	Winter visitor
Blue-capped Rock Thrush	*Monticola cinclorhynchus*	Insectivore	Summer visitor
Blue-fronted Redstart	*Phoenicurus frontalis*	Omnivore	Summer visitor
Common Stonechat	*Saxicola torquatus*	Insectivore	Resident
Grey Treepie	*Dendrocitta formosae*	Frugivore	Resident
Himalayan Bluetail	*Tarsiger rufilatus*	Insectivore	Resident
Hogdeson's redstart	*Phoenicurus hodgsoni*	Insectivore	Winter visitor
Little Forktail	*Enicurus scouleri*	Insectivore	Resident
Pied Bushchat	*Saxicola caprata*	Insectivore	Resident
Plumbous Water Redstart	*Rhyacornis fuliginosa*	Insectivore	Resident
Spotted Forktail	*Enicurus maculatus*	Insectivore	Resident
Verditer Flycatcher	*Eumyias thalassinus*	Insectivore	Summer visitor
White- capped Redstart	*Chaimarrornis leucocephalus*	Insectivore	Resident
White-browed BushRobin	*Tarsiger indicus*	Insectivore	Resident
White-tailed Rubythroat	*Luscinia pectoralis*	Insectivore	Resident
White-throated Redstart	*Phoenicurus schisticeps*	Insectivore	Winter visitor
Hirundinidae			
Barn Shallow	*Hirundo rustica*	Insectivore	Resident
Fringillidae			
Beautiful Rosefinch	*Carpodacus pulcherrimus*	Omnivore	Summer visitor
Collared Grosbeak	*Peripatus ater*	Omnivore	Resident
Common Rosefinch	*Carpodacus erythrinus*	Omnivore	Summer visitor
Little Bunting	*Emberiza pussila*	Omnivore	Winter visitor
Spot-winged Grosbeak	*Mycerobas melanozanthos*	Frugivore	Resident
White-browed Rosefinch	*Carpodacus thura*	Omnivore	Summer visitor
White-winged Grosbeak	*Mycerobas carnipes*	Frugivore	Resident
Black Bulbul	*Hypsipetes leucocephalus*	Omnivore	Resident
Himalayan Bulbul	*Pycnonotus leucogenys*	Omnivore	Resident

Red-vented Bulbul	*Pycnonotus cafer*	Omnivore	Resident
Timallidae			
Black chinned Babbler	*Stachyris pyrrhops*	Insectivore	Resident
Green-shrike Babbler	*Pteruthius xanthocholrus*	Omnivore	Resident
Paridae			
Black-lored Tit	*Parus xanthogenys*	Insectivore	Resident
Black-throated Tit	*Aegithalos concinnus*	Insectivore	Resident
Coal Tit	*Sitta cinnamoventris*	Insectivore	Resident
Great Tit	*Parus major*	Insectivore	Resident
Green-backed Tit	*Parus monticolus*	Insectivore	Resident
Nectarinidae			
Black-throated Sunbird	*Aethopyga saturate*	Frugivore	Resident
Crimson Sunbird	*Aethopyga siparaja*	Frugivore	Resident
Fire-breasted Flowerpecker	*Dicaeum cruentatum*	Frugivore	Resident
Green-tailed Sunbird	*Aethopyga nipalensis*	Frugivore	Resident
Purple Sunbird	*Nectarinia asiatica*	Frugivore	Resident
Turdidae			
White-throated Laughing Thrush	*Garrulax albogularis*	Insectivore	Resident
Blue Rock Thrush	*Monticola solitarius*	Insectivore	Summer visitor
Blue Whistling Thrush	*Myophonus caeruleus*	Omnivore	Resident
Oriental Magpie Robin	*Copsychus saularis*	Insectivore	Resident
Streaked Laughing Thrush	*Garrulax lineatus*	Insectivore	Resident
Sylviidae			
Blyth's leaf Warbler	*Phylloscopus reguloides*	Insectivore	Resident
Greenish Warbler	*Phylloscopus trochiloides*	Insectivore	Resident
Grey Bushchat	*Saxicola ferreus*	Insectivore	Resident
Hume's Leaf Warbler	*Phylloscopus humei*	Insectivore	Summer visitor
Lemon rumped Warbler	*Phylloscopus chloronotus*	Insectivore	Winter visitor
Red-billed Leothrinx	*Leothrix lutea*	Omnivore	Resident
Rufous Sibia	*Malacias capistratus*	Omnivore	Resident
Stripe-throated Yuhina	*Yuhina gularis*	Omnivore	Resident
White browed Fulvetta	*Alcippe vinipectus*	Omnivore	Resident
Yellow-browed Warbler	*Phylloscoppus inornatus*	Insectivore	Winter visitor
Cinclidae			
Brown Dipper	*Prunella fulvescens*	Insectivore	Resident
Laniidae			
Brown Shrike	*Cinclus pallasii*	Carnivore	Winter visitor
Grey-backed Shrike	*Lanius tephronotus*	Carnivore	Summer visitor
Long-tailed Shrike	*Lanius schach*	Carnivore	Resident
Certhiidae			
Brown-throated Treecreeper	*Lanius cristatus*	Insectivore	Resident
Sittidae			
Chestnut-bellied Nuthatch	*Certhia discolor*	Omnivore	Resident
Sturnidae			
Common Myna	*Falco tinnunculus*	Cmnivore	Resident

Cisticilidae			
Common Tailorbird	*Orthotomus sutorius*	Insectivore	Resident
Passeridae			
Eurasian Tree Sparrow	*Passer montanus*	Granivore	Resident
House Sparrow	*Passer domesticus*	Granivore	Resident
Russet Sparrow	*Passer rutilans*	Omnivore	Resident
Motacillidae			
Grey Wagtail	*Motacilla cinereal*	Insectivore	Summer visitor
Rosy Pipit	*Anthus roseatus*	Omnivore	Summer Visitor
Olive backed Pipit	*Anthus hodgsoni*	Insectivore	Winter visitor
Variegated Laughing Thrush	*Garrulax variegatus*	Insectivore	Resident
White Wagtail	*Motacilla alba*	Insectivore	Summer visitor
White-browed Wagtail	*Motacilla maderaspantensis*	Insectivore	Resident
Yellow Wagtail	*Motacilla flava*	Insectivore	Winter visitor
Campephagidae			
Long-tailed Minivet	*Pericrocotus ethologus*	Insectivore	Resident
Scarlet Minivet	*Pericrocotus flammens*	Insectivore	Resident
Zosteropidae			
Oriental White eye	*Zosterops palpebrosus*	Omnivore	Resident
Emberizidae			
Rock Bunting	*Emberiza cia*	Granivore	Resident
Cisticolidae			
Striated Prinia	*Prinia crinigera*	Insectivore	Resident
Sittidae			
Velvet-fronted Nuthatch	*Sitta frontalis*	Insectivore	Resident
Wall creeper	*Tichodroma muraria*	Omnivore	Winter visitor
Rhipiduridae			
White throated Fantail	*Rhipidura albicollis*	Insectivore	Resident
Yellow-bellied Fantail	*Chelidorhynx hypoxantha*	Insectivore	Summer visitor
Aegithalidae			
White-throated Tit	*Aegithalos niveogularis*	Insectivore	Resident

Annex II Species code used in Canonical Correspondence Analysis

Name of species	**Scientific Name**	**Species code**
Alpine Accentor	*Prunella collaris*	*Pru Col*
Alpine Chough	*Pyrrhocorax graculus*	*Pyr gra*
Altai Accentor	*Prunella himalayana*	*Pru him*
Ashy Drongo	*Dicrurus leucophaeus*	*Dic leu*
Asian Koel	*Eudynamys scolopacea*	*Eud sco*
Asian Paradise Flycatcher	*Terpsiphone paradise*	*Ter par*
Barn Shallow	*Hirundo rustica*	*Hir rus*
Beautiful Rosefinch	*Carpodacus pulcherrimus*	*Car pul*

Black Bulbul	*Hypsipetes leucocephalus*	*Hyp leu*
Black-chinned Babbler	*Stachyris pyrrhops*	*Sta pyr*
Black Drongo	*Dicrurus macrocercus*	*Dic mac*
Black Frankolin	*Francolinus francolinus*	*Fra fra*
Black Kite	*Milvus migrans*	*Mil mig*
Black-lored Tit	*Parus xanthogenys*	*Par xan*
Black-throated Sunbird	*Aethopyga saturate*	*Aet sat*
Black-throated Tit	*Aegithalos concinnus*	*Aeg con*
Blue Rock Thrush	*Monticola solitarius*	*Mon sol*
Blue Whistling Thrush	*Myophonus caeruleus*	*Myo cae*
Blue-capped Redstart	*Phoenicurus coeruleocephala*	*Pho coe*
Blue-capped Rock Thrush	*Monticola cinclorhynchus*	*Mon cin*
Blue-fronted Redstart	*Phoenicurus frontalis*	*Pho fro*
Blue-throated Barbet	*Megalaima asiatica*	*Meg asi*
Blyth's leaf Warbler	*Myophonus caeruleus*	*Myo cae*
Brown Accentor	*Phylloscopus reguloides*	*Phy reg*
Brown Dipper	*Prunella fulvescens*	*Pru ful*
Brown Shrike	*Cinclus pallasii*	*Cin pal*
Brown-throated Tree-creeper	*Lanius cristatus*	*Lan cri*
Chestnut-bellied Nuthatch	*Certhia discolor*	*Cer dis*
Coal Tit	*Sitta cinnamoventris*	*Sit cin*
Collared Grosbeak	*Peripatus ater*	*Per ate*
Common Kestrel	*Falco tinnunculus*	*Fal tin*
Common Myna	*Mycerobas affinis*	*Myc aff*
Common Pigeon	*Columba livia*	*Col liv*
Common Rosefinch	*Carpodacus erythrinus*	*Car ery*
Common Stonechat	*Saxicola torquatus*	*Sax tor*
Common Tailorbird	*Orthotomus sutorius*	*Ort sut*
Crimson Sunbird	*Aethopyga siparaja*	*Aet sip*
Egyptian Vulture	*Neophron percnopterus*	*Neo per*
Eurasian Cuckoo	*Cuculus canorus*	*Cuc can*
Eurasian Tree Sparrow	*Passer montanus*	*Pas mon*
Fire- breasted Flowerpecker	*Dicaeum cruentatum*	*Dic cru*
Fulvous- breasted Woodpecker	*Dendrocopos macei*	*Den mac*
Golden-throated Barbet	*Megalaima franklinii*	*Meg fra*
Great Barbet	*Megalaima virens*	*Meg vir*
Great Tit	*Parus major*	*Par maj*
Greater Yellownape	*Picus flavinucha*	*Pic fla*
Green Sandpiper	*Tringa ochropus*	*Tri och*
Green-backed Tit	*Parus monticolus*	*Par mon*
Greenish Warbler	*Phylloscopus trochiloides*	*Phy tro*
Green-shrike Babbler	*Pteruthius xanthocholrus*	*Pte xan*
Green-tailed Sunbird	*Aethopyga nipalensis*	*Aet nip*

Grey Bushchat	*Saxicola ferreus*	*Sax fer*
Grey-hooded Warbler	*Phylloscopus xanthoschistos*	*Phy xan*
Grey Treepie	*Dendrocitta formosae*	*Den for*
Grey Wagtail	*Motacilla cinereal*	*Mot cin*
Grey-backed Shrike	*Lanius tephronotus*	*Lan tep*
Grey-headed Woodpecker	*Picus canus*	*Pic can*
Hill Pigeon	*Columba rupestris*	*Col rup*
Himalayan Bluetail	*Tarsiger rufilatus*	*Tar ruf*
Himalayan Bulbul	*Pycnonotus leucogenys*	*Pyc leu*
Hogdeson's Redstart	*Phoenicurus hodgsoni*	*Pho hod*
House Crow	*Corvus splendens*	*Cor spl*
House Sparrow	*Passer domesticus*	*Pas dom*
Hume's Leaf Warbler	*Phylloscopus humei*	*Phy hum*
Kalij Pheasant	*Lophura leucomelanos*	*Lop leu*
Large-billed Crow	*Corvus macrorhynchos*	*Cor mac*
Lemon rumped Warbler	*Phylloscopus chloronotus*	*Phy chl*
Lesser Cuckoo	*Cuculus poliocephalus*	*Cuc pol*
Little Bunting	*Emberiza pussila*	*Emb pus*
Little Forktail	*Enicurus scouleri*	*Eni sco*
Long-tailed Minivet	*Pericrocotus ethologus*	*Per eth*
Long-tailed Shrike	*Lanius schach*	*Lan sch*
Northern Raven	*Corvus corax*	*Cor cor*
Olive-backed Pipit	*Anthus hodgsoni*	*Ant hod*
Oriental Magpie Robin	*Copsychus saularis*	*Cop sau*
Oriental Turtle Dove	*Streptopelia orientalis*	*Str ori*
Oriental White-eye	*Zosterops palpebrosus*	*Zos pal*
Pied Bushchat	*Saxicola caprata*	*Sax cap*
Plumbous Water Redstart	*Rhyacornis fuliginosa*	*Rhy ful*
Purple Sunbird	*Nectarinia asiatica*	*Nec asi*
Red- vented Bulbul	*Pycnonotus cafer*	*Pyc caf*
Red-billed Blue Magpie	*Urocissa erythrorhyncha*	*Uro ery*
Red-billed Chough	*Pyrrhocorax pyrrhocorax*	*Pyr pyr*
Red-billed Leothrix	*Leothrix lutea*	*Leo lut*
Rock Bunting	*Emberiza cia*	*Emb cia*
Rosy Pipit	*Anthus roseatus*	*Ant ros*
Rufous Sibia	*Malacias capistratus*	*Mal cap*
Rufous Treepie	*Dendrocitta vagabunda*	*Den vag*
Russet Sparrow	*Passer rutilans*	*Phy chl*
Scarlet Minivet	*Pericrocotus flammens*	*Per fla*
Spangled Drongo	*Dicrurus hottentottus*	*Dic hot*
Speckled Piculet	*Picumnus innominatus*	*Pic inn*
Spotted Dove	*Stigmatopelia chinensis*	*Stig chi*
Spotted Forktail	*Enicurus maculatus*	*Eni mac*

Spot-winged Grosbeak	*Mycerobas melanozanthos*	*Myc mel*
Steppe Eagle	*Aquila nipalensis*	*Aqu nip*
Streaked Laughing Thrush	*Garrulax lineatus*	*Gar lin*
Striated Prinia	*Prinia crinigera*	*Pri cri*
Stripe-throated Yuhina	*Yuhina gularis*	*Yuh gul*
Variegated Laughing Thrush	*Garrulax variegatus*	*Gar var*
Velvet-fronted Nuthatch	*Sitta frontalis*	*Sit fro*
Verditer Flycatcher	*Eumyias thalassinus*	*Eum tha*
Wall Creeper	*Tichodroma muraria*	*Tic mur*
Wedge-tailed green Pigeon	*Treron sphenurus*	*Tre sph*
White browed Fulvetta	*Alcippe vinipectus*	*Alc vin*
White- capped Redstart	*Chaimarrornis leucocephalus*	*Cha leu*
White throated Fantail	*Rhipidura albicollis*	*Rhi alb*
White Wagtail	*Motacilla alba*	*Mot alb*
White-browed Bush Robin	*Tarsiger indicus*	*Tar ind*
White-browed Rosefinch	*Carpodacus thura*	*Car thu*
White-browed Wagtail	*Motacilla maderaspantensis*	*Mot mad*
White-tailed Rubythroat	*Luscinia pectoralis*	*Lus pec*
White-throated Laughing Thrush	*Garrulax albogularis*	*Gar alb*
White-throated Redstart	*Phoenicurus schisticeps*	*Pho sch*
White-throated Tit	*Aegithalos niveogularis*	*Aeg niv*
White-winged Grosbeak	*Mycerobas carnipes*	*Myc car*
Yellow Wagtail	*Motacilla flava*	*Mot fla*
Yellow-bellied Fantail	*Chelidorhynx hypoxantha*	*Che hyp*
Yellow-billed Blue Magpie	*Urocissa flavirostris*	*Uro fla*
Yellow-browed Warbler	*Phylloscoppus inornatus*	*Phy ino*

Photo Plates

Photo 1 Black-chinned Babbler

Photo 2 Black-lored Tit

Photo 3 Plumbeous water Redstart

Photo 4 Brown Accentor

Photo 5 Striated Prinia

Photo 6 Greenish Warbler

Photo 7 Red-billed Leothrinx

Photo 8 Blue Rock Thrush

Photo 9 Grey Wagtail

Photo 10 Little Forktail

Photo 11 White-capped Redstart

Photo 12 Speckled Piculet