



Diversity, status and guild structure of the avifauna in the Ajodhya Foothills, Baghmundi, Purulia, West Bengal, India

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Abstract

Avifaunal diversity acts as an important indicator to evaluate different habitats both quantitatively and qualitatively. Avian species diversity of Ajodhya foothill areas (22.60°–23.50° N and 85.75°–86.65° E), Baghmundi block, Purulia, West Bengal, Eastern India was evaluated from January 2017 to December 2017 to prepare a checklist of birds with their present status and guild structure. The line transect method was used to record the avian diversity of eight study sites (96 samples) selected within the entire study area based on the variability of topography, habitat and vegetation types. The present study, the first scientific record of avian diversity in recent times from this less explored geographical area, recorded 167 bird species belonging to 19 orders and 58 families including two “near threatened” and two “vulnerable” species. The species number mean for a total of 96 samples was 53.66. Out of 167 species, 108 were resident while 59 species showed seasonal (20 species) or passage migration (39 species). Family Muscicapidae (10 species) dominated followed by Accipitridae and Ardeidae (9 species each). The highest species richness value was observed in summer (123) followed by winter (118) and the lowest in the post-monsoon season (101). Shannon–Wiener diversity index (H') of total of 96 samples was 4.17 and evenness (J) 0.815. Analysis of feeding guilds revealed dominance of omnivores (50 species), followed by carnivores (40 species) and insectivores (33 species). Rich avian diversity of the Ajodhya foothill area including some near threatened and vulnerable species recorded during the present study strongly emphasizes enforcement of conservation efforts to save the avian species diversity and its habitats from the prevailing threats.

Keywords Bird diversity · Foothill ecosystems · Diversity index · Feeding guild · Seasonal variation · Threats

Introduction

Biodiversity signifies the variety of life defining the quantity and variability in relation to the ecosystem in which they belong. Each species plays a specific role in the ecosystem to which it belongs. Observing the species diversity of a region enables the estimation of the prospective functional roles of the species (Mukherjee et al. 2015). The conservation of

global species diversity is a top priority in the modern era (Hu et al. 2011). Birds are among the best indicators of the ecological status of any given ecosystem (Bilgrami 1995; Harisha and Hosetti 2009; Choudaj and Wankhade 2021). They are ideal bio-indicators, useful models for studying a variety of environmental problems due to their sensitivity to the slightest of environmental changes, and are important indicators of the ecological conditions as well as productivity of an ecosystem (Newton 1995; Desai and Shanbhag 2007; Li and Mundkur 2007; Choudaj and Wankhade 2021). The study of avifaunal diversity is an essential ecological tool and can act as an indicator to evaluate different habitats both quantitatively and qualitatively (Bilgrami 1995; Sekercioglu 2012).

India is one of the 12 mega biodiversity countries. The Indian subcontinent is the home of 1313 bird species (Grimmett et al. 2011) out of a total of 9702 species found worldwide (Sibley and Monroe 1990). According to a recent report (Praveen et al. 2016) the number of bird species in

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India has declined to 1263. Barrowclough and co-authors (2016) predicted presence of 18,043 bird species worldwide by applying the evolutionary species concept instead of the biological species concept. However, a recent report (Ritchie and Roser 2021) estimated global bird species to be 11,158. There are many important birding sites in different parts of India and the avian species diversity of this country has been documented in numerous studies. Yet there are some regions within the country where avian species diversity is still least explored. Purulia district is situated in the western part (22.600–23.500 N and 85.750–86.650 E) of West Bengal, Eastern India. Ajodhya hill is located in the westernmost part of the district which is a part of the Dalma Hills and an extended part of the Eastern Ghats range. Baghmundi block is located at the foothill area of Ajodhya hill that represents the lowest step of the Chota Nagpur Plateau characterised by undulating land with scattered hills and dales. The Northern and eastern portions of the block are covered with dense dry deciduous forests. Other portions have hard dry lands with scattered bushes and jungle. Baghmundi forest range has a total forest cover of 142.45 km² (Samanta et al. 2017). The forest falls under Northern tropical dry deciduous forest and is mostly coppice Sal (*Shorea robusta*) forest mixed with miscellaneous species like Palash (*Butea monosperma*), Kusum (*Schleichera oleosa*), Mahua (*Madhuca longifolia*), Neem (*Azadirachta indica*) and Kendu (*Diospyros melanoxylon*) (Das 2015; Samanta et al. 2017). 74 trees, 59 shrubs, 23 climbers and 27 bamboos are the main reported floral species found in Purulia Forest Division (Das 2015; Samanta et al. 2017). River Subarnarekha separates the block from the Jharkhand State in the west and the ‘Sakha’ River separates it from Balarampur Block in the east. There are many hill streams and waterfalls in this region which are exclusively rain-fed. Purulia, one of the drought-affected districts of West Bengal, has a sub-tropical climate and is characterized by high evaporation and low precipitation. Its temperature is very high in summer and low in winter which varies from 2.8 degrees in winter to 52 degrees in summer (Das 2015). Rainfall defines the climate of the district. Majority of rainfall in the district comes from the southwest monsoon. The average annual rainfall varies between 1100 and 1500 mm (Das 2015). The relative humidity is high in the monsoon season, being 75–85%, but in summer it comes down to 25–35%. Due to undulated topography, nearly 50% of the rainfall flows away as runoff. The area is covered by mostly residual soil formed by weathering of bedrocks (Das 2015).

The basic study of the avifauna of a site should include the preparation of a checklist of species that will reflect the species diversity of that geographic region and identify the presence of rare species if any (Abie et al. 2019). This information can be used as an indicator of the importance of different sites or habitats for bird conservation (Bibby et al.

1998; Abie et al. 2019). Birds are good indicators of the ecological status of any given ecosystem as they play an important link in the food chain (Hossain and Baki 2015; Abie et al. 2019). Studies have suggested that the extinction risk of birds may increase with ecological specialization (Sekercioglu 2011). Any shifts in the relative abundance of birds are likely to affect ecological processes like seed dispersal, pollination, nutrient cycling (Lens et al. 2002; Sekercioglu 2011; Buechley et al. 2015).

The avian diversity of the Purulia district has hardly been studied to date (Das 2015). There is no recent published report about the avian diversity of the Purulia district except Mahato et al. (2021). Keeping this scenario in mind, the present study was undertaken to evaluate the avian diversity of Ajodhya foothill areas of Baghmundi block, Purulia district, and prepare a checklist of birds with their present status and guild structure which may indicate the health of the ecosystems of this important biogeographic region and help in designing conservation strategies.

Materials and methods

Study site and data collection

The present study was conducted in the Ajodhya foothill areas of Baghmundi block, Purulia district (22.60° to 23.50° N and 85.75° to 86.65° E), West Bengal, India from January 2017 to December 2017. Eight study sites were selected covering the entire study area based on the variability of topography, habitat and vegetation types. A short description of the study sites are given in Table 1 and their geographic locations are shown in Fig. 1. The line transect method was used, as the habitat of the study area was of open type with clear visibility from 15 m up to 50 m from the transect (Sutherland et al. 2005). Transect length was fixed (1000 m), but the width was adjusted according to habitat type and visibility: 15 m in forests; 20 m in agricultural fields; and 50 m in other open areas (Koli 2014; Shekhawat and Bhatnagar 2014). A fixed transect was laid in each of the eight study sites. Each transect was visited once per month with a total of 96 observations (12 observations for each of the eight study sites) to record seasonal variations in bird diversity.

The field surveys were conducted between 6 and 10 a.m. in the morning and between 4 and 7 p.m. in the evening, when birds were found to be most active. Birds were observed using the Olympus binocular (Olympus 8×40 DPS I, USA), and photographs were taken using digital cameras (Nikon D5200, Nikkor 55–300 mm lens, Nikon B700 and Canon Power shot SX500IS) for further identification. Birds were identified following Ali and Ripley (2007) and Grimmett et al. (2011). Number of individuals of each bird

Table 1 Name, geographic location, altitude, habitat and vegetation type of the study sites

Study Site	Geographic location	Altitude (m)	Habitat and Vegetation type
Site 1: Baghmundi village	23.1963 N, 86.0467 E	259.5	Rural area with human settlements and mixed vegetation
Site 2: Khatkadi	23.178 N, 86.074 E	256.4	Paddy field with pond and swamp area
Site 3: Matha	23.121 N, 86.077 E	256.8	Dry deciduous sal forest with hillock
Site 4: Burda	23.265 N, 86.007 E	297.0	Dam (Koirabera) with Sal forest
Site 5: Dowry Khal area	23.1856 N, 86.1072 E	363.1	Rocky hill area with moist deciduous forest and a hill stream flowing through it
Site 6: Rangamati	23.230 N, 85.875 E	227.5	Rural area with human settlement and mixed vegetation, Subarnarekha river flowing by the side
Site 7: Thurga dam Area	23.1987 N, 86.0637 E	272.7	Wetland with swamps and bushes with hillock
Site 8: PPSP Upper Dam Area	23.199 N, 86.101 E	487.7	Dam with mixed vegetation in the Ayodhya foothill

species observed from a particular site was recorded month-wise. The data recorded in a particular month from all the study sites were pooled together to calculate the diversity indices of the region as a whole. Monthly data were pooled into four seasons: summer (March to May); monsoon (June to August); post-monsoon (September to November) and winter (December to February). So there were 24 observations for each season (8 sites $\times$ 3 months). Migratory status of the enlisted birds was determined by personal observation as well as information available in the literature [Ali 2002; Ali and Ripley 2007; Grimmett et al. 2011; Sanyal and Roychowdhury 2012; Birdlife International 2018 (www.birdlife.org captured on 01.05.2022); Handbook of the Birds of the World Alive (www.hbw.com captured on 01.05.2022)]. The residential status of the birds was categorized as “winter visitor”, “summer visitor”, “resident”, and “passage visitor”. The birds that were encountered regularly in the study area were placed under the category “resident”; birds encountered only in winter and summer seasons were placed, respectively, under “winter visitor” and “summer visitor”; and birds that were encountered only once or twice during the study period were considered “passage visitor”. The IUCN status of the birds was recorded from IUCN red list of species (www.iucnredlist.org captured on 01.05.2022). The feeding habits of the birds were assigned as described by Ali and Ripley (2007) to analyse the guild structure of the recorded birds. During the field visits, information like threats to birds and other wildlife were also noted by interacting with local people.

Statistical analysis

To study the avian community structure Biodiversity Pro Software was used to analysis the data on the species richness and abundance (McAleece et al. 1997). The bird species diversity was calculated using Shannon–Wiener diversity index, i.e. $H' = -\sum p_i \ln p_i$ and Shannon $H_{\max} = \log_{10}(S)$. Measurement of Shannon’s evenness was calculated using the following formula $J = H'/H_{\max}$ (P_i = proportion of total

sample belonging to i th species, S = total number of species in habitats (species richness) (Magurran 2004). The relationship among species richness (S), information (H' —the Shannon–Wiener diversity index), and evenness (J) in the samples was made by SHE analysis (Buzas and Hayek 1998).

Results

During entire study period a total of 19,760 individuals comprising of 167 bird species belonging to 19 orders and 58 families was recorded from Ajodhya foothill areas of Baghmundi block, Purulia (Table 2). Of these, according to the International Union for Conservation of Nature and Natural Resources (IUCN 2018), two species are classified as “near threatened” (*Psittacula eupatria* and *Threskiornis melanocephalus*); while another two as “vulnerable” (*Ciconia episcopus* and *Leptoptilos javanicus*). All the remaining species ($n = 163$) are placed in the least concerned category. Non-passerine birds with 96 species outnumbered passerine birds (71 species). The family of birds which dominated the list in the present study was Muscicapidae (10 species) followed by Accipitridae and Ardeidae (9 species each).

The avian species richness varied in different seasons in the Ajodhya foothill areas (Fig. 2). Species richness value was highest in summer (123) followed by winter (118) whereas, this was lowest in post-monsoon season (101). Shannon–Wiener diversity index (H') of total 96 samples was 4.17 and evenness (J) 0.815. From season wise analysis of data Shannon–Wiener diversity index (H') was highest in winter (1.818) and minimum in post-monsoon season (1.754). $H_{\max}$ value was highest in the summer (2.09) followed by winter (2.072) and lowest in post-monsoon season (2.004). Shannon’s evenness value (J') was highest in monsoon (0.884) and lowest in summer (0.862). From the output of SHE analysis (Fig. 3) the association among S (species richness), H (information—Shannon–Weiner diversity index), and E (evenness) in the 96 samples can be inferred

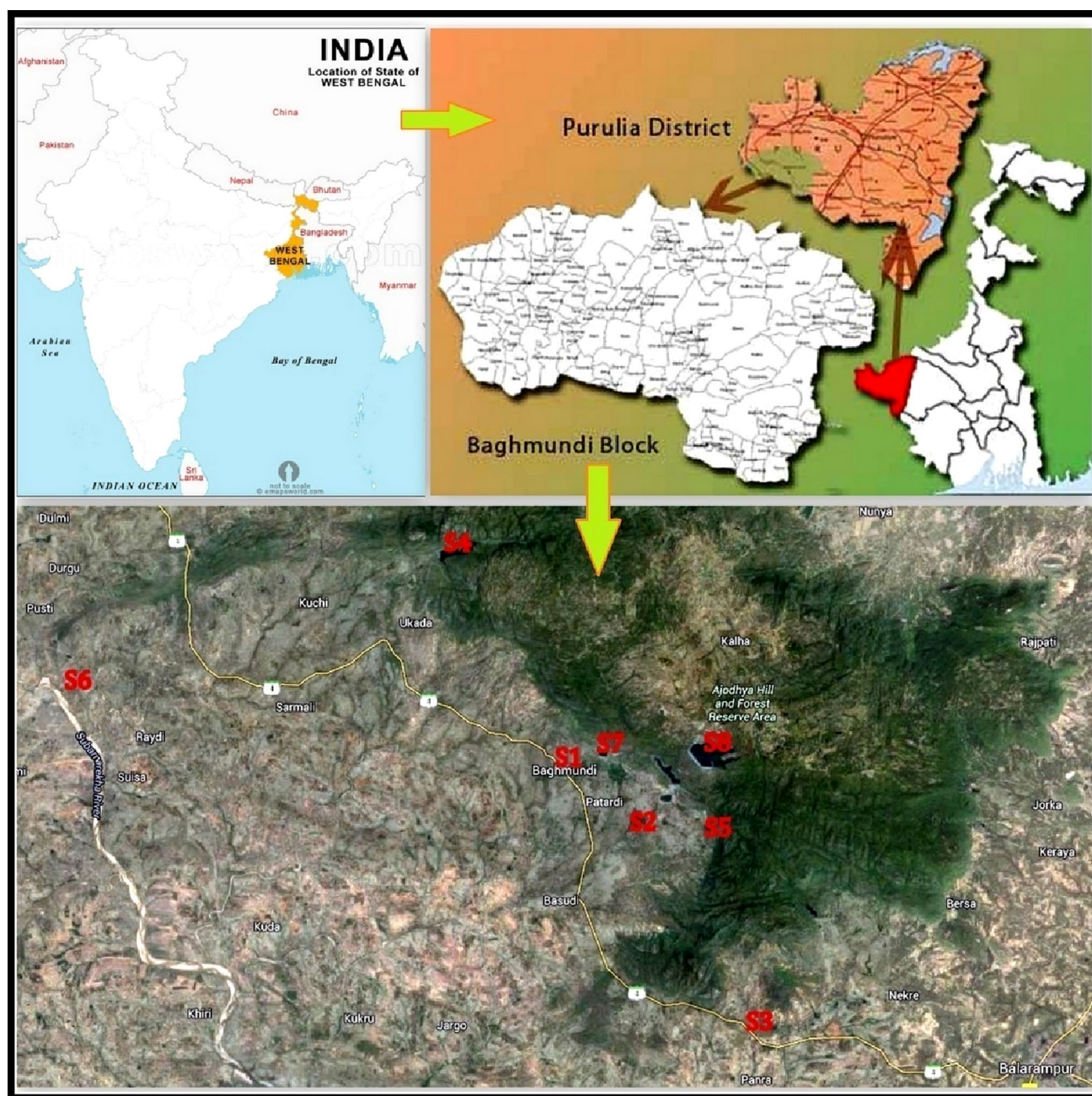


Fig. 1 Location of the study sites under present investigation in the Ajodhya foothill area

properly. As the number of individuals (N) increased with successive sampling events the species richness (S) also increased. In the observed bird community diversity (H) increased with increase in species richness ($\ln S$) and decrease in $\ln E$ as more sampling efforts was incorporated. This data indicates a diversified avian community in the studied area.

The analyses of data on residential status revealed that out of 167 species, 108 (64.7%) were resident, whereas the remaining species showed seasonal (20 species, 12%) and passage migration (39 species, 23.3%). Among the seasonal

migrants 15 species (9%) were identified as winter visitors and 5 species (3%) as summer visitors.

While analysing the guild structure diverse foraging habits were noted among the birds observed. Maximum number of species (50 species, 30%) was omnivorous, followed by carnivorous (40 species, 24%), insectivorous (33 species, 19.8%), invertivorous (other than insectivorous and molluscivorous) (15 species, 9%), granivorous (11 species, 6.6%), herbivorous (9 species, 5.4%), frugivorous (6 species, 3.6%), nectarivorous (2 species, 1.2%) and molluscivorous (1 species, 0.6%).

Table 2 Diversity, relative abundance (P_i) and feeding guild of avian fauna observed during the study period

S. no	Scientific name	English name	P_i	Residential status ^a	Guild
ORDER: Passeriformes					
Family: Aegithinidae					
1	<i>Aegithina tiphia</i> (Linnaeus, 1758)	Common Iora	0.000557	R	I
Family: Alaudidae					
2	<i>Eremopterix griseus</i> (Scopoli, 1786)	Ashy-crowned Sparrow-lark	0.003189	R	O
3	<i>Mirafra affinis</i> (Blyth, 1845)	Jerdon's Bushlark	0.000152	PV	O
Family: Artamidae					
4	<i>Artamus fuscus</i> (Vieillot, 1817)	Ashy Woodswallow	0.003341	R	I
Family: Campephagidae					
5	<i>Coracina macei</i> (Lesson, 1831)	Large Cuckooshrike	0.000456	PV	I
6	<i>Lalage melaschistos</i> (Hodgson, 1836)	Black-winged Cuckooshrike	0.000051	PV	I
7	<i>Pericrocotus cinnamomeus</i> (Linnaeus, 1766)	Small Minivet	0.003644	R	I
Family: Chloropseidae					
8	<i>Chloropsis jerdoni</i> (Blyth, 1844)	Jerdon's Leafbird	0.001215	R	O
Family: Cisticolidae					
9	<i>Cisticola juncidis</i> (Rafinesque, 1810)	Zitting Cisticola	0.000152	PV	I
10	<i>Orthotomus sutorius</i> (Pennant, 1769)	Common Tailorbird	0.008149	R	I
11	<i>Prinia hodgsonii</i> (Blyth, 1844)	Grey-breasted Prinia	0.000101	PV	I
12	<i>Prinia inornata</i> (Sykes, 1832)	Plain Prinia	0.001316	R	IV
13	<i>Prinia socialis</i> (Sykes, 1832)	Ashy Prinia	0.002683	R	IV
Family: Corvidae					
14	<i>Corvus macrorhynchos</i> (Wagler, 1827)	Large-billed Crow	0.000152	PV	O
15	<i>Corvus splendens</i> (Vieillot, 1817)	House Crow	0.008149	R	O
16	<i>Dendrocitta vagabunda</i> (Latham, 1790)	Rufous Treepie	0.000101	R	O
Family: Dicaeidae					
17	<i>Dicaeum erythrorhynchos</i> (Latham, 1790)	Pale-billed Flowerpecker	0.005112	R	O
Family: Dicruridae					
18	<i>Dicrurus hottentottus</i> (Linnaeus, 1766)	Hair-crested Drongo	0.000456	WV	O
19	<i>Dicrurus macrocerus</i> (Vieillot, 1817)	Black Drongo	0.020804	R	I
20	<i>Dicrurus caeruleus</i> (Linnaeus, 1758)	White-bellied Drongo	0.000202	PV	I
Family: Emberizidae					
21	<i>Emberiza bruniceps</i> (Brandt, 1841)	Red-headed Bunting	0.000051	WV	O
Family: Estrildidae					
22	<i>Euodice malabarica</i> (Linnaeus, 1758)	Indian Silverbill	0.021057	R	O
23	<i>Lonchura malacca</i> (Linnaeus, 1766)	Tricoloured Munia	0.001772	R	G
24	<i>Lonchura punctulata</i> (Linnaeus, 1758)	Scaly-breasted Munia	0.005112	R	G
25	<i>Lonchura striata</i> (Linnaeus, 1766)	White-rumped Munia	0.000709	PV	G
Family: Hirundinidae					
26	<i>Cecropis daurica</i> (Linnaeus, 1771)	Red-rumped Swallow	0.006682	R	I
27	<i>Hirundo smithii</i> (Leach, 1818)	Wire-tailed Swallow	0.000607	WV	I
Family: Laniidae					
28	<i>Lanius cristatus</i> (Linnaeus, 1758)	Brown Shrike	0.001519	WV	IV
29	<i>Lanius schach</i> (Linnaeus, 1758)	Long-tailed Shrike	0.002278	R	IV
30	<i>Lanius vittatus</i> (Valenciennes, 1826)	Bay-backed Shrike	0.000354	PV	I
Family: Leiotherichidae					
31	<i>Argya caudata</i> (Dumont, 1823)	Common Babbler	0.001873	R	O
32	<i>Turdoides striata</i> (Dumont, 1823)	Jungle Babbler	0.030927	R	I
Family: Monarchidae					
33	<i>Hypothymis azurea</i> (Boddaert, 1783)	Black-naped Monarch	0.000152	SV	I
34	<i>Terpsiphone paradisi</i> (Linnaeus, 1758)	Indian Paradise Flycatcher	0.001063	SV	IV

Table 2 (continued)

S. no	Scientific name	English name	P _i	Residential status ^a	Guild
Family: Motacillidae					
35	<i>Anthus hodgsoni</i> (Richmond, 1907)	Olive-backed Pipit	0.011338	WV	O
36	<i>Anthus rufulus</i> (Vieillot, 1818)	Paddyfield Pipit	0.001265	R	I
37	<i>Motacilla alba</i> (Linnaeus, 1758)	White Wagtail	0.00081	WV	C
38	<i>Motacilla cinerea</i> (Tunstall, 1771)	Grey Wagtail	0.001367	WV	I
39	<i>Motacilla citreola</i> (Pallas, 1776)	Citrine Wagtail	0.000101	WV	C
40	<i>Motacilla flava</i> (Linnaeus, 1758)	Yellow Wagtail	0.000304	WV	O
41	<i>Motacilla maderaspatensis</i> (Gmelin, 1789)	White-browed Wagtail	0.000658	R	I
Family: Muscicapidae					
42	<i>Copsychus saularis</i> (Linnaeus, 1758)	Oriental Magpie-robin	0.01144	R	I
43	<i>Cyanecula svecica</i> (Linnaeus, 1758)	Bluethroat	0.000557	WV	O
44	<i>Eumyias thalassinus</i> (Swainson, 1838)	Verditer Flycatcher	0.000962	WV	O
45	<i>Ficedula albicilla</i> (Pallas, 1811)	Taiga Flycatcher	0.000557	WV	I
46	<i>Ficedula erithacus</i> (Jerdon and Blyth, 1861)	Slaty-backed Flycatcher	0.000152	WV	O
47	<i>Kittacincla malabarica</i> (Scopoli, 1788)	White-rumped Shama	0.00081	R	O
48	<i>Oenanthe fusca</i> (Blyth, 1851)	Brown Rock Chat	0.000152	R	I
49	<i>Phoenicurus ochruros</i> (Gmelin, 1774)	Black Redstart	0.00086	WV	O
50	<i>Saxicola maurus</i> (Pallas, 1773)	Siberian Stonechat	0.000152	WV	I
51	<i>Saxicoloides fulicatus</i> (Linnaeus, 1766)	Indian Robin	0.018577	WV	O
Family: Nectariniidae					
52	<i>Aethopyga siparaja</i> (Raffles, 1822)	Crimson Sunbird	0.000051	PV	O
53	<i>Cinnyris asiaticus</i> (Latham, 1790)	Purple Sunbird	0.013312	R	N
54	<i>Leptocoma zeylonica</i> (Linnaeus, 1766)	Purple-rumped sunbird	0.001164	R	N
Family: Oriolidae					
55	<i>Oriolus kundoo</i> (Sykes, 1832)	Indian Golden Oriole	0.007441	R	O
56	<i>Oriolus xanthornus</i> (Linnaeus, 1758)	Black-hooded Oriole	0.000506	SM	O
Family: Passeridae					
57	<i>Passer domesticus</i> (Linnaeus, 1758)	House Sparrow	0.021057	R	G
Family: Phylloscopidae					
58	<i>Phylloscopus affinis</i> (Tickell, 1833)	Tickell's Leaf Warbler	0.000051	PV	I
59	<i>Phylloscopus collybita</i> (Vieillot, 1817)	Common Chiffchaff	0.001114	WV	O
Family: Pittidae					
60	<i>Pitta brachyura</i> (Linnaeus, 1766)	Indian Pitta	0.001772	SV	IV
Family: Ploceidae					
61	<i>Ploceus philippinus</i> (Linnaeus, 1766)	Baya Weaver	0.00987	R	G
Family: Pycnonotidae					
62	<i>Pycnonotus cafer</i> (Linnaeus, 1766)	Red-vented Bulbul	0.018678	R	O
Family: Sturnidae					
63	<i>Acridotheres ginginianus</i> (Latham, 1790)	Bank Myna	0.000152	PV	O
64	<i>Acridotheres tristis</i> (Linnaeus, 1766)	Common Myna	0.054566	R	O
65	<i>Gracupica contra</i> (Linnaeus, 1758)	Asian Pied Starling	0.04915	R	O
66	<i>Sturnia malabarica</i> (Gmelin, 1789)	Chestnut-tailed Starling	0.020399	R	O
67	<i>Sturnia pagodarum</i> (Gmelin, 1789)	Brahminy Starling	0.014882	R	O
Family: Sylviidae					
68	<i>Chrysomma sinense</i> (Gmelin, 1789)	Yellow-eyed Babbler	0.007036	R	O
Family: Turdidae					
69	<i>Zoothera dauma</i> (Latham, 1790)	Scaly Thrush	0.000051	WV	O
Family: Vangidae					
70	<i>Tephrodornis pondicerianus</i> (Gmelin, 1789)	Common Wood-shrike	0.000557	R	I

Table 2 (continued)

S. no	Scientific name	English name	P _i	Residential status ^a	Guild
Family: Zosteropidae					
71	<i>Zosterops palpebrosus</i> (Temminck, 1824)	Oriental White-eye	0.001519	PV	O
ORDER: Coraciiformes					
Family: Alcedinidae					
72	<i>Alcedo atthis</i> (Linnaeus, 1758)	Common Kingfisher	0.007744	R	C
73	<i>Ceryle rudis</i> (Linnaeus, 1758)	Pied Kingfisher	0.001417	R	C
74	<i>Halcyon smyrnensis</i> (Linnaeus, 1758)	White-throated Kingfisher	0.015236	R	C
75	<i>Pelargopsis capensis</i> (Linnaeus, 1766)	Stork-billed kingfisher	0.000051	PV	C
Family: Coraciidae					
76	<i>Coracias benghalensis</i> (Linnaeus, 1758)	Indian Roller	0.007289	R	C
Family: Meropidae					
77	<i>Merops orientalis</i> (Latham, 1802)	Green Bee-eater	0.019741	R	I
ORDER: Charadriiformes					
Family: Burhinidae					
78	<i>Burhinus indicus</i> (Salvadori, 1865)	Indian Thick-knee	0.000456	PV	IV
Family: Charadriidae					
79	<i>Charadrius dubius</i> (Scopoli, 1786)	Little Ringed Plover	0.001417	R	IV
80	<i>Vanellus cinereus</i> (Blyth, 1842)	Grey-headed Lapwing	0.000152	WV	IV
81	<i>Vanellus indicus</i> (Boddaert, 1783)	Red-wattled Lapwing	0.023233	R	IV
82	<i>Vanellus malabaricus</i> (Boddaert, 1783)	Yellow-wattled Lapwing	0.000405	R	IV
Family: Jacanidae					
83	<i>Hydrophasianus chirurgus</i> (Scopoli, 1786)	Pheasant-tailed Jacana	0.002784	R	IV
84	<i>Metopidius indicus</i> (Latham, 1790)	Bronze-winged Jacana	0.010579	R	O
Family: Laridae					
85	<i>Chlidonias hybrida</i> (Pallas, 1811)	Whiskered Tern	0.000557	SV	IV
86	<i>Larus ridibundus</i> (Linnaeus, 1766)	Black-headed Gull	0.000405	WV	O
Family: Recurvirostridae					
87	<i>Himantopus himantopus</i> (Linnaeus, 1758)	Black-winged Stilt	0.001012	WV	C
Family: Rostratulidae					
88	<i>Rostratula benghalensis</i> (Linnaeus, 1758)	Greater Painted-snipe	0.000456	R	O
Family: Scolopacidae					
89	<i>Actitis hypoleucos</i> (Linnaeus, 1758)	Common Sandpiper	0.003493	R	C
90	<i>Gallinago gallinago</i> (Linnaeus, 1758)	Common Snipe	0.004404	R	O
91	<i>Gallinago stenura</i> (Bonaparte, 1830)	Pin-tailed Snipe	0.000051	WV	O
92	<i>Tringa glareola</i> (Linnaeus, 1758)	Wood Sandpiper	0.000051	WV	I
93	<i>Tringa ochropus</i> (Linnaeus, 1758)	Green Sandpiper	0.000405	WV	IV
ORDER: Accipitriformes					
Family: Accipitridae					
94	<i>Accipiter badius</i> (Gmelin, 1788)	Shikra	0.002885	R	C
95	<i>Circaetus gallicus</i> (Gmelin, 1788)	Short-toed Snake Eagle	0.000101	PV	C
96	<i>Circus melanoleucos</i> (Pennant, 1769)	Pied Harrier	0.000051	PV	C
97	<i>Elanus caeruleus</i> (Desfontaines, 1789)	Black-winged Kite	0.008453	R	C
98	<i>Haliastur indus</i> (Boddaert, 1783)	Brahminy Kite	0.000101	PV	C
99	<i>Hieraaetus pennatus</i> (Gmelin, 1788)	Booted Eagle	0.000202	PV	C
100	<i>Milvus migrans</i> (Boddaert, 1783)	Black Kite	0.016349	R	C
101	<i>Pernis ptilorhynchus</i> (Temminck, 1821)	Oriental Honey Buzzard	0.000051	R	C
102	<i>Spilornis cheela</i> (Latham, 1790)	Crested Serpent-Eagle	0.000101	R	C

Table 2 (continued)

S. no	Scientific name	English name	P _i	Residential status ^a	Guild
ORDER: Falconiformes					
Family: Falconidae					
103	<i>Falco tinnunculus</i> (Linnaeus, 1758)	Common Kestrel	0.000051	WV	C
ORDER: Pelecaniformes					
Family: Ardeidae					
104	<i>Ardea alba</i> (Linnaeus, 1758)	Great White Egret	0.000456	PV	C
105	<i>Ardea intermedia</i> (Wagler, 1827)	Intermediate Egret	0.003695	R	C
106	<i>Ardea purpurea</i> (Linnaeus, 1766)	Purple Heron	0.000101	R	C
107	<i>Ardeola grayii</i> (Sykes, 1832)	Indian Pond Heron	0.016552	R	C
108	<i>Bubulcus ibis</i> (Linnaeus, 1758)	Cattle Egret	0.017716	R	C
109	<i>Egretta garzetta</i> (Linnaeus, 1766)	Little Egret	0.007896	R	C
110	<i>Ixobrychus cinnamomeus</i> (Gmelin, 1789)	Cinnamon Bittern	0.002784	R	C
111	<i>Ixobrychus flavicollis</i> (Latham, 1790)	Black Bittern	0.000202	R	C
112	<i>Nycticorax nycticorax</i> (Linnaeus, 1758)	Black-crowned Night Heron	0.007188	R	C
Family: Threskiornithidae					
113	<i>Pseudibis papillosa</i> (Temminck, 1824)	Red-naped Ibis	0.011186	R	C
114	<i>Threskiornis melanocephalus</i> (Latham, 1790)	Black-headed Ibis	0.000101	PV	I
ORDER: Cuculiformes					
Family: Cuculidae					
115	<i>Cacomantis passerinus</i> (Vahl, 1797)	Grey-bellied Cuckoo	0.000101	PV	I
116	<i>Centropus sinensis</i> (Stephens, 1815)	Greater Coucal	0.008656	R	C
117	<i>Clamator jacobinus</i> (Boddaert, 1783)	Jacobin Cuckoo	0.000557	PV	O
118	<i>Cuculus poliocephalus</i> (Latham, 1790)	Lesser Cuckoo	0.000051	PV	O
119	<i>Eudynamis scolopacea</i> (Linnaeus, 1758)	Western Koel	0.014882	R	F
120	<i>Hierococyx varius</i> (Vahl, 1797)	Common Hawk-cuckoo	0.006428	R	O
121	<i>Phaenicophaeus tristis</i> (Lesson, 1830)	Green-billed Malkoha	0.000051	PV	C
122	<i>Taccocua leschenaultii</i> (Lesson, 1830)	Sirkeer Malkoha	0.000051	PV	O
ORDER: Piciformes					
Family: Megalaimidae					
123	<i>Psilopogon haemacephalus</i> (Muller, 1776)	Coppersmith Barbet	0.01969	R	F
124	<i>Psilopogon lineatus</i> (Vieillot, 1816)	Lineated Barbet	0.006682	R	F
Family: Picidae					
125	<i>Dinopium benghalense</i> (Linnaeus, 1758)	Black-rumped Flameback	0.010782	R	I
126	<i>Jynx torquilla</i> (Linnaeus, 1758)	Eurasian Wryneck	0.000051	WV	I
127	<i>Leiopicus mahrattensis</i> (Latham, 1801)	Yellow-crowned Woodpecker	0.000051	PV	O
128	<i>Micropternus brachyurus</i> (Vieillot, 1818)	Rufous Woodpecker	0.000101	PV	O
ORDER: Galliformes					
Family: Phasianidae					
129	<i>Francolinus pondicerianus</i> (Gmelin, 1789)	Grey Francolin	0.014831	R	G
130	<i>Gallus gallus</i> (Linnaeus, 1758)	Red Junglefowl	0.023993	R	O
131	<i>Pavo cristatus</i> (Linnaeus, 1758)	Indian Peafowl	0.002683	R	O
132	<i>Perdica asiatica</i> (Latham, 1790)	Jungle Bush-Quail	0.001873	R	O
ORDER: Anseriformes					
Family: Anatidae					
133	<i>Anas crecca</i> (Linnaeus, 1758)	Common Teal	0.000253	WV	H
134	<i>Dendrocygna javanica</i> (Horsfield, 1821)	Lesser Whistling Duck	0.006125	R	G
135	<i>Mareca strepera</i> (Linnaeus, 1758)	Gadwall	0.001873	WV	H
136	<i>Netta rufina</i> (Pallas, 1773)	Red-crested Pochard	0.000101	WV	G
137	<i>Nettapus coromandelianus</i> (Gmelin, 1789)	Cotton Pygmy Goose	0.001012	R	H

Table 2 (continued)

S. no	Scientific name	English name	P _i	Residential status ^a	Guild
ORDER: Columbiformes					
Family: Columbidae					
138	<i>Columba livia</i> (Gmelin, 1789)	Rock Dove	0.055426	R	G
139	<i>Spilopelia chinensis</i> (Scopoli, 1768)	Spotted Dove	0.031687	R	G
140	<i>Spilopelia senegalensis</i> (Linnaeus, 1766)	Laughing Dove	0.017817	R	H
141	<i>Streptopelia decaocto</i> (Frivaldszky, 1838)	Eurasian Collared-dove	0.0123	R	G
142	<i>Streptopelia orientalis</i> (Latham, 1790)	Oriental Turtle Dove	0.000152	PV	H
143	<i>Streptopelia tranquebarica</i> (Hermann, 1804)	Red Collared Dove	0.000607	R	H
144	<i>Treron bicinctus</i> (Jerdon, 1840)	Orange-breasted Green Pigeon	0.000101	PV	F
145	<i>Treron phoenicopterus</i> (Latham, 1790)	Yellow-footed Green Pigeon	0.02784	R	F
ORDER: Bucerotiformes					
Family: Bucerotidae					
146	<i>Ocyrceros birostris</i> (Scopoli, 1786)	Indian Grey Hornbill	0.000152	R	F
Family: Upupidae					
147	<i>Upupa epops</i> (Linnaeus, 1758)	Hoopoe	0.008504	R	I
ORDER: Gruiformes					
Family: Rallidae					
148	<i>Amaurornis phoenicurus</i> (Pennant, 1769)	White-breasted Waterhen	0.013059	R	O
149	<i>Fulica atra</i> (Linnaeus, 1758)	Common Coot	0.000253	WV	O
150	<i>Gallinula chloropus</i> (Linnaeus, 1758)	Common Moorhen	0.001215	R	O
151	<i>Zapornia fusca</i> (Linnaeus, 1766)	Ruddy-breasted Crake	0.000101	PV	O
ORDER: Strigiformes					
Family: Strigidae					
152	<i>Athene brama</i> (Temminck, 1821)	Spotted Owlet	0.002177	R	C
153	<i>Bubo bengalensis</i> (Franklin, 1831)	Rock Eagle-owl	0.000202	R	C
154	<i>Glaucidium radiatum</i> (Tickell, 1833)	Jungle Owlet	0.000709	R	C
155	<i>Otus bakkamoena</i> (Pennant, 1769)	Indian Scops Owl	0.000202	R	C
ORDER: Psittaciformes					
Family: Psittaculidae					
156	<i>Psittacula cyanocephala</i> (Linnaeus, 1766)	Plum-headed Parakeet	0.011895	R	H
157	<i>Psittacula eupatria</i> (Linnaeus, 1766)	Alexandrine Parakeet	0.00577	R	H
158	<i>Psittacula krameri</i> (Scopoli, 1769)	Rose-ringed Parakeet	0.029915	R	H
ORDER: Ciconiiformes					
Family: Ciconiidae					
159	<i>Anastomus oscitans</i> (Boddaert, 1783)	Asian Openbill	0.014477	R	M
160	<i>Ciconia episcopus</i> (Boddaert, 1783)	Woolly-necked Stork	0.000506	R	C
161	<i>Leptoptilos javanicus</i> (Horsfield, 1821)	Lesser Adjutant	0.000557	R	C
ORDER: Suliformes					
Family: Phalacrocoracidae					
162	<i>Phalacrocorax carbo</i> (Linnaeus, 1758)	Great Cormorant	0.000101	WV	C
163	<i>Phalacrocorax fuscicollis</i> (Stephens, 1826)	Indian Cormorant	0.012098	R	C
ORDER: Caprimulgiformes					
Family: Caprimulgidae					
164	<i>Caprimulgus affinis</i> (Horsfield, 1821)	Savanna Nightjar	0.000051	R	IV
165	<i>Caprimulgus asiaticus</i> (Latham, 1790)	Indian Nightjar	0.00167	R	I
166	<i>Caprimulgus macrurus</i> (Horsfield, 1821)	Large-tailed Nightjar	0.000101	PV	I
ORDER: Podicipediformes					
Family: Podicipedidae					
167	<i>Tachybaptus ruficollis</i> (Pallas, 1764)	Little Grebe	0.002683	R	C

P_i = proportion of total sample belonging to ith species (relative abundance)

^aResidential Status: *R* resident, *SV* summer visitor, *WV* winter visitor, *PV* passage visitor

Feeding Habits (Guild): *I* Insectivorous, *IV* Invertivorous, *M* Molluscivorous, *O* Omnivorous, *G* Granivorous, *N* Nectarivorous, *F* Frugivorous, *C* Carnivorous, *H* Herbivorous

Fig. 2 Species richness, Shannon H' , $H_{\max}$ and J' values in different seasons

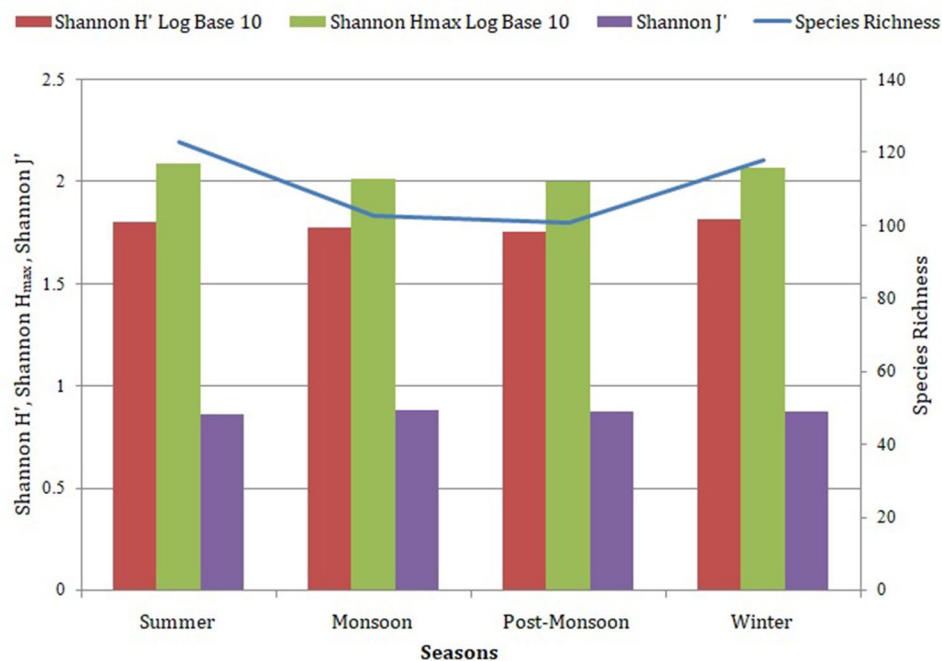
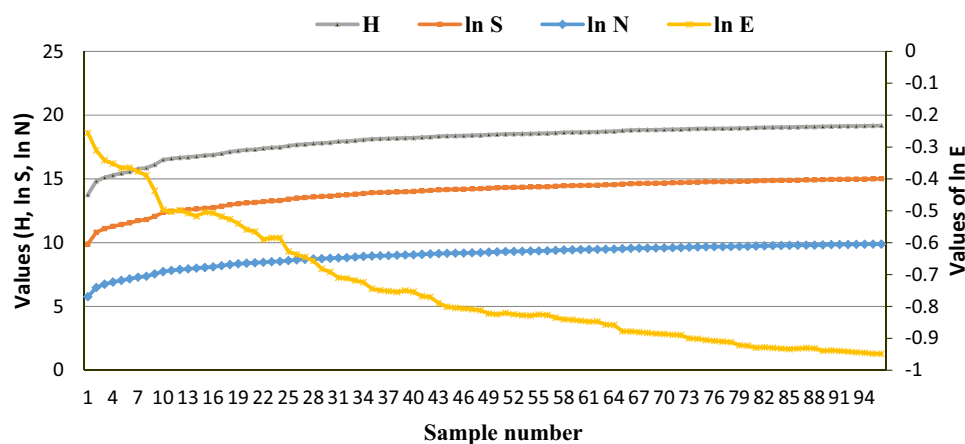


Fig. 3 Plot of SHE analysis calculated on one year data of 96 samples recorded during the study. Each point in x-axis represents sample number



Discussion

The present study reflects a rich avian diversity in the Ajothya foothill areas of Baghmundi block, Purulia. This is probably the first report of bird diversity in recent times from this geographic area which is part of an important eco-region (lowest step of the Chota Nagpur Plateau). There are few recent reports available on the avian diversity of some adjoining eco-regions. Verma (2011) reported 71 bird species comprising 36 families from Dalma Wildlife Sanctuary, Jharkhand. Adhurya et al. (2015) listed 186 bird species from Durgapur eco-region, West Bengal. The avian species assemblages in more or less similar landscapes like Bongaon in southern West Bengal, India recorded 119 avian species (Mukhopadhyay

and Mazumdar 2017). Another study from three different regions of North Bengal, India reported the presence of 117 bird species (Roy et al. 2012). Similar studies from other parts of India like Sultanpur National Park, Haryana, India found 111 species of birds (Singh et al. 2021). John Mohammad and Krishna (2016) enlisted 40 bird species from Wyrā and Pālēr reservoirs of Khammam district of Telangana state, India. 142 bird species were present in the Todgarh-Raoli Wildlife Sanctuary, Rajasthan, India (Koli 2014). Another study from Male Mahadeshwara Reserve Forest, South India recorded 102 bird species (Aravind et al. 2010). In similar habitat types of other tropical countries outside India, numerous studies have been carried out to assess avian diversity. A total of 123 bird species was recorded from a mixed fruit orchard and nearby isolated

forest patch on the mountain of Khao Luang, southern Thailand (Round et al. 2006). Marsden et al. (2001) found 111 avian species from forest fragments and *Eucalyptus* plantations around an Atlantic forest reserve, Brazil. Therefore, the avian species richness documented in the present study is comparable with similar studies conducted in different regions of India and other tropical countries. The presence of such a huge avian species in the region of the present study indicates a healthy ecosystem with high productivity (Choudaj and Wankhade 2021).

The presence of a large number (108 species) of residential birds strongly indicates that the area under the present study can support rich avian diversity. A significant number of seasonal (20 species) and passage (39 species) migrants recorded during the study further ascertain the area as an important birding site. The rich avian diversity recorded in the Ajodhya foothill areas might be due to the presence of diverse ecosystems in the region that provides nesting sites, shelter, and rich food availability to the avian species. Avian species richness has been found to be positively correlated with habitat heterogeneity (Panda et al. 2021; Lorenzón et al. 2016). The area selected for the present study consisted of diverse habitats like dry deciduous sal forest, rocky hilly areas with moist deciduous forests, human settlements with mixed forests, paddy fields with ponds and swamps, dams with mixed forests and wetlands. This remarkable habitat heterogeneity might be the key factor behind the presence of a huge 167 avian species in the study area. The area forms a transitional zone or ecotone between the hilly forest and plane lands. Such transitional zones are ecologically diverse and attract a large number of bird species (Khan and Pant 2017). Though agricultural landscapes are preferred by only a few avian species, agroecosystems have been considered very important for sustaining avian species diversity as about one-third of all avian species may be linked to such ecosystems considering their dependence on agroecosystem for food, foraging ground, shelter and breeding place for which birds visit such habitats frequently (Hossain and Aditya 2016; Sekercioglu 2012).

Muscicapidae is the largest family of birds in India with 370 species (Manakadan and Pittie 2001). The present study also revealed the same trend as muscicapidae was the dominant family with 10 species. Similarly, many other studies such as Sharma (1998), Chhangani (2002), Sankar et al. (2006) and Yaseen et al. (2011) have also found Muscicapidae to be the largest family.

Variations in species richness and Shannon–Wiener diversity index (H') values were observed among different seasons which might be due to fluctuations in weather conditions or variations in food availability and habitat quality (Loiselle and Blake 1991; Norris and Marra 2007). Species

richness and Shannon–Wiener diversity index (H') were higher in summer and winter seasons compared to monsoon and post-monsoon seasons. This might be due to the presence of summer and winter migrants which increased species richness and species diversity during these two seasons.

The resultant data on the guild structure reveals the resource utilization pattern by the avifauna of this area. The availability of food resources is directly dependent on the precipitation rate and as an arid district of West Bengal, Purulia is severely deprived of water. Therefore, the dearth of water acts as a limiting factor for the survival of avian groups and the presence of a lesser number of granivores, herbivores, frugivores and nectarivores justifies the fact. Interestingly, omnivores were highest in number followed by insectivores which might also be due to extreme weather conditions (Gaston 2000; Lawton 2000; Dapke et al. 2015; Hossain and Aditya 2016). A large number of insectivorous birds present in the study area may act as important bio-control agents of insect pests in agriculture, horticulture, and forests (Mahabal 2005; Thakur et al. 2010).

The presence of a large number of birds including two “near threatened” and two “vulnerable” species in the study area makes it more significant from the conservation aspects. Birds play significant ecological roles as pollinators and agents for seed dispersal (Bibi and Ali 2013; Koli 2014). Therefore the ecosystems of the Ajodhya foothill areas that form the habitat for the avian species should be protected from degradation.

Anthropogenic disturbances like encroaching into forest lands for agriculture or human settlement, cutting of trees from the forest for fuel and fodder, livestock grazing, hunting and poaching are posing serious threats for the ecosystem and wildlife of this region. Human induced habitat loss is considered to be one of the major threats to the avian diversity as habitat loss is likely to reduce viable habitats for birds and create barriers for dispersal (Sekercioglu et al. 2008). Immediate measures should be taken for the conservation of the diverse habitats from degradation by anthropogenic activities so that important ecosystem services that are derived from diverse avian species can be sustained (Choudaj and Wankhade 2021; Hossain and Aditya 2016).

Conclusion

We hope our present work, which is the pioneering one in recent times in this geographic area, will help to accentuate the importance of habitat conservation to protect the rich biodiversity of the region. Further investigation on the avian diversity of this region covering more study areas may

generate awareness among the local people and government authorities to save wildlife and their habitats.

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