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BIRD SPECIES COMPOSITION ALONG THE ALTITUDINAL GRADIENT IN HIMACHAL PRADESH (WESTERN HIMALAYA), INDIA

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ABSTRACT
Quantification of bird species composition along an elevational gradient in the western Himalayan region of Himachal Pradesh revealed that of a total of 322 species recorded during present investigations, maximum avifauna was observed in Pong Wetland (73.60% of the total), followed by Balh valley (59.32%) and Nalagarh areas (51.86%) of the Shiwalik zone, whereas, minimum diversity was seen in Kaza area (19.25%) of Trans-Himalayan region. Change in bird species composition along altitudinal gradient showed that there was a decrease in their diversity with increase in elevation. The avifaunal investigations further revealed a turnover of 93.48% from lower most to highest zone along the elevational gradient. Analysis of residential status showed that there was an overall decreasing trend in percentage of resident birds between localities along the altitudinal gradient. Moreover, it was very interesting to note that there was a significant increase in the percent composition of summer visitors from 7% in Pong Wetland to 68% in Kaza area. The explorations showed that there was a decrease in percentage of very common species across the Himalaya. However, percentage of uncommon showed an opposite trend. It increased from around 11% in Nalagarh (Shiwalik zone) to 32% in Kaza area (Trans-Himalayan zone).

KEYWORDS: Birds, change, altitudinal gradient, Himachal Pradesh, western Himalaya

INTRODUCTION

Historical influx of fauna from adjacent biogeographical regions and subsequent speciation in relation to local environment has greatly enriched the animal resources of the Himalayan region. There is a pronounced dominance of Palaearctic and endemic animals above timber line (3000 m), and largely Oriental and some Palaearctic and some Ethiopian elements at lower and middle altitudes (Mehta & Julka 2002). Bird communities separated by 1000 m altitude are different from one other mainly due to change in precipitation (Price *et al.*, 2003). Richness of bird diversity has been correlated with topography, precipitation and an interaction between topography and latitude (Rabhek & Graves 2001). One of the most general features of life on earth is changes of abundance and diversity of organisms along the earth's major environmental gradients, including elevation (Brown 2001). Most studies about change of bird species richness along elevational gradients have been carried out in different parts of the world mostly in tropical regions (Terborgh 1971, 1977; Navarro 1992; Blake & Loiselle 2000; Lee *et al.*, 2004; Herzog *et al.*, 2005; Paulsch & Muller-Hohenstein 2008) and a few studies have been undertaken in temperate zones (Rabhek 1995; Sergio & Pedrini 2007). In contradiction, studies on elevational changes of birds in Indian subcontinent are limited to a few studies (Price *et al.*, 2003; Raman *et al.*, 2005). Therefore, present study was designed to quantify avifaunal changes along an elevational gradient in the little explored western Himalayan region of Himachal Pradesh.

METHODOLOGY

Study area

Himachal Pradesh is mainly a hilly state of the Indian Himalayas lying between 30º 22' to 33º 12' North latitude and 75º 47' to 79º 04' East longitude. The physiography of this state is almost mountainous with elevations ranging from 350 to 6500 metres above mean sea level and total area of the state is 55,673 sq km. This hilly state is also divided by a general increase in elevation from west to east and from south to north into four biogeographical zones *viz*., Shiwalik or Outer Himalayas, Lower or Lesser Himalayas, Higher or Greater Himalayas and Trans Himalayas. The Shiwalik ranges are the southern-most zone of about 40 to 60 km width, comprising several highly eroded low ridges. A zone of medium to high ranges (about 80 km wide), the Lesser Himalaya runs north of the Shiwalik and parallel to the main range. The Great Himalayan ranges lie just towards the north of the Chandrabhaga river in Lahaul-Spiti and Pangi regions of Himachal Pradesh. This range is nearly 24 km wide and comprises the great peaks rising up to an elevation of over 6000 metres amsl. Spiti area of the state constitutes a separate and distinct unit, *i.e.* Trans-Himalaya (Mehta & Julka 2002; Mahabal 2005; Mehta 2005).

Natural vegetation of the state is classified into six broad types of forests *viz.*, Tropical forests (confined to foothills), represented by two subtypes, namely thorn-scrub of *Acacia* and *Zizyphus*, and dry deciduous forests of *Shorea robusta;* Subtropical forests (500-1800 m), which are further composed of two subtypes *i.e.* subtropical dry evergreen forests of *Terminalia, Albizzia, Olea etc* (below

1200 m), and subtropical pine forests of chir pine (*Pinus roxburghii*) found upto 1800 m; Temperate forests (1500-3000 m) which are also divided into two subtypes *i.e.* Himalayan moist temperate covers areas between 1500 and 3000 m, where the flora is dominated by oaks (*Quercus* spp.), deodar (*Cedrus deodara*), fir (*Abies pindrow*), blue pine (*Pinus wallichiana*) and horse chestnut (*Aesculus indica*), and another is the Himalayan dry temperate subtype of Holm oak (*Quercus ilex*) and edible pine (*Pinus gerardiana*) which is best developed at 2000 to 3000 m in the greater Himalayan regions of upper Sutlej valley in Kinnaur district; and Sub-Alpine and Alpine vegetation (above 4000 m) which is dominated by birch and rhododendron and interspersed with high-altitude meadows, found in most parts of Lahaul, Spiti and Kinnaur districts of the state (Mehta 2005; Narwade *et al.* 2006). Present studies on change of bird species composition with altitude were conducted in different altitudinal zones of Himachal Pradesh on the following lines:

Site Selection

Present avian studies were conducted in seven selected study sites *viz.*, Nalagarh (350 m, Solan), Pong Wetland (430 m, Kangra), Balh Valley (800 m, Mandi), Dev Nagar (1530 m, Shimla), Shimla (2100 m, Shimla), Kalatop-Khajjiar (2300 m, Chamba) and Kaza (3500 m, Lahaul & Spiti) of Himachal Pradesh (Table I; Fig. I).

TABLE I: Sites of bird study in Himachal Pradesh

S.No.	Locality (District)	Latitude (North)	Longitude (East)	Altitude (Metre)	Biogeographic Zone
1.	Nalagarh (Solan)	31° 02´	76° 43´	350	Sub tropical (Shiwalik)
2.	Pong Wetland (Kangra)	31° 58´	75° 57´	430	Sub tropical (Shiwalik)
3.	Balh Valley (Mandi)	31° 35´	76° 54´	800	Sub tropical (Shiwalik)
4.	Dev Nagar (Shimla)	31° 09´	77° 05´	1530	Sub temperate, (Middle Himalaya)
5.	Shimla (Shimla)	31° 06´	77° 09´	2100	Temperate (Middle Himalaya)
6.	Kalatop-Khajjiar (Chamba)	32° 32´	76° 03´	2300	Temperate (Middle Himalaya)
7.	Kaza (Lahaul & Spiti)	32° 11´	78° 05´	3500	Cold desert (Trans Himalaya)

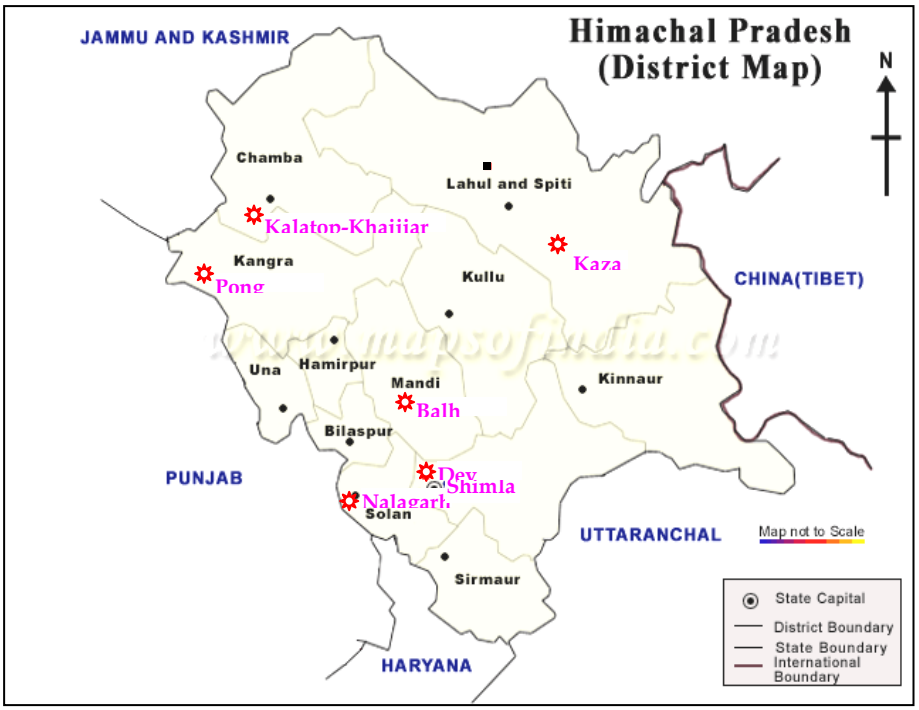

FIGURE I: Localities of Bird study in Himachal Pradesh
(Original source of map: www:mapsofindia.com)

These investigations were conducted during different seasons of the years 2002 to 2007 in various habitat types. Nalagarh site falls in the sub tropical zone of the Shiwalik hills and supports large scale agriculture with some scrub forest patches of *Acacia* spp., *Bauhinia variegata*, *Carissa opaca*, *Ficus reliogosa*, *Lantana* sp. etc., whereas, Pong

Wetland is a fresh water reservoir and has been declared as wetland of International Importance. This area has rugged ridges, forested glades and streams cutting through valleys and canyons. Forest patches of acacia and pines, marshes, agricultural fields and wasteland area are the main features of this area. Balh is a saucer shaped valley situated in the centre of Mandi district of Himachal Pradesh. The vegetation of the valley is subtropical type. It embraces agricultural land, a few forested patches and some fallow land. The area is drained by Suketi khud, which flows through middle of the valley alongwith a number of small seasonal and perennial streams. Besides, a few village ponds are also present in this valley. Dev Nagar is a small valley, surrounded by steep hills and falls in the middle Himalayan zone of Himachal Pradesh. The area supports sub-temperate type of forests of oak and rhododendron with few pine and deodar patches. Shimla, a hilly tract of temperate zone is situated in the lap of the northwest Himalayas and supports forests of deodar, pine, rhododendron, oak etc. The forest types vary with exposure and elevation. Moreover, this study site is one of the most populated zones of the state. Similarly, Kalatop-Khajjiar Wildlife Sanctuary in Chamba district of Himachal Pradesh harbors dense forests of deodar and oak, on a hilly tract. It is one of the oldest preserved forests in the state (notified on 01.07.1949). Geographically it is situated at the northwest termination of Dhauladhar range in the middle Himalayas. Khajjiar portion of the sanctuary is also known as mini Switzerland. However, Kaza area of Trans-Himalayan zone of the state has cold desert climate. Some of the forested and thorny patches of willow are found around villages only.

Sampling Strategies

Specific sampling strategies were adopted for studying the avifauna of various experimental sites as various localities selected were large enough and the target species were high in number. These strategies were mainly based upon the principle of exploration of a portion of the individuals in the whole population. Thus, Stratified Random Sampling Technique (Snedecore & Cochran 1993) was followed for studying the birds of each area, which involved the division of sites into different strata, based upon vegetation type and habitat.

Study design

Intensive studies conducted in selected sites were based on Line Transect Method (Burnham *et al.* 1980). Keeping in view the hilly and more rugged terrain of the state, Piecewise Linear Line Transects were marked and monitored on monthly basis in various study sites except the Kaza area which remains inaccessible during winter months. Further, these transects were monitored as open width transects, where birds were recorded irrespective of their distance from transect. Almost equal numbers of field days were spent in each locality so as get the data viable for comparison purposes. The birds were observed with the help of a 10x50 super Zenith field binoculars and 1000 mm Tele-lens of Questar make (especially water birds). Field identifications were carried out with the help of various field guides (Ali & Ripley 1983; Grimmett *et al.* 1999; Kazmierczak 2000).

Analysis and interpretation of avian data

The avian data generated in each survey and each transect run was recorded on separate data sheets for different seasons, habitat types, climatic zones etc. Each list was kept independent of other one. Besides diversity, the data was also analyzed for relative abundance of each bird species on a relative frequency scale of occurrence depending upon the number of sightings (Mc Kinnon &Philip 1993).

Total number of sheets taken for analysis of relative abundance for each intensive study site was equal to:

2 sheets (each habitat) x 3 (major seasons) x types of habitat

Based upon these, different categories assigned were: Very Common (recorded in more than 45 % of data sheets), Common (between 25-45 % of data sheets), Uncommon (between 10-24 % of data sheets) and Rare (recorded once or twice). The relative frequency scale was fixed in such a way so as to include the migrant species sighted seasonally in good numbers (which visited the area for a brief period of time) to their respective category. This method was modified from Narayan *et al.* (1986). Similarly, residential status was worked into various categories like resident, winter visitor, summer visitor etc. on the basis of the presence or absence method (Mc Kinnon & Philip 1993; Mehta *et al.*, 2002).

Primary data is available in the form of following publications: Thakur *et al.* (2002, 2003, 2006, 2008, 2011); Mattu and Thakur (2006); Thakur (2008); Thakur and Mattu (2011).

RESULTS

Intensive studies on avifauna conducted in seven selected study sites of Himachal Pradesh revealed the presence of 322 species of birds belonging to 190 genera, spread over 60 families and 17 orders. These included 167 species of birds spread over 121 genera, 51 families and 17 orders from Nalagarh area of Solan district; 237 species of birds belonging to 153 genera spread over 54 families and 17 orders from Pong Wetland, Kangra; 191 species of resident, winter migrant and summer visitor birds belonging to 129 genera spread over 47 families and 16 orders from Balh valley of Mandi; 143 species of birds spread over 98 genera, 39 families and 13 orders from Dev Nagar area of Shimla hills; 134 species of resident and migrant birds belonging to 92 genera spread over 36 families and 11 orders from Shimla area; 110 species of birds belonging to 77 genera, 33 families and 13 orders from Kalatop-Khajjiar Wildlife sanctuary, Chamba; 62 species of birds belonging to 43 genera, 20 families and 7 orders from Kaza area of Lahoul & Spiti district (Table II). Present studies showed that family Muscicapidae was the most dominant family in all the study sites, as it formed around 16% of the total avifauna in Nalagarh, 16.87% in Pong Dam Wetland, 27.75% in Balh Valley, 32.88% in Dev Nagar, 27.61% in Shimla, 25.45% in Kalatop-Khajjiar Wildlife Sanctuary and 17.74% in Kaza area. Overall percentage of this family in Himachal Pradesh was 17%. However, the contribution of families like Podicipedidae, Phalacrocoracidae, Anhingidae, Falconidae, Jacanidae, Recurvirostridae, Burhindae, Glariolidae, Caprimulgidae, Coraciidae, Upupidae,

Bucerotidae, Irenidae *etc*. in avifauna was below 2% in all the study sites. Studies on avifauna along the altitudinal gradient showed that there was a decrease in diversity with increase in elevation. For example, study sites of Pong Wetland (73.60%), Balh Valley (59.32%) and Nalagarh (51.86%) situated at lower altitudes had maximum bird diversity, whereas, study site of Kaza located at the highest elevation showed the minimum diversity (19.25%) of the state. However, other study sites of Dev Nagar, Shimla and Kalatop-Khajjiar area showed 44.41%, 41.61% and 34.16% of the diversity of birds respectively (Table II). Inter locality variations showed that there was an increase of 21.73% in diversity of birdlife between Nalagarh and Pong Wetland (Table II). However, there was an overall decreasing trend in diversity with increase in altitude and there was a decrease of 14.28% between Pong Wetland and Balh Valley, 14.90% between Balh Valley and Dev Nagar, 2.79% between Dev Nagar and Shimla, 7.45% between Shimla and Kalatop-Khajjiar, and 14.90% between Kalatop-Khajjiar and Kaza area. From these studies it appeared that there is a negative change with increase in altitude, with regards to the number of species (Table II).

TABLE II: Bird species composition in different study sites

Locality (District)	Species (Genera, Families, Orders)	Relative Abundance	Residential Status						
			R	R/LM	WV	SV	R/WV	R/SV	Total
Nalagarh (Solan)	167 (121, 51, 17)	VC	13	48	14	7	8	0	90
		C	9	20	14	6	3	0	52
		UC	4	3	10	1	0	1	19
		Ra	2	3	1	0	0	0	6
		Total	28	74	39	14	11	1	167
Pong Wetland (Kangra)	237 (153, 54, 17)	VC	14	56	36	8	11	0	125
		C	11	20	24	7	3	0	65
		UC	4	6	16	1	1	1	29
		Ra	5	4	8	1	0	0	18
		Total	34	86	84	17	15	1	237
Balh Valley (Mandi)	191 (129, 47, 16)	VC	6	37	11	7	5	7	73
		C	10	17	27	20	5	2	81
		UC	6	9	10	6	2	1	34
		Ra	1	1	1	0	0	0	3
		Total	23	64	49	33	12	10	191
Dev Nagar (Shimla)	143 (98, 39, 13)	VC	5	28	1	4	6	4	48
		C	5	27	9	16	4	6	67
		UC	1	7	6	8	1	1	24
		Ra	1	2	0	1	0	0	4
		Total	12	64	16	29	11	11	143
Shimla (Shimla)	134 (92, 36, 11)	VC	3	21	1	3	0	6	34
		C	3	22	2	12	3	6	48
		UC	3	18	4	13	3	7	48
		Ra	1	3	0	0	0	0	4
		Total	10	64	7	28	6	19	134
Kalatop-Khajjiar (Chamba)	110 (77, 33, 13)	VC	1	19	0	2	0	4	26
		C	6	23	2	12	0	8	51
		UC	3	13	2	10	0	4	32
		Ra	0	0	1	0	0	0	1
		Total	10	55	5	24	0	16	110
Kaza (Lahaul & Spiti)	62 (43, 20, 7)	VC	0	7	0	7	0	1	15
		C	1	7	0	14	0	3	25
		UC	0	1	0	19	0	0	20
		Ra	0	0	0	2	0	0	2
		Total	1	15	0	42	0	4	62

Residential status: R= Resident, R/LM= Resident with local movements, R/WV= Resident, with winter influx, R/SV= Resident with summer influx, WV= Winter visitor, SV= Summer visitor

Relative abundance: VC= Very common, C= Common, UC= Uncommon, Ra= Rare

The avifaunal investigations further revealed a turnover of 93.48% from lower most to highest zone along the elevational gradient, as only 6.52% (21) of the species in Nalagarh area were also found in Kaza area, whereas, a majority i.e. 93.48% (301 species) do not extend their distribution range from Shiwalik to Trans-Himalayan region. An insight on the qualitative analysis of the bird diversity of the localities separated by elevational gradient revealed that the species present in one locality were replaced by the others. The study showed that 80 species

present in Pong Wetland were not found in Balh Valley, whereas, there was an addition of 34 new species in the diversity of Balh Valley. Similarly, 71 species found in Balh Valley were absent in Dev Nagar and an addition of 23 new species was found between the two areas. The study further revealed that on moving from Dev Nagar to Shimla area, there was an addition of 27 new species in place of 36 species. Moreover, there was deletion of 36 species and an addition of 12 new one's between Shimla and Kalatop-Khajjiar Wildlife Sanctuary. Further, on comparison of quality of bird diversity of Kalatop-Khajjiar and Kaza areas it was found that there were 80 such species which were present in the former area and absent from the later, and an additional 32 new species were added in Kaza area. Analysis of residential status showed that there was an overall decreasing trend in percentage of resident birds between localities along the altitudinal gradient. It varied from 16.2 % in Nalagarh to 2% in Kaza area. Similarly, an overall decreasing trend in percentage of winter visitors was also observed between different study sites. Moreover, it was very interesting to note that there was a significant increase in the percentage composition of summer visitors from 7% in Pong Wetland to 68% in Kaza area. Similarly, percentage of species with summer influx also showed an overall increasing trend along the altitudinal gradient. However, there was no regular inclination in composition of local migrant and the species with winter influx (Table II; Fig. II).

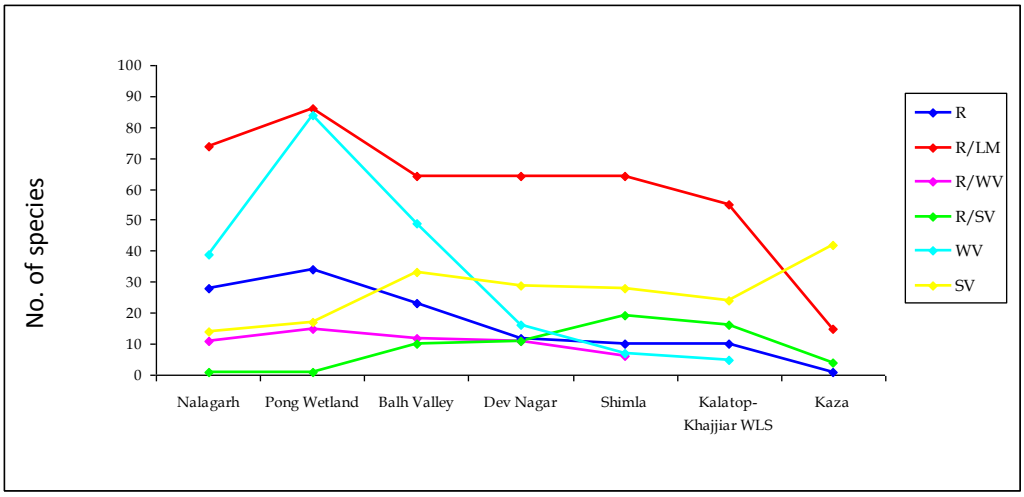

FIGURE II: Drift in residential status of birds in different study sites

The explorations showed that there was a decrease in the percentage of very common species across the Himalaya. It decreased from around 54% in Nalagarh to 24% in Kaza area. However, percentage of uncommon species of birds showed an opposite trend. It increased from around 11% in Nalagarh to 32% in Kaza area. Moreover, there was no regular increasing or decreasing tendency in percentage of common and rare bird species along the altitudinal gradient (Table II; Fig. III).

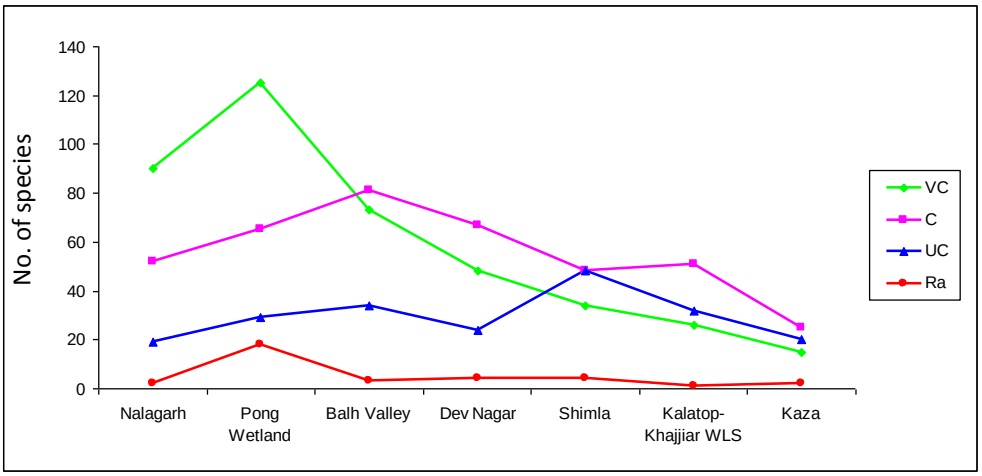

FIGURE III: Drift in relative abundance of birds in different study sites

DISCUSSION

Present investigation in overall sense reveals the presence of a continuously decreasing diversity type of pattern with increasing altitude (Sergio & Pedrini 2007). There is a close relationship between species richness and changing habitat complexity. This habitat complexity has been attributed to the decreasing height of woody vegetation, and differences of tree density and plant species richness between elevation belts (Rabhek 1995). Similar vegetation stratification is found in different zones of Himachal Pradesh (Narwade *et al.* 2006; Gaston 1995). Present account in a strict sense points towards hump-shaped

distributions of species richness with elevation (Rabhek 1995). Maximum values of precipitation, soil moisture and evapotranspiration at mid-elevation (Ding *et al.* 2005; Rabhek 2005; Lomolino *et al.* 2006) zones can be correlated with the presence of 59.32% of the total bird diversity in mid altitude area of Balh Valley as compared to 51.86% in Nalagarh (low altitude area). The hump-shaped distribution of species richness in the present case mainly arises due the presence of varied types of habitats in Pong Wetland which besides a number of winter visitors form north-central Asia, supports a number of resident and local migrant species due to the presence of marshes, agriculture fields, rugged ridges, forested glades and streams cutting through valleys and canyons.

Decrease in bird diversity from 167 species in Nalagarh to 62 species in Kaza area of Lahoul & Spiti can be explained with earlier work of Brown and Lomolino (1998) who emphasized that lower elevational zones as compared to higher altitudes usually have greater total amount of resources and population numbers, more refugia and space for species with larger home ranges, greater habitat diversity and greater potential for serving as target for potential immigrants. Moreover, earlier explorations (Gaston *et al.* 1993; Gaston 1995; Mahabal 2005) have also shown that the birdlife of two different altitudes are different from each other in Himachal Pradesh. A recent study showed that maximum number of bird species (313) were present in Kangra district and diversity decreased to 40 species in Kinnaur district of Himachal Pradesh therefore showing an overall decreasing trend in number of species with increase in altitude (Mahabal 2005). Similarly, maximum diversity (101 species) of birds was recorded in lowest zone of Kangra district of Himachal Pradesh (Mahabal & Sharma 1992). High turnover of 93.48% has been recorded during present study from lower most (350 m) to highest zone (3500 m) along the elevational gradient. This can be correlated with change in precipitation due to which the bird communities separated by 1000 m altitude in Himalayas are different from one other (Price *et al.* 2003). The bird diversity of South America has been correlated with topography, precipitation and an interaction between topography and latitude (Rabhek & Graves 2001).Predominance of resident and winter visitors in the lower areas of Himachal Pradesh, and increasing percentage of summer visitors and seasonal altitudinal migrants with altitude can be attributed to the abundance of feeding guilds which ultimately depends on habitat structure (Brunner 1998, 2001). The habitat structure in the present study area of Himachal Pradesh changes from sub-tropical type at lower elevations to dwarf alpine types at the highest zones (Narwade *et al.* 2006) which may influence species richness and composition by significantly affecting the abundance of feeding guilds.

Present study is in accordance with the earlier works of Mahabal (2005) who in his study on the birdlife of Himachal Pradesh observed that resident birds and winter visitors were predominantly observed in the Shiwalik Himalaya and showed subsequent decrease with corresponding increase in the altitude. However, percentage of summer visitors and seasonal altitudinal migrants was found to be in increasing order from Shiwalik to Trans-Himalayan region. Similarly, Gaston (1995) elucidated that in addition to the resident birds, Shiwalik Himalaya receives a flood of winter visitors from the adjacent high ranges and north and central Asia.

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