BIRD DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN SHIVAPURI NAGARJUN NATIONAL PARK, NEPAL

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Kirtipur, Kathmandu, Nepal

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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 or institutions.

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RECOMMENDATIONS

This is to recommend that the thesis entitled **"BIRD DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN SHIVAPURI NAGARJUN NATIONAL PARK, NEPAL"** has been carried out by Ms. Nabina Kunwar for the partial fulfillment of Master's Degree of Science in Zoology with special paper ecology and environment. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

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This thesis work submitted by Ms. Nabina Kunwar entitled **"BIRD DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN SHIVAPURI NAGARJUN NATIONAL PARK, NEPAL"** has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper ecology and environment.

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ABSTRACT

This study assessed the diversity of bird along elevational gradient of Shivapuri Nagarjun National Park though species richness of bird along an elevational gradient in Himalayan region including Nepal is less explored till present. The diversity, distribution pattern and habitat will help for biodiversity conservation. Understanding the habitat heterogeneity and bird diversity along elevational gradient is the key required to conserve the diversity. The major aims of this study were to explore diversity, habitat and distribution patterns of birds along elevational gradient in two site i.e. Sundarijal and Panimuhan. The study was carried out along the altitudinal gradients of Sundarijal and Panimuhan from 1300 m asl to 2700 m asl and 1600 m to 2700 m respectively. Point count method was used for the field survey. In both sites 15 and 12 point count locations were selected in every 100 m altitudinal differences and recorded all the seen and heard birds in each point count locations for about 20 minutes by using binoculars. Direct observation method was used for the bird's identification with the help of field guide book (Birds of Nepal). Microsoft Excel 2010, PAST, CANOCO software were used for data analysis. Shannon- Weiner (H) diversity index was 2.994 in Sundarijal and 2.694 in Panimuhan which showed significant diversity of bird. The highest bird species were recorded in lower mixed hardwood forest and least in upper mixed hardwood forest in both sites which concluded that bird species richness were significantly associated with habitat heterogeneity. The distribution pattern of bird was monotonically decreasing species richness with increasing elevation in both sites.

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ABBREVIATIONS

Abbreviated form	Details of abbreviations
cm	Centimeter
m asl	Meter above sea level
Ft.	Feet
km^2	Square kilometer
m	Meter
BCN	Bird Conservation Nepal
CCA	Canonical Correspondence Analysis
CITES	Convention on International Trade in Endangered Species
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature
NPWC	National Parks and Wildlife Conservation Act
SNNP	Shivapuri Nagarjun National Park

1. INTRODUCTION

1.1 Background

Birds have been integral to humans since prehistory. Some birds are keystone species as their presence and absence affect the ecosystem and other species indirectly. Birds and their diversity acts as a strong bio-indicator signals (Bhatt & Joshi 2011, Bregman et al. 2014) and represent the health of ecosystem and status of biodiversity as a whole (Chettri 2010, Pierson et al. 2015). Birds occupy many levels of tropic webs from mid-level consumers to top predators. The feathers are the main distinguished character of birds as compared to other vertebrates which is produced from loose and dry skin without any sweat gland as well as it consist of toothless beaked jaws, oviparous, with high metabolism rate, four chambered heart and light weight skeleton system. Birds live worldwide and range in size from the 5 cm bee humming bird to the 2.75 m ostrich.

Nepal is rich in biodiversity, reflection of its unique geographic position, diverse climatic conditions, landscape heterogeneity, complex topography, broader altitudinal range and great habitat variation so Nepal is known as the paradise of birds and it contains 8.87% of the global bird species. In a recent checklist for Nepal by (Price et al. 2011) a total of 887 species of birds are recorded including, 42 species are globally threatened, 35 are globally near threatened and 167 species that are nationally threatened. Spiny Babbler (*Turdoides nipalensis*) is the only one endemic bird to Nepal. Of the 878 bird species recorded, 168 species (19%) were nationally threatened which comprise 68 (40%) Critically Endangered species, 38 (23%) Endangered species and 62 (37%) Vulnerable species. Besides this, 62 species are considered Near Threatened and 22 species are Data Deficient (Inskipp et al. 2017).

The digestive and respiratory systems of birds are also uniquely adapted for flight. As with other native organisms, birds help in maintaining sustainable population level of their prey and predator species and even acts as a scavengers and decomposers. They are very important in plant reproduction as they act as pollinators or seed dispersal and natural control of insects as it feed bugs, worms, small mammals, fish, fruit, grain or nectar.

The study of avian feeding guilds (omnivore, carnivore, herbivore, frugivore, nectarivore, insectivore and granivore) play an important role in understanding the complexity of ecosystem structure and for providing updated information to different types of habitat in the ecosystem. Variation in vegetation structure affects the distribution of bird feeding guilds (Pearman 2002). They are warm blooded animals that have a much higher metabolism and temperature relatively high compared to human (40 degree Celsius or 105 degree Fahrenheit) but it may fluctuate according to climate, diet and activity.

Birds live in diverse habitats like deserts, mountains, forests, tundra's, near the bodies of water, cities, farm etc. Birdlife international has identified seven biomes (Alpine zone, temperate forest, sub-tropical moist forest, tropical moist forest, semiarid woodland and scrub, grassland and wetland) which support significantly high population of avian fauna in Nepal (Baral & Inskipp 2005).

Some birds migrate in regular seasonal way, often north and south along a flyway, between breeding and wintering grounds called as bird migration where as some birds does not migrate they are termed as resident bird, summer visitors are birds that arrive in spring from the south to breed, winter visitor birds that arrive in autumn from the north where the weather is milder and food is easily available and some are passage migrant are those which occur during spring and autumn to refuel and rest before moving on. Birds walk, run, hop, swim, perch, cling, fly and even dig. They lay their eggs and raise their young in holes in the ground, in nests of varying complexity in vegetation or on the ground, in holes in trees, in human-constructed nest boxes, and in or on various parts of buildings. Many birds are migratory, nesting and raising their young in temperate or higher latitudes during the warm months and spending the winter in tropical or sub-tropical areas. Birds are social, communicating with visual signals, calls, bird songs and participating in such social behaviors as cooperative breeding and hunting, flocking and mobbing of predators.

Habitat loss, degradation and fragmentation are the most important threats followed chemical poisoning, over-exploitation, climate change, hydropower, invasive species, intensification of agriculture, disturbance and limited conservation measures and research are also responsible for bird extinction (Inskipp et al. 2017) as well other threats are hunting and illegal trade. 9 species of birds are nationally protected under the National Parks and Wildlife Conservation Act-(NPWC Act 1973) and 113 birds are listed in CITES category. 55% of grassland birds of lowland Nepal are threatened, followed by 25% of wetlands birds and 24% of tropical and subtropical forest birds (Inskipp et al. 2017).

The existence of an elevational gradient of species richness has long been recognized and been studying in ecology (Stevens 1992, Lomolino 2001). Species richness is defined as the different species present in the certain area or landscape or in other word species richness is the measure of different species present in the particular area. So that elevation gradients may be the important reason for developing a theory of species diversity. Understanding the relationship between species richness and different environmental factors is an integral part of biodiversity management and conservation (Mittelbach et al. 2001). Altitudinal changes in bird species diversity provide important information on the limitation of bird species distribution pattern.

Distribution patterns of biotic communities along an elevational gradient are determined by several physical and ecological factors, which can vary with altitude, climate, and habitat structure and resource availability (Terborgh 1971 & 1977, Noon 1981, Lomolino 2001). Although patterns of species richness vary between taxa and regions, the number of species present tends to decrease with increasing altitude (Rahbek 1995 & 2005). The hump-shaped relation of species-richness to elevation, which may be the most prevalent pattern (Rahbek 1997). The altitudinal range in temperature is biologically informative, whereas range in elevation is insensitive to the strong relationship of temperature with latitude, where the strength of the altitudinal climatic gradient of any place is mediated by the regional macroclimate (Turner 2004, Hawkins 2003).

Decrease species richness with increasing elevation has been the pattern accepted by some authors (Terborgh 1977, Stevens 1992). In contrary, (Rahbek 1995) study showed that many elevational gradients have mid-elevational peaks in species richness. With respect to elevational range, some studies have found elevation ranges to be generally broader in the temperate than the tropics (Ghalambor et al. 2006, McCain 2009). The most common patterns seem to be either decreasing richness with increasing elevation or a hump-shaped pattern, in which diversity peaks at mid-elevations (Rahbek 2005). Thus, present study explores bird diversity and its distribution pattern along elevational gradients in Shivapuri Nagarjun National Park and investigating the cause that brings change in bird diversity with change in elevational range.

1.2 Objectives

1.2.1 General objective

The main aim of this study was to explore the diversity of birds along the altitudinal gradients of SNNP.

1.2.2 Specific objectives

- To investigate diversity of birds along the elevational gradients.
- To investigate bird habitat relationship.
- To determine distribution pattern of birds along the elevational gradients.

1.3 Research hypothesis

Bird diversity is affected by altitudinal gradients.

1.4 Rationale of study

Studies related to species richness along the elevation gradient in birds of Nepal are very insufficient (Paudel & Sipos 2014). Though diversity and distribution of birds are highly studied species in many national parks, including SNNP, research based on altitudinal gradient is scarce. So, this study is aimed at analyzing richness and distribution of birds considering the altitudinal factor as a major one. As well as it can provide ideas for birds conservation. It shows the relationship between birds diversity with respect to increasing elevation as well as helps in understanding present scenario of bird diversity. Therefore, this study might be a useful baseline for reference as well as for ecological planners in terms of avian species.

2. LITERATURE REVIEW

2.1 Diversity of birds

In comparison to small mammals, herpeto-fauna and invertebrates, studies regarding birds along with other conservation related activities are found to be abundant (BCN 2011). Elevational range size varies among species and depends on various factors like as habitat preferences, dispersal and establishment abilities, competition, predation, local abundance and climatic conditions (Gaston 1996, McCain 2006). With increase in elevation there is a trend of decrease in species richness of birds (Chettri et al. 2001).

Basnet et al. (2006) had recorded 63 species of birds from Pashupatinath forest and 64 from Swoyambhunath forests. In contrast, environmental factors such as patch size, habitat heterogeneity, energy availability and climatic variability have been proposed as explanations for observed altitudinal gradients in diversity (Rosenzweig 1995, Korner 2000, Hawkins et al. 2003). RAMSAR sites act as important site for bird diversity or bird hotspots because nearly 25% of Nepal's birds partially or completely depend on the wetlands because more than 80% of RAMSAR sites are located in lower gradients (IUCN 2004). A large number of bird species (485) has been recorded in the Koshi Tappu and Barrage area (Baral 2005). Thakur M. L (2013) carried study in Himachal Pradesh revealed the presence of 322 species of birds belonging to 190 genera, spread over 60 families and 17 orders. Ghimire (2015) carried study in Manang district and recorded 82 species of birds in total of 19 different plots, comprising of 24 families and the largest numbers of birds were represented from Muscicapidae followed by Corvidae, Fringillidae and Phylloscopidae.

Understanding of the different species including bird diversity is an integral part of biodiversity conservation (Kremen 1992). McCain (2009) showed that climate, productivity, mass effects, species-area relationships, Mid-Domain Effects, geomorphic constraints, evolutionary history, habitat structure and human-induced disturbances have also been included as important factors contributing for the mid-elevation peaks in species richness. Kandel et al. (2018) recorded 618 bird species belonging to 19 orders, 77 families, and 41 species are identified as globally threatened species under IUCN red list status by the help of 119 literature review in Kanchenjunga landscape, Eastern Himalayas. Grimett et al. (2000) reported that almost two thirds (62%) of the 878 bird species of Nepal have been classified primarily as residents but only a small number of these birds are actually sedentary and most of them are elevational migrants over short distances. The main purpose of this study was to determine the diversity of avian species with respect to altitudinal gradients.

2.2 Bird habitat relationship

According to Tewas et al. (2004) habitat heterogeneity provides different kind of niche and diverse resources exploitation so that diversity increased (Manu & Creswell 2007). According to Katuwal (2016) the sacred forest of Swoyambhunath support more bird diversity due to its habitat heterogeneity, inspite of high human settlement and its pressure, rubbish accumulation and unmanaged forest. According to (Basnet et al. 2016) the greatest number of bird diversity was recorded in slopes which consist of heterogeneous habitats and provide many habitats for birds in Central Himalayas. Acharya et al. (2011) reported that bird species richness along an eastern Himalaya gradient was high at mid-elevational range and was found significantly correlated with primary productivity and habitat suitability.

According to (Weather 1997, Seavy 2006) birds living in dry and hot habitat showed physiological adaptation like reduced thermal conductance, lower evaporative water loss (Weathers & Greene 1998) and higher heat tolerance (Weathers 1997). Though while studying about habitat heterogeneity climate also follows it (Koh et al. 2006). Unsustainable harvesting of natural resources in the forests has decreases woodlands as well as affects vegetation structure and composition, which directly influences the occupancy and resource use patterns of birds (Chettri et al. 2005). Habitat structural complexity with respect to the habitat heterogeneity hypothesis, might explain the diversity gradients of birds (Tews et al. 2004).

2.3 Distribution pattern of birds

When the altitude goes on increasing the bird diversity goes on decreasing (Thakur 2013). Birds are better preferred for studies than other taxonomic groups in terms of their habitat preferences and elevational limits (Both et al. 2006). Acharya et al. (2011) state that mountains having broad range of elevations are ideal for the study of elevational diversities. Climatic variables are also considered as the main driver of bird diversity (McCain 2009) and temperature shows a distinct pattern which gets decreases with increasing altitude, which directly affects the physiological tolerance of birds (Currie et al. 2004, Pan et al.

2016). Patterns of species richness along elevational gradients have long been expected to have parallel patterns of species richness along latitudinal gradients (Stevens 1992).

According to (Hunter & Yonzon 1993) more species are expected at low altitudes due to the presence of large areas suitable for species or due to suitable habitat. Species richness and the composition of birds often change rapidly with elevation (Blake et al. 2000 & Williams et al. 2010) which makes these gradients well suited for studying the responses of bird communities to different environmental factors (Korner 2007, McCain 2009). The richness is assumed to monotonically decline with increasing elevation because of decreasing in productivity due to diminishing temperature which directly affect the richness (Rahbek 1995) but a recent studies shows that there is a hump shaped pattern dominant where mid-elevation point has maximum species richness than other elevational points (Herzog et al. 2005).

One study done on birds in Western Himalayas of Uttarakhand showed a pattern of hump-shaped elevational richness and was significantly correlated with species richness and vegetation structure (Joshi & Bhatt 2015). Declines in species richness pattern have been affected due to declines in forest area at higher elevations, declines in abundance and size distribution of invertebrates, competition and changes in environmental conditions (Terborgh 1971, Janes 1994) which may also indirectly affect the bird abundance. According to the study done by (Price et al. 2014) in Eastern Himalayans in songs birds, hump-shaped elevational richness pattern was reported and that elevational distributions were well-explained by resource availability. Katuwal et al. (2016) states that the comparison of elevational and seasonal effects on species richness, with respect to single species distributions, demonstrated that both elevation and season are important for the study of characteristics of bird diversity in the mountain valleys of Nepal. This study also focuses on understanding the distribution pattern of avian species with respect to altitudinal gradients.

3. MATERIALS AND METHODS

3.1 Study Area

Shivapuri Nagarjun National Park is situated in the north side of Kathmandu valley. The headquarter of the park is situated at Panimuhan village which is 12 km far from the center of Kathmandu. It was the 9th national park which was established in 2002 A.D. The highest summit of the park is Shivapuri hill which is at 2732 m (8963 ft) which is the second largest peak that surround Kathmandu valley and the lowest is 1366 m asl. Geographically Shivapuri forest located within 27° 45' to 27° 52' N latitude and 85° 16' to 85° 45' E longitude and Nagarjun forest is located within 27°43' to 27° 46' N latitude and 85° 13' to 85° 18' E longitude. The park area covers 144 km^2 but it was extended by the Nagarjun Forest Reserve covering 15 km^2 in 2009 which comprises 23 village development committees of district of Kathmandu (12), Nuwakot (nine) and Sindhupalchowk (two) districts of Nepal and in east extend to Dhading district. The watershed area is the main source of water for Kathmandu valley with several hundred thousand cubic liter of water daily. But for this study only two sites were selected i.e. Sundarijal and Panimuhan. Geographically Sundarijal is located within 27° 45' N and 85° 25' E and ranging from 1350 m to 2732 m whereas Panimuhan is located within 28° 23' 50.50 '' N and 84° 07' 32.74 '' E and ranging from 1600 m to 2732 m.

The park is located in a transition zone between subtropical and temperate climate. The annual precipitation of about 1,400 mm. falls mostly from May to September, with 80% during monsoon. Temperatures vary from 2–17 °C (36–63 °F) during the winter season, rising to 19–30 °C (66–86 °F) during the summer season. Soils of the SNNP area contain metamorphic rocks such asphyllite, limestone and dolomite, gneiss and ingratiate which are loamy on the northern aspect and sandy on the southern aspect.

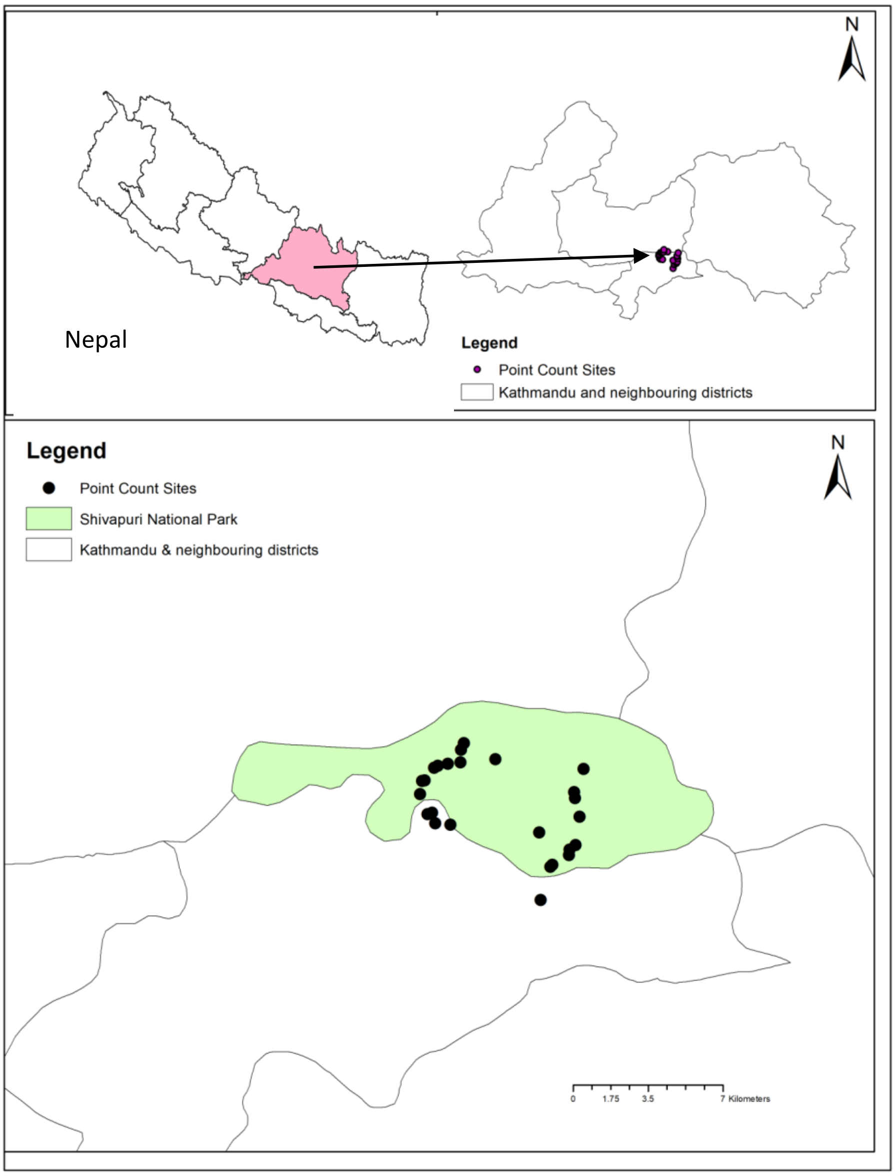

Figure 1: Location map of study area

3.1.1 Forest type

According to Shrestha (2012), vegetation has been classified into four major types such as:

(i) Lower Mixed Hardwood forests (LMHF) (1350-1500 m): dominant tree species are Chilaune (*Schima wallichi),* Dhale katus *(Castanopsis indica),*Utis *(Alnus nepalensis),* Kadam *(Anthosaphalus cadamba)* etc.

(ii) Pine Forests (PF) (1350-1600 m): dominant tree species are Khote sallo *(Pinus roxburghii),* Dhale katus *(Castanoipsis indica),* Kaphal *(Myrica esculanta),* Passi (*Pyrus pashia)* etc.

(iii) Upper Mixed Hardwood Forests (UMHF) (1500-2700 m): dominant tree species are Khasru (*Quercus semecarpifolia),* Saano jhingane *(Eurya acuminate), Iles dipyrens,* Aule chaanp *(Michelia champaka),* Laligurans *(Rhododendron arboretum), Symplocus species,* etc.

(iv) Oak Forests (OF) (2300-2700 m): dominant tree species are Karu *(Aesculus indica),*Okhar *(Juglans regia),* Lakuree *(Betulla fraxinus),* Utis *(Alnus nepalensis), Salix species, Quercus species, Celtis species* etc.

Besides these forest regions, the area was classified as Agriculture field and wetland.

- Agricultural field: It composed of land used for agriculture land or cultivation of different crops.
- Wetlands: It is a part of our landscape that are defined by the presence of water permanently or temporarily like ponds, river, marshy land etc.

3.1.2 Fauna

Ornithologists recorded 318 species of birds including Eurasian eagle-owl, Slender-billed scimitar-babbler, Barred cuckoo-dove and Golden-throated barbet by (BCN 2006).

3.2 Materials

Following tools were used for data collections

- Binoculars (20×100)
- Camera (Nikon 3000mm)
- Birds guide book (Grimmett et al. 2016)
- GPS (Garmin eTrex® 10)
- Record sheets

3.3 Data collection

3.3.1 Primary data collection

The primary data was collected by field survey using binoculars and birds guide book. The point count method was used for the data collection.

Point counts are commonly used for bird surveys in tropical forest (Lee & Marsden 2008). It is the stationary method of birds counting method widely used in surveying birds in different land uses and its types. Point counts are often widely used as important method to determine bird diversity and abundance and to assess habitat relationship and population response to environmental changes or managements (Thompson 2002). A point count consists of an observer standing at a predetermined location, usually along the road-side, and counting all birds seen or heard during a set period of time with the help of binoculars. Point counts generally take place in the early morning hours when most birds are at peak activity. Point count cannot be done if it is raining or thick fog so suitable weather must be there. This method is used for highly visible or vocal species. It is the time specific and distance specific survey.

This study was carried out from 15 June to 10 July, 2019. A total of 27 point count locations (15 point count location in Sundarijal and 12 point count location in Panimuhan) were made in every 100 m altitudinal differences and recorded all the seen and heard birds in each point count locations about 20 minutes by using binoculars. Direct observation method was used for the bird identification with the help of field guide book (Grimmett et al. 2016). The birds count was done from 6:30 am to 11 am in the morning and from 4 pm to 6 pm in the evening under favorable condition. The recorded birds were classified in different feeding guild.

3.4 Data Analysis

Data collected during field study was analyzed by using Ms-Excel in the form of pie charts, tables, bar diagram, etc. Shannon- Weiner (H) diversity index and evenness index for the diversity of the birds was calculated by using PAST. As well as species responses to different habitat were analyzed by using CANOCO version 4.56 (Ter Braak & Šmilauer 2002). The significance of the predictors was tested using Monte Carlo permutation test. For this data analysis elevation with respect to habitat type as well as distance to settlement and distance to water sources was used.

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,

$$H = -\sum (n_i/N) \log_e (n_i/N)$$

Or, if $P_i = n_i/N$

$$H = -\sum P_i \log_e P_i$$

Where,

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

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 evenly 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.

4. RESULTS

4.1 Diversity of birds

A total of 520 individuals (122 species) of birds belonging to 41 families and 12 orders were recorded in Sundarijal area. Among the recorded birds, 91 species of bird belongs to order Passeriformes, seven species belongs to Piciformes, six species belongs to Cuculiformes, four species belongs to Columbiformes and Accipitriformes, two species belongs to Coraciformes Apodiformes and Psittaciformes and one species belongs to Strigiformes, Pelecaniformes, Falconiformes and Galliformes. Similarly, the highest number of birds belongs to family Muscicapidae (21 species) followed by Sylviidae (11 species), Corvidae (eigth species), Cuculidae (six species), Paridae and Pycnonotodae (five species), Columbidae, Zosteropidae, Accipitridae and Picidae (four species), Turdidae, Megalaimidae, Nectariniidae, Leiotrichidae and Hirundinidae (three species), Scotocercidae, Psittacidae, Campephagidae, Sittidae, Sturnidae, Motacillidae, Stenostiridae, Apopidae and Passeridae (two species), Chloropseidae, Dacclonidae, Phasianidae, Aegithalidae, Vireonidae, Rhipiduridae, Phylloscopidae, Timallidae, Oriolidae, Alcedinidae, Ardeidae, Scisticolidae, Falconidae, Dicaeidae, Laniidae, Strigidae and Fringillidae (one species).

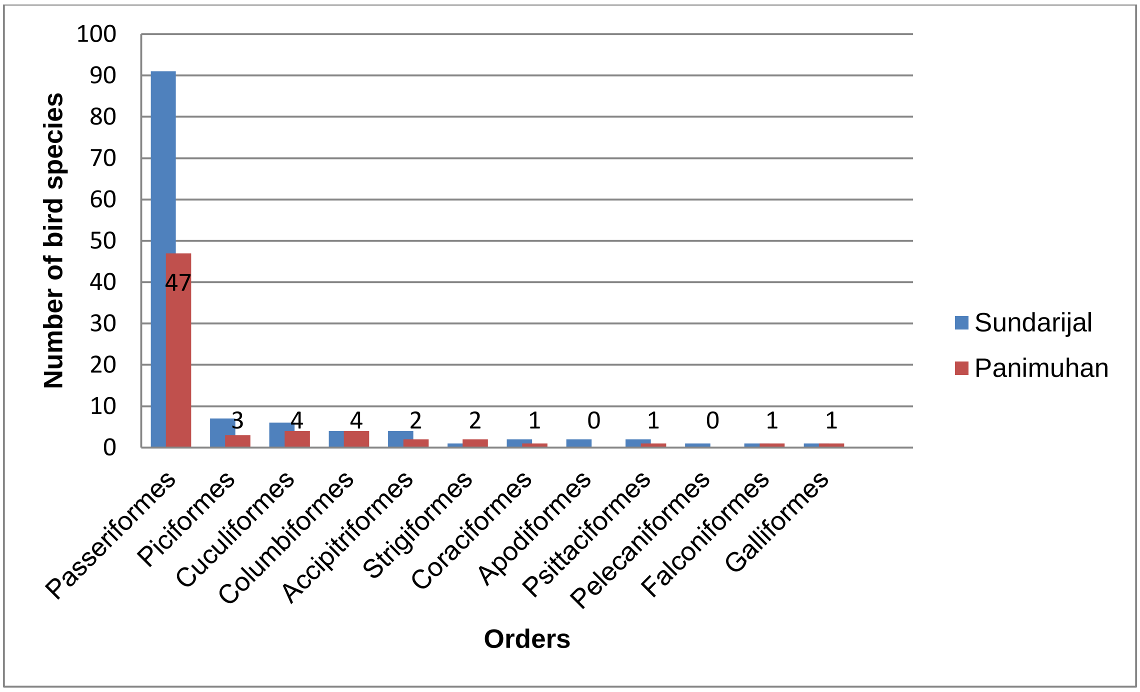

Figure 2: Taxonomic order wise species of birds in Sundarijal and Panimuhan

As well a total of 271 individuals (66 species) of birds belonging to 24 families and 10 orders were recorded in Panimuhan area. Among the recorded birds, 47 species of bird belongs to order Passeriformes, four species belongs to Cuculiformes and Columbiformes, three species belongs to Piciformes, two species belongs to Accipitriformes and Strigiformes, one species belongs to Coraciformes, Psittaciformes, Falconiformes and Galliformes. Similarly, the highest number of birds belongs to family Muscicapidae (15 species) followed by Corvidae (seven species), Sylviidae (six species), Cuculidae, Columbidae and Pycnonotodae (four species), Megalaimidae and Paridae (three species), Accipitridae, Strigidae, Zosteropidae and Turdidae (two species), Scotocercidae, Alcedinidae, Sturnidae, Falconidae, Nectariniidae, Stenostiridae, Passeridae, Phasianidae, Psittacidae, Hirundinidae, Campephagidae and Fringillidae (one species).

Table 1: Species richness along with diversity and evenness index in Sundarijal and Panimuhan

Forest	Species richness	Number of individual	Shannon's Index (H')	Evenness Index(E)
Sundarijal	122	520	2.994	0.1623
Panimuhan	66	271	2.694	0.2347

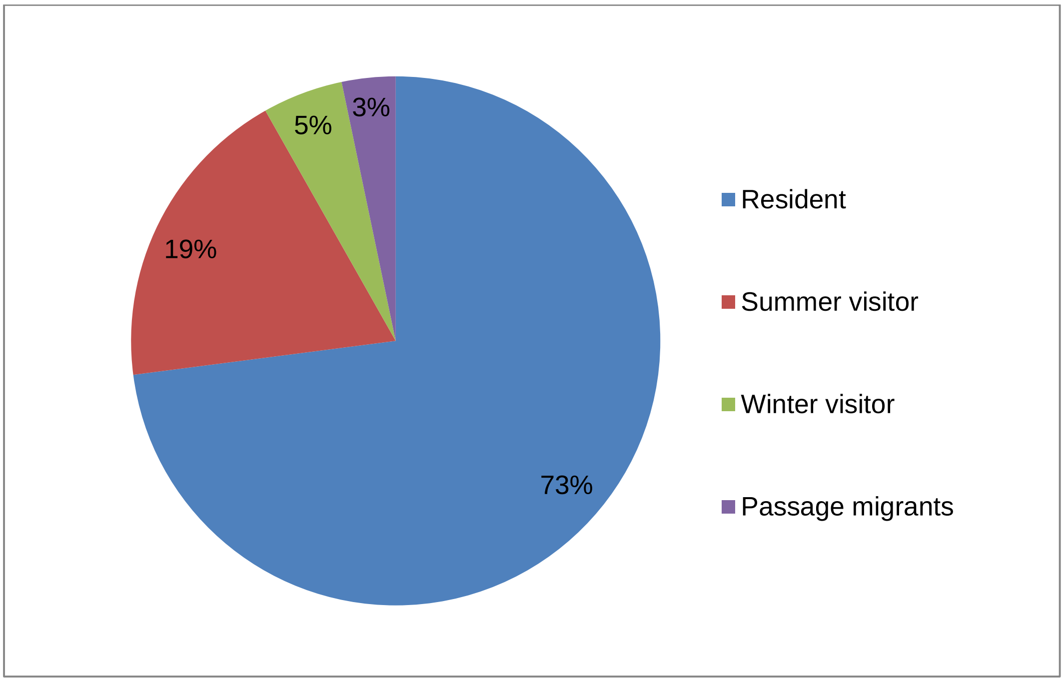

Figure 3: Residential bird status of Sundarijal

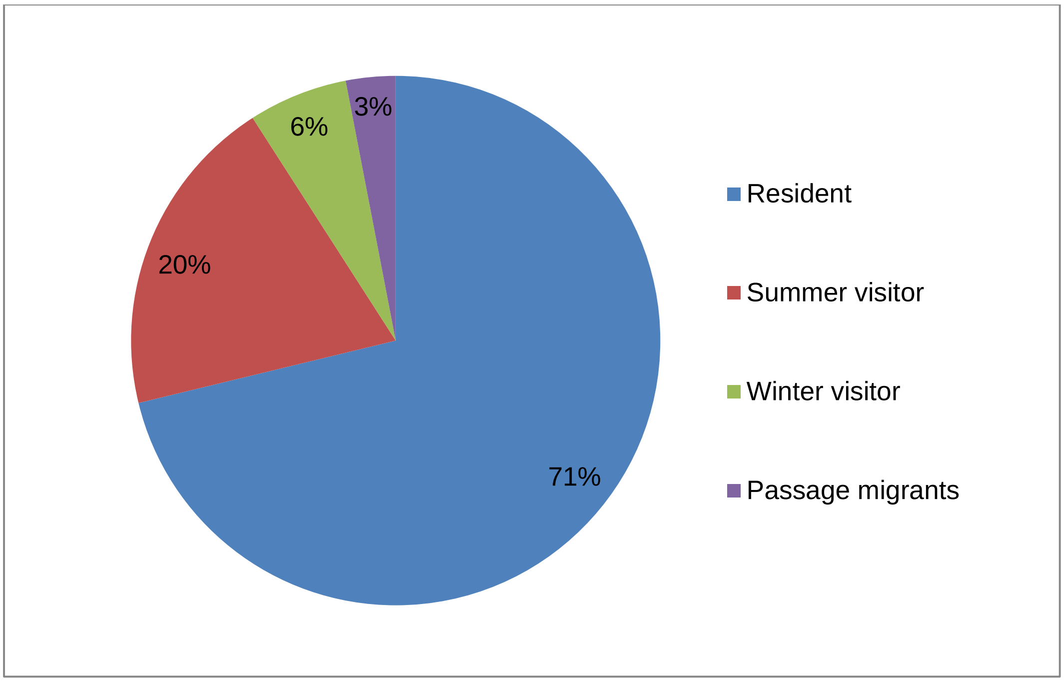

Figure 4: Residential bird status of Panimuhan

Out of total 122 species of birds 89 bird species were resident followed by 23 birds species were summer visitor, six bird species were winter visitor and four bird species were passage migrant in Sundarijal site, whereas in Panimuhan 47 bird species were resident followed by 13 summer visitor, four winter visitor and two passage migrants.

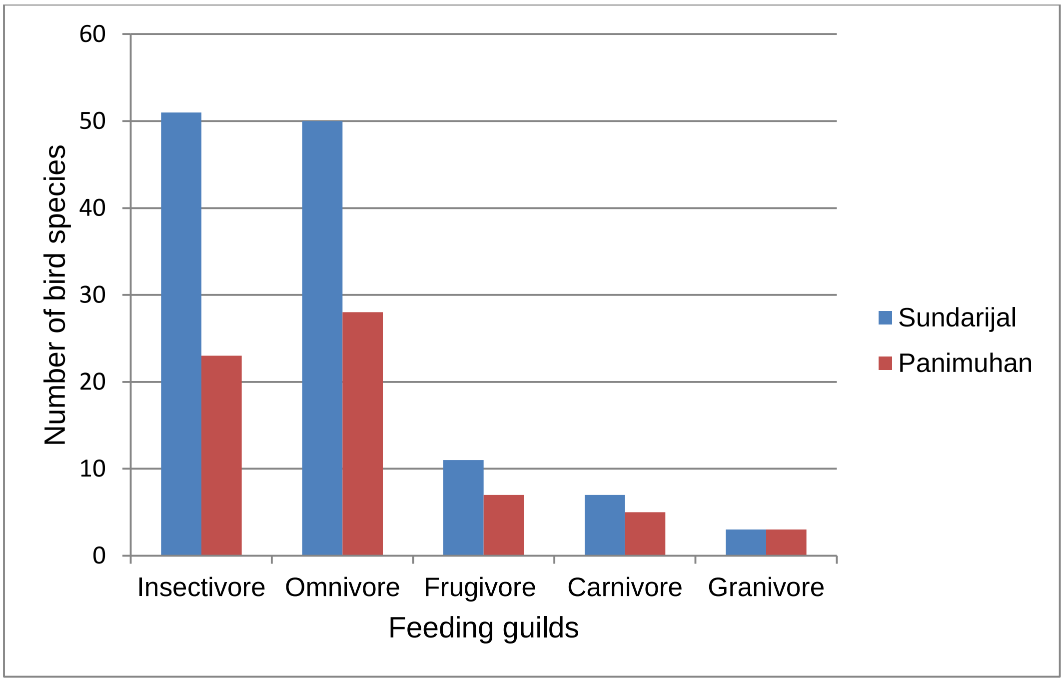

Figure 5: Bird species belonging to different feeding guild in Sundarijal and Panimuhan

The species recorded were categorized with respect to feeding guild. In Sundarijal site, insectivores were dominant species containing 51 species followed by omnivores 50 species, frugivore 11 species, carnivore seven species and least was granivore containing only three species whereas in Panimuhan site omnivore were dominant species containing 28 species followed by insectivore 23 species, frugivore seven, carnivore five species and least were granivore containing only three species.

4.2 Bird habitat relationship

In Sundarijal, maximum species richness were found in the lower mixed hardwood forest (64 species) followed by agricultural field (49 species), wetland (45 species), oak and pine forest (27 species) and minimum number of species were recorded in upper mixed hardwood forest (13 species) whereas in Panimuhan maximum species richness were found in Lower mixed hardwood forest (31 species) followed by wetland (21 species), pine forest (19 species), oak forest (15 species) and minimum number of species were recorded in upper mixed hardwood forest (11 species).

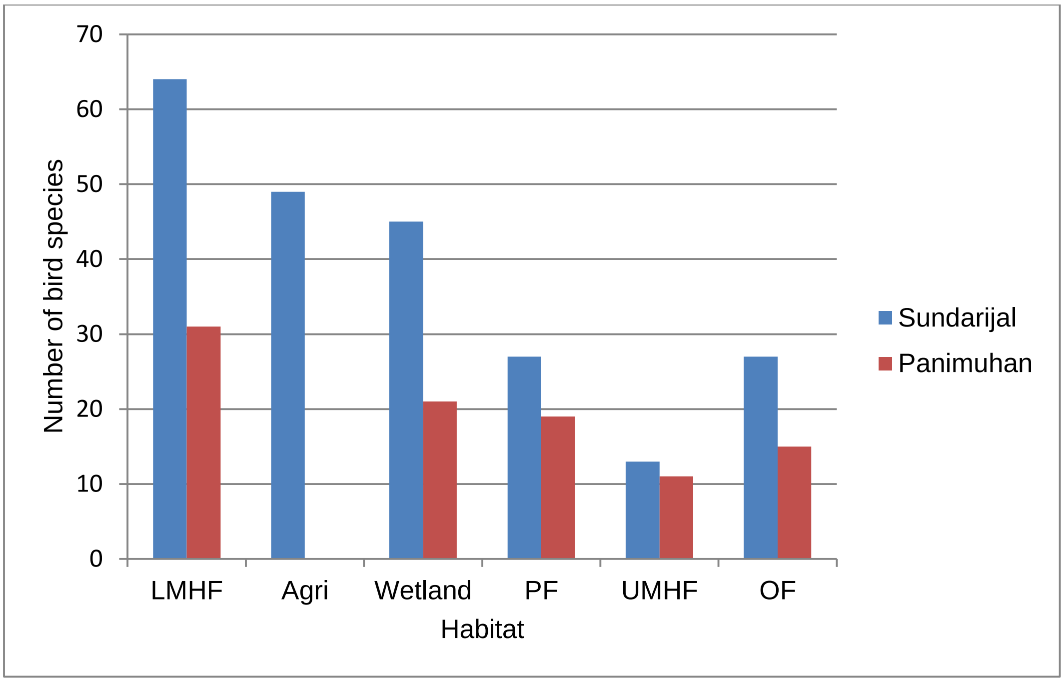

Figure 6: Bird species richness in different habitats (LMHF: Lower Mixed Hardwood Forest, Agri: Agricultural Field, PF: Pine Forest, UMHF: Upper Mixed Hardwood Forest and OF: Oak Forest) in Sundarijal and Panimuhan

4.2.1 Omnivore species response with habitat in Sundarijal

This study reveals that diversity of bird and its distribution is affected by various reasons such as habitat, elevation, distance to settlement and distance to water source. Result shows that bird species richness and diversity is positively associated with habitat and environmental variable. Omnivorous birds were significantly associated in lower mix hardwood forest, agricultural field and wetland than in pine forest, upper mixed hardwood forest and oak forest.

The birds like Common hawk cuckoo (*Hierococcyx varius*), Grey bush chat (*Saxiola ferrea*), Grey treepie (*Dendrocitta formosae*), Pied thrush (*Zosterops wardii*), Plumbeous water redstart (*Rhyacornis fuliginosus*), Spotted forktail (*Enicurus maculates*), Rock pigeon (*Columba livia*), Mountain bulbul (*Hypsipetes mcclellandii*), Large billed crow (*Corvus macrorhynchos*), House crow (*Corvus splendens*), Cattle egret (*Bubulcus ibis*), Common myna (*Acridotheres tristis*), Asian koel (*Eudynamys scolopaceus*) are some of the species confined in agricultural field, wetlands and lower mixed hardwood forest.

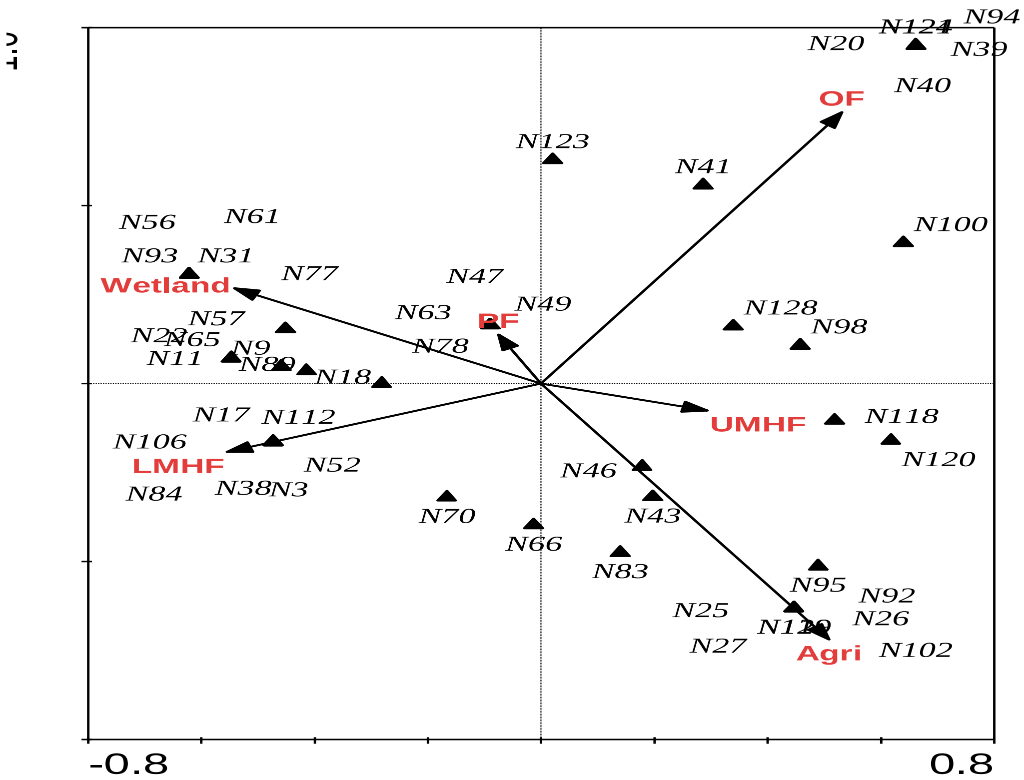

Figure 7: CCA ordination diagram (biplot) showing omnivorous birds response to different habitat types of Sundarijal. Monte-Carlo permutation test of significance of all canonical

axes: Trace=1.35, F=1.030, p= 0.324 (with 499 permutations). First two axes are displayed. The first axis accounts for 29.9% and the second axis 23.5% of the variability.

4.2.2 Insectivore species response with habitat in Sundarijal

Study reveals that insectivorous bird species richness and diversity was significantly associated to wetland, lower mixed hardwood forest, agricultural field than pine and oak forest.

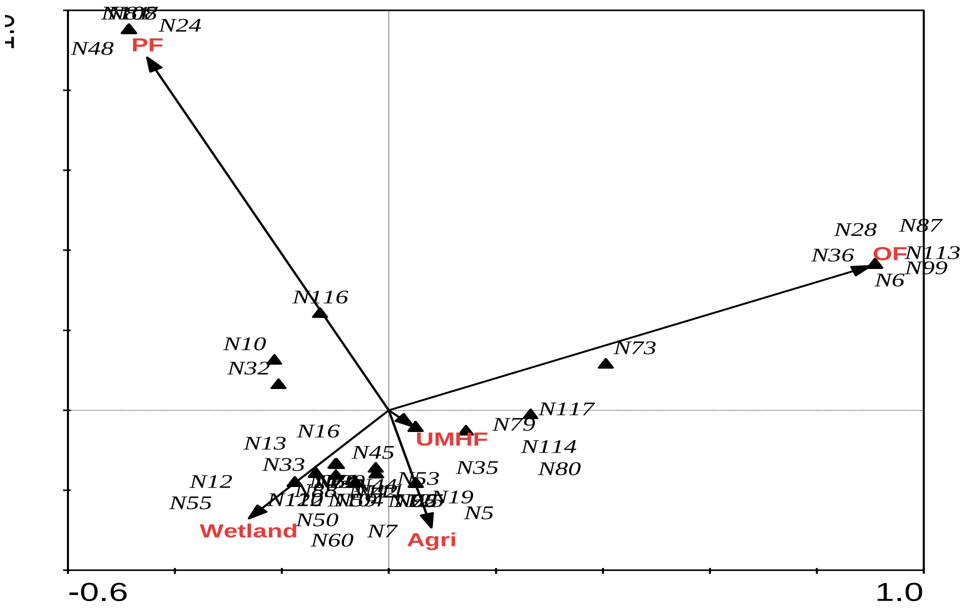

Figure 8: CCA ordination diagram (biplot) showing insectivorous birds response to different habitat types of Sundarijal. Monte-Carlo permutation test of significance of all canonical axes: Trace=2.848, F=0.957, p= 0.604 (with 499 permutations). First two axes are displayed. The first axis accounts for 26.9% and the second axis 23.9% of the variability.

4.2.3 Frugivore species response with habitat in Sundarijal

Frugivore bird species were mostly confined to agricultural field, wetland and pine forest.

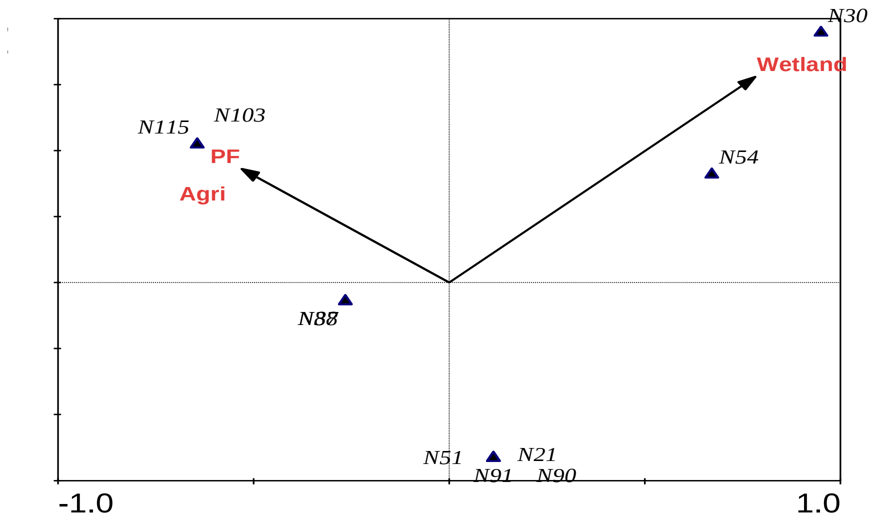

Figure 9: CCA ordination diagram (biplot) showing frugivorous birds response to different habitat types of Sundarijal. Monte-Carlo permutation test of significance of all canonical axes: Trace=1.35, F=1.357, p= 0.1460 (with 499 permutations). First two axes are displayed. The first axis accounts for 56.1% and the second axis 27.1% of the variability.

4.2.4 Omnivore species response with habitat in Panimuhan

Omnivore bird were significantly associated to Wetlands, Lower Mixed Hardwood Forest, Upper Mixed Hardwood Forest than compared to Oak Forest and Pine Forest.

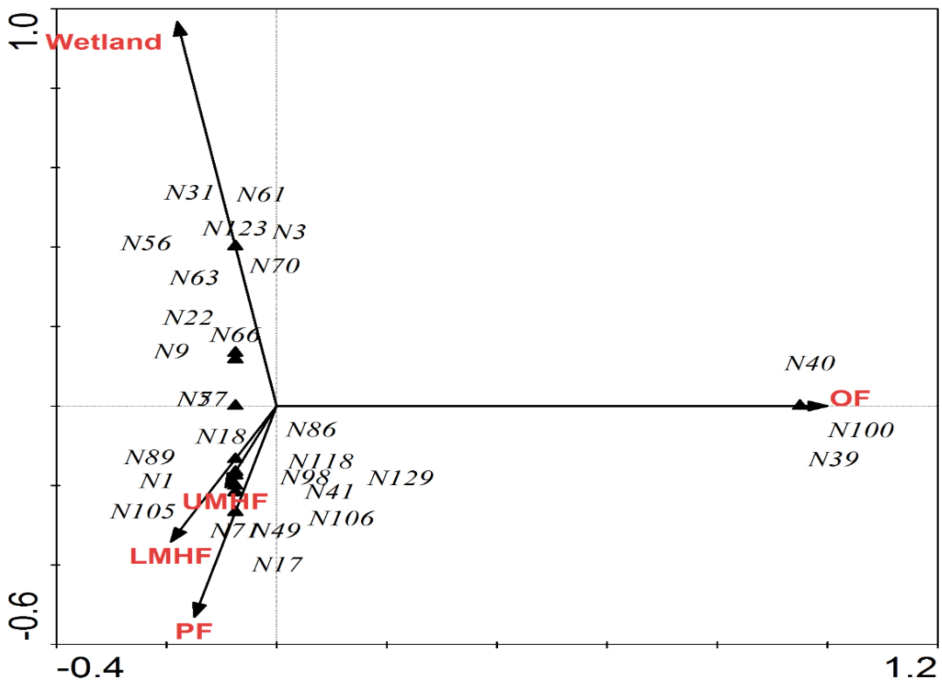

Figure 10: CCA ordination diagram (biplot) showing omnivorous birds response to different habitat types of Panimuhan. Monte-Carlo permutation test of significance of all

canonical axes: Trace=2.595, F=0.906, p= 0.5680 (with 499 permutations). First two axes are displayed. The first axis accounts for 38.5% and the second axis 26% of the variability.

4.2.5 Insectivore species response with habitat in Panimuhan

Insectivore bird species were mostly confined to lower mixed hardwood forest, upper mixed hardwood forest and oak forest than wetlands and in pine forest.

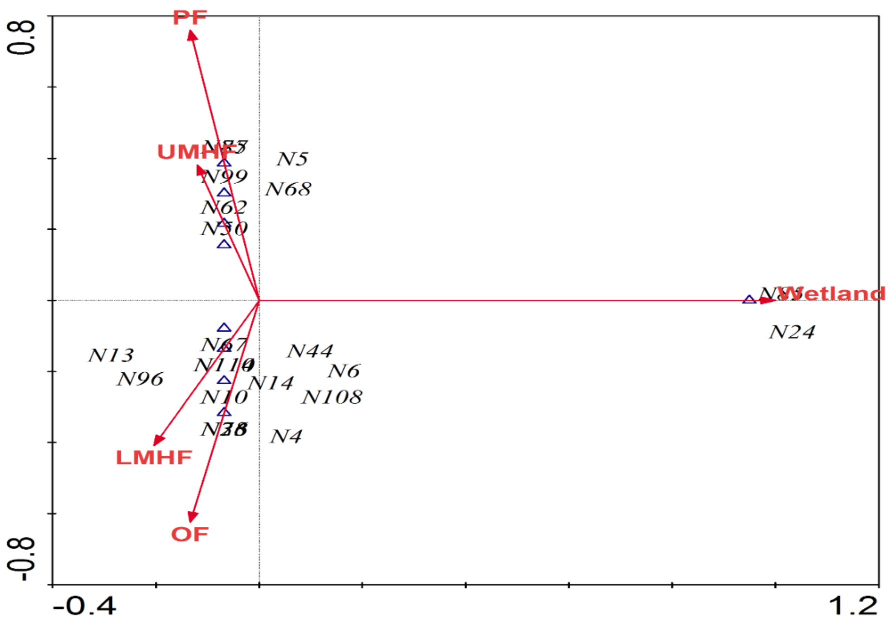

Figure 11: CCA ordination diagram (biplot) showing insectivorous birds response to different habitat types of Panimuhan. Monte-Carlo permutation test of significance of all canonical axes: Trace=2.89, F=0.978, p= 0.49 (with 499 permutations). First two axes are displayed. The first axis accounts for 34.5% and the second axis 28.6% of the variability.

4.2.6 Frugivore species response with habitat in Panimuhan

Frugivore bird species were significantly related to wetlands, lower mixed hardwood forest, oak forest and less in pine forest than other habitat.

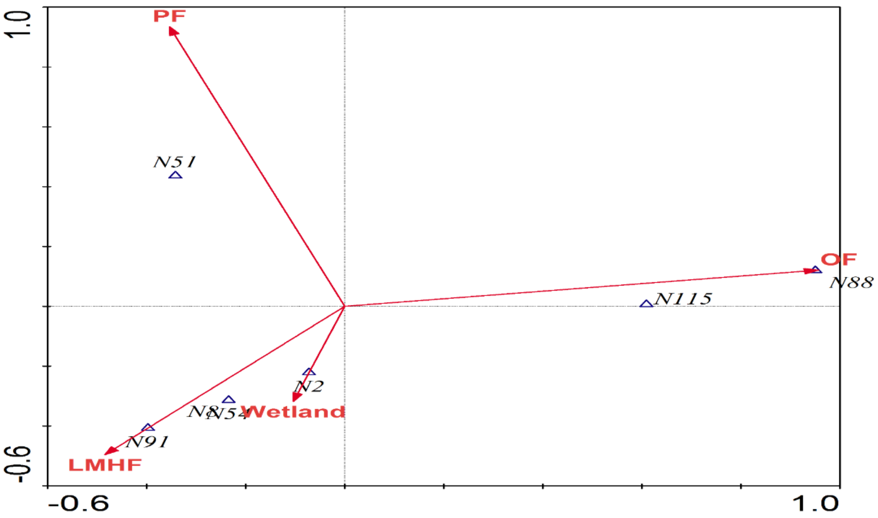

Figure 12: CCA ordination diagram (biplot) showing frugivorous birds response to different habitat types of Panimuhann. Monte-Carlo permutation test of significance of all canonical axes: Trace=1.35, F=1.357, p= 0.1460 (with 499 permutations). First two axes are displayed. The first axis accounts for 56.1% and the second axis 27.1% of the variability.

Due to insufficient or less data, CCA analysis was not possible for carnivore and granivore bird species. As this study was time limited and data were collected only in one season that might be the reason that carnivore and granivore bird species were less recorded. But recorded species were found near agricultural field or the place near human settlement.

4.3 Distribution pattern of bird species along the elevation

Bird species richness was significantly higher at 1400 m asl followed by 1300m asl and bird species richness goes on decreasing order with increasing altitude but at 2000 m asl and 2200 m asl. bird species richness get increased and again bird species richness goes on decreasing order with increasing altitude and at an elevation of 2700 m asl minimum bird species (7 species) was at recorded. The most abundant birds are Grey hooded warbler (*Seicercus xanthoschistos*), Red vented bulbul (*Pycnonotus cafer*), Himalayan bulbul (*Pycnonotus leucogenys*), Mountain bulbul (*Hypsipetes mcclellandii*), Long-tailed minivet (*Pericrocotus ethologus*), Red billed blue magpie (*Urocissa erythrorhyncha),* Grey headed canary flycatcher *(Culicicapa ceylonensis*), Blue whistling thrush (*Myophonus caeruleus*), Black lored tit (*Parus xanthogenys*), Golden throated barbet (*Megalaima franklinii*), Oriental turtle dove (*Streptopelia orientalis*), Scarlet minivet (*Pericrocotus flammeus*) and White throated laughing thrush (*Garrulux albogularis*). The rare bird species were Blue throated barbet (*Megalaima asiatica)*, Common kingfisher (*Alcedo atthis*), Common hawk cuckoo (*Hierococcyx varius*), Black faced warbler (*Abroscopus schisticeps*), Eurassian cuckoo (*Cuculus canorus)*, Indian cuckoo (*Cuculus micropterus*), Lesser yellownape (*Picus chlorophus*), Greater yellownape (*Picus flavinucha*), Asian barred owlet (*Glacidium cuculoides*), Tickells thrush (*Turdus unicolor*), Spotted owlet (*Athene brama*), Large billed crow (*Corvus macrorhynchos*), Rufous treepie (*Dendrocitta vagabunda*), Blue throated flycatcher (*Cyornis rubeculoides*) and Crimson sunbird (*Aethopyga siparaja).*

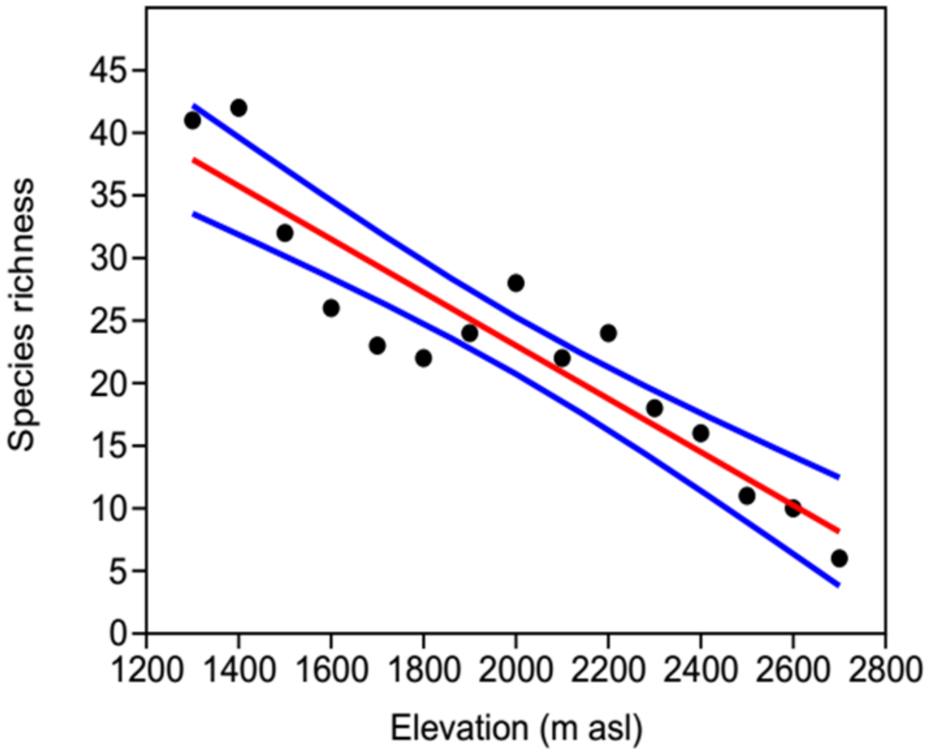

Figure 13: Distribution pattern of bird species along the elevation gradient in Sundarijal-Shivapuri peak area (r=-0.924, t= 8.73, p=0.0001 at 95% bootstrapped confidence intervals, N= 1999).

5. DISCUSSION

5.1 Diversity of bird

This study was mainly focused on the bird diversity, habitat and its distribution pattern along altitudinal gradients as well as to explore the factors affecting such distribution from around 1300 to 2700 m asl. The recent checklist of bird by (BCN 2006) had documented 318 species while this study had recorded only 130 bird species, minimum diversity was recorded that might be due to less studied site (i.e. only two sites) as well as limited time and effort and next reason might be due to applied sampling technique which doesn't have intensive effort therefore some bird like elusive or shy or small birds were not recorded so less number of bird species were recorded. In addition to this, this study was carried out only in one season that is rainy so some birds like winter migrants were not recorded.

This study showed that that bird species richness was significantly different in altitudinal gradients. Paudel and Sipos (2014) studied the birds of central Nepal and found a significant difference in bird species richness along with altitudinal gradient. Many studies have shown positive monotonic relationship between primary productivity and species richness of various plant and animal groups (Gaston 2000) does not support this result.

In this study, bird richness was maximum at 1400 m asl and minimum bird species richness was recorded at peak 2700 m asl. which showed the diversity decreases with increasing elevation. According to (Bhattarai & Vetaas 2004) there was significant decrease in plants species with increase in elevation along sub-tropical gradient in the Himalayas.

Tramer (1969) had studied in breeding bird diversity and showed that the species richness decreased with increasing elevation which is parallel to this result. Though the most commonly appeared hump shaped pattern and mid domain effect was not obtained because this study had been conducted in less number of elevation gradients as well as only one season data were recorded.

According to (Kattan & Franco 2004) due to less availability or scarcity of vegetation in higher elevation, food resources are declined. As a result, diversity of bird gets degraded. Similar trend was noticed in this study as minimum species of bird were recorded in higher elevation and Oak Forest habitat which indicates it is not so favorable for bird, which indicates that the forest, canopy cover, elevation and slope are the responsible factors for bird diversity. As well, there may be other factors too for the variation in species diversity.

In whole Nepal, (Price et al. 2011) had recorded 877 bird species, but the number of endangered species reported in this study was quite low because most of the endangered species of birds in Nepal occur either at lower altitudes or in higher altitudinal zones and this study was focused on intermediate altitudinal zones (BCN 2011). The next reason might be due to sampling technique which was not suitable for recording of rare species. In addition to this, as rare species are very elusive in nature, more effort and time is needed to record them in field. As well as this study was carried in rainy season that might be the reason for not recording of rare species. This study was based in one season only.

5.2 Bird habitat relationship

The main reason for the difference in habitat preference by bird species could be due to different vegetation types (Weller 1978) and abundant food. According to Rompre et al. (2007) bird species richness and composition are related to habitat preferences and habitat diversity. Wiens and Rotenberry (1981) also revealed that vegetation played an important role in habitat component for birds because it provides foraging opportunities, diversity of food, shelter or nesting and other conditions suitable for successful reproduction. Certain types of birds are confined to specific habitats such as agricultural fields, shrubs or forest. These ranges of habitat provided different kinds of food for various birds thus are distributed heterogeneously throughout the study region. So that with decreasing habitat heterogeneity and complexity in higher elevations, may decline bird species richness while increasing elevational gradients.

In previous study, it has been mentioned that most species were found around forest and cultivated lands (Murcia 1995) or in cultivated areas than in forest (Martin & Blackburn 2010). Most of the cultivated lands have high edge effects with high diversity in food availability and thus has huge role in distribution of birds. A greater variety of agro-ecosystem plants supports a greater diversity of insects because many insects need specific plants for food and habitat which positively influence the presence of insectivore bird species.

Birds of agricultural areas include granivore, frugivore, insectivore, carnivore, nectarivore and omnivores as well as agricultural field provides different feeding variety like grains, seeds, fruits, green vegetation, small insects etc so that birds are more confined in agricultural field in Sundarijal where as Panimuhan sites omnivore were more confined to lower elevational range. Standing crops also provide shelter to a variety of resident birds and also attract the migratory species (Sivaperuman et al. 2007).

Omnivore bird species often change their diet seasonally for whatever food sources are most readily available like insects, crops, ripen fruits and grain in the spring and summer where as in winter, any available food could be eaten and birds may even eat nuts or grains. Omnivore birds are able to utilize a wide range of available resources and are efficient at utilizing environments with diverse food sources as well they are familiar to human and trends towards the people. Therefore due to diverse kind of feeding habit and adaptability allows birds to have a wider range of choices and take advantage of more food sources for better survival, as a result presence of omnivore bird diversity was high.

In agricultural field, wide variety of crops and vegetable are grown which can provide food sources to insects, frogs, lizards, mouse and vegetable matter so that insectivore bird are highly attracted due to easy access to food. Due to this, insectivore species were confined in low elevation as well wetlands also provides insects for foraging in both sites. According to (Poulin et al. 1994, Dyrcz & Flinks 1995) insectivore birds feed a large variety of arthropod taxa.

In Sundarijal site insectivore birds richness decreased with increasing altitude and preferred agricultural field, low land in this study which is significantly associated with places at low altitudes where water is easily available (wetlands) and near agricultural field where the presence of insects are more and it's easy to forage in case of Panimuhan site insectivore were more confined to lower elevational range. Due to high protein content and easy digestibility, caterpillars comprise an optimal diet for nestling birds (Tremblay et al. 2005). Basnet et al. (2016) showed that species richness of frugivore declines at higher elevations in Nepal, similar result was found in this study.

Frugivore or nectarivore were more confined to habitat having human influences or disturb area like agricultural field which may be due to the higher number of flowering plants, different fruits plants under open conditions, as suggested by (Fraga 1989). The proportion of nectarivore bird decreases with increasing elevation or very minimum bird species were recorded in higher altitudinal range. Similar observations were also reported by (Laiolo 2003) and this study is also parallel to this statement as more species of nectarivore was obtained in agricultural field, wetlands and lower mixed hardwood Forest in Sundarijal site whereas in Panimuhan, agricultural field did not lie within the study field.

From direct observation granivore also showed a positive relationship to more disturbed and open habitat or near agricultural field might be due to availability of grains used by humans or while sundrying the grains for storing purposes or agricultural leftovers. This could be explained by the fact that forest openings generally have larger seed banks available to granivores (Diaz & Telleria 1996). According to (Jacinto et al. 2007, Elphick 2010) in agricultural field cultivation of rice, wheat and corn greatly attract granivores birds so they mostly prefer low land consisting agricultural field due to easy access to food in this study also the recorded minimum number of granivore species were found in near agricultural field.

In relative terms, higher but non-significant number of frugivores under open canopy conditions could be due to the visibility of fruit resulting from openness (Thompson & Willson 1978). Disturbances area probably plays significant role in interactions between temperate or seasonal fruits and birds and in community organization (Thomson 1978).

5.3 Distribution pattern

The study on global patterns of birds in elevational gradient shows one of the four patterns such as: 1) monotonic decreasing diversity, 2) constant at low elevations, 3) constant at low elevations but increasing towards the middle and 4) unimodal maximum at mid elevations (McCain 2009). Birds are temperature specific so that decrease in bird richness with increasing elevation might be due to more bird concentration in lower elevation. It is understood that the trend in species richness (birds) decreased monotonically with increase in elevation, following the latitudinal gradient pattern which relates to temperature decreasing with increasing elevation and consequently declining productivity (Rahbek 1995) similar pattern was observed in this study on both sites i.e Sundarijal and Panimuhan. The presence of residential birds were observed near settlement and agricultural field which were absent in higher altitude which contributed in lowering the diversity of higher elevation. In some elevational point where the settlement was present helps in residing the birds that were habitual to human settlement. Beside these in dense forest due to low visibility range as well as low frequency bird calls might be the reason for minimum number of birds recorded.

Area effects are also a commonly considered as influence on species richness patterns, in that richness tends to decline with elevation due to a decrease in available area (Rahbek 1997, Romdal & Grytnes 2007). Fleishman et al. (1998) also documented species richness decreases monotonically with elevation in butterflies. Fisher (1996) showed a monotonic decrease in ant species richness with increasing elevation. Other studies carried out in the mountains of Eastern Brazil have showed a decline in the number of bird species richness along elevational gradients (Holt 1928, Scott & Brooke 1985, Goerck 1999, Browne 2005, Mallet-Rodrigues et al. 2010). Therefore, more than one variable were responsible for the variation in species richness. It is obvious that the diversity and distribution pattern of bird varies along the elevational gradient because of numerous environmental and climatic factors.

6. CONCLUSION AND RECOMMENDATIONS

In this study, Shannon Weiner diversity index showed moderate diversity of birds in both sites. Most birds were associated with diverse habitat (like agriculture field and wetlands) which has high foraging space. Altitude gradients not only support species richness but also show some effect in distribution of different feeding guilds, as place which has broad ranges of feeding guild has recorded high bird diversity.

Based upon my study, I have following recommendations for further studies which are as follows:

- It is recommended that seasonal bird survey can be done to record higher bird diversity.
- Researches based on elevational distribution of birds in Shivapuri Nagarjun National Park from several possible routes are suggested to be explored.
- Proper valuation of biodiversity should be considered for its conservation strategies.

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APPENDICES

Appendix 1. Check-list of bird with common name, scientific name, family, order, residential status and feeding guild.

Bird species	Code name	Scientific name	Family	Order	Sp account	Feeding guild
Asian koel	N1	*Eudynamys scolopaceus*	Cuculidae	Cuculiformes	Summer visitor	Omnivore
Ashy wood pigeon	N2	*Columba pulchricollis*	Columbidae	Columbiformes	Resident	Frugivore
Asian barred owlet	N3	*Glaucidium cuculoides*	Strigidae	Strigiformes	Resident	Omnivore
Ashy throated warbler	N4	*Phylloscopus maculipennis*	Sylviidae	Passeriformes	Summer visitor	Insectivore
Abberant bush warbler	N5	*Cettia flavolivaceus*	Sylviidae	Passeriformes	Winter visitor	Insectivore
Ashy drongo	N6	*Dicrurus leucophaeus*	Corvidae	Passeriformes	Summer visitor	Insectivore
Barn swallow	N7	*Hirundo rustica*	Hirundinidae	Passeriformes	Summer visitor	Insectivore
Blue throated barbet	N8	*Megalaima asiatica*	Megalaimidae	Piciformes	Resident	Frugivore
Blue whistling thrush	N9	*Myophonus caeruleus*	Muscicapidae	Passeriformes	Resident	Omnivore
Black lored tit	N10	*Parus xanthogenys*	Paridae	Passeriformes	Resident	Insectivore

Black bulbul	N11	*Hypsipetes leucocephalus*	Pycnonotodae	Passeriformes	Resident	Omnivore
Black faced warbler	N12	*Abroscopus schisticeps*	Scotocercidae	Passeriformes	Resident	Insectivore
Black drongo	N13	*Dicrurus macrocercus*	Corvidae	Passeriformes	Resident	Insectivore
Bronze drongo	N14	*Dicrurus aeneus*	Corvidae	Passeriformes	Resident	Insectivore
Black kite	N15	*Milvus migrans*	Accipitridae	Accipitriformes	Passage visitor	Carnivore
Black throated tit	N16	*Aegithalos concinnus*	Aegithalidae	Passeriformes	Resident	Insectivore
Blue rock thrush	N17	*Monticola solitaries*	Muscicapidae	Passeriformes	Winter visitor	Omnivore
Blue capped rock thrush	N18	*Monticola cinclorhynchus*	Muscicapidae	Passeriformes	Summer visitor	Omnivore
Blue throated blue flycatcher	N19	*Cyornis rubeculoides*	Muscicapidae	Passeriformes	Summer visitor	Insectivore
Black redstart	N20	*Phoenicurus ochruros*	Muscicapidae	Passeriformes	Summer visitor	Omnivore
Black throated sunbird	N21	*Aethopyga saturate*	Nectariniidae	Passeriformes	Resident	Nectarivore
Blue capped redstart	N22	*Phoenicurus caeruleocephala*	Muscicapidae	Passeriformes	Winter visitor	Omnivore
Bonellis eagle	N23	*Aquila fasciata*	Accipitridae	Accipitriformes	Resident	Carnivore
Common stonechat	N24	*Saxicola torquata*	Muscicapidae	Passeriformes	Resident	Insectivore

Chestnut bellied nuthatch	N25	*Sitta castanae*	Sittidae	Passeriformes	Resident	Omnivore
Chestnut crowned warbler	N26	*Seicercus castaniceps*	Sylviidae	Passeriformes	Summer visitors	Omnivore
Common hawk cuckoo	N27	*Hierococcyx varius*	Cucilidae	Cuculiformes	Resident	Omnivore
Chestnut headed tesia	N28	*Tesia castaneocoronata*	Scotocercidae	Passeriformes	Resident	Insectivore
Common kingfisher	N29	*Alcedo atthis*	Alcedinidae	Coraciiformes	Resident	Carnivore
Crimson sunbird	N30	*Aethopyga siparaja*	Nectariniidae	Passeriformes	Resident	Nectarivore
common myna	N31	*Acridotheres tristis*	Sturnidae	Passeriformes	Resident	Omnivore
Cattle egret	N32	*Bubulcus ibis*	Ardeidae	Pelecaniformes	Resident	Insectivore
Common tailor bird	N33	*Orthotomus sutorius*	Scisticolidae	Passeriformes	Resident	Insectivore
Common kestrel	N34	*Falco tinnunculus*	Falconidae	Falconiformes	Resident	Carnivore
Eurasian cuckoo	N35	*Cuculus caronus*	Cucilidae	Cuculiformes	Summer visitor	Insectivore
Ferruginous flycatcher	N36	*Muscicapa ferruginea*	Muscicapidae	Passeriformes	Passage visitor	Insectivore
Fire breasted flowerpecker	N37	*Dicaeum ignipectus*	Dicaeidae	Passeriformes	Resident	Frugivore
Fulvous breasted woodpecker	N38	*Dendrocops macei*	Picidae	Piciformes	Resident	Omnivore

Fired capped tit	N39	*Cephalopyrus flammiceps*	Paridae	Passeriformes	Passage visitor	Omnivore
Green tailed sunbird	N40	*Aethopyga nepalensis*	Nectariniidae	Passeriformes	Resident	Omnivore
Grey treepie	N41	*Dendrocitta formosae*	Corvidae	Passeriformes	Resident	Omnivore
Grey wagtail	N42	*Motacilla cinerea*	Motacillidae	Passeriformes	Resident	Insectivore
Green backed tit	N43	*Parus monticolus*	Paridae	Passeriformes	Resident	Omnivore
Grey headed canary flycatcher	N44	*Culicicapa ceylonensis*	Stenostiridae	Passeriformes	Summer visitor	Insectivore
Greater yellownape	N45	*Picus flavinucha*	Picidae	Piciformes	Resident	Insectivore
Grey bush chat	N46	*Saxiola ferrea*	Muscicapidae	Passeriformes	Resident	Omnivore
Grey winged blackbird	N47	*Turdus boulboul*	Turdidae	Passeriformes	Resident	Omnivore
Golden spectacled warbler	N48	*Seicercus burkii*	Sylviidae	Passeriformes	Resident	Insectivore
Grey throated babbler	N49	*Stachyris nigriceps*	Sylviidae	Passeriformes	Resident	Omnivore
Grey hooded warbler	N50	*Seicercus xanthoschistos*	Sylviidae	Passeriformes	Resident	Insectivore
Golden throated barbet	N51	*Megalaima franklinii*	Megalaimidae	Piciformes	Resident	Frugivore
Rufous bellied woodpecker	N52	*Dendrocopos hyperythrus*	Picidae	Piciformes	Resident	Omnivore
Great tit	N53	*Parus major*	Paridae	Passeriformes	Resident	Insectivore
Great barbet	N54	*Megalaima virens*	Megalaimidae	Piciformes	Resident	Frugivore

Grey bellied cuckoo	N55	*Cacomantis passerines*	Cuculidae	Cuculiformes	Summer visitor	Insectivore
House crow	N56	*Corvus splendens*	Corvidae	Passeriformes	Resident	Omnivore
Himalayan bulbul	N57	*Pycnonotus leucogenys*	Pycnonotodae	Passeriformes	Resident	Omnivore
House swift	N58	*Apus affinis*	Apodidae	Apodiformes	Resident	Insectivore
Humes warbler	N59	*Phylloscopus humei*	Sylviidae	Passeriformes	Winter visitor	Insectivore
Himalayan swiftlet	N60	*Collacalia brevirostris*	Apodidae	Apodiformes	Summer visitor	Insectivore
House sparrow	N61	*Passer domesticus*	Passeridae	Passeriformes	Resident	Omnivore
Indian blue robin	N62	*Luscinia brunnea*	Muscicapidae	Passeriformes	Summer visitor	Insectivore
Indian cuckoo	N63	*Cuculus micropterus*	Cuculidae	Cuculiformes	Summer visitor	Omnivore
Orange headed thrush	N64	*Zoothera citrine*	Muscicapidae	Passeriformes	Summer visitor	Insectivore
Jungle myna	N65	*Acridotheres fuscus*	Sturnidae	Passeriformes	Resident	Omnivore
Kalij pheasant	N66	*Lophura leucomelanus*	Phasianidae	Galliformes	Resident	Omnivore
Large hawk cuckoo	N67	*Hierococcyx sparverioides*	Cuculidae	Cuculiformes	Summer visitor	Insectivore

Little forktail	N68	*Enicurrus scouleri*	Muscicapidae	Passeriformes	Resident	Insectivore
Long tailed shrike	N69	*Lanius schach*	Laniidae	Passeriformes	Resident	Insectivore
Large billed crow	N70	*Corvus macrorhynchos*	Corvidae	Passeriformes	Resident	Omnivore
Large niltava	N71	*Niltava grandis*	Muscicapidae	Passeriformes	Resident	Omnivore
Lesser yellownape	N72	*Picus chlorolophus*	Picidae	Piciformes	Resident	Insectivore
Lesser cuckoo	N73	*Cuculus poliocephalus*	Cuculidae	Cuculiformes	Summer visitor	Insectivore
Long tailed minivet	N74	*Pericrocotus ethologus*	Campephagidae	Passeriformes	Summer visitor	Insectivore
Liittle pied flycatcher	N75	*Ficedula westermanni*	Muscicapidae	Passeriformes	Summer visitor	Insectivore
Mountain hawk eagle	N76	*Spizaetus nipalensis*	Accipitridae	Accipitriformes	Resident	Carnivore
Mountain bulbul	N77	*Hypsipetes mcclellandii*	Pycnonotodae	Passeriformes	Resident	Omnivore
Maroon oriole	N78	*Oriolus traillii*	Oriolidae	Passeriformes	Resident	Omnivore
Nepal house martin	N79	*Delichon nipalensis*	Hirundinidae	Passeriformes	Resident	Insectivore
Olive backed pipit	N80	*Anthus hodgsoni*	Motacillidae	Passeriformes	Resident	Insectivore
Oriental magpie robin	N81	*Copsychus saularis*	Muscicapidae	Passeriformes	Resident	Insectivore
Oriental turtle dove	N82	*Streptopelia orientalis*	Columbidae	Columbiformes	Resident	Granivore
Oriental white eye	N83	*Zosterops palpebrosus*	Zosteropidae	Passeriformes	Resident	Omnivore
Orange billed leafbird	N84	*Chloropsis hardwickii*	Chloropseidae	Passeriformes	Resident	Omnivore

Plumbeous water redstart	N85	*Rhyacornis fuliginosus*	Muscicapidae	Passeriformes	Resident	Omnivore
Pied thrush	N86	*Zosterops wardii*	Turdidae	Passeriformes	Summer visitor	Omnivore
Pied bushchat	N87	*Saxiola caprata*	Muscicapidae	Passeriformes	Resident	Insectivore
Red billed blue magpie	N88	*Urocissa erythrorhyncha*	Corvidae	Passeriformes	Resident	Frugivore
Red vented bulbul	N89	*Pycnonotus cafer*	Pycnonotodae	Passeriformes	Resident	Omnivore
Rufous treepie	N90	*Dendrocitta vagabunda*	Corvidae	Passeriformes	Resident	Frugivore
Rose ring parakett	N91	*Psittacula krameri*	Psittacidae	Psittaciformes	Resident	Frugivore
Rufous vented yuhina	N92	*Yuhina occipitalis*	Zosteropidae	Passeriformes	Resident	Omnivore
Rock pigeon	N93	*Columba livia*	Columbidae	Columbiformes	Resident	Omnivore
Rosy pipit	N94	*Anthus roseatus*	Passeridae	Passeriformes	Winter visitor	Omnivore
Rufous sibia	N95	*Heterophasia capistrata*	Sylviidae	Passeriformes	Resident	Omnivore
Red rumped swallow	N96	*Cecropis daurica*	Hirundinidae	Passeriformes	Resident	Insectivore
Steppe eagle	N97	*Aquila nepalensis*	Accipitridae	Accipitriformes	Winter visitor	Carnivore
Straited laughing thrush	N98	*Garrulux striatus*	Sylviidae	Passeriformes	Resident	Omnivore
Streaked laughing thrush	N99	*Garrulux lineatus*	Sylviidae	Passeriformes	Resident	Insectivore

Stripe throated yuhina	N100	*Yuhina gularis*	Zosteropidae	Passeriformes	Resident	Omnivore
Spotted dove	N101	*Streptopelia chinensis*	Columbidae	Columbiformes	Resident	Granivore
Streak breasted scimitar babbler	N102	*Pamotorhinus ruficollis*	Timaliidae	Passeriformes	Resident	Omnivore
Slaty headed parakeet	N103	*Psittacula himalayana*	Psittacidae	Psittaciformes	Resident	Frugivore
Slaty backed forktail	N104	*Enicurus schistaceus*	Muscicapidae	Passeriformes	Resident	Insectivore
Small niltava	N105	*Niltava macgrigoriae*	Muscicapidae	Passeriformes	Resident	Omnivore
Straited bulbul	N106	*Pycnonotus striatus*	Pycnonotidae	Passeriformes	Resident	Omnivore
Spinny babbler	N107	*Turdoides nipalensis*	Leiothrichidae	Passeriformes	Resident	Insectivore
Scarlet minivet	N108	*Pericrocotus flammeus*	Campephagidae	Passeriformes	Resident	Insectivore
Spotted owlet	N109	*Athene brama*	Strigidae	Strigiformes	Resident	Carnivore
Snowy browed flycatcher	N110	*Ficedula hyperythra*	Muscicapidae	Passeriformes	Summer visitor	Insectivore
Spotted forktail	N111	*Enicurus maculatus*	Muscicapidae	Passeriformes	Resident	Insectivore
Tickells thrush	N112	*Turdus unicolor*	Turdidae	Passeriformes	Summer visitor	Omnivore
Tickells leaf warbler	N113	*Phylloscopus affiins*	Phylloscopidae	Passeriformes	Passage visitor	Insectivore
Verditer flycatcher	N114	*Eumyias thalassina*	Muscicapidae	Passeriformes	Summer visitor	Insectivore

Wedge tailed green pigeon	N115	*Treron sphenura*	Columbidae	Columbiformes	Resident	Frugivore
White throated fantail	N116	*Rhipidura albicollis*	Rhipiduridae	Passeriformes	Resident	Insectivore
White throated laughing thrush	N117	*Garrulux albogularis*	Leiotrichidae	Passeriformes	Resident	Insectivore
Whiskered yuhina	N118	*Yuhina flavicollis*	Zosteropidae	Passeriformes	Resident	Omnivore
White tailed robin	N119	*Myiomela leucura*	Muscicapidae	Passeriformes	Summer visitor	Omnivore
White tailed nuthatch	N120	*Sitta himalayensis*	Sittidae	Passeriformes	Resident	Omnivore
White bellied Erpornis	N121	*Erpornis zantholeuca*	Vireonidae	Passeriformes	Resident	Omnivore
White capped red start	N122	*Chaimarrornis leucocephalus*	Muscicapidae	Passeriformes	Resident	Insectivore
White collared blackbird	N123	*Turdus albocintus*	Turdidae	Passeriformes	Resident	Omnivore
White browed fulvetta	N124	*Fulvetta vinipectus*	Sylviidae	Passeriformes	Resident	Omnivore
White crested laughing thrush	N125	*Garrulux leucolophus*	Leiotrichidae	Passeriformes	Resident	Insectivore
White throated kingfisher	N126	*Halcyon smyrnensis*	Dacelonidae	Coraciiformes	Resident	Carnivore

Yellow breasted green finch	N127	*Carduelis spinoides*	Fringillidae	Passeriformes	Resident	Granivore
Yellow billed blue magpie	N128	*Urocissa flaviostris*	Corvidae	Passeriformes	Resident	Omnivore
Yellow browed tit	N129	*Sylviparus modestus*	Paridae	Passeriformes	Resident	Omnivore
Yellow bellied fantail	N130	*Chelidorhynx hypoxantha*	Stenostiridae	Passeriformes	Summer visitor	Insectivore

Appendix 2. Photoplates

Photo 1: Plumbeous water redstart (male)

Photo 2: Oriental turtle dove

Photo 3: Great tit

Photo 4: Red-billed blue magpie

Photo 5: Oriental white eye

Photo 6: Ashy drongo

Photo 7: Verditer flycatcher

Photo 8:White throated kingfisher

Photo9: White–throated laughing thrush

Photo10: Crimson sunbird

Photo 11: Blue-throated barbet

Photo 12: Blue whistling thrush

Photo 13: A researcher in field