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Altitudinal Differences of Bird Assemblages, Profusion, and Feeding Guilds in Khunjerab, Lal Suhanra and Hingol National Parks

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ABSTRACT

Studying avian diversity across different altitudes reveals how altitude impacts species distribution and adaptation, informing conservation strategies and ecological knowledge. This study presents a comprehensive analysis of avian species diversity, abundance, and feeding guilds across Khunjerab (KNP), Lal Suhanra (LSNP), and Hingol National Parks (HNP), with different elevations. KNP, LSNP, HNP located in distinct geographical area, were surveyed using point count method between April 2021 and April 2023. Six surveys were conducted at each site for primary data collection. Equipment such as GPS, binoculars, cameras, and field guides facilitated accurate data collection and bird identification. The results revealed that LSNP exhibited the highest species richness with 179 species, followed by HNP with 120 species, and KNP with 51 species. For KNP, LSNP and HNP, the Simpson's Index values are 0.89, 0.92, and 0.91, indicating high diversity within the studied populations. The Shannon-Wiener Index values of 3.46, 4.94, and 4.47 further support this, demonstrating substantial species richness and evenness. With reference to elevation gradient, LSNP has the mid elevation and exhibited the maximum species richness as compared to KNP and HNP. Similarity indices showed a high overlap in species composition between HNP and LSNP, suggesting similar ecological conditions, while KNP showed low similarity with the other parks. According to feeding habits, carnivores were most abundant in LSNP (78) and HNP (63), followed by omnivores whereas omnivores were most prevalent in KNP (20) followed by insectivores. The findings provide a critical baseline for future research and conservation efforts across the elevation gradient.

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Authors' Contribution
KA and ZA conceptualized the study. KA, ZA, RA, UA, ZI and AB collected primary data from field. KA, ZA and RA assembled and analyzed the dataset. KA drafted the manuscript. ZA reviewed and improved the manuscript.

Key words
Avian diversity, Khunjerab, Lal Suhanra, Hingol, National Parks, Feeding guilds

INTRODUCTION

Birds play pivotal role as the biological indicator of an ecosystem and provide invaluable information regarding environmental changes, feeding guilds, species abundance and diversity of an ecosystem (Mekonen, 2017). The key determinants of any bird assemblage or community are their elevation range and heterogeneity of their habitat (Ding *et al*., 2019). The research reveals the insights of an ecological study that how habitat heterogeneity impacts the bird's diversity, abundance and feeding guilds within varied altitudinal gradients of Khunjerab, Lal Suhanra, and Hingol National parks in Pakistan considering the complex ecosystem structures. The aspects like composition, structure and function shows significant change fueled by different abiotic and biotic factors (Bisht and Bhat, 2013; Liu *et al*., 2021; Zhou *et al*., 2021; Wani and Akash, 2022). Specifically, the topographical attributes like edaphic conditions, slope, elevation and aspect play key part in molding the structures of community and distribution of different species particularly in mountain eco-regions (Gairola *et al*., 2011; Dar and Sundarapandian, 2016).

The habitat conditions are greatly impacted by the alterations in the topographical regions of an ecosystem as in mountainous areas, coastal and plain areas, as changes in these factors induce change in moisture and temperature of the eco-region (Raulings *et al*., 2010). Complex environmental conditions impact the local topology by affecting solar radiations, exposure to wind, hydrology and interaction within biotic factors, thereby significantly impacting distribution and richness patterns of the species

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(Moeslund *et al.*, 2013). The afore-mentioned mega-climatic changes along with micro-climatic changes lead towards prominent alterations over spatial scales in terms of species distribution and richness patterns (McCain and Grytnes, 2010).

At the habitat level, the abundance or availability of the species are directly linked with the edaphic gradients, management of habitat and type or structure of vegetation, that directly influence the overall gradient of the habitat by controlling the distribution of endemic and migrant species and the overall composition of the habitat (Khuroo *et al.*, 2011; Somveille *et al.*, 2013). Seasonal climate variations and altitudinal gradients in different topological areas give natural conditions for studying the temporal changes in species in terms of ecological and evolutionary impacts of environmental changes that are described by changes in temperature, altitude and feeding guilds (Barry, 2008; McCain and Grytnes, 2010; McCain and Colwell, 2011). Elevation significantly controls the temperature and precipitation and, therefore, the fauna of the eco-region, which directly impacts the feeding habit, food availability and habitat (Carnicer *et al.*, 2012; Sohil and Sharma, 2020; Kumar *et al.*, 2022).

Besides, feeding guilds, species richness and habitat species associations are used as factors that determine avian diversity and abundance (Lee and Marsden, 2008; Mekonen, 2017). Similar to previous research works conducted in different regions of the world, it has been identified that avian feeding guilds are greatly affected by the habitat heterogeneity (Ding *et al.*, 2019; Panda *et al.*, 2021). Therefore, feeding guilds provide insights and help us understand the avian communities' shifts in response to the changes in the environment (Bhat *et al.*, 2023). Previous researches revealed that feeding guilds are significantly impacted by change in elevation gradient and that some are elevation-specific (Kissling *et al.*, 2012; Bhat *et al.*, 2023).

In this broader ecological framework, this paper aims to discuss the interactions between habitat heterogeneity, avian feeding guilds, and bird species diversity and abundance in the Khunjerab, Lal Suhanra, and Hingol National Parks in Pakistan. Extensive review of literature and ecological research laid the foundation of this comprehensive investigation of how selected national parks are impacted by different ecological parameters like elevation, temperature and vegetation, providing a detailed view of the ecological process and factors involved. The amalgamation of insights from diverse ecological studies sets the stage for a comprehensive exploration of how these national parks respond to varying ecological parameters, offering a nuanced understanding of the ecological dynamics at play in these unique ecosystems. This research gap is the reason why the present study seeks to investigate avian species diversity and distribution patterns in the selected study sites and further postulate that changes in elevation and the different habitat types affect the species diversity, abundance, and feeding guilds differently. This will also contribute to understanding the factors that impact the ecology, hence fostering avian communities' conservation.

MATERIALS AND METHODS

Study site

The present study was carried out in three distinct national parks of Pakistan which are Khunjerab (KNP), Lal Suhanra (LSNP), and Hingol National Parks (HNP), having different habitat conditions. KNP is situated in Hunza Gilgit-Baltistan, LSNP is in Bahawalpur district of Punjab and HNP is in Awaran, Lasbela and Gwadar districts of Balochistan as shown in Figure 1.

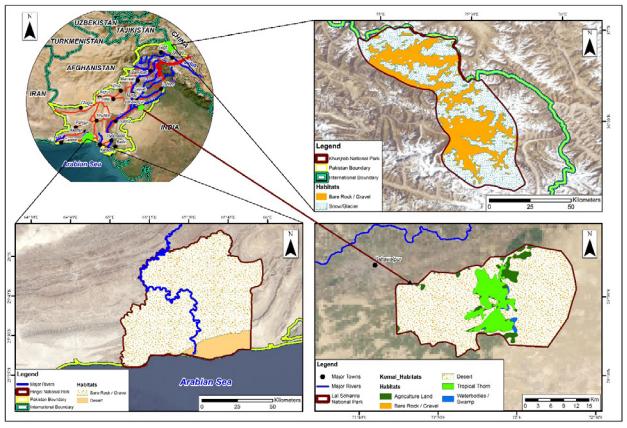

Fig. 1. Study area map showing different habitats of KNP, LSNP and HNP.

Khunjerab National Park (KNP)

KNP is located at Latitude: 36°30'N; Longitude: 75°30'E (ICIMOD, 2020), and stands at the elevation of 3310 –7460 meters above sea level (asl) (FWEGB, 2020). KNP was established in 1975 (Qureshi *et al.*, 2011), and it is the third largest national park of Pakistan covering an area of 560,714 acres (226,913) hectares (ICIMOD, 2020). KNP is known to have cold climate throughout the year with winter temperatures ranging between 2°C -7°C and summers temperatures at between 19°C - 32°C.

Lal Suhanra National Park (LSNP)

LSNP is located at coordinates of 29° 19 N 71° 55 E, and stands at an altitude between 110 and 145 meters asl, covering an area of 162,568 acres (65,789 hectares) and was

established in 1972. It has also been declared as UNESCO Biosphere Reserve. LSNP has a rather different climate: the hottest month is July, with temperature reaching 50°C, while the lowest temperatures are in January, which range between 6 and 10 °C.

Hingol National Park (HNP)

HNP is located at 25° 36'N 65° 40E and has an altitude ranging between 27m-1500m covering an area of 1,507,343 acres (610,474 hectares). This Park was established in 1988 and is characterized by a hot climate, hot and dry or hot and humid depending on the season. The annual average temperature of HNP varies between 5°C in winter and 34 ° C in summer, and during summer it ranges between 25°C to 50°C (Khan *et al*., 2010).

Materials/equipment

The tools used in the present study are GPS to record elevation asl latitude and longitude coordinates of the survey and observation points; binoculars were used when observing the birds and surroundings without disturbing the birds; Nikon p-900 camera was used for taking pictures of the birds and the environment and spotting scope was used for close observation of birds.

Identification of the birds both during the fieldwork as well as later on was done with the help of field guides. Firstly, with regards to the specific habitats and locations, the information was gathered using a geographic information system (GIS) where all the important habitats and the preferences of certain species can be found were recorded in order to avoid redundancy of the data while ensuring maximum coverage of the habitat.

Survey methods

The surveys were conducted between April 2021 to April 2023, to cover the numerous habitats involved in the study. Six surveys were conducted at each National Park for primary data collection. Bird census was performed with the point count technique (Bibby *et al*., 2001). Point count method was used for the estimation of density of a bird species. Bird calls were also noted on the same fixed mid-point within a defined area of one-hundred-meter radius. A digital range finder was used to calculate the 100m radius for observation. The observation period for each point was different due to the habitat where the points were present. In dense forests (tropical), the observation time was 40 min, and for open areas like deserts, snow, and waterbodies, the observation time was 20 min. A Bushnell Falcon 10x50 mm wide-angle binocular was used for observation, along with a Nikon P900 camera for photographic record. Different field guides were used for bird identification, including birds of Pakistan (Roberts, 1991, 1992, 1997), birds of Pakistan (Grimmett *et al*., 2008), and the birds of the Indian sub-continent (Grimmett *et al*., 1998). Birds were observed from dawn (30 min) to 11:30 AM and again from 3:00 to 3:30 PM before sunset, following the methodology of He *et al*. (2019). Surveys were not conducted at midday or during harsh weather due to low bird activity (He *et al*., 2019).

Habitat types

For the current study, land cover/land use was extracted using Karra *et al*. (2021). Number of points selected in each habitat varied due to the overall area available and accessible. For KNP two types of habitats were observed: bare rock or gravel comprising 1498.19 km^2 and snow or glacier comprising 1806.06 km^2. Overall bare rock or gravel covered 45.3% and snow and glaciers covered the majority of the areas; 54.7% as shown in Figure 1. For LSNP we observed five types of habitats: agricultural land comprising 31.66 km^2, desert comprising 521.27 km^2, bare rock/ gravel comprising 0.25 km^2, tropical thorns comprising 78.46 km^2 and water bodies or swamps comprising 3.91 km^2. Overall agricultural land, desert, bare rock / gravel, tropical thorns and water bodies or swamps covered 5.0%, 82.0%, 0.04%, 12.3% and 0.6% area, respectively (Fig. 1). For HNP we observed two types of habitats; bare rock or gravel comprising 5148.35 km^2 and desert comprising 479.40 km^2. Overall bare rock or gravel covered 91.5% and desert covered 8.5% of the area, as shown in Figure 1. The various habitats encountered in the present study have the following characteristics.

Agricultural land: Fertile soil, dry, and hot climate in plain areas, and a cooler climate in hilly areas are characteristics of agricultural land. It comprises cultivated land that is used for crops growing and a natural mix of vegetation.

Bare rock/Gravel: Extreme temperatures with rocky and gravelly terrain. The vegetation is very scarce, or in some areas, there is no vegetation cover. The soil is usually poor in nutrients and thin.

Desert: Harsh environmental conditions include low water availability, extreme temperatures, and high winds. The climate is usually hot with sandy terrains, and thin vegetation cover. Species with high adaptivity to harsh conditions are present.

Tropical thorns: Harsh environmental conditions include low water availability and extreme temperatures. Thin vegetation containing thorny shrubs in arid areas Species with high adaptivity to harsh conditions are present.

Snow/Glacier: Vegetation is limited, and wildlife is well-adapted to colder conditions and extreme climatic conditions with peaks covered with snow and glaciers.

Water bodies/ Swamps: Provides important breeding grounds for birds and animals and has a diverse ecosystem.

Data analysis

The Shannon-Wiener Index was used to quantify the diversity of a community using the following formula: H' = ∑ (pi * ln pi), Where H' Shannon-Wiener index; pi is the relative abundance of each species in the community (the proportion of individuals of a species in the community, expressed as a fraction), and ln is the natural logarithm.

Simpson's Index was used to quantify the dominance of individual species within a community, using the formula: Simpson's Index = 1 - Σ (n(n-1))/ (N(N-1)), Where, Σ is summation symbol, N is total number of individuals, and n is number of individuals of single species.

Pielou's Index was used to measure species evenness within a community using the formula: Index = Shannon-Wiener Index/ log(N), where N is the total number of individuals in the community.

Margalef's diversity index was computed for the study area by applying the following formula:

$$D_{Mg} = \frac{S-1}{ln\ ln\ N}$$

Where, D_{Mg} is Margalef's Diversity Index, S is No. of Species, *N* is the total no. of individuals in the sample.

Menhinick's diversity index was computed for the study area with the help of following mathematical equation:

$$D_{Mn} = \frac{S}{\sqrt{N}}$$

Where, D_{Mn} is Menhinick's Diversity index, S is No. of species, *N* is the total no. of individuals in the sample Relative abundance was mathematically, computed using the formula:

$$RA = \frac{n}{N} \times 100$$

Where, RA is relative abundance, n is Number of individuals of the species in the specific area, and N is the total number of individuals of all species in a specific area.

Sorenson's similarity index (SSI) was used to determine the interspecific linkages between species in different habitats (Sørensen, 1948). SSI between two was calculated using the formula (Nath *et al*., 2005): SSI = (2C/(a+b))*100, Where, C is number of species in both habitats *a* and *b*, a is the number of species in habitat *a,* b = number of species in habitat *b*

Jaccard similarity index determined and compared the similarities between various habitats. It was calculated using the following formula (Magurran, 2021): C*j* = *a*/ (*a* + *b*+ *c*), Where, *a* is the number of common species in both habitats, *b* is the number of species in habitat *a*, not in habitat *b* while *c* is the number of species in habitat *b*, not present in habitat *a*.

RESULTS

The species richness of three altitudinally different National parks; KNP, LSNP and HNP was 51, 179 and 120, respectively (Table I). Although selected national parks were on different geographical locations, have different habitats and environmental conditions, seven avian species were common in the selected national parks: common sandpiper, eurasian golden oriole, common gull-billed tern, house sparrow, long-tailed shrike, oriental skylark, and rock pigeon. These seven species can be referred to as the generalist species, as they were present in three selected study areas.

Table I. Species diversity, ecological indices, IUCN status, occurrence, and feeding guilds of Khunjerab National Park (KNP), Lal Suhanra National Park (LSNP), and Hingol National Park (HNP) birds.

National parks	KNP	LSNP	HNP
Species richness	51	179	120
Number of families	25	62	54
Number of orders	10	18	20
IUCN status			
Least concern (LC)	49	161	104
Near threatened (NT)	2	8	11
Vulnerable (VU)	-	4	2
Endangered (EN)	-	4	3
Critically endangered (CR)	-	2	-
Occurrence			
Breeding resident (BR)	18	73	42
Passage migrant (PM)	01	20	14
Summer visitor (SV)	21	10	6
Winter visitor (WV)	11	76	58
Topographical parameters			
Area (acres)	560,71	162,568	1,507,343
Elevation (meters above sea level (asl))	3310-7460	110-145	27-1500
Ecological indices			
Pielou's index	0.503	0.577	0.555
Simpson's index	0.891	0.921	0.916
Shannon-wiener index	3.460	4.949	4.472
Margalef's index	7.269	20.766	24.899
Menhinick's index	1.636	2.463	2.136
Census index	0.294	8.304	0.560
Feeding guilds			
Herbivore	02	05	04
Granivore	03	04	04
Omnivore	20	42	26
Insectivore	14	40	15
Piscivore	-	09	08
Carnivore	12	78	63

KNP

The total 971 individuals of 51 species (Table II) were recorded belonging to 25 families (Fig. 2A) and 10 orders. Out of 51 avian species the most abundant were long-tailed shrike (75), white wagtail (58), house sparrow (58), and common hoopoe (56), belonging to family Laniidae, Motacillidae, Passeridae, and Upupidae, respectively. While the least abundant species included, hill pigeon, snow pigeon, white-browed tit-warbler, great rosefinch, and northern wheatear, belonging to Family Columbidae (02) and Aegithalidae (03), respectively. KNP has two distinct habitats, Bare rock/Gravel and Snow/Glaciers. Seventeen species were observed in both habitats while 34 species were recorded in only one habitat (Table II).

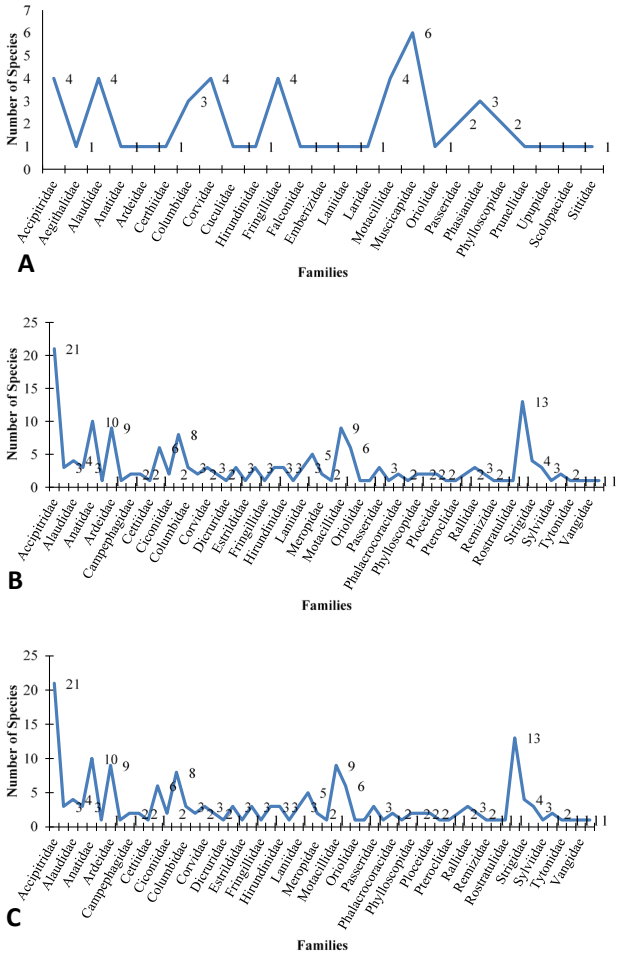

Fig. 2. Dominant bird families of KNP (A), LSNP (B) and HNP (C).

According to IUCN red list, two species are near threatened; Himalayan vulture and bearded vulture, while 49 species are least concern. With respect to population trend, 20 species showed decreasing trend, six species showed increasing trend. Stable population trend was observed in 21 species, while three species showed trend showed unknown trend. Eighteen species are breeding resident, 21 species summer visitor and 11 species are winter visitor and one species is passage migrant (northern wheatear).

The ecological indices provide further insight into the park's diversity and stability. Pielou's Index of 0.503 suggests a lower evenness, indicating that certain species dominate. Simpson's Index of 0.891 points to relatively high species diversity, albeit with some dominance. The Shannon-Wiener Index of 3.460 reflects moderate species diversity with variable distribution. Margalef's Index of 7.269 and Menhinick's Index of 1.636 indicate moderate species richness relative to the number of individuals. The Census Index of 0.294 highlights a moderate abundance of bird species within KNP.

The park supports variety of species with different feeding guilds, including 20 omnivores, 14 insectivores, 12 carnivores, three granivores (rock pigeon, snow pigeon, and chukar) and two herbivores (hill pigeon and Brandt's mountain finch).

LNP

The total 5278 individuals of 179 species (Table III) were recorded belonging to 62 families (Fig. 2B) and 18 orders. Out of 179 avian species the most abundant were white-throated kingfisher (99), Asian green bee-eater (92) and black kite (87), belonging to the family Alcedinidae, Meropidae, and Accipitridae, respectively. While the least abundant species included, Indian skimmer (one), eurasian thick-knee (two), and common reed bunting (two), belonging to Family Laridae, Burhinidae and Emberizidae, respectively. According to Landcover/land use, there are five habitats in LSNP. Agriculture land, desert, bare rock/gravel, tropical thorn and waterbodies/streams with 85, 106, 61, 42 and 101 species, respectively. Eight species were observed in all habitats while 58 species were recorded in only one habitat (Table III).

Out of 179, 161 avian species are least concern (LC), eight species are near-threatened (NT), four species are vulnerable (VU) including eastern imperial eagle, tawny eagle, common pochard, and river tern, four species are endangered (EN) (Egyptian vulture, steppe eagle, black-bellied tern, and Indian skimmer). There were two critically endangered (CR) birds: red-headed vulture and white-rumped vulture.

With respect to population trend 64 species showed decreasing trend, while 34 species showed increasing trends. Total of 58 species showed stable population trend and 23 species showed unknown trend. Out of total, 73 species

Table II. Bird species recorded in KNP during field Surveys.

Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
Accipitriformes					
Accipitridae	Eurasian sparrowhawk (*Accipiter nisus*)	LC	Stable	SV	31
	Golden eagle (*Aquila chrysaetos*)	LC	Stable	BR	9
	Himalayan griffon (*Gyps himalayensis*)	NT	Decreasing	BR	11
	Bearded vulture (*Gypaetus barbatus*)	NT	Decreasing	BR	2
Anseriformes					
Anatidae	Ruddy shelduck (*Tadorna ferruginea*)	LC	Unknown	WV	13
Bucerotiformes					
Upupidae	Common hoopoe (*Upupa epops*)	LC	Decreasing	SV	54
Charadriiformes					
Laridae	Common gull-billed tern (*Gelochelidon nilotica*)	LC	Decreasing	WV	32
Scolopacidae	Common sandpiper (*Actitis hypoleucos*)	LC	Decreasing	SV	41
Columbiformes					
Columbidae	Hill pigeon (*Columba rupestris*)	LC	Decreasing	SV	1
	Rock pigeon (*Columba livia*)	LC	Decreasing	BR	23
	Snow pigeon (*Columba leuconota*)	LC	Stable	BR	1
Cuculiformes					
Cuculidae	Common cuckoo (*Cuculus canorus*)	LC	Decreasing	SV	13
Falconiformes					
Falconidae	Common kestrel (*Falco tinnunculus*)	LC	Decreasing	BR	43
Galliformes					
Phasianidae	Chukar (*Alectoris chukar*)	LC	Stable	BR	6
	Common quail (*Coturnix coturnix*)	LC	Decreasing	WV	9
Phasianidae	Himalayan snowcock (*Tetraogallus himalayensis*)	LC	Stable	BR	5
Passeriformes					
Aegithalidae	White-browed tit warbler (*Leptopoecile sophiae*)	LC	Stable	WV	1
Alaudidae	Eurasian skylark (*Alauda arvensis*)	LC	Decreasing	WV	5
	Greater short-toed lark (*Calandrella brachydactyla*)	LC	Unknown	WV	10
	Horned lark (*Eremophila alpestris*)	LC	Decreasing	BR	2
	Oriental skylark (*Alauda gulgula*)	LC	Decreasing	SV	7
Certhiidae	Bar-tailed treecreeper (*Certhia himalayana*)	LC	Decreasing	BR	13
Corvidae	Common raven (*Corvus corax*)	LC	Increasing	BR	15
	Large-billed crow (*Corvus macrorhynchos*)	LC	Stable	BR	31
	Red-billed chough (*Pyrrhocorax pyrrhocorax*)	LC	Decreasing	BR	3
	Yellow-billed chough (*Pyrrhocorax graculus*)	LC	Stable	BR	4
Emberizidae	Rock bunting (*Emberiza cia*)	LC	Increasing	SV	37
Fringillidae	Brandt's mountain-finch (*Leucosticte brandti*)	LC	Stable	BR	2
	European goldfinch (*Carduelis carduelis*)	LC	Decreasing	WV	6
	Red-fronted serin (*Serinus pusillus*)	LC	Stable	BR	3
	Great rosefinch (*Carpodacus rubicilla*)	LC	Stable	WV	1

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Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
Hirundinidae	Asian house martin (*Delichon dasypus*)	LC	Increasing	SV	4
Laniidae	Long-tailed shrike (*Lanius schach*)	LC	Unknown	SV	81
Motacillidae	Citrine wagtail (*Motacilla citreola*)	LC	Increasing	SV	51
	Grey wagtail (*Motacilla cinerea*)	LC	Stable	SV	24
	Rosy pipit (*Anthus roseatus*)	LC	Stable	SV	11
	White wagtail (*Motacilla alba*)	LC	Stable	SV	59
Muscicapidae	Black redstart (*Phoenicurus ochruros*)	LC	Increasing	WV	45
	Blue rock thrush (*Monticola solitarius*)	LC	Stable	SV	22
	Bluethroat (*Luscinia svecica*)	LC	Stable	SV	51
	Northern wheatear (*Oenanthe oenanthe*)	LC	Decreasing	PM	1
	Pied wheatear (*Oenanthe pleschanka*)	LC	Stable	SV	2
	Variable wheatear (*Oenanthe picata*)	LC	Stable	WV	51
Oriolidae	Eurasian golden oriole (*Oriolus oriolus*)	LC	Stable	SV	3
Passeridae	House sparrow (*Passer domesticus*)	LC	Decreasing	BR	59
	Spanish sparrow (*Passer hispaniolensis*)	LC	Decreasing	WV	12
Phylloscopidae	Greenish warbler (*Phylloscopus trochiloides*)	LC	Increasing	SV	22
	Mountain chiffchaff (*Phylloscopus sindianus*)	LC	Stable	SV	4
Prunellidae	Alpine accentor (*Prunella collaris*)	LC	Stable	SV	2
Sittidae	Wallcreeper (*Tichodroma muraria*)	LC	Stable	BR	13
Pelecaniformes					
Ardeidae	Black-crowned night-heron (*Nycticorax nycticorax*)	LC	Decreasing	SV	20

* LC, Least Concern; NT=Near threatened; ** BR, Breeding resident; PM; Passage migrant; SV, Summer visitor; WV, Winter visitor.

Table III. Bird species recorded in LSNP during field surveys.

Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
Accipitriformes					
Accipitridae	Black kite (*Milvus migrans*)	LC	Stable	BR	87
	Black-winged kite (*Elanus caeruleus*)	LC	Stable	BR	40
	Brahminy kite (*Haliastur indus*)	LC	Decreasing	BR	61
	Cinereous vulture (*Aegypius monachus*)	NT	Decreasing	WV	21
	Egyptian vulture (*Neophron percnopterus*)	EN	Decreasing	BR	19
	Eurasian buzzard (*Buteo buteo*)	LC	Increasing	WV	14
	Griffon vulture (*Gyps fulvus*)	LC	Increasing	WV	29
	Western marsh-harrier (*Circus aeruginosus*)	LC	Stable	WV	51
	Eurasian sparrowhawk (*Accipiter nisus*)	LC	Stable	WV	36
	Eastern imperial eagle (*Aquila heliaca*)	VU	Decreasing	WV	21
	Long-legged buzzard (*Buteo rufinus*)	LC	Stable	WV	52
	Montagu's harrier (*Circus pygargus*)	LC	Decreasing	WV	13
	Northern goshawk (*Accipiter gentilis*	LC	Unknown	PM	3
	Pallid harrier (*Circus macrourus*)	NT	Decreasing	WV	16
	Red-headed vulture (*Sarcogyps calvus*)	CR	Decreasing	PM	7

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Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
	Shikra (*Accipiter badius*)	LC	Stable	BR	45
	Short-toed snake eagle (*Circaetus gallicus*)	LC	Stable	BR	24
	Steppe eagle (*Aquila nipalensis*)	EN	Decreasing	WV	62
	Tawny eagle (*Aquila rapax*)	VU	Decreasing	BR	19
	White-eyed buzzard (*Butastur teesa*)	LC	Stable	BR	22
	White-rumped vulture (*Gyps bengalensis*)	CR	Decreasing	BR	3
Pandionidae	Osprey (*Pandion haliaetus*)	LC	Increasing	WV	35
Anseriformes					
Anatidae	Common pochard (*Aythya ferina*)	VU	Decreasing	WV	20
	Common teal (*Anas crecca*)	LC	Unknown	WV	39
	Cotton pygmy-goose (*Nettapus coromandelianus*)	LC	Stable	PM	6
	Ferruginous pochard (*Aythya nyroca*)	NT	Decreasing	WV	15
	Lesser whistling-duck (*Dendrocygna javanica*)	LC	Decreasing	SV	15
	Mallard (*Anas platyrhynchos*)	LC	Increasing	WV	25
	Northern pintail (*Anas acuta*)	LC	Decreasing	WV	15
	Red-crested pochard (*Netta rufina*)	LC	Unknown	PM	9
	Ruddy shelduck (*Tadorna ferruginea*)	LC	Unknown	WV	11
	Indian spot-billed duck (*Anas poecilorhyncha*)	LC	Decreasing	BR	8
Bucerotiformes					
Upupidae	Common hoopoe (*Upupa epops*)	LC	Decreasing	BR	56
Caprimulgiformes					
Apodidae	Little swift (*Apus affinis*)	LC	Increasing	BR	19
Caprimulgidae	European nightjar (*Caprimulgus europaeus*)	LC	Decreasing	WV	8
	Sykes's nightjar (*Caprimulgus mahrattensis*)	LC	Stable	BR	6
Charadriiformes					
Burhinidae	Eurasian thick-knee (*Burhinus oedicnemus*)	LC	Decreasing	BR	2
Charadriidae	Grey plover (*Pluvialis squatarola*)	LC	Decreasing	PM	21
	Kentish plover (*Charadrius alexandrinus*)	LC	Decreasing	WV	28
	Little ringed plover (*Charadrius dubius*)	LC	Stable	WV	50
Charadriidae	Northern lapwing (*Vanellus vanellus*)	NT	Decreasing	WV	12
	Red-wattled lapwing (*Vanellus indicus*)	LC	Unknown	BR	77
	White-tailed lapwing (*Vanellus leucurus*)	LC	Unknown	WV	29
Glareolidae	Collared pratincole (*Glareola pratincola*)	LC	Decreasing	SV	13
	Indian courser (*Cursorius coromandelicus*)	LC	Stable	WV	3
	Little pratincole (*Glareola lactea*)	LC	Unknown	SV	16
Jacanidae	Pheasant-tailed jacana (*Hydrophasianus chirurgus*)	LC	Decreasing	SV	36
Laridae	Black-bellied tern (*Sterna acuticauda*)	EN	Decreasing	WV	5
	Caspian gull (*Larus cachinnans*)	LC	Increasing	WV	20
	Common gull-billed tern (*Gelochelidon nilotica*)	LC	Decreasing	WV	37
	Indian skimmer (*Rynchops albicollis*)	EN	Decreasing	SV	1
Laridae	River tern (*Sterna aurantia*)	VU	Decreasing	WV	38

Table continued on next page.....

Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
Recurvirostridae	Black-winged stilt (*Himantopus himantopus*)	LC	Increasing	BR	71
	Pied avocet (*Recurvirostra avosetta*)	LC	Unknown	WV	15
Rostratulidae	Greater painted-snipe (*Rostratula benghalensis*)	LC	Decreasing	BR	19
Scolopacidae	Common greenshank (*Tringa nebularia*)	LC	Stable	WV	24
	Common redshank (*Tringa totanus*)	LC	Unknown	WV	23
	Common sandpiper (*Actitis hypoleucos*)	LC	Decreasing	WV	38
	Common snipe (*Gallinago gallinago*)	LC	Decreasing	WV	28
	Dunlin (*Calidris alpina*)	LC	Decreasing	WV	13
	Eurasian curlew (*Numenius arquata*)	NT	Decreasing	WV	28
	Green sandpiper (*Tringa ochropus*)	LC	Increasing	WV	41
	Jack snipe (*Lymnocryptes minimus*)	LC	Stable	WV	10
	Little stint (*Calidris minuta*)	LC	Increasing	PM	35
	Marsh sandpiper (*Tringa stagnatilis*)	LC	Decreasing	WV	24
	Spotted redshank (*Tringa erythropus*)	LC	Stable	WV	13
	Temminck's stint (*Calidris temminckii*)	LC	Unknown	WV	22
	Wood sandpiper (*Tringa glareola*)	LC	Stable	WV	37
Ciconiiformes					
Ciconiidae	Black stork (*Ciconia nigra*)	LC	Unknown	PM	16
	Painted stork (*Mycteria leucocephala*)	LC	Increasing	WV	18
Columbiformes					
Columbidae	Red collared dove (*Streptopelia tranquebarica*)	LC	Decreasing	SV	22
	Rock pigeon (*Columba livia*)	LC	Decreasing	BR	25
	Eurasian collared dove (*Streptopelia decaocto*)	LC	Increasing	BR	65
Coraciiformes					
Alcedinidae	Common kingfisher (*Alcedo atthis*)	LC	Unknown	BR	58
	Pied kingfisher (*Ceryle rudis*)	LC	Unknown	BR	64
	White-throated kingfisher (*Halcyon smyrnensis*)	LC	Increasing	BR	99
Coraciidae	European roller (*Coracias garrulus*)	LC	Decreasing	PM	29
	Indian roller (*Coracias benghalensis*)	LC	Increasing	BR	48
Meropidae	Blue-cheeked bee-eater (*Merops persicus*)	LC	Stable	SV	25
	Asian green bee-eater (*Merops orientalis*)	LC	Increasing	BR	92
Cuculiformes					
Cuculidae	Pied cuckoo (*Clamator jacobinus*)	LC	Stable	SV	30
	Greater coucal (*Centropus sinensis*)	LC	Stable	BR	34
Falconiformes					
Falconidae	Laggar falcon (*Falco jugger*)	NT	Decreasing	BR	4
	Peregrine falcon (*Falco peregrinus*)	LC	Increasing	WV	11
	Red-necked falcon (*Falco chicquera*)	NT	Decreasing	BR	10
Galliformes					
Phasianidae	Common quail (*Coturnix coturnix*)	LC	Decreasing	WV	8
Gruiformes					
Rallidae	Common coot (*Fulica atra*)	LC	Increasing	WV	28
	Common moorhen (*Gallinula chloropus*)	LC	Stable	BR	41

Table continued on next page.....

Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
	Water rail (*Rallus aquaticus*)	LC	Decreasing	WV	10
Passeriformes					
Acrocephalidae	Blyth's reed warbler (*Acrocephalus dumetorum*)	LC	Increasing	PM	19
	Clamorous reed warbler (*Acrocephalus stentoreus*)	LC	Stable	WV	26
	Moustached warbler (*Acrocephalus melanopogon*)	LC	Stable	WM	14
Alaudidae	Black-crowned sparrow lark (*Eremopterix nigriceps*)	LC	Increasing	BR	13
	Crested lark (*Galerida cristata*)	LC	Decreasing	BR	47
	Greater short-toed lark (*Calandrella brachydactyla*)	LC	Unknown	WV	11
	Oriental skylark (*Alauda gulgula*)	LC	Decreasing	BR	8
Campephagidae	Long-tailed minivet (*Pericrocotus ethologus*)	LC	Decreasing	WV	19
	Small minivet (*Pericrocotus cinnamomeus*)	LC	Stable	BR	20
Cettiidae	Cetti's warbler (*Cettia cetti*)	LC	Increasing	WV	7
Cisticolidae	Ashy prinia (*Prinia socialis*)	LC	Stable	BR	25
	Common tailorbird (*Orthotomus sutorius*)	LC	Stable	BR	35
	Graceful prinia (*Prinia gracilis*)	LC	Stable	BR	3
	Plain prinia (*Prinia inornata*)	LC	Stable	BR	70
	Rufous-fronted prinia (*Prinia buchanani*)	LC	Stable	BR	26
	Striated prinia (*Prinia crinigera*)	LC	Stable	BR	17
	Yellow-bellied prinia (*Prinia flaviventris*)	LC	Decreasing	BR	32
	Zitting cisticola (*Cisticola juncidis*)	LC	Increasing	BR	19
Corvidae	Common raven (*Corvus corax*)	LC	Increasing	BR	14
	House crow (*Corvus splendens*)	LC	Stable	BR	57
	Rufous treepie (*Dendrocitta vagabunda*)	LC	Decreasing	BR	47
Dicruridae	Black drongo (*Dicrurus macrocercus*)	LC	Unknown	BR	81
Emberizidae	Red-headed bunting (*Emberiza bruniceps*)	LC	Stable	PM	9
	Reed bunting (*Emberiza schoeniclus*)	LC	Decreasing	PM	2
	Rock bunting (*Emberiza cia*)	LC	Increasing	WV	32
Estrildidae	Red avadavat (*Amandava amandava*)	LC	Stable	BR	14
Fringillidae	Common rosefinch (*Carpodacus erythrinus*)	LC	Decreasing	PM	19
Hirundinidae	Barn swallow (*Hirundo rustica*)	LC	Decreasing	WV	34
	Pale martin (*Riparia diluta*)	LC	Unknown	WV	10
	Wire-tailed swallow (*Hirundo smithii*)	LC	Increasing	SV	24
Laniidae	Bay-backed shrike (*Lanius vittatus*)	LC	Stable	BR	48
	Long-tailed shrike (*Lanius schach*)	LC	Unknown	BR	75
	Isabelline shrike (*Lanius isabellinus*)	LC	Stable	WV	62
Monarchidae	Indian paradise-flycatcher (*Terpsiphone paradisi*)	LC	Stable	PM	46
Motacillidae	Citrine wagtail (*Motacilla citreola*)	LC	Increasing	WV	49
	Grey wagtail (*Motacilla cinerea*)	LC	Stable	WV	27
	Paddyfield pipit (*Anthus rufulus*)	LC	Stable	BR	46
	Rosy pipit (*Anthus roseatus*)	LC	Stable	WV	15
	Tawny pipit (*Anthus campestris*)	LC	Stable	WV	21

Table continued on next page.....

Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
	Tree pipit (*Anthus trivialis*)	LC	Decreasing	PM	23
	White wagtail (*Motacilla alba*)	LC	Stable	WV	56
	White-browed wagtail (*Motacilla maderaspatensis*)	LC	Stable	WV	29
	Western yellow wagtail (*Motacilla flava*)	LC	Decreasing	PM	35
Muscicapidae	Black redstart (*Phoenicurus ochruros*)	LC	Increasing	WV	41
	Bluethroat (*Luscinia svecica*)	LC	Stable	WV	49
	Desert wheatear (*Oenanthe deserti*)	LC	Stable	WV	27
	Pied buschhat (*Saxicola caprata*)	LC	Stable	BR	68
	Red-breasted flycatcher (*Ficedula parva*)	LC	Increasing	PM	29
	Variable wheatear (*Oenanthe picata*)	LC	Stable	WV	50
Oriolidae	Eurasian golden oriole (*Oriolus oriolus*)	LC	Stable	PM	4
Passeridae	House sparrow (*Passer domesticus*)	LC	Decreasing	BR	58
	Sind sparrow (*Passer pyrrhonotus*)	LC	Stable	BR	22
	Spanish sparrow (*Passer hispaniolensis*)	LC	Decreasing	WV	19
Phylloscopidae	Brook's leaf warbler (*Phylloscopus subviridis*)	LC	Stable	WV	3
	Common chiffchaff (*Phylloscopus collybita*)	LC	Increasing	WV	52
Ploceidae	Baya weaver (*Ploceus philippinus*)	LC	Stable	BR	35
	Streaked weaver (*Ploceus manyar*)	LC	Stable	BR	38
Pycnonotidae	Red-vented bulbul (*Pycnonotus cafer*)	LC	Increasing	BR	83
	White-eared bulbul (*Pycnonotus leucotis*)	LC	Decreasing	BR	48
Remizidae	White-crowned penduline tit (*Remiz coronatus*)	LC	Decreasing	WV	6
Rhipiduridae	White-browed fantail (*Rhipidura aureola*)	LC	Stable	BR	26
Sturnidae	Bank myna (*Acridotheres ginginianus*)	LC	Increasing	BR	41
	Common myna (*Acridotheres tristis*)	LC	Increasing	BR	81
	Rosy starling (*Pastor roseus*)	LC	Unknown	PM	35
Sylviidae	Yellow-eyed babbler (*Chrysomma sinense*)	LC	Stable	BR	22
Vangidae	Common woodshrike (*Tephrodornis pondicerianus*)	LC	Stable	BR	24
Zosteropidae	Indian white-eye (*Zosterops palpebrosus*)	LC	Decreasing	BR	62
Pelecaniformes					
Ardeidae	Black-crowned night-heron (*Nycticorax nycticorax*)	LC	Decreasing	SV	29
	Cattle egret (*Bubulcus ibis*)	LC	Increasing	BR	38
	Great bittern (*Botaurus stellaris*)	LC	Decreasing	WV	5
	Grey heron (*Ardea cinerea*)	LC	Unknown	WV	32
	Indian pond-heron (*Ardeola grayii*)	LC	Unknown	BR	82
	Little bittern (*Ixobrychus minutus*)	LC	Decreasing	WV	5
	Little egret (*Egretta garzetta*)	LC	Increasing	BR	51
	Purple heron (*Ardea purpurea*)	LC	Decreasing	BR	25
	Yellow bittern (*Ixobrychus sinensis*)	LC	Unknown	BR	21
Pelecanidae	Dalmatian pelican (*Pelecanus crispus*)	NT	Decreasing	PM	24
Threskiornithidae	Eurasian spoonbill (*Platalea leucorodia*)	LC	Unknown	WV	21
	Glossy ibis (*Plegadis falcinellus*)	LC	Decreasing	PM	27

Table continued on next page.....

Order/ Family	Common name/ Scientific name	IUCN status	Trend	Occurrence	Count
Piciformes					
Picidae	Eurasian wryneck (*Jynx torquilla*)	LC	Decreasing	WV	17
	Sind woodpecker (*Dendrocopos assimilis*)	LC	Stable	BR	8
Psittaciformes					
Psittacidae	Rose-ringed parakeet (*Alexandrinus krameri*)	LC	Increasing	BR	38
Pterocliformes					
Pteroclidae	Chestnut-bellied sandgrouse (*Pterocles exustus*)	LC	Stable	BR	14
Strigiformes					
Strigidae	Indian scops-owl (*Otus bakkamoena*)	LC	Stable	BR	25
	Northern long-eared owl (*Asio otus*)	LC	Decreasing	WV	4
	Short-eared owl (*Asio flammeus*)	LC	Decreasing	WV	8
	Spotted owlet (*Athene brama*)	LC	Stable	BR	43
Tytonidae	Common barn owl (*Tyto alba*)	LC	Stable	BR	12
Suliformes					
Phalacrocoracidae	Great cormorant (*Phalacrocorax carbo*)	LC	Increasing	WV	37
	Indian cormorant (*Phalacrocorax fuscicollis*)	LC	Unknown	BR	5

* LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered; CR, critically endangered. ** BR, breeding resident; PM, passage migrant; SV, summer visitor; WV, winter visitor.

are breeding resident, 20 passage migrant, 10 species summer visitor and 76 species are winter visitor. The park sustains diverse feeding guilds, including 78 carnivores, 42 omnivores, five herbivores, 41 insectivores, nine piscivores and four granivores (red collared dove, rock pigeon, red avadavat, and chestnut-bellied sandgrouse), all contributing to the ecological balance.

Ecological indices portray a high level of diversity and complexity in LSNP. Pielou's Index of 0.577 indicates moderate evenness. Simpson's Index of 0.921 reflects high species diversity with even distribution. The Shannon-Wiener Index of 4.949 signifies high species diversity with relatively even species abundances. Margalef's Index of 20.766 and Menhinick's Index of 2.463 indicate high species richness. The Census Index of 8.304 suggests a high abundance of bird species within the national park.

HNP

The total 3,155 individuals of 120 species (Table IV) were recorded from 54 families (Fig. 2C) and 20 orders, where most abundant were white-throated kingfisher (99), Asian green bee-eater (96) and black kite (81), belonging to the family Alcedinidae, Meropidae, and Accipitridae, respectively. The least abundant species included brown noddy (one), red-throated loon (one), and black-bellied sandgrouse (one). belonging to Family Laridae, Gaviidae, and Pteroclidae, respectively. HNP has two distinct habitats. Bare rock/gravel and desert. Twenty-six species were observed in both habitats while 94 species were recorded in only one habitat (Table IV). Bare rock/gravel inhabited 108 species while 38 species were recorded in the desert.

For population trend 50 species showed a decreasing trend including, 19 species showing increasing trend, 35 species showed stable population trend and 16 species showed Unknown trend. The HNP species are classified into least concern, near threatened or vulnerable, underscoring the need for conservation efforts. Out of 120, 104 avian species are LC, 11 species are NT category, three species are EN including, Egyptian vulture and Steppe eagle and two species fall under VU category including Eastern imperial eagle and MacQueen's bustard. Forty-two species are breeding resident, 14 passage migrant, six species are summer visitor and 58 species are winter visitor

Ecological indices for HNP reveal a healthy ecosystem with significant diversity. Pielou's Index of 0.555 shows moderate evenness. Simpson's Index of 0.916 indicates high species diversity with even distribution. The Shannon-wiener index of 4.472 reflects high species diversity. Margalef's index of 24.899 and Menhinick's index of 2.136 suggest high species richness relative to the number of individuals. The Census Index of 0.560 indicates a moderate abundance of bird species within the national park.

Hingol supports diverse feeding guilds, including 63 carnivores, 26 omnivores, 15 insectivores, eight piscivores, four herbivores (eurasian teal, marbled duck, eurasian collared dove and see-see partridge), and four granivores (rock dove, black-bellied sandgrouse, chestnut-bellied sandgrouse, and Lichtenstein's sandgrouse).

Table IV. Bird species recorded in HNP during field surveys.

Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
Accipitriformes					
Accipitridae	Black kite (*Milvus migrans*)	LC	Stable	BR	81
	Brahminy kite (*Haliastur indus*)	LC	Decreasing	BR	59
	Cinereous vulture (*Aegypius monachus*)	NT	Decreasing	WV	19
	Egyptian vulture (*Neophron percnopterus*)	EN	Decreasing	BR	20
	Eurasian buzzard (*Buteo buteo*)	LC	Increasing	WV	13
	Griffon vulture (*Gyps fulvus*)	LC	Increasing	WV	31
	Golden eagle (*Aquila chrysaetos*)	LC	Stable	BR	5
	Eastern imperial eagle (*Aquila heliaca*)	VU	Decreasing	WV	18
	Long-legged buzzard (*Buteo rufinus*)	LC	Stable	WV	49
	Pallid harrier (*Circus macrourus*)	NT	Decreasing	WV	11
	Shikra (*Accipiter badius*)	LC	Stable	SV	45
	Short-toed snake eagle (*Circaetus gallicus*)	LC	Stable	BR	24
	Steppe eagle (*Aquila nipalensis*)	EN	Decreasing	WV	58
	White-eyed buzzard (*Butastur teesa*)	LC	Stable	BR	23
Anseriformes					
Anatidae	Common teal (*Anas crecca*)	LC	Unknown	WV	37
	Mallard (*Anas platyrhynchos*)	LC	Increasing	WV	24
	Marbled duck (*Marmaronetta angustirostris*)	NT	Decreasing	WV	11
Caprimulgiformes	Northern pintail (*Anas acuta*)	LC	Decreasing	WV	10
Caprimulgidae	European nightjar (*Caprimulgus europaeus*)	LC	Decreasing	WV	7
	Sykes's nightjar (*Caprimulgus mahrattensis*)	LC	Stable	BR	5
Charadriiformes					
Burhinidae	Eurasian thick-knee (*Burhinus oedicnemus*)	LC	Decreasing	BR	2
	Great thick-knee (*Esacus recurvirostris*)	NT	Decreasing	BR	2
Charadriidae	Greater sand plover (*Charadrius leschenaultii*)	LC	Decreasing	WV	11
	Grey plover (*Pluvialis squatarola*)	LC	Decreasing	WV	18
	Kentish plover (*Charadrius alexandrinus*)	LC	Decreasing	WV	29
	Siberian sandplover (*Charadrius mongolus*)	EN	Decreasing	WV	19
	Little ringed plover (*Charadrius dubius*)	LC	Stable	WV	45
Dromadidae	Crab-plover (*Dromas ardeola*)	LC	Stable	PM	7
Glareolidae	Collared pratincole (*Glareola pratincola*)	LC	Decreasing	SV	11
	Cream-coloured courser (*Cursorius cursor*)	LC	Decreasing	WV	12
Haematopodidae	Eurasian oystercatcher (*Haematopus ostralegus*)	NT	Decreasing	WV	8
Laridae	Brown noddy (*Anous stolidus*)	LC	Stable	PM	1
	Caspian gull (*Larus cachinnans*)	LC	Increasing	WV	22
	Common gull-billed tern (*Gelochelidon nilotica*)	LC	Decreasing	WV	31
	White-cheeked tern (*Sterna repressa*)	LC	Decreasing	SV	4
Laridae	Common tern (*Sterna hirundo*)	LC	Unknown	SV	13
Recurvirostridae	Black-winged stilt (*Himantopus himantopus*)	LC	Increasing	BR	63

Table continued on next page.....

Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
	Pied avocet (*Recurvirostra avosetta*)	LC	Unknown	BR	17
Scolopacidae	Red-necked phalarope (*Phalaropus lobatus*)	LC	Decreasing	WV	14
	Ruddy turstone (*Arenaria interpres*)	LC	Decreasing	WM	7
Scolopacidae	Bar-tailed godwit (*Limosa lapponica*)	NT	Decreasing	WV	10
	Common redshank (*Tringa totanus*)	LC	Unknown	WV	19
	Common sandpiper (*Actitis hypoleucos*)	LC	Decreasing	WV	51
	Curlew sandpiper (*Calidris ferruginea*)	NT	Decreasing	WV	18
	Dunlin (*Calidris alpina*)	LC	Decreasing	WV	11
	Green sandpiper (*Tringa ochropus*)	LC	Increasing	WV	37
	Little stint (*Calidris minuta*)	LC	Increasing	WV	29
	Marsh sandpiper (*Tringa stagnatilis*)	LC	Decreasing	PM	29
	Sanderling (*Calidris alba*)	LC	Unknown	WV	9
	Terek sandpiper (*Xenus cinereus*)	LC	Decreasing	WV	16
	Whimbrel (*Numenius phaeopus*)	LC	Decreasing	WV	9
Stercorariidae	Parasitic jaeger (*Stercorarius parasiticus*)	LC	Stable	WM	6
	Pomarine jaeger (*Stercorarius pomarinus*)	LC	Stable	WM	1
Ciconiiformes					
Ciconiidae	Painted stork (*Mycteria leucocephala*)	LC	Increasing	WV	21
Columbiformes					
Columbidae	Rock pigeon (*Columba livia*)	LC	Decreasing	BR	27
	Eurasian collared dove (*Streptopelia decaocto*)	LC	Increasing	SV	59
Coraciiformes					
Alcedinidae	Common kingfisher (*Alcedo atthis*)	LC	Unknown	BR	56
	White-throated kingfisher (*Halcyon smyrnensis*)	LC	Increasing	BR	99
Coraciidae (Rollers)	European roller (*Coracias garrulus*)	LC	Decreasing	PM	25
	Indian roller (*Coracias benghalensis*)	LC	Increasing	BR	43
Meropidae	Blue-cheeked bee-eater (*Merops persicus*)	LC	Stable	PM	22
	Asian green bee-eater (*Merops orientalis*)	LC	Increasing	BR	96
Falconiformes					
Falconidae	Common kestrel (*Falco tinnunculus*)	LC	Decreasing	WV	35
	Laggar falcon (*Falco jugger*)	NT	Decreasing	BR	3
	Peregrine falcon (*Falco peregrinus*)	LC	Increasing	WV	11
Galliformes					
Phasianidae	See-see partridge (*Ammoperdix griseogularis*)	LC	Stable	BR	5
Gaviiformes					
Gaviidae	Red-throated loon (*Gavia stellata*)	LC	Decreasing	WV	1
Gruiformes					
Rallidae	Common coot (*Fulica atra*)	LC	Increasing	WV	22
Otidiformes					
Otididae	Little bustard (*Tetrax tetrax*)	NT	Decreasing	PM	3
	Macqueen's bustard (*Chlamydotis macqueenii*)	VU	Decreasing	WV	2

Table continued on next page.....

Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
Passeriformes					
Alaudidae	Black-crowned sparrow lark (*Eremopterix nigriceps*)	LC	Increasing	BR	18
	Crested lark (*Galerida cristata*)	LC	Decreasing	BR	54
	Greater hoopoe lark (*Alaemon alaudipes*)	LC	Decreasing	BR	11
	Hume's lark (*Calandrella acutirostris*)	LC	Stable	SV	2
	Oriental skylark (*Alauda gulgula*)	LC	Decreasing	BR	9
Campephagidae	Small minivet (*Pericrocotus cinnamomeus*)	LC	Stable	BR	21
Cisticolidae	Common tailorbird (*Orthotomus sutorius*)	LC	Stable	BR	29
	Rufous-fronted prinia (*Prinia buchanani*)	LC	Stable	BR	25
Corvidae	House crow (*Corvus splendens*)	LC	Stable	BR	63
Dicruridae	Black drongo (*Dicrurus macrocercus*)	LC	Unknown	BR	88
Emberizidae	Black-headed bunting (*Emberiza melanocephala*)	LC	Unknown	PM	15
	Grey-necked bunting (*Emberiza buchanani*)	LC	Stable	WV	26
	Striolated bunting (*Emberiza striolata*)	LC	Increasing	BR	35
Fringillidae	Trumpeter finch (*Bucanetes githagineus*)	LC	Stable	BR	9
Hirundinidae	Barn swallow (*Hirundo rustica*)	LC	Decreasing	WV	39
Laniidae	Bay-backed shrike (*Lanius vittatus*)	LC	Stable	BR	56
	Long-tailed shrike (*Lanius schach*)	LC	Unknown	BR	69
	Isabelline shrike (*Lanius isabellinus*)	LC	Stable	WV	54
Motacillidae	Tawny pipit (*Anthus campestris*)	LC	Stable	WV	27
	Water pipit (*Anthus spinoletta*)	LC	Stable	WV	26
Muscicapidae	Desert wheatear (*Oenanthe deserti*)	LC	Stable	WV	34
	Red- breasted flycatcher (*Ficedula parva*)	LC	Increasing	PM	31
	Rufous-tailed scrub robin (*Cercotrichas galactotes*)	LC	Stable	PM	8
	Variable wheatear (*Oenanthe picata*)	LC	Stable	WV	61
Oriolidae	Eurasian golden oriole (*Oriolus oriolus*)	LC	Stable	PM	3
Passeridae	Eurasian tree sparrow (*Passer montanus*)	LC	Decreasing	WV	19
	House sparrow (*Passer domesticus*)	LC	Decreasing	BR	65
Phylloscopidae	Common chiffchaff (*Phylloscopus collybita*)	LC	Increasing	WV	56
Pycnonotidae	White-eared bulbul (*Pycnonotus leucotis*)	LC	Decreasing	BR	50
Sturnidae	Rosy starling (*Pastor roseus*)	LC	Unknown	PM	32
Vangidae	Common wood shrike (*Tephrodornis pondicerianus*)	LC	Stable	BR	22
Pelecaniformes					
Ardeidae	Grey heron (*Ardea cinerea*)	LC	Unknown	WV	39
	Indian pond-heron (*Ardeola grayii*)	LC	Unknown	BR	89
	Little egret (*Egretta garzetta*)	LC	Increasing	BR	63
	Western reef egret (*Egretta gularis*)	LC	Stable	BR	31
Pelecanidae	Dalmatian pelican (*Pelecanus crispus*)	NT	Decreasing	WV	19
	Great white pelican (*Pelecanus onocrotalus*)	LC	Unknown	WV	15
Threskiornithidae	Eurasian spoonbill (*Platalea leucorodia*)	LC	Unknown	WV	19
Piciformes					
Picidae	Eurasian wryneck (*Jynx torquilla*)	LC	Decreasing	PM	21
	Sind woodpecker (*Dendrocopos assimilis*)	LC	Stable	BR	5

Table continued on next page.....

Order/ Family	Common name (Scientific name)	IUCN status	Trend	Occurrence	Count
Podicipediformes					
Podicipedidae	Great crested grebe (*Podiceps cristatus*)	LC	Unknown	WV	9
Procellariiformes					
Procellariidae	Persian shearwater (*Puffinus persicus*)	LC	Decreasing	PM	2
Pterocliformes					
Pteroclidae	Black-bellied sandgrouse (*Pterocles orientalis*)	LC	Decreasing	WV	1
	Chestnut-bellied sandgrouse (*Pterocles exustus*)	LC	Stable	BR	19
	Lichtenstein's sandgrouse (*Pterocles lichtensteinii*)	LC	Stable	BR	9
Strigiformes					
Strigidae	Short-eared owl (*Asio flammeus*)	LC	Decreasing	WV	8
	Spotted owlet (*Athene brama*)	LC	Stable	BR	39
Suliformes					
Phalacrocoracidae	Great cormorant (*Phalacrocorax carbo*)	LC	Increasing	WV	31
	Indian cormorant (*Phalacrocorax fuscicollis*)	LC	Unknown	BR	9
Sulidae	Masked booby (*Sula dactylatra*)	LC	Decreasing	PM	9

*LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered; **BR, breeding resident; PM, passage migrant; SV, summer visitor; WV, winter visitor.

Table V. Similarity between selected sites with respect to Sorensen and Jaccard similarity index.

National parks	Sørensen similarity index	Jaccard similarity index
HNP vs. LSNP	0.655	0.480
HNP vs. KNP	0.116	0.062
LSNP vs. KNP	0.208	0.116

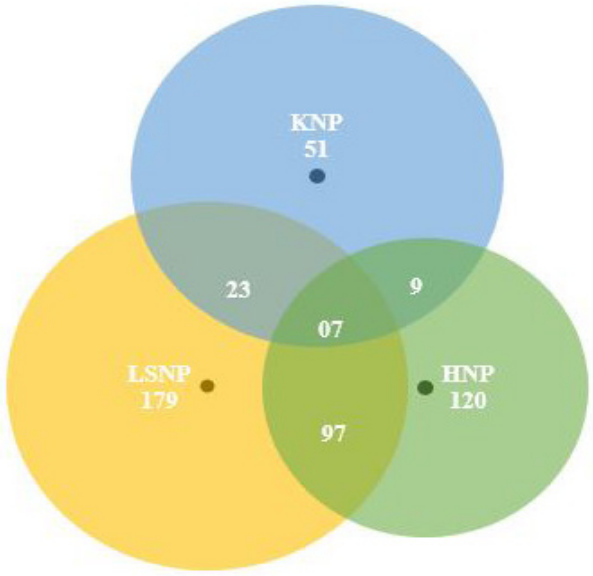

Fig. 3. Overlapping of avian species among KNP, LSNP and HNP.

The Sørensen and Jaccard similarity indices indicate varying degrees of similarity in avian species composition across HNP, LSNP and KNP. The indices revealed a high similarity between HNP and LSNP. This suggests that there is 48% overlap in species composition and likely similar ecological conditions. Ninety-seven bird species are common in HNP and LSNP (Fig. 3). The indices showed low similarity between HNP and KNP and only 6.2% species overlap is there (Table V). Only 9 species are common in HNP and KNP; common sandpiper, eurasian golden oriole, common gull-billed tern, house sparrow, long-tailed shrike, oriental skylark, rock dove, common kestrel, and golden eagle. For LSNP and KNP, there was low similarity in avian species composition. The value indicates 1.16% overlap but still reflects significant differences in the avian communities and ecological settings of these two national parks. Total 23 species are common between LSNP and KNP. In terms of common species, only 7 species are common in selected altitudinally different national parks, common sandpiper, eurasian golden oriole, common gull-billed tern, house sparrow, long-tailed shrike, oriental skylark and rock dove.

DISCUSSION

The comparative analysis of avian diversity across three national parks, KNP, LSNP and HNP, has revealed the ecological dynamics and conservation status of these regions. The species richness was highest in LSNP (179) followed by 120 species in HNP and 51 in KNP. The mid elevation (LSNP) was found to be most rich in avian

diversity. Several studies have shown that species richness is greater at mid-elevational ranges compared to both lower and higher elevations (Hu *et al*., 2018; Ding *et al*., 2019; Pandey *et al*., 2020). Khan *et al*. (2018) reported 74 bird species with 7443 individuals in LSNP. A total of 204 species were recorded by Ghalib *et al*. (2008) in HNP while Qureshi *et al*. (2011) reported forty bird species from KNP. This difference in the number of species between the three national parks may be attributed to the types of environments, climatic factors and geographical position of the national parks. HNP with coastal and desert habitats, is moderately rich in species, whereas KNP in the extremely high-altitude mountainous region, is the poorest in species richness. A similar trend was also noted in other studies (Neupane *et al*., 2020). Currently, there are only two habitats in HNP and KNP while there are five habitats in LSNP. Out of all the surveyed national parks, LSNP offered the greatest opportunities in species richness because of the varying types of land use, which include agricultural land, wetland, and forest (Schaub *et al*., 2010; Acharya *et al*., 2011; Ferger *et al*., 2014). Available habitats in LSNP such as agricultural land are chief sources of food for many bird species such as fruits, grains, insects, and rodents that are known to enhance bird richness (Chettri *et al*., 2005; Kunwar *et al*., 2023). On the other hand, higher elevation is associated with lower productivity of habitats and hence the associated invertebrate resources are diminished and patchily distributed. This scarcity of food resources reduces the existing bird species in the higher elevation zones (Hu *et al*., 2018).

The occurrence data also provided necessary information about the distribution of avian species in the national parks related to the seasonal aspects. KNP despite the extreme condition such as high altitude was able to offer habitats for resident birds and acted as a breeding and belt stopover site for migrants (Qureshi *et al*., 2011). This suggests that KNP provides suitable habitats for both resident and migratory avian species, despite its high-altitude alpine and subalpine ecosystems (Williamson and Witt, 2021). LSNP supported a diverse avian community throughout the year, with significant numbers of both resident and migratory species. These results are consistent with Khan *et al*. (2018). HNP is home to many species of birds with high number of passage migrants and winter migrants implying that the climatic conditions favor these areas and therefore, the habitats offered at the site are favorable for these birds (McGrann and Furnas, 2016). Additionally, there are notable numbers of passage migrants and winter migrants, indicating the national park's importance as a stopover site and wintering ground for migratory birds.

The diversity and variety of bird life in KNP displays its unique alpine landscape. Many birds found here belong to distinct groups, unlike those in HNP and LSNP. This habitat, with high evenness and richness of species, suggests that there is a well-balanced bird community that manages to thrive in a challenging alpine setting (Achmad *et al*., 2021). Conversely, LSNP has more variety in species, and diversity statistics suggests that it hosts a broader array of habitats suitable for various bird populations to varying degrees (Kusumoarto *et al*., 2020).

Within each national park, the bird guild analysis reveals that how different species of birds coexist based on their feeding strategies and habitat use. KNP has a lower diversity of avian guilds compared to other national parks; carnivores and insectivores dominate likely because of the high insect population at this elevation (Katuwal *et al*., 2016). Herbivores and granivores are few due to limited plant-based food sources in this harsh environment (Santhakumar *et al*., 2018). LSNP stands out with the highest guild diversity, rich vegetation provides various food resources supporting insectivores, carnivores, omnivores, herbivores, piscivores, and granivores. This guild diversity highlights the complex food web interactions within LSNP's ecosystem (Blondel, 2003). HNP's feeding guild composition lies between KNP and LSNP. Piscivorous birds such as gulls and terns are likely found in HNP because it is a coastal landscape park. In addition, the abundance of insectivore and carnivore species at mid elevations like LSNP has been reported by Katuwal *et al*. (2016).

CONCLUSION

This study highlights the avian species richness across KNP, LSNP, and HNP, each showcasing unique ecological characteristics. Khunjerab hosts 51 species with moderate diversity and richness, while Lal Suhanra, with its diverse habitats, is the richest, harboring 179 species. Hingol, with bare rock/gravel and desert habitats, supports 120 species. Despite distinct geographical and ecological differences, seven generalist avian species were common across all national parks, indicating ecological resilience. Similarity indices show high species composition overlap between Hingol and Lal Suhanra, suggesting similar ecological conditions, while Khunjerab's unique environment shows low overlap with the other national parks.

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IRB approval

The Advanced Studies and Research Board of University of the Punjab, Lahore, Pakistan approved this study (D. No. 8471/Acad, dated: 30/10/2023).

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Acharya, B.K., Sanders, N.J., Vijayan, L. and Chettri, B., 2011. Elevational gradients in bird diversity in the Eastern Himalaya: An evaluation of distribution patterns and their underlying mechanisms. *PLoS One*, **6**: 1-14. https://doi.org/10.1371/journal.pone.0029097

Achmad, A., Damayanti, U. and Maulany, R.I., 2021. Bird diversity analysis in the lower mountain forest of mount Bulusaraung to support ecotourism's activities in Bantimurung Bulusaraung National Park. *In IOP Conf. Ser. Earth Environ. Sci.,* **886**: 1-14. https://doi.org/10.1088/1755-1315/886/1/012047

Barry, R.G., 2008. *Mountain weather and climate*. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/CBO9780511754753

Bhat, A.H., Mir, A.H. and Charoo, S.A., 2023. Influence of habitat heterogeneity on the elevational distribution and guild structure of birds in the Rajparian Wildlife Sanctuary, Kashmir Himalaya. *Ornithol. Res.*, **31**: 51-61. https://doi.org/10.1007/s43388-022-00111-3

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S., 2001. *Bird census techniques* (2nd edition), Academic Press, Elsevier, San Diego, CA.

Bisht, A.S. and Bhat, A.B., 2013. Vegetational structure and plant diversity relation in a sub-alpine region of Garhwal Himalaya, Uttarakhand India. *Afr. J. Pl. Sci.*, **7**: 401-406. https://doi.org/10.5897/AJPS11.013

Blondel, J., 2003. Guilds or functional groups: Does it matter? *Oikos*, **100**: 223-231. https://doi.org/10.1034/j.1600-0706.2003.12152.x

Carnicer, J., Brotons, L., Stefanescu, C. and Penuelas, J., 2012. Biogeography of species richness gradients: linking adaptive traits, demography and diversification. *Biol. Rev.*, **87**: 457-479. https://doi.org/10.1111/j.1469-185X.2011.00210.x

Chettri, N., Deb, D.C., Sharma, E. and Jackson, R., 2005. The relationship between bird communities and habitat: A study along a trekking corridor in the Sikkim Himalayas. *Mount. Res. Dev.*, **25**: 235-243. https://doi.org/10.1659/0276-4741(2005)025[0235:TRBBCA]2.0.CO;2

Dar, J.A. and Sundarapandian, S., 2016. Patterns of plant diversity in seven temperate forest types of Western Himalaya, India. *J. Asia-Pac. Biol.,* **9**: 280-292. https://doi.org/10.1016/j.japb.2016.03.018

Ding, Z., Liang, J., Hu, Y., Zhou, Z., Sun, H., Liu, L., Liu, H., Hu, H. and Si, X., 2019. Different responses of avian feeding guilds to spatial and environmental factors across an elevation gradient in the central Himalaya. *Ecol. Evol.,* **9**: 4116-4128. https://doi.org/10.1002/ece3.5040

Ferger, S.W., Schleuning, M., Hemp, A., Howell, K.M. and Böhning-Gaese, K., 2014. Food resources and vegetation structure mediate climatic effects on species richness of birds. *Glob. Ecol. Biogeol*., **23**: 541-549. https://doi.org/10.1111/geb.12151

FWEGB, 2020. *Government of Gilgit-Baltistan: Khunjerab National Park*. Available at: https://fwegb.gov.pk/khunjerab-national-park/ (accessed 2022 Dec 25)

Gairola, S., Sharma, C.M., Suyal, S. and Ghildiya, S.K., 2011. Species composition and diversity in mid-altitudinal moist temperate forests of the Western Himalayas. *J. For. Environ. Sci*., **27**: 1-15.

Ghalib, S.A., Jabbar, A., Wind, J., Zehra, A. and Abbas, D., 2008. Avifauna of Hingol national park, Balochistan. *Pakistan J. Zool.,* **40**: 317-330.

Grimmett, R., Inskipp, C. and Inskipp, T., 1998. *Birds of the Indian subcontinent*. Christopher Helm an imprint of A and C Black (Publisher) Ltd, 35 Bedford Row, London WC1R 4JH, 888.

Grimmett, R., Roberts, T. and Inskipp I., 2008. *Birds of Pakistan*. Christopher Helm, London Yale University Press, New Heaven. pp. 256.

He, X., Wang, X., DuBay, S., Reeve, A.H., Alström, P., Ran, J., Liu, Q. and Wu, Y., 2019. Elevational patterns of bird species richness on the eastern slope of Mt. Gongga, Sichuan Province, China. *Avian Res.*, **10**: 1-12. https://doi.org/10.1186/s40657-018-0140-7

Hu, Y., Ding, Z., Jiang, Z., Quan, Q., Guo, K., Tian, L., Hu, H. and Gibson, L., 2018. Birds in the Himalayas: What drives beta diversity patterns along an elevational gradient? *Ecol. Evol*., **8**: 11704-11716. https://doi.org/10.1002/ece3.4622

ICIMOD, 2020. *Khunjerab National Park*. Available at: https://www.icimod.org/wp-content/uploads/2019/12/Khunjerab-National-Park.pdf (accessed 2022 Dec 24).

Karra, K., Kontgis, C., Statman-Weil, Z., Mazzariello, J.C., Mathis, M. and Brumby, S.P., 2021. Global land

use/land cover with Sentinel 2 and deep learning. In: *2021 IEEE International Geoscience and Remote Sensing Symposium.* pp. 4704-4707. https://doi.org/10.1109/IGARSS47720.2021.9553499

Katuwal, H.B., Basnet, K., Khanal, B., Devkota, S., Rai, S.K., Gajurel, J.P., Scheidegger, C. and Nobis, M.P., 2016. Seasonal changes in bird species and feeding guilds along elevational gradients of the Central Himalayas, Nepal. *PLoS One*, **11**: 1-17. https://doi.org/10.1371/journal.pone.0158362

Khan, B.N., Ahmad, R., Ali, Z., Yasmeen, R., Azhar, M., Abid, F., Mehmood, S. and Raza, H., 2018. Study of vertebrate diversity at Lal Suhanra National Park, Pakistan. *J. Anim. Pl. Sci.,* **28**: 1725-1734.

Khan, M.Z., Ghalib, S.A., Zehra, A. and Hussain, B., 2010. Bioecology and conservation of the birds of Hingol National Park, Balochistan. *J. Basic appl. Sci.*, **6**: 175-184.

Khuroo, A.A., Weber, E., Malik, A.H., Reshi, Z.A. and Dar, G.H., 2011. Altitudinal distribution patterns of the native and alien woody flora in Kashmir Himalaya, India. *Environ. Res*., **111**: 967-977. https://doi.org/10.1016/j.envres.2011.05.006

Kissling, W.D., Sekercioglu, C.H. and Jetz, W., 2012. Bird dietary guild richness across latitudes, environments and biogeographic regions. *Glob. Ecol. Biogeol.*, **21**: 328-340. https://doi.org/10.1111/j.1466-8238.2011.00679.x

Kumar, S., Sohil, A., Kichloo, M.A. and Sharma, N., 2022. Landscape heterogeneity affects diurnal raptor communities in a sub-tropical region of northwestern Himalayas, India. *PLos One*, **17**: 1-20. https://doi.org/10.1371/journal.pone.0246555

Kunwar, N., Pandey, N., Singh, K.D. and Bhattarai, B.P., 2023. Bird diversity along an elevational gradient in ShivapuriNagarjun National Park, Nepal. *Our Nature,* **21**: 1-15. https://doi.org/10.3126/on.v21i1.50756

Kusumoarto, A., Gunawan, A. and Hikmat, A., 2020. The biodiversity of flora and fauna in the re-vegetation area in the post-mining area of pongkor. *IOP Conf. Ser. Earth Environ. Sci*., **501**: 1-8. https://doi.org/10.1088/1755-1315/501/1/012035

Lee, D.C. and Marsden, S.J., 2008. Increasing the value of bird-habitat studies in tropical forests: Choice of approach and habitat measures. *Bird Conserv. Int.*, **18**: 109-124. https://doi.org/10.1017/S0959270908000373

Liu, J.J., Xu, Y., Shan, Y.X., Burgess, K.S. and Ge, X.J., 2021. Biotic and abiotic factors determine species diversity–productivity relationships in mountain meadows. *J. Pl. Ecol.*, **14**: 1175-1188. https://doi.org/10.1093/jpe/rtab064

Magurran, A.E., 2021. Measuring biological diversity. *Curr. Biol.*, **31**: 1174-1177. https://doi.org/10.1016/j.cub.2021.07.049

McCain, C.M. and Colwell, R.K., 2011. Assessing the threat to montane biodiversity from discordant shifts in temperature and precipitation in a changing climate. *Ecol. Lett.*, **14**: 1236-1245. https://doi.org/10.1111/j.1461-0248.2011.01695.x

McCain, C.M. and Grytnes, J.A., 2010. Elevational gradients in species richness. ELS, John Wiley & Sons, pp. 1-10. https://doi.org/10.1002/9780470015902.a0022548

McGrann, M.C. and Furnas, B.J., 2016. Divergent species richness and vocal behavior in avian migratory guilds along an elevational gradient. *Ecosphere*, **7**: 1-26. https://doi.org/10.1002/ecs2.1419

Mekonen, S., 2017. Birds as biodiversity and environmental indicator. *Indicator*, **7**: 28-34.

Moeslund, J.E., Arge, L., Bøcher, P.K., Dalgaard, T. and Svenning, J.C., 2013. Topography as a driver of local terrestrial vascular plant diversity patterns. *Nord. J. Bot.*, **31**: 129-144. https://doi.org/10.1111/j.1756-1051.2013.00082.x

Nath, P.C., Arunachalam, A., Khan, M.L., Arunachalam, K. and Barbhuiya, A.R., 2005. Vegetation analysis and tree population structure of tropical wet evergreen forests in and around Namdapha National Park, northeast India. *Biodiv. Conserv.,* **14**: 2109-2135. https://doi.org/10.1007/s10531-004-4361-1

Neupane, J., Khanal, L., Gyawali, B. and Chalise, M.K., 2020. Elevational pattern and seasonality of avian diversity in Kaligandaki River Basin, central Himalaya. *J. Threat. Taxa,* **12**: 16927-16943. https://doi.org/10.11609/jott.5815.12.14.16927-16943

Panda, B.P., Prusty, B.A.K., Panda, B., Pradhan, A. and Parida, S.P., 2021. Habitat heterogeneity influences avian feeding guild composition in urban landscapes: Evidence from Bhubaneswar, India. *Ecol. Process.*, **10**: 1-10. https://doi.org/10.1186/s13717-021-00304-6

Pandey, N., Khanal, L. and Chalise, M.K., 2020. Correlates of avifaunal diversity along the elevational gradient of Mardi Himal in Annapurna Conservation Area, Central Nepal. *Avian Res*., **11**: 1-14. https://doi.org/10.1186/s40657-020-00217-6

Qureshi, R., Khan, W.A., Bhatti, G.R., Khan, B.A.B.A.R., Iqbal, S., Ahmad, M.S., Abid, M. and Yaqub, A., 2011. First report on the biodiversity of Khunjerab National Park, Pakistan. *Pak. J. Bot.,*

43: 849-861.

Raulings, E.J., Morris, K.A.Y., Roache, M.C. and Boon, P.I., 2010. The importance of water regimes operating at small spatial scales for the diversity and structure of wetland vegetation. *Freshw. Biol.,* **55**: 701-715. https://doi.org/10.1111/j.1365-2427.2009.02311.x

Roberts, T.J., 1997. *The mammals of Pakistan*. Revised Edition. Oxford University Press, Karachi. pp. 525.

Roberts, T.J., 1991. *The birds of Pakistan*. Volume 1. Oxford University Press, Karachi. pp. 598.

Roberts, T.J., 1992. *The birds of Pakistan*. Volume 2. Oxford University Press, Karachi. pp. 617.

Santhakumar, B., Arun, P.R., Sony, R.K., Murugesan, M. and Ramesh, C., 2018. The pattern of bird distribution along the elevation gradient of the Sutlej River basin, western Himalaya, India. *J. Threat. Taxa*, **10**: 12715-12725. https://doi.org/10.11609/jott.3949.10.13.12715-12725

Schaub, M., Martinez, N., Tagmann-Ioset, A., Weisshaupt, N., Maurer, M.L., Reichlin, T.S., Abadi, F., Zbinden, N., Jenni, L. and Arlettaz, R., 2010. Patches of bare ground as a staple commodity for declining ground-foraging insectivorous farmland birds. *PLoS One*, **5**: 1-5. https://doi.org/10.1371/journal.pone.0013115

Sohil, A. and Sharma, N., 2020. Assessing the bird guild patterns in heterogeneous land use types around Jammu, Jammu and Kashmir, India. *Ecol. Process.*, **9**: 1-15. https://doi.org/10.1186/s13717-020-00250-9

Somveille, M., Manica, A., Butchart, S.H. and Rodrigues, A.S., 2013. Mapping global diversity patterns for migratory birds. *PLoS One*, **8**: 1-10. https://doi.org/10.1371/journal.pone.0070907

Sorensen, T., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on danish commons. *Biol. Skrifter/Kongelige Danske Videnskabernes Selskab,* **5**: 1-34.

Wani, Z.A. and Akash, S., 2022. Tree diversity and regeneration dynamics in Gulmarg wildlife sanctuary, Kashmir Himalaya. *Acta Ecol. Sin.,* **43**: 375-381. https://doi.org/10.1016/j.chnaes.2022.05.003

Williamson, J.L. and Witt, C.C., 2021. Elevational niche-shift migration: Why the degree of elevational change matters for the ecology, evolution, and physiology of migratory birds. *Ornithology*, **138**: 1-26. https://doi.org/10.1093/ornithology/ukaa087

Zhou, T., Zhang, J., Qin, Y., Jiang, M. and Qiao, X., 2021. The effects of biotic and abiotic factors on the community dynamics in a mountain subtropical forest. *Forests*, **12**: 1-15. https://doi.org/10.3390/f12040427