Avifaunal Diversity in Managed Urban Ecosystem: A Case Study of Banaras Hindu University, Varanasi

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Abstract. University campuses are becoming important places for conducting a large number of studies on plant and animal taxa including avian diversity. However, a systematic study on the avian diversity in the Banaras Hindu University (BHU) campus (Asia's largest residential university campus) of Varanasi is still lacking. The present study deals with the species abundance, diversity and species richness of avian communities in the BHU campus. We conducted a bird survey in the BHU campus between 2019 and 2020. Employing line-transect method, a total of 141 bird species under 62 families were recorded from the study area. A rich diversity of species recorded indicates the importance of the university campuses in urbanized region to serve as a critical habitat for birds. To conserve this rich bird diversity of the campus, we suggest sustainable management of habitats through restoration of degraded habitats, reduction in habitat destruction, conservation awareness programmes and increased research on assessment of diversity.

Keywords: Avian diversity, Banaras Hindu University, Biodiversity, Campus birds, Conservation status, Urban landscape, Varanasi.

1. Introduction

Worldwide, urban areas are growing both in size and number (Melles et al., 2003). Today, over half of the world's population lives in cities. The rapid urbanization is degrading wildlife habitats and reducing biodiversity (McKinney, 2002; Gupta et al., 2009; Goddard et al., 2010; Banville et al., 2017). The biodiversity in the urban ecosystems can be conserved through maintaining urban green spaces (Shaffer, 2018) such as greenways, avenues, parks, defence premises and university campuses (Rajashekara & Venkatesha, 2017; Sohil & Sharma, 2020). This need paved the way for biodiversity research in urban parks (McFrederick & LeBuhn, 2006; Palliwoda et al., 2017), and university campuses (Gupta et al., 2009; Liu et al., 2017) which harbours a considerable biological diversity (Liu et al., 2021).

University campuses including college campuses are important component of green cover in urban landscapes that provide opportunities for biodiversity conservation (Vallejo et al., 2009; Zhang et al., 2018). These campuses are more important in developing countries where private green spaces are often scarce (Goddard et al., 2010; Liu et al., 2021). University campuses provide habitats for plants, and animals including insects and birds (Wheeler, 2008; Liu et al., 2017; Zhang et al., 2018). These areas attract both local and migratory species of birds and thus are ideal locations for avifaunal surveys (Grimmett & Inskipp, 2007; Fischer & Islam, 2020; Guthula et al., 2022). Bird population, abundance and diversity are important indicators to know the biological richness and overall health of an ecosystem (Adang et al., 2015; Dendup et al., 2021).

Bird species of various campuses of universities and institutes in India and across the world have been recorded. In India studies on bird diversity can be traced from Kurukshetra University (395.369 acre: Total:92 species; migrants:21 and residents:71) (Gupta et al., 2009), Govind Ballabh Pant Institute of Himalayan Environment and Development (Total:61 species; migrants:1 and residents:60) (Palita et al., 2011), Sálim Ali Centre for Ornithology and Natural History (55 acre; Total:145 species; 72 migrants; 73 residents) (Ali et al., 2013), and Bangalore University (1099.98 acre; Total:106 species; migrants:7; resident migrants:20; and residents:79) (Rajashekara & Venkatesha, 2017). University campuses across the world have also been assessed for avian diversity including University of the Philippines, Philippines (1218.23 acre; 36 species) (Vallejo Jr et al., 2008), Hokkaido University, Japan (494.21 acre; 88 species) (Namba et al., 2010), Sabaragamuwa University, Sri Lanka (125 acre; 145 species) (Surasinghe & Alwis, 2010), and Dhaka University, Bangladesh (275.083 acre; 78 species) (Chowdhury et al., 2014). The composition, abundance and diversity of birds have not been recorded in the Banaras Hindu University (BHU) campus despite covering an extensive geographical area (over 1300 acre) and comprising a rich diversity of habitats and plant species.

This study aims to fill this important research gap by surveying avian diversity in BHU campus located in Varanasi district of Uttar Pradesh, India. The objective of the study is to provide a primary survey database for environmental monitoring, conservation, management, and sustainability along with providing basic avifauna information for campus biodiversity studies. BHU campus is a managed urban ecosystem in Varanasi city, which provides important habitats to the bird. Hence the campus should be wisely used and developed without disturbing the activity of the birds and their habitats. Understanding the diversity of birds in the BHU campus can be

useful to conservation managers and planners to formulate conservation strategies in an urban landscape.

2. Materials and methods

2.1. Study area

The present study of avifaunal diversity was conducted in the campus of Banaras Hindu University (BHU, 25° 15' 52" N & 82° 59' 41" E) located on the western bank of the Ganga River in the Varanasi district of Uttar Pradesh, India (Fig. 1).

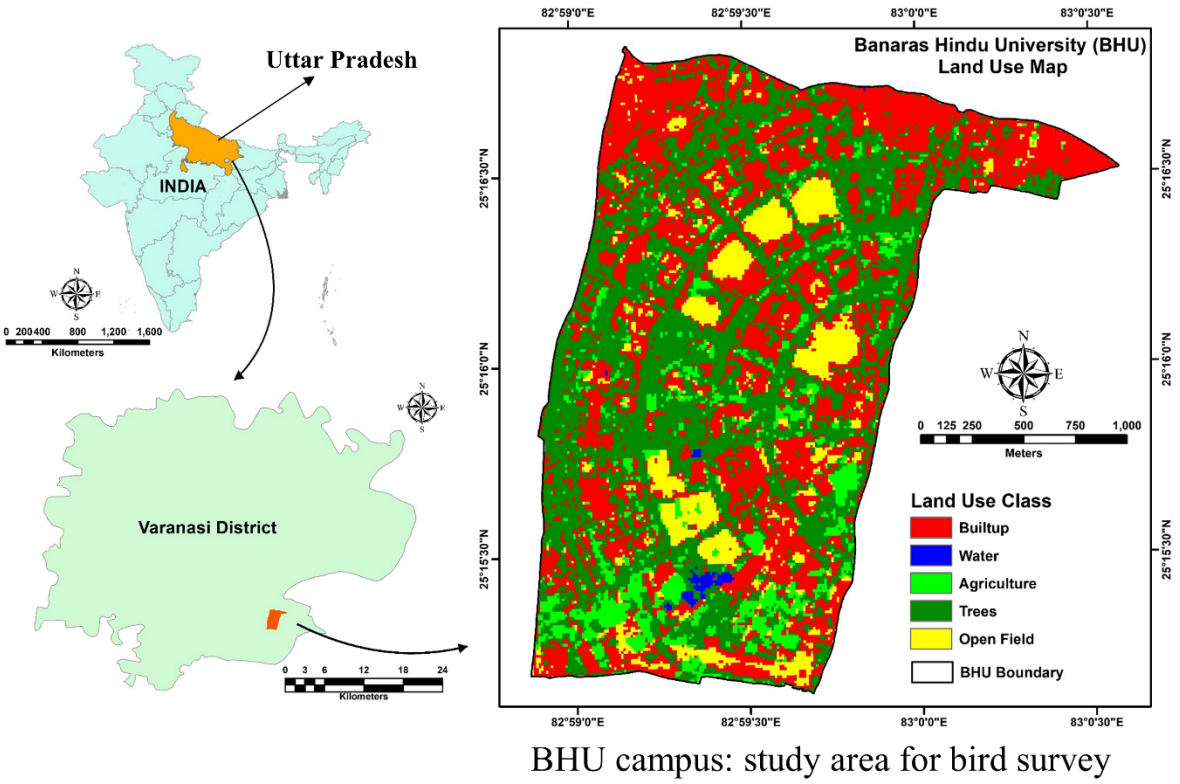

Figure 1. Map of the study area showing the location of Banaras Hindu University campus

BHU is the largest residential university in Asia and covers an area over 1,300 acres (5.3 km^2) (Nayak and Ghosh, 2020). This university campus is a managed urban ecosystem and is known for its green cover and extensive space in urbanized Varanasi. The BHU campus enjoys humid sub-tropical climate with three distinct seasons: summer (March to June), monsoon (July to October) and winter (November to February).

Landscape of the study area is characterized by a flat topography with fertile alluvial soil. The campus exhibits a rich diversity of habitats including parks, home gardens, botanical and herbal gardens, sacred natural sites of temples, ponds, wetlands, crop fields, grasslands, bushes, and road side vegetation corridors (Singh et al., 2019; Nayak & Ghosh, 2020). The total length of roads planted with trees on both sides is 30.8 km in the campus of BHU (Singh et al., 2019). The flora of BHU campus comprises 574 species belonging to 426 genera and 111 families of angiosperm (Dubey, 2004; Singh et al., 2019). The important tree species of the BHU campus include *Mangifera indica, Syzygium cumini, Tectona grandis, Terminalia arjuna, Delonix regia, Madhuca longifolia* and *Tamarindus indica*. These tree species provide food and shelter to a variety of bird species.

2.2. Bird survey

The bird survey was carried out in the BHU campus for one year between March 2019 and February 2020 using fixed-distance line transect method (Hostetler & Main, 2001; Hovick et al., 2015; Raynor et al., 2017). In line transect method, observer continually walks and records all birds either side of the track (Bibby et al., 1998). Nineteen transects were placed in the BHU campus and each transect was of 400 m long, and 20 m wide, on either side. Distance between two transect was at least 200 m. Along each 400 m long transect, all the birds seen or heard were recorded within 20 m from either side of the transect line (from the centre of road). At each sampling station, prefixed transects were walked down at a uniform pace of about 1-1.5 km h^{-1} (Rajashekara & Venkatesha, 2017). Birds were surveyed on mornings (06.00-10.00 h) when the birds sing most actively and exhibit more flights under the conditions of low human activity (Bibby et al., 1998; Das et al., 2010). Opportunistic observations were done at least once a month so as not to miss any species during the survey period.

Birds were not surveyed during raining or windy days. Birds which flew high overhead from the upper canopies of trees and buildings in the campus or have occurred outside the transect boundary were omitted in the counts. Regular fortnightly surveys between March, 2019 and February, 2020 were done by walk on fixed transects laid in the campus. Thus a cumulative total of 24 surveys were done for each transect during the entire study period. All bird surveys were conducted by the first author (RS). During survey, the observer wore light color clothes to minimize the attraction of birds. Olympus (10*50x) binocular for close observation of the birds was used. The photographs of the birds were taken with a CANON digital camera (EOS 200D II)

with 250mm zooming lens. Standard field guides (Ali, 2002; Grimmett et al., 2016) were used for identification of the birds in the field. The checklist of the birds was prepared using the standardized common and scientific names of the birds of the Indian subcontinent by Gill et al. (2020). During the survey, the feeding habit of bird species and the type of habitat they are found were also observed. We also noted anthropogenic activities that potentially pose threats to the birds of the campus.

2.3. Data analysis

We tested the bird data sets for normality using the Shapiro-Wilk test. Species richness was presented as the total number of species in the study area. The relative diversity (RDi) of families was estimated using the following formula (La Torre-Cuadros et al., 2007):

$$RD_i = [(\text{Number of bird species in a family})/(\text{Total number of species})].100$$

Bird species were classified into six major feeding guilds: insectivore (IV), carnivore (CV), grainivore (GV), nectivore (NV), frugivore (FV) or omnivore (OV) (Ali and Ripley, 1987; Barth et al., 2015). We followed the IUCN Red List (2021) to compile the global population trend (decreasing, increasing, stable, and unknown) of the recorded species. Following Devi et al. (2012) and Ali et al. (2013) residential status of the recorded birds was categorized into three categories as: (1) Residents (RS) (species found in the study area throughout the year), Winter Migrants (WM) (species migrants from outside India during winter) and Local Migrants (LM) (species migrate locally within the area but are residents of India). Depending on the frequency of sightings during the field visits birds were classified (Ali et al., 2013) as abundant (A) (birds sighted in more than 80% of the visits), common (C) (sighted in 60-<80 %), uncommon (U) (sighted in 40-<60%), occasional (O) (sighted in 20-<40%) and rare (R) (sighted in <20%).

3. Results and discussion

3.1. Results

The Banaras Hindu University campus houses a good number of avifauna as it has a rich and varied vegetation pattern and possesses a diversity of habitats including water bodies, agricultural fields, gardens and parks, vegetated roads, home gardens. A total of 141 species of birds belonging to 62 families were recorded from the study area (Table 1). The Shapiro-Wilk test showed that bird data sets had a significant departure from normality, $W(141) = 0.92$, $p < 0.001$.

Table 1. Checklist of the birds recorded in Banaras Hindu University campus of Varanasi, India.

	Family/Common name	Zoological name	Feeding status	Residential status	Abundance status	Conservation status	Global status
	Accipitridae (3)						
1	Black kite	*Milvus migrans* (Boddaert, 1783)	CV	RS	O	LC	→
2	Indian Spotted Eagle	*Clanga hastata* (Lesson, R, 1831)	CV	RS	O	VU	↓
3	Oriental Honey-buzzard	*Pernis ptilorhynchus orientalis* Taczanowski, 1891	CV	RS	U	LC	→
	Acrocephalidae (3)						
4	Blyth's Reed Warbler	*Acrocephalus dumetorum* Blyth, 1849	OV	WM	R	LC	↑
5	Booted Warbler	*Iduna caligata* (Lichtenstein, MHK, 1823)	IV	WM	C	LC	↑
6	Sykes's Warbler	*Iduna rama* (Sykes, 1832)	IV	WM	U	LC	→
	Aegithinidae (1)						
7	Common Iora	*Aegithina tiphia* (Linnaeus, 1758)	OV	RS	C	LC	?
	Alaudidae (5)						
8	Ashy-crowned Sparrow Lark	*Eremopterix griseus* (Scopoli, 1786)	OV	RS	U	LC	→
9	Bengal Bush Lark	*Mirafra assamica* Horsfield 1840	OV	RS	C	LC	→
10	Crested Lark	*Galerida cristata lynesi* Whistler, 1928	OV	RS	U	LC	↓
11	Indian Bush Lark	*Mirafra erythroptera* Blyth, 1845	OV	RS	U	LC	→
12	Oriental Skylark	*Alauda gulgula* Franklin, 1831	OV	RS	U	LC	↓
	Alcedinidae (3)						
13	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	CV	RS	U	LC	?
14	Pied Kingfisher	*Ceryle rudis insignis* Hartert, 1910	CV	RS	U	LC	?
15	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	CV	RS	U	LC	↑
	Apodidae (2)						
16	Asian Palm Swift	*Cypsiurus balasiensis* (Gray, JE, 1829)	IV	RS	C	LC	→
17	Little Swift	*Apus affinis* (Gray, JE, 1829)	IV	RS	U	LC	↑

	Ardeidae (4)						
18	Western Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	CV	RS	C	LC	↑
19	Great Egret	*Ardea alba* Linnaeus, 1758	CV	RS	U	LC	?
20	Indian Pond-heron	*Ardeola grayii* (Sykes, 1832)	CV	RS	U	LC	?
21	Intermediate Egret	*Ardea intermedia* Wagler, 1829	CV	RS	U	LC	↓
	Bucerotidae (2)						
22	Indian Grey Hornbill	*Ocyceros birostris* (Scopoli, 1786)	OV	RS	O	LC	→
23	Oriental Pied Hornbill	*Anthracoceros albirostris* (Shaw 1808)	OV	RS	O	LC	→
	Burhinidae (2)						
24	Eurasian Stone-curlew	*Burhinus oedicnemus harterti* Vaurie, 1963	CV	RS	R	LC	↓
25	Great Stone-curlew	*Esacus recurvirostris* (Cuvier, 1829)	CV	RS	R	NT	↓
	Campephagidae (3)						
26	Indian Cuckooshrike	*Coracina macei* (Lesson, R, 1831)	OV	RS	C	LC	↓
27	Long-tailed Minivet	*Pericrocotus ethologus* Bangs & Phillips, JC, 1914	IV	RS	U	LC	↓
28	Small Minivet	*Pericrocotus cinnamomeus* (Linnaeus, 1766)	IV	RS	C	LC	→
	Caprimulgidae (3)						
29	Indian Nightjar	*Caprimulgus asiaticus* Latham, 1790	IV	RS	U	LC	→
30	Large-tailed Nightjar	*Caprimulgus macrurus albonotatus* Tickell, 1833	IV	RS	U	LC	→
31	Savanna Nightjar	*Caprimulgus affinis monticolus* Franklin, 1831	IV	RS	U	LC	→
	Charadriidae (2)						
32	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	OV	RS	C	LC	?
33	River Lapwing	*Vanellus duvaucelii* (Lesson, R, 1826)	IV	RS	C	NT	↓
	Ciconiidae (2)						
34	Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	CV	RS	U	NT	↓

35	Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	CV	RS	U	NT	↓
	Cisticolidae (5)						
36	Ashy Prinia	*Prinia socialis* Sykes, 1832	IV	RS	C	LC	→
37	Common Tailorbird	*Orthotomus sutorius guzuratus* (Latham, 1790)	IV	RS	C	LC	→
38	Grey-breasted Prinia	*Prinia hodgsonii* Blyth, 1844	IV	RS	U	LC	→
39	Plain Prinia	*Prinia inornata* Sykes, 1832	IV	RS	U	LC	→
40	Zitting Cisticola	*Cisticola juncidis cursitans* (Franklin, 1831)	IV	RS	U	LC	↑
	Columbidae (4)						
41	Eurasian Collared Dove	*Streptopelia decaocto* (Frivaldszky, 1838)	GV	RS	A	LC	↑
42	Orange-breasted Green-Pigeon	*Treron bicinctus* (Jerdon, 1840)	FV	RS	C	LC	↓
43	Rock Dove	*Columba livia gaddi* Zarudny & Loudon, 1906	GV	RS	A	LC	↓
44	Eastern Spotted Dove	*Streptopelia chinensis* (Scopoli, 1786)	GV	RS	C	LC	↑
	Coraciidae (1)						
45	Indian Roller	*Coracias benghalensis* (Linnaeus, 1758)	CV	RS	U	LC	↑
	Corvidae (3)						
46	House Crow	*Corvus splendens* Vieillot, 1817	OV	RS	A	LC	→
47	Large-billed Crow	*Corvus macrorhynchos tibetosinensis* Kleinschmidt, O & Weigold, 1922	OV	RS	U	LC	→
48	Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)	OV	RS	O	LC	↓
	Cuculidae (4)						
49	Banded Bay Cuckoo	*Cacomantis sonneratii* (Latham, 1790)	IV	RS	U	LC	→
50	Asian Koel	*Eudynamys scolopaceus* (Linnaeus, 1758)	OV	RS	C	LC	→
51	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	OV	RS	U	LC	→
52	Grey-bellied Cuckoo	*Cacomantis passerinus* (Vahl, 1797)	IV	RS	O	LC	→
	Dicaeidae (2)						

53	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos* (Latham, 1790)	NV	RS	U	LC	→
54	Thick-billed Flowerpecker	*Dicaeum agile* (Tickell, 1833)	NV	RS	O	LC	→
	Dicruridae (2)						
55	Ashy Drongo	*Dicrurus leucophaeus longicaudatus* Jerdon, 1862	IV	RS	U	LC	?
56	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817	IV	RS	C	LC	?
	Emberizidae (1)						
57	Red-headed Bunting	*Emberiza bruniceps* Brandt, JF, 1841	IV	WM	O	LC	→
	Estrildidae (3)						
58	Tricolored Munia	*Lonchura malacca* (Linnaeus, 1766)	GV	RS	U	LC	→
59	Indian Silverbill	*Euodice malabarica* (Linnaeus, 1758)	GV	RS	O	LC	→
60	Scaly-breasted Munia	*Lonchura punctulata* (Linnaeus, 1758)	GV	RS	R	LC	→
	Falconidae (2)						
61	Common Kestrel	*Falco tinnunculus* Linnaeus, 1758	CV	RS	R	LC	↓
62	Laggar Falcon	*Falco jugger* Gray, JE, 1834	CV	RS	O	NT	↓
	Fringillidae (1)						
63	Common Rosefinch	*Carpodacus erythrinus* (Pallas, 1770)	GV	LM (W)	R	LC	↓
	Glareolidae (1)						
64	Indian Courser	*Cursorius coromandelicus* (Gmelin, JF, 1789)	IV	RS	R	LC	→
	Hemiprocnidae (1)						
65	Crested Treeswift	*Hemiprocne coronata* (Tickell, 1833)	IV	RS	C	LC	↓
	Hirundinidae (4)						
66	Asian House Martin	*Delichon dasypus cashmeriense* (Gould, 1858)	IV	LM (W)	C	LC	↑
67	African Plain Martin	*Riparia paludicola* (Vieillot, 1817)	IV	RS	R	LC	↓
68	Pale Martin	*Riparia diluta* (Sharpe & Wyatt, 1893)	IV	RS	R	LC	?
69	Streak-throated Swallow	*Petrochelidon fluvicola* (Blyth, 1855)	IV	RS	O	LC	↑

	Irenidae (1)						
70	Jerdon's Leafbird	*Chloropsis jerdoni* (Blyth, 1844)	IV	RS	O	LC	→
	Laniidae (3)						
71	Bay-backed Shrike	*Lanius vittatus* Valenciennes, 1826	CV	RS	C	LC	→
72	Brown Shrike	*Lanius cristatus* Linnaeus, 1758	CV	WM	R	LC	↓
73	Long-tailed Shrike	*Lanius schach erythronotus* (Vigors, 1831)	CV	RS	O	LC	?
	Leiothrichidae (3)						
74	Common Babbler	*Argya caudata* (Dumont, 1823)	OV	RS	C	LC	→
75	Jungle Babbler	*Argya striata* (Dumont, 1823)	OV	RS	A	LC	→
76	Striated Babbler	*Argya earlei* (Blyth, 1844)	OV	RS	U	LC	↓
	Locustellidae (1)						
77	Striated Grassbird	*Megalurus palustris toklao* (Blyth, 1843)	OV	RS	C	LC	?
	Meropidae (2)						
78	Green Bee-eater	*Merops orientalis* Latham, 1801	IV	RS	C	LC	↑
79	Blue-tailed Bee-eater	*Merops philippinus* Linnaeus, 1767	IV	RS	O	LC	→
	Monarchidae (1)						
80	Indian Paradise-flycatcher	*Hypothymis paradisi* (Linnaeus, 1758)	IV	RS	R	LC	→
	Motacillidae (6)						
81	Paddyfield Pipit	*Anthus rufulus* Vieillot, 1818	IV	RS	U	LC	→
82	Richard's Pipit	*Anthus richardi* Vieillot, 1818	IV	WM	O	LC	→
83	Tawny Pipit	*Anthus campestris* (Linnaeus, 1758)	IV	WM	U	LC	→
84	Tree Pipit	*Anthus trivialis* (Linnaeus, 1758)	IV	LM (W)	U	LC	↓
85	White-browed Wagtail	*Motacilla maderaspatensis* Gmelin, JF, 1789	IV	RS	R	LC	→
86	White Wagtail	*Motacilla alba* Linnaeus, 1758	IV	WM	O	LC	→
	Musicapidae (8)						

87	Black Redstart	*Phoenicurus ochruros phoenicuroides* (Moore, F, 1854)	IV	LM (W)	R	LC	↑
88	Bluethroat	*Luscinia svecica* (Linnaeus, 1758)	IV	LM (W)	U	LC	→
89	Indian Robin	*Copsychus fulicatus* (Linnaeus, 1766)	IV	RS	C	LC	→
90	Isabelline Wheatear	*Oenanthe isabellina* (Temminck, 1829)	IV	WM	O	LC	→
91	Oriental Magpie-Robin	*Copsychus saularis* (Linnaeus, 1758)	OV	RS	C	LC	→
92	Pied Bush Chat	*Saxicola caprata burmanicus* Baker, ECS, 1922	IV	RS	C	LC	→
93	Siberian Rubythroat	*Calliope calliope* (Pallas, 1776)	IV	WM	O	LC	→
94	Tickell's Blue Flycatcher	*Cyornis tickelliae* Blyth, 1843	IV	RS	U	LC	→
	Nectariniidae (2)						
95	Crimson Sunbird	*Aethopyga siparaja seheriae* (Tickell, 1833)	NV	RS	O	LC	→
96	Purple Sunbird	*Cinnyris asiaticus* (Latham, 1790)	NV	RS	C	LC	→
	Oriolidae (2)						
97	Black-hooded Oriole	*Oriolus xanthornus* (Linnaeus, 1758)	OV	RS	O	LC	→
98	Indian Golden Oriole	*Oriolus kundoo* Sykes, 1832	OV	RS	U	LC	?
	Paridae (1)						
99	Great Tit	*Parus major* Linnaeus, 1758	IV	RS	O	LC	↑
	Passeridae (2)						
100	House Sparrow	*Passer domesticus indicus* Jardine & Selby, 1831	OV	RS	C	LC	↓
101	Yellow-throated Sparrow	*Gymnoris xanthocollis* (Burton, 1838)	OV	RS	U	LC	→
	Phalacrocoracidae (1)						
102	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	CV	RS	O	LC	?
	Phasianidae (4)						
103	Black Francolin	*Francolinus francolinus* (Linnaeus, 1766)	OV	RS	R	LC	→
104	Common Quail	*Coturnix coturnix (*Linnaeus, 1758)	OV	LM (W)	R	LC	↓

105	Indian Peafowl	*Pavo cristatus* Linnaeus, 1758	OV	RS	C	LC	→
106	Rain Quail	*Coturnix coromandelica* (Gmelin, JF, 1789)	OV	RS	R	LC	→
	Phylloscopidae (3)						
107	Common Chiffchaff	*Phylloscopus collybita tristis* Blyth, 1843	IV	WM	O	LC	↑
108	Greenish Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	IV	LM (W)	O	LC	↑
109	Hume's Leaf Warbler	*Phylloscopus humei* (Brooks, WE, 1878)	IV	LM (W)	R	LC	→
	Picidae (2)						
110	Black-rumped Flameback	*Dinopium benghalense* (Linnaeus, 1758)	OV	RS	C	LC	→
111	Yellow-crowned Woodpecker	*Leiopicus mahrattensis* (Latham, 1801)	IV	RS	R	LC	→
	Pittidae (1)						
112	Indian Pitta	*Pitta brachyura* (Linnaeus, 1766)	IV	LM (S)	O	LC	↓
	Ploceidae (2)						
113	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)	OV	RS	O	LC	→
114	Black-breasted Weaver	*Ploceus benghalensis* (Linnaeus, 1758)	OV	RS	O	LC	→
	Psittaculidae (2)						
115	Plum-headed Parakeet	*Psittacula cyanocephala* (Linnaeus, 1766)	FV	RS	U	LC	↓
116	Rose-ringed Parakeet	*Psittacula krameri borealis* (Neumann, 1915)	FV	RS	U	LC	↑
	Pteroclidae (1)						
117	Chestnut-bellied Sandgrouse	*Pterocles exustus hindustan* Meinertzhagen, R, 1923	GV	RS	R	LC	→
	Pycnonotidae (3)						
118	Himalayan Bulbul	*Pycnonotus leucogenys* (Gray, JE, 1835)	OV	RS	O	LC	↑
119	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	OV	RS	C	LC	↑
120	White-eared Bulbul	*Pycnonotus leucotis* (Gould, 1836)	OV	RS	O	LC	↓
	Rallidae (2)						

121	Brown Crake	*Amaurornis akool* (Sykes, 1832)	OV	RS	R	LC	?
122	Eurasian Coot	*Fulica atra* Linnaeus, 1758	OV	RS	R	LC	↑
	Ramphastidae (2)						
123	Brown-headed Barbet	*Psilopogon zeylanicus* (Gmelin, JF, 1788)	OV	RS	O	LC	→
124	Coppersmith Barbet	*Psilopogon haemacephalus indicus* (Latham, 1790)	FV	RS	U	LC	↑
	Rhipiduridae (1)						
125	White-browed Fantail	*Rhipidura aureola* Lesson, R, 1831	IV	RS	O	LC	→
	Sittidae (2)						
126	Indian Nuthatch	*Sitta castanea* Lesson, R, 1830	OV	RS	C	LC	?
127	Indian Spotted Creeper	*Salpornis spilonota* (Franklin, 1831)	IV	RS	R	LC	↓
	Stenostiridae (1)						
128	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)	IV	LM (W)	R	LC	→
	Strigidae (2)						
129	Jungle Owlet	*Glaucidium radiatum* (Tickell, 1833)	CV	RS	R	LC	→
130	Spotted Owlet	*Athene brama* (Temminck, 1821)	CV	RS	O	LC	→
	Sturnidae (2)						
131	Pied Myna	*Gracupica contra* (Linnaeus, 1758)	OV	RS	C	LC	↑
132	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	OV	RS	A	LC	↑
	Sylviidae (2)						
133	Eastern Orphean Warbler	*Sylvia crassirostris* Cretzschmar,1827	OV	WM	O	LC	↑
134	Yellow-eyed Babbler	Chrysomma sinense (Gmelin, JF, 1789)	OV	RS	O	LC	→
	Timaliidae (1)						
135	Tawny-bellied Babbler	*Dumetia hyperythra* (Franklin, 1831)	OV	RS	U	LC	↓
	Turdidae (2)						
136	Scaly Thrush	*Zoothera dauma* (Latham, 1790)	OV	RS	O	LC	↓

137	Tickell's Thrush	*Turdus unicolor* Tickell, 1833	OV	LM (W)	O	LC	?
	Turnicidae (1)						
138	Common Buttonquail	*Turnix sylvaticus dussumier* (Temminck, 1828)	OV	RS	R	LC	↓
	Upupidae (1)						
139	Eurasian Hoopoe	*Upupa epops* Linnaeus, 1758	OV	RS	U	LC	↓
	Vangidae (1)						
140	Common Woodshrike	*Tephrodornis pondicerianus* (Gmelin, JF, 1789)	IV	RS	U	LC	→
	Zosteropidae (1)						
141	Indian White-eye	*Zosterops palpebrosus* (Temminck, 1824)	OV	RS	C	LC	↓

Note: RS: Residents, WM: Winter Migrants, LM: Local Migrants; LC: Least Concern; NT: Near Threatened; VU: Vulnerable; CV: Carnivorous; OV: Omnivorous; IV: Insectivorous; FV: Frugivorous; GV: Granivorous; NV: Nectarivorous; ?: Unknown; →: Stable; ↑: Increasing; ↓: Decreasing; A: Abundant; C: Common; O: Ocassional; R: Rare; and U: Uncommon.

Among 62 bird families, Musicapidae was most diverse family (8 species; RD_i=5.67) (Table 2). Motacillidae (6 species; RD_i = 4.25) was second most diverse bird family.

Table 2. Relative diversity (RD_i) of various avian families in the Banaras Hindu University campus of Varanasi, India.

Bird families	Number of bird species	Relative diversity (RD_i)
Accipitridae	3	2.12
Acrocephalidae	3	2.12
Aegithinidae	1	0.70
Alaudidae	5	3.54
Alcedinidae	3	2.12
Apodidae	2	1.41
Ardeidae	4	2.83
Bucerotidae	2	1.41
Burhinidae	2	1.41
Campephagidae	3	2.12
Caprimulgidae	3	2.12

Charadriidae	2	1.41
Ciconiidae	2	1.41
Cisticolidae	5	3.54
Columbidae	4	2.83
Coraciidae	1	0.70
Corvidae	3	2.12
Cuculidae	4	2.83
Dicaeidae	2	1.41
Dicruridae	2	1.41
Emberizidae	1	0.70
Estrildidae	3	2.12
Falconidae	2	1.41
Fringillidae	1	0.70
Glareolidae	1	0.70
Hemiprocnidae	1	0.70
Hirundinidae	4	2.83
Irenidae	1	0.70
Laniidae	3	2.12
Leiothrichidae	3	2.12
Locustellidae	1	0.70
Meropidae	2	1.41
Monarchidae	1	0.70
Motacillidae	6	4.25
Musicapidae	8	5.67
Nectariniidae	2	1.41
Oriolidae	2	1.41
Paridae	1	0.70
Passeridae	2	1.41
Phalacrocoracidae	1	0.70

Phasianidae	4	2.83
Phylloscopidae	3	2.12
Picidae	2	1.41
Pittidae	1	0.70
Ploceidae	2	1.41
Psittaculidae	2	1.41
Pteroclidae	1	0.70
Pycnonotidae	3	2.12
Rallidae	2	1.41
Ramphastidae	2	1.41
Rhipiduridae	1	0.70
Sittidae	2	1.41
Stenostiridae	1	0.70
Strigidae	2	1.41
Sturnidae	2	1.41
Sylviidae	2	1.41
Timaliidae	1	0.70
Turdidae	2	1.41
Turnicidae	1	0.70
Upupidae	1	0.70
Vangidae	1	0.70
Zosteropidae	1	0.70

Six foraging guilds were found in the study area. The campus avifauna is composed of insectivorous (53 bird species, 37.59%) followed by omnivorous (49 species, 34.75%), carnivorous (23 species, 16.31%), granivorous (8 species, 5.67%), frugivorous (4 species, 2.84%), and nectarivorous (4 species, 2.87%) (Fig. 2).

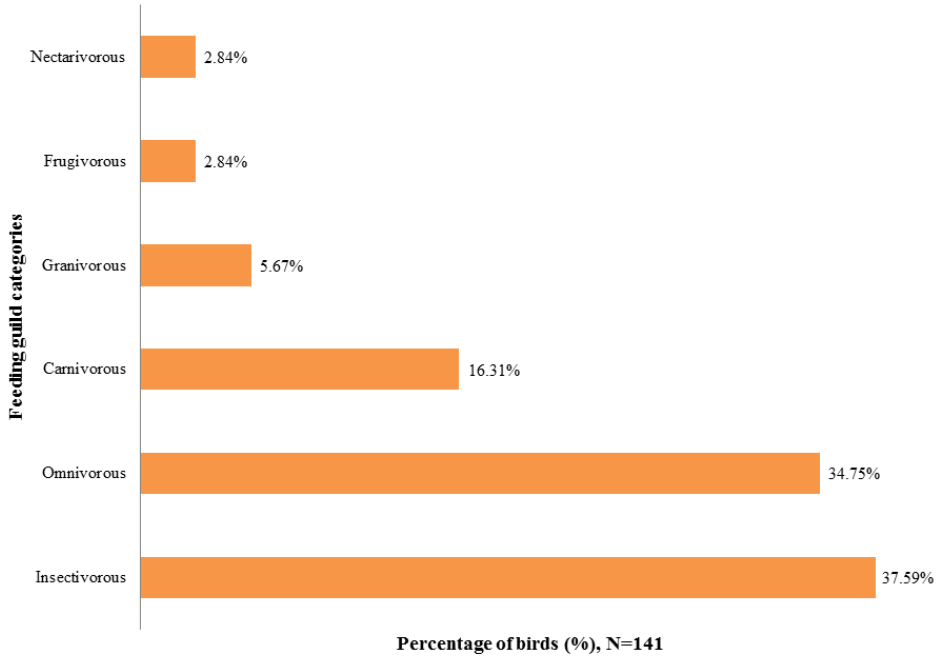

Figure 2. Feeding Guilds of avian species recorded in Banaras Hindu University campus of Varanasi, India.

According to the residential status of the birds, 118 bird species (83.69%) were residents, 12 bird species (8.51%) were winter migrants and 11 bird species (7.80%) were local migrants (Fig. 3).

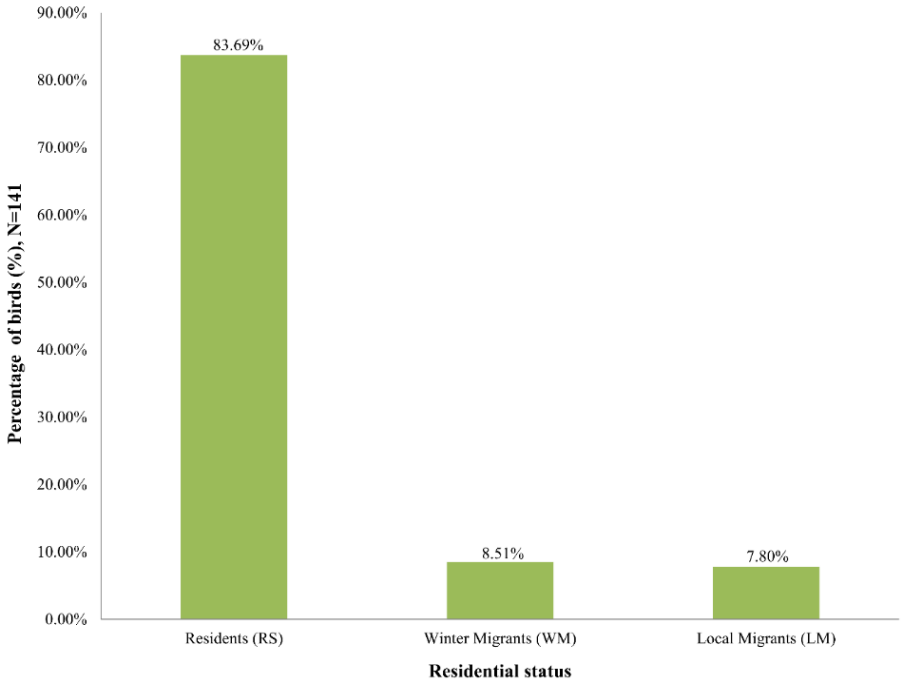

Figure 3. Residential status of avian species recorded in Banaras Hindu University campus of Varanasi, India

Among the total species recorded in the campus, 43 (30.50%) species were uncommon, 36 (25.53%) species were occasional, 32 (22.69%) species were common, 25 (17.53%) species were rare and 5 (3.55%) species were abundant (Fig. 4).

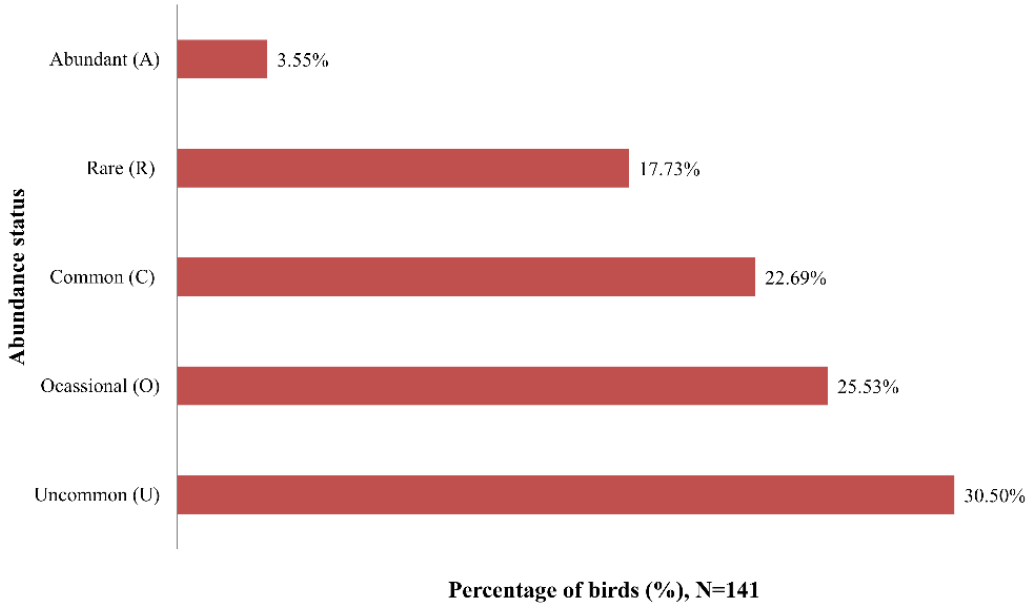

Figure 4. Abundance status of avian species recorded in Banaras Hindu University campus of Varanasi, India

The pictures of some commonly found birds in the Banaras Hindu University campus are given the Figure 5.

Figure 5. Commonly found birds in the Banaras Hindu University campus, Varanasi, India

According to the IUCN Red List, out of the 141 species recorded, 135 species (95.74%) were Least Concern, five species (3.55%) and one species (0.71%) was vulnerable (Fig. 6).

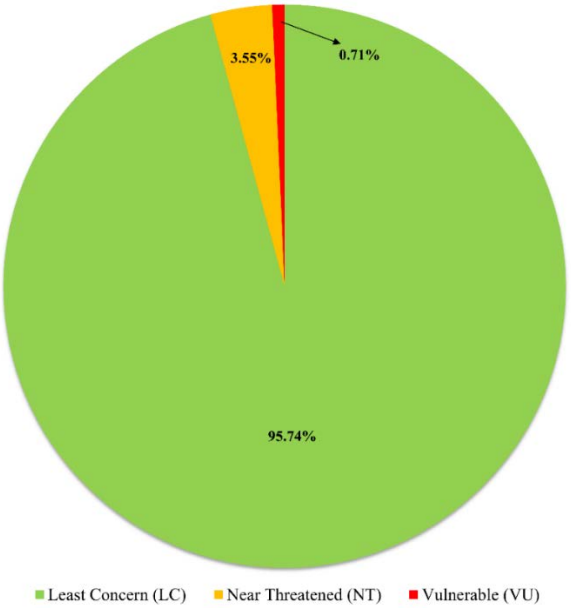

Figure 6. Conservation status of avian species recorded in Banaras Hindu University campus of Varanasi, India

According to the global population trend, the campus of Banaras Hindu University houses 68 globally stable bird species (48.22%), 33 globally decreasing species (23.40%), 24 globally increasing species (17.02%) and 16 species (11.35%) whose global population trend was unknown (Fig. 7).

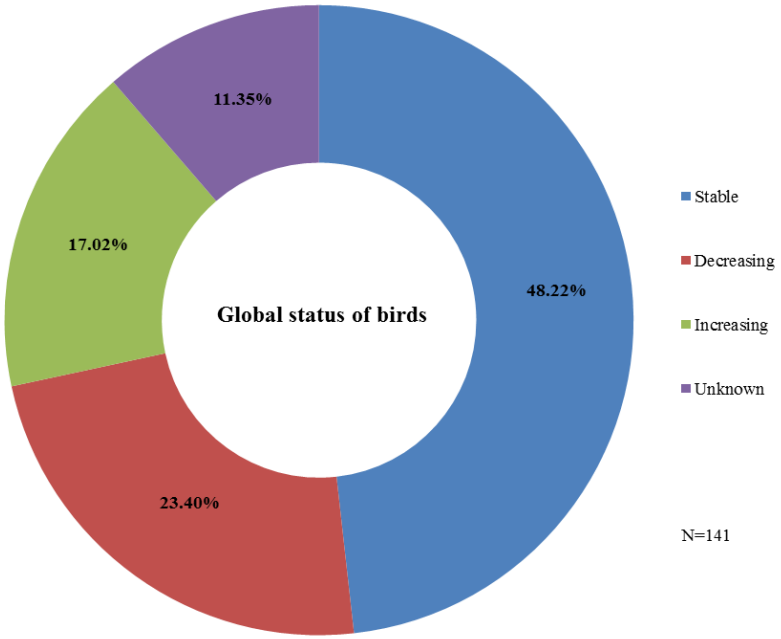

Figure 7. Global status of avian species recorded in Banaras Hindu University campus of Varanasi, India

3.2. Discussion

The diversity of birds indicates the importance of the university campus as a suitable bird habitat. Banaras Hindu University consists of a mosaic of habitats, which house a rich diversity of bird species. Increase in the number of habitats results in increase of species diversity in a landscape (Martínez et al., 2015) due to an expansion in the number of partitionable niche dimensions (Cramer & Willig, 2005). The presence of rich vegetation diversity in the campus provided food, breeding sites and cover for birds. About 8.51% of birds were winter migrants in the campus, which indicated that study area provided food and habitat to visitors also along with resident birds. Avian species serve as potential indicators of integrity and stability of ecosystem structure and functions (Hossain & Aditya, 2016). Bird surveys give useful information for identifying priority areas for conservation. BHU campus is rich in avifauna but problems have arisen recently as the habitats of these birds are threatened and degrading due to increasing construction of buildings, unplanned activities, vehicular pollution, and rising human disturbances. If the destruction of different habitats and human interference is continued at the present rate, the avifauna of the campus will be adversely affected. The university campus calls for more effort in conservation and management of natural habitats and avifauna. The BHU campus is under severe threat of urbanization and anthropogenic impacts including disturbances and rampart rise in buildings and settlements at the cost of green cover. Further, many water bodies and wetlands in the campus are losing their existences. These modifications and disturbances are reducing the habitats for avifauna. Birds are sensitive to the local landscape and modification in vegetation patterns can disturb the avifauna in the area (Jain et al., 2005; Das et al., 2010). Constructions are important for education and development but the university administration needs urgent and sustainable actions for better management of the green cover and natural habitats. BHU is among the greenest landscapes in Varanasi city, which should be managed well to attract more bird species and make the campus habitable for various birds. Habitat heterogeneity should be maintained for the conservation of species richness in habitats (McGarigal & McComb, 1992; Chakdar et al., 2016). Therefore, some areas of the university should be kept out of the developmental activities. The degraded wetlands of the university should be restored to enhance habitat heterogeneity and biodiversity in the campus.

4. Conclusions

Present findings indicate that the availability of a variety of food resources and habitats in BHU campus are key factors for richness and the abundance of bird populations. BHU campus is home to 141 bird species including residents (118), winter migrants (12) and local migrants (11). University campuses are important urban green spaces for biodiversity research particularly avian and plant diversity. To increase human well-being and conserve nature and its services, natural habitats in the Banaras Hindu University campus need sustainable management.

Besides education and research, such large university can be used for conservation of ecosystem and its services in urban landscapes. Campus biodiversity-based educational and research should be promoted. Biodiversity in the university campuses provides a unique chance to link people with nature and its ecosystem services. Local people, students and university employees should be aware about the richness and ecosystem services linked with avian diversity. Specific awareness programme would be helpful in educating the public and people to protect the habitats and birds in university campuses (Rajashekara & Venkatesha, 2017). Management of habitats, periodic monitoring of bird populations and timely awareness play a key role in conservation of bird species in a landscape (Dendup et al., 2021).

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