

1. INTRODUCTION

1.1 GENERAL BACKGROUND

Nagarjun Royal Forest is one of the several unique ecological areas found around the foothills surrounding the valley of Kathmandu. Because of its prevailing topographical and climatic conditions avian diversity is very rich there.

Birds are perhaps one of the best known animal groups in terms of distribution and abundance, and thus make excellent subjects for biodiversity studies. They are interesting as well in their ability to fly long distances quickly. This ability has given them the opportunity to leave areas in times of seasonal food shortage, or to go to areas with seasonally abundant food sources (Cannings, 1998). Birds are the most dynamic and susceptible for the structure of forest ecosystems (Zhijun, 1995).

Diversity depends upon two parameters (Odum, 1971), the number of species present (species richness) and the relative abundance of each species (species evenness).

Nepal is renowned internationally for its high diversity of bird species. The high total of 861 species has been recorded which is over 8% of the world's known birds (BCN/DNPWC, 2004). Roughly 650 species of birds are resident that probably breed in Nepal (BCN, 1997) of which 29 bird species in Nepal are identified as globally threatened by Birdlife International in 1999 (BLI, 2001). One species, the Spiny Babbler is endemic to Nepal (Robson, 1999). 226 bird species are included in the National Red Data Book on the basis of the global, regional, national and ecological importance. Of these 184 (81%) are breeding species, with the remainder being migrants. And, 11 bird species are believed to be extinct from Nepal (BPP, 1995a). 22 species are considered to be at risk and listed as rare, vulnerable or endangered categories by IUCN, 111

species listed in the appendices of convention on International Trades in Endangered Species of Wild Flora and Fauna (CITES) (DNPWC/WWF 2002), Government of Nepal has given legal protection status to 9 birds (BPP, 1995a).

The alarming number of 133 (15%) bird species of Nepal's birds is considered threatened. As many as 72 bird species are thought to be critically threatened or endangered meaning there is an extremely high or very high risk of their becoming extirpated in Nepal in the near future (BCN/DNPWC, 2004).

The observed species diversity is an indication of not only the amount of rainfall the area receives annually, but also the degree of topographical and habitat variation within the study area (Makuloluwa et al., 1997). Nepal's species richness can be attributed to the factor like - the dramatic changes in altitude within the short span of area, Nepal's geographic position; a region of overlap between Palaearctic realm and Oriental realm and Nepal's varied climate in the country (Inskipp and Inskipp, 1991).

The main requirements of birds are the wooded areas with good vegetation, where they can nest, breed, form territories and get enough food (Narve et al., 1997). Nepal's major habitat types consist of forest, wetland and grassland. However, Nepal is of great value for birds, mainly because of its forest which cover much larger areas than the country's wetlands or grasslands. There is a wide range of forests comprising tropical, sub-tropical, temperate, sub-alpine and alpine types which together hold the high proportion of 77% of Nepal's breeding birds (Inskipp and Inskipp, 1991).

A total of 88 (68%) species of the total threatened bird species (133) depend on forests. This high proportion of forest birds is to be expected as forests are the major habitats in Nepal. Many of the threatened forest birds require dense or moist condition with plenty of undergrowth or tree covered with epiphytes. These species are particularly sensitive to change in the forest ecosystems (Baral et al., 1996).

Nearly 60% of Nepal's forests are within the mid hill belts. So, the biodiversity contained in the mid hills ecosystem is of international importance. The mid hills are not only important in terms of the absolute number of species, but within Nepal, many species have a range restricted to this zone. 691 bird species (belonging to 18 orders) are found in the mid hills, which is about 83% of all species recorded for Nepal. 29 bird species are confined to this zone. The main characteristics of the mid hills vegetation are the great variety of different forest types and the marked regional differences in their distribution (BPP, 1995b).

The natural vegetation of the mid hill region is mostly forest ranging from *Schima-Castanopsis* in the east to *Pinus roxburghii* in the west. Due to high population density and the utilization of every accessible niche for subsistence farming the natural ecosystem of the mid hills are depleted. A considerable amount of forest lands remains however, according to late 1970s figure, 41% of the mid hills are under forest. The rate of loss of woody vegetation is considerably more in the mid hill zone which is related to the dense population (BPP, 1995b).

Bird population are highly sensitive to change and monitoring birds can give important early warning signs of future environmental crisis (BLI, 2000). Birds are relatively easy to census as they are well known, easily recognizable and simpler to locate than many other taxonomic groups. Birds can be useful indicators of the state of the environment and are also key species for education and public awareness (Bibby et al., 2000a). Baral and Inskipp point out that although bird diversity is four times greater than mammals, only eight bird species are protected by law compared to 26 mammals in Nepal (BLI, 2005).

A considerable proportion (36%) of Nepal's breeding species are altitudinal migrants which spend much of their time outside the breeding season in forests lower down and usually in a different climatic zone. In addition there are 33 winter visitors to Nepal's forests. To effectively conserve all Nepal's forest

birds it is therefore important to also protect forests utilized in the non-breeding season (Inskipp, 1989).

1.2 OBJECTIVES

The main objectives of this study were:

- To explore the seasonal diversity of avian fauna in NRF.
- To explore the relative abundance of birds present in the study area.
- To assess the present status of the avian fauna in the study area.
- To see the seasonal changes in species richness in different habitats like forest edges and interior of the forest.

1.3 JUSTIFICATION

Despite having a rich diversity of avifauna and being a nearest birding place from Kathmandu Metropolitan city, proper investigation and research work on birds are still lacking. This is because most of such researches were carried out in protected areas like National Parks and Wildlife Reserves only, however it is of equal importance that birds of this type of forest should also be protected. Thus, present study will definitely provide a valuable information regarding the bird conservation and to develop this place as a potential area for avian fauna ecotourism.

1.4 LIMITATION

The present study was carried out with limited time and financial resources. Due to rugged topography and tight security reasons at the entrance gate of the study area, there were some problems to visit the study area at required and desirable time.

2. STUDY AREA

2.1 LOCATION

Present study was conducted in Nagarjun Royal Forest (27° 43' 37.13" North (N) to 27° 46' 22.84" N and 85° 13' 52.9" East (E) to 85° 18' 14.38" E) in northernmost border of Kathmandu valley (Figure 1). The Nagarjun forest occupies an area of 16.45 km² at the border of Kathmandu and Nuwakot districts. Main range of the hill runs to east-west direction with its highest peak, Jamacho 2,188 metres (m) high, which rises abruptly from the floor of Kathmandu valley (1,300m). Many spurs of the hill run in different direction forming gullies and narrow valleys. Since 1972, infrastructure development works have been carried out with the main objective of achieving effective protection against deforestation and further loss of wild fauna. A 29 kilometre (KM) fence wall and 31 KM of motorable road up to Jamacho has been constructed. This forest is one of the scenic beauties of Kathmandu and comes under Royal protection.

2.2 GEOLOGY AND SOIL

The NRF largely consists of quartzite rock but also consists of limestone, siliceous limestone and calcisilicate rocks of uncertain age to certain extent (Hagen, 1959). Soil composition of Nagarjun varies with different types of forest i.e. *Schima wallichii* forest consists of dry hard light brown, light blackish brown to blackish soil with less humus, dry oak forest consists of dry light brown soil with some humus, mixed-broadleaved consists of humid light reddish brown to black soil with rich humus and pine forest consists of dry light brown to light brownish red soil without or with some humus (Kanai et al. 1970).

2.3 CLIMATE

Nagarjun forest is a typical Mahabharata hill and enjoys mostly sub-tropical type of climate and partly temperate climate (Chaudhary, 1998), with rainy

Figure 1: Map Showing the Land Cover Types in Nagarjun Royal Forest

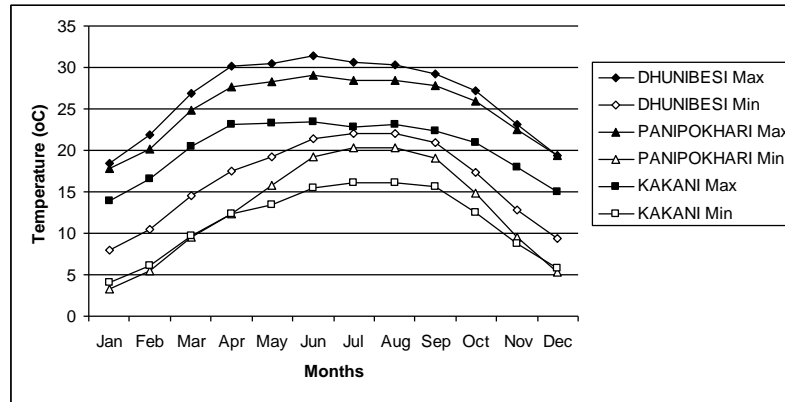


Figure 2: Monthly Average (Five Yearly, 2001-2005) Maximum and Minimum Temperatures for Kakani, Dhunibesi and Panipokhari

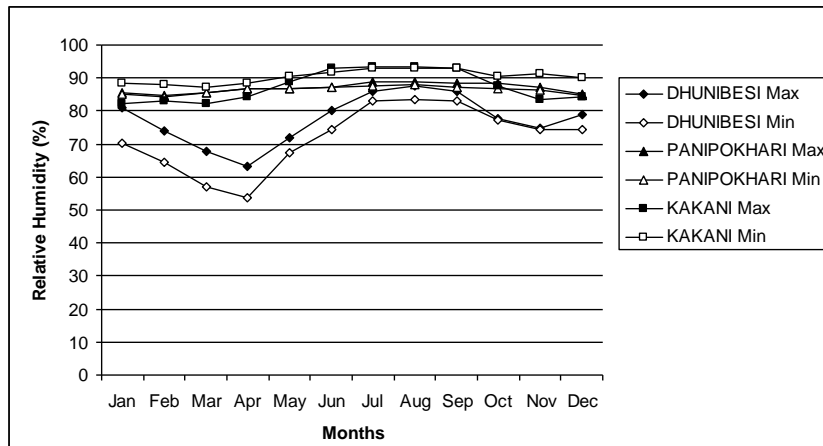


Figure 3: Monthly Average (Five Yearly, 2001-2005) Maximum and Minimum Relative Humidity for Kakani, Dhunibesi and Panipokhari

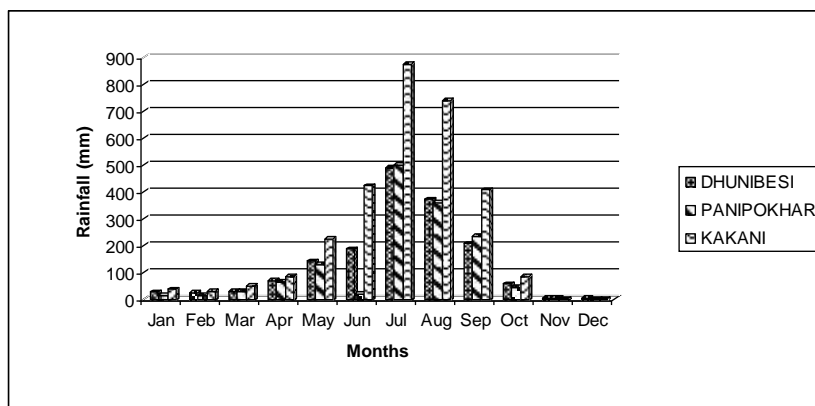


Figure 4: Monthly Average (Five Yearly, 2001-2005) Rainfall for Kakani, Dhunibesi and Panipokhari

summer and dry winter. The southern side is sunny and is evidently much drier than the northern forested side. As the climatic data of the Nagarjun area is not available, the climatic record of nearest meteorological stations i.e. Dhunibesi (27° 43" N and 85° 11" E, and elevation at 1085m), Kakani (27° 48"E and 85° 15" E, and elevation at 2064m) and Panipokhari, Maharajgunj (27° 44" N and 85° 20" E, and elevation at 1,335m) were used for analysis.

The mean monthly temperatures of the area ranged from 3.32⁰C (January) recorded at Panipokhari to 30.58⁰C (July at Dhunibesi (Figure 2). In all the three stations, December, January and February were coldest months while June, July and August were hottest months. Average monthly relative humidity of the area ranged from 53.9% (April) at Dhunibesi to 93.46% (August) at Kakani (Figure 3). Similarly, the average monthly rainfall ranged from 4.12 millimetre (mm) in December at Kakani to 873.86 mm in July at Kakani (Figure 4). July, August and September were most humid months, and July and August were most precipitous months.

2.4 BIODIVERSITY

The study area is rich in biodiversity. The reason for this may be maximum protection achieved by this forest from security forces than any other protected areas in Kathmandu valley.

2.4.1 FLORA

The flora of Nagarjun has been documented by Kanai and Shakya (1970) for Department of Medicinal Plants, Ministry of Forest, Government of Nepal. This study revealed that the Nagarjun hill mainly consists of four types of forests - *Schima wallichii* forest, pine forest, mixed broadleaved forest and dry oak forest. There are few small patches of grassy meadows.

The *Schima wallichii* forest occupies most parts of the hill, nearly up to 1800m altitude from the base. It occupies about 61.29% areas (10.10sq.km.) of the

NRF (Nagarkoti, 2006). In lower parts, *Schima wallichii* is associated with *Castanopsis indica*, *C. tribuloides* in some places and with *Juglans regia* in other places. Common shrubs and trees are *Myrsine semiserrata*, *Sarcococca coriacea*, *Ligustrum nepalense* etc. But in other parts, it is associated with *Machilus duthiei*, *Phoebe lanceolata*, *Quercus spicata*, *Pyrus pashia*, *Ligustrum nepalens* etc. with undergrowth of shrubs and small trees like *Sarcococca coriacea*, *Smilax aspera*, *Arundinaria falcata*, *Eriobotrya hookeriana*, *Desmodium oxyphyllum*, *Myrsine semiserrata* etc.

The pine forest consists exclusively of *Pinus roxburghii*, occupies the southern slopes of the hill mainly at lower altitudes .It occupies about 9.08% area (1.49sq.km.) of the NRF .Only small trees of *Myrica esculenta*, *Schima wallichii* are noticed forming secondary layer. The common shrubs are *Sarcococca coriacea*, *Berberis asiatica*, *Myrsine semiserrata*, *Colebrookia oppositifolia*, *glochidion velutinum*, *rubus ellipticus* etc.

The mixed broadleaved forest occurs at an altitude of 1800-2000m in the concaved northern slopes of the ridge. It occupies about 27.91% area of (4.60sq.km.) the NRF and consists of *Phoebe lanceolata*, *Machilus duthiei*, *Michelia kisopa* as main components along with *Acer oblongum*, *Quercus glauca* etc. Common shrubs are *Camellia kissi*, *Caryopteris grata*, *Dodecadenia grandiflora*, *Lindera pulcherrima*, *Sarcococca hookeriana* etc. In this type of forest, the shrubs and surface layer are relatively dense in comparison with those of the other forest types.

The dry oak forest of *Quercus lanuginosa* occupies the highest position in vertical zonations of the forests in this range. It occupies about 1.72% area (0.28sq.km.) of the NRF. This forest is localized on the steep rocky and exposed southern and western slopes of the ridge at an altitude of 2000-2188m on south, west and east, while 2050-2188m in north. Very few trees of *Lyonia ovalifolia* and *Rhododendron arboreum* were found in the forest. The common shrubs of forest edges and open places are *Berberis asiatica*, *Caryopteris grata*,

Desmodium floribundum, *Gaultheria fragrantissima*, *Inula cappa*, *Phyllanthus parvifolius*, *Rubus ellipticus* etc.

2.4.2 FAUNA

The fauna of Nagarjun forest has been described by HMG/ADB/FINNIDA (1988), Shrestha, (1997), Malla (2000) and others. The birds of the forest have been studied by Shrestha (2001). According to him, the important birds of forest are *Hieraaetus fasciatus* (Bonelli's Eagle), *Urocissa flavirostris* (Yellow-billed Blue Magpie), *Urocissa erythrorhyncha* (Red-billed Blue Magpie), *Spelaeornis caudatus* (Spotted Babbler), *Psittacula himalayana* (Slaty-headed Parakeet), *Blythipicus pyrrhotis* (Red-eared Rufous Woodpecker), *Picus flavinucha* (Large Yellow-naped Woodpecker), *Chrysocolaptes lucidus* (Large Golden-backed Woodpecker), *Aquila rapax nipalensis* (Steppe Eagle), *Ictinaetus malayensis* (Black Eagle), *Falco jugger* (Laggar Falcon), *Falco peregrinus* (Peregrine Falcon), *Columba hodgsonii* (Speckled wood pigeon), *Arborophila torqueola* (Common Hill Partridge), *Francolinus francolinus* (Black Partridge), *Alcedo atthis* (Eurasian Kingfisher), *Merops leshenaulti* (Chestnut-headed Bee-eater), *Megalaima franklinii* (Golden-throated Barbet), *Glaucidium brodiei* (Collared Pigmy owlet) etc.

Similarly, the important mammals are bats like *Rhinolophus pusillus blythi*, *Hipposiderous amiger*, *Megaderma lyra lyra* and *Minopterus schreibersii fuliginosus* (Malla, 2000), *Calloscirus pygerythrush lokroides* (Hoary bellied squirrel), *Sus scrofa* (Wild Boar), *Macaca mulatta* (Rhesus Monkey), *Panthera pardus* (Spotted leopard), *Neofelis nebulosa* (Clouded leopard), *Muntiacus muntjac* (Barking Deer or Red Deer), *Presbytis entellus* (Common langur), *Melursus ursinus* (Sloth bear) and *Martes flavigula* (Himalayan yellow throated marten) (HMG/ADB/FINNIDA, 1988).

2.5 BOUNDARY AND ACCESS

The Nagarjun Royal Forest is bordered by concrete wall and barbed wire fence in almost all directions. The forest has entry points at 7 different places - Raniban, Ain Danda, Mudkhu, Baikhu, Ichangu, Batase and Badridanda. The forest is accessible by road. Even inside the forest, there is gravel road to go to different places within the forest.

3. MATERIALS AND METHODS

3.1 RECONNAISSANCE SURVEY

Before the data collection, reconnaissance survey was carried out in the months of November/December 2004 to explore the major habitats of birds in NRF. This was done by visiting many places of NRF to find out the highly rich sites of birds. Besides, as much local knowledge as possible on the distribution of key species and habitat types were obtained by discussing with people walking that forest, armies and officers. Detailed notes on sightings and calls were made and identification problems of birds were compared and discussed.

3.2 FIELD SURVEY

Habitat types of the study area were classified using previous literatures and current survey and it was mapped using Geographic Information System (GIS) by Arcview GIS.

3.2.1 LINE TRANSECT

Bird communities were investigated along four predetermined line transects respectively (Figure 5) covering all major habitat types like *Schima wallichii* forest, mixed broadleaved forest, pine forest, dry oak forest, grasslands and streams. Length of the transects ranged from 4 to 6 km. Out of the four transects, two were passing through interior of the forest while remaining two were passing through the forest edges as follows-

The first transect run through the forest edges starting from Fulbari gate to Raniban. It covered *Schima wallichii* forest and pine forest.

The second transect run through interior of the altitudinally graded forest comprising the main range of the hill rising abruptly in elevation from the floor (1,300m) to the highest peak at Jamacho (2,188m). It covered major forests like *Schima wallichii* forest, mixed broadleaved forest, pine forest, dry oak forest and grassland.

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Figure 5: Map showing the different transects in the study area

The third transect also run through the interior of the forest starting from Mudkhu gate to Damdame. It covered *Schima wallichii* forest, mixed broadleaved forest and streams.

The fourth transect run through forest edges covering roadside along with the wall of the NRF.

3.2.2 DATA COLLECTION

After considering all available techniques, no distance measuring method was adopted as described by Bibby et al. (2000a).

The study was carried out for four seasons starting from May 2005 to Feb 2006 .During this period, the area was actively searched for birds and at every sighting the species were identified and particulars concerning its number, activities and habitat were recorded.

Birds were observed with the help of 10-30×50 Barska binocular. The observed birds were identified following Ali (1996), Ali (1997), Ali and Ripley (1983) and Grimemett et al.(2003).Calls of some birds were recorded and identified with the help of audio cassette of Bird songs of Nepal(Connop,1993) and Bird songs of Himalayas(Connop, Year?). Census was started early in the morning (30 minutes after sunrise). Transects were covered in a uniform speed. No census was done on days with very heavy rain and fog.

3.3 DATA ANALYSIS

3.3.1 SPECIES DIVERSITY

Species diversity of birds was calculated in each season by using Shannon-Wiener function as described by Southwood and Henderson (2000).

The function is,

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

Or,

$$H = - \sum \frac{n_i}{N} \log_e \frac{n_i}{N}$$

Where,

H = Index of species diversity

P_i = The proportion of individuals in the i^{th} species = $\frac{n_i}{N}$

n_i = Importance value for each species (number of individuals)

N = Total importance value (Total number of individuals)

3.3.2 RELATIVE DIVERSITY (EVENNESS)

For relative diversity of species, Jacob's coefficient was used,

$$J = \frac{H}{H_{\max}} \quad [\because H_{\max} = \log_e k]$$

Where,

J = Relative diversity

H = Calculated species diversity index

H_{\max} = Proportion of maximum possible diversity

k = Number of species

3.3.3 RELATIVE ABUNDANCE (ENCOUNTER RATES)

For this, field hours for the number of individuals of each species observed were recorded. Encounter rates were calculated for each species by dividing the number of birds recorded by the number of hour spent searching giving figure

of birds per hour for each species (Bibby et al., 2000b). These were categorized in crude ordinal scales of abundance as:

Abundance category (number of individuals/10 field hours)	Abundance score	Ordinal scale
<0.1	1	Rare
0.1 - 2.0	2	Uncommon
2.1 - 10.0	3	Frequent
10.0 - 40.0	4	Common
40.0 +	5	Abundant

This result however does not give an accurate density estimates but can be used in future for monitoring large scale changes in abundance of species. These encounter rates also give an indication of the abundance index of different species. For longer periods of study with replication of data this can also be used as an abundance index.

3.3.4 TWO-WAY ANOVA (ANALYSIS OF VARIANCE)

Seasonal variation in the number and species richness of birds in different habitat transects were analyzed by using two-way ANOVA. Two-way ANOVA was calculated by SPSS software programme. This allow to observe whether there is significant difference in species richness in the four seasons as well as in the four transects which has been categorized into forest edge, roadside, interior of forest and interior of altitudinally graded forest

4. RESULT

4.1 BIRD COMPOSITION

A total of 117 bird species belonging to 12 orders and 37 families were sighted and recognized by their calls in the NRF during the study period of four seasons. Seventy-seven bird species, which is the highest number of species (65.81%), were represented by the order Passeriformes along with 22 families. Other major orders were Piciformes (2 families, 8 species), Cuculiformes (1 family, 6 species), Accipitriformes (1 family, 5 species), Coraciiformes (4 families, 4 species), Strigiformes (1 family, 3 species), Galliformes (1 family, 2 species), Falconiformes and Psittaciformes both represented 1 family with 2 species. While Apodiformes and Ciconiformes both represented 1 family along with 1 species only. Number of bird species represented by order and families are shown in figure 6.

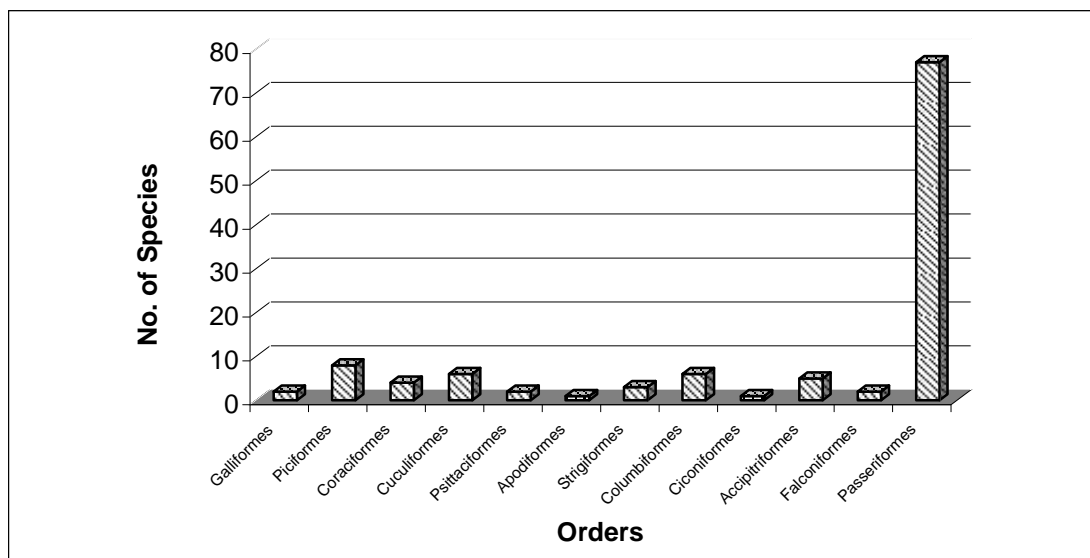


Figure 6: Number of Bird Species Represented by Orders

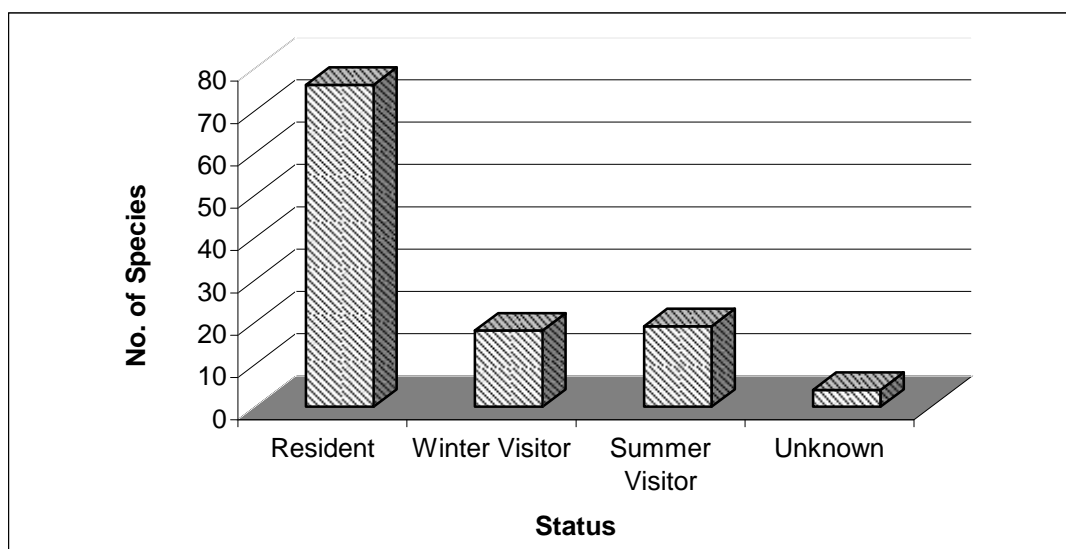


Figure 7: Number of Bird Species Represented by Status

Among them, 76 (64.95%) of species were resident, 18 (15.38%) were winter visitors and 19 (16.23%) were summer visitors. Status of 4 species was unknown. Some tropical bird species like Dollarbird (*Eurystomus orientalis*), Indian Peafowl (*Pavo cristatus*) and Greater Racket-tailed Drongo (*Dicrurus paradiseus*) were also observed.

4.2 SPECIES DIVERSITY

Species diversity of birds was based on Shannon-Wiener Diversity Index. Shannon-Wiener Diversity Index (\bar{H}) showed highest value in spring season (3.7916) followed by winter (3.7267), autumn (3.4323) and rainy (3.295) seasons.

Table 1: Bird Species Diversity in the Study Area

Seasons	Number of species	Number of birds (mean)	Shannon-Wiener Index (\bar{H})	Jacob's coefficient (J)
Spring	78	381	3.7916	0.870
Rainy	52	355	3.295	0.834
Autumn	63	613	3.4323	0.828
Winter	81	719	3.7267	0.848

4.3 RELATIVE DIVERSITY (EVENNESS)

For Relative Diversity (Evenness), Jacob's Coefficient was used. Higher value of relative diversity was shown in spring (0.870) followed by winter (0.848), rainy (0.834) and autumn (0.828).

Table 2: Birds Recorded During Spring Season and Their Seasonal Relative Abundance and Encounter Rates

S.N.	Common Name	Scientific Name	Population	No. of individuals per 10 hrs	Relative abundance
1.	Kaliz Pheasant	<i>Lophura leucomelanos</i>	2	1.25	U
2.	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	2	1.25	U
3.	Greater Yellownappe	<i>Picus flavinucha</i>	1	0.625	U
4.	Great Barbet	<i>Megalaima virens</i>	5	3.125	F
5.	Golden-throated Barbet	<i>Megalima franklinii</i>	1	0.625	U
6.	Blue-throated Barbet	<i>Megalima asiatica</i>	7	4.375	F
7.	Coppersmith Barbet	<i>Megalaima haemacephala</i>	1	0.625	U
8.	Common Kingfisher	<i>Alcedo atthis</i>	1	0.625	U
9.	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	1	0.625	U
10.	Chestnut-headed Bee eater	<i>Merops leschenaulti</i>	30	18.75	C
11.	Indian Cuckoo	<i>Cuculus micropterus</i>	9	5.625	F
12.	Eurasian Cuckoo	<i>Cuculus canorus</i>	5	3.125	F
13.	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	3	1.875	U
14.	Asian Koel	<i>Eudynamys scolopacea</i>	8	5	F
15.	Drongo Cuckoo	<i>Surniculus lugubris</i>	2	1.25	U
16.	Green-billed Malkoha	<i>Phaenicophaeus tristis</i>	1	0.625	U
17.	Rose-ringed Parakeet	<i>Psittacula krameri</i>	2	1.25	U
18.	Slaty-headed Parakeet	<i>Psittacula himalayana</i>	5	3.125	F
19.	Collared Owlet	<i>Glaucidium brodiei</i>	1	0.625	U
20.	Spotted Owlet	<i>Athene brama</i>	2	1.25	U
21.	Rock Pigeon	<i>Columba livia</i>	1	0.625	U
22.	Spotted Dove	<i>Streptopelia chinensis</i>	3	1.875	U
23.	Red Collared Dove	<i>Streptopelia tranquebarica</i>	1	0.625	U
24.	Barred Cuckoo Dove	<i>Macropygia unchall</i>	1	0.625	U
25.	Cattle Egret	<i>Bubulus ibis</i>	1	0.625	U
26.	Black Kite	<i>Milvus migrans</i>	6	3.75	F
27.	Peregrine Falcon	<i>Falco peregrinus</i>	1	0.625	U
28.	Golden-fronted Leaf bird	<i>Chloropsis aurifrons</i>	1	0.625	U
29.	Long-tailed Shrike	<i>Lanius schach</i>	5	3.125	F

30.	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	15	9.375	F
31.	Rufous Treepie	<i>Dendrocitta vagabunda</i>	3	1.875	U
32.	Grey Treepie	<i>Dendrocitta formosae</i>	11	6.875	F
33.	House Crow	<i>Corvus splendens</i>	18	11.25	C
34.	Large-billed Crow	<i>Corvus macrorhynchos</i>	4	2.5	F
35.	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	6	3.75	F
36.	Maroon Oriole	<i>Oriolus traillii</i>	3	1.875	U
37.	Large Cuckooshrike	<i>Coracina macei</i>	1	0.625	U
38.	Black-winged Cuckoo-shrike	<i>Coracina melaschistos</i>	1	0.625	U
39.	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	4	2.5	F
40.	Scarlet Minivet	<i>Pericrocotus flammeus</i>	6	3.75	F
41.	Black Drongo	<i>Dicrurus macrocercus</i>	5	3.125	F
42.	Ashy Drongo	<i>Dicrurus leucophaeus</i>	2	1.25	U
43.	Bronzed Drongo	<i>Dicrurus aeneus</i>	8	5	F
44.	Spangled Drongo	<i>Dicrurus hottentottus</i>	4	2.5	F
45.	Great Tit	<i>Parus major</i>	4	2.5	F
46.	Black-lored Tit	<i>Parus xanthogenys</i>	26	16.25	C
47.	Black-throated Tit	<i>Aegithalos concinnus</i>	1	0.625	U
48.	Barn Swallow	<i>Hirundo rustica</i>	3	1.875	U
49.	Red-rumped Swallow	<i>Hirundo daurica</i>	2	1.25	U
50.	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	12	7.5	F
51.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	12	7.5	F
52.	Mountain Bulbul	<i>Hypsipetes mcclellandii</i>	2	1.25	U
53.	Black Bulbul	<i>Hypsipetes leucocephalus</i>	10	6.25	F
54.	Common Tailorbird	<i>Orthotomus sutorius</i>	4	2.5	F
55.	Greenish Warbler	<i>Phylloscopus trochiloides</i>	17	10.625	C
56.	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	32	20	C
57.	Blue-capped Rock Thrush	<i>Monticola cinclorhynchus</i>	1	0.625	U
58.	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	4	2.5	F
59.	Blue-throated Flycatcher	<i>Cyornis rubeculoides</i>	2	1.25	U
60.	Pale Blue Flycatcher	<i>Cyornis unicolor</i>	1	0.625	U
61.	Small Niltava	<i>Niltava magrigoriae</i>	1	0.625	U
62.	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	6	3.75	F
63.	Oriental Magpie Robin	<i>Copsychus saularis</i>	1	0.625	U
64.	Slaty-backed Forktail	<i>Enicurus schistaceus</i>	1	0.625	U
65.	Pied Bushchat	<i>Saxicola caprata</i>	1	0.625	U
66.	Common Stonechat	<i>Saxicola torquata</i>	1	0.625	U

67.	Common Myna	<i>Acridotheres tristis</i>	5	3.125	F
68.	Jungle Myna	<i>Acridotheres fuscus</i>	5	3.125	F
69.	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	8	5	F
70.	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	1	0.625	U
71.	White-crested Laughingthrush	<i>Garrulax leucolophus</i>	10	6.25	F
72.	Rusty-cheeked Scimitar Babbler	<i>Pomatorhinus erythrogenys</i>	1	0.625	U
73.	Nepal Fulvetta	<i>Alcippe nipalensis</i>	1	0.625	U
74.	Plain Flowerpecker	<i>Dicaeum concolor</i>	1	0.625	U
75.	Fire-breasted Flowerpecker	<i>Dicaeum ignipectus</i>	1	0.625	U
76.	Crimson Sunbird	<i>Aethopyga siparaja</i>	1	0.625	U
77.	White-rumped Munia	<i>Lonchura striata</i>	2	1.25	U
78.	Paddyfield Pipit	<i>Anthus rufulus</i>	1	0.625	U
Total			381		

Table 3: Birds Recorded During Rainy Season and Their Seasonal Relative Abundance and Encounter Rates

S.N.	Common Name	Scientific Name	Population	No. of individuals per 10 hrs	Relative abundance
1.	Kalij Pheasant	<i>Lophura leucomelanos</i>	4	2.5	F
2.	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	1	0.625	U
3.	Lesser Yellownape	<i>Picus flavinucha</i>	1	0.625	U
4.	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	5	3.125	F
5.	Great Barbet	<i>Megalaima virens</i>	17	10.625	C
6.	Blue-throated Barbet	<i>Megalaima asiatica</i>	16	10	F
7.	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	1	0.625	U
8.	Eurasian Cuckoo	<i>Cuculus canorus</i>	1	0.625	U
9.	Asian Koel	<i>Eudynamis scolopacea</i>	2	1.25	U
10.	Rock Pigeon	<i>Columba livia</i>	1	0.625	U
11.	Oriental Turtle Dove	<i>Sterptopelia orientalis</i>	24	15	C
12.	Spotted Dove	<i>Sterptopelia chinensis</i>	1	0.625	U
13.	Cattle Egret	<i>Bubulus ibis</i>	3	1.875	U
14.	Black Kite	<i>Milvus migrans</i>	18	11.25	C
15.	Peregrine Falcon	<i>Falco peregrinus</i>	1	0.625	U
16.	Long-tailed Strike	<i>Lanius schach</i>	2	1.25	U
17.	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	30	18.75	C
18.	Rufous Treepie	<i>Dendrocitta vagabunda</i>	6	3.75	F
19.	Grey Treepie	<i>Dendrocitta formosae</i>	8	5	F
20.	House Crow	<i>Corvus splendens</i>	18	11.25	C
21.	Large-billed Crow	<i>Corvus macrorhynchos</i>	3	1.875	U

22.	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	6	3.75	F
23.	Maroon Oriole	<i>Oriolus traillii</i>	2	1.25	U
24.	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	7	4.375	F
25.	Scarlet Minivet	<i>Pericrocotus flammeus</i>	6	3.75	F
26.	Black Drongo	<i>Dicrurus macrocercus</i>	3	1.875	U
27.	Bronzed Drongo	<i>Dicrurus aeneus</i>	2	1.25	U
28.	Great Tit	<i>Parus major</i>	1	0.625	U
29.	Black-lored Tit	<i>Parus xanthogenys</i>	29	18.125	C
30.	Red-rumped Swallow	<i>Hirundo daurica</i>	2	1.25	U
31.	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	2	1.25	U
32.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	6	3.75	F
33.	Mountain Bulbul	<i>Hypsipetes mccllellandii</i>	1	0.625	U
34.	Black Bulbul	<i>Hypsipetes leucocephalus</i>	9	5.625	F
35.	Greenish Warbler	<i>Phylloscopus trochiloides</i>	8	5	F
36.	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	20	12.5	C
37.	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	3	1.875	U
38.	Verditer Flycatcher	<i>Eumyias thalassina</i>	2	1.25	U
39.	Small Niltava	<i>Niltava magrigoriae</i>	1	0.625	U
40.	Rufous-bellied Niltava	<i>Niltava sundara</i>	1	0.625	U
41.	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	4	2.5	F
42.	Oriental Magpie Robin	<i>Copsychus saularis</i>	1	0.625	U
43.	Slaty-backed Forktail	<i>Enicurus schistaceus</i>	1	0.625	U
44.	Common Stonechat	<i>Saxicola torquata</i>	1	0.625	U
45.	Common Myna	<i>Acridotheres tristis</i>	2	1.25	U
46.	Jungle Myna	<i>Acridotheres fuscus</i>	4	2.5	F
47.	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	32	20	C
48.	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	2	1.25	U
49.	White-throated Laughingthrush	<i>Garrulax albogularis</i>	1	0.625	U
50.	White-crested Laughingthrush	<i>Garrulax leucolophus</i>	31	19.375	C
51.	Rusty-cheeked Scimitar Babbler	<i>Pomatorhinus erythrogenys</i>	1	0.625	U
52.	White-bellied Yuhina	<i>Yuhina zantholeuca</i>	1	0.625	U
Total			355		

Table 4: Birds Recorded During Autumn Season and Their Seasonal Relative Abundance and Encounter Rates

S.N.	Common Name	Scientific Name	Population	No. of individuals per 10 hrs	Relative abundance
1.	Kaliz Pheasant	<i>Lophura leucomelanos</i>	3	1.875	U
2.	Indian Peafowl	<i>Pavo cristatus</i>	1	0.625	U
3.	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	6	3.75	F
4.	Lesser Yellownappe	<i>Picus flavinucha</i>	1	0.625	U
5.	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	1	0.625	U
6.	Great Barbet	<i>Megalaima virens</i>	20	12.5	C
7.	Blue-throated Barbet	<i>Megalaima asiatica</i>	4	2.5	F
8.	Dollarbird	<i>Eurystomus orientalis</i>	1	0.625	U
9.	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	1	0.625	U
10.	Himalayan Swift	<i>Collocalia brevirostris</i>	45	28.125	C
11.	Eurasian Eagle Owl	<i>Bubo bubo</i>	1	0.625	U
12.	Spotted Owlet	<i>Athene brama</i>	1	0.625	U
13.	Rock Pigeon	<i>Columba livia</i>	3	1.875	U
14.	Ashy Wood Pigeon	<i>Columba pulchricollis</i>	2	1.25	U
15.	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	3	1.875	U
16.	Spotted Dove	<i>Streptopelia chinensis</i>	1	0.625	U
17.	Black Kite	<i>Milvus migrans</i>	16	10	F
18.	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>	1	0.625	U
19.	Long-tailed Shrike	<i>Lanius schach</i>	2	1.25	U
20.	Grey-backed Shrike	<i>Lanius tephronotus</i>	1	0.625	U
21.	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	8	5	F
22.	Rufous Treepie	<i>Dendrocitta vagabunda</i>	17	10.625	C
23.	Grey Treepie	<i>Dendrocitta formosae</i>	39	24.375	C
24.	House Crow	<i>Corvus splendens</i>	13	8.125	F
25.	Large-billed Crow	<i>Corvus macrorhynchos</i>	3	1.875	U
26.	Maroon Oriole	<i>Oriolus traillii</i>	3	1.875	U
27.	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	9	5.625	F
28.	Scarlet Minivet	<i>Pericrocotus flammeus</i>	9	5.625	F
29.	Black Drongo	<i>Dicrurus macrocercus</i>	58	36.25	C
30.	Ashy Drongo	<i>Dicrurus leucophaeus</i>	5	3.125	F
31.	Bronzed Drongo	<i>Dicrurus aeneus</i>	9	5.625	F
32.	Great Tit	<i>Parus major</i>	6	3.75	F
33.	Black-lored Tit	<i>Parus xanthogenys</i>	54	33.75	C
34.	Black-throated Tit	<i>Aegithalos concinnus</i>	2	1.25	U
35.	Barn Swallow	<i>Hirundo rustica</i>	8	5	F

36.	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	10	6.25	F
37.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	40	25	C
38.	Mountain Bulbul	<i>Hypsipetes mccllellandii</i>	1	0.625	U
39.	Oriental White-eye	<i>Zosterops palpebrosus</i>	11	6.875	F
40.	Common Tailorbird	<i>Orthotomus sutorius</i>	1	0.625	U
41.	Hume's Warbler	<i>Phylloscopus humei</i>	16	10	F
42.	Greenish Warbler	<i>Phylloscopus trochiloides</i>	8	5	F
43.	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	50	31.25	C
44.	Blue-capped Rock Thrush	<i>Monticola cinclorhynchus</i>	1	0.625	U
45.	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	2	1.25	U
46.	Verditer Flycatcher	<i>Eumyias thalassina</i>	2	1.25	U
47.	Rufous bellied Niltava	<i>Niltava sundara</i>	1	0.625	U
48.	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	12	7.5	F
49.	Oriental Magpie Robin	<i>Copsychus saularis</i>	3	1.875	U
50.	Slaty-backed Forktail	<i>Enicurus schistaceus</i>	2	1.25	U
51.	Common Myna	<i>Acridotheres tristis</i>	4	2.5	F
52.	Jungle Myna	<i>Acridotheres fuscus</i>	11	6.875	F
53.	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	25	15.625	C
54.	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	3	1.875	U
55.	White-crested Laughingthrush	<i>Garrulax leucolophus</i>	28	17.5	C
56.	Rusty-cheeked Scimitar Babbler	<i>Pomatorhinus erythrogenys</i>	12	7.5	F
57.	Streak-breasted Scimitar Babbler	<i>Pomatorhinus ruficollis</i>	1	0.625	U
58.	Spiny Babbler	<i>Turdoides nipalensis</i>	2	1.25	U
59.	White-bellied Yuhina	<i>Yuhina zantholeuca</i>	2	1.25	U
60.	House Sparrow	<i>Passer domesticus</i>	2	1.25	U
61.	Eurasian Tree Sparrow	<i>Passer montanus</i>	2	1.25	U
62.	White-rumped Munia	<i>Lonchura striata</i>	2	1.25	U
63.	Scaly-breasted Munia	<i>Lonchura punctulata</i>	2	1.25	U
Total			613		

Table 5: Birds Recorded During Winter Season and their Seasonal Relative Abundance and Encounter Rates

S.N.	Common Name	Scientific Name	Population	No. of individuals per 10 hrs	Relative abundance
1.	Kalij Pheasant	<i>Lophura leucomelanos</i>	13	8.12	F
2.	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	2	1.25	U
3.	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	2	1.25	U
4.	Great Barbet	<i>Megalaima franklinii</i>	13	8.125	F
5.	Golden-throated Barbet	<i>Megalaima asiatica</i>	1	0.625	U
6.	Blue-throated Barbet	<i>Megalaima asiatica</i>	9	5.625	F
7.	Coppersmith Barbet	<i>Megalaima haemacephala</i>	2	1.25	U
8.	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	1	0.625	U
9.	Drongo Cuckoo	<i>Surniculus lugubris</i>	2	1.25	U
10.	Rose-ringed Parakeet	<i>Psittacula krameri</i>	6	3.75	F
11.	Collared Owlet	<i>Glaucidium brodiei</i>	1	0.625	U
12.	Spotted Owlet	<i>Athene brama</i>	1	0.625	U
13.	Rock Pigeon	<i>Columba livia</i>	20	12.5	C
14.	Ashy Wood Pigeon	<i>Columba pulchricollis</i>	1	0.625	U
15.	Spotted Dove	<i>Streptopelia chinensis</i>	3	1.875	U
16.	Black Kite	<i>Milvus migrans</i>	7	4.375	F
17.	Crested Serpent Eagle	<i>Spilornis cheela</i>	1	0.625	U
18.	Besra	<i>Accipiter virgatus</i>	3	1.875	U
19.	Common Buzzard	<i>Buteo buteo</i>	1	0.625	U
20.	Steppe Eagle	<i>Aquila nipalensis</i>	7	4.375	F
21.	Common Kestrel	<i>Falco tinnunculus</i>	4	2.5	F
22.	Grey-backed Shrike	<i>Lanius tephronotus</i>	1	0.625	U
23.	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	26	16.25	C
24.	Rufous Treepie	<i>Dendrocitta vagabunda</i>	2	1.25	U
25.	Grey Treepie	<i>Dendrocitta formosae</i>	9	5.625	F
26.	House Crow	<i>Corvus splendens</i>	20	12.5	C
27.	Large Billed Crow	<i>Corvus macrorhynchos</i>	2	1.25	U
28.	Maroon Oriole	<i>Oriolus traillii</i>	11	6.875	F
29.	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	27	16.875	C
30.	Scarlet Minivet	<i>Pericrocotus flammeus</i>	33	20.625	C
31.	Yellow-bellied Fantail	<i>Rhipidura hypoxantha</i>	24	15	C
32.	Black Drongo	<i>Dicrurus macrocercus</i>	4	2.5	F
33.	Bronzed Drongo	<i>Dicrurus aeneus</i>	10	6.25	F
34.	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	1	0.625	U

35.	Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i>	1	0.625	U
36.	Great Tit	<i>Parus major</i>	1	0.625	U
37.	Black-lored Tit	<i>Parus xanthogenys</i>	53	33.125	C
38.	Black-throated Tit	<i>Aegithalos concinnus</i>	2	1.25	U
39.	Barn Swallow	<i>Hirundo rustica</i>	4	2.5	F
40.	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	18	11.25	C
41.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	21	13.125	C
42.	Mountain Bulbul	<i>Hypsipetes mccllellandii</i>	1	0.625	U
43.	Black Bulbul	<i>Hypsipetes leucocephalus</i>	67	41.875	A
44.	Oriental White-eye	<i>Zosterops palpebrosus</i>	16	10	F
45.	Common Tailorbird	<i>Orthotomus sutorius</i>	4	2.5	F
46.	Grey-sided Bush Warbler	<i>Cettia brunnifrons</i>	2	1.25	U
47.	Hume's Warbler	<i>Phylloscopus humei</i>	14	8.75	F
48.	Dusky Warbler	<i>Phylloscopus fuscatus</i>	3	1.875	U
49.	Blyth's Leaf Warbler	<i>Phylloscopus reguloides</i>	3	1.875	U
50.	Buff-barred Warbler	<i>Phylloscopus pulcher</i>	10	6.25	F
51.	Greenish Warbler	<i>Phylloscopus trochiloides</i>	2	1.25	U
52.	Golden-spectacled Warbler	<i>Seicercus burkii</i>	14	8.75	F
53.	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	48	30	C
54.	Chestnut-crowned Warbler	<i>Seicercus castaniceps</i>	3	1.875	U
55.	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	7	4.375	F
56.	Scaly Thrush	<i>Zoothera dauma</i>	3	1.875	U
57.	Dark-throated Thrush	<i>Turdus ruficollis</i>	3	1.875	U
58.	Chestnut-bellied Rock Thrush	<i>Monticola rufiventris</i>	1	0.625	U
59.	Red-throated Flycatcher	<i>Ficedula parva</i>	1	0.625	U
60.	Small Niltava	<i>Niltava magrigoriae</i>	1	0.625	U
61.	Rufous-bellied Niltava	<i>Niltava sundara</i>	1	0.625	U
62.	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	14	8.75	F
63.	Oriental Magpie Robin	<i>Copsychus saularis</i>	1	0.625	U
64.	Slaty-back Forktail	<i>Enicurus schistaceus</i>	1	0.625	U
65.	Pied Bushchat	<i>Saxicola caprata</i>	2	1.25	U

66.	Common Stonechat	<i>Saxicola torquata</i>	2	1.25	U
67.	Common Myna	<i>Acridotheres tristis</i>	3	1.875	U
68.	Jungle Myna	<i>Acridotheres fuscus</i>	13	8.125	F
69.	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	26	16.25	C
70.	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	6	3.75	F
71.	White-throated Laughingthrush	<i>Garrulax albogularis</i>	1	0.625	U
72.	White-crested Laughingthrush	<i>Garrulax leucolophus</i>	14	8.75	F
73.	Rusty-cheeked Scimitar Babbler	<i>Pomatorhinus erythrogenys</i>	11	6.875	F
74.	White-bellied Yuhina	<i>Yuhina zantholeuca</i>	2	1.25	U
75.	Nepal Fulvetta	<i>Alcippe nipalensis</i>	1	0.625	U
76.	Fire-breasted Flowerpecker	<i>Dicaeum ignipectus</i>	2	1.25	U
77.	House Sparrow	<i>Passer domesticus</i>	3	1.875	U
78.	Eurasian Tree Sparrow	<i>Passer montanus</i>	3	1.875	U
79.	White-rumped Munia	<i>Lonchura striata</i>	3	1.875	U
80.	Scaly-breasted Munia	<i>Lonchura punctulata</i>	1	0.625	U
81.	Spot-winged Grosbeak	<i>Mycerobas melanozanthos</i>	36	22.5	C
Total			719		

4.4 RELATIVE ABUNDANCE (ENCOUNTER RATES)

Among 117 species present in the study area, 10(8.54%) species were common in its relative abundance with Encounter rates (ER) 10-40, 26(22.22%) species were frequent with ER 2-10 and 81(69.23%) species were uncommon with ER 0.1-2.0. No single bird had its relative abundance rare or abundant.

Out of the 76 resident species, 10 species (13.15%) were common in its relative abundance with the Encounter Rates (ER) 10-40. These include Red-billed Blue Magpie (*Urocissa erythrorhyncha*), Grey Treepie (*Dendrocitta formosae*), House Crow (*Corvus splendens*), Black Drongo (*dicrurus macrocerus*), Black-lored Tit (*Parus xanthogenys*), Red-vented Bulbul (*Pycnonotus cafer*), Black Bulbul (*Hypsipetes leucocephalus*), Grey hooded

warbler (*Seicercus xanthoschistos*), Chestnut-bellied Nuthatch (*Sitta castanea*) and White-crested Laughingthrush (*Garrulax leucolophus*).

Table 6: Relative Abundance (Encounter Rates) of the Birds Recorded in the Study Area

S.N.	Common Name	Scientific Name	Total No. of individuals	No. of individuals per 10 hours	Relative Abundance
1	Kaliz Pheasant	<i>Lophura leucomelanos</i>	22	3.4375	F
2	Indian Peafowl	<i>Pavo cristatus</i>	1	0.15625	U
3	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	11	1.718	U
4	Lesser Yellownappe	<i>Picus chlorolophus</i>	2	0.3125	U
5	Greater Yellownappe	<i>Picus flavinucha</i>	1	0.15625	U
6	Bay Woodpecker	<i>Blythipicus Pyrrhotis</i>	8	1.25	U
7	Great Barbet	<i>Megalaima virens</i>	55	8.59375	F
8	Golden-throated Barbet	<i>Megalaima franklinii</i>	2	0.3125	U
9	Blue-throated Barbet	<i>Megalaima asiatica</i>	36	5.625	F
10	Coppersmith Barbet	<i>Megalaima haemacephala</i>	3	0.46875	U
11	Dollarbird	<i>Eurystomus orientalis</i>	1	0.15625	U
12	Common Kingfisher	<i>Alcedo atthis</i>	1	0.15625	U
13	White-throated Kingfisher	<i>Halcyon smyrenensis</i>	3	0.46875	U
14	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	30	4.6875	F
15	Indian Cuckoo	<i>Cuculus micropterus</i>	9	1.40625	U
16	Eurasian Cuckoo	<i>Cuculus canorus</i>	6	0.9375	U
17	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	4	0.625	U
18	Asian Koel	<i>Eudynamis scolopacea</i>	10	1.5625	U
19	Drongo Cuckoo	<i>Surniculus lugubris</i>	4	0.625	U
20	Green-billed Malkoha	<i>Phaenicophaeus tristis</i>	1	0.15625	U
21	Rose-ringed Parakeet	<i>Psittacula krameri</i>	8	1.25	U
22	Slaty-headed Parakeet	<i>Psittacula himalayana</i>	5	0.78125	U
23	Himalayan Swiflet	<i>Collocalia brevirostris</i>	45	7.03125	F
24	Eurasian Eagle Owl	<i>Bubo bubo</i>	1	0.15625	U
25	Collared Owlet	<i>Glaucidium brodiei</i>	2	0.3125	U
26	Spotted Owlet	<i>Athene brama</i>	4	0.625	U
27	Rock Pigeon	<i>Columba livia</i>	25	3.90625	F
28	Ashy Wood Pigeon	<i>Columba pulchricollis</i>	3	0.46875	U
29	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	27	4.21875	F
30	Spotted Dove	<i>Streptopelia chinensis</i>	8	1.25	U
31	Red Collared Dove	<i>Streptopelia tranquebarica</i>	1	0.15625	U
32	Barred Cuckoo Dove	<i>Macropygia unchall</i>	1	0.15625	U
33	Cattle Egret	<i>Bubulcus ibis</i>	4	0.625	U
34	Black Kite	<i>Milvus migrans</i>	47	7.34375	F
35	Crested Serpent Eagle	<i>Spilornis cheela</i>	1	0.15625	U
36	Besra	<i>Accipiter virgatus</i>	3	0.46875	U

37	Common Buzzard	<i>Buteo buteo</i>	1	0.15625	U
38	Steppe Eagle	<i>Aquila nipalensis</i>	7	1.09375	U
39	Common Kestrel	<i>Falco tinnunculus</i>	4	0.625	U
40	Peregrine Falcon	<i>Falco peregrinus</i>	2	0.3125	U
41	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>	2	0.3125	U
42	Long-tailed Shrike	<i>Lanius schach</i>	9	1.40625	U
43	Grey-backed Shrike	<i>Lanius tephronotus</i>	2	0.3125	U
44	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	79	12.34375	C
45	Rufous Treepie	<i>Dendrocitta vagabunda</i>	28	4.375	F
46	Grey Treepie	<i>Dendrocitta formosae</i>	67	10.46875	C
47	House Crow	<i>Corvus splendens</i>	69	10.78125	C
48	Large-billed Crow	<i>Corvus macrorhynchos</i>	12	1.875	U
49	Yellow-bellied Fantail	<i>Rhipidura hypoxantha</i>	24	3.75	F
50	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	12	1.875	U
51	Maroon Oriole	<i>Oriolus traillii</i>	19	2.96875	F
52	Large Cuckooshrike	<i>Coracina macei</i>	1	0.15625	U
53	Black-winged Cuckooshrike	<i>Coracina melaschistos</i>	1	0.15625	U
54	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	47	7.34375	F
55	Scarlet Minivet	<i>Pericrocotus flammeus</i>	54	8.4375	F
56	Black Drongo	<i>Dicrurus macrocercus</i>	70	10.9375	C
57	Ashy Drongo	<i>Dicrurus leucophaeus</i>	7	1.09375	U
58	Bronzed Drongo	<i>Dicrurus aeneus</i>	29	4.53125	F
59	Spangled Drongo	<i>Dicrurus hottentottus</i>	4	0.625	U
60	Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i>	1	0.15625	U
61	Greater Rackettailed Drongo	<i>Dicrurus paradiseus</i>	1	0.15625	U
62	Great Tit	<i>Parus major</i>	12	1.875	U
63	Black-lored Tit	<i>Parus xanthogenys</i>	162	25.3125	C
64	Black-throated Tit	<i>Aegithalos concinnus</i>	5	0.78125	U
65	Barn Swallow	<i>Hirundo rustica</i>	15	2.34375	F
66	Red-rumped Swallow	<i>Hirundo daurica</i>	4	0.625	U
67	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	42	6.5625	F
68	Red-vented Bulbul	<i>Pycnonotus cafer</i>	79	12.34375	C
69	Mountain Bulbul	<i>Hypsipetes mccllellandii</i>	5	0.78125	U
70	Black Bulbul	<i>Hypsipetes leucocephalus</i>	86	13.4375	C
71	Oriental White-eye	<i>Zosterops palpebrosus</i>	27	4.21875	F
72	Common Tailorbird	<i>Orthotomus sutorius</i>	9	1.40625	U
73	Grey-sided Bush Warbler	<i>Cettia brunnifrons</i>	2	0.3125	U
74	Dusky Warbler	<i>Phylloscopus fuscatus</i>	3	0.46875	U
75	Blyth's Leaf Warbler	<i>Phylloscopus reguloides</i>	3	0.46875	U
76	Buff-barred Warbler	<i>Phylloscopus pulcher</i>	10	1.5625	U
77	Hume's Warbler	<i>Phylloscopus humei</i>	30	4.6875	F
78	Greenish Warbler	<i>Phylloscopus trochiloides</i>	35	5.46875	F
79	Golden-spectacled Warbler	<i>Seicercus burkii</i>	14	2.1875	F

80	Grey-hooded Warbler	<i>Seicercus xanthoschistos</i>	150	23.4375	C
81	Chestnut-crowned Warbler	<i>Seicercus castaniceps</i>	3	0.46875	U
82	Blue-capped Rock Thrush	<i>Monticola cinclorhynchus</i>	2	0.3125	U
83	Chestnut-bellied Rock Thrush	<i>Monticola rufiventris</i>	1	0.15625	U
84	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	16	2.5	F
85	Scaly Thrush	<i>Zoothera dauma</i>	3	0.46875	U
86	Dark-throated Thrush	<i>Turdus ruficollis</i>	3	0.46875	U
87	Oriental Magpie Robin	<i>Copsychus saularis</i>	6	0.9375	U
88	Slaty-backed Forktail	<i>Enicurus schistaceus</i>	5	0.78125	U
89	Common Stonechat	<i>Saxicola torquata</i>	4	0.625	U
90	Pied Bushchat	<i>Saxicola caprata</i>	3	0.46875	U
91	Red-throated Flycatcher	<i>Ficedula parva</i>	1	0.15625	U
92	Verditer Flycatcher	<i>Eumyias thalassina</i>	4	0.625	U
93	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	36	5.625	F
94	Small Niltava	<i>Niltava magrigoriae</i>	3	0.46875	U
95	Rufous-bellied Niltava	<i>Niltava sundara</i>	3	0.46875	U
96	Pale Blue Flycatcher	<i>Cyornis unicolor</i>	1	0.15625	U
97	Blue-throated Flycatcher	<i>Cyornis rubeculoides</i>	2	0.3125	U
98	Common Myna	<i>Acridotheres tristis</i>	14	2.1875	F
99	Jungle Myna	<i>Acridotheres fuscus</i>	33	5.15625	F
100	Chestnut-bellied Nuthatch	<i>Sitta castanea</i>	91	14.21875	C
101	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	12	1.875	U
102	White-throated Laughingthrush	<i>Garrulax albogularis</i>	2	0.3125	U
103	White -crested Laughingthrush	<i>Garrulax leucolophus</i>	83	12.96825	C
104	Rusty-cheeked Scimitar Babbler	<i>Pomatorhinus erythrogenys</i>	25	3.90625	F
105	Streak-breasted Scimitar Babbler	<i>Pomatorhinus ruficollis</i>	1	0.125625	U
106	Spiny Babbler	<i>Turdoides nipalensis</i>	2	0.3125	U
107	White-bellied Yuhina	<i>Yuhina zantholeuca</i>	5	0.78125	U
108	Nepal Fulvetta	<i>Alcippe nipalensis</i>	2	0.3125	U
109	Plain Flowerpecker	<i>Dicaeum concolor</i>	1	0.15625	U
110	Fire-breasted Flowerpecker	<i>Dicaeum ignipectus</i>	3	0.46875	U
111	Crimson Sunbird	<i>Aethopyga siparaja</i>	1	0.15625	U
112	House Sparrow	<i>Passer domesticus</i>	5	0.78125	U

113	Eurasian Tree Sparrow	<i>Passer montanus</i>	5	0.78125	U
114	White-rumped Munia	<i>Lonchura striata</i>	7	1.09375	U
115	Scaly-breasted Munia	<i>Lonchura punctulata</i>	3	0.46875	U
116	Paddyfield Pipit	<i>Anthus rufulus</i>	1	0.15625	U
117	Spot-winged Grosbeak	<i>Mycerobas melanozanthos</i>	36	5.625	F

Note:

Abundance

U = Uncommon (ER = 0.10-.0)

F = Frequent (ER = 2.1-10.0)

C = Common (ER = 10.1-40.1)

A = Abundant (ER = 40.0>)

21 (27.63 %) species were frequent in its relative abundance with the encounter rates (ER) 2 to 10. These include Kaliz Pheasant (*Lophura leucomelanos*), Great Barbet (*Megalaima virens*), Blue-throated Barbet (*Megalaima asiatica*), Rock Pigeon (*Columba livia*), Oriental Turtle Dove (*Streptopelia orientalis*), Rufous Treepie (*Dendrocitta vagabunda*), Maroon Oriole (*Oriolus traillii*), Long-tailed Minivet (*Pericrocotus ethologus*), Scarlet Miniret (*Pericroctus flammeus*), Bronzed Drongee (*Dicrurus aeneus*), Black Kite (*Milvus migrans*), Barn Swallow (*Hirundo rustica*), Himalayan Bulbul (*Pycnonotus leucogenys*), Oriental White-eye (*Zosterops polpebrosus*), Greenish Warbler (*Phylloscopus trochiloides*), Golden-spectacled Warbler (*Seicercus burkii*), Blue Whistling Thrush (*Myophonus caeruleus*), Grey-headed canary Flycatcher (*Culicicapa ceylonensis*), Common Myna (*Acridotheres tristis*), Jungle Myna (*Acridotheres fuscus*), Rusty-cheeked Scimitar Babbler (*Pomatorhinus erythrogeus*).

45 (59.21%) species were uncommon in its relative abundance with the encounter rates (ER) 0.1 to 2.0. These were Fulvous-breasted Woodpecker (*Dendrocopos macei*), Lesser Yellowthroat (*Picus chlorolophus*), Greater Yellowthroat (*Picus flavinucha*), Bay Woodpecker (*Blythipicus pyrrhotis*), Golden-throated Barbet (*Megalaima franklinii*), Copper-smith Barbet (*Megalaima haemacephala*), Common Kingfisher (*Alcedo atthis*), White-throated kingfisher (*Hylcyon smyrnensis*), Drongo Cuckoo (*Surniculus lugubris*), Rose-ringed Parakeet (*Psittacula krameri*), Eurasian Eagle Owl

(*Bubo bubo*), Collared Owlet (*Glaucidium brodiei*), Spotted owlet (*athene brama*), Ashy Wood Pigeon (*Columba pulchricollis*), Spotted Dove (*Streptopelia chinensis*), Barred Cuckoo Dove (*Macropygia unchall*), Cattle Egret (*Bubulcus ibis*), Peregrine Falcon (*Falco peregrinus*), Long-tailed Shrike (*Laninus schach*), Large-billed Crow (*Corvus macrorhynchos*), Ashy Drongo (*Dicrurus leucophaeus*), Lesser Racket-tailed Drongo (*Dicrurus remifer*) Great Tit (*Parus major*), Black-throated Tit (*Aegithalos concinnus*), Mountain Bulbul (*Hypsipetes mccllellandii*), Common Tailorbird (*Orthotomus sutorius*), Verditer Flycatcher (*Eumyias thalassina*), Small Niltava (*Niltava magrigroriae*), Rufous-bellied Niltava (*Niltava sundara*), Oriental Magpie Robin (*Copsychus saularis*), Slaty-backed Forktail (*Enicurus schistaceus*), Pied Bushchat (*Saxicola caprata*), Common Stonechat (*Saxicola torquata*), Velvet-fronted Nuthatch (*Sitta frontalis*), White-throated Laughingthrush (*Garrulax albogularis*), Streak-breasted Scimitar Babbler (*Pomatorhinus ruficollis*), Spiny Babbler (*Turdoides nipalensis*), White-bellied Yuhina (*Yuhina zantholeuca*), Nepal Fulvetta (*Alcippe nipalensis*), Fire-breasted Flowerpecker (*Dicaeum ignipectus*), House Sparrow (*Passer domesticus*), Eurasian Tree Sparrow (*Passer montanus*), White-rumped Munia (*Lonchura striata*), Scaly-breasted Munia (*Lonchura punctulata*) and Paddy-field pipit (*Anthus rufulus*).

Relative abundance of birds in each season was also calculated. In spring season, 45 species fell in the common category, 28 species in frequent category while five species were encountered commonly. In rainy season, 30 species fell in uncommon category, 13 species in frequent category while only nine species were encountered commonly. In autumn, 34 species fell in the uncommon category, 19 species in frequent category, while 10 species were encountered commonly. In winter season, 45 species fell in the uncommon category, 23 species in frequent category while two species were encountered commonly and one species was encountered abundantly (Figure 8).

Figure 8: Abundance Ratings of Birds in Different Seasons

4.5 BIRD DISTRIBUTION WITH HABITAT ASSOCIATION

Among six different habitat types, 112 species, which is the highest number of species, were recorded in the *Schima wallichii* forest (SWF). 28 species were observed in pine forest (PF), 18 species were observed in mixed broadleaved forest (MBLF), 10 species were observed in dry oak forest (DOF), 10 species in grassland (G) and two species in streams (S). However, *Schima wallichii* forest (SWF) had a greater number of habitat specific birds than other habitats. Out of the total 117 bird species, 78(66.66%) species observed were exclusive

to *Schima wallichii* forest. Only one species, Barred Cuckoo Dove (*Macropygia unchall*) was found exclusively in mixed broadleaved forest. Likewise, one species, Himalayan swiftlet (*Collocalia brevirostris*) was found exclusively in dry oak forest (DOF). Slaty-backed Forktail (*Enicurus schistaceus*) was the only species found exclusively in streams. No single species was exclusively found in pine forest (PF) and grassland (G).

Figure 11: Species composition of avifauna at the different habitats of the study area showing the number of exclusive and common species

And the remaining species were distributed in more than one habitat three species (2.56%) were observed only in SWF and MBLF, 14 species (11.96%) were observed only in SWF and PF, one species (0.8547%) were observed only in SWF and S , one species (0.8547%) were observed only in MBLF and DOF, three species (2.56%) were observed only in SWF, MBLF and PF, one species (0.8547%) were observed only in SWF, MBLF, PF and OF, three species (2.56%) were observed only in SWF, MBLF, PF, DOF and G, three species (2.56%) were observed only in SWF, MBLF, PF and G, two species (1.7094%) were observed only in SWF, MBLF, PF and DOF, one species (0.8547%) were

observed only in SWF, PF and DOF, 1 species (0.8547%) were observed only in SWF, MBLF and DOF, 2 species (1.794%) were observed only in SWF, PF and G, one species (0.8547%) were observed only in SWF, MBLF, and G.

4.6 SPECIES RICHNESS

The number and species richness of birds in Nagarjun Royal Forest declined during Monsoon and increased during winter months. During winter season, more bird species (81) were present compared to other seasons. In spring, autumn and rainy seasons 78, 63 and 52 species were observed respectively.

Figure 12: Seasonal Fluctuation of Species Richness of Birds Shown in Different Transects

Similarly in different transects, transect 1 comprising forest edges had the highest number of bird species (88) or species richness was highest there. 61 species were recorded in transect 4 comprising forest edges with roadside, 56 species were recorded in transect 3 comprising interior of forest and 47 species were recorded in transect 2 comprising interior with altitudinally graded forest ranging from low SWF to high altitude DOF. Two-way ANOVA showed a significant difference in the total number of bird species in different seasons ($F = 5.211$, $P = 0.023$ and $df = 3$) as well as in different transects ($F = 14.531$, $P = 0.001$ and $df = 3$). Of the 41 species of birds observed in transect 2, most of them occurred in low altitude of SWF and PF and number of species declined gradually towards the high altitude forests of MBLF and DOF.

Figure 13: Fluctuation of Species Richness of Birds in Different Transects Shown in Different Seasons

Similarly, total mean number of individuals were highest in winter (719), while in autumn, spring and rainy seasons it were 613, 381 and 355 respectively. Two-way ANOVA showed a significant difference in the number of birds in different seasons ($F = 6.647$, $P = 0.012$ and $df = 3$) as well as in different transects ($F = 4.310$, $P = 0.038$ and $df = 3$).

Table 7: Bird species recorded in NRF those included in NRDB, CITES Appendices and BCN Categories

S.N.	Common Name	Scientific Name	Status NRDB	Appendices CITES	Category BCN
1.	Kalij Pheasant	<i>Lophura leucomelanos</i>	S		
2.	Indian Peafowl	<i>Pavo cristatus</i>	S		
3.	Dollarbird	<i>Eurystomus orientalis</i>	S		
4.	Slaty-headed Parakeet	<i>Psittacula himalayana</i>	S	II	
5.	Eurasian Eagle Owl	<i>Bubo bubo</i>	V	II	
6.	Collared Owlet	<i>Glaucidium brodiei</i>		II	
7.	Barred Cuckoo Dove	<i>Macropygia unchall</i>	V		V
8.	Black Kite	<i>Milvus migrans</i>		II	
9.	Crested Serpent Eagle	<i>Spilornis cheela</i>	S	II	
10.	Besra	<i>Accipiter virgatus</i>		II	
11.	Common Buzzard	<i>Buteo buteo</i>	S	II	
12.	Steppe Eagle	<i>Aquila nipalensis</i>		II	
13.	Common Kestrel	<i>Falco tinnunculus</i>		II	
14.	Peregrine Falcon	<i>Falco peregrinus</i>	E	I	
15.	Pale Blue Flycatcher	<i>Cyornis unicolor</i>	E		V

NRDB codes

E= Endangered

V=Vulnerable

S=Susceptible

BCN category

V= Vulnerable

The NRF supports 10 nationally threatened species of birds which are included in the National Red Data Book (BPP, 1995). Among them two species, Peregrine Falcon (*Falco peregrinus*) and Pale Blue Flycatcher (*Cyornis unicolor*) are under endangered category. Two species, Eurasian Eagle Owl (*Bubo bubo*) and Barred Cuckoo Dove (*Macropygia unchall*) are under vulnerable category. And remaining five species, Crested Serpent Eagle (*Spilornis cheela*), Common Buzzard (*Buteo buteo*), Indian Peafowl (*Pavo*

crisatatus), Kaliz Pheasant (*Lophura leucomelanos*), Slaty-headed Parakeet (*Psittacula himalayana*) and Dollarbird (*Eurystomus orientalis*) are under susceptible category.

Nine species recorded from NRF are listed in Appendix-II and one species, Peregrine Falcon (*Falco peregrinus*) is listed in Appendix - I of Convention on International Trades of Endangered Species of Wild Flora and Fauna (CITES) (Table 7).

Two species, Barred Cuckoo Dove (*Macropygia unchall*) and Pale Blue Flycatcher (*Cyornis unicolor*) recorded in NRF are included in vulnerable category by BCN.

5. DISCUSSION

A total of 117 species of birds belonging to 12 orders and 37 families were sighted and heard in NRF.

More than 260 species have been recorded from Phulchowki hills (Inskipp, 1989), Limbu and Gurung (1998). Panthi (1997) has found 59 species of birds in Gokarna forest. 55 species were recorded from Taudaha area (Shah, 2000), 85 species were recorded from Setidevi Community Forest (Ojha, 2004). 160 species from Chitlang forest (Manandhar et al., 1992) were recorded. The apparent richness of the bird species in NRF may be due to the presence of a mosaic of habitat such as *Schima wallichii* forest, mixed broadleaved forest, pine forest, dry oak forest, grasslands, streams etc. and the altitudinal variation within the study area. Makuloluwa et al. (1997) has also suspected that the species richness in Hanthana is due to the presence of mosaic of habitat.

Out of the 117 species, 76 (64.95%) species were resident, 18 (15.38%) species were winter visitors, 19 (16.23%) species were summer visitors and 4 (3.41%) species were unknown to its status. Approximately, 71% of Nepal's birds are resident (Inskipp, 1989). The study area mostly supported resident species and few migrant species. MacArthur (1972) has shown that seasonal movements are fundamental in many species as an adaptive strategy in varied forest habitats. The bird community in any given habitat type is not static but changes seasonally (Avery et al, 1989)

Winter migrants constitute about 18 species. Majority of them were raptors like Crested Serpent Eagle (*Spilornis cheela*), Besra (*Accipiter virgatus*), Common Buzzard (*Buteo buteo*), Steppe Eagle (*Aquila nipalensis*) and Common Kestrel (*Falco tinnunculus*). And other important winter migrants are warblers like Grey-sided Bush Warbler (*Cettia brunnifrons*), Hume's Warbler (*Phylloscopus humei*), Dusky Warbler (*Phylloscopus fuscatus*), Blyth's leaf Warbler (*Phylloscopus reguloides*), Buff-barred Warbler (*Phylloscopus pulcher*),

Chestnut-crowned Warbler (*Seicercus castaniceps*) etc. Most of them were *phylloscopus* warblers. Austin (1970) suspected that the changes in food availability could account for seasonal shift in habitat use by the warblers of Southern Nevada, but he added that the temperature extremes in the low lands during the fall rather than a decrease in food availability per second, could act to prevent use of such areas by physiologically intolerant species. In the study area also the seasonal shift of some warblers may be both due to the changes in food availability and temperature fluctuation within the different seasons of the year. The study area may hold a good amount of food and a favourable temperature for these species during the winter season. When the winter passes by, the food availability may decrease and the temperature of the study area rises which may be intolerant for these species.

Other some important winter visitors are Yellow-bellied Fantail (*Rhipidura hypoxantha*), Scaly Thrush (*Zoothera dauma*), Dark-throated Thrush (*Monticola rufiventris*), Red-throated Flycatcher (*Ficedula parva*) and Spot-winged Grosbeak (*Mycerobas melanozanthos*).

About 149 species are winter migrants in Nepal (Inskipp and Inskipp, 1991). Unavailability of sufficient water resources in the study area is the main cause for the low number of winter migrants. Only few number of small hill streams are present in the study area which are unable to attract the aquatic migratory birds. But only those migratory birds which are dependent on forest ecosystem were present in the study area because of the availability of such type of habitat. Shah (2000) and Shrestha (2000) have also argued that most of the migratory birds in Nepal are aquatic species such as Ducks, Geese, water hens, Snipes and Storks.

Similarly, 62 species of birds are summer visitors to Nepal (Inskipp and Inskipp, 1991). In the study area, only 19 species were summer visitors. Majority of them were cuckoos like Indian Cuckoo (*Cuculus micropterus*), Eurasian Cuckoo (*Cuculus canorus*) and Lesser Cuckoo (*Cuculus*

poliocephalus). Other important species like Chestnut-headed Bee-eater (*Merops leschenaulti*) Asian Koel (*Eudynamys scolopacea*), Slaty-headed Parakeet (*Psittacula himalayana*), Golden-fronted Leaf bird (*Chloropsis aurifrons*), Eurasian golden Oriole (*Oriolus oriolus*); Blue-throated Flycatcher (*Cyornis rubeculoides*) and Pale Blue Flycatcher (*Cyornis unicolor*) are some representative species of summer visitors.

The status of Dollarbird (*Eurystomus orientalis*), Indian peafowl (*Pavo cristatus*), Greater Racket-tailed Drongo (*Dicrurus paradiseus*) and Himalayan Swiftlet (*Collocalia brevirostris*) were unknown.

Species diversity index showed a highest value in spring season ($\bar{H} = 3.7916$) followed by winter season ($\bar{H} = 3.7267$), autumn season ($\bar{H} = 3.4323$) and rainy season ($\bar{H} = 3.295$). Relative diversity (Evenness) was highest during spring season (0.870) followed by winter season (0.848), rainy season (0.834) and autumn season (0.828). This shows that spring and winter seasons were most favourable for birds than autumn and rainy seasons. Jayson and Mathew (2000a) has found the diversity index values higher during summer (December to April) and lower during monsoon (May to November) at silent valley and Mukkali which was attributed to the availability of more fruits. There was increase in the density and number of birds in December (Jayson and Mathew, 2000b) in silent valley Kerala.

Relative abundance (Encounter rates) of the resident birds observed was mostly uncommon. 45 (59.2%) species were uncommon, 21 (27.63%) species were encountered frequently and 10 (13.15%) species were common. No single bird species in the study area had its relative abundance rare or abundant. In Terai Arc Landscape also rare and uncommon species were higher than the common and abundant species (DNPWC/WWF, 2003).

In the study area, *Schima wallichii* forest covered the largest area (61.29%) and the bird species were also higher in *Schima wallichii* forest than pine forest, dry

oak forest, mixed broadleaved forest and grasslands. Pine forest, dry oak forest and grassland produced a structurally less complex ecosystem having a small size and therefore supported a smaller number of bird species. In contrast, *Schima wallichii* forest having larger area, produced a complex ecosystem and thus supported a higher number of bird species. Other factor may be the availability of food which is higher in *Schima wallichii* forest. The main requirements of birds are a wooded area with good vegetation, where they can nest, breed, form territories, and get enough food (Narve et al., 1997). The *Schima wallichii* forest supports all these favourable conditions, due to which bird species are higher. Grimmett et al. (2003) have identified the broadleaved sub-tropical forest dominated by the *Schima-castanopsis* is second in species richness of birds of tropical forest.

NRF, however, lies in a sub-tropical and temperate zones, some tropical bird species like Dollarbird (*Eurystomus orientalis*), Indian Peafowl (*Pavo cristatus*) and Greater Racket-tailed Drongo (*Dicrurus paradiseus*) were also observed. Inskipp and Inskipp (1991) has stated Dollarbird (*Eurystomus orientalis*) to be found upto 365m in Nepal. Only two records of this bird had been found from the Kathmandu valley this century. And, they have also stated that Greater Racket-tailed Drongo (*Dicrurus paradiseus*) are also mainly found below 150 m, uncommon upto 365m and rarely at higher altitudes.

The Kaliz Pheasant (*Lophura leucomelanos*), were mostly seen in the mixed broadleaved forest as well as in the *Schima wallichii* forest mostly in a group of 2 to 4 in number. Chhetri (2002) also found this species widely in dense broadleaved forest of middle hills of Nepal. Ojha (2004) also found this bird in this type of habitat even very close to the settlement. The species mainly prefers closed forest of *Schima wallichii* with high understorey and even low understorey (Gautam and Baral, 2002). Mishra (1996) has also found the maximum sighting of Kaliz in such type of habitat mostly in group of 1 to 5 in Harsang Wildlife Sanctuary, India.

Tree sparrow (*Passer montanus*) (Field, 2004) showed a strong preference for nest sites adjacent to wetland habitats. However, in NRF, such type of habitat is lacking. So, very few number of this bird was seen.

All the species of woodpeckers in the study area like Fulvous-breasted Woodpecker (*Dendrocopos macei*), Greater Yellownape (*Picus flavinucha*), Lesser Yellownape (*Picus chlorolophus*), and Bay Woodpecker (*Blythipicus pyrrhotis*) were seen mostly in *Schima wallichii* forest. Shackelford et al. (1997) has also found that woodpeckers' presence and abundance were primarily associated with the occurrence of large snags and logs and they preferred more hardwoods than pines.

Spiny Babbler (*Turdoides nipalensis*), only endemic bird of Nepal was found in scrub habitat of the forest. Shrestha (1998) has mentioned that this bird is mostly found in scrubs with secondary growth and has also reported this bird from the NRF.

The number of bird species as well as the number of birds observed in the study area were significantly different in all seasons as well as in all transects. Hutto (1985) has also found significant (ANOVA season X habitat) shift in the occupancy of the various habitat types from spring to fall, as evidenced by combined bird densities.

In this study, the number of species (species richness) were highest during winter season (81 species) followed by spring season (78 species), autumn season (63 species) and rainy season (52 species). Reid et al. (2002) have also recorded highest bird abundance and richness during winter and spring in Chile. At silent valley and Mukkali also the total number, density and species richness of birds declined during monsoon and increased in the dry months (Jayson and Mathew, 2000a). This variation in species richness is due to the variation in observation period as well as climatic condition and availability of food. Gunawardena (1999) and Natarajan (1992) have also reported that the

population of birds varies throughout the year depending upon the climatic condition and availability of food.

One factor influencing the abundance and species richness is detectability. Seasonal differences in detectability are common for most of the bird species (Emlen, 1971). These differences result from changes in weather and habitat structure. Increasing the foliage density decreases the visibility of birds. In the study area, foliage may be increasing and decreasing in different seasons. Rainfall also may have some influence on detectability of birds. There may be difference in detectability of birds between the forest edges and interior of the forests also. Forest edges have open habitat and the birds can be detected easily while interior of forest have the dense vegetation due to which the birds are hardly detected and identified.

The study indicated that seasonal variation in species richness of birds in forest edges and roadsides (i.e. transects 1 and 4) is higher than that of the other interior areas of the forest (i.e. transects 2 and 3). The graph showed in figure 12 gives an idea that more migratory birds (winter visitors and summer visitors) were present in the forest edges fluctuating the species richness seasonally in the area.

Transect 1 (forest edge) had the higher number and species richness (88) of birds than that of the interior of the forest. Birds prefer the sunlight around the edge of the forest (Wang, 1995). As a result plant seeds are often deposited in such areas in bird faeces, thus creating suitable conditions for germination. Forests near the road margins had reduced canopy cover and height and higher numbers of fallen branches of tree than did forest interiors. Bird communities near forest edges also differed markedly from those in forest edges interiors (Laurence, 2004). Forest edges of the study area may be more suitable for more species than interior of the forest.

According to Daniels (1989), there is an increase in bird species diversity when forests are disturbed. In the study area, the disturbance were higher in the roadside (Transect 4) followed by the forest edge (Transect 1) which were

created by people and the vehicles passing through that road. Vehicles in the road make noise to the forest birds. However, in contrast to this, Svein et al. (2000) has found significant increase in the number of species with distance from the edge. But more common species were found in edge whereas less common species were found in the interior of the forest as found in the present study area. Common species like Spotted Dove (*Streptopelia chinensis*), House Sparrow (*Passer domesticus*), Tree Sparrow (*Passer montanus*), Common Tailor-bird (*Orthotomus sutorius*), Oriental Magpie Robin (*Copsychus saularis*), Common Myna (*Acridotheres tristis*), Jungle Myna (*Acridotheres fuscus*) etc. were restricted to the forest edges while less common species like Barred Cuckoo Dove (*Macropygia unchall*), Red-throated Flycatcher (*Ficedula parva*) White-throated Laughingthrush (*Garrulax albogularis*), Spot-winged Grosbeak (*Mycerobas melanozanthos*), Streak-breasted Scimitar Babbler (*Pomatorhinus ruficolis*), Yellow-bellied Fantail (*Rhipidura hypoxantha*) etc. were found in interior of the forest. Beehler et al. (1987) has shown that heavily disturbed forest usually supports much fewer forest specialist species and more generalized feeders.

Transect 2 with interior of altitudinally graded forests, ranging from low *schima wallichii* forest to high altitude dry oak forest had lowest number of 41 species. Most of them occurred in low altitude of *schima wallichii* forest and pine forest and the number of bird species observed gradually decreased along with increasing altitude. Begon et al. (1996) has stated that species richness generally decreases with increasing elevation. In different studies done by Ranawana et al. (1996) in Sri Lanka and Shiu et al. (2003) in Taiwan also, there were decline in species richness with increasing elevation. This may be due to the change in vegetation, food resources and cold climate at high altitudes. Adolfo et al. (1992) has also found significant decline in bird species with altitude.

6. CONCLUSION

The present study has been carried out with the main objectives of exploration of seasonal diversity, relative abundance and assessment of status of the avian fauna in NRF. Another objective of this study was to see the seasonal changes in species richness of birds in different habitats like forest edges and interior of the forest. During the study period which included all the four seasons i.e. spring, rainy, autumn and winter, the birds were observed along the four predetermined transects covering all the major habitat types. Shannon-Wiener function was used to calculate the species diversity and encounter rates of every species were calculated to find out its relative abundance.

Altogether 117 bird species belonging to 12 orders and 37 families were observed in the study area. Among them, 76 species were resident, 18 species were winter visitors and 19 species were summer visitors. Four species of them were unknown to its status. Nagarjun forest, however, lies in a sub-tropical and temperate zones, some tropical bird species like Dollarbird (*Eurystomus orientalis*), Indian Peafowl (*Pavo cristatus*) and Greater Racket-tailed Drongo (*Dicrurus paradiseus*) were also observed.

Shannon Wiener diversity Index showed highest value during spring followed by winter, autumn and lowest during the rainy season. Similarly, relative diversity (evenness) was also highest during spring season followed by winter; rainy and lowest was observed during autumn season.

It was found that out of the 76 resident bird species, only 10 species were encountered commonly and 21 species were encountered frequently. The highest number of 45 species fell into the uncommon category.

Among the six different habitat types, the highest number of 112 bird species was recorded from the *Schima wallichii* forest, which covers the largest area of all the forest, followed by pine forest (28 species), mixed broadleaved forest

(18 species), oak forest (10 species), grassland (10 species) and streams (two species). The forest with high structural diversity supports richest avifauna because it provides both shelter and food. The highest number of 40 species was habitat specific to *Schima wallichii* forest and was exclusively observed in this habitat. In each habitat of mixed broadleaved forest, dry oak forest and streams, only one species was exclusively observed. No species were habitat specific to pine forest and grassland.

The species richness of birds were significantly different in all seasons ($F = 5.211$, $P = 0.023$ and $df = 3$) as well as in transects ($F = 14.531$, $P = 0.001$ and $df = 3$). Similarly, the mean number of birds were also significantly different in all seasons ($F = 6.647$, $P = 0.12$ and $df = 3$) as well as in all transects ($F = 4.310$, $P = 0.038$ and $df = 3$). The species richness was higher during spring and winter seasons while it lowered during rainy and autumn seasons. It was also found that forest edges covered higher number of bird species than the interior of the forests but more common species were present in forest edges while less common species were present in the interior of the forest. The study indicated that most of the birds in the study area occurred in the low altitude of *schima wallichii* forest and pine forest

Out of the 117 bird species recorded, 10 species have been listed in the National Red Data Book and 10 species have been included in the Appendices of CITES. Two species recorded are listed in vulnerable category by BCN. Thus, it can be concluded from the study that NRF provides a good habitat for many important birds. Due to the presence of mosaic of different habitats as well as an altitudinal variation within the study area, it supports a rich diversity of both residential as well as migratory bird species.

7. RECOMMENDATION

Some useful recommendation, which will be helpful for the conservation of birds in the Nagarjun forest are as follows:

- Although, Nagarjun forest lies near to the Kathmandu valley, a regular monitoring of birds is lacking. So, the birds should be monitored regularly in a long term basis to assess the habitat change and its effect on birds and also to evaluate the management needs for the conservation of important birds.
- The study area also supported some nationally threatened species of birds as indicated by the study. These points to the importance of conserving the forest to ensure the survival of these vulnerable species.
- NRF being rich in biodiversity, it is recommended that this area be set aside for scientific research and recreational use.
- Road passing through the edge of the forest along with its wall is a major route for vehicles moving out of the valley. These vehicles make extreme noise, obviously affecting the forest birds. So, to minimize the noise, this area should be declared as a silent zone for vehicles.
- Many people or tourists visiting the forest specially Jamacho for different religious and recreational purposes pollute the area by littering and disposing different non-degradable wastes like plastic materials such as bottles of mineral water; soft drink, packets of instant noodles; biscuits and other snacks etc. These pollutants will definitely create an adverse effect on biodiversity including the bird population as well.
- Nagarjun on top of Jamacho is the good view point of Kathmandu valley, and has its own scenic beauty in itself. Rich biodiversity of Nagarjun forest also attracts many tourists and this is the nearest birding place from Kathmandu Metropolitan City for different bird watchers as well as to other people also. So, this forest should be developed as a

potential area for avian fauna ecotourism to encourage bird conservation.

- As conservation is not possible without the active participation of local people of that area, awareness programmes on conservation of birds and their importance should be conducted regularly.
- During the study, there were many problems entering the forest through entrance gate. Researchers should be facilitated to enter the forest without any objections to encourage the research work to be done timely and effectively.

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