BIRD DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN THE MANANG DISTRICT, CENTRAL 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 the sources of the information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATION

This is to recommend that the thesis entitled **"Bird diversity along an elevational gradient in the Manang region, central Nepal"** has been carried out by **Anuj Ghimire** for the partial fulfillment of the requirements for the **Degree of Masters of Science in Zoology** with special paper on **'Ecology'**. This is his original work and has been carried out under my supervision. To the best of our knowledge, this thesis work has not been submitted for any other degree in any institutions.

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2015

LETTER OF APPROVAL

On the recommendation of the supervisor Associate Prof. Dr.Mukesh Kumar Chalise, this thesis submitted byAnuj Ghimire**"Bird diversity along an elevational gradient in the Manang region, central Nepal"** is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for the Degree of Masters of Science in Zoology (Ecology).

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CERTIFICATE OF ACCEPTANCE

This thesis submitted byAnuj Ghimire entitled **"**Bird diversity along an elevational gradient in the Manang region, central Nepal**"** has been approved as a partial fulfillment of the requirements for the **Degree of Masters of Science in Zoology** (Ecology).

EVALUATION COMMITTEE

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Date: ....   Signature: ....

ABSTRACT

Species richness of birds along an elevational gradient in Himalayan region including Nepal is less explored till the present. Studying diversity and community structure of birds will help biodiversity conservation. The present study explores the patterns of diversity and distribution patterns of avian fauna in Manang region, central Nepal and also explores the factors that affect the diversity and distribution. In addition, I also tested if there is any validity of Bergmann's rule for birds in Manang region. To fulfill the above mentioned objectives, data on the distribution of bird communities were collected along an elevational gradient in two valleys in Manang, central Nepal between August and October 2014. In addition to this, I also collected data on a range of environmental variables at all sites in order to determine their association with bird diversity and species composition of bird communities. Point count method in 19 different localities each with an approximate difference of 200 meters above sea level were conducted. At each plot, birds were recorded within a circle of 50 meters radius from a fixed point in a center. Different environmental variables, such as slopes, shrubs, agricultural fields were also documented to see the affect distribution of bird species were recorded at each sampling point. To find out the determinants of bird species richness, generalized linear model (GLM) with Poisson distribution and log link function was used and multivariate analysis (Canonical Correspondence Analysis, CCA) was used to show the relationship between bird species composition and environmental variables. I found that there were 82 species of birds in total of 19 different plots, comprising of 24 families. The largest numbers of birds were represented from Muscicapidae followed by Corvidae, Fringillidae and Phylloscopidae. The highest number of birds were common (n=53) followed by scarce (n=16), frequent (n=10) and rare. Bird species richness significantly decreased with increasing elevations in the overall dataset in Manang district. Species richness of all the birds in Manang increased with the presence of forest and shrubs whereas it decreases with the increase of slope of the land. Surprisingly, there were more species of birds near the settlements in Manang. As species richness, bird composition was influenced by elevation and also other factors such as steepness of the land, presence of agricultural fields or shrubby area. It was found that the body size of the birds increased with increasing elevation ($p=0.0007$; $r^2=0.0657$), meaning that the Bergmann's rule was true for birds from Manang.

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ABBREVIATIONS

ACAP	Annapurna Conservation Area Project
DNPWC	Department of National Park and Wildlife Conservation
CBS	Central Bureau of Statistics
Asl	Above sea level
BCN	Bird conservation Nepal
ICIMOD	International Centre for Integrated Mountain Development
DHM	Nepal Department of Hydrology and Meteorology
M	Meters
CCA	Canonical Correlation Analysis
GLM	Generalized Linear Model
NTNC	Nature trust for nature conservation
VDC	Village Development Committee
Mm	millimeters
IUCN	International Union for Conservation of Nature
CITES	Convention on International Trade in Endangered Species
MDE	Mid Domain Effect
Km^2	Square kilometers
Cm	Centimeters
Df	Degree of Freedom

1. INTRODUCTION

1.1 Background

Species richness is defined as the total number of different species represented in an ecological community or a landscape, in other words species richness is the measure of number different types of animals present in a particular area. Understanding patterns of species richness is an important in conservation of particular species (Spackman and Hughes 1995).According to Hawkins et al. (2007) climate is the main factor responsible for variation in species richness. Other factors such as productivity (Mittelbach et al. 2001), historic events (Hawkins et al. 2007), isolation (Lomolino 2001) and species are effect (Rahbek 1997) have been considered responsible for various patterns of species richness. Understanding the relationship between species richness and different environmental factors is an important part in managing and preserving the biodiversity (Mittelbach et al. 2001). Körner (2003) claims that elevation gradients can provide valuable insights for developing a theory of species diversity. Understanding of the different species including bird diversity and community structure is an integral part of biodiversity conservation (Kremen 1992).

Although there are more than 120 different plausible hypotheses explaining different distribution patterns of species richness (Palmer 1994), the most common pattern which explains trend of species richness along elevation gradient is unimodalpattern (Herzog et al. 2005) as for latitudinal gradient in the world (Stevens 1992). In unimodal curve, there is the maximum species richness in the middle of the elevational gradient, which is referred to as the Mid-domain Effect or Hard Boundary Effect (Colwell and Hurtt 1994; Colwell and Lees 2000). The Mid-domain Effect (MDE) is a null model that assumes organisms are mixed up over their distributional ranges then they tend to crowd together in the center than at edges (Colwell et al. 2004). The most important hypothesis which explains the distribution of organisms is Rapport's hypothesis and it states that the latitudinal ranges of plants and animals are generally smaller at low than at high latitudes meaning that there is an expectation of higher diversity of plants in tropical regions than in other regions (Stevens

1992). The next important rule is Bergmann's rule. Bergmann's rule is an eco-graphic principle which states that within a broadly distributed taxonomic clade, populations and species of larger size are found in colder environments, and species of smaller size are found in warmer regions. In simpler words Bergmann's rule suggests that the animals that live in higher elevation or colder regions tend to have larger body compared to the similar organism that live in warmer regions. This rule was purposed by Carl Bergmann a nineteenth century German biologist. So, the understanding of morphological characteristics, behavior and adaptation of organism is important as it has an immense role in management and conservation (Caro 2007). According to Traylor (1950) 95% of the total birds species follow the Bergmann's rule. James (1970) supports this fact and claims that generally birds are larger in northern region compared to the southern. One of the most studied trends in ecology is body size variations among animals (Angilletta Jr and Dunham 2003). A general observation shows that organisms tend to be larger on the cooler regions (Mayr 1956). Ashton et al. (2000)and also Meiri and Dayan (2003) showed that among endothermic animals many mammals exhibit Bergmann's clines, along with studies from (Ashton (2002a) showed that birds follow the cline as well. These patterns were described by (Olalla-Tarraga 2007) as an evolutionary response that helps to minimize the heat loss in the colder environments. Ashton et al. (2003) showed that turtles seem to follow the Bergmann's rule while snake and lizards reverse it. Cushman et al. (1993) showed that Bergmann's rules applies to the invertebrates as well, it was supported by Arnett and Gotelli (1999).

Nepal, covering two thirds of the total Himalayan range, with a wide elevational range (60-8848 m asl) and varied bioclimatic conditions could be a unique place to carry out such studies (Grytnes and Vetaas 2002). Nepal's location at the border of Palearctic and Oriental realm enhances the diversity, along with the climatic diversity favors a high biodiversity and the eastern part of Nepal represents a global hotspot for biodiversity in the world (Mittermeier et al. 1999; Thompson 2009). Studies on species richness are mainly carried out for plants(Acharya et al. 2011,Baniya et al. 2010,Grau et al. 2007) along an elevational gradient (100-7200 m asl) but are poorly studied for animals especially birds except few, (Hunter and Yonzon 1993,Thiollay 1980) in Nepal. Currently, there are 871 species of birds in Nepal (Nepal 2012), which makes up about 8% of total birds of the World. According to (BCN and DNPWC 2011) there are 871 species of birds and out of the total five are considered threatened and more than 100 species face threat with due to destruction of their habitats (BCN and DNPWC 2011). It is important to study avian distribution to determine the factors affecting diversity and distribution of birds on different forested hills in Nepal. Thus, the present study explores the patterns of diversity and distribution patterns of avian fauna in Manang and also explore the factors that affect the diversity and distribution. To fulfill the above mentioned objectives, data on the distribution of bird communities were collected along an elevational gradient in two valleys in Manang, central Nepal. In addition to this, I also collected data on a range of environmental variables at all sites in order to determine their association with bird diversity and species composition of bird communities.

1.2 Objectives

The main objectives of the study was to explore the patterns of diversity and distribution patterns of avian fauna in Manang and also explore the factors that affect the diversity and distribution.

The specific objectives were :

- To observe diversity and distribution patterns of birds and factors affecting species richness and composition of bird Manang region, central Nepal.
- To test the validity of Bergmann's rule for birds in Manang.

1.3 Rationale of the study

Nepal is very rich in biodiversity. Out of the total species of birds found in the world, Nepal harbors 8% of the total birds (Acharya 2008). Studies related to species richness along the elevation gradient in birds of Nepal are very insufficient (Paudel and Šipoš 2014,Thiollay 1980) and the validity of Bergmann's rule has not been tested. It is very essential to understand the state of species richness of birds in a wide area, which aids in conservational work (Mittelbach et al. 2001). At present day, with rapid developmental works that has been going on in various places, it is necessary to study about the diversity of that area, which will aid in conservational activities of those particular taxa. Habitat loss and fragmentation is at maximum, and it is essential to study about the patterns of distribution and factors affecting them.

This study aims to understand the trends of species richness variation along different elevation bands in Manang district, along with the factors affecting the distribution of the birds. It also provides insights on validity of the Bergmann's rule in birds of Manang. Studying species richness of the avian fauna not only helps to determine the species present in Manang, but it will also assist in determining the factors affecting the distribution of birds in very high elevations of Himalayan range. Understanding the state and patterns of distribution of birds will help in conservation efforts of those birds' species. Birds of Manang are less studies, the last study of avian fauna dates back to (Thiollay 1980) where he has enlisted the checklist of birds of Manang. So, there is a necessity to fulfill this long temporal gap and update the status of birds in Manang district.

1.4 Limitations of the study

Although the study was carried out during 2014 in Manang region, there were few limitations during the study. They are written below:

- Size of the birds were not measured in the field but were extracted from field guide book (Grimmet et al. 2000).
- The final field was obstructed by the extreme snowfall in October 2014 caused by the Hud-Hud cyclone that reached south India.

2. LITERATURE REVIEW

2.1 Species richness and composition

The species richness and species composition of any area is associated with its habitat, elevation and other environmental factors (López-González et al. 2014). Studying the diversity and distribution along the elevational gradients can be very helpful in understanding biodiversity and also aid in conservation of that species (Hunter and Yonzon 1993). It is obvious that the diversity and distribution pattern of any species varies along the elevational gradient because of numerous environmental factors. Previous studies on species richness have considered various factors responsible for elevation pattern in species richness. Hawkins et al. (2007) suggested that climate was responsible for the species richness pattern, likewise other factors like productivity (Mittelbach et al. 2001) , species area effect (Rahbek 1997), vegetation patterns/types (MacArthur et al. 1962) and temperatures (McCain 2007) are considered responsible for the patterns along the elevation gradient.

A general pattern of decline in species richness with an increase in elevation is widely recognized. The richness is assumed to monotonically decline with increase in elevation because of decreasing productivity due to diminishing temperature (Rahbek 1995) but a recent evidence suggests that there's a hump shaped pattern dominant in such cases with maximum richness at a mid-elevation point (Herzog et al. 2005). Such patterns are repeatedly exhibited in case of avian, mammalian and herpeto fauna worldwide (Acharya et al. 2011). The study on global patterns of birds in elevational gradient showed that 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). She also showed that bird diversity on mountains where humidity is high either declines with elevation or is relatively constant over low-elevations, while on dry mountains it is unimodal or constant over a broad, low-elevation region, usually with a mid-elevation maximum (McCain 2009).

2.2 Variation in Species Richness with elevation gradient

The decreasing in species richness along the latitudinal gradient from equator to the pole has been previously elaborated by (Dobzhansky 1950). Kusnezov (1957) studied the variation amongst ant species along the latitudinal gradient, where he described that the tropics has more species which decreases along the latitudinal gradient as we move from equator to the poles. Species richness along the elevation gradient seems to follow similar pattern to that of latitudinal gradient, where same factors are used to describe the trends (MacArthur 1972, Rahbek 1997). A relation between climatic factors with latitude generally shows this pattern (Richerson and Lum 1980). Blake and Loiselle (2000) showed that species richness and community composition of the birds change promptly along elevational gradients. Birds are habitat specific and with the increasing elevation there is a trend of decrease in species richness of birds (Chettri et al. 2001). The estimation of species richness by interpolating species from a minimum to a maximum range of elevation results in sharp decrease of species richness towards the higher end of the gradient (Grytnes and Vetaas 2002). The evidence for latitudinal decrease in species richness has been known for a very long time, the elevational trends in species richness are assumed to imitate the latitudinal trends in species richness (Grytnes and Vetaas 2002). A number of studies have supported that there's a tendency of decrease in species richness with increasing elevation. It is shown by Bhattarai and Vetaas (2003) that a significant decrease in plants species with increase in elevation along sub-tropical gradient in the Himalayas. Apart from the general trend of species richness decline in high elevation (Colwell and Hurtt 1994) and (Colwell and Lees 2000) described the mid elevation peak through mid-domain effects. McCain (2004) observed a mid-domain effect among the small mammals of Costa Rica, where the increasing elevation, there was a substantial drop in species richness. Lomolino (2001) along with (Grytnes and Vetaas 2002) and (Li et al. 2009) explain that a series of different factors such as biological, climatic, spatial factors govern the mid elevation peak in species richness. Bhattarai and Vetaas (2003) found a significant relationship between species richness and climatic variables for all life forms. Physical environment along with elevation plays an important role in determining the abundance, diversity and richness patterns of any organisms (Körner and Paulsen 2004). According to (Rahbek 2005) mid elevation peak in species richness is the most common pattern. A recent study, (Herzog et al. 2005) suggested that, there's a dominant hump shaped pattern with the maximum richness being localized to a mid-elevation and further increase in elevation resulting in decrease in species richness.Bruun et al. (2006) witnessed a significant interactions between local topography, elevation Species richness, the richness diminished in case of dwarf-shrubs. McCain and Grytnes (2010) showed that there are four different types of Species richness- elevation interaction; decrease in species richness with increase in elevation, no changes in richness across low elevations, then a decreasing pattern without mid elevation or mid domain effect and lastly a unimodal pattern with mid elevation peak. The species richness of birds in Himalayas tends to be high in mid-elevations, and primary productivity and factors associated with habitat results in variation in avian species richness (Acharya et al. 2011). Hu et al. (2011) claims that a monotonic decline in species richness is the most common pattern. It is emphasized by (Hortal et al. 2013) that species richness does decrease with increasing elevation but not with habitat diversity.

2.2 Bergmann's Rule in body size of Birds along Elevation gradient

Traylor (1950) suggests that ninety five percent of bird species showed a trend of increase in their body size with increase in elevation, which may be due to the colder environment on higher elevation. Mayr (1956) defines Bergmann's rule as races of warm blooded vertebrates from cooler climates tend to be larger than races of the same species from warmer climates. The decreasing temperature correlates with increasing in weight and larger wings (Rand 1961). Interspecific studies have found that larger bodied species are found on higher latitudes (Lindsey 1966,Zeveloff and Boyce 1988). Variation in size of the birds are a general trends, usually the different species of birds that vary in size geographically are larger on the northern region James (1970). Clinal variation exists amongst birds with increasing elevation which may be influenced by various selective pressures, the most important one being thermoregulation (Behle 1973,Johnston 1969). According to (Hamilton 1961) sedentary birds are most likely to follow the Bergmann's rule because migratory birds do not have to go through the selective pressures. Larger body mass corresponds to greater resistance to starvation, which can be advantageous at higher elevation where resources are scares based on different seasons (Calder 1984,Lindstedt and Boyce 1985). Blackburn and Gaston (1996) provided evidence that most of the migrant birds tend to be larger bodied and live towards the northern part. According to (Ashton 2002a,2002b) a significant relationship between larger bodied birds and higher elevation, supporting the application Bergmann's rule in avian fauna. Interspecific studies have found that larger bodied species are found on higher latitudes (Lindsey 1966,Zeveloff and Boyce 1988).Yom-Tov (2001) showed that the body mass of few bird species declined significantly from 1950 to 1999 relating it with global warming. Meiri and Dayan (2003) showed that over 72% of birds follow the Bergmann's rule. According to (Ramirez et al. 2008) Bergmann's rule applies to the new world birds. Salewski et al. (2010) along with (Van Buskirk et al. 2010) also proposed the change in body size of avian fauna in correlation with the increasing temperature, suggesting that body size tends to decrease in warmer climate.

3. MATERIALS AND METHODS

3.1 Location and Physiography

Manang extends from east to west and is situated between 28°37’56” to 28°39’55” North latitude and 83°59’83” to 84°07’97” East longitude. It is a part of trans-Himalayan region of north-central Nepal having semi-arid type of climate and phytogeography (Bhattarai et al. 2007) with an area of 2246 km^2. The elevation of Manang ranges from 1880 to 8136 meters above sea level (m asl). It covers 25% of the Annapurna Conservation Area, which is the first and the largest conservation area of Nepal (NTNC 2008). It borders Lamjung and Gorkha districts to the east, Myagdi and Mustang districts to the west, China to the north, and Kaski and Lamjung districts to the south.

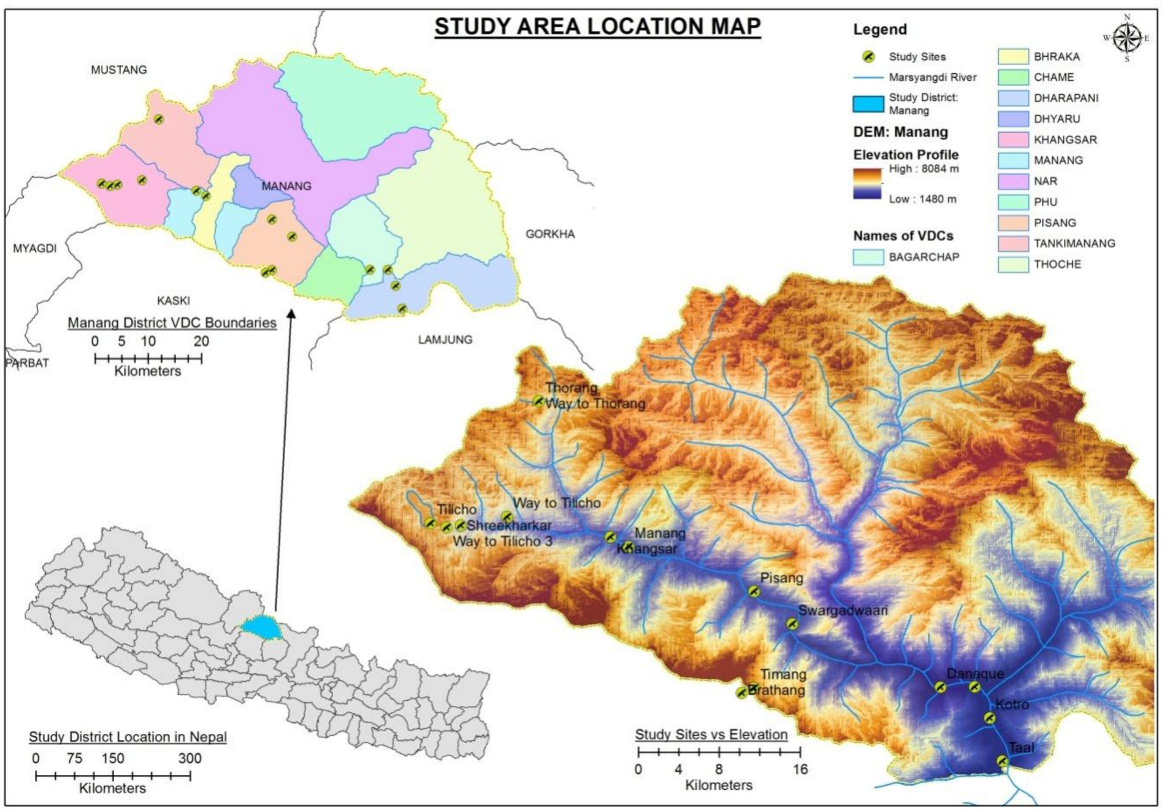

Figure 1. Map of study area, Manang Central Nepal

Manang district is distinctly divided into three board ecological-cultural zones; Nyeshang (Upper Manang), Gyasumdo (Lower Manang) and Nar-Phoo (Måren et al. 2015). The great variation in climatic conditions gives rise to a variety of vegetation types, ranging from subtropical, temperate, xerophyllous to alpine vegetation. According to (Barnekow Lillesø et al. 2005) trans-Himalayan region occupies the largest area whereas sub-tropical the least area (Fig 1)

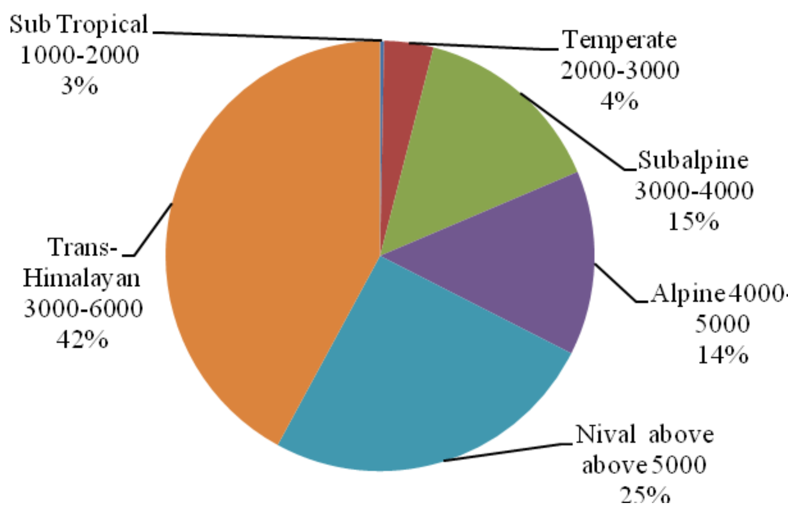

Figure 2 Physiographic divisions of Manang district, central Nepal.

Out of the total area, around 83.56% of the total area is occupied by mountain and hill, 4.58% of the total area is forest and shrubs cover, whereas grassland and lake and river cover 10.92% and 0.29% respectively. Cultivated land accounts for 0.25% of the total land. Almost one third of the area is in form a U shaped valley with Marsyangdi river running along the course of it, making it highly favorable for cultivation and settlement (Pohle 1990).The major river system of the area is Marsyangdi river, which along with its tributaries like Jharkhola, Dudhkhola and Narkhola drains from the North, from the Lake Tilicho to the south, forming longitudinal valleys. With the reference to the existing ecozones, the district can be divided into 3 valleys: Gyasumdo valley, comprising most of the southern region of the district, Nar-Phoo valley of the Northern region and Nyeshang valley occupying the western region of the district. It is part of the western development region and has 13 Village Development

Committees (VDCs). The district has it's headquarter at Chame, located at an elevation of 2680m asl.

3.2 Climate

The study area lies in the rain shadow of the Annapurna massif that acts as climatic barriers and block the monsoon clouds. As a result, the area receives less than 400 mm per year precipitation (ICIMOD 1995), occurring mostly during the monsoon season (June-September). Hence, the climate in the area is cold-temperate and relatively dry. Snow is common in winter. Soil moisture decreases from east to west in the valley, and the south facing slopes are significantly drier than those facing north (Bhattarai et al. 2004).

Climate data from the nearest Meteorological station Chame, shows that mean annual precipitation is 900 mm (Anon. 2011) The average annual rainfall of Manang, from 2003 to 2012 is 89.38 mm (DHM 2013). The maximum average temperature of the area in the same time range is 21.5 degrees Celsius in June to minimum average temperature of -3.31 Degrees Celsius in January. The average, minimum and maximum rainfall along with average temperature is shown in the figure below (Fig. 2). Due to the unavailability of the climatic data's from 2013 to present day, only the data's from 2003 to 2012 has been listed below.

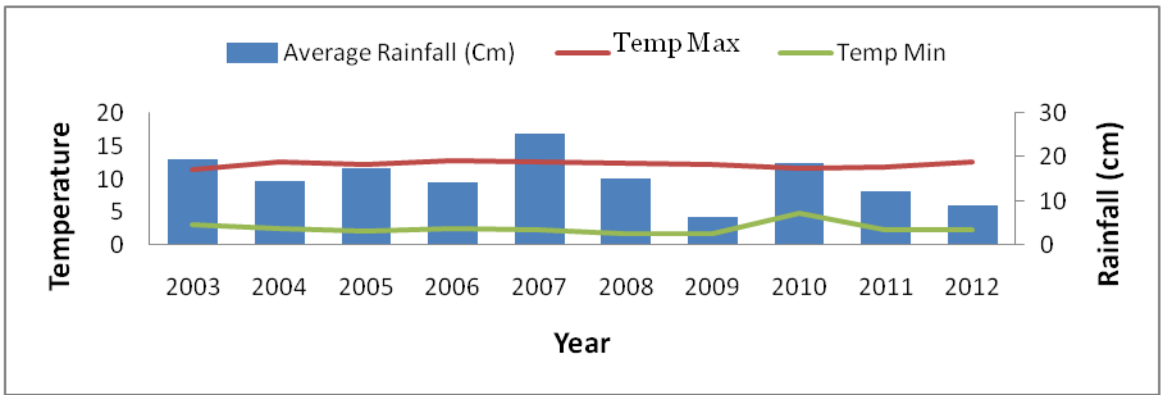

Figure 3 Average annual Temperature (Maximum and Minimum) and Rainfall (cm) of Chame, Manang (2002-2012).

3.3 Demography, Socio Economy and Culture

Majority of people living in Manang are Gurungs and the rest are Chhetree, Brahman, Magar, Tamang and Newar. The total population is 6538 and the density is 3 people per square kilometers (CBS 2012). Gyasumdo has majority of Gurungs and rest of them are Gyasumdopas. Gurungs represent a population group which is culturally oriented partly towards Tibetan Buddhist tradition and partly toward Nepalese Hindu traditions where are Gyasumdo are strictly Buddhist, with an orientation towards Tibetan Buddhism.

3.4 Vegetation of Manang

The extreme variation in attitude and landscape of Manang provide a diverse vegetation pattern. The upper valley of Manang or the Gyasumdo comprises of sub-tropical vegetation with Oak and Rhododendron in the lower belts and conifers such as *Picea smithiana* in upper region. The dominant species in the sub-tropical zone and temperate zone includes *Acacia, catechu, Hordeum vulgare, Schima wallichi, Phascolus munga, Rheum emodi* etc. Pine forest replaces those species in Nyeshang valley with an upper belt of Fir (*Abies spectabilis*) and Birch (*Betula utilis*). The south facing slopes of Marsyangdi comprises of vast number of pines and juniper forest. The vegetation pattern of Nar-phoo valley is completely different from the timberline vegetation of the other valleys, with a desert type vegetation that are rich in steppe-vegetation of Tibetan plateau. The predominant species are *Berberis, Astragalus, Junipers, Rosa, Caragana, Ephedra* etc.along with extensive grasslands.

The alpine part is dominated by grass, *Caragana* and other bushes, changing the character to the semidesert like bushland. The southern slope comprises of *Betula utilis*, Pines and Junipers.

3.5 Fauna of Manang

The fauna of Manang comprises of Himalayan Langurs *(Semnopithecus schistaceus),* Himalayan Tahr *(Hemitragus jemlahicus),* Blue sheep *(Pseudois nayaur),* Snow Leopard*(Panthera uncia*) (Khatiwada et al. 2007), Himalayan Serow *(Capricornis thar),* Large-eared Pika (*Ochotona macrotis*), Red Panda *(Ailurus fulgens),* Musk deer *(Moschus chrysogaster),*Himalayan black bear *(Selenarctos thibetanus)*, the mountain weasel (*Mustela altaica*). Recently there was a discovery of the rare Pallas Cat *(Otocolobus manul)*

(Huettmann et al. 2015)

The herpetofauna includes Kashmir *Rock Agama (Laudakia tuberculata),Himalayan Pit Viper (Gloydius himalayanus),* Northern White-Lipped Pit Viper (*Trimeresurus septentrionalis Kramer)* Himalayan Toad (*Bufo himalayanus*), Annapurna Ground Skink (*Scincella capitanea*) and Himalayan Ground Skink (*Scincella himalayanus*) (Shah and Tiwari 2004)

3.6 Research Design

3.6.1 Research Plots

The field work was carried out three times during August and October, 2014. The sample started at the lowest point of Manang named as Tal village (1400 m asl) up to Thorang la pass (5400 m asl). During the first field, I collected data from Tal to Manang (Tal-Dharapani-Bagarchap-Quiche-Danaque-Timang-Thanchok-Khodo-Chape-Bhratang-Dhikurpokhari-Pisang lower-Pisang upper-Hongde (Humde)-Mungje-Bhrakha-Manang). During the second field trip, I collected data from Tal to Thorang pass (as Tal-Dharapani-Bagarchap-Quiche-Danaque-Timang-Thanchok-Khodo-Chape-Bhratang-Dhikurpokhari-Pisang lower-Pisang upper-Hongde (Humde)-Mungje-Bhrakha-Manang-Khangsar-Tare Ghumba-Srikharkha-Pongdekharka-Tilicho base camp-Tilicho pass-Tilicho and back from Tilicho-Srikharkha-Yakharka-Thorang base-Thorang pass). The plots were set up randomly, with every 200 meters rise in elevation, which was recorded using a Gramin GPS. A fixed point count plot was setup at every sampling site. Birds were recorded from 19 different sites with an elevational ranges from 1600 to 5400 m asl (Table 1).

3.6.2 Data collection

Point counts methods was used to count the number of species of birds found in Manang(Biddy et al. 2000). Points count methods are used to estimate population densities, defining population trends, assessing habitat preferences, mostly in avian fauna (Johnson 2000). At each plot, birds were recorded within a circle of 50 meters radius from a fixed point in a center (Schulze et al. 2004). A digital range finder was used to estimate the 50 meter radius. The birds were observed using a Nikon 8 x 42 binoculars and photographed using Canon 1100 D camera. For the identification purpose, field books Birds of Nepal (Grimmet et al. 2000) was used. The birds were observed in the plot during the active time period of 6:00 Am to 9:00 am in the morning and 3:00 pm to 5:00 in the evening. The conservation status was obtained from books (BCN and DNPWC 2011) and online databases (CITES, 2015; IUCN, 2015)

Table 1 List of places in Manang where bird were observed.

S.N.	**Places**	**Elevation (m)**
1	Tal	1654
2	Kotro	1829
3	Dharapani	2033
4	Danakyu	2249
5	Timang	2404
6	Upper Timang	2608
7	Bharatang	2804
8	Dhikurpokhari	3088
9	Pisang	3247
10	Manang	3462
11	Khaansar	3638
12	Upper Khansaar	3802
13	Sreekharka	4001
14	Yak Kharka	4080
15	Upper Shreekharka	4200
16	Thorang Phedi	4480
17	Way to Thorang La	5001
18	Tilicho lake	5014
19	Thorang La Pass	5401

Different environmental variables which affect the distribution of bird species were recorded at each sampling point. The variables are described below:

Elevation: The elevation of particular sampling site was recorded using altitmeter in meters above sea level.

Slope: The inclination of each sampling site was recorded using clinomter.

Forests: It was specifically classified as land covered with trees or other woody vegetation (Stainton, 1972). There were sub temperate forest in the lower elevation to the alpine region. The presence was given a value of one and absence as zero.

- Agricultural field: It composed of land used for agriculture land or cultivation of different crops. Here too presence was given a value of one and absence as zero.
- Shrubs: It was classified as a land covered with medium sized woody plants with multiple stems and shorter height, usually under 6 meters tall.
- Open land: it generally is composed of grassland without any other tall vegetation such as trees or shrubs. Presence was given a value of one and absence as zero.
- Distance from settlement : It refers to numerical description of how far the settlement is from the sampling point. The distance was measured in meters.
- Distance from the water : It refers to numerical description of how far the water bodies like river, ponds, streams were from the sampling point. In most of the cased distance from Marsyangdi river was measure in meters.

Body size measurements were taken from the Birds of Nepal field book (Grimmet et al. 2000) since it was not possible to trap the birds and measure their body size . They were taken in centimeters (cm). In case of mentioning of body ranges, I averaged the body size to fit the study objectives.

3.7 Data Processing and Statistical Analysis

To find out the determinants of bird species richness, generalized linear model (GLM) with Poisson distribution and log link function. The analyses were carried out using S-Plus (2000). The figures were drawn using STATISTICA (Inc 2004)

Multivariate tests of species composition were carried out using unimodal technique because I have only presence/absence data (Lepš and Šmilauer 2003) and gradient length was quite long (5.24). Therefore,Canonical Correspondence Analysis (CCA) was used to show the relationship between bird species and environmental variables. The significance of the predictors was tested using Monte Carlo permutation test. All tests were carried out using Canoco 5.01 (Ter Braak and Smilauer 2012). For these data, I tested the effect of elevation, and the local habitat characteristics: forest, shrub, openland, Agricultural field, distance from settlement and distance from water and slope. Significant habitat characteristics were selected using a forward step-wise selection procedure (Leps and Smilauer, 2003).

To test the reliability of Bergmann's rule, size of different birds was plotted against the elevation. The data from all season were kept together and then were plotted on a graph to see overall pattern.

4. RESULTS

4.1 Species diversity and conservation status of birds

There were 82 species of birds in total of 19 different plots, comprising of 24 families (Table 2). During the first field 93 different types of birds were recorded and a total of 158 different types of birds were recorded during the second field. After merging the field data from both the fields, it was found that, open land type had high species richness (83) which included species such as, followed by Shrubs (53) and settlement area had the least species richness. The largest numbers of birds were represented from Muscicapidae followed by Corvidae, Fringillidae and Phylloscopidae. Passeriformes were the most abundant with Muscicapidae being most common in both fields, followed by Corvidae. Black redstart (*Phoenicurus ochruros*), Common Hoope (*Upupa epops*), Grey Backed Shrike *(Lanius tephronotus*), Large Billed Crow (*Corvus macrorhynchos*), Oriental turtle dove (Streptopelia orientalis) were most abundant in shurbs. Rufous Sibia (*Heterophasia capistrata*), White capped redstart (*Chaimarrornis leucocephalus*), White wag tail (*Motacilla alba*) were common in Open lands. Red Billed Chough (*Pyrrhocorax pyrrhocorax*), Yellow Billed Chough *(Pyrrhocorax graculus*) were the most common ones around the settlement areas in slightly higher elevation. Common Hoope (*Upupa epops*) was found from 1600 meters asl in Taal to 4200 m asl Khangsar area

The highest number of birds were common (n=53) followed by scarce (n=16), frequent (n=10) and rare. The highest numbers of birds are resident followed by summer visitors followed by winter visitors and vagrant (Table 2)

Table 2 List of families of bird species observed in the Manang district, central Nepal.

S.N	***Family***
1	Phylloscopidae
2	Accipitridae
3	Campephagidae
4	Columbidae
5	Corvidae
6	Emberizidae
7	Falconidae
8	Fringillidae
9	Hirundinidae
10	Laniidae
11	Leiothrichidae
12	Motacillidae
13	Muscicapidae
14	Nectariniidae
15	Paridae
16	Passeridae
17	Phasianidae
18	Phylloscopidae
19	Prunellidae
20	Pycnonotidae
21	Rhipiduridae
22	Sylviidae
23	Turdidae
24	Upupidae

For detail checklist of birds, refer to appendices II

4.2 Species richness

Bird species richness significantly decreased with increasing elevations in the overall dataset in Manang district (Table 2, Fig 1). Specifically, the species richness increased up to 3200 m als and declined all the way up to 5200 m asl.The highest number of species were recorded at an elevation of 3274 m asl and the lowest was above 5000 m asl at Thorang pass.

Species richness of all the birds in Manang increased with the presence of forest and shrubs whereas it decreases with the increase of slope of the land (Fig 2). Surprisingly, there were more species of birds near the settlements than far away in Manang.

Table 3 Generalized linear model (GLM) with Poisson distribution and log link function test showing the effects of different environmental factors on bird species richness in Manang region, central Nepal. Values marked in bold are significant.

	Df	**Deviance**	**Resid. Df**	**Resid. Dev**	**Pr(Chi)**	**R^2**
Altitude	1	10.58	27	93.69	**0.0011**	0.1015
Forest	1	24.10	26	69.59	**<0.001**	0.2311
Shrubs	1	8.60	25	60.99	**0.0034**	0.0825
Agricultural fields	1	0.02	24	60.97	0.8877	**-**
Slope	12	40.72	9	11.84	**0.0001**	0.3905
Distance from settlement	1	7.83	23	53.14	**0.0051**	0.0751
Distance from water	1	0.25	22	52.89	0.6150	**-**

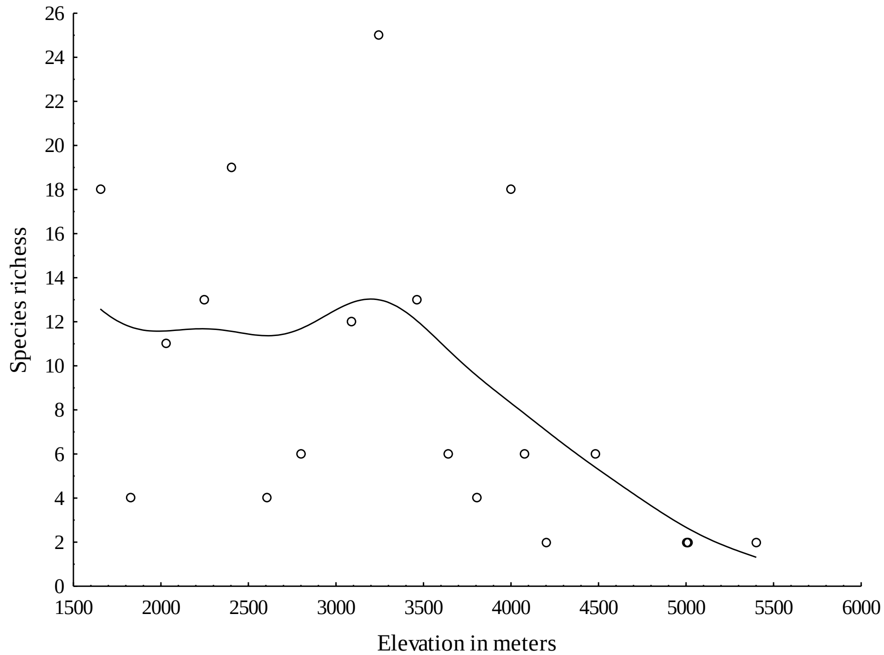

Figure 4 Relationship between bird species richness and elevation in Manang, central Nepal.

It was found that there was a significant difference in species richness of birds with increasing elevation. Starting from 1600 meters asl the species richness remained more or less similar. The richness reached a maximum point at 3200 meters asl and then started declining as the evelation increased above 3200 meters reaching a minimum of 2 species in 5400 meters asl.

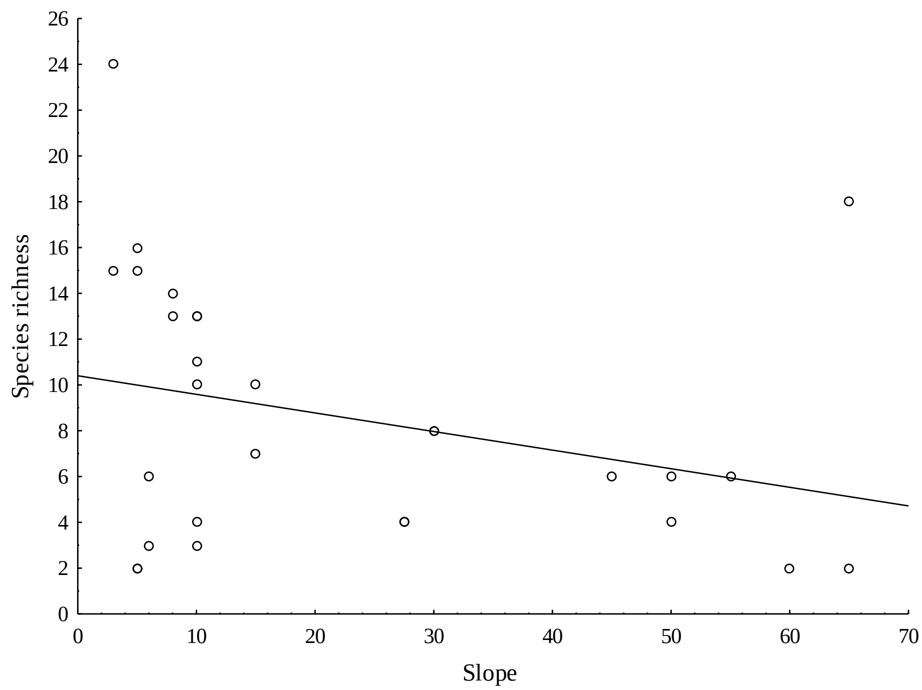

Figure 5 Relationship between slope of an area and species richness in Manang, central Nepal.

Slope also had an effect on Species richness of the birds, with increasing slopes the birds species richness declines significantly.

4.3 Species composition

Species composition was significantly affected by elevation ($p = 0.002$). The species that were recorded at the higher elevations were *Grandala coelicolor* (Gra coe), *Pyrrhocorax graculus* (Phy tro), *Columba leuconota* (Col leu), *Aquila chrysaetos* (Aqu chr), *Phoenicurus ochruros* (Pho orh). Species such as *Parus xanthogenys* (Par xan), *Phylloscopus pulcher* (Phy pul), *Enicurus scouleri* (Eni sco), *Heterophasia capistrata* (Het cap), *Motacilla alba* (Mot alb) and *Motacilla cine*rea (Mot cin) prevailed at the lower elevations (see Fig 3).

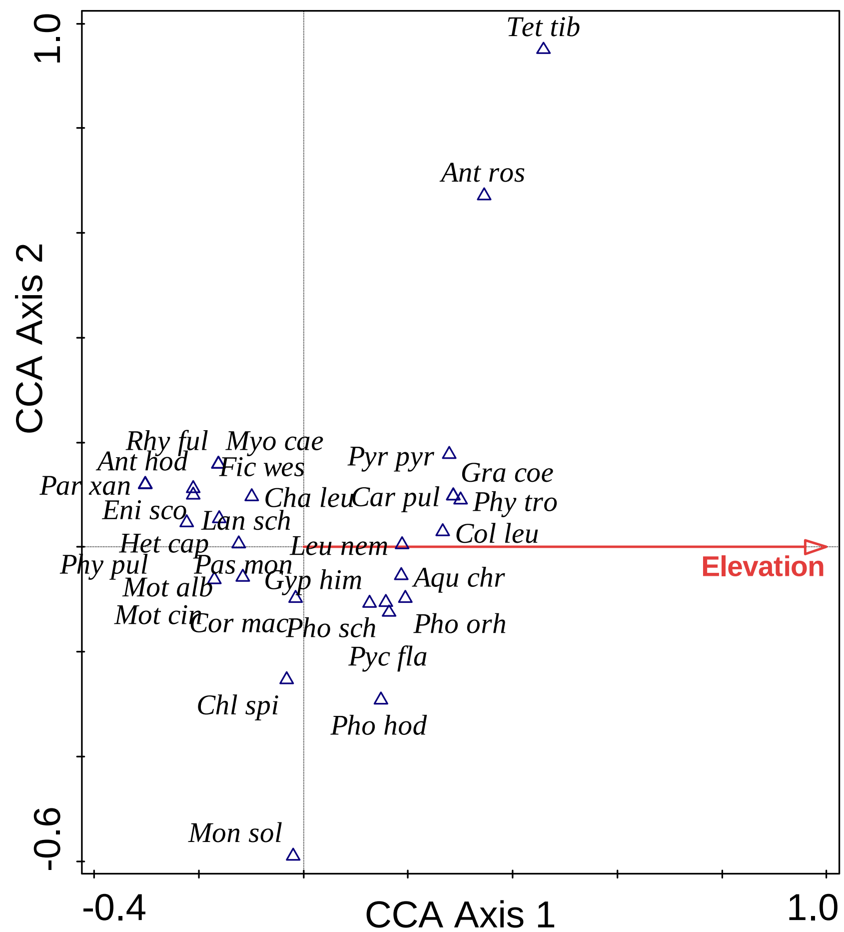

Figure 6 Relationship between the elevation and composition of birds. First axis explains 11.33 % and the second axis explains 9.91 % of the total variation in the dataset. For details of species name see Appendix 1.

Apart from elevation, presence of agricultural fields (p = 0.002, explains % = 7.0) and steepness of the land (p = 0.048, explains % = 5.6) significantly influenced the distribution of the bird communities in Manang, central Nepal. Likewise, presence of shrubs (p = 0.088, explains % = 5.6) marginally influenced the composition of bird species.

CCA diagram shows that some birds such as *Garrulax lineatus* (Gar lin), *Phylloscopushumei* (Phy hum), *Alectorischukar* (Ale chu), *Columbalivia* (Col liv), *Phoenicurus erythrogastrus* (Phe ery) and *Nucifraga caryocatactes* (Nuc car) tend to prefer areas covered with shrubs.

*Lanius tephro*notus (Lan tep), *Phoenicurus schisticeps* (Pho sch), *Aquila chrysaetos* (Aqu chr), *Delichon dasypus* (Del das) and *Motacilla flava* (Mot fla) were found in Agricultural fields whereas *Columba leuconota* (Col leu), *Phoenicurusochruros* (Pho orh), *Lanius schach* (Lan sch), *Phylloscopus trochiloides* (Pys fla), *Phylloscopus pulcher* (Phy pul), *Delichon nipalensis* (Del nip) and *Tetraogallus tibetanus* (Tet tib) were found in places with higher slopes. Birds like *Parus xanthogenys* (Par xan), *Anthus hodgsoni* (Ant hod), *Enicurus scouleri* (Eni sco), *Chaimarrornisleucocephalus* (Cha leu) and *Leucosticte nemoricola* (Leu nem) were found living in different habitats than the places with shrubs, agricultural or in steep places.

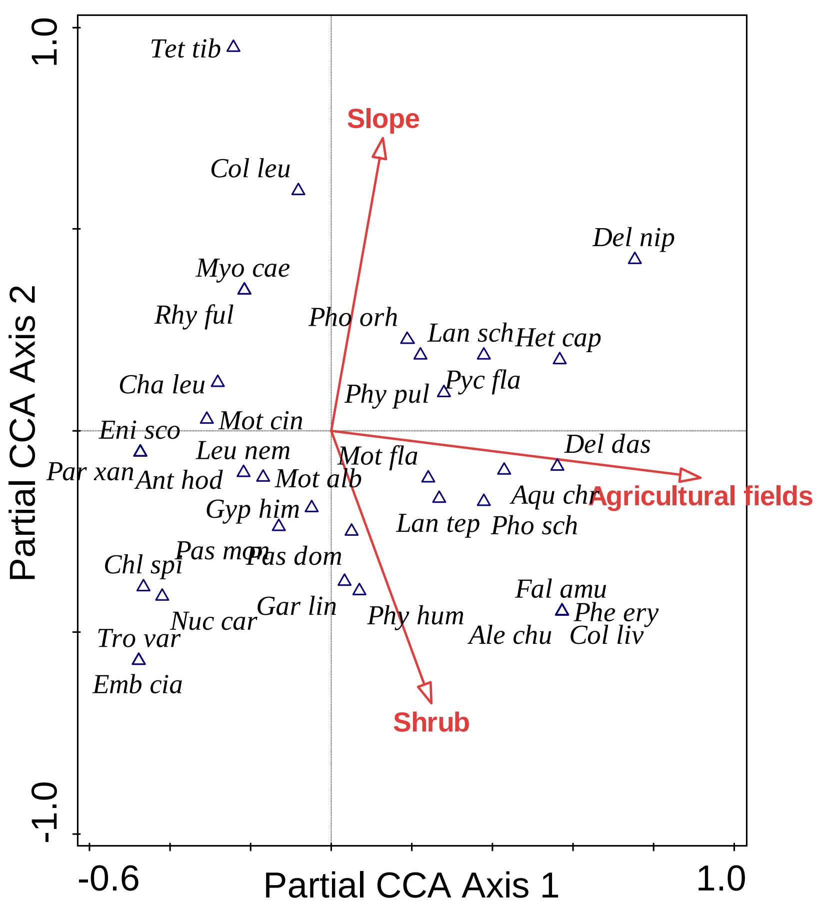

Figure 7 Relationship between different Environmental factors and composition Manang, central Nepal.

4.4 Bergmann's Rule for Birds

The smallest bird were *Carduelis carduelis* with the average size of 7.5 cm and *Leucosticte nemoricola* (average size size 9 cm) recorded in Pisang and *Prunella collaris* (average size 8.5 cm) recorded at Thorang Phedi. The largest birds were *Tetraogallus himalayensis*with the average size of 72 cm recorded in Thorang phedi, *Gyfamilips himalayensis* with average size of 62.5 cm and *Gypaetus barbatus* with average size of 57.5 cm. *Upupa epops* (Common Hoope) with the size of 31 cm was found to be distributed throughout the study areas during our field visits.

Bergmann's rule for bird was found to be true, that is the body size of birds proportionally increased with increasing elevation. Thus, I found that the body size of birds significantly (p=0.0007; r^2=0.0657) increased with increasing elevations in Manang region (Fig 5).

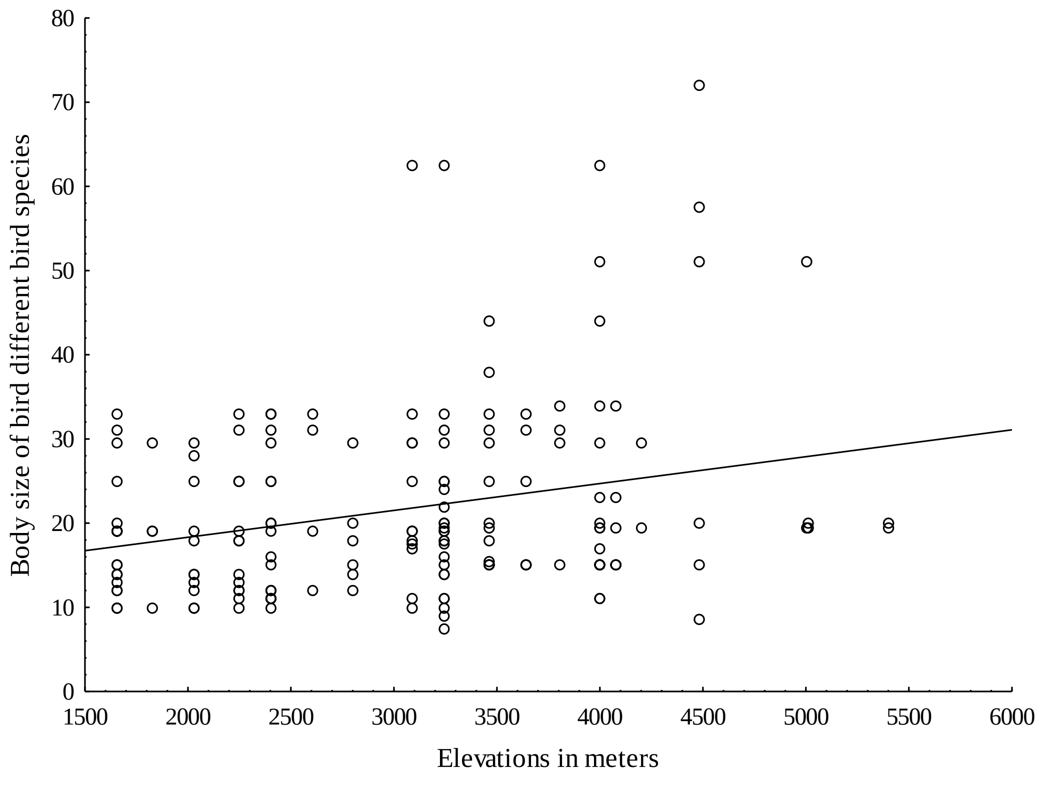

Figure 8 Relationship between body size of bird species and elevations in Manang region, central Nepal.

5. DISCUSSION

This study describes the distribution of birds in elevational ranges finds how the birds are distributed and explores the factors affecting such distribution from an elevation of around 1400 to 5400 m als. The explanations of variations in species richness and community of bird species, and also the variation of body size along an elevational range are discussed below.

5.1 Species richness and composition

A significant difference in bird species richness along the elevation gradient was observed in the previous study from Nepal for birds (Paudel and Šipoš 2014,Thiollay 1980) and in the world (McCain, 2009) and also mammals (McCain 2004) in Costa Rica. The effect of habitat diversity on the species richness and composition of bird species was previously mentioned (Rompré et al. 2007). The reasons for having less occurrences of birds in higher elevations might be due to the fact that birds are temperature specific and hence they were more concentrated in lower elevations. It is understood that the trend in species richness decreases monotonically with increase in elevation, imitating the latitudinal gradient pattern which relates to the decreasing temperature and consequently due to decline in productivity (Rahbek 1995). The trend of species richness related to productivity has also been explained in two ways, the first one states that species richness increases with increase in productivity (Brown and Lomolino 1998,Hutchinson 1959). The second explanation states that species richness increases with increasing productivity and then reaches a mid-level and decreases, forming a hump shaped pattern (Rosenzweig and Abramsky 1993,Tilman 1982). In this study, there seem to be an increase in the species richness with increasing elevations and has reached the maximum point at about 3200 meters, and from there it has continuously declined and again inclined a little bit at around 4000 meters then decreasing as we go higher than 5000 meters. This shows that productivity in Manang is not uniformly distributed as there is variation in topography and climate of the area. Variation in Nepal's avian fauna is well distributed over elevational gradient, with lesser number of species as we go higher than 5000 meters (Hunter and Yonzon 1993). Though the hump shaped pattern hasn't been achieved to the fullest, as the study has been conducted in less number elevation gradients and the mid domain effect wasn't also attained due to the same reason. This might be due to the fact that my study did not cover the elevational gradient from very low to high but was just represented from the part of whole elevational gradient in Nepal. The reason behind having peculiar pattern in my study is also due to the variable climatic factors, as suggested by in previous study (Ruggiero and Hawkins 2008). It mentions that temperature plays an important role in determining the species richness of birds.

The reason for having less species up in the higher elevation is due to the species-area relationship. It shows that the hilly or mountain areas in higher elevations provide less land than partly flat areas of valleys at low elevations (Hunter and Yonzon, 1993). The next reason could be due to the availability of sparse vegetation in higher elevations cause existence of poor food resources , thus, there are lower bird diversity in higher elevations (Kattan and Franco 2004).

In addition to elevation, this study also found that the distribution pattern was affected availability of forest. As my finding bird species richness was in dense forest areas in previous study (MacArthur and MacArthur 1961). It was suggested that there is more food in forest as tropical forest support more diversity than temperate with less food availability.

The community composition of bird is affected by elevation as in species richness. This is in agreement with the previous studies from different parts of the world (Jankowski et al. 2013,Roth et al. 2014). 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. In the 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 and Blackburn 2010) or forest as prime habitat for most of breeding birds (Trzcinski et al. 1999). Most of the cultivated lands have high edge effects with high diversity in food availability and thus has huge role in distribution of birds. The forest provides high provide high resources for many birds with specific feeding habits and also preferring particular type of habitat (Diaz and Telleria 1996).

The present study also shows that the composition of some birds differ with the steepness of slopes. This finding is similar to previous studies. The areas with shallower slopes and ecotones (transition zone between two biomes) are rich in food resources for birds and thus host different kinds of birds with high (Diaz and Telleria 1996,Melo et al. 2001).

5.2 Body size trend along the elevation gradient

This study is coherent with Bergmann's rule which is an eco-graphical principle which states that the population or species of larger size are found in colder environment or higher elevation. Many supporting evidences have come from numerous research in birds, amphibians (Ashton 2002a), reptiles, where turtles follow it and lizard and snakes reverse it (Ashton et al. 2003), mammals (Ashton et al. 2000, Blackburn and Hawkins 2004, Freckleton et al. 2003), moths and butterflies (Nylin and Svärd 1991). Ashton (2002b) suggests that majority of bird species are larger at higher elevations and colder environment. He claims that Bergmann's rule holds true for all the avian fauna throughout the world, in both cases where temperature or elevation is used as a factor affecting it. The birds species from 1600 meters asl to 5400 meters asl was studied, as it gets colder when we move up the elevation from 1600 meters, and the test for Bergmann's rule in body size of the birds in respect to increasing elevation was highly significant because the larger body will have a higher thermal inertia for cooling, which allows them to maintain heat for more time and keep a high body temperature despite the lower thermal availability

6. CONCLUSIONS AND RECOMMENDATIONS

From the present study, I found that bird species richness, composition and body size vary along an elevational gradient and distribution of birds in Manang, central Nepal.
Specifically, the following are the main conclusions:

- Most of the birds were common and least were rare types in the study area.
- Species richness was affected by the presence of forest, shrubs and slope of the land. There were more species of birds near the settlements than far away in Manang.
- Bird communities were fully influenced by elevation, presence of agricultural fields, steepness of the land and partly by the presence of shrubs in Manang.
- It was found that Bergmann's rule was true for birds from Manang, It states that the population or species of larger size are found in colder environment or higher elevation because the larger body will have a higher thermal inertia for cooling, which allows them to maintain heat for more time and keep a high body temperature despite the lower thermal availability.

Based upon my study, I have recommendations for further studies and they are as follows :

- Although there is high diversity of bird in the study area, in depth should be designed to cover more seasons with in a year and in between year.
- Though 82 species of birds were identified, there were over 100 species of birds of which small birds such as Warblers were very hard to identify on the field or photograph. Thus, one should use net to trap the small birds for proper identifications.

- During the three visits it was found that the trees were being depleted which will definitely affect the birds, so a proper management is required in the field for forest depletion.

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8. APPENDICES

I. Abbreviations of Scientific name of species for CCA

S.N	Species	Abbreviations
1	Aethopyga nipalensis	Aet nip
2	Alectoris chukar	Ale chu
3	Anthus cervinus	Ant cer
4	Anthus hodgsoni	Ant hod
5	Anthus roseatus	Ant ros
6	Anthus trivialis	Ant tri
7	Aquila chrysaetos	Aqu chr
8	Buteo buteo	But but
9	Carduelis carduelis	Car car
10	Carpodacus pulcherrimus	Car pul
11	Carpodacus puniceus	Car pun
12	Carpodacus rodochroa	Car rod
13	Carpodacus rubicilla	Car rub
14	Chaimarrornis leucocephalus	Cha leu
15	Chloris spinoides	Chl spi
16	Columba leuconota	Col leu
17	Columba livia	Col liv
18	Corvus macrorhynchos	Cor mac
19	Delichon dasypus	Del das
20	Delichon nipalensis	Del nip
21	Emberiza cia	Emb cia
22	Enicurus scouleri	Eni sco
23	Eumyias thalassinus	Eum tha
24	Falco amurensis	Fal amu
25	Ficedula strophiata	Fic str
26	Ficedula superciliaris	Fic sup
27	Ficedula tricolor	Fic tri
28	Ficedula westermanni	Fic wes
29	Fringilla coelebs	Fri coe
30	Garrulax affinis	Gar aff
31	Garrulax lineatus	Gar lin
32	Grandala coelicolor	Gra coe
33	Gypaetus barbatus	Gyp bar
34	Gyps himalayensis	Gyp him
35	Haematospiza sipahi	Hae sip
36	Heterophasia capistrata	Het cap
37	Hypsipetes leucocephalus	Hyp leu
38	Lanius schach	Lan sch
39	Lanius tephronotus	Lan tep
40	Leucosticte nemoricola	Leu nem
41	Minla strigula	Min str
42	Monticola solitarius	Mon sol
43	Motacilla alba	Mot alb

44	Motacilla cinerea	Mot cin
45	Motacilla flava	Mot fla
46	Mycerobas carnipes	Myc car
47	Myophonus caeruleus	Myo cae
48	Nucifraga caryocatactes	Nuc car
49	Parus xanthogenys	Par xan
50	Passer domesticus	Pas dom
51	Passer montanus	Pas mon
52	Pericrocotus brevirostris	Per ate
53	Pericrocotus speciosus	Per rub
54	Periparus ater	Per bre
55	Periparus rubidiventris	Per spe
56	Phoenicurus erythrogastrus	Phe ery
57	Phoenicurus hodgsoni	Pho hod
58	Phoenicurus ochruros	Pho orh
59	Phoenicurus schisticeps	Pho sch
60	Phylloscopus affinis	Phy aff
61	Phylloscopus humei	Phy hum
62	Phylloscopus occipitalis	Phy occ
63	Phylloscopus pulcher	Phy pul
64	Pycnonotus leucogenys	Phy reg
65	Pyrrhocorax graculus	Phy tro
66	Phylloscopus reguloides	Pru col
67	Phylloscopus trochiloides	Pyc fla
68	Prunella collaris	Pyc leu
69	Pycnonotus flaviventris	Pyr gra
70	Pyrrhocorax pyrrhocorax	Pyr pyr
71	Rhipidura albicollis	Rhi alb
72	Pyrrhula erythrocephala	Pyr ery
73	Rhyacornis fuliginosa	Rhy ful
74	Saxicola torquatus	Sax tor
75	Seicercus burkii	Sei bur
76	Streptopelia orientalis	Str ori
77	Trochalopteron affine	Tro aff
78	Tetraogallus himalayensis	Tet him
79	Tetraogallus tibetanus	Tet tib
80	Trochalopteron variegatum	Tro var
81	Turdus ruficollis	Tur ruf
82	Upupa epops	Upu epo

II. Checklist of birds observed in Manang

S.N.	Scientific name	Family	Common name	Location	Altitude (m)	Time of observation	Habitat	Body Size (cm)	Visiter
1	*Aethopyga nipalensis*	Nectariniidae	Green-tailed Sunbird	Timang	2404	August	Forest	11	R
2	*Alectoris chukar*	Phasianidae	Chukar Partridge	Manang	3462	August and October	Open land	38	R
3	*Anthus cervinus*	Passeridae	Red-Throared Pipit	Sreekharka	4001	October	Open land	15	R
4	*Anthus hodgsoni*	Motacillidae	Olive Backed Pipit	Tal	1654	August and October	Open land	15	V
5	*Anthus roseatus*	Passeridae	Rosy Pipit	Yak Kharka-Thorang Phedi	4080-4480	October	Open land	15	R
6	*Anthus trivialis*	Passeridae	Tree Pipit	Sreekharka	4001	October	Open land	15	R
7	*Aquila chrysaetos*	Accipitridae	Golden Eagle	Manang, shrekharka	3462, 4001	August and October	Open land	75-88	WV
8	*Buteo buteo*	Accipitridae	The Common Buzzard	Dharapani	2033	October	Forest	51-56	R
9	*Carduelis carduelis*	Fringillidae	European Goldfinch	Pisang	3247	October	Shrubby land	13-15	WV
10	*Carpodacus pulcherrimus*	Fringillidae	Beautiful Rosefinch	Sreekharka, Yakkharka	4001-4080	October	Open land	15	WV
11	*Carpodacus puniceus*	Fringillidae	Red Fronted Rose Finch	Tilicho lake	5014	October	Shrubby land	20	V
12	*Carpodacus rodochroa*	Fringillidae	Pink Browed Rose Finch	Pisang	3247	October	Shrubby land	15	R
13	*Carpodacus rubicilla*	Fringillidae	Great Rosefinch	Sreekharka	4001	October	Open land	51	R
14	*Chaimarrornis leucocephalus*	Muscicapidae	White Capped Redstart	Tal-Pisang	1654-3247	August and October	Open land	19	R
15	*Chloris spinoides*	Fringillidae	Yellow Breasted Green finch	Tal-Pisang	1654-3247	August and October	Shrubby land, forest and settlement areas	14	R
16	*Columba leuconota*	Columbidae	Snow Pigeon	Upper Khansaar, Sreekharkha, Yakharka	3802-4080	October	Open land	34	R
17	*Columba livia*	Columbidae	Rock Pigeon	Manang	3462	August and October	Open land	33	R
18	*Corvus macrorhynchos*	Corvidae	Large Billed Crow	Tal-Upper Sreekharka	1654-4200	August and October	Shrubby land, forest and open land	46-59	R
19	*Delichon dasypus*	Hirundinidae	Asian House Martin	Danakyu	2249	August and October	Agricultural field and settlement areas	12	R
20	*Delichon nipalensis*	Hirundinidae	Nepal House Martin	Dharapani	2033	August and October	Agricultural field and settlement areas	13	R
21	*Emberiza cia*	Emberizidae	Rock bunting	Pisang	3247	August and October	Open land	16	R
22	*Enicurus scouleri*	Muscicapidae	Little Forktail	Tal	1654	August and October	Shrubby land	12	R

23	*Eumyias thalassinus*	Muscicapidae	Verditer Flycatcher	Timang	2404	October	Shrubby land	15	R
24	*Falco amurensis*	Falconidae	Amur Falcon	Manang	3462	August and October	Shrubby land	28-31	R
25	*Ficedula strophiata*	Muscicapidae	Rufous Gorgotted Flycatcher	Dharapani	2033	August	Shrubby land	14	V
26	*Ficedula superciliaris*	Muscicapidae	Ultramarine Flycathcher	Timang	2404	August	Forest	12	R
27	*Ficedula tricolor*	Muscicapidae	Slaty Blue flycatcher	Danakyu	2249	August	Shrubby land	13	R
28	*Ficedula westermanni*	Muscicapidae	Little Pied Flycatcher	Tal-Timang	1654-2404	August	Open land	10	R
29	*Fringilla coelebs*	Fringillidae	Common Chaffinch	Timang	2404	October	Shrubby land	16	R
30	*Garrulax affinis*	Leiothrichidae	Black Faced Laughing Thrush	Bharatang	2804	October	Shrubby land	18	R
31	*Garrulax lineatus*	Leiothrichidae	Streaked Laughing Thrush	Timang and Pisang	2404-3247	October	Open and shrubby land	20	R
32	*Grandala coelicolor*	Muscicapidae	Grandala	Sreekharka and Yak Kharka	4001-4080	October	Open land	23	WV
33	*Gypaetus barbatus*	Accipitridae	Lammergeier	Thorang Phedi	4480	October	Open land	100-115	R
34	*Gyps himalayensis*	Accipitridae	Himalayan Griffon	Dhikurpokhari, Pisang, Sreekharka	3247-4001	August and October	Agricultural field, forest and open land	115-125	WV
35	*Haematospiza sipahi*	Fringillidae	Scarlet Finch	Danakyu	2249	August	Shrubby land	18	UR
36	*Heterophasia capistrata*	Leiothrichidae	Rufous Sibia	Dharapani - Timang	2033-2404	August and October	Forest	12	R
37	*Hypsipetes leucocephalus*	Pycnonotidae	Black bulbul	Danakyu	2249	August	Shrubby land	25	WSV
38	*Lanius schach*	Laniidae	Long Tailed Shrike	Tal-Timang	1654-2404	August and October	Agricultural field and forest	25	R
39	*Lanius tephronotus*	Laniidae	Grey Backed Shrike	Danakyu-Khangshar	2249-3638	August and October	Shrubby land, forest and open land	25	WV
40	*Leucosticte nemoricola*	Fringillidae	Plain Mountain Finch	Pisang-Sreekharka-Yakkharka	3247-4080	August and October	Shrubby land	9	R
41	*Minla strigula*	Leiothrichidae	Chestnut Tailed Minla	Dharapani	2033	October	Shrubby land	14	R
42	*Monticola solitarius*	Muscicapidae	Blue Rock Thrush	Bharatang	2804	August and October	Open land	20	SV
43	*Motacilla alba*	Motacillidae	White Wagtail	Tal-Dhikurpokhari-Kotro-Pisang	1654-3088-1829-3247	August and October	Open land	19	V
44	*Motacilla cinerea*	Motacillidae	Grey wagtail	Kotro	1829	August and October	Open land	19	R
45	*Motacilla flava*	Motacillidae	Yellow Wag tail	Dharapani-Danakyu-Dhikurpokhari	2033-3247	August and October	Open land	18	R
46	*Mycerobas carnipes*	Fringillidae	White-winged Grosbeak	Pisang	3247	October	Shrubby land	22	R
47	*Myophonus caeruleus*	Muscicapidae	Blue Whistling Thrush	Tal-Upper Timang	1654-2608	August and October	Open and shrubby land	33	R

48	*Nucifraga caryocatactes*	Corvidae	Spotted Nutcracker	Dhikurpokhari-Pisang	3088-3247	August and October	Shrubby land and forest	32-35	R
49	*Parus xanthogenys*	Paridae	Himalayan Black Lored tit	Tal	1654	August and October	Shrubby land	13	R
50	*Passer domesticus*	Passeridae	House Sparrow	Tal-Manang	1654-3462	August and October	settlement areas	15	R
51	*Passer montanus*	Passeridae	Eurassian Tree Sparrow	Tal-Pisang	1654-3247	August and October	settlement areas	14	R
52	*Pericrocotus brevirostris*	Campephagidae	Short Billed Minivet	Timang	2404	August	Agricultural field	20	R
53	*Pericrocotus speciosus*	Campephagidae	Scarlet Minivet	Timang	2404	August	Forest	20-22	R
54	*Periparus ater*	Paridae	Coal Tit	Pisang	3247	October	Shrubby land	11	R
55	*Periparus rubidiventris*	Paridae	Rufous Vented Tit	Bharatang	2804	October	Shrubby land	12	V
56	*Phoenicurus erythrogastrus*	Muscicapidae	White Winged Redstart	Manang	3462	August and October	Open land	18	WV
57	*Phoenicurus hodgsoni*	Muscicapidae	Hodgsons Redstart	Bharatang-Sreekharka	2804-4001	October	Open and shrubby land	15	R
58	*Phoenicurus ochruros*	Muscicapidae	Black Redstart	Manang-Srekharka	3462-4001	August and October	Agricultural field and open land	15	R
59	*Phoenicurus schisticeps*	Muscicapidae	White Throated Redstart	Manang-Khangshar	3462-3638	August and October	Open land	15	R
60	*Phylloscopus affinis*	Phylloscopidae	Tickell's Leaf Warbler	Timang, Pisang and Sreekharka	2404, 3247 and 4001	October	Open and shrubby land	11	R
61	*Phylloscopus humei*	Phylloscopidae	Hume's warbler	Dhikurpokhari-Pisang	3088-3247	October	Shrubby land and forest	10	WV
62	*Phylloscopus occipitalis*	Phylloscopidae	Western Crowned warbler	Danakyu	2249	October	Shrubby land	11	R
63	*Phylloscopus pulcher*	Phylloscopidae	Buff-Barred Warbler	Tal-Danakyu	1654-2249	October	Shrubby land	10	WV
64	*Phylloscopus reguloides*	Phylloscopidae	Blyth's Leaf Warbler	Timang	2404	October	Shrubby land	11	SV
65	*Phylloscopus trochiloides*	Sylviidae	Greenish Warbler		4001	October	Open and shrubby land	11	WV
66	*Prunella collaris*	Prunellidae	Alpine Accentor	Thorang Phedi	4480	October	Open land	15.5-17	R
67	*Pycnonotus flaviventris*	Pycnonotidae	Black Crested Bulbul	Tal	1654	October	Shrubby land	19	R
68	*Pycnonotus leucogenys*	Pycnonotidae	Himalayan Bulbul	Tal	1654	August	Forest	20	R
69	*Pyrrhocorax graculus*	Corvidae	Yellow Billed Chough	Manang-Tilicho lake-Thorang pass	3247-5401	August and October	Open land	37-39	R
70	*Pyrrhocorax pyrrhocorax*	Corvidae	Red Billed chough	Pisang - Thorang pass	3247-5401	August and October	Open land	36-40	R
71	*Pyrrhula erythrocephala*	Fringillidae	Red-Headed Bullfinch	Dhikurpokhari	3088	October	Forest	17	R
72	*Rhipidura albicollis*	Rhipiduridae	White Throated Fantail	Dharapani	2033	August	Shrubby land	19	R
73	*Rhyacornis fuliginosa*	Muscicapidae	Plumbeous Water Redstart	Tal, Timang and Upper Timang	1654, 2404 and 2608	August and October	Open land	12	R

74	*Saxicola torquatus*	Muscicapidae	Common Stonechat	Sreekharka	4001	October	Open land	17	WV/R
75	*Seicercus burkii*	Phylloscopidae	Golden-Spectacled Warbler	Kotro	1829	October	Shrubby land	10	R
76	*Streptopelia orientalis*	Columbidae	Oriental turtle dove	Danakyu-Khangshar	2249-3680	August and October	Shrubby land and forest	33	R
77	*Tetraogallus himalayensis*	Phasianidae	Himalayan Snowcock	Thorang Phedi	4480	October	Open land	72	R
78	*Tetraogallus tibetanus*	Phasianidae	Tibetan Snowcock	Thorang Phedi-Way to Thorang La 5001	4480-5001	October	Open land	51	R
79	*Trochalopteron affine*	Leiothrichidae	Black Faced Laughing Thrush	Pisang	3247	August	Shrubby land	18	R
80	*Trochalopteron variegatum*	Leiothrichidae	Variegated Laughing Thrush	Pisang	3247	August and October	Shrubby land	24	R
81	*Turdus ruficollis*	Turdidae	Dark Throated Thrush	Pisang	3247	October	Shrubby land	25	WV
82	*Upupa epops*	Upupidae	Common Hoope	Tal-Upper Khansaar	1654-3802	August and October	Open and shrubby land	31	R

Note: R, resident; WV, winter visitor; SV, summer visitor; V, vagrant.

III.Rainfall data of Chame, Manang

Years	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2003	40	49	115.5	DNA	40.2	137.8	113	203.8	149.4	7	0	443.3
2004	27.6	22	5	49.2	46.6	168	258.4	186	185	26	0	0
2005	89	38	100	104	80	60	239.4	309.5	21	133	0	0
2006	0	0	67	0	101	42	366.2	287	84	0	0	0
2007	7	174.1	7	146	6	180	435	438.8	250	27	0	11.7
2008	36.2	41.8	50	53	80.6	385.6	210.5	88	59.5	9	0	2
2009	0	12	49.3	0	94.3	7	68.5	141	21	86.2	0	3
2010	16.3	66.7	55	64.5	184.5	135.1	235	263.4	214.5	0	0	0
2011	11.4	18.3	37	DNA	57.7	184.5	223.5	143.4	124.8	0	7.6	0
2012	92.7	12	8	103	DNA	26.2	138.2	179.2	51	DNA	DNA	DNA
2013	DNA	DNA	DNA	DAN	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA

IV. Photo plates

The Grandala

Red Billed Chough

Snow Pigeon

Green Tailed Sunbird