

# Avian Diversity in Kaligandaki River Basin, Annapurna Conservation Area, Nepal

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## ABSTRACT

Birds represent an important component of earth's biodiversity and the study of avian diversity is an essential ecological tool, which acts as an indicator to evaluate different habitat types and conditions. The main aim of this study was to assess the diversity and abundance of birds and the seasonal variation in Kaligandaki River basin, within Annapurna Conservation Area. Data were collected in two seasons of 2019- winter (January and February) and summer (May and June) using point count method. Birds were surveyed within 90 different plots with three replications on each 100 m elevational rise during 6 AM to 11 AM in the morning and 3 PM to 5 PM in the evening. During this study, a total of 1,036 individuals of 120 bird species from 33 families of eight orders were recorded. Out of eight orders, order Passeriformes had the highest species richness followed by the order Piciformes and Columbiformes. Family Muscicapidae had the highest number of bird species, followed by Sylviidae, Corvidae and Fringillidae. Analysis of feeding guild structure revealed insectivores as the largest feeding guild followed by omnivores. Number of resident birds were higher than summer and winter migrants. Shannon-Weiner diversity index ( $H' = 4.134$ ) and the evenness index ( $e = 0.5205$ ) indicated the diverse assemblage of the avian fauna in the study area. However, analysis of variance by one-way ANOVA ( $F_{stat} = 0.48$ ,  $p > 0.05$ ) revealed no significant variation in species richness in the two seasons. Extensive avian survey covering all seasons is important for further exploration of more diverse community assemblage and composition in the area, which might play a crucial role in developing baseline information and implementing conservation implications.

Key Words: Bird Diversity; Community; Elevational Gradient; Evenness; Feeding Guilds; Passeriformes.

## INTRODUCTION

Birds are the good indicators of ecological status of any given ecosystem as they are present in almost all climatic belts and respond to various habitat structures (MacArthur and MacArthur 1961, Harisha and Hosetti 2009, Hossain and Baki 2015). They fulfill many ecological functions in their habitats, maintaining them and supporting biodiversity. They also serve as the best ecological system for studying and understanding the patterns of biodiversity and their associated drivers ((McCain 2009). Birds play a vital link in food chains of the ecosystem and play a functional role in flower pollination and seed dispersal. Exploring the status of avian fauna in respect to their diversity and abundance can guide management at regional and landscape levels (Canterbury et al. 2000).

The composition and structure of bird

communities may change along gradients as elevation increases, change and decline in forest stand structure, site productivity, vegetation composition and available land area may obstruct the availability of important resources for birds (Rahbek 2005, McCain 2009, Mengesha et al. 2011). Avian species of highland environments are responsive to seasonal variation in climate, which is mainly attributable to resource bottlenecks for availability of food and water as well as the temperature regulation requirements (Herzog et al. 2005). One of the key factors influencing the breeding success, survival and population of bird species is seasonality that plays a considerable role in determining food and cover availability of an area (Mengesha and Bekele 2008). Changes in the seasons also determine the prime factors like spatial and temporal microhabitat conditions and the variation in the amount of precipitation and temperature (Mengesha

et al. 2011). Such determinants of food and cover resources reveal the richness, abundance and diversity of bird species (Waterhouse et al. 2002).

Nepal holds a rich diversity of birds representing about 9% of the world's known bird species which is enhanced by its location at the border of Palearctic and Oriental realm (Inskipp et al. 2016). Till date, 887 species of birds have been recorded in Nepal, distributed throughout the tropical to alpine bio-climatic regions with altitudinal variations (BCN, 2019). Around 650 species of birds are resident species to Nepal, many of which are seasonal altitudinal migrant (Grimmett et al. 2016). About 150 species migrate from northern part in winter and about 30-40 species migrate from the southern part in summer, defining the seasonal migration in the country (Inskipp and Inskipp 1991). Among 887 species of birds recorded from Nepal, 42 species are globally threatened and 35 are globally near threatened (IUCN 2018).

Substantial variation in geography, landscape, climatic conditions and land cover is an important characterization of mountain environment and are known to favor large number of species, including avian fauna (Becker et al. 2007, Korner 2007). These areas are also known to be a global hotspot for bird species presenting a supreme area for discovering variation in species diversity over little spatial expanses (Inskipp et al. 2010, Renner 2011). Exploration and evaluation of bird community is important tool in biodiversity conservation and identifications of conservation priorities (Sethy et al. 2015). Obtaining information on diversity and composition of bird communities is also essential to ascertain the health of the particular ecosystem or any regional landscapes (Kiros et al. 2018). However, anthropogenic activities have greatly influenced the mountain environment and the organisms therein. The Annapurna Conservation Area (ACA) in the Nepal Himalaya is one of the major tourist destinations and the area is under tremendous pressure of developmental activities such as roads, hydropower, walking trails, recreation centers, etc. Understanding the diversity and abundance of birds from an Important Bird Area, Kaligandaki River basin of the ACA can provide useful baseline for upcoming studies and conservation of those locally inhabiting birds. Therefore, this study aimed to explore the number of bird species and their abundance in the Kaligandaki River basin of the ACA and also focused on seasonal variation on species richness between the winter and summer seasons.

## STUDY AREA

The study was carried out in Kaligandaki River basin within Annapurna Conservation Area which is a major tributary of the Ganges River Basin and an important sub basin of the Narayani River with a catchment area of approximately 11,830 km<sup>2</sup>. It has geographic location in between 27°43' N to 29°19' N and 82°53' E to 84°26' E. Elevation of the basin ranges from 183 m to 8143 m above sea level (Figure 1). The study area has a noticeable topographic difference from sub-tropical to sub-alpine habitats supporting highly diverse form of fauna. The area is an important bird and biodiversity area (IBA) as well as a migratory corridor for birds moving south to India in winter with a record of about 40 bird species, including Demoiselle Crane and nearly 20 raptors migrating along the valley. This study covered an area of Kaligandaki River Basin from an elevation range of 800m (Beni, Myagdi district) to 3800 m (Muktinath, Mustang district). The area shows a wide variation on vegetation composition from lowest sub-tropical region with broadleaved *Schima wallichii*, *Castanopsis indica* and *Pinus roxburghii* forests, temperate forests of mixed broadleaved and oaks with rhododendron species, blue pine *Pinus wallichiana* on the upper dry ridges and slopes up to subalpine forests of birch *Betula utilis*, blue pine and juniper species.

## METHODS

### Bird Survey

Point count method was used to count the number of birds in the study area which was undertaken from a fixed location for a fixed time at intervals along the route for a given duration at each point.

As a survey design, plots were set up with every 100 meters rise in elevation, recorded using Garmin Etrex 10 GPS and three fixed-point count plots or the replicates were set up at every elevational band from 800 m to 3800 m asl. Thus, a total of 90 sampling replicates were set up within 30 elevational points. Two districts, Myagdi and Mustang of Annapurna Conservation Area along Kaligandaki River basin were covered for the bird survey. Birds were recorded in a circular plot of 30 m radius from the fixed point in a center, for 15 minutes and observed directly using binoculars. Photographs were taken whenever possible. Identification of birds were done using field book, Birds of Nepal (Grimmett et al. 2016). Observation and recording of birds were

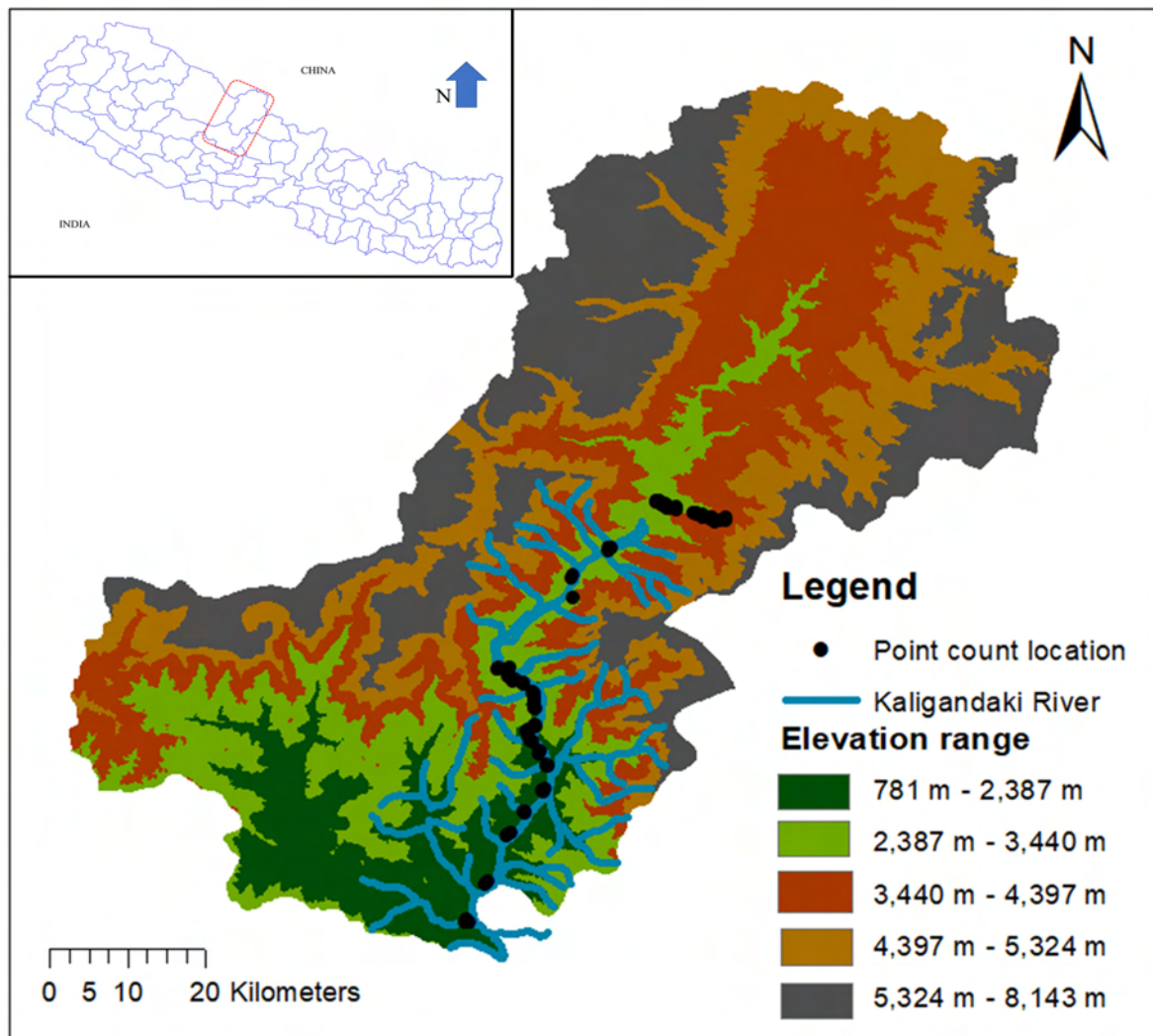


Figure 1. Map of Annapurna Conservation Area (ACA) showing the Kaligandaki River basin where this study was carried out. The figure in inset shows position of the ACA in the map of Nepal

conducted in the plot during 6 AM to 11 AM in the morning and 3 PM to 5 PM in the evening, the active time period of birds. Field data collection was carried out in two seasons of 2019- winter (January and February) and summer (May and June).

### Feeding Guild Classification

All the recorded bird species of the study area were categorized into the five feeding guilds based on the field guidebook 'Birds of Nepal' (Grimmett et al. 2016). Classification was done 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), carnivores (feeding on fishes, amphibians, reptiles, birds

and mammals), granivore (feeding on seeds, grains, acorns).

### Data Analysis

All the collected data from the field were arranged, organized and entered into Microsoft excel for analysis.

### Diversity Measures

Shannon-Weiner diversity index ( $H'$ ) was used to analyze bird diversity of the study area. It was calculated as:

$$H' = -\sum P_i (\ln P_i)$$

Where,

$H'$  = Index of species diversity;

$P_i$  = the proportion of individuals in the  $i^{\text{th}}$  species,

$P_i = n_i/N;$

$n_i$  = Importance value for each species (number of individuals); and,

$N$  = Total importance value (total number of individuals)

Species Richness (S) 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.

To calculate whether the species were evenly distributed among the different point count stations and among the different seasons, the evenness index (E) was used. It was calculated as,

$$E = \frac{H'}{H'_{\max}}$$

Where,

$H'$  = Shannon-Wiener diversity index;

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

$S$  = Species richness, the total number of species. Abundance of each species was calculated as the frequency of occurrence of species in each plot.

Abundance = Frequency of occurrence of species in each plot.

### Beta Diversity Measurement

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 in two communities. Sorenson's Index of similarity for qualitative data (presence/absence) was calculated as:

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

Where,

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

$A$  = Number of species found in one community (one season); and,

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

### Analysis of Variance

One-way ANOVA was used to analyze the significant variation in species richness and abundance of birds in two seasons among point count stations assuming the null hypothesis as,  $H_0$  = There is no significant variation

in species richness and abundance of birds between two seasons (summer and winter).

## RESULTS

### Species Richness, Diversity and Abundance

A total of 1,036 individuals of 120 bird species from 33 families of eight orders were recorded by point count method during the study period in Kaligandaki River basin. Out of eight 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).

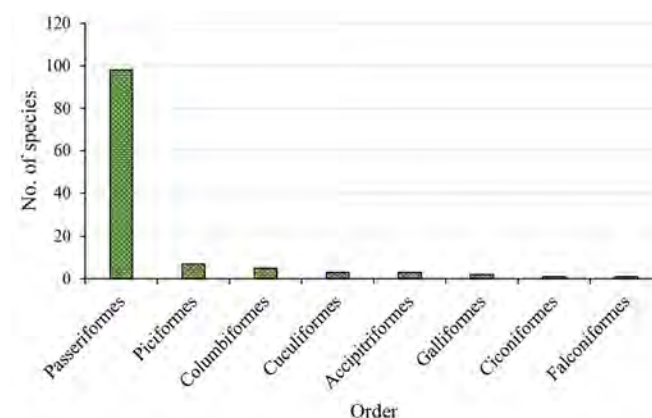


Figure 2. Number of bird species in different orders observed in the Kaligandaki River basin of the ACA

Among 33 families recorded, family Muscicapidae had 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 each). 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).

Analysis of data on feeding guild structure of birds

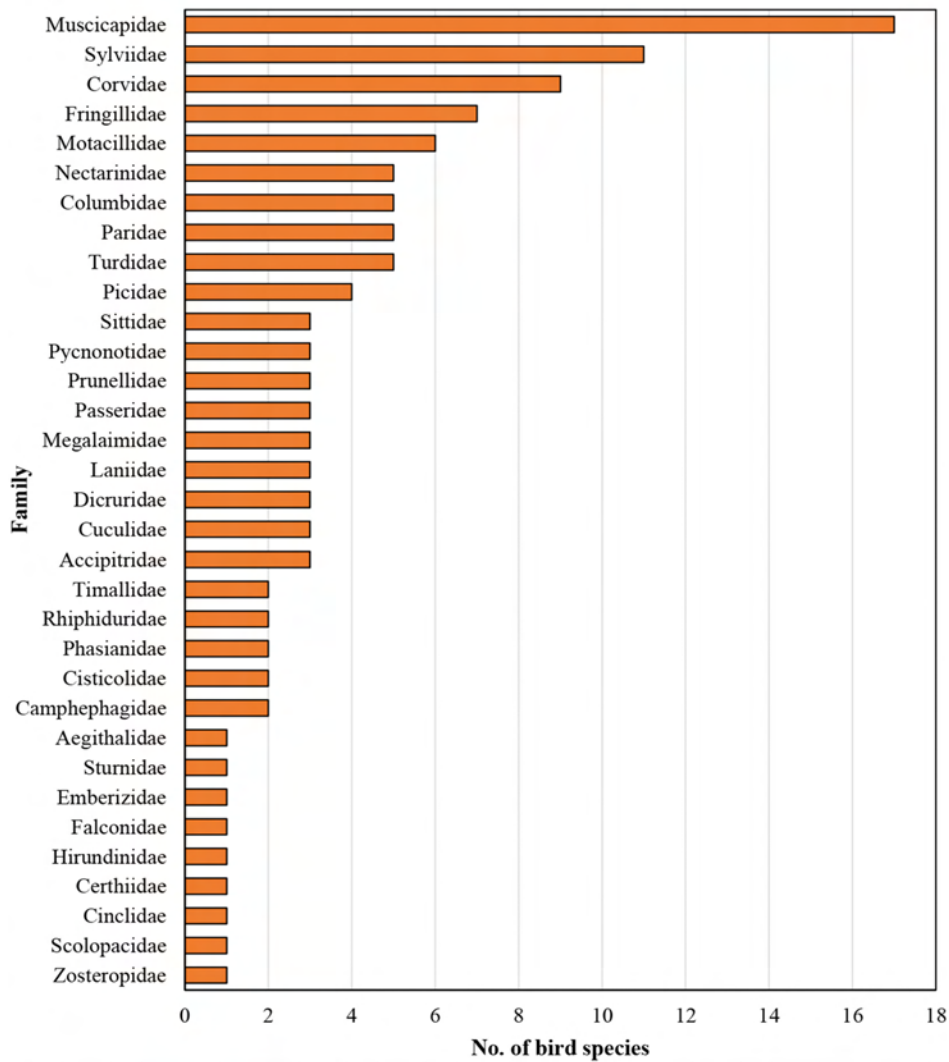


Figure 3. Number of bird species in different families observed in the Kaligandaki River basin of the ACA

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).

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 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

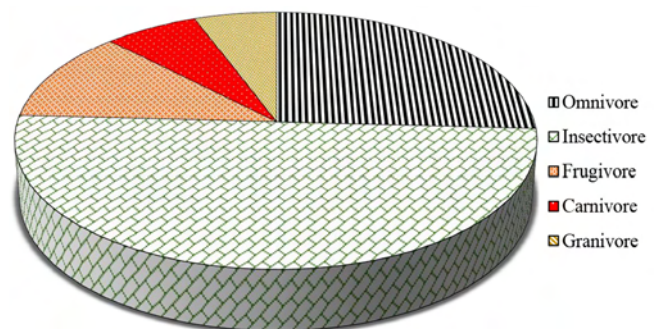


Figure 4. Species richness in different feeding guilds of birds observed in Kaligandaki River basin of the ACA

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).

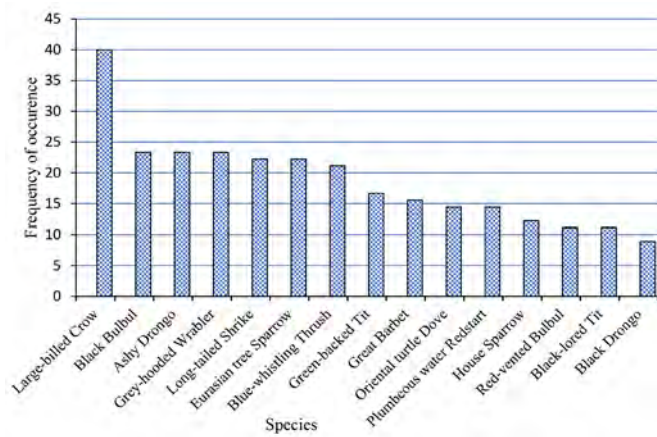


Figure 5. Most frequently observed species of birds in the Kaligandaki River basin of the ACA

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). 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.

The overall diversity index (H') was 4.134 and the evenness index (E) was 0.5205 which indicates that Kaligandaki river basin has highly diverse bird assemblage.

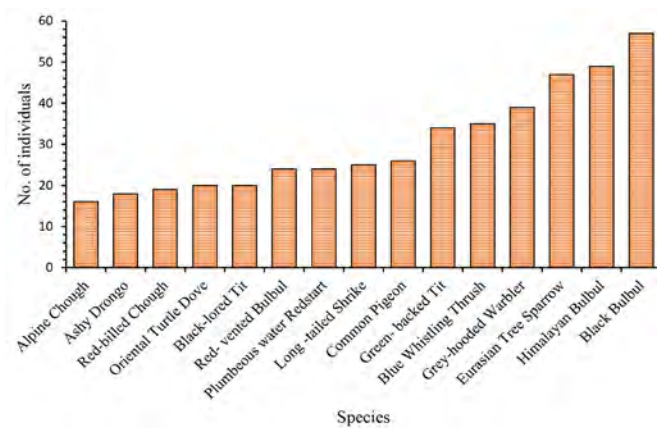


Figure 6. Most populated birds in the Kaligandaki River basin of the ACA

Table 1. Elevation-wise Diversity index (H') and Evenness index (E) for the birds in the Kaligandaki River basin of the ACA

Elevation (m)	Diversity index (H')	Evenness (E)
827	2.581	0.8256
937	2.484	0.8567
1078	2.576	0.7733
1165	2.438	0.8809
1262	2.329	0.7335
1367	2.709	0.8338
1457	2.57	0.8713
1552	2.558	0.9217
1662	2.582	0.9448
1735	2.479	0.9178
1830	2.154	0.8615
1950	2.575	0.8204
2050	2.793	0.8595
2147	2.327	0.9311
2250	2.135	0.8459
2345	1.937	0.8673
2435	2.146	0.9499
2530	2.206	0.9076
2654	1.981	0.9066
2747	1.841	0.9008
2857	1.847	0.9057
2951	1.494	0.8911
3062	1.475	0.8743
3169	1.609	1
3270	1.099	1
3371	1.609	1
3470	1.471	0.8706
3562	1.332	0.9473
3663	1.359	0.7786
3770	1.992	0.9158

**Seasonal Variation**

**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 whereas 577 individuals of 95 species of six orders belonging to 29 families were recorded from summer season. Fifty-six species of birds were common for both summer and winter season (Table 2).

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 more diverse bird assemblage in summer season as compared to winter season. The evenness index was found to be higher in winter (E=0.6287) than in summer season (e=0.5784) revealing more even distribution of birds in winter season than in summer season (Table 2).

Table 2. Species richness, diversity and evenness of the 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.

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 3) and ( $P=0.486071 > 0.05$ ), null hypothesis is accepted i.e., there is not any significant variation in species richness of birds between two seasons in different point count locations.

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 not any significant variation in abundance of birds between two seasons in different point count locations.

### 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). The checklist of the avian species, their taxonomic position, nutritional guild and migratory status recorded during the study has been presented in the tabulated form (Table 4).

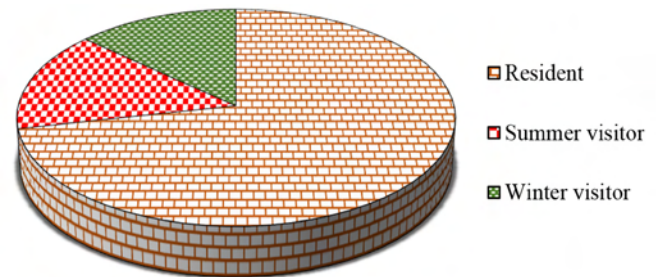


Figure 7. Residential status of birds of the Kaligandaki River basin in ACA

### DISCUSSION

This study explored the avian diversity along Kaligandaki River basin of the Annapurna Conservation Area (ACA), one of the important birds and biodiversity areas of the Nepal Himalayas. During the study period of two seasons- winter and summer 2019 AD, a total of 120 species of birds belonging to eight orders and 33 families were recorded in the Kaligandaki River basin. Diversity index of birds in Kaligandaki River basin showed highly diverse bird assemblage in the area throughout different elevations. Highly diverse avian forms of the study area might be ascribed to the greater habitat complexity (MacArthur 1966, Pan et al. 2016, Hu et al. 2018) along an elevation gradient of Kaligandaki River basin. Habitat heterogeneity was considered by the vegetation composition like riverine *Alnus nepalensis* forest, *Schima wallichii* forest, mixed forest with *Tooni ciliata* and *Bombyx ceiba*, *Pinus roxburghii* forest, *Pinus wallichiana* forest, *Betula utilis* forest from lower

Table 3. ANOVA Table between species richness of birds and Abundance of birds in two different seasons.

Variable	Source of Variation	Df	SS	MSS	P-value	F Statistics	F Critical
Richness	Between Seasons	1	2.68	2.68	0.486	0.487	3.89
	Within Seasons	175	982.31	5.52			
	Total	176	985				
Abundance	Between Seasons	1	54.45	54.45	0.090	2.903787	3.89
	Within Seasons	175	3357.74	18.75			
	Total	176	3392.19				

Table 4. List of bird species Kaligandaki River basin and their taxonomic position, feeding guild category and migratory status

S.N	Common Name	Scientific Name	Order	Family	Feeding Guild	Migratory status
1	Black Frankolin	<i>Francolinus francolinus</i>	Galliformes	Phasianidae	Omnivore	Resident
2	Kalij Pheasant	<i>Lophura leucomelanos</i>	Galliformes	Phasianidae	Insectivore	Resident
3	Blue-throated Barbet	<i>Megalaima asiatica</i>	Piciformes	Megalaimidae	Frugivore	Resident
4	Golden-throated Barbet	<i>Megalaima franklinii</i>	Piciformes	Megalaimidae	Frugivore	Resident
5	Great Barbet	<i>Megalaima virens</i>	Piciformes	Megalaimidae	Frugivore	Resident
6	Greater Yellownappe	<i>Picus flavinucha</i>	Piciformes	Picidae	Insectivore	Resident
7	Grey-headed Woodpecker	<i>Picus canus</i>	Piciformes	Picidae	Insectivore	Resident
8	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	Piciformes	Picidae	Insectivore	Resident
9	Speckled Piculet	<i>Picumnus innominatus</i>	Piciformes	Picidae	Insectivore	Resident
10	Eurasian Cuckoo	<i>Cuculus canorus</i>	Cuculiformes	Cuculidae	Insectivore	Summer visitor
11	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	Cuculiformes	Cuculidae	Insectivore	Summer visitor
12	Asian Koel	<i>Eudynamis scolopacea</i>	Cuculiformes	Cuculidae	Omnivore	Resident
13	Common Pigeon	<i>Columba livia</i>	Columbiformes	Columbidae	Granivore	Resident
14	Hill Pigeon	<i>Columba rupestris</i>	Columbiformes	Columbidae	Granivore	Resident
15	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	Columbiformes	Columbidae	Granivore	Summer visitor
16	Spotted Dove	<i>Stigmatopelia chinensis</i>	Columbiformes	Columbidae	Granivore	Resident
17	Wedge-tailed green Pigeon	<i>Treron sphenurus</i>	Columbiformes	Columbidae	Granivore	Resident
18	Green Sandpiper	<i>Tringa ochropus</i>	Ciconiformes	Scolopacidae	Insectivore	Winter visitor
19	Black Kite	<i>Milvus migrans</i>	Accipitriformes	Accipitridae	Carnivore	Winter visitor
20	Steppe Eagle	<i>Aquila nipalensis</i>	Accipitriformes	Accipitridae	Carnivore	Winter visitor
21	Egyptian Vulture	<i>Neophron percnopterus</i>	Accipitriformes	Accipitridae	Carnivore	Resident
22	Common Kestrel	<i>Mycerobas affinis</i>	Falconiformes	Falconidae	Carnivore	Winter visitor
23	Alpine Accentor	<i>Prunella collaris</i>	Passeriformes	Prunellidae	Omnivore	Resident
24	Altai Accentor	<i>Prunella himalayana</i>	Passeriformes	Prunellidae	Omnivore	Winter visitor
25	Brown Accentor	<i>Phylloscopus reguloides</i>	Passeriformes	Prunellidae	Omnivore	Winter visitor
26	Alpine Chough	<i>Pyrrhocorax graculus</i>	Passeriformes	Corvidae	Omnivore	Resident
27	Grey-hooded Warbler	<i>Phylloscopus xanthoschistos</i>	Passeriformes	Corvidae	Insectivore	Resident
28	House Crow	<i>Corvus splendens</i>	Passeriformes	Corvidae	Omnivore	Resident
29	Large-billed Crow	<i>Corvus macrorhynchos</i>	Passeriformes	Corvidae	Omnivore	Resident
30	Northern Raven	<i>Corvus corax</i>	Passeriformes	Corvidae	Omnivore	Resident
31	Red-billed Blue Magpie	<i>Urocissa flavirostris</i>	Passeriformes	Corvidae	Frugivore	Resident
32	Red-billed Chough	<i>Pyrrhocorax pyrrhocorax</i>	Passeriformes	Corvidae	Omnivores	Resident
33	Rufous Treepie	<i>Dendrocitta vagabunda</i>	Passeriformes	Corvidae	Frugivore	Resident
34	Yellow-billed Blue Magpie	<i>Urocissa flavirostris</i>	Passeriformes	Corvidae	Frugivore	Resident
35	Ashy Drongo	<i>Dicrurus leucophaeus</i>	Passeriformes	Dicruridae	Insectivore	Summer visitor
36	Black Drongo	<i>Dicrurus macrocercus</i>	Passeriformes	Dicruridae	Insectivore	Resident
37	Spangled Drongo	<i>Dicrurus hottentottus</i>	Passeriformes	Dicruridae	Insectivore	Resident
38	Asian Paradise Flycatcher	<i>Terpsiphone paradise</i>	Passeriformes	Muscicapidae	Insectivore	Summer visitor
39	Blue-capped Redstart	<i>Phoenicurus coeruleocephala</i>	Passeriformes	Muscicapidae	Insectivore	Winter visitor
40	Blue-capped Rock Thrush	<i>Monticola cinclorhynchus</i>	Passeriformes	Muscicapidae	Insectivore	Summer visitor
41	Blue-fronted Redstart	<i>Phoenicurus frontalis</i>	Passeriformes	Muscicapidae	Omnivore	Summer visitor
42	Common Stonechat	<i>Saxicola torquatus</i>	Passeriformes	Muscicapidae	Insectivore	Resident
43	Grey Treepie	<i>Dendrocitta formosae</i>	Passeriformes	Muscicapidae	Frugivore	Resident
44	Himalayan Bluetail	<i>Tarsiger rufilatus</i>	Passeriformes	Muscicapidae	Insectivore	Resident
45	Hogdeson's redstart	<i>Phoenicurus hodgsoni</i>	Passeriformes	Muscicapidae	Insectivore	Winter visitor
46	Little Forktail	<i>Enicurus scouleri</i>	Passeriformes	Muscicapidae	Insectivore	Resident
47	Pied Bushchat	<i>Saxicola caprata</i>	Passeriformes	Muscicapidae	Insectivore	Resident
48	Plumbous Water Redstart	<i>Rhyacornis fuliginosa</i>	Passeriformes	Muscicapidae	Insectivore	Resident
49	Spotted Forktail	<i>Enicurus maculatus</i>	Passeriformes	Muscicapidae	Insectivore	Resident
50	Verditer Flycatcher	<i>Eumyias thalassinus</i>	Passeriformes	Muscicapidae	Insectivore	Summer visitor
51	White-capped Redstart	<i>Chaimarrornis leucocephalus</i>	Passeriformes	Muscicapidae	Insectivore	Resident
52	White-browed BushRobin	<i>Tarsiger indicus</i>	Passeriformes	Muscicapidae	Insectivore	Resident
53	White-tailed Rubythroat	<i>Luscinia pectoralis</i>	Passeriformes	Muscicapidae	Insectivore	Resident
54	White-throated Redstart	<i>Phoenicurus schisticeps</i>	Passeriformes	Muscicapidae	Insectivore	Winter visitor
55	Barn Shallow	<i>Hirundo rustica</i>	Passeriformes	Hirundinidae	Insectivore	Resident
56	Beautiful Rosefinch	<i>Carpodacus pulcherrimus</i>	Passeriformes	Fringillidae	Omnivore	Summer visitor
57	Collared Grosbeak	<i>Peripatus ater</i>	Passeriformes	Fringillidae	Omnivore	Resident

S.N	Common Name	Scientific Name	Order	Family	Feeding Guild	Migratory status
58	Common Rosefinch	<i>Carpodacus erythrinus</i>	Passeriformes	Fringillidae	Omnivore	Summer visitor
59	Little Bunting	<i>Emberiza pusilla</i>	Passeriformes	Fringillidae	Omnivore	Winter visitor
60	Spot-winged Grosbeak	<i>Mycerobas melanozanthos</i>	Passeriformes	Fringillidae	Frugivore	Resident
61	White-browed Rosefinch	<i>Carpodacus thura</i>	Passeriformes	Fringillidae	Omnivore	Summer visitor
62	White-winged Grosbeak	<i>Mycerobas carnipes</i>	Passeriformes	Fringillidae	Frugivore	Resident
63	Black Bulbul	<i>Hypsipetes leucocephalus</i>	Passeriformes	Pycnonotidae	Omnivore	Resident
64	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	Passeriformes	Pycnonotidae	Omnivore	Resident
65	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Passeriformes	Pycnonotidae	Omnivore	Resident
66	Black-chinned Babbler	<i>Stachyris pyrrhops</i>	Passeriformes	Timallidae	Insectivore	Resident
67	Green-shrike Babbler	<i>Pteruthius xanthochlorus</i>	Passeriformes	Timallidae	Omnivore	Resident
68	Black-lored Tit	<i>Parus xanthogenys</i>	Passeriformes	Paridae	Insectivore	Resident
69	Black-throated Tit	<i>Aegithalos concinnus</i>	Passeriformes	Paridae	Frugivore	Resident
70	Coal Tit	<i>Sitta cinnamoventris</i>	Passeriformes	Paridae	Insectivore	Resident
71	Great Tit	<i>Parus major</i>	Passeriformes	Paridae	Insectivore	Resident
72	Green-backed Tit	<i>Parus monticolus</i>	Passeriformes	Paridae	Insectivore	Resident
73	Black-throated Sunbird	<i>Aethopyga saturate</i>	Passeriformes	Nectarinidae	Frugivore	Resident
74	Crimson Sunbird	<i>Aethopyga siparaja</i>	Passeriformes	Nectarinidae	Frugivore	Resident
75	Fire-breasted Flowerpecker	<i>Dicaeum cruentatum</i>	Passeriformes	Nectarinidae	Frugivore	Resident
76	Green-tailed Sunbird	<i>Aethopyga nipalensis</i>	Passeriformes	Nectarinidae	Frugivore	Resident
77	Purple Sunbird	<i>Nectarinia asiatica</i>	Passeriformes	Nectarinidae	Frugivore	Resident
78	White-throated Laughing Thrush	<i>Garrulax albogularis</i>	Passeriformes	Turdidae	Insectivore	Resident
79	Blue Rock Thrush	<i>Monticola solitarius</i>	Passeriformes	Turdidae	Insectivore	Summer visitor
80	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	Passeriformes	Turdidae	Omnivore	Resident
81	Oriental Magpie Robin	<i>Copsychus saularis</i>	Passeriformes	Turdidae	Insectivore	Resident
82	Streaked Laughing Thrush	<i>Garrulax lineatus</i>	Passeriformes	Turdidae	Insectivore	Resident
83	Blyth's Leaf Warbler	<i>Phylloscopus reguloides</i>	Passeriformes	Sylviidae	Insectivore	Resident
84	Greenish Warbler	<i>Phylloscopus trochiloides</i>	Passeriformes	Sylviidae	Insectivore	Resident
85	Grey Bushchat	<i>Saxicola ferreus</i>	Passeriformes	Sylviidae	Insectivore	Resident
86	Hume's Leaf Warbler	<i>Phylloscopus humei</i>	Passeriformes	Sylviidae	Insectivore	Summer visitor
87	Lemon-rumped Warbler	<i>Phylloscopus chloronotus</i>	Passeriformes	Sylviidae	Insectivore	Winter visitor
88	Red-billed Leothrix	<i>Leothrix lutea</i>	Passeriformes	Sylviidae	Omnivore	Resident
89	Rufous Sibia	<i>Malacias capistratus</i>	Passeriformes	Sylviidae	Omnivore	Resident
90	Stripe-throated Yuhina	<i>Yuhina gularis</i>	Passeriformes	Sylviidae	Omnivore	Resident
91	White-browed Fulvetta	<i>Alcippe vinipectus</i>	Passeriformes	Sylviidae	Omnivore	Resident
92	Yellow-browed Warbler	<i>Phylloscopus inornatus</i>	Passeriformes	Sylviidae	Insectivore	Winter visitor
93	Common Tailorbird	<i>Orthotomus sutorius</i>	Passeriformes	Sylviidae	Insectivore	Resident
94	Brown Dipper	<i>Prunella fulvescens</i>	Passeriformes	Cinclidae	Insectivore	Resident
95	Brown Shrike	<i>Cinclus pallasii</i>	Passeriformes	Laniidae	Carnivore	Winter visitor
96	Grey-backed Shrike	<i>Lanius tephronotus</i>	Passeriformes	Laniidae	Carnivore	Summer visitor
97	Long-tailed Shrike	<i>Lanius schach</i>	Passeriformes	Laniidae	Carnivore	Resident
98	Brown-throated Treecreeper	<i>Lanius cristatus</i>	Passeriformes	Certhiidae	Insectivore	Resident
99	Chestnut-bellied Nuthatch	<i>Certhia discolor</i>	Passeriformes	Sittidae	Omnivore	Resident
100	Common Myna	<i>Falco tinnunculus</i>	Passeriformes	Sturnidae	Omnivore	Resident
101	Eurasian Tree Sparrow	<i>Passer montanus</i>	Passeriformes	Passeridae	Granivore	Resident
102	House Sparrow	<i>Passer domesticus</i>	Passeriformes	Passeridae	Granivore	Resident
103	Russet Sparrow	<i>Passer rutilans</i>	Passeriformes	Passeridae	Omnivore	Resident
104	Grey Wagtail	<i>Motacilla cinerea</i>	Passeriformes	Motacillidae	Insectivore	Summer visitor
105	Rosy Pipit	<i>Anthus roseatus</i>	Passeriformes	Motacillidae	Omnivore	Summer visitor
106	Olive-backed Pipit	<i>Anthus hodgsoni</i>	Passeriformes	Motacillidae	Insectivore	Winter visitor
107	Variiegated Laughing Thrush	<i>Garrulax variegatus</i>	Passeriformes	Motacillidae	Insectivore	Resident
108	White Wagtail	<i>Motacilla alba</i>	Passeriformes	Motacillidae	Insectivore	Summer visitor
109	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	Passeriformes	Motacillidae	Insectivore	Resident
110	Yellow Wagtail	<i>Motacilla flava</i>	Passeriformes	Motacillidae	Insectivore	Winter visitor
111	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	Passeriformes	Campephagidae	Insectivore	Resident
112	Scarlet Minivet	<i>Pericrocotus flammeus</i>	Passeriformes	Campephagidae	Insectivore	Resident
113	Oriental White eye	<i>Zosterops palpebrosus</i>	Passeriformes	Zosteropidae	Omnivore	Resident
114	Rock Bunting	<i>Emberiza cia</i>	Passeriformes	Emberizidae	Granivore	Resident
115	Striated Prinia	<i>Prinia crinigera</i>	Passeriformes	Cisticolidae	Insectivore	Resident
116	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	Passeriformes	Sittidae	Insectivore	Resident
117	Wall Creeper	<i>Tichodroma muraria</i>	Passeriformes	Sittidae	Omnivore	Winter visitor
118	White-throated Fantail	<i>Rhipidura albicollis</i>	Passeriformes	Rhipiduridae	Insectivore	Resident
119	Yellow-bellied Fantail	<i>Chelidorhynch hypoxantha</i>	Passeriformes	Rhipiduridae	Insectivore	Summer visitor
120	White-throated Tit	<i>Aegithalos niveogularis</i>	Passeriformes	Aegithalidae	Insectivore	Resident

subtropical to higher sub-alpine region. Other land-use types included riverbank, agricultural area, human settlement area, shrublands, grasslands, scrublands and some barren area that enhanced wide habitat, shelter and resources to the species (Cantebury et al. 2000, Lee and Rotenberry 2005, Collis and Edward 2014, Ferger et al. 2014, Ding et al. 2019). Among the eight orders of birds from the study area, the avian community was found to be dominated by the order Passeriformes. Passeriformes has been recorded as the largest order/group in most of the studies, avian surveys and researches till date (Chaudhari et al. 2009, Jeevan et al. 2013, Kiros et al. 2018, Abie et al. 2019, Adhikari et al. 2019).

This study was conducted along the river basin from an elevation range of 800 to 3800 m asl which featured the most distinct gradient from lower sub-tropical to sub-alpine habitats that is ideally suited to highest number of bird species (Inskipp and Inskipp 2003). Vegetation like broadleaved *Schima wallichii*, *Castanopsis indica*, *Pinus roxburghii* on dry slopes supported the species like Magpies, Drongos, Bulbuls, Tits, Warblers etc. *Alnus nepalensis*, occurring mainly along rivers and streams also provide shelter and resources to the most of aquatic birds. Temperate forests of mixed broadleaves and oaks *Quercus lamellosa*, *Q. lanata* and *Q. semecarpifolia* with rhododendron species in upper part favored the species like Rosefinches and Grosbreaks. Species like Buntings, Wagtails, Large-billed Crows and Northern Ravens were dominant in the subalpine forests of birch *Betula utilis*, blue pine and juniper species. Most of water dependent birds, like Forktail species, Brown Dipper, White-capped Water Redstart, Plumbeous Water Redstart, etc. were recorded in the riverbanks and streams. Therefore, the distinctly varied vegetative composition, land use types and habitat structures as well as the climatic conditions and wide elevational range within the study area has produced high species richness and diversity.

Bird assemblages is not static and there might be fluctuation in the number and species with season (Avery and Riper 1989). Seasonality brings about variation in numerous factors including microclimatic aspects as well as the environmental factors (Mengesha and Bekele 2008). Factors like temperature, humidity, rainfall, vegetation, food availability, etc. have profound impact on species composition and community structure of avian fauna (Gatson et al. 2000). Seasons have direct influence on the food availability and hence seasonal variation in species diversity occur due to the change in foraging behavior of the species (Robertson and Hackwell, 1995). Seasonal migration of birds occurs to escape adverse environmental conditions commonly from north to south in winter season. Avoiding extreme climates and with the purpose of breeding, birds from

lowland India arrive Nepal in summer season. In this study, we found a slight variation in species richness in between summer and winter seasons, statistically there was no significant variation among these. This difference may be because of climatic and biotic influences that gets changing in different seasons and time period.

Many other studies are in line with the results of seasonal variation as Shoo et al. (2005) discussed about temperature and climate changes with the seasons that ultimately alter the diversity and distribution patterns of the avian species. As per the results of this study the less encountered species in winter season may be accredited to the amount of available vigor in a system, usually quantified as primary productivity, a major determinant of species richness, which is, in most cases lower in winter season (Bailey et al. 2004). The harsh, snowy and cold winter season of mountain area is the main reason to have food availability as a particular constraint on bird diversity, because the resources supply (food and cover) usually is at its lowest level during this time (Moen 1976, Marra and Holberton 1998, Wang et al. 2013). Furthermore, least observation and recording of bird species in winter season might be because of the harsh climatic conditions with snowfall below to 2000m asl in the study area. This might have reduced visibility and exploration of the avian fauna too. Similar to this finding, Aryal et al. (2013) also found less species during winter season than summer season in Ghunsa valley of Kanchanjunga Conservation Area in eastern Nepal as the landscapes above 3000 m were covered by snow and comparatively few species were recorded due to inaccessibility.

Likewise, another probable reason for least recorded species in winter might be because of a smaller number of winter migrants recorded in the area during study period. In Nepal, of the total 887 bird species recorded, about 650 species, numerically high species are resident, in comparison to about 150 winter visitors and around 60 summer visitors (Grimmett et al. 2016, BCN 2019). The minor and insignificant variation between these two seasons may be explained by the occurrence of highest resident which are common to both seasons. Additionally, half of the species we observed were insectivores, which are the habitat specialists and residents (Hu et al. 2018). A number of bird species are altitudinal migrants in Nepal moving from lower altitudes to higher in summer and vice versa which could be a possible reason to record a high number of species in summer season in the study, principally due to altitudinal migrants. Different contrasting findings have been made based on seasonal variation in species richness that revealed high biodiversity value in winter

season as compared to winter season (Kafle 2005, Giri and Chalise 2008, Thakuri 2011, Thapa and Saud 2013). Therefore, seasonal variation in richness and abundance of bird species can be described as an impact and response to a resource bottleneck for food and cover during winter season followed by superior and enhanced resource accessibility in the summer seasons.

## CONCLUSIONS

The study established that Kaligandaki River basin of Annapurna Conservation area has diverse bird assemblage harboring a large number of bird species varying species-wise from lower sub-tropical to higher sub-alpine region. Bird diversity varied significantly with rising elevation, decreased productivity and scarce forest stands along the basin which concludes that availability of resources is the major determinant of avian community structure in mountain area. Statistically insignificant seasonal variation revealed less bird diversity in winter season than in summer season attributed mostly to the unfavorable conditions during winter.

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**Author contributions:** JN and LK designed the study and JN conducted the field surveys. JN and LK performed data analysis and wrote the manuscript. MKC supervised the research and provided multiple revisions in the early stages of writing. All authors read and approved the final manuscript.

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