JOURNAL OF ECOLOGY AND CONSERVATION
Jul-Sept 2024, VOL. 2, ISSUE 3, pp. 15-20
https://doi.org/10.61577/jec.2024.100013

RESEAPRO JOURNALS

ORIGINAL ARTICLE

OPEN ACCESS

Diversity and habitat association of birds in the Someshwar range of Madi, Chitwan, Nepal

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ABSTRACT

This study investigates seasonal variations in bird diversity and its relationship with vegetation structure in the Someshwar Range Forest, Madi, Chitwan, Nepal. The forest was divided into lower and upper elevation belts, and bird data were collected using the point count method, identifying 101 bird species across 11 orders and 32 families. Seasonal analysis revealed higher species richness in winter compared to summer, though statistical tests indicated no significant seasonal variation ($P = 0.674$). The increased richness in winter is likely due to enhanced food availability and favorable weather conditions, while the lower summer richness may be attributed to harsher environmental factors. Elevation significantly influenced bird diversity, with greater species richness observed in the lower belts (ANOVA: $F = 5.46$, $P < 0.05$). A strong positive correlation was found between bird species richness and tree species diversity ($r = 0.69$) and tree density ($r = 0.71$). Conversely, a negative correlation with tree diameter at breast height (DBH) ($r = -0.539$) suggests that areas with larger, older trees may support fewer bird species. These findings highlight the critical role of habitat diversity and structure in supporting avian populations and emphasize the effects of elevation and seasonal changes on bird diversity.

KEYWORDS

Species richness; Edge effect; Elevation belt; Correlation; Sustainable Development

ARTICLE HISTORY

Received 18 July 2024;
Revised 30 July 2024;
Accepted 06 August 2024

Introduction

Bird diversity is a critical indicator of habitat quality and ecosystem health due to birds' sensitivity to environmental changes and habitat variations [1]. As mobile and highly responsive species, birds provide insights into the impacts of habitat degradation, climate change, and other environmental pressures. Nepal harbors a remarkable diversity of avian species, with 892 bird species across 24 orders and 100 families,representing over 9% of global avian diversity (Bird Conservation Nepal [BCN] and Department of National Parks and Wildlife Conservation [DNPWC][2]. By 2022, 172 ofthese species were nationally threatened, underscoring conservation needs [2]. Key habitats for birds in Nepal include forests, wetlands, and grasslands, with forests and shrubs supporting approximately 77% of the breeding bird population [3].

Globally, bird diversity is influenced by various local environmental factors such as climate, habitat structure, resource availability, and competition [4,5]. Vegetation characteristics, including canopy cover, tree diversity, and habitat complexity, are essential for supporting higher bird species richness [6,7]. However, elevation plays a crucial role in determining resource availability, influencing forest structure and, consequently, bird diversity [8]. This study aligns with the United Nations Sustainable Development Goals (UN-SDGs), particularly SDG 15 (Life on Land), by emphasizing the importance of biodiversity conservation. Understanding the avian diversity in the Someshwar Range Forest and surrounding areas provides insights into habitat quality and contributes to biodiversity conservation in the Madi region, Chitwan, Nepal.

This study aims to bridge knowledge gaps by establishing a baseline for avian diversity and examining the relationship between bird diversity and habitat structure in this understudied region, which is vital for informed conservation management.

Materials and Methods

Study Area

The Someshwar Range, located in Madi Municipality, Chitwan, extends in an east-west orientation and is linked to India's Balmiki Wildlife Sanctuary. This area features rugged terrain with deep ravines and steep slopes, reaching elevations of up to 870 meters above sea level [9]. The region is hydrologically important due to several rivers, including the Reu, Magai, Ghagar, and Anar, which originate within the range.

The predominant vegetation consists of tropical to subtropical forests, with Sal (*Shorea robusta*) being the primary species. The climate is subtropical, with temperatures reaching up to 40°C during the summer months and experiencing four distinct seasons. The area also supports a variety of mammal species, such as the Bengal tiger (*Panthera tigris tigris*), common leopard (*Panthera pardus*), Sambar deer (*Cervus unicolor*), barking deer (*Muntiacus muntjak*), sloth bear (*Melursus ursinus*), Hanuman langur (*Semnopithecus entellus*), and wild boar (*Sus scrofa*) [9] (Figure 1).

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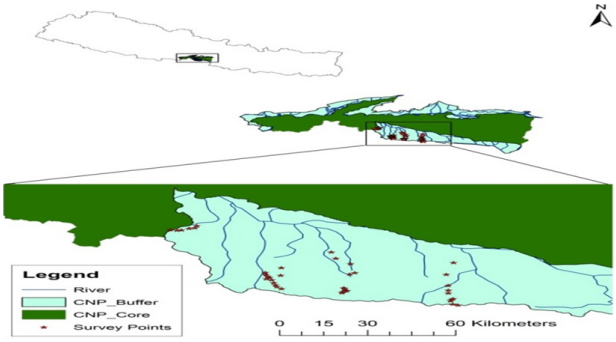

Figure 1. Map of Study Area

Sampling Design

Sampling was carried out in the community forests of Madi Municipality. A 1:25,000 topographic map of the Someshwar Range, along with field reconnaissance, guided the study design. The range was divided into two elevation zones: (a) the Lower Belt, characterized by higher disturbance, and (b) the Upper Belt, representing less disturbed areas. Forty sampling plots were established, with 20 in each zone. Bird surveys were conducted along human trails at 50-meter elevation intervals starting from 210 meters.

Bird Survey Technique

Bird surveys employed the point count method within 50-meter circular plots. This method is advantageous in challenging terrains compared to line transects. Additionally, the call count method was used to detect less visible bird species [10]. Fieldwork was conducted during two distinct seasons, winter and summer, to capture seasonal variations and ensure comprehensive data collection. Observations were made between 6:30 AM and 11:00 AM, with each plot surveyed for 15 minutes, avoiding repeat counts of the same species. Equipment included Bushnell binoculars (8 x 42 magnification) and a Canon camera (50x zoom). Bird identification followed standard field guides, and plot locations were recorded with a GPS device (e-trex 10) [11].

Vegetation Survey

The vegetation survey utilized the same plots as the bird survey but focused on a 10-meter circular plot for vegetation analysis. Tree diameter at breast height (DBH) was recorded, including only trees with DBH ≥ 10 cm [12]. Tree density and basal area were calculated per hectare to assess forest structure [13]. Local residents assisted in identifying tree species, with herbarium samples collected for expert verification [14].

Data analysis was conducted using SPSS version 17.0. Chi-square tests were employed to examine seasonal differences in bird species richness [15]. Analysis of Variance (ANOVA) was used to compare bird species richness between the two elevation belts [16]. Pearson's correlation coefficient was used to assess relationships between tree structural variables and bird richness [15]. The hypotheses tested were:

- **H_0:** There is no significant difference in bird species richness between seasons.
- **H_0:** There is no significant difference in bird species richness between elevation belts.

Bird data analysis

Bird data was analyzed as species richness, Diversity, Evenness and Relative abundance for two different habitat belts and two different seasons.

Marglef Species richness index (d) = S-1/ log N

Where, S= Number of species
N = Number of individuals

Species Diversity Index

The diversity of species was calculated by using Shannon-Weiner diversity index

Shannon Weiner diversity index is designated as H', which is calculated as:

$H' = -\Sigma (ni/N) \log (ni/N)$
Or, if $Pi = ni/N$
$H' = -\Sigma Pi \log_e Pi$

Where,

ni = Importance values for each species are the number of individuals in each species and the abundance of each species.
N = Total Importance value, the total number of individuals observed.

Pi= ni/ N = Relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.

Evenness index

To calculate whether species are distributed evenly across seasons and across landscape elements, the evenness index was determined by the equation

E= H'/ log S

Where, H' = Shannon-Wiener's diversity index.

S= Species richness is the number of species and is simply a count of the number of different species in a given area.
Relative abundance: Relative abundance refers to the evenness of the distribution of individuals among species in the community. Two communities may be equally rich in species but differ in relative abundance.
Relative abundance or % of Dominance = ni/ N × 100
Based on population status, birds were further categorized into in Very common, Common, fairly common and Rare.

Vegetation Analysis

Density

To compare tree density between two different belts, the tree density was calculated as:

$$\text{Density (No /m}^2) = \frac{\text{No. of individuals of a species}}{\text{Size of plot} \times \text{total no. of sample plot}}$$

Basal area dominance

Dominance is calculated based on basal area, which is the cross-sectional area of a tree at breast height. This is the main characteristic that determines dominance.

Basal Area (cm^2) == $C^2/ 4\pi$

Where, C= circumference of tree at breast height,

$\pi = 3.14$

https://doi.org/10.61577/jec.2024.100013

DBH class

All the trees were classified in-to nine DBH class and density of trees in each dbh class were compared between lower belt and upper belt forest. The nine DBH classes were 10-25cm, 25-40cm, 40-55cm, 55-70cm, 70-85cm, 85-100cm, 100-115cm, 115-130cm and >130cm.

Results

This study identified a total of 101 bird species belonging to 11 orders and 32 families across two seasons. Winter surveys recorded 87 species and summer surveys recorded 79 species, with 65 species observed in both seasons.

Table 1. Comparison of Bird Species Diversity and Richness by Season in the Someshwar Range

Seasons	Number of species	Number of Individuals	Shannon wiener index	Evenness index
Winter	87	1167	1.71	0.88
Summer	79	1059	1.64	0.86

Table 1 compares bird species diversity and richness in the Someshwar Range across two seasons: winter and summer. During winter, a total of 87 species and 1,167 individuals were recorded, yielding a Shannon-Wiener index of 1.71, which indicates moderate diversity, alongside an evenness index of 0.88. In contrast, summer recorded 79 species and 1,059 individuals, resulting in a slightly lower Shannon-Wiener index of 1.64 and an evenness index of 0.86. This comparison illustrates that winter supports a greater species richness and diversity compared to summer, despite a relatively similar level of evenness in both seasons.

A Chi-square test indicated no statistically significant difference in species richness between seasons ($p = 0.674$, $\chi^2 = 1.134$, $df = 1$). However, season-specific species were noted: winter surveys recorded *Psarisomus dalhousiae* (Long-tailed Broadbill), *Calidris ferruginea* (Common Sandpiper), and *Elanus caeruleus* (Black-shouldered Kite). Conversely, *Merops orientalis* (Green Bee-eater), *Megalaima asiatica* (Blue-throated Barbet), and *Psittacula alexandri* (Red-breasted Parakeet) were unique to summer observations.

Bird-Habitat Relationship in Someshwar Range

The Lower Belt of the Someshwar Range is characterized by moderate human disturbance, with plains and hills supporting diverse habitats, including agricultural lands, human settlements, and forest edges. The Upper Belt, in contrast, is marked by steep, forested slopes with minimal human activity and comprises primarily subtropical mixed forests.

Table 2. Characteristics of different belt of Someshwar range.

Parameters	Lower belt	Upper belt
Elevation (m)	210- 410	410- 810
Landscape	Plain + Hill	Hill
Human disturbances	Moderate	Low
Dominant tree species	Sal tree	Subtropical mixed forest
Fire Incident	Rare	Common (in summer season)

Table 2 outlines the characteristics of the lower and upper belts of the Someshwar Range. The lower belt, situated at an elevation of 210-410 meters, features a landscape that includes both plains and hills, with moderate human disturbances. The dominant tree species in this area is the Sal tree. In contrast, the upper belt ranges from 410 to 810 meters in elevation and is characterized by hilly terrain with low human disturbances. The dominant vegetation in this belt is subtropical mixed forest. Fire incidents are rare in the lower belt but common during the summer season in the upper belt. These differences highlight the varying ecological conditions and human impacts across the elevation gradient in the Someshwar Range.

In total, 47 tree species were identified from 40 sampling plots across the two belts, with 39 species in the Lower Belt and 28 in the Upper Belt. The Lower Belt had a higher prevalence of smaller diameter trees (10-25 cm, 25-40 cm, 40-55 cm), while the Upper Belt featured larger diameter trees (130 cm+) and exhibited a more uniform DBH distribution. The Lower Belt's higher tree density and species diversity contributed to a richer bird community, whereas the Upper Belt had larger average DBH and basal area. One-way ANOVA showed a significant difference in bird species richness between the belts ($F = 5.46$, $df = 1$, $P < 0.05$). Bird species richness positively correlated with tree species diversity ($r = 0.69$) and tree density ($r = 0.71$) but negatively with tree diameter at breast height (DBH) ($r = -0.54$).

Table 3. Summary of Vegetation Characteristics and Bird Community Structure between Lower and Upper Belts of the Someshwar Range

Variables	Forest Range(belts)	
	Lower belt	Upper belt
1). Bird variables		
Species Richness	87	61
Individual Recorded	1499	714
Shannon Weiner's diversity index	2.002	1.577
Evenness index	0.88	0.85
Marglef species richness	28.04	25.81
2). Tree structural variables		
Density (Number/Ha)	578	420
Diversity	1.28	1.14
Evenness	0.79	0.78
DBH (Mean ± SD)	56.30	83.63
Total species	39	28
Basal Area(m^2/Ha)	101.62	256.15

https://doi.org/10.61577/jec.2024.100013

Table 3 presents a summary of vegetation characteristics and bird community structure between the lower and upper belts of the Someshwar Range. In the lower belt, bird species richness reached 87, with a total of 1,499 individuals recorded and a Shannon-Weiner diversity index of 2.002, indicating relatively high diversity and an evenness index of 0.88. The Margalef species richness index was 28.04. Conversely, the upper belt had 61 species with 714 individuals, a lower diversity index of 1.577, and an evenness index of 0.85, alongside a Margalef index of 25.81. For tree structural variables, the lower belt had a density of 578 trees per hectare, a diversity of 1.28, and an evenness of 0.79, while the upper belt reported a density of 420 trees per hectare, a diversity of 1.14, and an evenness of 0.78. The mean diameter at breast height (DBH) was significantly lower in the lower belt (56.30 ± SD) compared to the upper belt (83.63 ± SD). The total species recorded were 39 in the lower belt and 28 in the upper belt, with basal area measuring 101.62 m^2/ha in the lower belt and 256.15 m^2/ha in the upper belt. This comparison highlights the significant differences in both bird communities and tree structures across the elevation gradient in the Someshwar Range.

Discussion

The survey documented 101 bird species, representing about 15.7% of the species recorded in Chitwan District and 11.3% of Nepal's avifauna [2,17]. The limited species count may result from seasonal survey constraints and reduced habitat diversity in the study area [18]. Winter was found to host a greater bird diversity, potentially due to better food availability, conducive temperatures, and flowering patterns attracting both resident and migratory species [19,20]. This seasonal variation, supported by Chi-square analysis, aligns with similar observations in regions like Karnataka, India, and Nawalparasi, Nepal, where winter surveys consistently yielded higher diversity [21,22].

Tree species diversity and bird species richness positively correlated ($r = 0.69$), suggesting that greater tree variety supports a wider range of avian species by offering more resources [23,24]. Tree density similarly correlated positively with avian diversity ($r = 0.71$), while a negative correlation ($r = -0.54$) was observed with tree DBH, implying that areas with larger trees, though possibly supporting fewer bird species, offer unique habitat niches [25-27]. Further, bird diversity in the Lower Belt was significantly higher than in the Upper Belt ($F = 5.46$, $df = 1$, $P < 0.05$). This difference may be attributed to factors like proximity to human settlements and microhabitat variation, which tend to attract species that benefit from edge habitats and resources available in human-modified landscapes [28,29].

Table 4. Summary of Similar Studies on Bird Diversity and Vegetation Structure across Different Regions and Seasons

Author(s) and Year	Study Area	Seasons Surveyed	Methods Used	Species Richness	Diversity Indices	Key Findings
Pandey et al. [30]	Mardi Himal, Annapurna Conservation Area	Winter, Summer	Point count method	112	Hump-shaped richness pattern	Species richness peaked at mid-elevation; environmental factors influenced bird diversity significantly.
Kumar and Sahu [31]	Panipat, Haryana, India	April 2015 - March 2016	Point-transect, direct observations	99	Significant seasonal differences	Highest species richness in Passeriformes; important for conservation due to presence of near-threatened species.
Katuwal et al. [32]	Central Himalayas, Nepal	Pre-monsoon, Monsoon, Post-monsoon	318 plots with 50 m radius	178	Richness peaked at mid-elevation	Resident birds more diverse than migratory; distinct seasonal changes in insectivore species richness.
Nepali et al. [33]	Dhaneshwor Baikiwa Community Forest, Kavrepalanchowk	January - August 2019	Mackinnon's Listing Method, Point Count	108	Winter: H=3.929, E=0.627; Summer: H=3.808, E=0.625	Highest diversity in winter; diversity influenced by habitat type and human activities.
Our Study	Someshwar Range, Nepal	Winter and Summer	Fixed-Point, Call Counts	101	Shannon-Wiener, Margalef	Winter had higher richness; vegetation structure impacted avian diversity.

https://doi.org/10.61577/jec.2024.100013

Table 4 presents a comparative analysis of avian diversity studies across various regions, illustrating significant differences in species richness, diversity indices, and key findings. Pandey et al. reported a species richness of 112 in the Mardi Himal region, highlighting a hump-shaped richness pattern peaking at mid-elevation, significantly influenced by environmental factors [30]. In contrast, Kumar and Sahu documented 99 species in Panipat, Haryana, with notable seasonal variations, particularly a peak in Passeriformes, emphasizing the area's conservation importance due to near-threatened species [31]. Meanwhile, Katuwal et al. identified 178 species in the Central Himalayas, finding that resident birds were more diverse than migratory species, with richness also peaking at mid-elevation and displaying distinct seasonal variations in insectivore diversity [32]. Similarly, Nepali et al. reported 108 species in the Dhaneshwor Baikiwa Community Forest, noting the highest diversity in winter, influenced by habitat type and human activities, with a high Shannon diversity index of 3.929 [33]. In our study in the Someshwar Range, Nepal, we found a richness of 101, indicating higher diversity in winter compared to summer, with vegetation structure impacting avian diversity significantly. Overall, this comparative analysis highlights how elevation, seasonality, and habitat type profoundly affect avian diversity, reinforcing the need for targeted conservation efforts, particularly in regions where species richness may be threatened by environmental changes and human activities.

Conclusions

The results demonstrate a clear link between seasonal changes, vegetation structure, and bird diversity in the Someshwar Range. The study's findings highlight that the Lower Belt, with its higher tree density and diversity, supports a richer avian community. The higher species richness recorded during winter underscores the seasonal movement of migratory birds and the influence of climatic conditions on avian diversity. Consequently, a positive relationship between bird species richness, tree species diversity, and density is evident, reinforcing the importance of vegetation structure in shaping bird communities. To further support avian diversity, habitat management efforts should prioritize maintaining and enhancing tree species diversity, especially in areas of human impact. Additionally, community awareness and outreach programs can promote sustainable land-use practices that benefit both the local ecosystem and avian populations. Extending this research over a more extended period and incorporating additional habitat types would likely provide a more comprehensive understanding of bird diversity in the Someshwar Range.

Acknowledgments

I extend my sincere gratitude to Professor Dr. Tej Bahadur Thapa of the Central Department of Zoology for his guidance and support throughout this research. I also thank the Department of National Parks and Wildlife Conservation (DNPWC) for granting permission to conduct this study. Special thanks to Dhiraj Lamsal and Ram B. Khadka for their invaluable fieldwork assistance. I also acknowledge Suraj Baral, Ganesh Ghimire, Shivish Bhandari, Hari Basnet and Namrata Chapagain for their support and contributions.

Disclosure Statement

No potential conflict of interest was reported by the author.

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