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Habitat-dependent avian diversity in the agri-industrial zone of Jhajjar, Haryana, India

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ABSTRACT

The study was performed to evaluate the habitat-dependent avian diversity in the southern region of Haryana from March 2021 to March 2023. The study aimed to identify avian species diversity in three habitats (agrifields, human settlement, and industrial zone) along with diversity indices and relative diversity. A total of 5037 birds belonging to 17 orders, 41 families, and 88 species were investigated with Simpson's diversity index of 0.973 and Shannon–Wiener index of 4.04. Analysis of threat status revealed 38 species with stable population trends, 19 increasing, 20 decreasing, and 11 species having unknown trends. Out of 88 species, the IUCN status of two species *Aquila nipalensis* and *Psittacula eupatria* was endangered and near threatened, respectively; the rest 86 belonged to the least concern category. Of the total, 81% of species were residential, 10 were winter migratory, and 7 were summer migratory. Among the three habitats, agrifields were the most diverse, followed by human settlement and industrial zone. Diversified assemblages of birds suggested the region as a suitable habitat for both resident and migratory birds. This study highlights the need for more regular investigations to assess yearly avian diversity and possible threats to design comprehensive conservation plans.

1. INTRODUCTION

Birds are considered crucial species in different ecosystems, act as pollinators and pest control agents, regulate the physio-chemical resources of the ecosystem, and have diversified feeding guilds [1,2]. Avian species diversity, community structure, habitat utilization, and status variation reflect a habitat's environmental well-being, resource availability, and ecosystem health [3,4]. Even minor changes in the environment are reflected in the bird community. Moreover, bird diversity assessment provides more integrated and direct knowledge about ecosystem functioning and resource richness [5,6]. Therefore, evaluating the species composition and diversity provides crucial insight into ecosystem integrity, ecological understanding, land use patterns, and habitat potential [7,8].

India is one of the four mega-diversity harboring countries situated in the oriental realm; it has various geophysical resources to support a wide range of animal and plant species [9,10]. It harbors 13% of global avian diversity, comprising ~1400 species. Haryana is situated in the Great Plains of India and is home to nearly 400 bird species. In Haryana, almost 86% of the area comes under agrifields. However, most of the studies concerning avian diversity were confined to lakes, wetlands, and protected areas of Haryana [11-14]. However, recently, the focus has been slowly shifting to assessment and conservation outside wetlands and protected areas. Agrifields serve as a buffer zone for avian biodiversity and its protection [15]. These agrifields also serve as breeding grounds and nesting and roosting sites for birds. Although less than 1% of bird species dwell in agrifields as their primary habitat, nearly one-third of global bird species use agrifields for perching, roosting, nesting, and so on [4,16]. Conversion of forest areas into agricultural land, intensification of agriculture, and industrial development have caused adverse impacts on species diversity [17,18]. Assessment of habitat heterogeneity on avian community structure and resource management in the agrifields is significant for bird conservation and environmental understanding of avian communities [19,20].

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Therefore, it becomes necessary to document the avian diversity in agrifields of Haryana to investigate the role of resource distribution, anthropogenic activities, and habitat composition on avian diversity. This study aimed to prepare a checklist to document the habitat dependence, composition, and distribution of avifauna in agrifields of Jharli, Jhajjar region of southern Haryana, that can be further used as a baseline for further scientific research.

2. MATERIALS AND METHODS

2.1. Study Site

The study of avian population diversity was conducted on a 20 km^2 area of the village Jharli, Sunderheti, Jhanswa, in the Jhajjar district of Haryana [Figure 1]. The Epicenter of the study site—Jharli—is 35 km south of the district headquarters, Jhajjar, and about 90 km southwest of the national capital, New Delhi. The study area includes the largest thermal power plant in Haryana, established in 2007 on 2191 acres, and 4 cement factories. The study site experiences a semi-arid, dry, deciduous climate with uniform elevation, an average temperature of 25°C, and a mean precipitation of 476 mm/year. The place was selected due to varying degrees of annual average temperature and rainfall in different seasons, including winter, summer, and monsoon, and habitat variation, including industrial area, village establishments, and agrifields. Each habitat type experiences varying degrees of disturbance, water availability, and vegetation cover. Agrifields consist of crop-growing areas, forest patches, and ponds with no significant establishment. Prime vegetation consists of weeds, grasses, and seasonal crops, including *Brassica nigera*, *Hordum vulgare*, *Triticum aestivum*, *Pennisetum glaucum*, and so on. Human settlement includes residential zones and standing water bodies having vegetation cover of *Cupparis deciduas*, *Azadirachta indica*, *Prosopis cineraria*, *Acacia nilotica*, and *Ziziphus mauritiana*. The industrial zone consists of an industrial area including a thermal power plant, cement factories, and market area.

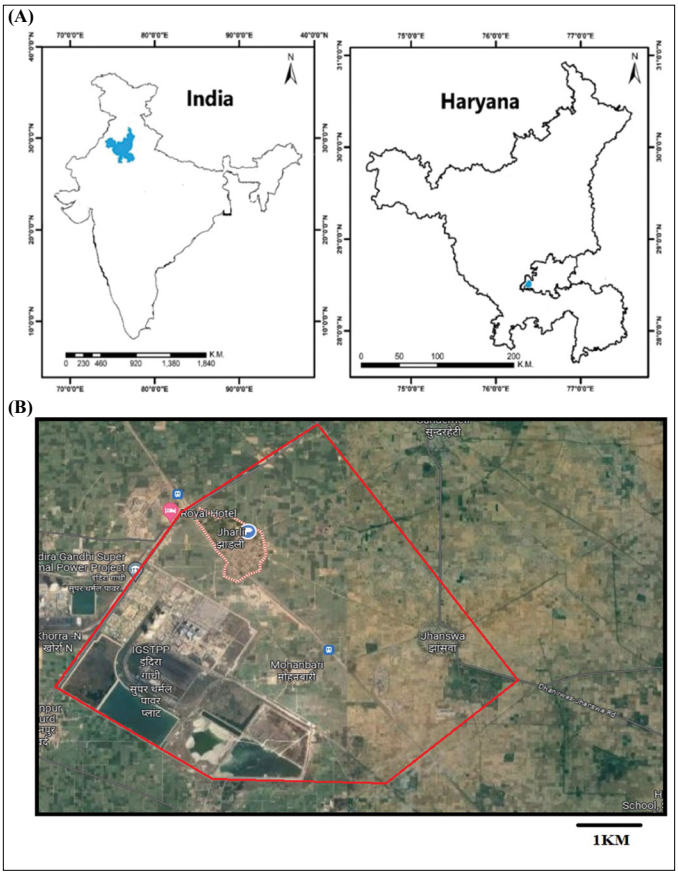

Figure 1: (A) Location and **(B)** outline map of the study site.

2.2. Sampling Methods

The point and count method was used to access the birds with the help of binoculars and a digital camera. A total of 50 points were designated with at least 200 m distance in between them along existing trails. Regular fortnight visits to the study site were made from March 2021 to March 2023 between 6 a.m. to 9 a.m. and 4 p.m. to 6 p.m. Birds were identified by their morphological traits, calls, and habits. Population trends and threat status were accessed from IUCN Red List 2022 (Version 2022.2). Literature, field guide, and field observation were accessed to evaluate feeding guilds and migration status. Birds were classified as winter migratory (recorded from September to March), summer migratory (recorded from March to September), and resident (recorded throughout the year).

Simpson's diversity index (D) was calculated using the following equation:

$$D = 1 - \sum n\left(n-1\right) / N\left(N-1\right)$$

where n is the individual in a single species and N is the total number of individuals in all the species.

Shannon–Weiner Index (H') was calculated using the following equation:

$$H' = \left(\sum_{i=1}^{s} Pi\, lnPi\right)$$

where Pi is the proportion of each species recorded in the study.

Jaccard's species similarity index (J) between different habitat types was accessed using the following equation:

$$J = \frac{C}{A + B - C}$$

where C is the common species in both habitats, A is the species in one habitat, and B is the species in another habitat.

3. RESULTS AND DISCUSSION

A total of 5037 bird individuals were observed from the study site from March 2021 to March 2023. These birds belonged to 88 species from 41 families distributed among 17 orders dwelling in three different habitat types, i.e., agrifields, human settlement, and industrial zone [Table 1]. Recently, few studies have reported 75 bird species in Tilyar Lake, Rohtak [12], 149 bird species in 2022 and 111 bird species in Sultanpur National Park, Gurugram, in 2020 [14,21], and 124 species from Mandothi wetland, Jhajjar [13] in southern Haryana. Interestingly, all the known studies so far have evaluated avian diversity in or around wetlands. This study was the first to document the avian diversity in agri-industrial zones from southern Haryana. Earlier, a few studies documented the avian diversity in the agricultural landscape

Table 1: Checklist of birds recorded in the study area.

	Family	Names	Zoological Name	TS	PT	MS	HT	N
Order: Accipitriformes								
	Accipitridae	Black kite	*Milvus migrans*	LC	U	R	A,I	8
		Black-shouldered kite	*Elanus axillaris*	LC	In	R	A, L	17
		Shikra	*Accipiter badius*	LC	S		A	12
		Eurasian sparrowhawk	*Accipiter nisus*	LC	S		A	7
		Steppe eagle	*Aquila nipalensis*	EN	D		A	4
Order: Anseriformes								
	Anatidae	Indian spot-billed duck	*Anas poecilorhyncha*	LC	D		L	23
Order: Bucerotiformes								
	Bucerotidae	Indian gray hornbill	*Ocyceros birostris*	LC	S		A,L,I	12
	Upupidae	Common hoopoe	*Upupa epops*	LC	D		A,L	37
Order: Caprimulgiformes								
	Apodidae	Little swift	*Apus affinis*	LC	In		A,L	41
Order: Charadriiformes								
	Burhinidae	Eurasian thick-knee	*Burhinus oedicnemus*	LC	D		A	36
	Charadriidae	Red-wattled lapwing	*Vanellus indicus*	LC	U		A,L,I	62
	Recurvirostridae	Black-winged stilt	*Himantopus himantopus*	LC	In		A	48
	Scolopacidae	Common sandpiper	*Actitis hypoleucos*	LC	D	W	L	24
Order: Columbiformes								
	Columbidae	Rock pigeon	*Columba livia*	LC	D		A,L,I	254
		Yellow-footed green pigeon	*Treron phoenicopterus*	LC	In		L	118
		Eurasian collared dove	*Streptopelia decaocto*	LC	In		A,L,I	223
		Laughing dove	*Spilopelia senegalensis*	LC	S		A	67
Order: Coraciiformes								
	Alcedinidae	White breasted kingfisher	*Halcyon smyrnensis*	LC	In		A,L,I	23
	Coraciidae	European roller	*Coracias garrulous*	LC	D	Sm	A	18
		Indian roller	*Coracias benghalensis*	LC	In		A	8
	Meropidae	Asian green bee eater	*Merops orientalis*	LC	In	Sm	A,L,I	143
		Blue-tailed bee eater	*Merops philippinus*	LC	S	Sm	A	51
Order: Cuculiformes								
	Cuculidae	Western koel	*Eudynamys scolopaceus*	LC	S		A,L,I	26
		Jacobin cuckoo	*Clamator jacobinus*	LC	S	Sm	A,L	16
		Greater coucal	*Centropus sinensis*	LC	S		A	37
		Gray-bellied cuckoo	*Cacomantis passerines*	LC	S	Sm	A	17
Oredr: Galliformes								
	Phasianidae	Black francolin	*Francolinus francolinus*	LC	S		A,I	34
		Gray francolin	*Francolinus pondicerianus*	LC	S		A	56
		Indian peafowl	*Pavo cristatus*	LC	S		L	23
		Common quail	*Coturnix coturnix*	LC	D		A	66
Order: Gruiformes								
	Rallidae	Common coot	*Fulica atra*	LC	In		L	30
		Common moorhen	*Gallinula chloropus*	LC	S		L	19
		Purple swamphen	*Porphyrio porphyrio*	LC	U		L	16
		White-breasted waterhen	*Amaurornis phoenicurus*	LC	U		L	48

(Continued)

Table 1: (Continued)

	Family	Names	Zoological Name	TS	PT	MS	HT	N
Order: Passeriformes								
	Cisticolidae	Ashy prinia	*Prinia socialis*	LC	S		A	123
		Jungle prinia	*Prinia sylvatica*	LC	D		A	43
		Common tailorbird	*Orthotomus sutorius*	LC	S		A	23
	Corvidae	House crow	*Corvus splendens*	LC	S		A,L,I	378
		Large-billed crow	*Corvus macrorhynchos*	LC	S		A,L,I	14
		Rufous treepie	*Dendrocitta vagabunda*	LC	D		A,L,I	17
	Dicruridae	Black drongo	*Dicrurus macrocercus*	LC	U		A	59
	Estrildidae	White-throated munia	*Euodice malabarica*	LC	S		A	87
	Hirundinidae	Plain martin	*Riparia chinensis*	LC	D		A,L	156
		Wire-tailed swallow	*Hirundo smithii*	LC	In	Sm	L,I	36
	Laniidae	Bay-backed shrike	*Lanius vittatus*	LC	S		A	16
		Long-tailed shrike	*Lanius schach*	LC	U		A	8
	Leiotrichidae	Common babbler	*Argya caudate*	LC	S		A	27
		Jungle babbler	*Turdoides striata*	LC	S		A.L,I	147
	Motacillidae	Gray wagtail	*Motacilla cinerea*	LC	S	W	A,L,I	76
		Western yellow wagtail	*Motacilla flava*	LC	D	W	A,L,I	57
		White wagtail	*Motacilla alba*	LC	S	W	A,L,I	102
		White-browed wagtail	*Motacilla maderaspatensis*	LC	S		A,L,I	34
	Muscicapidae	Red-throated flycatcher	*Ficedula albicilla*	LC	S	W	A	23
		Black redstart	*Phoenicurus ochruros*	LC	In	W	A	18
		Bluethroat	*Cyanecula svecica*	LC	S	W	A	35
		Brown rockchat	*Oenanthe fusca*	LC	S		A,L,I	63
		Pied bush chat	*Saxicola caprata*	LC	S		A,L	45
		Common stonechat	*Saxicola torquatus*	LC	S	W	A	29
		Indian Robin	*Saxicoloides fulicatus*	LC	S		A,L,I	78
	Nectariniidae	Purple sunbird	*Cinnyris asiaticus*	LC	S		A	24
	Passeridae	House sparrow	*Passer domesticus*	LC	D		A,L	134
		Chestnut-shouldered bush sparrow	*Gymnoris xanthocollis*	LC	S		A	84
	Phylloscopidae	Common chiffchaff	*Phylloscopus collybita*	LC	In	W	A,L,I	76
	Ploceidae	Black-breasted weaver	*Ploceus benghalensis*	LC	S		A	62
	Pycnonotidae	Red vented bulbul	*Pycnonotus cafer*	LC	In		A,L,I	78
		White-eared bulbul	*Pycnonotus leucotis*	LC	D		A	17
	Rhipidurinae	White-browed fantail	*Rhipidura aureola*	LC	S	W	A	14
	Sturnidae	Asian pied starling	*Gracupica contra*	LC	In		A	98
		Bank myna	*Acridotheres ginginianus*	LC	In		A,L,I	143
		Common myna	*Acridotheres tristis*	LC	In		A,L	165
		Brahminy starling	*Sturnia pagodarum*	LC	U		A,L	85
		Rosy starling	*Pastor roseus*	LC	U	P	A	263
	Sylviidae	Lesser whitethroat	*Sylvia curruca*	LC	S		A,L,I	69
	Vangidae	Common woodshrike	*Tephrodornis pondicerianus*	LC	S		A	19
	Zosteropidae	Indian white eye	*Zosterops palpebrosus*	LC	D		I	12

(Continued)

Table 1: (Continued)

	Family	Names	Zoological Name	TS	PT	MS	HT	N
Order: Pelecaniformes								
	Ardeidae	Cattle egret	*Bubulcus ibis*	LC	In		A,L	49
		Great white egret	*Ardea alba*	LC	U		L,I	5
		Purple heron	*Ardea purpurea*	LC	D		A,L,I	3
		Little egret	*Egretta garzetta*	LC	In		A,L,I	72
		Intermediate egret	*Ardea intermedia*	LC	D		L	27
		Indian pond heron	*Ardeola grayii*	LC	U		L,	23
		Black-crowned night heron	*Nycticorax nycticorax*	LC	D		L	14
Order: Piciformes								
	Picidae	Black-rumped flameback	*Dinopium benghalense*	LC	S		A,L	7
Order: Podicipediformes								
	Podicipedidae	Little grebe	*Tachybaptus ruficollis*	LC	D		L	15
Order: Psittaciformes								
	Psittacidae	Alexandrine parakeet	*Psittacula eupatria*	NT	D		A,L,I	29
		Rose-ringed parakeet	*Psittacula krameri*	LC	In		A,L,I	47
Order: Strigiformes								
	Strigidae	Spotted owlet	*Athene brama*	LC	S		A,I	38
Order: Suliformes								
	Phalacrocoracidae	Indian cormorant	*Phalacrocorax fuscicollis*	LC	U		L,I	47

TS: Threat status. PT: Population trend. MS: Migratory status. HT: Habitat type. N: Number count. LC: Least concerned. NT: Near threatened. U: Unknown. S: Stable. In: Increasing. D: Decreasing. W: Winter migratory. Sm: Summer migratory. P: Passage migratory. A: Agrifields. L: Locality. I: Industry.

Table 2: Order-wise species and family diversity in the study site.

Orders	Species	Families
Accipitriformes	5	1
Anseriformes	1	1
Bucerotiformes	2	2
Caprimulgiformes	1	1
Charadriiformes	4	4
Columbiformes	4	1
Coraciiformes	5	3
Cuculiformes	4	1
Galliformes	4	1
Gruiformes	4	1
Passeriformes	41	19
Pelecaniformes	7	1
Piciformes	1	1
Podicipediformes	1	1
Psittaciformes	2	1
Strigiformes	1	1
Suliformes	1	1

of Panipat (101 species among 44 families of 15 orders), Karnal (79 species among 36 families of 14 orders), and Sirsa (87 species among 39 families of 16 orders) district in Haryana and reported 101 birds [19,20,22].

In this study, species diversity revealed Passeriformes as the most diverse order (41 species) followed by the order Pelecaniformes (7 species), orders Coraciiformes and Accipitriformes (5 species each), and orders Charadriiformes, Columbiformes, Cuculiformes, Galliformes, and Gruiformes (4 species each). Orders Bucerotiformes and Psittaciformes comprise two species each, while orders Anseriformes, Caprimulgiformes, Piciformes, Podicipediformes, Strigiformes, and Suliformes were represented by one species each [Tables 1 and 2]. The results are in accordance with earlier studies stating Passeriformes as the dominant order of avian community in Bhindawas bird sanctuary [12,14,23], Tilyar Lake, Haryana [12], Sultanpur national park, Haryana [14,21], and Jhunjhunu, Rajasthan [24].

The migratory status revealed the presence of 7 summer migratory, 10 winter migratory, and 71 residential birds [Table 1]. Recent studies have also reported that resident birds constitute the majority of birds dwelling in the agricultural landscapes followed by winter and summer migratory in West Bengal, Haryana, and Uttar Pradesh [19,25,26]. Further insight revealed that the order Passeriformes (n = 11) contributed the maximum in migratory birds, followed by Coraciiformes (n = 3), Cuculiformes (n = 2), and Charadriiformes (n = 1). Winter migratory birds belonged to only two orders, i.e., Passeriformes (n = 9) and Charadriiformes (n = 1), while summer migratory birds belonged to three orders, i.e., Coraciiformes (n = 3), Passeriformes (n = 2), and Cuculiformes (n = 2). Haryana is a part of the Central Asian Flyway and is a crucial roosting site for winter migratory birds. Congenial environment, food availability, and nesting sites are prerequisites for wintering grounds for migratory birds. The area of southern Haryana is an agrarian region with an adequate supply of food, water, and roosting sites that might have attracted migratory birds.

Habitat-wise diversity and abundance revealed that agrifields habitat witnessed the highest species richness (n = 72 species) followed by human settlement (n = 51 species) and industrial zone (n = 32 species) [Figure 2]. Agrifields habitat was most crowded with 3089 birds (61.32%), having *Pastor roseus*—a passage migrant as the most abundant species (n = 263) during its migratory period; otherwise, *Streptopelia decaocto* (n = 186) was the most abundant species. Human settlement harbored 1595 birds (31.67%), with *Corvus splendens* (n = 198) as the most abundant species. The industrial zone was the least populous with a mere 353 birds (7.01%), with *C. splendens* (n = 37) as the most abundant species [Table 1]. These findings were in accordance with the fact that avian diversity tends to be higher with increasing vegetation diversity and heterogeneous vegetation cover [27]. The agrifields habitat is characterized by a seasonal crop cycle, intermediate tree cover including a canopy of large trees, shrubs, water source, and relatively low disturbance than human settlement and industrial zones. The human settlement was the second most diverse habitat characterizing residential areas, small standing water bodies, and grazing grounds which provide suitable food resources and bird nesting sites. In contrast, the industrial zone harbored the least bird diversity, possibly due to large anthropogenic activities, buildings, high pollution, heavy vehicle load, and limited resource availability. The lower avian diversity in the industrial zone aligns with the findings of an earlier study in West Bengal, India, stating noise pollution as a limiting factor for avian diversity [28].

The population diversity index represents the richness and evenness of species of a particular habitat. Evenness and richness are the primary characteristics of an avian community; they reveal the structure and composition of a community. The Simpson diversity index shows the number of species present and the relative abundance of each species. It is highly useful for assessing the level of biodiversity in a particular habitat. The results of this study revealed an overall diversity index of 0.973 at the study site. Habitat-wise Simpson's index showed agrifields as the most diverse habitat type with a diversity index of 0.968, human settlement with a diversity index of 0.957, and the least diverse industrial zone with a diversity index of 0.941 [Figure 3]. Agrifields were the most diverse habitat due to their varying feeding resources, low disturbance, and ample space. Moreover, the Shannon diversity index measures the heterogeneity of a community with higher weightage to species richness and evenness [29,30]. Overall, the Shannon index of 4.04 was observed, indicating a high rate of heterogeneity, including high species richness and evenness. At the same time, the habitat-wise Shannon index was recorded as 3.84 in agrifields habitat, 3.52 in human settlement, and 3.16 in the industrial zone [Figure 4]. The results of the Shannon–Wiener index were in line with the results of Simpson's diversity index. Results further revealed agrifields as a more heterogeneous habitat with higher species richness and evenness than human settlement and industrial zone. The findings are in accordance with the fact that the availability of food, diverse roosting and nesting sites, topographical features, and low anthropogenic activities affect species richness and community structures [31,32]. The agrifield regions offer ample nesting sites, food, tree cover, and relatively low anthropogenic activities which might have contributed to bird diversity positively.

Global population trends reveal the global population of species, while study site analysis helped ecologists understand the importance

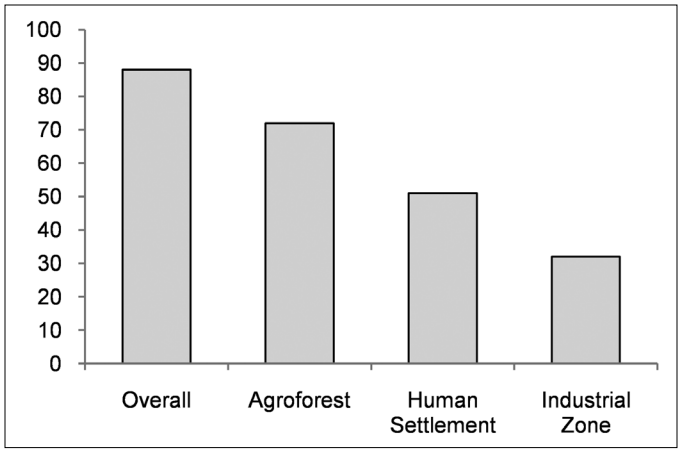

Figure 2: Species richness of different habitats in the study area.

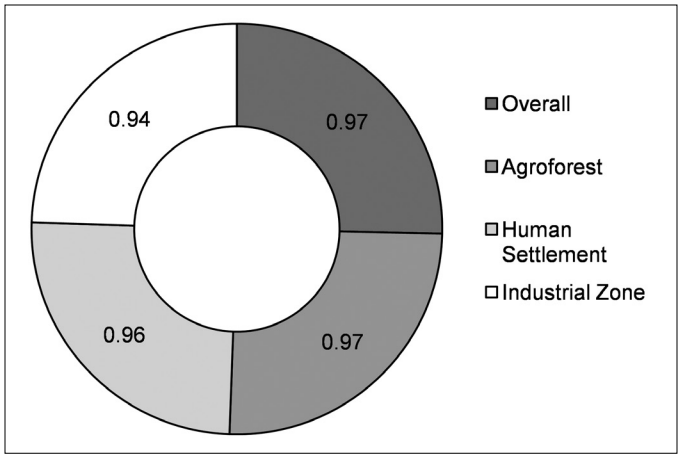

Figure 3: Pie chart representing Simpson's diversity index of different habitats in the study area.

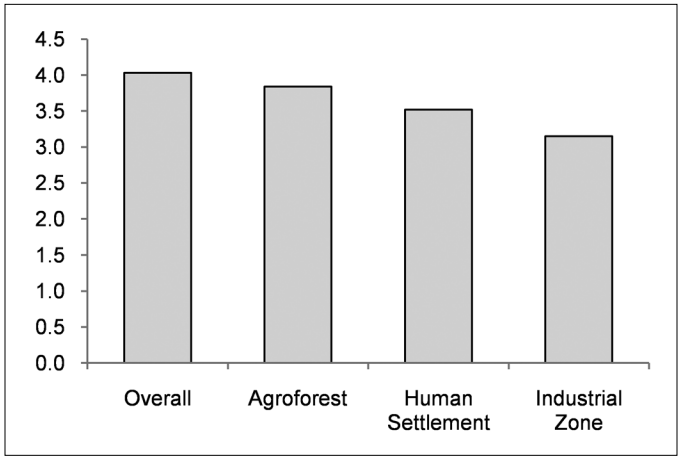

Figure 4: Bar graph representing Shannon–Wiener index in different habitats study area.

of specific habitat types for bird conservation and population. In this study, the stable population trend was the most represented population trend, represented by 38 species (43.2%). Decreasing and increasing population trends were represented by 20 species (22.7%) and 19 species (21.6%), respectively. Unknown population trend was the

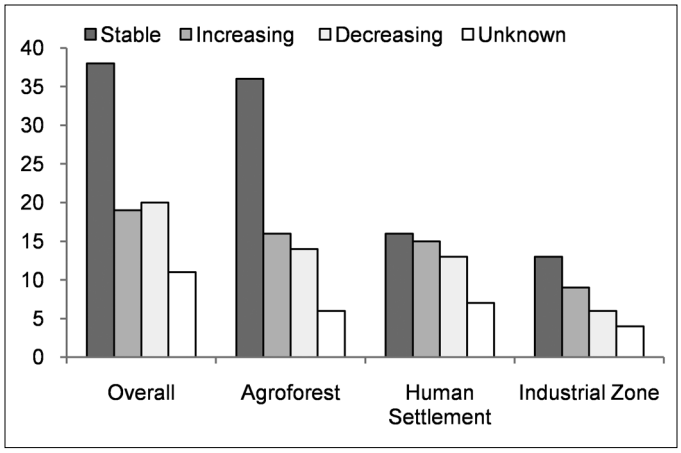

Figure 5: Population trends of the avian population in different habitats in the study area.

Table 3: Jaccard's similarity index of different habitats.

0.28	A	L	I
A	**1.0**		
L	0.41	**1.0**	
I	0.37	0.51	**1.0**

A: Agrifield habitat. L: Locality habitat. I, Industrial habitat.

least represented population trend, represented by 11 species (12.5%). Habitat-wise population trend analysis revealed that agrifields had 36 species with stable species, 16 with increasing, 14 with decreasing, and 5 with unknown population trends. Whereas human settlement harbored 16 species with stable, 15 with increasing, 13 with decreasing, and 7 with unknown population trends. Industrial zone habitat nurtured 13 with stable, 9 with increasing, 6 with decreasing, and 4 with unknown population trends [Figure 5]. Overall, the presence of 20 species with a decreasing population trend remarked the importance of the site in avian conservation and survival. Furthermore, the presence of 19 species with increasing population trend highlighted suitable resource availability and community ecology for nesting, roosting, and feeding to these species. In this study, the endangered species *A. nipalensis* was recorded in agrifields only and the threatened species *P. eupatria* was recorded in all three habitats. Both endangered and threatened species were having decreasing population trends. Nearly similar trends were observed in agricultural landscapes of Panipat and Sultanpur National Park [19,21].

As bird species are bio-indicators of environmental health and well-being, the similarity index denotes similarity in resource management and various ecological supports in different habitats. More similarity highlights two different habitats as a buffer zone to each other; species similarity is due to similarity in resource availability. Jaccard's similarity index shows the similarity in avian communities of different habitats. Notably, 28.4% species similarity is observed among all three habitats of the study area, while the highest species similarity is observed between locality and industrial area (50.9%). Agrifields habitat shared more species similarity with locality habitat (41.4%) than with industrial habitat (36.8%) [Table 3].

The study site is close to Sultanpur National Park, Bhindawas Bird Sanctuary, Dighal, and Mandothi wetlands, where a significant number of migratory and water birds have been recorded [13,14,23,33]. The relatively fewer birds at the study site may be due to the absence of a substantial water body, intensive agricultural practices, and anthropogenic disturbances. However, despite limited resource availability, the study site supports significant avian species, highlighting the importance of this site in conserving bird diversity.

4. CONCLUSIONS

This study was the first to record avian diversity in different habitats of agrifields in southern Haryana. The study concluded that low disturbance, suitable habitat, variety of food resources, and safe nesting and brooding sites are the utmost determining factors for avian diversity in specific habitats. Anthropogenic disturbances such as habitat fragmentation and alternation in resource availability severely affect avian diversity. It was concluded from the study that agrifields served as preferable habitats, being a source of diverse food, nesting, roosting, and foraging sites for avian species. Seasonal crop cycle, mixed vegetative cover, and low disturbance in agrifields ensure high species richness and ecological stability to its avian community. Despite food availability, human settlements and industrial zones dwell in low avian diversity, possibly due to anthropogenic disturbance and low vegetation. Habitat-dependent avian diversity studies are very scarce in Haryana, so further investigation of the role of various factors crucial for avian diversity is recommended. Seasonal bird assemblage, migration patterns, and the relation between crop cycle and dependent bird diversity should be analyzed with a scientific approach and ecological knowledge to design effective and sustainable conservation plans.

5. ABBREVIATIONS

RDi: Relative diversity; TS: Threat status; PT: Population trend; MS: Migratory status; HT: Habitat type; N: Number count; LC: Least concerned; NT: Near threatened; U: Unknown; S: Stable; In: Increasing: D: Decreasing; W: Winter migratory: Sm: Summer migratory: P: Passage migratory; A: Agrifields; L: Locality; I: Industry.

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7. AUTHORS' CONTRIBUTIONS

All the authors have made substantial contributions to the content of the manuscript. JS, VS, and VM worked on the concept and design. JS, SG, and MC performed data acquisition. VS, SG, and VM performed data analysis. JS, MC, and VM drafted the manuscript. JS and VM critically revised the manuscript. JS and VS performed statistical analysis. VM supervised and finally approved the manuscript.

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9. CONFLICT OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

10. ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

11. DATA AVAILABILITY

All the data is available with the authors and shall be provided upon request.

12. USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

13. PUBLISHER'S NOTE

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REFERENCES

1. Fraixedas S, Lindén A, Piha M, Cabeza M, Gregory R, Lehikoinen A. A state-of-the-art review on birds as indicators of biodiversity: advances, challenges, and future directions. Ecol Indic. 2020;118:106728. https://doi.org/10.1016/j.ecolind.2020.106728
2. Basile M, Storch I, Mikusiński G. Abundance, species richness and diversity of forest bird assemblages – the relative importance of habitat structures and landscape context. Ecol Indic. 2021;133:108402. https://doi.org/10.1016/j.ecolind.2021.108402
3. Lindenmayer DB, Franklin JF, Fischer J. General management principles and a checklist of strategies to guide forest biodiversity conservation. Biol Conserv. 2006;131:433-45.
4. Tanalgo KC, Pineda JAF, Agravante ME, Amerol ZM. Bird diversity and structure in different land-use types in lowland south-central Mindanao, Philippines. Trop Life Sci Res. 2015;26:85.
5. Khan MS, Aftab A, Syed Z, Nawab A, Ilyas O, Khan A. Composition and conservation status of avian species at Hastinapur Wildlife Sanctuary, Uttar Pradesh, India. J Threat Taxa. 2013;5:4714-21.
6. Khan MS, Pant A. Conservation status, species composition, and distribution of Avian Community in Bhimbandh Wildlife Sanctuary, India. J Asia-Pac Biodivers. 2017;10:20-6.
7. Wretenberg J, Lindström Å, Svensson S, Pärt T. Linking agricultural policies to population trends of Swedish farmland birds in different agricultural regions. J Appl Ecol. 2007;44:933-41. https://doi.org/10.1111/j.1365-2664.2007.01349.x
8. Hiron M, Berg Å, Eggers S, Josefsson J, Pärt T. Bird diversity relates to agri-environment schemes at local and landscape level in intensive farmland. Agric Ecosyst Environ. 2013;176:9-16.
9. Bawa KS. Hurdles for conservation science in India. Curr Sci. 2006;91:1005.
10. Maurya NK, Tripathi AK, Chauhan A, Pandey PC, Lamine S. Recent advancement and role of drones in forest monitoring: research and practices. In: Pandey PC, Arellano P, editors. Adv. Remote Sens. For. Monit. 1st ed. Wiley; 2022, p. 221-54.
11. Kumar P, Gupta SK. Status of wetland birds of Chhilchhila wildlife sanctuary, Haryana, India. J Threat Taxa. 2013;3969-76.
12. Singh J, Antil S, Goyal V, Malik V. Avifaunal diversity of Tilyar Lake, Rohtak, Haryana, India. J Threat Taxa. 2020;12:15909-15.
13. Rai D, Yadav A. Avian community composition in and around Mandothi wetlands, Haryana, India. J Appl Nat Sci. 2023;15:408-21. https://doi.org/10.31018/jans.v15i1.4385
14. Sonia Rani, Rani A, Rai D. Assessment of diversity and IUCN status of birds at Sultanpur National Park (Haryana) India. Biol Bull. 2023. https://doi.org/10.1134/S1062359023600915
15. Waltert M, Bobo KS, Sainge NM, Fermon H, Mühlenberg M. From forest to farmland: habitat effects on afrotropical forest bird diversity. Ecol Appl. 2005;15:1351-66.
16. Sekercioglu CH. Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. J Ornithol. 2012;153:153-61.
17. Donald PF, Green RE, Heath MF. Agricultural intensification and the collapse of Europe's farmland bird populations. Proc R Soc Lond B Biol Sci. 2001;268:25-9. https://doi.org/10.1098/rspb.2000.1325
18. Robinson RA, Sutherland WJ. Post-war changes in arable farming and biodiversity in Great Britain. J Appl Ecol. 2002;39:157-76. https://doi.org/10.1046/j.1365-2664.2002.00695.x
19. Kumar P, Sahu S. Composition, diversity and foraging guilds of avifauna in agricultural landscapes In Panipat, Haryana, India. J Threat Taxa. 2020;12:15140-53. https://doi.org/10.11609/jott.5267.12.1.15140-15153
20. Kour A, Singh D, Kiran, Ahlawat S, Kumar S, Punia N, et al. Documentation of avian species composition and assemblage in agricultural landscapes of Sirsa, Haryana. Environ and Ecol. 2023;41:1799-809.
21. Singh J, Hooda S, Phogat A, Malik V. Avian Diversity and Habitat Use of Sultanpur National Park, Haryana, India. Asian J Conserv Biol. 2021;10:124-33. https://doi.org/10.53562/ajcb.RKPR3560
22. Kour A, Singh D. Documentation of Avian Species Composition and Assemblage in Agricultural Landscapes of Karnal, Haryana. Bull Pure Appl Sci Zool. 2023.
23. Gupta RC, Parasher M, Kaushik TK. An enquiry into the avian biodiversity of Bhindawas Bird Sanctuary in Jhajjar District in Haryana State in India. J Exp Zool India. 2011;14:457-65.
24. Shekhawat DS, Bhatnagar C. Guild, status, and diversity of avian fauna in the Jhunjhunu district, Rajasthan, India. J Asia-Pac Biodivers. 2014;7:262-7. https://doi.org/10.1016/j.japb.2014.06.001
25. Hossain A, Aditya G. Avian diversity in agricultural landscape: records from Burdwan, West Bengal, India. Proc Zool Soc. 2016;69:38-51. https://doi.org/10.1007/s12595-014-0118-3
26. Yashmita-Ulman, Singh M. Bird composition, diversity and foraging guilds in agricultural landscapes: a case study from eastern Uttar Pradesh, India. J Threat Taxa. 2021;13:19011-28. https://doi.org/10.11609/jott.7089.13.8.19011-19028
27. Azman NM, Latip NSA, Sah SAM, Akil MAMM, Shafie NJ, Khairuddin NL. Avian diversity and feeding guilds in a secondary forest, an oil palm plantation and a paddy field in Riparian areas of the Kerian River Basin, Perak, Malaysia. Trop Life Sci Res. 2011;22:45.
28. Saha DC, Padhy PK. Effect of air and noise pollution on species diversity and population density of forest birds at Lalpahari, West Bengal, India. Sci Total Environ. 2011;409:5328-36. https://doi.org/10.1016/j.scitotenv.2011.08.062
29. Clarke KR, Warwick RM. Change in marine communities. Approach Stat Anal Interpret. 2001;2:1-168.
30. Hollenbeck JP, Ripple WJ. Aspen and conifer heterogeneity effects on bird diversity in the northern yellowstone ecosystem. West North Am Nat. 2007;67:92-101.
31. Sohil A, Sharma N. Assessing the bird guild patterns in heterogeneous land use types around Jammu, Jammu and Kashmir, India. Ecol Process. 2020;9:49. https://doi.org/10.1186/s13717-020-00250-9
32. Ghosh T, Sardar S, Sarkar S. Diversity of avian fauna in and around Kalyani, a sub-urban city near Kolkata, West Bengal, India. Int J Sci Res Biol Sci. 2024;11.
33. Kumar P. Assessing avian diversity and conservation status in Dighal Wetlands, Haryana, India. J Threat Taxa. 2023;15:23996-4008.

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