Environmental Challenges 5 (2021) 100317

Contents lists available at ScienceDirect

Environmental Challenges

journal homepage: www.elsevier.com/locate/envc

Influence of season and habitat on birds in a mid-altitudinal village ecosystem of Kailash Sacred Landscape-India

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A R T I C L E I N F O

Keywords:
Bird diversity
Habitat structure
Seasonal changes
Village ecosystem
Western Himalaya
Pithoragarh district

A B S T R A C T

The Himalayan biodiversity hotspot with high species diversity, is lesser-known in terms of the seasonal variations within the bird community across different land uses especially in and around human modified land use areas. As seasonal migration of birds impacts the mid altitudinal range more, we monitored four seasons in different habitats of a village ecosystem of the Indian part of Kailash Sacred Landscape lying in the mid-altitudinal range. A total of 408 point counts were conducted, and 2335 individuals of 95 species were recorded belonging to 32 families. Among them, 48 are Himalayan endemics, 15 are Oak forest specialists, and 30 are migratory (altitudinal/local and long-range). We recorded maximum bird diversity in the agricultural land and least in the Chir pine forest. The Spring season was the most species-rich and diverse among all four seasons in this village ecosystem and most of its adjoining habitats. The present study aims to create a baseline on the influence of seasonal change on the avian structure across habitat types in a mid-altitudinal village ecosystem.

1. Introduction

Himalaya is rich in biological diversity (Myers et al., 2000; Brooks et al., 2006), having extreme variation in eco-climatic conditions coupled with diverse topographic and landscape features (Rawat and Sathyakumar, 2002; Negi et al., 2012). It exhibits close affinities with adjacent biogeographic regions and represents a high level of endemism among flora and fauna (Pandit et al., 2000; Telwala et al., 2013). Over 10,000 species of plants and nearly 1000 bird species are found in the Himalayas, with 330 designated Important Bird Areas (Pandit et al., 2014; Arya and Gopi, 2021).

More than 488 protected areas are present in the Hindukush Himalayan region, covering nearly 39% of its geographical area, whereas 12% of Hindukush Himalaya is present in the Indian Himalayan region, with 135 protected areas (Chettri et al., 2009). Besides the protected area network, village ecosystems that include agriculture fields and nearby forest habitats also play an essential role in improving species diversity, owing to the habitat and food variety in the Himalayan region (Arya and Gopi, 2021; Elsen et al., 2018).

The Kailash Sacred Landscape that is part of the Himalayan region is a transboundary landscape that spreads across three countries *viz.* China, Nepal, and India. The Indian part of the landscape majorly falls in the Pithoragarh district of state Uttarakhand. Pithoragarh is the easternmost district that lies biogeographically at the junction of western and central Himalaya and falls under Trans Himalaya and Greater Himalaya biotic province. It ranges between 400 and 7500 m altitude, supporting different eco-climatic zones such as Sub-tropical, Temperate, Sub-alpine, Alpine, and Trans-Himalayan zone that provide various habitats to other native species (G.B. Pant Institute of Himalayan Environment and Development (GBPIHED) 2010).

Mid-elevation ranges are said to support high species richness in the Himalayas (Bhatt and Joshi, 2011; Acharya et al., 2011; Pan et al., 2016), and during seasonal change, the diversity and richness pattern noticeably fluctuate (Price et al., 2011; Dixit et al., 2016; Elsen et al., 2016). Various factors such as climate, elevation gradients, species-area relationship, productivity, mid domain effects, evolutionary history, geomorphic constraints, habitat character, and anthropogenic disturbances can affect the diversity and richness (Acharya et al., 2011; McCain, 2009; Katuwal et al., 2016). Habitat structure is also an essential factor influencing the avian community (MacArthur and MacArthur, 1961; Chettri et al., 2005; Srinivasan and Wilcove, 2021). Various habitat parameters reflect inter-specific dynamics and population trends associated with the habitat (O'Connell et al., 2000). Similarly, temporal dynamics of bird species richness and composition can be influenced by the seasonal changes in climate that are an additional prominent characteristic in the mountainous ecosystem (Elsen et al., 2018; Chettri et al., 2005; Acharya et al., 2010). For example, due to extreme temperature and low food availability in high elevation ranges during winter, birds migrate to the lower elevation areas. Conversely, some birds of lower altitudinal ranges or plain ar-

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https://doi.org/10.1016/j.envc.2021.100317
Received 16 July 2021; Received in revised form 22 September 2021; Accepted 8 October 2021

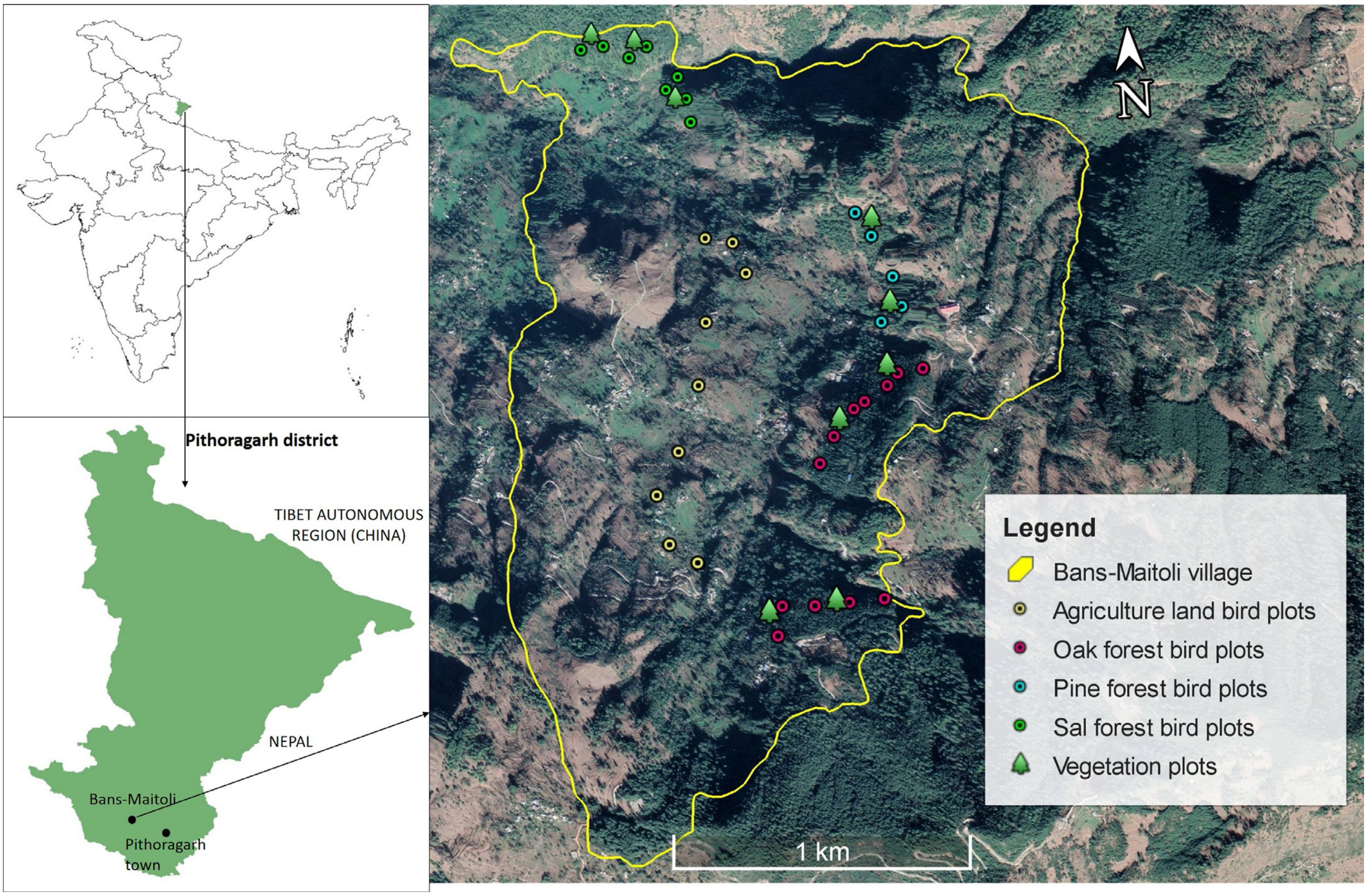


Fig. 1. Location of the study area, Birds monitoring, and vegetation plots in different habitats of Bans-Maitoli village ecosystem.

Table 1
Bird monitoring and vegetation plots in different habitat types of Bans-Maitoli village ecosystem along with elevational zones.

Habitat	Elevational zone (m)	Vegetation plots	Birds monitoring plots	Total point counts
Oak Forest	1380–1800	4	12	144
Chir Pine Forest	1330–1590	2	5	60
Sal Forest	940–1150	3	8	96
Agriculture land	850–1650	–	9	108
Total		**9**	**34**	**408**

eas expand their ranges to mid and high elevation areas for suitable food and habitat during the summers (Terborgh, 1977; Vazquez and Givnish, 1998; Naithani and Bhatt, 2010). Consequently, many species utilize different habitats and resources in different seasons in the Himalayas (Laiolo et al., 2004). However, studies on the seasonal influences on avian diversity are far and few between, in the Himalayan region (Elsen et al., 2018; Elsen et al., 2016; Katuwal et al., 2016; Srinivasan et al., 2019; Chettri et al., 2001).

Therefore, we selected the Bans-Maitoli village ecosystem (located at the mid-elevation range in the Greater Himalaya) for bird monitoring to assess the influences of seasonal changes on bird diversity in different habitats of a mid-altitudinal village ecosystem. The Bans-Maitoli village is surrounded by agricultural land and its community-managed forests that were monitored throughout the seasons.

2. Methods

2.1. Study area

Bans – Maitoli village is located about 25 km northwest of Pithoragarh district headquarters between 29.61342 to 29.60747 N latitude and 80.1391 to 80.1493 E longitude. The district is the easternmost district of Uttarakhand that shares an international boundary with Nepal in the east and Tibet Autonomous Region (TAR) in the north. Its average annual temperature during summer is 23.19 °C, and during winters is 8.44 °C, with 1051.4 mm of average annual rainfall.

Bans-Maitoli village is distributed in 9 hamlets of 427 households with a total population of 1350. The village represents a heterogeneous landscape in the form of Forest-Grassland and Agriculture interface. It makes the Bans-Maitoli village ecosystem that covers approximately 5 Sq. km of the area with an elevation range of 800 – 1800 m a.s.l. (Fig. 1). It forms a part of Gokarneshwar gad micro-watershed in the Bin block Pithoragarh District. There are three types of forests in the village ecosystem such as Sub-tropical broadleaf forests dominated by Sal (*Shorea robusta*), Montane broadleaf forest by Banj oak (*Quercus leucotrichophora*), and Conifer forest by Chir Pine (*Pinus roxburghii*), covering the different areas in different elevational zones (Table 1).

2.2. Data collection

2.2.1. Bird survey

The survey was carried out between the year 2014 and 2016 during the morning (0700–1100 hrs) and evening sessions (1530–1830 hrs) when birds are known to be more active (Trnka et al., 2006). Fixed width point counts of 25 m radius were performed for the bird sampling (Bibby et al., 2000). We selected 34 bird monitoring plots with a minimum of 200 m distance in the different habitat types (12, 5, 8, and 9 in Oak, Chir Pine, Sal forests, and Agriculture land, respectively) of the Bans-Mailtoli village ecosystem. Due to terrain constraints (steep and inaccessible), five monitoring plots were laid in the Chir Pine forest. Four seasons viz. Winter (mid-October to mid-February), Spring (mid-February to mid-April), Summer (mid-April to June), and Monsoon (July to mid-October) were monitored, and two replicates in each season were conducted in each habitat type. A total of 102 bird sampling points in the selected monitoring plots were laid in each season. Altogether 408 point counts were performed, of which 144 were in Oak forests, 60 in Chir Pine forests, 96 in Sal forests, and 108 in the agricultural land of the study area during different seasons. Birds were observed with the aid of 8 × 42 Bushnell binocular for 15 min at a point and identified with the help of the field guide (Grimmett et al., 2011).

2.2.2. Vegetation survey

The vegetation survey was conducted once during September and October 2015 in the different forest habitats of the Bans-Maitoli village ecosystem. A vegetation plot of 20m*20 m quadrat was laid with a minimum distance of 500 m (nearby or at the bird monitoring plots) within each forest habitat. All the tree species were counted, and their girth at the breast height (GBH) was measured (Rana et al., 2011). Altogether, nine vegetation plots were laid, of which four in Oak, three in Sal, and two plots were laid in Chir Pine forest. Within each 20m*20 m plot, two 5m*5 m of quadrats were laid for the shrub abundance and richness, and all the shrubs, seedling, and sapling were counted within the plot. Trees less than 20 cm in GBH were counted as saplings (Rai et al., 2012).

2.3. Data analysis

We used Past 3x software (Hammer et al., 2001) for computing Shannon diversity (H) and Margalef's richness (R) at each point (MacArthur and MacArthur, 1961). For each habitat type, the average values of diversity and richness were calculated. The relative abundance index was calculated in percentage by dividing the total observations by the particular species observation. A Two-way ANOVA test with Tukey post hoc test was performed to determine the significant differences in bird species diversity (BSD) and bird species richness BSR between different habitats during different seasons. Vegan package in R software was used to calculate ANOVA and Tukey post hoc test (Oksanen et al., 2019).

The formula for Shannon Diversity H = - ΣPi (log Pi). (where H is Shannon Diversity, Pi is the proportion of a species and the total number of species in a sample.)

Formula for Margalef richness R = (S-1)/log (n). (where S is the total number of species and n is the total number of individuals in a sample.)

In the vegetation analysis, the density of trees and shrubs was calculated as the number of individuals per hectare using the formula D = (Ni/A) × 10,000. (where Ni is the number of individuals in a plot and A is the plot area.)

We assigned the global range to each species by following the website Birds of the world (Birds of the World 2021). Migration status and forest dependency were set to bird species based on the field observations and description in the field guide (Grimmett et al., 2011). Species migrating within the Indian subcontinent were termed altitudinal/local migration, and if they were migrating outside the Indian subcontinent, they were termed as long-range migratory species.

3. Results

3.1. Vegetation structure

We recorded overall tree density in the forest habitat as 703 trees per hectare area with an average GBH of 77.6 cm and 21,000 individuals per hectare as the shrub density. Within different forest habitats, maximum tree density was found in Oak forest (950 trees/hectare) with an average GBH of 71.8 cm, followed by Chir Pine forest (675 trees/hectare) with 75.89 cm of mean GBH. The least tree density was in Sal forest, 391 trees/hectare, but average GBH was the highest (86.46 cm) compared to other forest habitats. Maximum tree richness was found in the Oak forest, trees such as *Pinus roxburghii* (Chir Pine), *Myrica esculenta* (Kafal), and *Rhododendron arboreum* (Rhododendron) were recorded within the forest habitat. In contrast, Sal forest was mixed with the few Chir Pine trees, and in Chir Pine forest, no other tree species were recorded.

On the other hand, shrub density was highest in Sal forest (28,200 individuals/hectare). The number of seedlings and saplings of Sal trees was higher than the other habitats. However, the infestation of weed *Ageratina adenophora* was also higher in the Sal forest. Oak forest was the second-highest in shrub density (21,400 individuals/hectare) but highest in species richness. Species such as *Pyracantha* sp. and *Symplocos* sp. are abundant in Oak forest, sapling and seedlings of *Pyrus pashia, Rhododendron arboreum, Myrica esculenta, Quercus leucotrichophora* and *Q. glauca* were recorded from the Oak forest.

3.2. Overall bird status

A total of 2335 individuals of 95 species belonging to 32 families were recorded from 408 point counts in the study area. Among the recorded species; 48 are Himalayan endemic, 4 species are endemic to the Western and Central Himalayas, 11 species are restricted to the Himalaya of South Asia (Afghanistan, Pakistan east to Mayanmar), and 33 species are restricted to the Himalayas and occur from India to Indo china and/or South-eastern China (Birds of the World, 2021). Based on the forest dependency, 15 Oak forest specialist species (exclusively recorded from the Oak forests) were recorded. A total of 30 altitudinal/local and long-range migratory species were recorded. Among the migration status, we recorded 14 species as summer visitors (Photo plate 1), 15 winter visitors (Photo plate 2), and one species (Greenish leaf Warbler) as a passage visitor. Among the winter visitor species, two species (Black-throated Accentor, Black-throated Thrush) are long-range migratory (Migrating from out of the Indian sub-continent), and the rest 13 species are altitudinal migrants. The schedule status of the Indian Wildlife Protection Act 1972 revealed that 57 species are placed under Schedule IV and are protected under the Indian law (Table. 2).

3.3. Birds in different habitats

Within different habitats in all the seasons, the maximum number of species and their individuals were recorded from the agro-ecosystem; 67 species and 1109 individuals, followed by Oak forest (65 species and 743 individuals), Sal forest (47 species, 353 individuals), and Pine forest (35 species, 130 individuals) (Fig. 2.1 and 2.2).

Overall point diversity within different habitats reveals that agricultural land has the highest BSD (1.33 ± 0.03) and BSR (1.6 ± 0.04) among all the habitats followed by Oak forest (BSD 0.93 ± 0.03, BSR 1.2 ± 0.04) and least in the Chir Pine forest (BSD 0.49 ± 0.05, BSR 0.8 ± 0.09). ANOVA test finds out that there is a highly significant difference in the BSD ($F_{3, 404} = 67.66$, $P = 2 \times 10^{-16}$) and BSR ($F_{3, 404} = 29.3$, $P = 2 \times 10^{-16}$) in different habitats. Further, Tukey post hoc test brings out that agricultural land was significantly different from the Oak, Chir pine and Sal forests in BSD and BSR with p-value <0.001. Oak forest was also found to be significantly different in BSD and BSR from Chir pine with p-value <0.0001, and from Sal forest in BSD with p-value <0.05. Sal forest was also found significantly different from the Chir pine forest in BSD and BSR with p-value <0.001 (Fig. 2.2).

Table 2
Birds recorded during point counts from Bans-Maitoli village ecosystem with status of restricted range, migration, Indian wildlife protection, habitat of occurrence, and relative abundance index.

Family/Scientific name	English name	GR	IWPA schedule	MS	Habitat	RAI (%)
Columbidae						**2.7**
Columba rupestris	Hill Pigeon		IV	R	O	0.51
Streptopelia orientalis	Oriental Turtle Dove		IV	R	A, O, S, P	1.33
Streptopelia chinensis	Spotted Dove		IV	R	A, O, P	0.64
Streptopelia decaocto	Eurasian Collared Dove		IV	R	S	0.04
Treron sphenurus	Wedge-tailed Green Pigeon*	H3	IV	R	O	0.17
Strigidae						**0.09**
Glaucidium cuculoides	Asian Barred Owlet	H3	IV	R	A, P	0.09
Picidae						**3.51**
Dendrocopos auriceps	Brown-fronted Woodpecker	H1	IV	R	A, O, S, P	1.03
Chrysophlegma flavinucha	Greater Yellow-naped Woodpecker*		IV	R	O	0.3
Picoides canicapillus	Gray-capped pygmy woodpecker		IV	R	S	0.47
Picus canus	Gray-headed woodpecker		IV	R	O, S, P	0.9
Picus chlorolophus	Lesser Yellow-naped Woodpecker		IV	R	O, S	0.3
Picus sqamatus	Scaly-bellied Woodpecker*	H1	IV	R	O	0.47
Picumnu innominatus	Speckled Piculet*		IV	R	O	0.04
Megalaimidae						**2.91**
Psilopogon asiaticus	Blue-throated Barbet	H3	IV	R	A, O, S, P	1.07
Psilopogon virens	Great Barbet	H3	IV	R	A, O, S, P	1.84
Upupidae						**0.09**
Upupa epops	Common Hoopoe			SV/LM	A	0.09
Psittaculidae						**8.01**
Psittacula cyanocephala	Plum-headed Parakeet		IV	R	A, O, S	2.4
Psittacula hamlayana	Slaty-headed Parakeet	H2	IV	R	A, O, S	5.61
Campephagidae						1.16
Pericrocotus ethologus	Long-tailed Minivet	H3	IV	R	A, O, S, P	1.16
Dicruridae						**1.07**
Dicrurus leucophaeus	Ashy Drongo		IV	SV/LM	A, O, S, P	0.77
Dicrurus hottentottus	Hair-crested Drongo		IV	R	A	0.3
Rhipiduridae						**1.24**
Rhipidura albicollis	White-throated Fantail			R	A, O, S	1.24
Stenostiridae						**0.13**
Chelidorhynx hypoxantha	Yellow-bellied Fairy-fantail	H3		WV/LM	A, O, S	0.13
Corvidae						**5.87**
Garrulus lanceolatus	Black-headed Jay	H1	IV	R	A, O, S, P	0.47
Dendrocitta formosa	Gray treepie		IV	R	A, O, S, P	2.87
Corvus macrorhynchos	Large-billed Crow			R	A, S, P	0.39
Urocissa erythrorhyncha	Red-billed Blue Magpie	H3	IV	R	A, O, S, P	1.84
Urocissa flavirostris	Yellow-billed Blue Magpie*	H2	IV	R	O	0.3
Monarchidae						**0.04**
Terpsiphone paradisi	Indian Paradise-Flycatcher			SV/LM	A	0.04
Dicaeidae						**0.09**
Dicaeum ignipectus	Fire-breasted Flowerpecker*	H3	IV	R	O	0.09
Nectariniidae						**0.69**
Aethopyga saturata	Black-throated Sunbird*	H3	IV	R	O	0.13
Aethopyga siparaja	Crimson Sunbird		IV	SV/LM	S	0.04
Aethopyga nipalensis	Green-tailed Sunbird	H3	IV	R	A, O	0.34
Cinnyris asiaticus	Purple Sunbird		IV	SV/LM	A	0.17
Prunellidae						**0.21**
Prunella atrogularis	Black-throated Accentor			WV	A	0.21
Passeridae						**2.48**
Passer domesticus	House Sparrow			R	A	1.71
Passer cinnamomeus	Russet Sparrow			R	A	0.77
Motacillidae						**0.34**
Anthus roseatus	Rosy Pipit	H3	IV	WV/LM	A	0.21
Motacilla maderaspatensis	White-browed Wagtail			R	A	0.13
Fringillidae						**1.76**
Carpodacus erythrinus	Common Rosefinch		IV	WV/LM	A, O	0.39
Procarduelis nipalensis	Dark-breasted Rosefinch	H3	IV	WV/LM	A	0.09
Carpodacus rodochroa	Pink-browed Rosefinch*	H2		WV/LM	O	0.17
Chloris spinoides	Yellow-breasted Greenfinch	H2	IV	WV/LM	A, O, S	1.11
Emberizidae						**0.26**
Melophus lathami	Crested Bunting		IV	WV/LM	A	0.26
Paridae						**7.97**
Parus xanthogenys	Black-lored Tit	H2	IV	R	A, O, S, P	0.69
Aegithalos concinnus	Black-throated Tit	H3	IV	R	A, O, P	2.91
Parus cinereus	Cinereous Tit		IV	R	A, O, S, P	2.66
Parus monticolus	Green-backed Tit	H3	IV	R	A, O, S, P	1.71
Cisticolidae						**0.81**
Prinia hodgsonii	Gray-breasted prinia			R	A, S	0.77

(*continued on next page*)

Table 2 (*continued*)

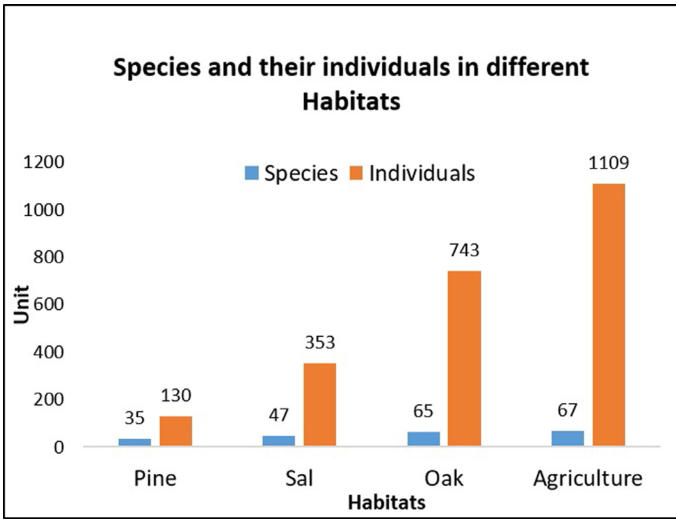
Family/Scientific name	English name	GR	IWPA schedule	MS	Habitat	RAI (%)
Pycnonotidae						**15.25**
Hypsipetes leucocephalus	Black Bulbul	H3	IV	R	A, O, S, P	2.91
Pycnonotus leucogenys	Himalayan Bulbul	H2	IV	R	A, O, S, P	9.76
Ixos mcclellandii	Mountain Bulbul*	H3	IV	R	O	0.04
Pycnonotus cafer	Red-vented Bulbul		IV	R	A, O, S	2.53
Phylloscopidae						**16.52**
Phylloscopus pulcher	Buff-barred Warbler*	H3		WV/LM	O	0.64
Phylloscopus trochiloides	Greenish Leaf Warbler			PV/LM	A	0.3
Phylloscopus xanthoschistos	Gray-hooded leaf warbler	H2		R	A, O, S, P	8.95
Phylloscopus humei	Hume's Leaf Warbler			SV/LM	A, O, S, P	4.15
Phylloscopus chloronotus	Lemon-rumped Warbler	H2		WV/LM	A, O, S	2.18
Phylloscopus affinis	Tickell's Leaf Warbler			WV/LM	A, O	0.3
Scotocercidae						**0.17**
Cettia brunnifrons	Gray-sided bush warbler	H3		WV/LM	A	0.17
Zosteropidae						**1.28**
Zosterops palpebrosus	Oriental White-eye		IV	R	A, O, S	1.2
Yuhina gularis	Stripe-throated Yuhina*	H3		R	O	0.09
Timaliidae						**2.27**
Stachyridopsis pyrrhops	Black-chinned Babbler	H1	IV	R	A, O, S	1.93
Pomatorhinus erythrogenys	Rusty-cheeked Scimitar Babbler	H2	IV	R	A, O	0.34
Leiothrichidae						**6.38**
Trudoides striata	Jungle Babbler		IV	R	A, O	1.41
Heterophasia capistrata	Rufous Sibia	H2		R	A, O, P	1.2
Trochalopteron lineatum	Streaked Laughingthrush	H2	IV	R	A, O	0.26
Garrulax leucolophus	White-crested Laughingthrush	H3	IV	R	A, O, S, P	2.61
Garrulax albogulris	White-throated Laughingthrush*	H3	IV	R	O	0.9
Certhiidae						**1.11**
Certhia himalayana	Bar-tailed Treecreeper			R	O, S, P	1.11
Prinia crinigera	Striated Prinia	H3		R	P	0.04
Sittidae						**1.88**
Sitta cinnmoventris	Chestnut-bellied Nuthatch	H3		R	A, O, S, P	1.8
Tichodroma muraria	Wallcreeper			WV/LM	P	0.09
Sturnidae						**3.77**
Acridotheres tristis	Common Myna		IV	R	A	3.77
Muscicapidae						**9.04**
Myphonus caeruleus	Blue Whistling Thrush	H3		R	A, O, S, P	2.74
Monticola cinclorhynchus	Blue-capped Rock Thrush			SV/LM	O, S, P	0.21
Monticola rufiventris	Chestnut-bellied Rock Thrush	H3		R	A, P	0.09
Phoenicurus caeruleocephala	Blue-capped Redstart			R	P	0.04
Phoenicurus frontalis	Blue-fronted Redstart	H3		WV/LM	A, O, S	0.47
Enicurus schistaceus	Slaty-backed Forktail	H3		R	A	0.04
Saxicola maurus	Siberian Stonechat			SV/LM	A	0.09
Saxicola ferreus	Gray bushchat	H3		R	A, O, S, P	2.4
Saxicola caprata	Pied Bushchat			SV/LM	S	0.09
Tarsiger rufilatus	Himalayan Bush Robin	H3		R	A, O, S	0.26
Copsychus saularis	Oriental Magpie Robin			R	A	0.13
Niltava macgrigoriea	Small Niltava	H3		R	A	0.09
Niltava sundara	Rufous-bellied Niltava*	H3		R	O	0.04
Culicicapa ceylonensis	Gray-headed canary-flycatcher		IV	SV/LM	A, O, S	0.43
Muscicapa sibirica	Dark-sided Flycatcher*		IV	SV/LM	O	0.09
Ficedula strophiata	Rufous-gorgeted Flycatcher	H3	IV	R	O, S	0.51
Ficedula ruficauda	Rusty-tailed Flycatcher*		IV	SV/LM	O	0.09
Ficedula superciliaris	Ultramarine Flycatcher		IV	SV/LM	A, S, P	0.39
Eumiyas thalassinus	Verditer Flycatcher		IV	SV/LM	A, O, S, P	0.86
Turdidae						**0.9**
Turdus atrogularis	Black-throated Thrush		IV	WV	A, O, S	0.17
Turdus boulboul	Gray-winged blackbird	H3		R	A, O, S, P	0.73

Abbreviations. * = Forest specialist, **GR =** Global Range; **H1**=Restricted to Western and Central Himalaya (Afghanistan, Pakistan, India and Nepal), **H2**=Restricted to Himalaya of South Asia (Afghanistan, Pakistan eastward to Myanmar), **H3**= Restricted to Himalaya and occurring from India to Indo china and/or South-eastern China. **IWPA** = Indian Wildlife Protection Act (1972) Schedule. **MS=** Migration status; **R=** Resident, **LM=** Local/Altitudinal migratory, **SV=** Summer visitor, **WV=** Winter visitor, **PV=** Passage visitor. **Habitat; A=** Agriculture field, **O=** Oak forest, **S=** Sal forest, **P=** Pine forest. **RAI%=** Relative abundance index in percent.

3.4. Birds during different seasons

Among different seasons, a maximum number of species were recorded during spring (70) and winter season (62), followed by summer (60) and monsoon season (57). In contrast, species abundance was highest during spring (694 individuals), followed by monsoon (628 individuals), summer (524 individuals), and least in the winter season (489 individuals) (Fig. 3.1 and 3.2).

Diversity indices per point reveal that among the different seasons in the village ecosystem maximum BSD 1.08 ± 0.05 and BSR 1.39 ± 0.06 was recorded during spring season followed by Monsoon (BSD 0.94 ± 0.04, BSR 1.19 ± 0.05), and Summer season BSD (0.87 ± 0.04) is slightly higher than Winter (BSD 0.86 ± 0.05) whereas BSR in Winter (1.15 ± 0.06) is higher than Summer (BSR 1.13 ± 0.06). ANOVA test found the significance difference in BSD ($F_{3,\ 404}$ = 4.92, P = 0.002) and BSR ($F_{3,\ 404}$ = 3.86, P = 0.009) among different seasons. Tukey post hoc test revealed the significant differences in BSD (P = 0.004) and BSR (P = 0.03) between winter-spring seasons, and BSD (P = 0.007) and BSR (P = 0.03) between summer-spring seasons (Fig. 3.2).



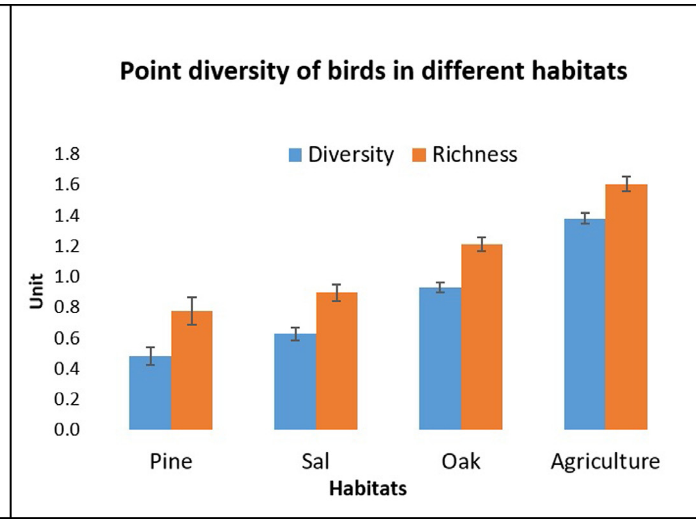
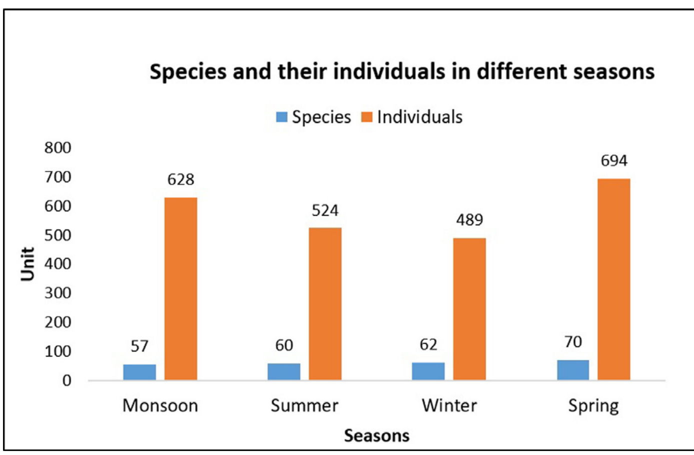


Fig. 2.1. Species and their individuals recorded from different habitats of the village ecosystem.
Figure 2.2. Point diversity of birds within different habitats. Significant differences in BSD ($F_{3,\ 404}$ = 67.66, $P = 2 \times 10^{-16}$) and BSR ($F_{3,\ 404}$ = 29.3, $P = 2 \times 10^{-16}$) was found during different habitats.



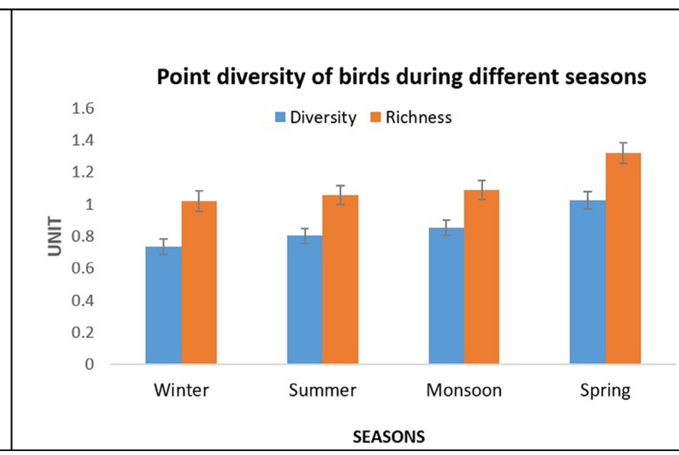


Fig. 3.1. Bird species and their individuals recorded in different seasons.
Fig. 3.2. Point diversity of birds during different seasons. Significant differences in BSD ($F_{3,\ 404}$ = 4.92, $P = 0.002$) and BSR ($F_{3,\ 404}$ = 3.86, $P = 0.009$) was found during differences seasons.

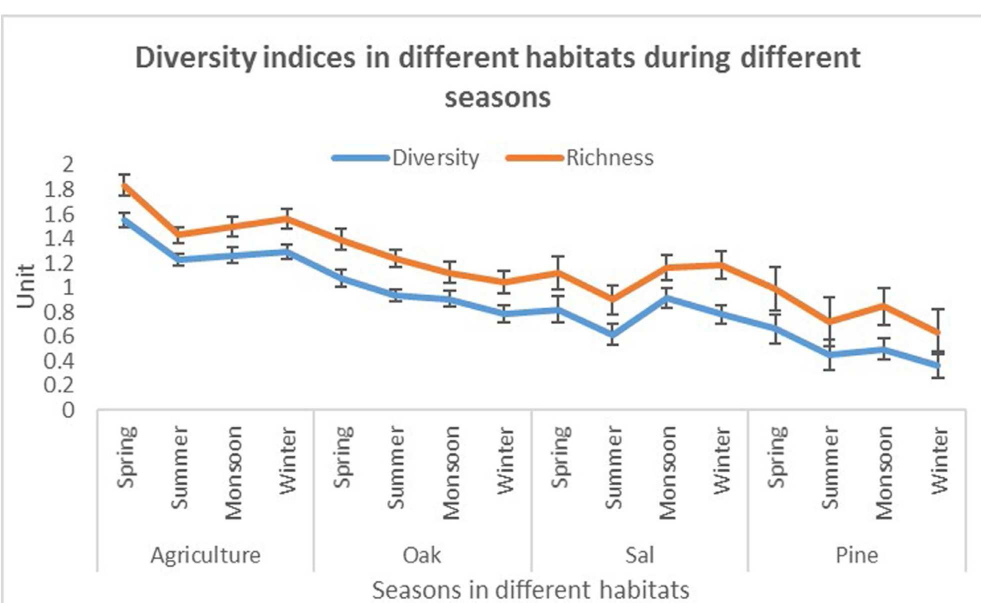


Fig. 4. Average point BSD and BSR in different habitats during different seasons. Pine forest ($F_{3,\ 56}$ = 1.27, $P = 0.29$) and BSR ($F_{3,\ 56}$ = 0.73, $P = 0.54$) (no significance difference). Sal forest ($F_{3,\ 92}$ = 2.065, $P = 0.11$) and BSR ($F_{3,\ 92}$ = 1.205, $P = 0.31$) (no significance difference). Oak forest BSD ($F_{3,\ 140}$ = 3.5, P = .02) and BSR ($F_{3,\ 140}$ = 3.11, $P = 0.028$) (significance difference). Agriculture filed: BSD $F_{3,\ 104}$ = 6.58, $P<0.001$ and BSR $F_{3,\ 104}$ = 4.93, $P<0.01$ (significance difference among seasons).

Photo plate 1. Some summer migratory birds recorded from the Bans-Maitoli Village ecosystem. **A.** Ashy Drongo, **B.** Common Hoopoe, **C.** Pied Bushchat, **D.** Indian Paradise-Flycatcher, **E.** Blue-capped Rock Thrush, **F.** Siberian Stonechat.

3.5. Seasonal variation of bird diversity in different habitats

During different seasons in different habitats, the maximum number of species were recorded from agriculture land, of which summer (43 species) and spring (40 species) seasons were more species-rich than winter (34 species) and monsoon (33 species) seasons. Oak and Sal forests have the maximum number of species during the spring season (40, 29), followed by Monsoon (39, 27) and least in summer (36, 22) and winter (37, 22). Whereas, Pine forest had the least species numbers throughout the seasons monsoon (18) followed by spring (15), winter (15), and summer season (13).

Diversity indices per point in different habitats during different seasons found that the agricultural land had the maximum BSD (1.55 ± 0.06) and BSR (1.83 ± 0.09) during spring season followed by winter (BSD 1.29 ± 0.06, BSR 1.56 ± 0.08), and least in summer season (BSD 1.23 ± 0.05, BSR 1.42 ± 0.07). A significant difference was found among the seasons in BSD ($F_{3,\ 104} = 6.58$, $P = .0004$) and BSR ($F_{3,\ 104} = 4.93$, $P = .003$). Tukey Post hoc test revealed Spring season was significantly higher in BSD than monsoon ($P = 0.003$), summer (P=.0007) and winter seasons ($P = .01$). Whereas BSR in the spring season was significantly higher from monsoon ($P = .01$), and summer ($P = .002$) seasons.

Similarly, in Oak forest maximum BSD (1.08 ± 0.07) and BSR (1.4 ± 0.08) was recorded during spring seasons followed by summer (BSD 0.94 ± 0.05, BSR 1.24 ± 0.07), monsoon (BSD 0.9 ± 0.07, BSR 1.12 ± 0.09) and least during winter (BSD 0.8 ± 0.07, BSR 1.04 ± 0.09). ANOVA test reveals the significant difference in BSD ($F_{3,\ 140} = 3.5$, $P = 0.02$) and BSR ($F_{3,\ 140} = 3.11$, $P = .028$). Significantly difference found between winter and spring seasons in BSD ($P = 0.008$) and BSR ($P = 0.02$).

In Sal forest, maximum BSD (0.91 ± 0.08) was recorded during monsoon season followed by spring (BSD 0.82 ± 0.1) and winter (BSD 0.78 ± 0.07) whether BSR (1.19 ± 0.11) was highest in Winter Season followed by monsoon (BSR 1.16 ± 0.11) and spring seasons (BSR 1.12 ± 0.13). Least BSD (0.61 ± 0.08) and BSR (0.9 ± 0.12) were recorded during summer season. ANOVA test finds no significant difference in BSD ($F_{3,\ 92} = 2.065$, $P = 0.11$) and BSR ($F_{3,\ 92} = 1.205$, $P = 0.31$) among different seasons in the Sal forest.

Pine forest has the maximum BSD (0.66 ± 0.12) and BSR (0.98 ± 0.18) during spring season followed by monsoon (BSD 0.5 ± 0.08, BSR 0.85 ± 0.15), summer (BSD 0.45 ± 0.12, BSR 0.72 ± 0.2) and least in winter (BSD 0.36 ± 0.11, BSR 0.64 ± 0.18). There were no significant differences found in BSD ($F_{3,\ 56} = 1.27$, $P = 0.29$) and BSR ($F_{3,\ 56} = 0.73$, $P = 0.54$) during different seasons in the Chir pine forest (Fig. 4).

3.6. Abundant bird families and species

Among the 32 recorded avifaunal families from the study area, Muscicapidae was the most species-rich family with 19 species. Blue Whistling thrush (2.74%) and Gray Bush chat (2.40%) were the most abundant species. Picidae was the second richest family (7 species), of which species such as Brown-fronted Woodpecker (1.03%) and Gray-headed Woodpecker (0.9%) were the most abundant. Phylloscopidae family was the most abundant (16.52%) and third species-rich (6 species) family of which Gray-hooded Leaf Warbler (8.95%), Hume's

Photo plate 2. Some winter migratory birds recorded from the Bans-Maitoli Village ecosystem. **A.** Pink-browed Rosefinch, **B.** Dark-breasted Rosefinch, **C.** Yellow-breasted Greenfinch, **D.** Crested Bunting, **E.** Blue-fronted Redstart, **F.** Wallcreeper.

Leaf Warbler (4.15%), and Lemon-rumped Warbler (2.18%) were the most abundant species. Pycnonotidae family was the second-largest family (14.44%), and Himalayan Bulbul (9.76%), Black Bulbul (2.91%), and Red-vented Bulbul (2.53%) were the most abundant species in the family (Table 2).

4. Discussion

Among the recorded 95 species in point counts, nearly 50% were endemic to the Himalayan region. More than 30% were migratory species such as passage, summer, and winter visitors (Figure Photo plate 1 and Photo plate 2). Moreover, 60% of the species recorded have been accorded conservation priority in India under schedule IV of the Wildlife Protection Act 1972. It represents the vital role of the village ecosystem in providing suitable habitats to these conservation significant species.

Among the recorded Himalayan endemic and forest specialist species, ten species such as Yellow-billed Blue Magpie, Pink-browed Rosefinch, Wedge-tailed Green Pigeon, Fire-breasted Flowerpecker, White-throated Laughingthrush, Rufous-bellied Niltava, Black-throated Sunbird, Buff-barred Warbler, Mountain Bulbul, and Stripe-throated Yuhina were found in both categories. However, change in the land-use patterns and forest degradation in the Himalayas makes these range-restricted and forest specialist species more vulnerable to extinction, making them have high conservation significance value.

Naturalists have widely reported seasonal migration in the Himalayas over the past few decades (Grimmett et al., 1998; Kery et al., 2001). It occurs due to fluctuations in food productivity and climatic conditions (Acharya et al., 2010; Blake and Loiselle, 1991; Norris and Marra, 2007). Our study area that is located at the mid-elevation range, which is at the junction of the low and high elevation ranges of the Himalayas supports 30 migratory species. This corroborates previous observations by ornithologists/naturalists that food and suitable habitat availability during seasonal change plays a major role in the diversity of species encountered (Vazquez and Givnish, 1998; Naithani and Bhatt, 2010).

We found avifaunal richness and abundance was highest in agricultural land. Similarly, Elsen et al. (Elsen et al., 2016) found that the agricultural land is most diverse in terms of birds during winters in the Himalayas. Typically, in the Himalayas, traditional agriculture is diverse, with a variety of fodder, ornamental and sacred plants in the croplands using organic farming practices (Bisht et al., 2006). We recorded various fodder trees like *Ficus racemosa, Ficus palmata, Grewia optiva, Celtis australis, Pyrus passia* from the agricultural land of the village. Different birds use branches of these trees for perching and foraging purposes. Previous studies have discussed the premise that if agricultural lands are managed organically and maintained with diverse shade trees, they can harbor a significant amount of wild biodiversity with unique community assemblages of plants and animals (Harvey et al., 2006; Sharma and Vetaas, 2015; Mellink et al., 2017). Another reason could be due to the edge effect at the junction of forest and agriculture land, and due to the open area in the agricultural land, detection of birds is high as compared to the forest. This highlights the importance of agricultural land in the elevation band in terms of species enrichment.

Oak forest was the second-highest in the BSD and BSR, as the forest supports high richness and density of trees and shrubs, which provides shelter and suitable habitat to different forest-dwelling bird species. On the other hand, the Chir Pine forest supported the least bird diversity; a probable reason could be the similarity of this habitat to a monoculture, as the variety of tree species was negligible in this forest. Another possible cause is that the density and diversity of shrubs were also the lowest in this habitat. A previous study has recorded that avifaunal diversity depends on habitat variety with different species of trees and shrubs (Laiolo et al., 2004).

We have also recorded the highest number of species during spring season as most of the Himalayan birds start breeding (Elsen et al., 2018; Shahabuddin et al., 2021) and become more vocally active which increases their detection rates. Another factor could be that spring is a transition season between winter and summer, and the mid-elevation areas are the juncture of crossovers from lower to higher altitudes and vice-versa in the landscape. We found BSD and BSR were highest during spring seasons in all the habitat types except Sal forest.

In Sal forest, maximum BSD was recorded in the monsoon season. Despite the tree density being significantly lower than other forest types, the shrub density increases during the monsoon, which supports high bird diversity (Acharya et al., 2011). In contrast, BSR was highest during the Winter season as sal forest is present in lower elevation areas, and during winters, birds residing at high altitudes migrate to these areas (Naithani and Bhatt, 2010).

The insectivorous feeding guild is the richest and most abundant in the Himalayas (Katuwal et al., 2016; Acharya et al., 2010; Laiolo et al., 2004). This study recorded Muscicapidae (19 species), Picidae (7 species), Phylloscopidae (6 species) families as most species-rich. The species belonging to these families predominantly depend on insects for food. Gray-hooded Warbler and Hume's Leaf Warbler were the most encountered species from the most abundant family Phylloscopidae. Studies that were done by Ghosh et al. (2011) and Shahabuddin et al. (2017) reported Gray-hooded Warbler and Hume's Leaf Warbler as the most abundant species in the Phylloscopidae family from the Himalayan foothills and nearby districts (Almora and Nainital), respectively.

Nesting or roosting sites of a species represent the population persistence of that species in the landscape (Arya et al., 2021). Similarly, we have observed an active nesting site of Bearded Vulture and Common Kestrel on a cliff near the Chir pine forest and a roosting site of Himalayan vulture and Egyptian Vulture on a hilltop during winters. It represents that the village ecosystem also provides suitable habitats to these globally threatened and top predatory bird species.

5. Conclusion

The present study recorded the seasonal pattern of avian diversity over two years in a mid-altitudinal range village ecosystem in Western Himalaya. The region supports many conservations priority species such as Himalayan endemics, and Oak forest specialists. Most of the species recorded are more susceptible to land-use change and forest degradation. The BSD and BSR values positively correlate with habitat diversity, indicating that a more diverse habitat supports higher abundance values. Anthropogenic pressure in the Sal forest is much higher than in other forests and requires conservation and better management attention. Spring season (Breeding season) was observed to be the most species-rich and diverse amongst the other seasons. Winter was the second most species-rich season but least in species abundance, whereas monsoon was high in species abundance but least in terms of species richness.

The studies on the seasonal pattern of avian diversity in different habitats are significantly lower in the Indian Himalayan Region. This study aims to provide a basic understanding of how avifaunal diversity pattern changes across seasons in different habitat types in a mid-altitudinal region which serves as a juncture for crossover.

Credit taxonomy

Sumit Kumar Arya: Field methodology, Formal analysis, Data Curation, Writing - original draft, Writing - review & editing. Govindan Veeraswami Gopi: Conceptualization, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

We are grateful to ICIMOD for providing the grant to carry out this study. We thank Dr. G.S. Rawat, Dr. P.K. Mathur and Dr. B.S. Adhikari for encouraging us during the study. We thank Director and Dean, Wildlife Institute of India for providing Institutional support. Our sincere thanks to the Head-men of the village Darshan Singh Bhandari and Jivan Singh for providing logistic supports, Dr. Arti Kala, Alka Chaudhary, Ajaz Hussain, Deep Shah for helping during the field surveys, and to Arundhati Mohanty, Shahid Dar, and Sougato Sadhukhan for providing valuable inputs during data analysis and writing.

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