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Study Of Avifauna Of Rajparian Wildlife Sanctuary, Kashmir Himalaya: Diversity, Status And Seasonal Variation

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Abstract: The value of local and regional landscapes for avian conservation requires a thorough understanding of the diversity and structure of bird communities. The present study was conducted in the Rajparian Wildlife Sanctuary to assess the diversity, status and seasonal variation of avifauna. Weekly surveys were conducted from July 2019 to December 2021, following the line transect method. 102 bird species were recorded during the study period, categorized under 12 orders and 37 families, including 60 resident species, 24 summer migrants, 3 winter visitors, 8 passage migrants and 7 local altitudinal migrants. Among the dominant families, the Muscicapidae accounted for 17 species with a 15.7 relative diversity index value. Renyi diversity profile and rarefaction analysis revealed that of all the studied seasons, the summer season has the highest diversity and richness. Considerable variation in Sorensen dissimilarity between different seasonal pairs was observed, with the lowest dissimilarity found between summer and autumn (β_{SOR} = 0.07) and the highest between autumn and winter (β_{SOR} = 0.21). The current study will serve as a baseline for future avian research as well as for management implications in the sanctuary.

Key words: Avifaunal diversity, Rajparian Wildlife Sanctuary, Seasonal variation

Introduction

Birds are considered one of the best studied vertebrate groups on the planet since they are conspicuous, ubiquitous and have been extensively examined (Whelan *et al*. 2008). They inhibit nearly all habitats around the globe and have many ecological functions (wenny *et al*. 2011). Bird community composition is a key indicator of the health and economic vitality of local ecosystems and regional landscapes (Nagya *et al*. 2017). In addition to delivering critical ecosystem services, they also serve as seed dispersers, scavengers and predators (Gregory *et al*. 2003; Sodhi *et al*. 2011). The importance of landscapes for the conservation of birds requires a comprehensive understanding of bird community structure and diversity (Kattan and Franco 2004). Several ecosystems rely on birds as a component of the natural food chain (Whelan *et al*. 2008). Avian species richness and diversity can be used as an effective tool for monitoring different habitats, both qualitatively and quantitatively (Bilgrami 1995). Vegetation loss and degradation, hunting, pollution, invasive species and disease all pose persistent threats to avifauna (Sodhi *et al*. 2011). In addition to supporting biodiversity, protected areas, such as national parks and wildlife sanctuaries, play an essential role in functions such as providing ecosystem services, climatic stabilization and prevention of natural disasters (Defries *et al*. 2007; Heal 2000). The subcontinent of India is one of the most biologically diverse regions on earth, with highly varied climatic conditions, diverse habitats, and long stretches of vegetative cover, supporting over 13% of all birds (Grimmett et al. 1998; Ali 2002). Globally, the Himalayan regions are considered affluent because they are surrounded by broad- leaved mixed forests, dry deciduous forests, moist deciduous forests and coniferous forests (Joshi & Bhatt 2013).

Located in the Himalayan region, Jammu and Kashmir is endowed with abundant natural resources and harbours a rich diversity of birds. With 28 designated bird areas (Islam and Rahmani 2012), Jammu and Kashmir is home to approximately 12 globally threatened bird species and six near-threatened species (Rahmani *et al*. 2013). Bird surveys have been conducted for all three regions of Jammu, Kashmir, and Ladakh (Pfister 2001; Aggarwal *et al*. 2008; Bhat and Bhat 2012; Kait *et al*. 2014; Sharma and Kichloo 2015; Sharma and Sohil 2017). However, the diversity and richness of bird species are not known for the Rajparian wildlife sanctuary. Through this study, we aim to understand the biodiversity, richness, composition and seasonal variations of avian species in the sanctuary.

Material and Methods

Study area: Rajparian Wildlife Sanctuary (Fig.1) is located in the district Anantnag of Jammu and Kashmir, between 33º 36′ 30″ to 33º 42′ 30″ N latitude and 75º 25′ 30″ to 75º 31′ 15″ E longitudes at an elevation ranging from 2360 m and 4270 m above sea level. The Anantnag-Semthan-Kishtwar road (NH-1B) leads to the sanctuary, which is approximately 100 km from Srinagar and about 41 km from Anantnag in the south-east direction. The Sanctuary covers an area of 48.27 km^2 and takes its name from the Rajparian Nallah that runs through it and serves as a major catchment region for the Bringi River, a tributary of the Jhelum. In 1948, the sanctuary was designated as the game reserve for Hangul (*Cervus hanglu hanglu*), and in 1981, it was upgraded to the Rajparian Wildlife Sanctuary.

Varied altitude, aspect and soil conditions have brought about different vegetation structures in the area, including dense forest, grassland, grazing land, scrub vegetation, riverine vegetation and barren rocky areas. The dominant vegetation of the study area includes *Pinus wallichiana*, *Picea smithiana*, *Acer caesium*, *Salix alba*, *Betula utilis*, *Aesculus indica*, *Juglanus regia*, *Ulmus wallichiana*, *juniperus squamata*, and *Rhododendron anthopogan.* The sanctuary is abode to many mammalian species, including Asiatic Black Bear, Musk Deer, Himalayan Grey Langur, and Red Fox. The region is characterized by four seasons: spring, summer, autumn and winter

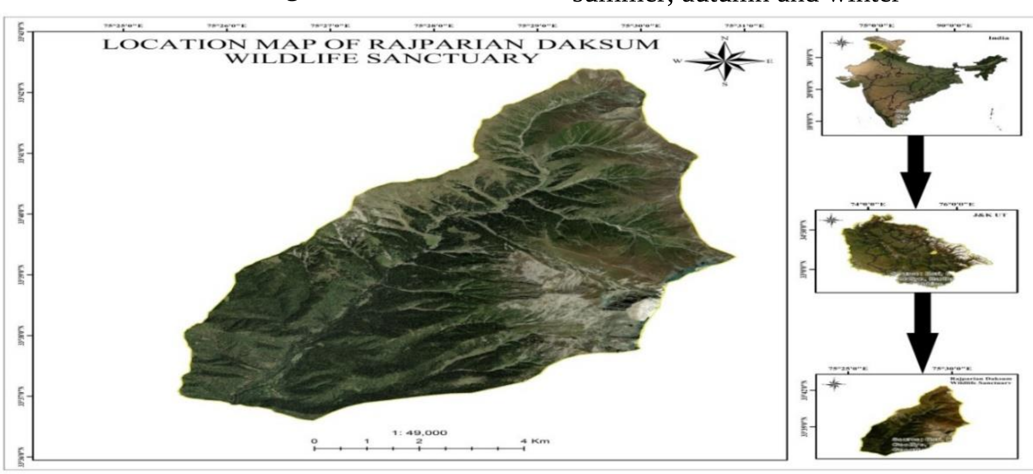


Fig.1: Location map of the study area

Sampling procedure

Several study sites, including dense forests, grasslands, riverine areas, scrub vegetation and barren rocky habitats, were selected for sampling birds within the Rajparian wildlife sanctuary, based on the vegetation structure from 2019 to 2021, covering all seasons. Following Bibby *et al*. (2000), a total of 28 linear transects were laid, varying in length from 100 m to 500 m and in width from 25 m to 50 m, covering almost all study sites and habitat types. The length of the transects varied according to the vegetation and accessibility of the area. All sampling points were taken through a stratified random method and a distance of almost 250 m was maintained between two sampling points in order to avoid double counting of birds. For surveying birds, weekly sampling was done mainly during the morning and evening hours when birds were found most active, avoiding inclement weather conditions. Based on sighting frequency, bird species were ranked into the following categories: very common (VC)-sighted > 10 times, common (C)-sighted 7-9 times, uncommon (UC)-sighted 3-6 times and rare (R)-sighted once or twice, for analysis of relative abundance following McKinnon and Phillip (1993). Migratory and threat status of bird species were assigned following Grimmett *et al*. (2011) and the IUCN Red List of Threatened Species respectively. Bird species were observed using binoculars (Nikon Action 8 X 40 8.2) and photographs were taken with a digital camera (Nikon D5600 with a 60-300 mm lens kit). Bird species were identified using field guides by Grimmett *et al. (*2011) and Ali (2002). For call and song notes, BirdNET and Merlin applications were used.

Data Analysis

The iNext 2.0.20 R package was used to calculate individual and coverage-based rarefaction and extrapolation curves based on abundance data for all seasons (Hsieh *et al*. 2020). To determine which pairs of studied seasons showed significant differences in species richness, we used the Tukey HSD test for multiple pairwise comparisons between their means.

The Vegan 2.5-7 package was used to calculate the species diversity of the studied seasons using the Renyi diversity profile approach (Oksanen *et al*. 2020). Based on the average abundance data of the three-year period and a scaling parameter (α) that ranges from zero to infinity, the Renyi diversity profile values (H_α) were determined using the following formula:

$$H_\alpha = \frac{1}{1-\alpha} ln \sum_{i=1}^{S} p_i^{\alpha}$$

Where, pi is the average abundance of a bird species, and α is the scaling parameter (Legendre and Legendre 1998; Kindt and Coe 2005; Oksanen *et al*. 2020). Renyi profile values at the scales of 0, 1, 2 and infinity (∞) indicate species richness, the Shannon diversity index, the Simpson diversity index and the Berger-Parker diversity index, respectively. In the present study, the diversity values for the default α scale of 0, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64 and infinity (∞) were calculated and plotted against the corresponding Renyi diversity profiles for each studied season.

Using the betapart 1.5.4 package (Baselga *et al*. 2012), seasonal patterns of beta diversity components for avian species was investigated by analyzing the turnover and nestedness components based on presence absence data and the Sørensen index. Based on this method, observed dissimilarity (β_{SOR}) is partitioned into two additive components, species turnover or replacement (β_{SIM}), and nestedness (β_{SNE}) (Baselga and Orme 2017). The relative diversity was calculated using the following formula (Torre-Cuadros *et al*. 2007):

$$RDi = \frac{\text{Number of bird species in a family}}{\text{Total number of species}} \times 100$$

Results and Discussion

A total of 102 bird species categorized under 12 orders and 37 families were recorded in the study area, including two near-threatened and one vulnerable bird species (Table 2). The rich diversity in the area could be attributed to varied altitude, aspect and soil conditions that have brought about rich vegetation cover for nesting, roosting, the availability of foraging material and low accessibility to predators (Gabbe *et al*. 2002; Hu & Cardoso 2009; Jokimäki *et al*. 2012). The highest number of bird species were recorded from the order Passeriformes (75.5%), followed by Accipitriformes (5.9%). Other earlier studies have also reported the order Passeriformes to be the most dominant order (Bhat and Bhat 2012; Singh *et al*. 2013; Wani *et al*. 2013). The diversity of passerine species is high due to their ability to inhibit a variety of habitats and consume an array of food items, such as invertebrates, grains, nuts, floral buds, fruits and nectar (Beresford *et al*. 2005). Family Muscicapidae was found to be most dominant with 17 species followed by Fringillidae (9 species). Other authors (Wani *et al*. 2013; Thakur 2010) also found the family Muscicapidae to be dominant. Analysis of the relative diversity (RDi) of bird families revealed that the highest RDi value was (16.7) for the family Muscicapidae (Fig.2). Analysis of data on residential status revealed that out of 102 bird species, 60 were residents, 24 were summer migrants, 3 were winter visitors, 8 were passage migrants and 7 were local altitudinal migrants. The hierarchical cluster analysis based on the residential status was divided into two major clusters with permanent residential species forming one separate cluster, while seasonal migrants collectively form second cluster (Fig. 3). Furthermore, the second cluster is further sub-divided into three sub-clusters with summer and passage migrants forming two separate sub-clusters, while winter and local altitudinal migrants are grouped together into the third sub-cluster (Fig. 3).

Further, the relative abundance analysis indicated that 16 species were very common (VC), 27 were common (C), 41 were uncommon (UC) and 18 were occasionally sighted (O) species (Fig. 4). During the study period, the highest numbers of individuals were recorded for spot winged tit (11.2 ± 15.2; mean ± SD) and the lowest for European Roller and Tibetan Blackbird (0.3 ± 0.1; mean ± SD)

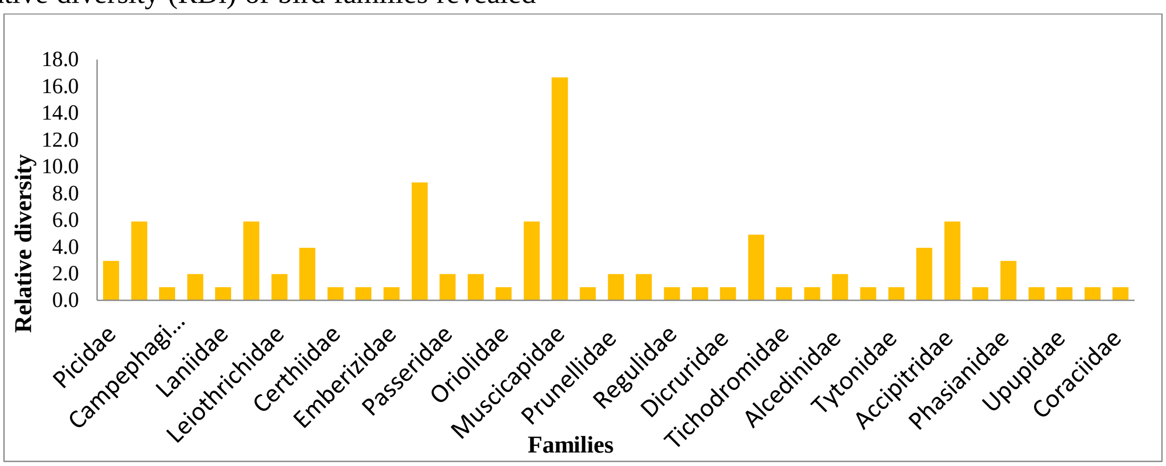


Fig.2: Bar graph showing families of birds and their relative diversity

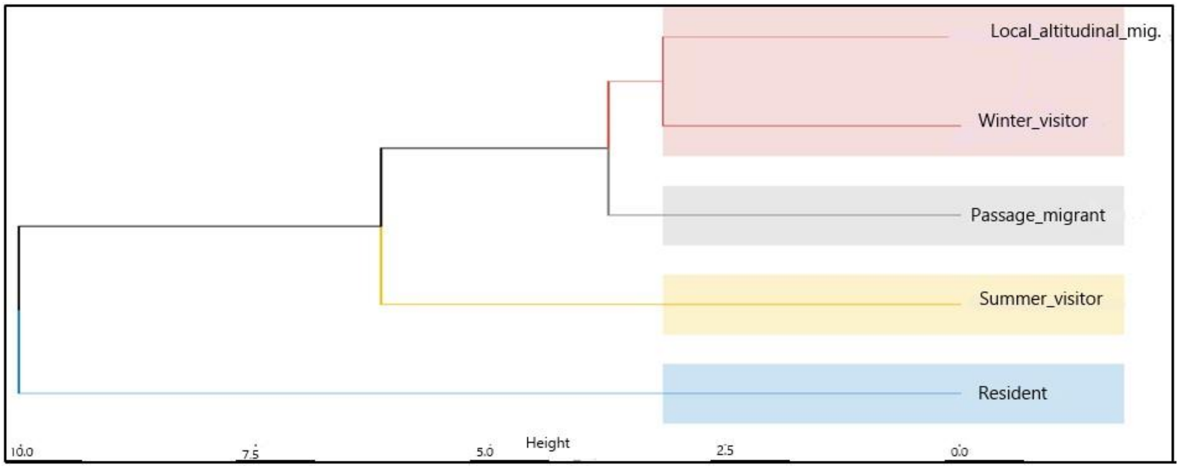


Fig. 3: Dendrogram showing residential status of birds, based on compositional data.

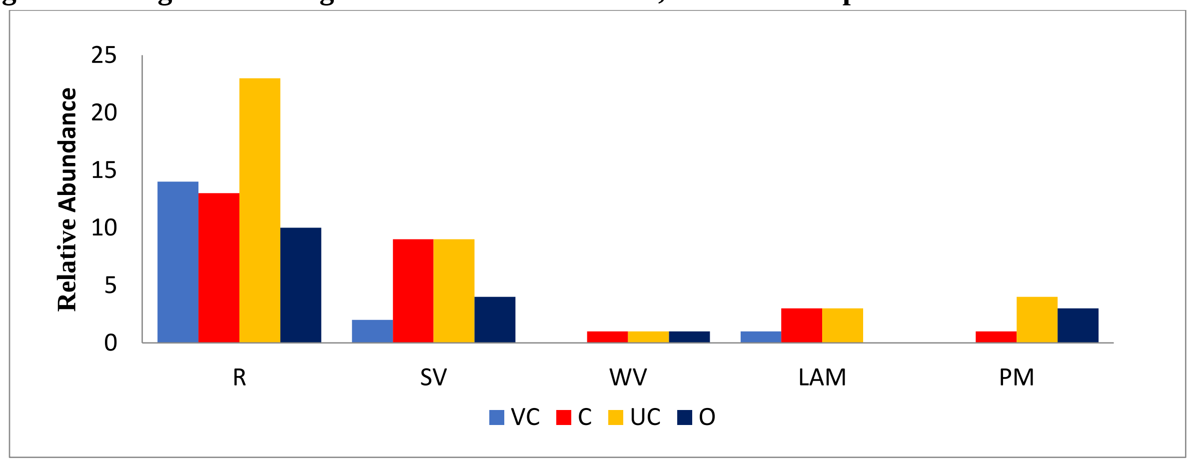


Fig. 4: Bar graph showing residential status (R = resident; SV = summer visitor; WV = winter visitor; PV = passage visitor and LAM = local altitudinal migrant) and relative abundance (VC = very common; C = common, UC = uncommon, and O = occasional) of birds in Rajparian Wildlife Sanctuary.

Seasonal diversity:

The Renyi diversity profiles showed that, of all the studied seasons, the summer season had the highest species diversity in terms of all the scaling parameters (α) chosen. On the other hand, the winter season showed the lowest species diversity (fig. 5). A possible reason for the high diversity and richness of birds in summer could be the increased number of migrants flocking to the wildlife sanctuary during the summer for food and breeding. This may be due to the availability of feeding and breeding grounds in the summer, when the flowers and fruit are in bloom, which is unlike in the winter. In winters, the sanctuary remains covered with snow and most species show altitudinal migration to new feeding and breeding grounds in order to escape harsh climatic conditions. Winter migrants move from high elevation breeding grounds to non-breeding sites to find food (Dingle & Drake 2007; Rappole 2013), while inter-altitudinal and inter-continental summer migrants move to higher elevations to breed (Cade & Hoffman 1993; Norbu *et al*. 2013).

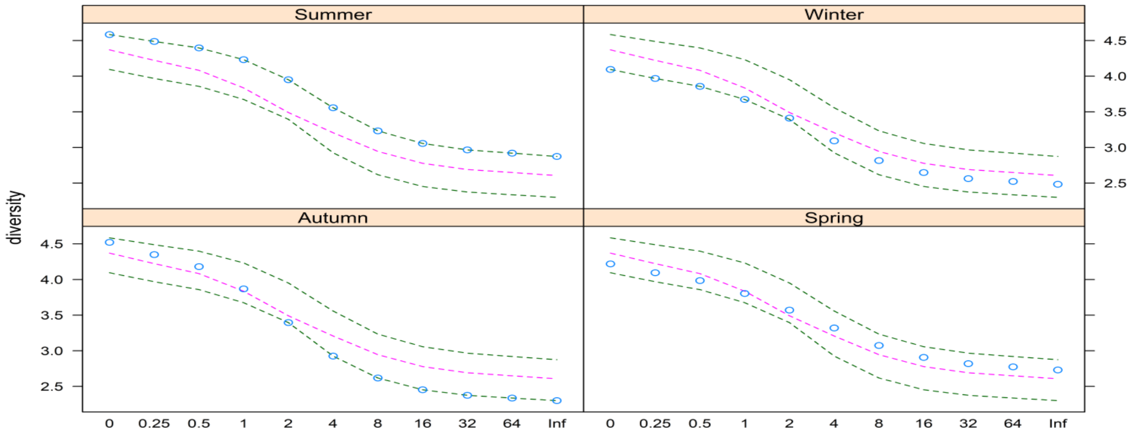


Fig. 5: Renyi diversity profiles of birds for the studied seasons. The dots denote the diversity value for the seasons; the outer two dashed lines represent the extremes; and the inner pink line represents the median in the data.

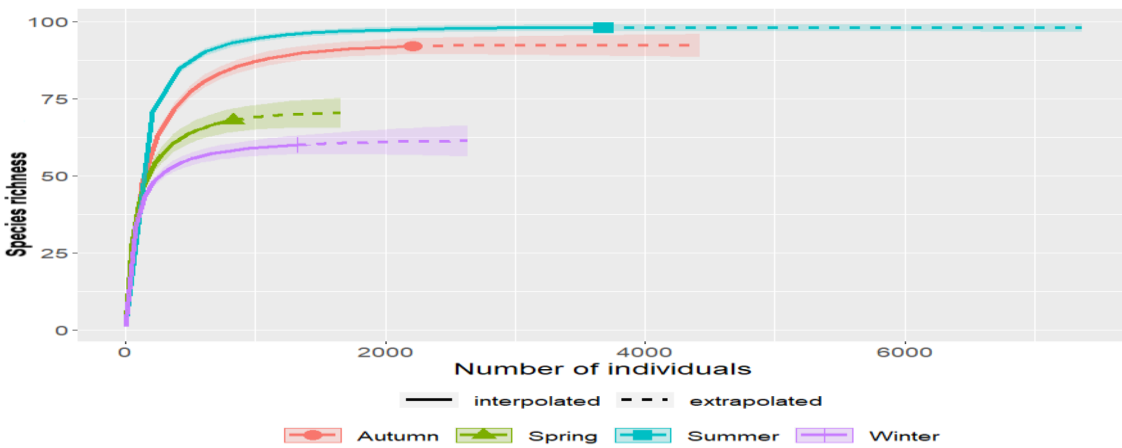


Fig.6: Rarefaction and extrapolation curves of bird species for the studied seasons. A solid line represents the rarefaction curves, a dashed line represents the extrapolation curves, and a shaded area represents the 95% confidence intervals of species richness. The solid symbols represent the reference samples.

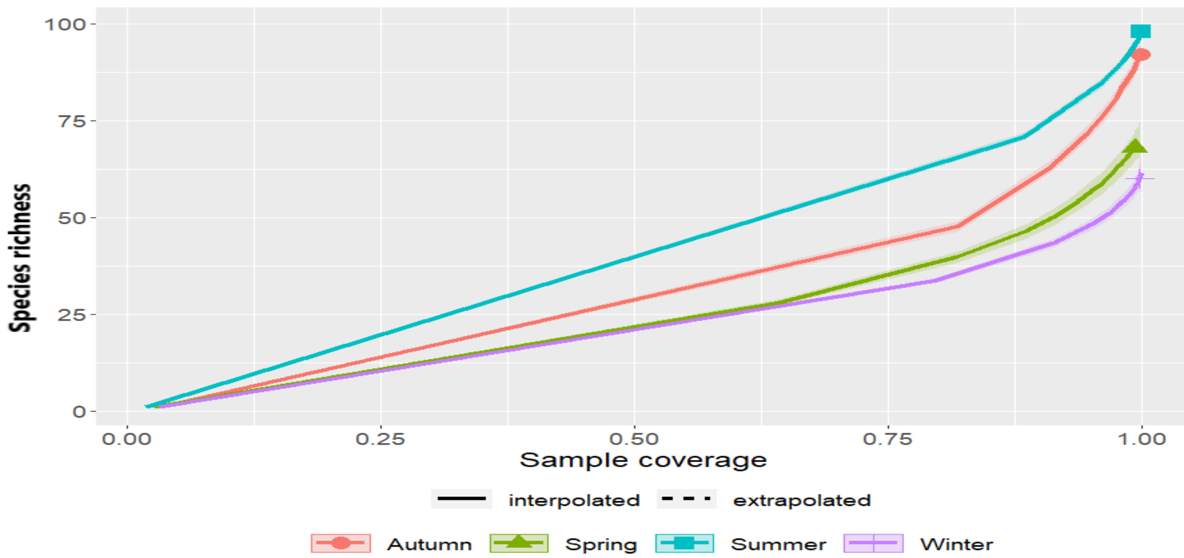
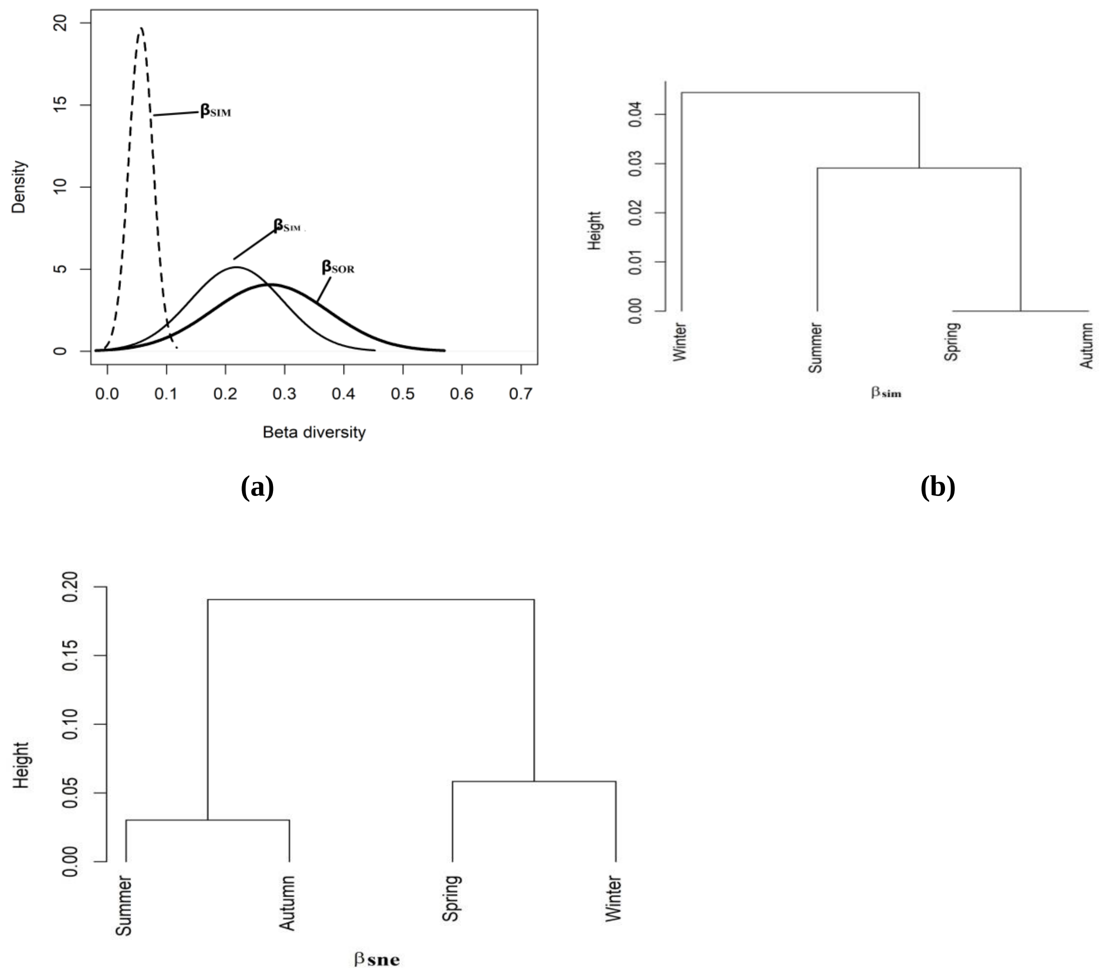


Fig. 7: Coverage based rarefaction and extrapolation curves of bird species for the studied seasons

On the basis of individual rarefaction and extrapolation curves, the summer season has the highest species richness, whereas the winter season has the lowest. Also, the studied seasons showed clear asymptotic curves (Fig. 6). However, the coverage-based rarefaction and extrapolation curve revealed that all the studied seasons showed an adequate sampling effort with sample coverage of more than 95% (Fig.7). The highest numbers of individuals were recorded in summer seasons (30 ± 31; mean ± SD) and lowest in the winter (13 ± 20; mean ± SD)

The overall Sorensen Dissimilarity Index among the studied seasons was high (β_{SOR}=0.27). Furthermore, the nestedness component (β_{SNE}= 0.21) had a significant contribution to the overall dissimilarity compared to the turnover component (β_{SIM} = 0.05), indicating that the overall dissimilarity is more likely a result of richness differences (nestedness) compared with species replacements (turnover) (Fig 8a)

There were also considerable variation in Sorensen dissimilarity between different seasonal pairs, with the lowest dissimilarity found between summer and autumn (β_{SOR} = 0.07) and the highest found between autumn and winter (β_{SOR} = 0.21). In the majority of comparisons, pair-wise dissimilarity was caused by nestedness rather than species turnover (Table 1). Further, the cluster analysis based on the turnover component of dissimilarity (β_{SIM}) revealed that the winter season differs greatly from the rest of the seasons in terms of bird species composition, followed by spring and autumn (Fig. 8b). On the other hand, the cluster analysis based on the nestedness component of dissimilarity (β_{SNE}) revealed winter and spring to be highly dissimilar from the rest of the seasons (Fig. 8c)



(a) (b)

(c)

Fig. 8 (a-c): Seasonal differences in bird species composition. Showing the partitioning of total dissimilarity (β_{SOR} – black solid line) into species turnover (β_{SIM}– dashed line) and nestedness (β_{SNE}– gray solid line) components (a), average clustering of β_{SIM}(b) and β_{SNE}(c) components of species dissimilarity among the studied seasons.

Table 1: Pair-wise Sorenson dissimilarity (β_{SOR}) along with the turnover (β_{SIM}) and nestedness (β_{SNE}) components.

Sorenson dissimilarity (β_{SOR})			
	Spring	**Summer**	**Autumn**
Summer	0.19277108		
Autumn	0.15000000	0.07368421	
Winter	0.12500000	0.29113924	0.21052632
Turnover component of dissimilarity (β_{SIM})			
	Spring	**Summer**	**Autumn**
Summer	0.01470588		
Autumn	0.00000000	0.04347826	
Winter	0.06666667	0.06666667	0.00000000
Nestedness component of dissimilarity (β_{SNE})			
	Spring	**Summer**	**Autumn**
Summer	0.17806520		
Autumn	0.15000000	0.03020595	
Winter	0.05833333	0.22447257	0.21052632

Table 2: Systematic list and status of birds recorded from Rajparian Wildlife Sanctuary, Kashmir

S. No	Common name	Scientific name	Status	Distribution	IUCN status
Order: Piciformes					
Family: Picidae					
01	Himalayan woodpecker	*Dendrocopos himalayensis*	R	VC	LC
02	Brown fronted woodpecker	*Dendrocopos auriceps*	R	C	LC
03	Scaly bellied woodpecker	*Picus squamatus*	R	C	LC
Order: Passeriformes					
Family: Motacillidae					
04	White wagtail	*Motacilla alba*	S	C	LC
05	Yellow wagtail	*Motacilla flava*	P	C	LC
06	Grey wagtail	*Motacilla cinerea*	R	C	LC
07	Citrine wagtail	*Motacilla citreola*	S	UC	LC
08	Rosy Pipit	*Anthus roseatus*	R	C	LC
09	Tree pipit	*Anthus trivialis*	R	C	LC
Family: Campephagidae					
10	Long tailed minivet	*Pericrocotus ethologus*	S	C	LC
Family: Pycnonotidae					
11	Himalayan bulbul	*Pycnonotus leucogenys*	R	VC	LC
12	Black Bulbul	*Hypsipetes leucocephalus*	R	UC	LC

Family: Laniidae					
13	Long tailed shrike	*Lanius schach*	S	VC	LC
Family: Turdidae					
14	Mistle thrush	*Turdus viscivorus*	R	C	LC
15	Tibetan Blackbird	*Turdus maximus*	R	O	LC
16	Chestnut Thrush	*Turdus rubrocanus*	R	C	LC
17	Black-throated Thrush	*Turdus atrogularis*	W	UC	LC
18	Alpine Thrush	*Zoothera mollissima*	R	O	LC
19	Tickell's Thrush	*Turdus unicolor*	S		LC
Family: Leiothrichidae					
20	Variegated laughing Thrush	*Garrulax variegates*	LAM	VC	LC
21	Streaked laughing thrush	*Garrulax lineatus*	LAM	VC	LC
Family: Paridae					
22	Spot winged tit	*Parus melanolophus*	R	C	LC
23	Rufous-vented Tit	*Parus rubidiventris*	R	C	LC
24	Cinereous Tit	*Parus cinerous*	S	C	LC
25	Green backed tit	*Parus monticolus*	LAM	C	LC
Family: Certhiidae					
26	Bar tailed tree creeper	*Certhia himalayana*	LAM	C	LC
Family: Troglodytidae					
27	Winter wren	*Troglodytes troglodytes*	LAM	UC	LC
Family: Emberizidae					
28	Rock bunting	*Emberiza cia*	R	C	LC
Family: Fringillidae					
29	Plain mountain Finch	*Leucosticte nemoricola*	R	C	LC
30	Spectacled Finch	*Callacanthis burtoni*	R	O	LC
31	Brambling	*Fringilla montifringilla*	W	C	LC
32	Common Rosefinch	*Carpodacus erythrinus*	P	UC	LC
33	Black and yellow Grosbeak	*Mycerobas icterioides*	R	UC	LC
34	Orange Bullfinch	*Pyrrhula aurantiaca*	R	UC	LC
35	Yellow-breasted Greenfinch	*Chloris spinoides*	S	UC	LC
36	European Goldfinch	*Carduelis carduelis*	R	UC	LC
37	Fire-fronted Serin	*Serinus pusillus*	R	UC	LC
Family: Passeridae					
38	Russet Sparrow	*Passer rutilans*	R	C	LC
39	Common Sparrow	*Passer domesticus*	R	VC	LC
Family: Sturnidae					
40	Common Myna	*Acridotheres tristis*	R	VC	LC
41	Common Starling	*Sturnus vulgaris*	S	C	LC
Family: Oriolidae					
42	Golden oriole	*Oriolus oriolus*	S	C	LC
Family: Corvidae					
43	Large billed Crow	*Corvus macrorhynchos*	R	VC	LC
44	Yellow billed blue Magpie	*Urocissa flavirostris*	R	VC	LC
45	Eurasian Jackdaw	*Corvus monedula*	R	VC	LC
46	Large Spotted nut cracker	*Nucifraga multipunctata*	R	C	LC

47	House Crow	*Corvus splendens*	R	VC	LC
48	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	R	O	LC
Muscicapidae					
49	Blue whistling- Thrush	*Myophonus caeruleus*	R	VC	LC
50	Siberian Stonechat	*Saxicola maurus*	P	UC	LC
51	Himalayan Bluetail	*Tarsiger rufilatus*	R	UC	LC
52	Little Forktail	*Enicurus scouleri*	LAM	UC	LC
53	Himalayan Rubythroat	*Calliope pectoralis*	S	UC	LC
54	Spotted Forktail	*Enicurus maculates*	LAM	C	LC
55	Blue-capped Redstart	*Phoenicurus coeruleocephala*	R	UC	LC
56	Blue-fronted Redstart	*Phoenicurus frontalis*	W	O	LC
57	Black Redstart	*Phoenicurus ochruros*	P	UC	LC
58	Chestnut-bellied rock Thrush	*Monticola rufiventris*	S	O	LC
59	Plumbeous water Redstart	*Rhyacornis fuliginosa*	R	VC	LC
60	White-capped Redstart	*Chaimarrornis leucocephalus*	R	VC	LC
61	Blue rock Thrush	*Monticola solitaries*	R	O	LC
62	Grey Bushchat	*Saxicola ferreus*	R	C	LC
63	Ultramarine Flycatcher	*Ficedula superciliaris*	R	UC	LC
64	Kashmir Flycatcher	*Ficedula subrubra*	S	O	VU
65	Dark-sided Flycatcher	*Muscicapa sibirica*	S	UC	LC
Cinclidae					
66	Brown Dipper	*Cinclus pallasii*	R	VC	LC
Prunellidae					
67	Black-throated Accentor	*Prunella atrogularis*	P	UC	LC
68	Rufous-breasted Accentor	*Prunella strophiata*	S	UC	LC
Sittidae					
69	Kashmir Nuthatch	*Sitta cashmirensis*	R	UC	LC
70	White-cheeked Nuthatch	*Sitta leucopsis*	R	UC	LC
Regulidae					
71	Goldcrest	*Regulus regulus*	P	UC	LC
Monarchidae					
72	Asian paradise Flycatcher	*Terpsiphone paradisi*	S	C	LC
Dicruridae					
73	Ashy Drongo	*Dicrurus leucophaus*	S	C	LC
Phylloscopidae					
74	Lemon-rumped Warbler	*Phylloscopus chloronotus*	S	C	LC
75	Hume's Warbler	*Phylloscopus humei*	S	C	LC
76	Common Chiffchaff	*Phylloscopus collybita*	P		LC
77	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	R	UC	LC
78	Western Crowned Warbler	*Phylloscopus occipitalis*	S	UC	LC
Trichodromidae					
79	Wallcreeper	*Tichodroma muraria*	R	UC	LC
Acrociphalidae					
80	Clamorous Reed Warbler	*Acrocephalus stentoreus*	S	UC	LC
Order: Coraciidformes					

Family: Alcedinidae					
81	Common Kingfisher	*Alcedo atthis*	R	C	LC
82	White-throated Kingfisher	*Halcyon smyrnensis*	R	UC	LC
Order: Strigiformes					
Family: Strigidae					
83	Tawny Owl	*Strix aluco*	R	UC	LC
Tytonidae					
84	Barn Owl	*Tyto alba*	R	UC	LC
Order: Columbiformes					
Family: Columbidae					
85	Common Pigeon	*Columba livia*	R	VC	LC
86	Oriental Turtle-dove	*Streptopelia orientalis*	R	VC	LC
87	Eurasian Collared-dove	*Streptopelia decaocto*	S	UC	LC
88	Snow Pigeon	*Columba leuconota*	R	O	LC
Order: Accipitriformes					
Family: Accipitridae					
89	Himalayan Vulture	*Gyps himalayensis*	R	UC	NT
90	Common Kestrel	*Falco tinnunculus*	S	O	LC
91	Bearded Vulture	*Gypaetus barbatus*	R	O	NT
92	Eurasian Sparrowhawk	*Accipiter nisus*	R	UC	LC
93	Golden Eagle	*Aquila chrysaetos*	R	O	LC
94	Black-eared Kite	*Milvus migrans*	R	UN	LC
Order: Pelecaniformes					
Family: Ardeidea					
95	Grey Heron	*Ardea cinerea*	R	UC	LC
Order: Galliformes					
Family Phasianidae					
96	Chukar Partridge	*Alectoris chukar*	R	UC	LC
97	Himalayan Monal	*Lophophorus impejanus*	R	O	LC
98	Koklass Pheasant	*Pucrasia macrolopha*	R	O	LC
Order: Charadriiformes					
Family: Scolopacidae					
99	Solitary Snipe	*Gallinago solitaria*	P	O	LC
Order: Bucerotiformes					
Family: Upupidae					
100	Common Hoopoe	*Upupa epops*	S	VC	LC
Order: Falconiformes					
Family: Falconidae					
101	Peregrine Falcon	*Falco peregrines*	R	UC	LC
Order: Coraciiformes					
Family: Coraciidae					
102	European Roller	*Coracias garrulus*	S	O	LC

R = resident; SV = summer visitor; WV = winter visitor; PV = passage visitor and LAM = local altitudinal migrant, VC = very common; C = common, UC = uncommon, and O = occasional, LC = least concerned, VU = vulnerable, NT = near threatened

Conclusion

From the present study, it can be concluded that the Rajparian Wildlife Sanctuary is home to several avian species. A complex vegetation structure in this area probably contributes to the immense diversity and richness of avifauna by providing shelter, suitable niches, microhabitats and appropriate foraging substrates. The richness and diversity of species vary significantly between seasons. Due to the presence of many summer migrants and the existence of sufficient habitat conditions that allow resident bird species to thrive. Species diversity and richness remained high during the summer seasons. Winters, on the other hand, saw a decline in the diversity and abundance of birds due to heavy snowfall, which forced many species to migrate to other feeding and breeding grounds, reducing bird diversity and abundance.

Acknowledgements

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Ethics approval and consent to participate

All requisite information and data were collected without disturbing the birds and their habitat. Photographic recordings were made using a telephoto lens

Declaration of competing interests

The authors declare that they have no competing interests

Abbreviations

IUCN = International Union for Conservation of Nature, R = resident; SV = summer visitor; WV = winter visitor; PV = passage visitor and LAM = local altitudinal migrant, HSD = Honest significant differences

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