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Research Article

Avian diversity and habitat assessment of insectivorous bird species in arid agro-ecosystem of Haryana, India

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Abstract
Although studies have examined avian diversity in agricultural landscapes, the habitat analysis of beneficial bird species in arid agro-ecosystems remains unexplored. The present study aimed to assess the habitat of insectivorous birds within the rice-wheat cropping systems of Ahmadpur (Location I) and Mirpur (Location II) villages in the Sirsa district of Haryana during 2022-2023. The study documented 701 individuals of 63 avian species belonging to 14 orders and 38 families across the selected sites. Six feeding guilds were identified with insectivorous (40%) being dominant. Wheat (*Rabi*) and rice (*Kharif*) crop fields supported 50 and 62 avian species, with 6 and 14 being unique to each location. The House Sparrow was the most abundant species, with relative abundances of 23.17% at Location I and 18.06% at Location II. Nesting sites of 6 species at Location I and 9 species at Location II, with thorny trees in agricultural landscapes being the most preferred nesting sites. Cup-shaped nests were built by 44.45% of nesting species. Anthropogenic disturbances, predation and agricultural practices were the major causes of nest abandonment. Rice fields, and associated vegetation were found to provide essential breeding habitats and support for various bird species, particularly those favouring wetland habitats. The conservation and management of these ecosystems are vital for maintaining avian biodiversity and ensuring ecological balance in arid agro-ecosystems.

Keywords: Agro-ecosystems, Avian diversity, Anthropogenic disturbances, Feeding guilds, Nesting sites, Species richness

INTRODUCTION

Birds are found in almost every corner of Earth, and have adapted to breed in a wide range of habitats (Schweizer and Liu 2018). Birds are a potential taxon for monitoring worldwide environmental changes because of their ease of detection, well-understood population biology, behaviour, and predictable responses to environmental shifts (Fraixedas *et al.,* 2020).

The structure and complexity of the habitat play a major role in shaping the avian community and influencing species diversity (Kler *et al*., 2015). Habitat selection is a basic behavioural adaptation through which organisms connect with essential resources for survival and reproduction (Leclerc *et al*., 2016). Birds constantly make decisions about habitat use based on the availability of resources like food and shelter (McLoughlin *et al*., 2010). Nest site selection influenced by factors like vegetation structure, food availability, predation pressure (Sohi and Kler, 2017) and anthropogenic disturbances is crucial for successful reproduction (Cheng *et al*., 2020; Jara *et al*., 2020).

Agricultural habitats particularly rice and wheat fields serve as vital foraging and breeding grounds for both resident and migratory bird species (Kler *et al*., 2022; Blount *et al*., 2021). Haryana, a significant contributor to India's food grain production, supports large-scale rice and wheat cultivation (Kumari *et al*., 2020). The rice-wheat cropping system forms the backbone of farming in northwest India (Dhanda *et al*., 2022), with rice fields attracting waterbirds due to abundant food supply, while wheat fields provide essential habitat for insectivorous birds that help control pest populations (Marty, 2017; Borad and Parasharya, 2018).

However, agricultural landscapes usually support fewer bird species and individuals than natural habitats (Sviridova *et al*., 2020). Agricultural practices such as tilling, spraying and harvesting can directly impact bird populations by destroying nests during breeding (Santangeli *et al*., 2015). Additionally, the composition and structure of the surrounding landscapes significantly influenced bird communities in cultivated areas (Lindsay, 2013). The present study was conducted to assess avian diversity and analyse the habitat of insectivorous bird species in the arid agro-ecosystems of Sirsa district, Haryana, India.

MATERIALS AND METHODS

Study area

Sirsa district (29.53°N 75.02°E) located in the extreme western part of Haryana, experiences significant temperature variations throughout the year. During cold season, the daily mean temperature varies from 5-21 ° C, while in the hot season soar 41-46 °C, occasionally reaching as high as 49 °C. Dust storms with low relative humidity, are common during the summer. The district receives an average annual rainfall between 100 to 400 mm. The primary source of water supply in the Sirsa district is the Bhakra Irrigation System. The total irrigation requirements for rice and wheat range from 120-150 cm and 35-40 cm, respectively. However, Sirsa's soil presents several challenges, including low organic matter, high infiltration rate, limited water-holding capacity, low fertility, waterlogging, and salinity issues (Singh *et al.,* 2006).

The present investigation was carried out in the rice-wheat cropping system of two villages in Sirsa district-Ahmadpur (Location I) and Mirpur (Location II) from November to October during 2022-2023. Wheat, grown as a *Rabi* crop from November to April, and, rice cultivated as a *Kharif* crop from May to October, were the focus. Location I, consisting of two fields (Field I at 29° 34'08"N & 75°00'07"E and Field II laid and 29°34'17"N & 74°58'57"E) had several features including three electricity poles, a field shelter for storing tools, a submersible motor, a cemented water tank and a small water canal close to the Field II. Tree diversity in Location I included Dhek (*Melia azedarach*), Guava (*Psidium guajava*), Jamun (*Syzygium cumini*), Kikar (*Acacia Nilotica*), Neem (*Azadirachta Indica*), Safeda (*Eucalyptus*), Mulberry (*Morus alba*) and Sheesham (*Dilbergia sissoo*). Location II also had two fields (Field III at 29°35'21"N & 75°01'18"E and Field IV at 29° 35'27"N & 75°02'00"E). This location featured an electricity pole, a field shelter for two field workers, two submersible motors and a water canal near Field III. Tree species in this location included Dhek (*Melia azedarach*), Ber (*Zizyphus mauritiana*), Kikar (*Acacia Nilotica*), White *Acacia* (*Acacia albida*), Safeda (*Eucalyptus*), Mulberry (*Morus alba*) and Sheesham (*Dilbergia sissoo*).

Methodology

Birds inhabiting and foraging in the selected study sites were counted by employing the point count method (five points in each field), and bird composition was observed monthly at dawn and dusk following Verner (1985). Bird identification was conducted based on visual observations, as described by Ali (2002) using Nikon 8×42 binocular. The species diversity was analysed using the Shannon-Wiener Index. During the breeding season each tree and the edges, bunds, crop fields, corners of the walls and roofs in the study area were carefully surveyed for nesting sites. The status of each nest, *i.e.* whether active or not, was determined through regular examination of its contents. Observations related to nesting activities included the number of nests, type of nests, nesting sites, nest height, materials utilized for nest construction, and the surrounding environment. Clutch size was recorded as the total number of eggs laid by a female in single breeding attempt. Abandoned or fallen eggs were analysed for egg parameters, including egg length, egg breadth, egg weight, egg volume, egg shape index and egg specific gravity. Egg dimensions (length and breadth) were measured using a digital vernier calliper and egg weight was recorded using a common weighing balance. Egg volume was determined from length and breadth using an empirical formula (Galbraith, 1988) -:

Egg volume = (0.457) (L) (B^2) 10^{-3} ml Eq. 1

An egg shape index (ESI) and specific gravity of the eggs were calculated according to Stadelman and Cotterill (1995) using formula:

Egg shape index =Egg breadth (mm) / Egg length X100 Eq. 2

Eggs were classified into three categories based on SI: sharp egg (SI < 71), a normal (standard) egg (SI = 71-76) or round egg (SI > 76) (Duman M *et al*., 2016).

Egg specific gravity (gm/cm^3) = Egg weight (gm)/ Egg volume cm^3 Eq. 3

Statistical analysis

To find the significant difference between the relative abundance of bird species between Location I and location II and within the species data was statistically analysed using a two-way analysis of variance (ANOVA) using SPSS (version 26.0).

RESULTS AND DISCUSSION

The study identified 701 individual birds from 63 avian species belonging to 14 orders and 38 families in selected locations of Sirsa district, Haryana (Table 1). In

line with Praveen *et al*., (2020), Passeriformes, the most common bird order in India dominated this study as well, comprising (55 %) of documented species. It was followed by Charadriiformes (6 %), Columbiformes (6 %) and Cuculiformes (6 %). The family Muscicapidae (8 %) had the highest representation, with Columbidae (6 %) and Cuculidae (6 %) next in abundance. Six feeding guilds were identified namely carnivorous (11 %), frugivorous (8 %), granivorous (9 %), insectivorous (40 %), nectarivorous (1 %) and omnivorous (31 %). Out of 18 species unique to Location I, 8 were insectivorous, while 11 species exclusive to Location II included 4 insectivorous. Insectivorous species play a crucial role in controlling insect and rodent populations in the ecosystem (Mariyappan *et al*., 2023). Thirty-four avian species were common to both the selected Locations.

Wheat (*Rabi*) crop fields in Sirsa supported 50 avian species, fewer than the 83 and 80 bird species recorded in wheat fields of Bhatinda and Gujrat, by Kaur and Sidhu, (2022) and Borad and Parasharya, (2018) respectively. Six species were exclusively recorded in wheat crop fields namely Alexandrine Parakeet (frugivore), Black-headed Ibis (insectivore), House Crow (omnivore), Shikra (carnivore), Spotted Owlet (carnivore) and Taiga Flycatcher (insectivore). Location I had 9 unique species, with 56 %, while location II had 9 unique species, 11 % of which were insectivorous. House Sparrow was the most abundant species at both Locations with 10.79% and 30.44% of the populations in locations I and II, respectively.

Rice (*Kharif*) supported 62 avian species, lesser than 95 avian species documented by Gogoi *et al*., (2023) in Assam. Fourteen species were found exclusively in rice crop fields namely Bank Myna (Omnivore), Brahminy Starling (omnivore), Brown-headed Barbet (frugivore), Common Sandpiper (insectivore), Grey-bellied Cuckoo (insectivore), Indian Pond Heron (insectivore), Indian Spot-billed Duck (omnivore), Lesser Whistling Duck (omnivore), Little Egret (insectivore), Oriental Skylark (omnivore), Oriental White-eye (insectivore), Pied Cuckoo (insectivore) and Scally-breasted Munia (omnivore). Eighteen unique species were recorded in Location I, with 39 % being insectivorous and 10 species were unique to Location II, 50 % of which were insectivores. Rice fields serving as temporary wetlands during the growing season, attracted 8 water-dependent species including Black-winged stilt, Cattle Egret, Common Sandpiper, Indian Black Ibis, Indian Pond Heron, Indian Spot-billed Duck, Lesser Whistling Duck and White-breasted Waterhen.

Resident species comprised 91 % of birds recorded, with 8 % being winter visitors and 1% summer visitors. Among documented avifauna, three species namely, Alexandrine Parakeet (*Psittacula eupatria),* Black-headed Ibis (*Threskiornis melanocephalus)* and Indian Silverbill (*Euodice malabarica)* are listed as Near Threatened species in IUCN RedList (2024).

Globally, 15 species were noted to have decreasing population trends, 12 increasing, 31 stable and 5 with unknown trends, according to the IUCN RedList (2024). The current trends showed an increase for 7 avian species, a decrease for 4 and stability for 24. Alexandrine Parakeet (*Psittacula eupatria)*, Brown Rock Chat (*Oenanthe fusca)* and Common Tailorbird (*Orthotomus sutorius)*, whereas 4 avian species namely Bank Myna (*Acridotheres ginginianus)*, Barn Swallow (*Hirundo rustica)*, Oriental Skylark (*Alauda gulgula)* and White Wagtail (*Motacilla alba)* were found to be rapidly declining (State of India's Birds, 2023).

Wheat (*Rabi*) fields had the highest species richness and diversity during winter and early summer (January to April), when the wheat was in its flowering and maturity stages, providing abundant food in the form of insects and grains. Similar findings were noted by Borad and Parasharya, (2018). The highest species richness and diversity in the rice (*Kharif*) fields were recorded from late summers to early rainy season (June-July), when the fields were flooded. Significant differences in species abundance between the two locations were revealed through a two-way ANOVA for both wheat (ANOVA, $F=4.40$, $df=49$, $p=3.75\times10^{-7}$) and rice (ANOVA, $F=16.97$, $df=1$, $p=1.29\times10^{-4}$; $F=5.70$, $df=55$, $p=6.04\times10^{-10}$). Jaccard's similarity index indicated that the species composition was most similar between Fields II and III, likely due to comparable habitats and vegetation.

In terms of breeding 6 bird species were found nesting in the wheat and rice fields of Location I, and nine in Location II (Table 2), with most species preferring thorny trees like *Acacia nilotica*, which deter predators and increase breeding success. House Sparrow and other species build cup-shaped nests, which are resource-efficient, a characteristic also noted by Price and Griffith, (2017). Breeding sites were mainly in agricultural lands (88.89%), built-up areas (55.56%), and waterbodies (22.23%). Egg measurements from fallen and abandoned nests showed that Red-wattled Lapwing had the largest eggs in both Locations (Table 3). Anthropogenic disturbances and predation were the primary causes of nest abandonment. Most nesting species had sharp or elongated eggs, which are contained in Englert Duursma *et al*. (2018), who found spherical eggs more common in hot environments with closed nests.

Conclusion

This study emphasizes the crucial role of avian diversity, particularly insectivorous birds, in maintaining eco-

Table 1. Avian species recorded in selected Wheat (*Rabi*) and Rice (*Kharif*) crop fields of Sirsa, Haryana during 2022-2023

Sl. No.	Species Name	Family	Order	Feeding Guild	Migratory Status	Habitat Type	IUCN Status
1	Alexandrine Parakeet	Psittaculidae	Psittaciformes	Frugivore	R	T	NT
2	Ashy Prinia	Cisticolidae	Passeriformes	Insectivore	R	T	LC
3	Asian Koel	Cuculidae	Cuculiformes	Frugivore	R	T	LC
4	Bank Myna	Sturnidae	Passeriformes	Omnivore	R	T	LC
5	Barn Swallow	Hirundinidae	Passeriformes	Insectivore	R	W	LC
6	Baya Weaver	Ploceidae	Passeriformes	Omnivore	R	T	LC
7	Black Drongo	Dicruridae	Passeriformes	Insectivore	R	T	LC
8	Black Francolin	Phasianidae	Galliformes	Omnivore	R	T	LC
9	Black-headed Ibis	Threskiornithidae	Pelecaniformes	Insectivore	R	B	NT
10	Black-winged Kite	Accipitridae	Accipitriformes	Carnivore	R	T	LC
11	Black-winged Stilt	Recurvirostridae	Charadriiformes	Insectivore	R	B	LC
12	Brahminy Starling	Sturnidae	Passeriformes	Omnivore	R	T	LC
13	Brown Rock Chat	Muscicapidae	Passeriformes	Insectivore	R	T	LC
14	Brown Shrike	Laniidae	Passeriformes	Insectivore	WV	T	LC
15	Brown-headed Barbet	Ramphastidae	Piciformes	Frugivore	R	T	LC
16	Cattle Egret	Ardeidae	Pelecaniformes	Insectivore	R	B	LC
17	Common Babbler	Leiothrichidae	Passeriformes	Omnivore	R	T	LC
18	Common Hoopoe	Upupidae	Bucerotiformes	Insectivore	R	T	LC
19	Common Moorhen	Rallidae	Gruiformes	Omnivore	R	W	LC
20	Common Myna	Sturnidae	Passeriformes	Omnivore	R	T	LC
21	Common Sandpiper	Scolopacidae	Charadriiformes	Insectivore	WV	W	LC
22	Common Tailorbird	Cisticolidae	Passeriformes	Insectivore	R	T	LC
23	Eurasian Collared Dove	Columbidae	Columbiformes	Granivore	R	T	LC
24	Greater Coucal	Cuculidae	Cuculiformes	Omnivore	R	T	LC
25	Green Bee-eater	Meropidae	Coraciiformes	Insectivore	R	T	LC
26	Grey Francolin	Phasianidae	Galliformes	Omnivore	R	T	LC
27	Grey-bellied Cuckoo	Cuculidae	Cuculiformes	Insectivore	SV	T	LC
28	House Crow	Corvidae	Passeriformes	Omnivore	R	T	LC
29	House Sparrow	Passeridae	Passeriformes	Omnivore	R	T	LC
30	Indian Black Ibis	Threskiornithidae	Pelecaniformes	Omnivore	R	B	LC
31	Indian Grey Hornbill	Bucerotidae	Bucerotiformes	Frugivore	R	T	LC
32	Indian Pond Heron	Ardeidae	Pelecaniformes	Carnivore	R	B	LC
33	Indian Robin	Muscicapidae	Passeriformes	Insectivore	R	T	LC
34	Indian Roller	Coraciidae	Coraciiformes	Carnivore	R	T	LC
35	Indian Silverbill	Estrildidae	Passeriformes	Omnivore	R	T	NT
36	Indian Spot-billed Duck	Anatidae	Anseriformes	Omnivore	R	W	LC
37	Jungle Babbler	Leiothrichidae	Passeriformes	Granivore	R	T	LC
38	Laughing Dove	Columbidae	Columbiformes	Granivore	R	T	LC
39	Lesser Golden-backed Wood-	Picidae	Piciformes	Granivore	R	T	LC

Contd…...

Table 1. Contd…….

40	Lesser Whistling Duck	Anatidae	Anseriformes	Omnivore	R	W	LC
41	Lesser White-throat	Sylviidae	Passeriformes	Insectivore	WV	T	LC
42	Little Egret	Ardeidae	Pelecaniformes	Carnivore	R	B	LC
43	Oriental Magpie Robin	Muscicapidae	Passeriformes	Insectivore	R	T	LC
44	Oriental Skylark	Alaudidae	Passeriformes	Omnivore	R	T	LC
45	Oriental White-eye	Zosteropidae	Passeriformes	Insectivore	R	T	LC
46	Pied Bushchat	Muscicapidae	Passeriformes	Insectivore	R	T	LC
47	Pied Cuckoo	Cuculidae	Cuculiformes	Insectivore	R	T	LC
48	Plain Prinia	Cisticolidae	Passeriformes	Insectivore	R	T	LC
49	Purple Sunbird	Nectariniidae	Passeriformes	Nectari-vore	R	T	LC
50	Red-vented Bul-bul	Pycnonotidae	Passeriformes	Omnivore	R	T	LC
51	Red-wattled Lap-wing	Charadriidae	Charadriiformes	Insectivore	R	B	LC
52	Rock Pigeon	Columbidae	Columbiformes	Granivore	R	T	LC
53	Rose-ringed Par-akeet	Psittaculidae	Psittaciformes	Frugivore	R	T	LC
54	Rufous Treepie	Corvidae	Passeriformes	Omnivore	R	T	LC
55	Scally-breasted Munia	Estrildidae	Passeriformes	Omnivore	R	T	LC
56	Shikra	Accipitridae	Accipitriformes	Carnivore	R	T	LC
57	Spotted Owlet	Strigidae	Strigiformes	Carnivore	R	T	LC
58	White Wagtail	Motacillidae	Passeriformes	Insectivore	WV	T	LC
59	White-breasted Waterhen	Rallidae	Gruiformes	Omnivore	R	W	LC
60	White-browed Wagtail	Motacillidae	Passeriformes	Insectivore	R	T	LC
61	White-eared Bul-bul	Pycnonotidae	Passeriformes	Omnivore	R	T	LC
62	White-throated Kingfisher	Alcedinidae	Coraciiformes	Carnivore	R	B	LC
63	Yellow-legged	Columbidae	Columbiformes	Granivore	R	T	LC

R: Resident, WV: Winter visitor, SV: Summer visitor, T: Terrestrial. W: Water dependent, NT: Near Threatened, LC: Least Concerned

Table 2. Nesting Preferences, nest types and area around nesting sites of different breeding birds in wheat (*Rabi*) and rice (*Kharif*) crop fields of Sirsa, Haryana

Sl. No.	Species Name	Nest Height	Nesting Site	Type of nest	Area around nesting sites
1	Baya Weaver	4.92±0.55	*Ziziphus mauritiana*	Closed nest	Waterbody and agriculture fields
2	House Sparrow	3.15±0.31	*Acacia nilotica, Acacia albida*	Cavity nest	Agriculture fields and built up
3	Laughing Dove	3.24±0.00	*Acacia nilotica*	Cup shaped nest	Waterbody and agriculture fields
4	Plain Prinia	0.68±0.00	*Zea mays*	Cup shaped nest	Agriculture fields
5	Purple Sunbird	1.15±0.10	*Acacia nilotica*	Closed nest	Agriculture fields and built up
6	Red-vented Bulbul	2.33±0.65	*Combretum indicum, Acacia nilotica*	Cup shaped nest	Agriculture fields and built up
7	Red-wattled Lapwing	--	Ground Nest	Simple nest	Agriculture fields, built up and fellow lands
8	Rock Pigeon	2.53±0.13	Roof shed of building	Simple nest	Built up
9	White-eared Bulbul	1.98±0.00	*Salix alba*	Cup shaped nest	Agriculture fields

Table 3. Egg parameters of abandoned/fallen eggs of different breeding avian species in selected wheat (*Rabi*) and rice (*Kharif*) crop fields of Location I and Location II

Sl. No.	Species Name	Clutch Size (Eggs No.)	Egg length (mm)	Egg width (mm)	Egg weight (gm)	Egg Volume (cm^3)	Egg specific gravity (gm/cm^3)	Egg shape index
Location I								
1	House Sparrow	2.50±0.29	20.27±0.68	13.66±0.55	2.50±0.90	1.75±0.19	1.46±0.30	67.34±1.73
2	Laughing Dove	2.00±0.00	24.03±0.11	14.02±0.19	12.36±0.17	2.16±0.07	5.73±0.11	58.33±0.53
3	Purple Sunbird	2.00±0.00	15.92±0.10	10.84±0.06	1.18±0.02	0.85±0.01	1.38±0.00	68.06±0.08
4	Red-vented Bulbul	2.33±0.33	20.12±0.08	15.20±0.10	1.24±0.05	2.13±0.04	0.58±0.02	75.57±0.21
5	Red-wattled Lapwing	3.17±0.40	41.46±0.29	29.52±0.15	17.04±0.28	16.51±0.26	1.03±0.01	71.19±0.35
6	Rock Pigeon	2.00±0.00	32.13±0.23	26.42±0.37	15.96±0.06	10.25±0.36	1.56±0.05	82.22±0.53
Location II								
1	Baya Weaver	2.75±0.25	16.10±0.07	12.50±0.13	1.60±0.06	1.15±0.03	1.40±0.08	77.61±0.62
2	House Sparrow	2.80±0.20	20.15±0.23	12.05±0.27	2.30±0.16	1.34±0.07	1.71±0.04	59.80±0.85
3	Laughing Dove	2.00±0.00	23.92±0.14	14.45±0.11	12.01±0.11	2.28±0.02	5.26±0.10	60.43±0.80
4	Plain Prinia	3.00±0.00	7.05±0.07	4.79±0.11	0.93±0.06	0.07±0.00	12.52±0.07	67.86±0.82
5	Purple Sunbird	4.00±0.00	16.02±0.04	10.87±0.11	1.20±0.04	0.86±0.02	1.39±0.02	67.87±0.54
6	Red-vented Bulbul	3.50±0.50	20.35±0.11	15.21±0.03	1.18±0.05	2.15±0.02	0.55±0.02	74.74±0.26
7	Red-wattled Lapwing	2.75±0.25	40.63±0.26	29.14±0.16	16.18±0.11	15.77±0.26	1.03±0.01	71.74±0.25
8	Rock Pigeon	2.00±0.00	32.10±0.09	26.58±0.11	15.30±0.16	10.36±0.05	1.48±0.02	82.80±0.57
9	White-eared Bulbul	2.00±0.00	17.98±0.30	15.71±0.15	1.14±0.02	2.03±0.07	0.56±0.03	87.36±0.65

logical balance and supporting pest control in Haryana's arid agro-ecosystems. Among 63 species, insectivorous comprised 40%, underscoring their importance for sustainable agriculture. Passeriformes dominated the species composition (55%), with Muscicapidae as the most represented family and House Sparrow (10.79%) the most abundant species. Wheat fields showed higher diversity in winter, while rice fields attracted more species during the rainy season. Breeding patterns favoured thorny trees like *Acacia nilotica* for protection. Conservation concerns were raised for the Near Threatened species-Alexandrine Parakeet, Black-headed Ibis, and Indian Silverbill. The study highlights the need for conservation strategies to address habitat disruptions and ensure the sustainability of agro-ecosystems.

Conflict of interest

The authors declare that they have no conflict of interest.

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