Altitudinal turnover of bird diversity over an elevation gradient in the Great Himalayan National Park, Western Himalayas, India

Name: N. S. Chiranjeevi
Designation: 3rd year BS-MS student
Institute: Indian Institute of Science Education and Research Tirupati
Id Number: 201501030
PI: Dr. Vivek Ramachandran

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Introduction

Many geographic factors like precipitation, area, temperature, the presence of biogeographic barriers and elevation gradient determine the changes in biological diversity in a landscape [3]. These factors create patterns in the distribution of species, some notable ones are the mid domain effect and Rapoports's rule to name a few [4,5,10]. The relation between the latitude gradient, geographical area and the diversity of species has been studied in great detail in regions all around the world [1,2,3]. Climatic conditions are another major factor that determines the variation in species diversity. Mean Annual Temperature (MAT) and Mean Annual Precipitation (MAP) are responsible either directly, as through physiological tolerances or indirectly by affecting the primary productivity of the region. [20, 21]

Studies on latitudinal diversity gradient are common but have been conducted only in certain regions and comprise only few organisms.[25,26] There was a meta-analysis conducted on nearly 600 latitudinal gradients combined from multiple studies that has tried to study variation of diversity over large gradients between different organisms. [27]

There have also been a few studies on the altitudinal variation of species (primarily avian species) diversity, specifically in the the Central and Eastern Himalayas [6, 7]. This Himalayas are perfect for conducting a study of this kind as they have a huge elevation gradient which enables a more rigorous analysis of the variations through large changes in altitude. The study area for the research conducted in Teesta Valley, Sikkim in the Eastern Himalayas [6] spanned an elevation gradient of 4500m, one of the most extensive studies of its kind. These studies have showed that the species richness was highest at intermediate elevations. Like other studies primary productivity was an important factor responsible for the variation in species richness.

The study in the Central Himalayas in the Mount Qomolangma National Nature Reserve, China spanned an elevation gradient of 3600m. The results show that as the MAT and MAP decrease with elevation and this is largely responsible for the fall in species diversity with increasing altitude. There was a peak in species richness in the intermediate altitudes which is consistent with studies done on other plants and animals. [22,23]

The aim of this project is to study the relation between species diversity and the elevation gradient of bird species in the Western Himalayas, specifically in Himachal Pradesh in the Great Himalayan National Park(GHNP). The GHNP is 754km² in area, with the adjacent Tirthan and Sainj Wildlife Sanctuaries contributing an additional 61 km² and 90km² of land, respectively. It is home to 209 species of birds [8]. There have been studies and surveys conducted on specific endangered birds like the Western Trogopan, Monal and other phesants [9]. There has however no studies on the species diversity and its relation to the altitude. This project is an attempt to fill that gap and create baseline data for further such research on bird species in this region.

In this project we have focused only on avian species and we wish to study their diversity and how it varies with elevation gradient in the Great Himalayan National Park, Western Himalayas, India.

Methods

Study area

The study area was limited to the Thirth and Sainge Valley, located within The Great Himalayan National park, Himachal Pradesh. The total length of the trails traversed was 55km between the 5 campsites (Gushaini 1500m, Rolla 2100m, Shilt 3100m, Rohini Thatch 3500m Rakthisar 3800m) across an elevation gradient of 2500m starting from 1500 to 4000m. The point counts were done in and around different the campsites along the trekking routes through a variety of habitat that included alpine meadows, dense mixed temperate forests, coniferous forest, open streams, farm land, and village settlements.

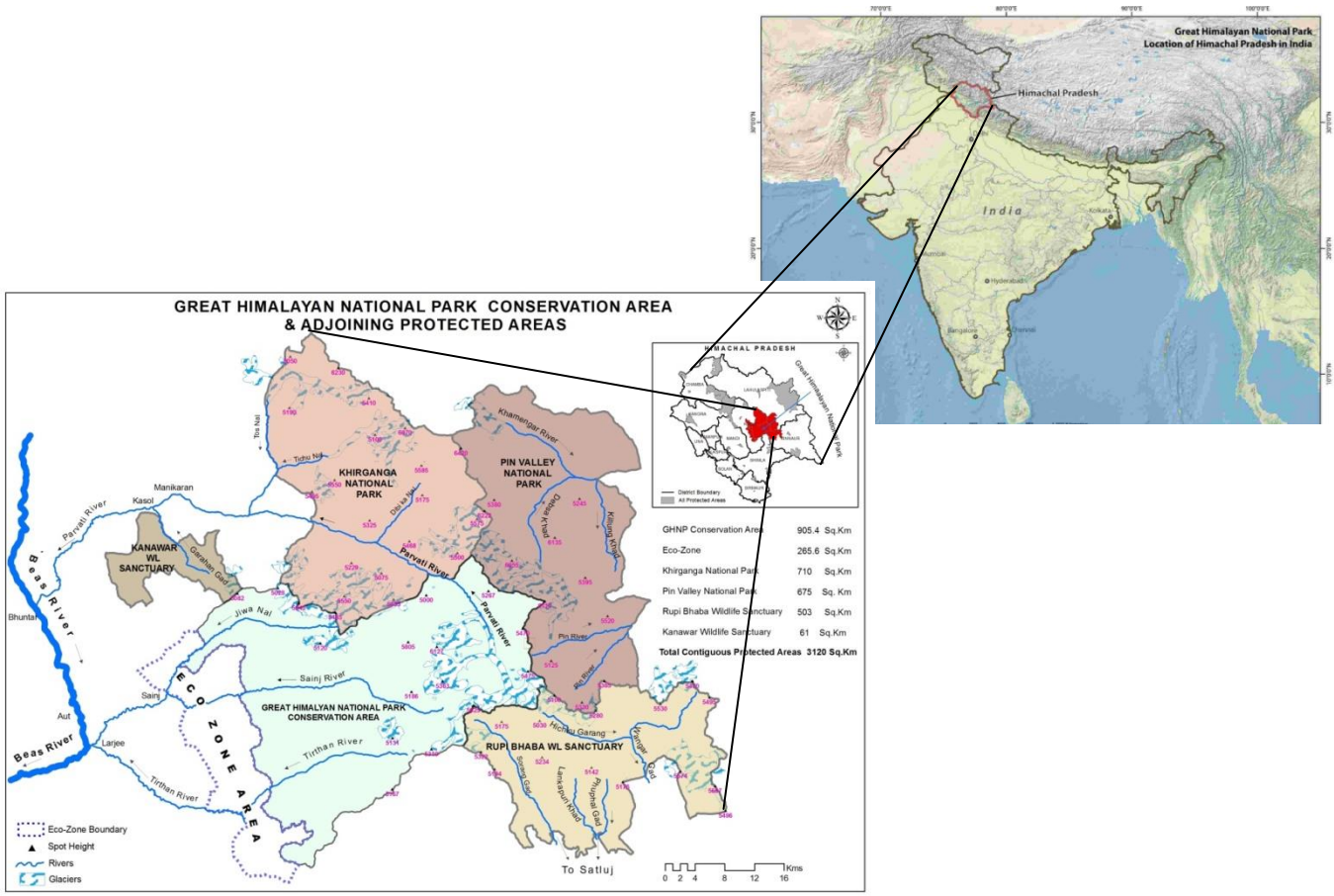

Figure.1. Map of the Great Himalayan National Park.

Sampling

The sampling of birds was done by means of double observer point counts [14] for a period of 10 minutes each over a period of 30 days in the months of May and June 2017. The altitudinal range, the species, the number of individuals, and the distance from the observer were recorded. Birds were primarily spotted by vision whereas some were detected by their calls. The distance of bird detection ranged from 5 to 70m. The point counts were done at the times of high bird activity which was in the morning (between 5:00am and 10:00am) and evening (between 4:00pm and 7:00pm)

Data Analysis

The data we collected was analysed using R [15], along with its associated packages, vegan, Biodiversity, Distance, and SPECIES to draw species accumulation and rank abundance curves and species estimators such as Chao1 and Jackknife to determine sampling completeness. We have also used Excel to sort the data to different formats for processing, and for making tables and a few graphs.

Species richness

To determine variation of species richness across elevation ranges we had plotted the total number of species of birds as a function of the elevation band in which they were found. We had sampled in 5 elevation bands of 500m each and recorded the total number of species sighted in each band.

Rank Abundance

The rank abundance curve shows us the predominance of each species in the region. It is a function of the number of individuals of a given species spotted in each point count. The most abundant species receives the highest rank and next most the following rank and so on and so forth.

Species accumulation

A Species accumulation curve describes the rate of species discovery as a function of the time spent searching for them. It is useful in determining the total number of species in each region as theoretically if we spend a long enough time looking for different species we would eventually find all of them which is indicated in the graph if it reached an asymptote.

Sampling completeness

We estimate of the total number of species in each region using estimators such as Chao1 and Jackknife and when we compare it with the total number of species we have found and determine the percentage of completeness of our sampling, i.e. the % of species we found in comparison to the estimated total number of species present.

Species detection curves

Species detection curves plot the probability of detecting a bird as a function of the distance from the observer. The histograms behind the graph represent the normalized distribution of number of birds spotted at different distances from the observer.

Results

Species richness at different elevation ranges.

From the 50 point counts we had conducted we had counted a total of 267 individuals, an average of 5 per point count. The number of species we identified was 63 (Table.1.) with an average of 17 species in each elevation band. There was a peak in richness in the mid elevation range (21 species) with a decrease on either of the other extremes. In the elevation band 2000-2500 sampling was difficult due to the dense forests, which made it difficult to walk, see and identify birds. It is evident in the dip in species diversity in in this range as seen in Figure.1. The graph is asymmetrical and hence differs from mid domain prediction.

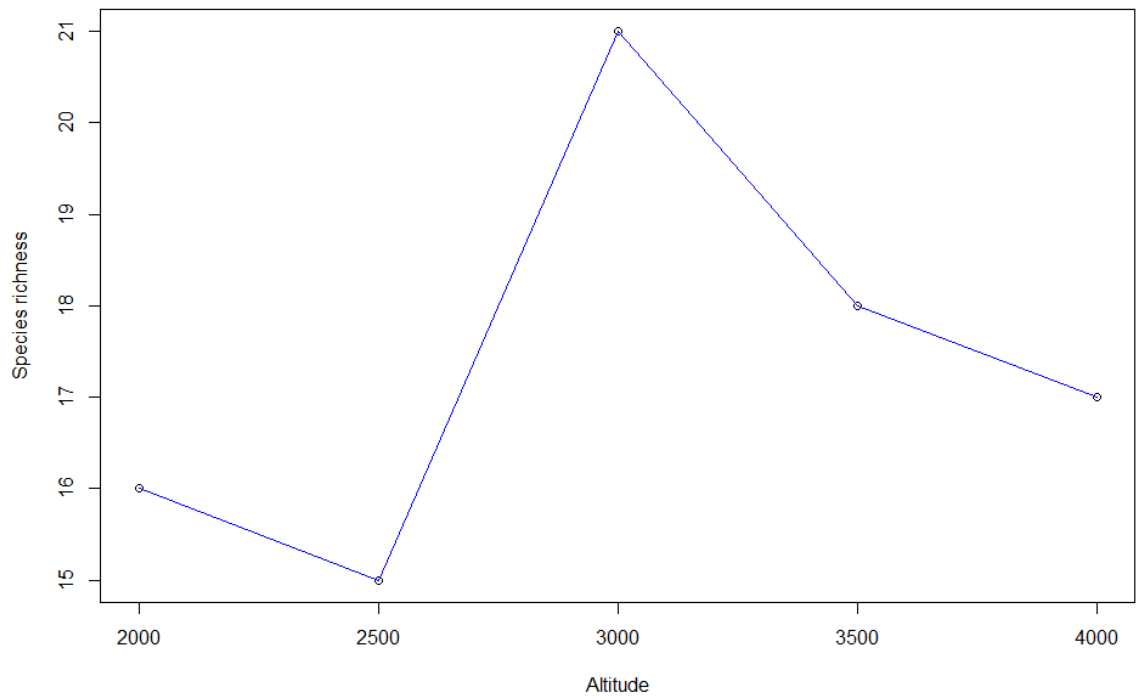

Figure 2. Elevation distribution patterns of birds. Species Richness of birds plotted as function of elevation Range.

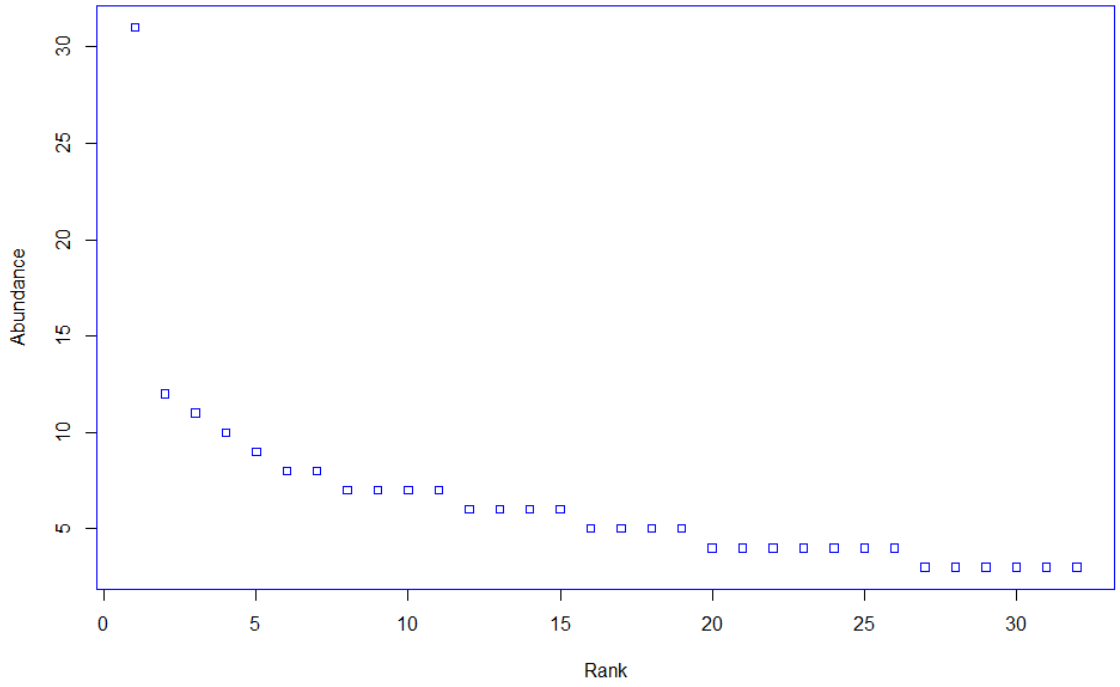

Figure.3. Rank abundance curve of birds. Curve based on the number of birds of each species detected in the GHNP

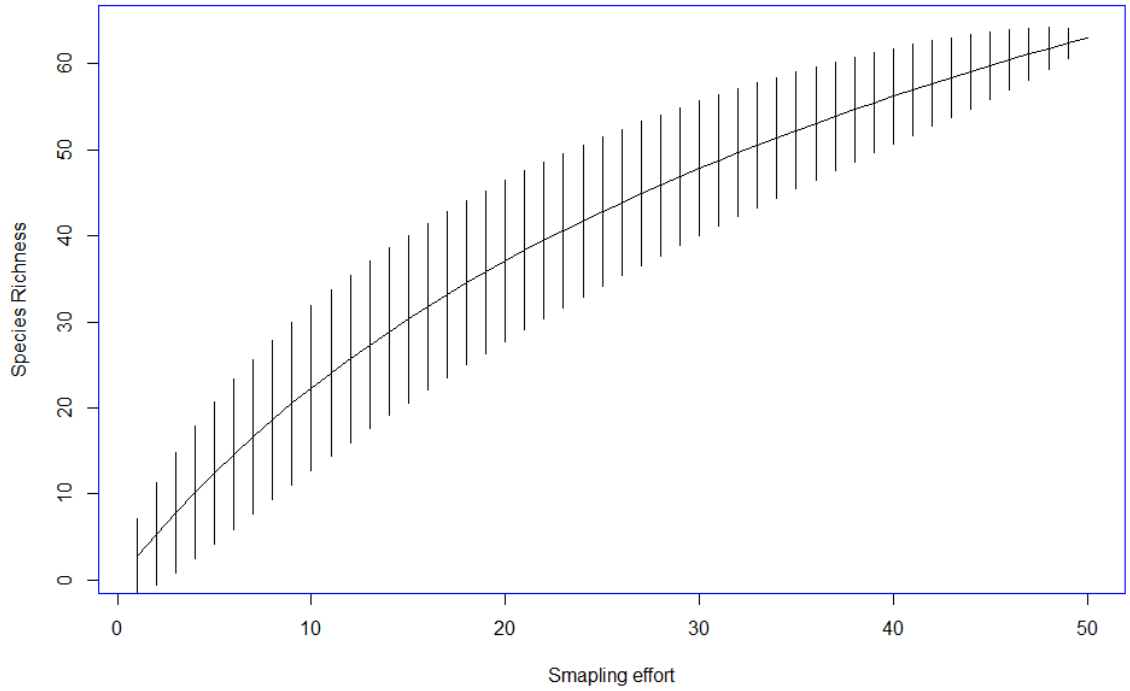

Figure.3. Species abundance curve of birds. Curve based on the number of species of birds as detected as function of sampling effort in the GHNP

Rank abundance curve

In construction of a rank abundance curve we have included only those species where three or more individuals were spotted (Table.2.). We can see that the most abundant species is the Slatey headed parakeet which accounts for 15% of all individuals we had found (30 individuals seen). It was followed by the Upland pipet, Large billed crow and the Oriental white eye representing 5.8%, 5.3%, and 4.8% of the population respectively (12, 11 and 10 individuals seen respectively).

Species accumulation curve and sampling completeness

The species shows us that our sampling is incomplete as no asymptote is reached. Using Richness estimators such as Chao1 and Jackknife we had found that we had discovered 66.74% and 67.46% of the total number species respectively. The accumulation curve was constructed for all point counts throughout the all elevation ranges. Species accumulation curves for each elevation range could not be constructed due to the limited time and resources in this project. This is only an estimate based on the data we have collected.

Species Detection curves

Among the 32 species considered in constructing the rank abundance curve, only the top 15 ranks were chosen to create the species detection curves for each altitudinal range. The individuals spotted in altitudinal range were divided into two groups based on their size. Group 1 consisted of birds that were less than 18cm in length, and Group 2 consisted of birds that were bigger than 18cm (Table.3.).

A majority of the birds were spotted at about 20m away from the observer as the histograms in both categories peaked at this point. They gradually decrease with distance reaching a minimum at farthest distance from the observer.

The detection probability curve monotonically decreases with distance for both small and large sized birds. Small birds were hard to identify at large distances, mostly due to their size. Large birds on the other hand were found up to distances of 70 meters.

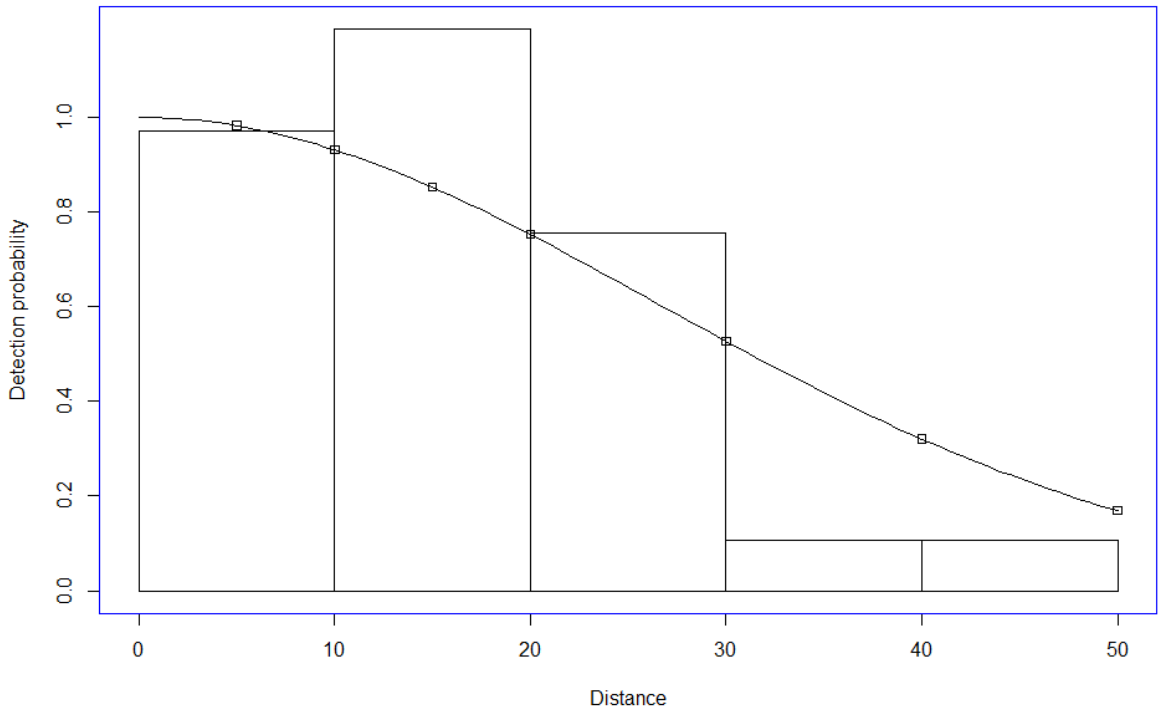

Figure.4. Species Detection Curve for Group1 birds. Shows the probability of detection of birds as a function of distance.

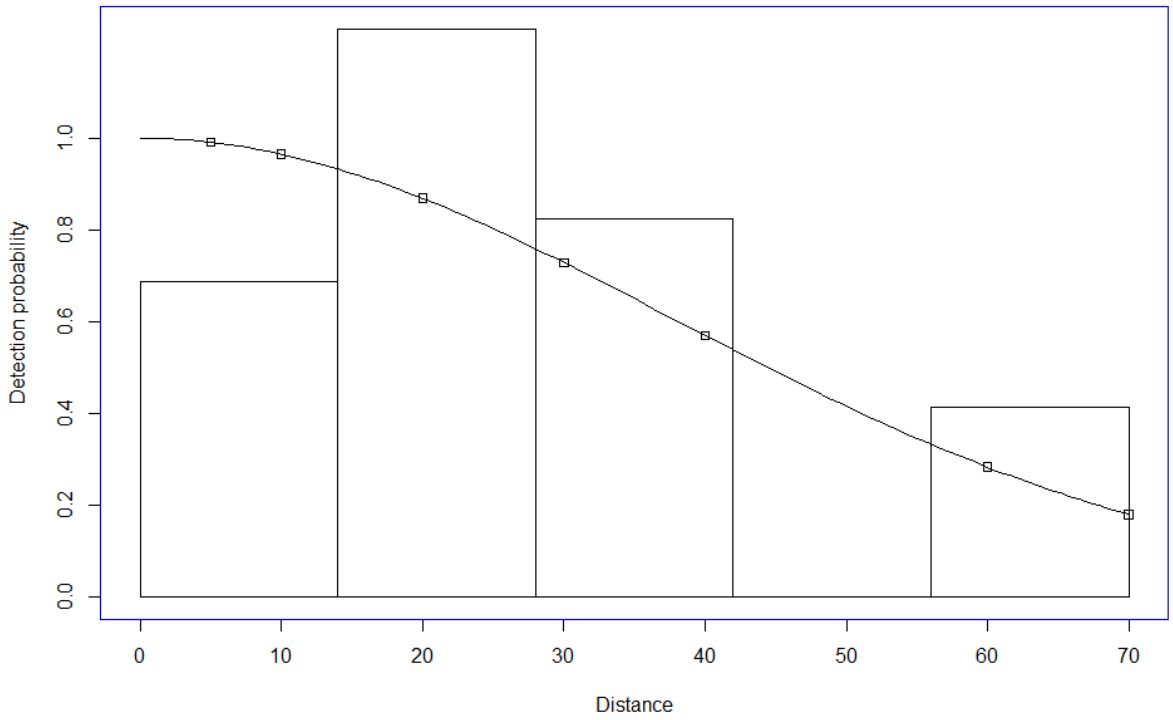

Figure.5. Species Detection Curve for Group 2 birds. Shows the probability of detection of birds as a function of distance.

Discussion

The results of our study show that there is a peak in bird species diversity at mid elevation ranges, specifically in the range 2500m-3000m. This is a pattern is consistent with studies done on other birds and animals in the Himalayas [17, 18]. This also extends to plants as well [19]. All of which supports of the mid domain effect [16]. The curve however is not symmetric, as there is a dip in the altitudinal range 2000m-2500m. This is due to incomplete sampling given the presence of dense mixed forest growing in this region is was difficult to readily detect and identify the birds. The most abundant birds in given altitudinal range were the Oriental white eye, Slatey headed parakeet, White rumped needletail, Streaked Laughing thrush and the Upland pipet for gradients of 500m from 1500m to 4000m.

The most abundant species of bird found in the entire region was the Slatey headed parakeet, spanning an elevation range of 1000 meters (1500-2500m). It was followed by the Upland pipet found only at altitude above 3500m. The Large billed crow was the most ubiquitous of the bird species, found in every elevation range stating from altitude 1500m to 4000m. It might be due to presence of human settlements along these sites of our study.

The rank abundance curve and the estimators of species diversity show that we have only identified about 67% of all species present in the region. This is expected as this was only a small study conducted by only 2 observers for a period of over one month. Further time spent on this project would give us a more realistic and complete picture of the bird diversity in the region.

The species detection curves show that detection probability fell faster in Group 1 as compared to Group 2. This is because Group 1 birds which were smaller were more easily seen at shorter distances from the observer as compared to larger birds that were seen up to distances of 70m away. In both cases however most birds were seen about 20 m away. This shows that it easier to detect both small and large birds at shorter distances but larger birds can be detected at even larger distances due to their size.

This preliminary study is essential in ascertaining the total bird diversity in the region as it provides baseline data for further studies. These studies are vital in estimating the patterns in species richness and how the altitudinal ranges of species can change with seasons and on a longer scale with climate change [13]. This data will also contribute in conservation efforts as it will provide a better understanding of the nature of bird populations and the habitats they occupy. Determining the total species diversity and their elevation ranges are important in conservation efforts of these species. With the threat of global warming looming in the back ground the ranges of these species is subject to change.[12] Knowing how much these ranges changes can help the GHNP, and other national parks and wild life sanctuaries to extend the limits to help conserve these sensitive species which are highly susceptible to climatic changes. These studies will immensely help in conservation efforts to protect endangered species in these fragile habitats not only in The GHNP but all biodiversity hotspots around the world.

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Appendix

Table.1. List of all species seen in the study and the elevation ranges in which they were found (marked with *).

SPECIES	1500-2000m	2000-2500m	2500-3000m	3000-3500m	3500-4000m
Alpine Ascenta					*
Bar tailed treecreeper			*	*	
Black redstart				*	
Black throated tit			*		
Blackbird				*	
Blue whistling thrush	*	*			
Canary flycatcher	*				
Chestnut tailed minla			*		
Collored grosbeak				*	
Dark breasted rosefinch	*				
Dipper		*			
Eurasian sparrow hawk	*	*			
Eurasian treecreeper				*	
Golden bush robin				*	
Grandala					*
Grasshopper warbler					*
Great barbet	*				
Green backed tit	*	*			
Greenish warbler	*			*	
Grey bushchat			*		
Grey crested tit				*	
Grey hooded warbler		*			
Himalayan bulbul	*				
Himalayan Snow Cock					*
Himalayan swiftlet		*			
House sparrows	*				
Jungle crow	*	*	*	*	*
Koklas pheseant			*		
Large billed leaf warbler			*		
Lemon rumped warbler				*	
Little forktail		*			
Little pied flycatcher		*			
Longtailed minivet				*	

Miss Gould's sunbird		*			
Mistle Thrush					*
Oriental white eye	*				
Pink browed rosefinch					*
Red billed chough					*
Rock Bunting					*
Rufous gorgeted flycatcher		*	*		
Rufous naped tit			*		
Rufous sibia		*	*	*	
Scaley bellied woodpecker				*	
Scarlet Finch					*
Slatey blue Flycatcher			*	*	
Slatey headed parakeet	*	*			
Spot winged tit			*	*	
Spotted forktail	*				
Spotted nutcracker			*	*	
Streaked laughing thrush			*	*	
Sulphur bellied Flycatcher				*	
Sulphur bellied warbler				*	
Tickell's leaf warbler					*
Upland pipet					*
Utramarine flycatcher			*		
Varigated laughing thrush			*		
Verditer flycatcher			*		
Whiskred yuhina		*			
White Capped Bunting					*
White headed redstart	*				
White rumped needle tail			*		
Yellow billed blue magpie	*				
Yellow rumped warbler			*	*	

Table.3. The list Species in Groups 1 (species less than 18cm in length) and Group 2 (species more than 18cm in length)

Group 1	
Species	Size
Yellow rumped warbler	9
Oriental white eye	10
Greenish warbler	10
Tickell's leaf warbler	11
White rumped needle tail	11
Himalayan swiftlet	13
Grey bushchat	15
Upland pipet	17

Group 2	
Species	Size
Streaked laughing thrush	18
Rofous sibia	21
Eurasian sparrow hawk	28
Blue whistling thrush	33
Slatey headed parakeet	39
Jungle crow	41
Yellow billed blue magpie	63