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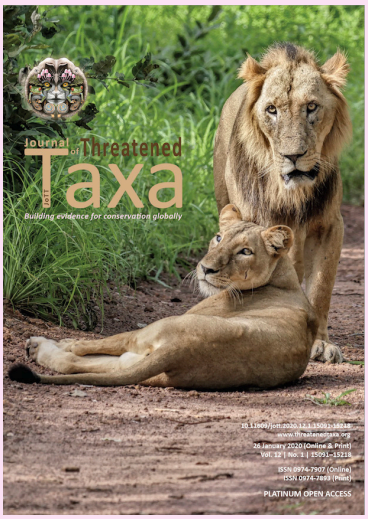

Communication

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Parmesh Kumar & Sharmila Sahu

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COMMUNICATION

Composition, diversity and foraging guilds of avifauna in agricultural landscapes In Panipat, Haryana, India

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Abstract: Avian communities are very good indicators of integrity and stability of ecosystem structure and functions. Assessment of bird assemblages in different landscapes is therefore emphasized from an environmental monitoring viewpoint. Bird surveys were carried out from April 2015 to March 2016 to document the avian species assemblage of agricultural landscapes in Panipat, Haryana, India. Point-transect in amalgam with opportunistic encounter methods were used to collect data. A total of 101 bird species under 44 families and 15 orders were recorded from the study area. The bird species richness was highest for the order Passeriformes (48), followed by Pelecaniformes (15), Charadriiformes (6), and the remaining 12 orders. Ardeidae was the most diverse bird family in the study area. Among the recorded avifauna, 77 species were residents, 18 species were winter migrants and six species were summer migrants. Species richness was recorded to be highest in the month of January compared to the remaining months. Species richness, abundance, diversity and evenness differed significantly ($P < 0.05$) between seasons as well as among the agricultural landscapes. Most bird species were insectivorous (36) followed by carnivorous (26), omnivorous (24), granivorous (9), frugivorous (5) and nectarivorous (1). Painted Stork *Mycteria leucocephala*, Black-necked Stork *Ephippiorhynchus asiaticus*, Black-headed Ibis *Threskiornis melanocephalus*, and Alexandrine Parakeet *Psittacula eupatria* are four Near Threatened species found in this region. Interestingly, five species having globally declining population trends are still common in the study area. The observed richness of avian species in the study area calls for further studies on habitat preference, seasonal changes, nest ecology, and breeding biology to understand species specific roles of birds in agro-ecosystems.

Keywords: Agroecosystem, avian communities, ecosystem structure, point-transect, species diversity.

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Author contribution: PK conceived and designed the study as well as wrote the final draft of the manuscript. SS performed the field surveys, analysed the data and prepared rough draft of the manuscript. Both authors read and approved the final manuscript.

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INTRODUCTION

Agroecosystems are among the most productive ecosystems on earth, occupying 38% of the earth's terrestrial area (Foley et al. 2011). In addition to various ecosystem services, agricultural landscapes serve as unique habitats for a huge diversity of wildlife including invertebrates, amphibians, reptiles, birds, and mammals (Bambaradeniya et al. 1998). Birds constitute an important component of the biotic community in the agro-ecosystems and execute varied functional roles as seed dispensers, pollinators, scavengers, nutrient depositors, predators of insect pests and rodents (Dhindsa & Saini 1994; Whelan et al. 2008; Sekercioglu 2012). Because of the variety of ecological functions performed by birds, they are generally recognised as valuable indicators of the overall biodiversity in agricultural landscapes (Malhi 2006).

Birds are known to play a dual role as pests and as biological control agents of insect pests in agroecosystems (Dhindsa & Saini 1994; Bianchi et al. 2006; Narayana et al. 2019). The agricultural landscapes provide a concentrated and highly predictable source of food to many bird species in the form of grains, seeds, fruits, green vegetation of the crop plants, grasses, weeds, insects, other invertebrates, and rodents (O'Connor & Shrubb 1986; Dhindsa & Saini 1994; Asokan et al. 2009). In agro-ecosystems, most bird species are insectivorous and play an important role in maintaining the population of insect pests and thereby are beneficial to farmers (Asokan et al. 2009). Studies of avian diversity in agricultural landscapes of India, however, are very limited compared to natural and protected ecosystems (Dhindsa & Saini 1994; Hossain & Aditya 2016; Narayana et al. 2019).

In the past few decades, Haryana State has witnessed tremendous changes in its agroecosystem owing to intensive agriculture and its mechanization, excessive use of pesticides and fertilizers along with rapid urbanization and industrial growth. All these developmental activities have resulted in several ecological changes in the agroecosystems, and consequently affected the avifauna of the state. As a result, documentation of bird assemblages in agroecosystems need priority to assess the impact of changing natural habitat and agricultural practices (Mallik et al. 2015; Hossain & Aditya 2016; Mukhopadhyay & Mazumdar 2017; Narayana et al. 2019). Information on species richness and community structure of birds will help in developing suitable conservation strategies for sustaining birds without interfering with the objective of intensive agricultural practices in heterogeneous agricultural landscapes (Dhindsa & Saini 1994; Sundar & Kittur 2013; Hossain & Aditya 2016). Panipat is one of the agriculturally advanced districts of Haryana, India. Till date no data is available on the bird diversity in agricultural landscapes of the district. In this context, the present study made an attempt to record species composition and diversity of avian fauna in agricultural landscapes of the district Panipat, Haryana.

MATERIALS AND METHODS

Study area

The study was conducted in all five development blocks (Panipat, Samalkha, Israna, Bapoli and Madlauda) of district Panipat, Haryana, India, taking at least two study sites in each development block. Panipat, is situated between 29.150–29.450 ^{0}N and 76.633–77.150 ^{0}E at an elevation of 244.5m and has an area of 1,268km^2 (Figure 1). A brief description of the selected agricultural landscapes is given in Table 1. Net area sown in the district is 93,000ha which constitutes 71% of the total area. Agricultural activities of the district are dependent on tube wells and canals. The district is mainly drained by the river Yamuna and its tributaries. Rice-wheat cropping system dominates with the consequent marginalization of pulses and oilseed. Sugarcane is also being grown in the study area as a cash crop. The district forms a part of the Indo-Gangetic alluvial plain with flat terrain. The study area experiences sub-tropical climate with three major seasons, i.e., rainy (July to September), a cool dry (October to February) and the hot dry season (March to June). Temperature is as high as 45^0 C in summer and as low as 3^0 C in winter. The average annual rainfall in the district is 467mm and generally increases from south-west to north-east. Most of the precipitation is received during the monsoon and some rain is also received during the cold season in association with passing western disturbances.

Data collection

Bird surveys were conducted in selected sites on a fortnightly basis from April 2015 to March 2016. Point-transect method was used to record bird species (Sutherland 2006; Narayana et al. 2019). One-km transect was laid at each study site and a point was marked at every 200m distance and the birds species were recorded in 20m radius. On arrival at a survey point, an initial 5min settling-down period was used prior to counting the birds and 15min were spent at each

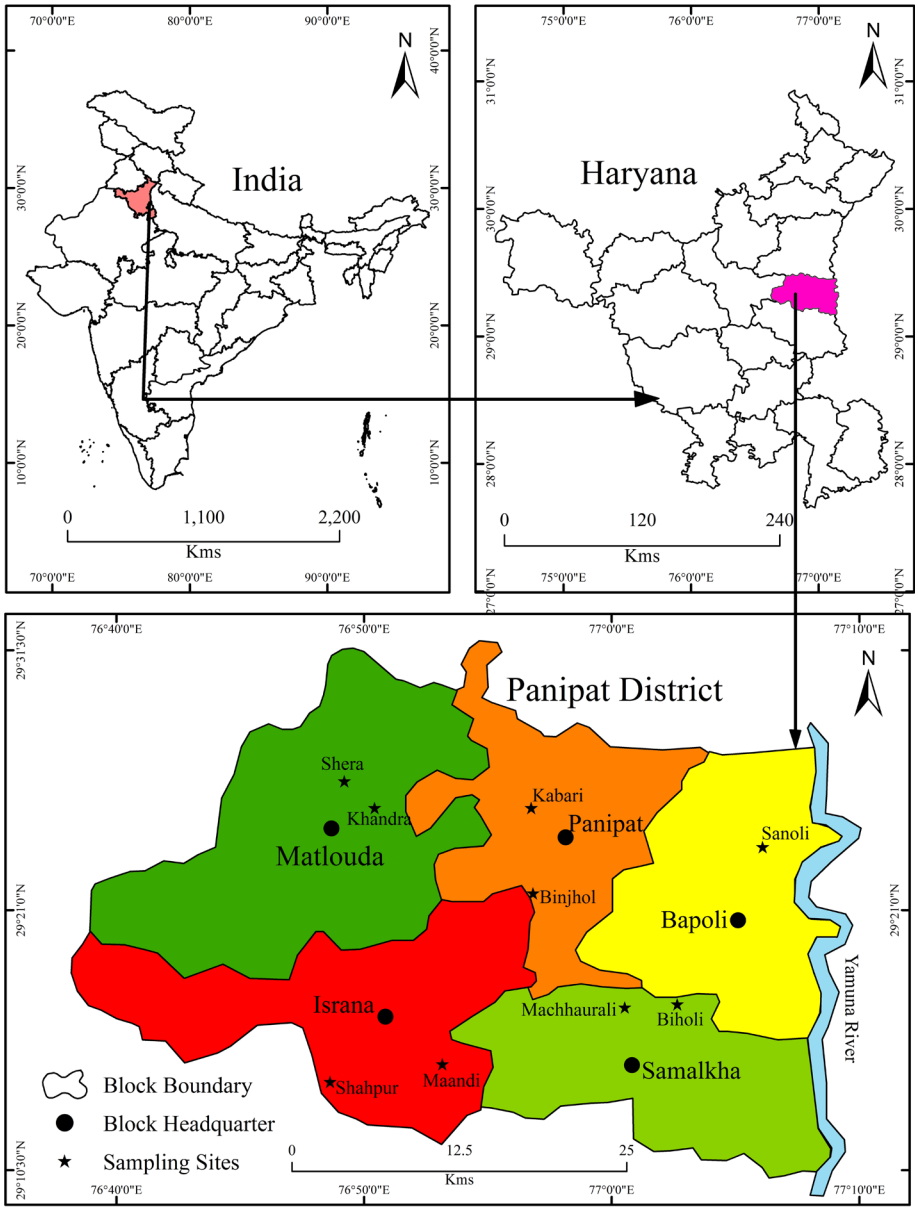

Figure 1. Panipat, Haryana, India with location of study sites.

Table 1. Summary of general characteristics of the selected agricultural landscapes.

Agricultural Landscape/ Block	Co-ordinates	Elevation (m)	General features
Panipat	29.395^{0}N & 76.968^{0}E	219	Rice-wheat cropping system dominates with the consequent marginalization of pulses and oilseed. Sugarcane is also being grown in the study area as cash crop. Agricultural activities are dependent on tube wells and on western Jamuna canal (WJC). Panipat Museum with dense vegetation is located in the vicinity of the selected agricultural landscape.
Samalkha	29.238^{0}N & 77.014°E	227	Rice-wheat cropping system along with sugarcane dominates in the landscape. The selected agricultural landscape is surrounded by the wetland (river Yamuna).
Israna	29.276^{0}N & 76.851^{0}E	231	Wheat and paddy are the main crops in the area. Agricultural activities are mainly dependent on tube wells and distributaries of WJC. Educational Institutions, temples and ponds are located in the vicinity of selected agricultural landscape.
Bapoli	29.360^{0}N & 77.057^{0}E	234	Wheat, paddy and sugarcane are the main agricultural crops grown in the area. The patches of tall wooded trees, orchards, dense vegetation, grasses and the wetlands (river Yamuna) surrounding the selected agricultural fields added to the rich habitat heterogeneity of the selected area.
Madlauda	29.401^{0}N & 76.801^{0}E	236	Paddy, wheat, sugarcane, mustard, jowar, bajra are the crops grown in the area. Selected agricultural landscape is irrigated by tube wells. The selected site was located in the vicinity of industrial area (Thermal Power Plant of Panipat) with enhanced anthropogenic activities.

point to count and record all birds observed. Each point location on transect was surveyed as many as 24 times during the entire study period. Birds were counted at their point of first detection and care was taken to ensure that the same birds were not counted again. Birds were counted directly, aided by a pair of field binoculars (Nikon 8 x 40), during hours of peak activity 06.00–10.00 h or 16.00–18.00 h. Bird species, number of individuals and habitat were recorded. Overpasses except for habitually aerial bird species such as swallows and swifts were not recorded. Call notes of birds were also used for locating the birds. Field visits were carried out on foot only on days with suitable weather conditions (i.e., in the absence of rain or strong wind). The direction of point-transects and the timing of observations was alternated during every subsequent visit. In addition, opportunistic observations of birds at other times were also included to document a comprehensive checklist. Identification of birds was done following Grimmett et al. (2011). Taxonomic position (order and family), common, and scientific names of recorded bird species were assigned following Praveen et al. (2016). For residential status, birds were categorised as resident, winter visitor and summer visitor on the basis of presence or absence in the study area (Kumar et al. 2016). We also assigned a local status to each species on the basis of the percentage of frequency of sightings following Mackinnon & Phillipps (1993) as common (C)—sighted on 80–100% of field visits, fairly common (FC)—sighted on 60–79.9% of field visits, uncommon (UC)—sighted on 20–59.9% of field visits, and rare (RA)—sighted on less than 19.9% of field visits. For determination of the feeding guilds, foraging birds were observed by focal sampling method using field binoculars and data were obtained on the type of food taken by the species. The probable food items collected from the feeding sites further helped in substantiating the observations and in evaluating the availability of food. On the basis of direct observations and description given by Ali & Ripley (1987), recorded bird species were categorized into six major feeding guilds (Figure 2): insectivorous (species that feed exclusively on insects), carnivorous (species that feed mainly on non-insect invertebrates and vertebrates), granivorous (species that feed on grains/seeds), frugivorous (species that feed predominantly on fruits), nectarivorous (species that feed on floral nectar), and omnivorous (species that feed on both plant parts and other animals).

Species richness was calculated as total number of bird species observed in the study area. The relative diversity (RDi) of bird families was calculated using the following formula (Torre-Cuadros et al. 2007):

$$RDi = \frac{\text{Number of bird species in a family}}{\text{Total number of species}} \times 100$$

Species similarity between any two agricultural landscapes was measured by Jaccard's similarity index as

Jaccard's similarity index (C_j) = a / (a + b + c)

where a is number of species common to both the landscapes, b is number of the species unique to the first landscape and c is the number of the species unique to the second landscape. Shannon–Wiener's diversity and species evenness indices of birds were estimated using PAST version 3.26 software. We pooled the recorded field data corresponding to two seasons, i.e., summer (April–September) and winter (October–March) to test the seasonal variation of bird assemblages in the study area. Two way ANOVA Tukey HSD test were used to analyse difference in the values of diversity and other indices of bird population between seasons and among the five selected agricultural landscapes at 5% level of significance (SPSS 24.0 version). The conservation status of recorded bird species and their global population trend (decreasing, increasing, stable or unknown) were compiled from the Red List of IUCN (2019).

RESULTS AND DISCUSSION

A total of 101 species of birds belonging to 82 genera, 44 families, and 15 orders were recorded during the study period (Table 2). The study area supports about 8% of the total avian species found in India (Praveen et al. 2016) and this richness of avifauna is comparable with reports of earlier studies carried out in agricultural landscapes in different parts of India. For instance, Abdar (2014) recorded 97 species from agricultural habitats of the Western Ghats, Maharashtra; Hossain & Aditya (2016) encountered 144 bird species from Burdwan, West Bengal; and Narayana et al. (2019) recorded 128 species of birds belonging to 59 families and 19 orders from agricultural landscapes of Nalgonda District in Telangana State. A maximum number of bird species belonged to the order Passeriformes (48), followed by Pelecaniformes (15), Charadriiformes (6), and the remaining, 12 orders. More than half (68.3%) of the species recorded during the study belonged to one of three orders (Passeriformes, Pelecaniformes, and Charadriiformes). These results are in agreement with previous records that order Passeriformes constitutes the most predominant avian taxa in India (Praveen et al. 2016).

Table 2. List of bird species recorded from agricultural landscapes of the district Panipat, Haryana, India together with their respective taxonomic positions, residential status, feeding guild, local status, landscape, IUCN Red List status, and global population trend.

	Order/family /common name	Scientific name	Residential status	Feeding guild	Local status	Agricultural landscape					Red List status	Global population trend
						PA	SA	IS	BA	MA		
	Order: GALLIFORMES Family: Phasianidae											
1	Indian Peafowl	*Pavo cristatus*	R	O	CO	✓	✓	✓	✓	✓	LC	→
2	Black Francolin	*Francolinus francolinus*	R	O	UC	✓	✓	×	×	✓	LC	→
3	Grey Francolin	*Francolinus pondicerianus*	R	O	FC	✓	✓	✓	×	×	LC	→
	Order: PHOENICOPTERIFOMES Family: Podicipedidae											
4	Little Grebe	*Tachybaptus ruficollis*	R	C	UC	×	×	×	✓	×	LC	↓
	Order: COLUMBIFORMES Family: Columbidae											
5	Rock Pigeon	*Columba livia*	R	G	CO	✓	✓	✓	✓	✓	LC	↓
6	Eurasion Collared Dove	*Streptopelia decaocto*	R	G	FC	×		×	✓	×	LC	↑
7	Spotted Dove	*Spilopelia chinensis*	R	G	FC	✓	✓	✓	✓	✓	LC	↑
8	Laughing Dove	*Streptopelia senegalensis*	R	G	CO	✓	✓	✓	✓	✓	LC	→
9	Yellow-legged Green Pigeon	*Treron phoenicopterus*	R	F	UC	✓	✓	×	✓	×	LC	↑
	Order: CAPRIMULGIFORMES Family: Apodidae											
10	Indian House Swift	*Apus affinis*	R	I	UC	×	×	×	✓	×	LC	↑
	Order: CUCULIFORMES Family: Cuculidae											
11	Greater Coucal	*Centropus sinensis*	R	O	CO	✓	✓	✓	✓	✓	LC	→
12	Pied Cuckoo	*Clamator jacobinus*	S	I	UC	✓	×	×	✓	×	LC	→
13	Asian Koel	*Eudynamys scolopaceus*	R	O	FC	✓	✓	×	✓	×	LC	→
14	Drongo Cuckoo	*Surniculus lugubris*	S	I	RA	×		×	✓	×	LC	↓
15	Common Hawk Cuckoo	*Hierococcyx varius*	S	I	RA	×	✓	×	×	×	LC	→
	Order: GRUIFORMES Family: Rallidae											
16	White-breasted Waterhen	*Amaurornis phoenicurus*	R	O	CO	✓	✓	✓	✓	✓	LC	?
17	Purple Swamphen	*Porphyrio porphyrio*	R	O	FC	×	×	×	×	✓	LC	?
	Order: PELECANIFORMES Family: Ciconiidae											
18	Painted Stork	*Mycteria leucocephala*	W	C	RA	×	×	×	✓	×	NT	↓
19	Asian Openbill	*Anastomus oscitans*	W	C	RA	×	✓	×	×	×	LC	?
20	Black-necked Stork	*Ephippiorhynchus asiaticus*	W	C	RA	×	✓	×	×	×	NT	↓

	Order/family /common name	Scientific name	Residential status	Feeding guild	Local status	Agricultural landscape					Red List status	Global population trend
						PA	SA	IS	BA	MA		
	Family: Ardeidae											
21	Black-crowned Night Heron	*Nycticorax nycticorax*	R	C	UC	×	×	×	✓	×	LC	↓
22	Indian Pond Heron	*Ardeola grayii*	R	C	CO	✓	✓	✓	✓	✓	LC	?
23	Cattle Egret	*Bubulcus ibis*	R	C	CO	✓	✓	✓	✓	✓	LC	↑
24	Grey Heron	*Ardea cinerea*	R	C	RA	×	×	×	✓	×	LC	?
25	Purple Heron	*Ardea purpurea*	R	C	RA	×	✓	×	×	×	LC	↓
26	Great Egret	*Ardea alba*	W	C	UC	×	✓	×	✓	×	LC	?
27	Intermediate Egret	*Ardea intermedia*	W	C	UC	✓	✓	✓	✓	✓	LC	↓
28	Little Egret	*Egretta garzetta*	R	C	UC	×	✓	×	✓	×	LC	↑
	Family: Threskiornithidae											
29	Black-headed Ibis	*Threskiornis melanocephalus*	R	C	UC	✓	×	✓	✓	×	NT	↓
30	Indian Black Ibis	*Pseudibis papillosa*	R	C	C	✓	✓	✓	✓	✓	LC	↓
31	Glossy Ibis	*Plegadis falcinellus*	R	C	UC	✓	✓	✓	✓	✓	LC	↓
	Family: Phalacrocoracidae											
32	Little Cormorant	*Microcarbo niger*	R	C	FC	✓	✓	×	✓	×	LC	?
	Order: CHARADRIIFORMES Family: Recurvirostridae											
33	Black-winged Stilt	*Himantopus himantopus*	R	C	CO	✓	✓	✓	✓	✓	LC	↑
	Family: Charadriidae											
34	Little Ringed Plover	*Charadrius dubius*	W	C	UC	×	×	×	✓	×	LC	→
35	Red-wattled Lapwing	*Vanellus indicus*	R	C	CO	✓	✓	✓	✓	✓	LC	?
	Family: Jacanidae											
36	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	S	O	RA	×	×	×	✓	×	LC	↓
	Family: Scolopacidae											
37	Common Sandpiper	*Actitis hypoleucos*	W	I	CO	✓	×	✓	×	×	LC	↓
38	Common Redshank	*Tringa totanus*	W	C	FC	×	×	✓	✓	✓	LC	?
	Order: ACCIPITRIFORMES Family: Accipitridae											
39	Black-winged Kite	*Elanus caeruleus*	R	C	UC	×	×	×	×	✓	LC	→
40	Shikra	*Accipiter badius*	R	C	FC	✓	✓	✓	✓	✓	LC	→
41	Brahminy Kite	*Haliastur Indus*	R	C	RA	×	×	×	✓	×	LC	↓
42	Black Kite	*Milvus migrans*	R	C	FC	✓	×	✓	×	✓	LC	?
	Order: STRIGIFORMES Family: Strigidae											
43	Spotted Owlet	*Athene brama*	R	C	FC	✓	✓	✓	✓	✓	LC	→

	Order/family /common name	Scientific name	Residential status	Feeding guild	Local status	Agricultural landscape					Red List status	Global population trend
						PA	SA	IS	BA	MA		
	Order: BUCEROTIFORMES Family: Bucerotidae											
44	Indian Grey Hornbill	*Ocyceros birostris*	R	O	FC	✓	✓	✓	✓	×	LC	→
	Family: Upupidae											
45	Common Hoopoe	*Upupa epops*	R	O	CO	✓	✓	✓	✓	✓	LC	↓
	Order: PICIFORMES Family: Picidae											
46	Lesser Golden-Backed Woodpecker	*Dinopium benghalense*	R	I	RA	×	×	×	✓	×	LC	→
	Family: Ramphastidae											
47	Brown-headed Barbet	*Psilopogon zeylanicus*	R	F	FC	✓	✓	✓	✓	×	LC	→
48	Coppersmith Barbet	*Psilopogon haemacephalus*	R	F	FC	✓	✓	✓	✓	×	LC	↑
	Order: CORACIIFORMES Family: Meropidae											
49	Green Bee-eater	*Merops orientalis*	R	I	CO	✓	✓	✓	✓	✓	LC	↑
	Family: Coraciidae											
50	Indian Roller	*Coracias benghalensis*	R	I	FC	×	✓	×	×	×	LC	↑
	Family: Alcedinidae											
51	White-throated Kingfisher	*Halcyon smyrnensis*	R	C	CO	✓	✓	✓	✓	✓	LC	↑
	Order: PSITTACIFORMES Family: Psittaculidae											
52	Alexandrine Parakeet	*Psittacula eupatria*	R	F	RA	✓	×	×	✓	×	NT	↓
53	Rose-ringed Parakeet	*Psittacula krameri*	R	F	CO	✓	✓	✓	✓	✓	LC	↑
	Order: PASSERIFORMES Family: Campephagidae											
54	Long-tailed Minivet	*Pericrocotus ethologus*	W	I	UC	✓	×	×	×	×	LC	↓
	Family: Oriolidae											
55	Eurasian Golden Oriole	*Oriolus oriolus*	S	O	RA	✓	×	×	×	×	LC	→
	Family: Dicruridae											
56	Black Drongo	*Dicrurus macrocercus*	R	I	CO	✓	✓	✓	✓	✓	LC	?
	Family: Laniidae											
57	Bay-backed shrike	*Lanius vittatus*	R	I	FC	×	✓	✓	✓	✓	LC	→
58	Long-tailed Shrike	*Lanius schach*	R	I	FC	×	×	✓	✓	✓	LC	?
	Family: Corvidae											
59	RufousTreepie	*Dendrocitta vagabunda*	R	I	CO	✓	✓	✓	✓	×	LC	↓

	Order/family /common name	Scientific name	Residential status	Feeding guild	Local status	Agricultural landscape					Red List status	Global population trend
						PA	SA	IS	BA	MA		
60	House crow	*Corvus splendens*	R	O	CO	✓	✓	✓	✓	✓	LC	→
61	Large-billed Crow	*Corvus macrorhynchos*	W	O	UC	✓	✓	✓	✓	✓	LC	→
	Family: Nectariniidae											
62	Purple Sunbird	*Cinnyris asiaticus*	R	N	FC	✓	✓	✓	✓	✓	LC	→
	Family: Ploceidae											
63	Black-breasted Weaver	*Ploceus benghalensis*	R	G	UC	×	×	×	✓	×	LC	→
64	Streaked Weaver	*Ploceus manyar*	R	G	UC	×	×	✓	×	×	LC	→
65	Baya Weaver	*Ploceus philippinus*	R	G	FC	×	✓	✓	✓	✓	LC	→
	Family: Estrildidae											
66	Indian Silverbill	*Euodice malabarica*	R	G	FC	×	✓	×	✓	×	LC	→
67	Scaly-breasted Munia	*Lonchura punctulata*	R	G	FC	✓	✓	✓	✓	✓	LC	→
	Family: Passeridae											
68	House Sparrow	*Passer domesticus*	R	O	UC	✓	✓	✓	✓	✓	LC	↓
	Family: Motacillidae											
69	Paddyfield Pipit	*Anthus rufulus*	R	I	UC	×	✓	×	×	✓	LC	→
70	Western Yellow Wagtail	*Motacilla flava*	W	I	UC	✓	✓	✓	✓	×	LC	↓
71	Grey Wagtail	*Motacilla cinerea*	W	I	FC	✓	✓	✓	✓	✓	LC	→
72	Citrine Wagtail	*Motacilla citreola*	W	I	FC	✓	×	✓	✓	×	LC	↑
73	White-browed Wagtail	*Motacilla maderaspatensis*	R	I	FC	✓	✓	✓	✓	✓	LC	→
74	White Wagtail	*Motacilla alba*	W	I	FC	✓	✓	×	✓	×	LC	→
	Family: Alaudidae											
75	Crested Lark	*Galerida cristata*	R	O	RA	×	×	×	×	✓	LC	↓
	Family: Cisticolidae											
76	ZittingCisticola	*Cisticola juncidis*	R	I	FC	×	✓	×	✓	×	LC	↑
77	Ashy Prinia	*Prinia socialis*	R	I	FC	✓	✓	✓	✓	✓	LC	→
78	Plain Prinia	*Prinia inornata*	R	I	FC	✓	×	✓	✓	✓	LC	→
79	Common Tailorbird	*Orthotomus sutorius*	R	I	FC	✓	✓	✓	✓	✓	LC	→
	Family: Acrocephalidae											
80	Paddyfield Warbler	*Acrocephalus agricola*	S	O	RA	×	×	✓	×	✓	LC	↓
	Family: Hirundinidae											
81	Red-rumped Swallow	*Cecropis daurica*	R	I	UC	✓	×	×	×	×	LC	→
82	Wire-tailed Swallow	*Hirundo smithii*	R	I	C	✓	✓	✓	✓	✓	LC	↑
83	Barn Swallow	*Hirundo rustica*	R	I	RA	×	✓	×	✓	×	LC	↓
84	Plain Martin	*Riparia paludicola*	R	I	RA	✓	✓	×	×	×	LC	↓

	Order/family /common name	Scientific name	Residential status	Feeding guild	Local status	Agricultural landscape					Red List status	Global population trend
						PA	SA	IS	BA	MA		
	Family: Pycnonotidae											
85	Red-vented Bulbul	*Pycnonotus cafer*	R	O	CO	✓	✓	✓	✓	✓	LC	↑
	Family: Sylviidae											
86	Lesser Whitethroat	*Sylvia curruca*	W	O	UC	×	×	×	✓	×	LC	→
	Family: Zosteropidae											
87	Oriental White-eye	*Zosterops palpebrosus*	R	I	UC	×	✓	×	✓	×	LC	↓
	Family: Leiothrichidae											
88	Large Grey Babbler	*Argya malcolmi*	R	O	FC	✓	✓	✓	✓	✓	LC	→
89	Common Babbler	*Argya caudata*	R	O	FC	×	✓	✓	×	×	LC	→
90	Jungle Babbler	*Turdoides striata*	R	O	FC	×	×	×	×	✓	LC	→
	Family: Sturnidae											
91	Asian Pied Starling	*Gracupica contra*	R	O	FC	✓	×	✓	✓	✓	LC	↑
92	Brahminy Starling	*Sturnia pagodarum*	R	O	UC	✓	×	×	✓	✓	LC	?
93	Common Myna	*Acridotheres tristis*	R	O	C	✓	✓	✓	✓	✓	LC	↑
94	Bank Myna	*Acridotheres ginginianus*	R	I	FC	✓	×	✓	✓	×	LC	↑
	Family: Muscicapidae											
95	Indian Robin	*Saxicoloides fulicatus*	R	I	FC	✓	✓	×	×	✓	LC	→
96	Oriental Magpie Robin	*Copsychus saularis*	R	I	FC	✓	✓	✓	✓	×	LC	→
97	Verditer Flycatcher	*Eumyias thalassinus*	W	I	RA	×	×	×	✓	×	LC	→
98	Bluethroat	*Cyanecula svecica*	W	I	RA	✓	✓	×	×	×	LC	→
99	Black Redstart	*Phoenicurus ochruros*	W	I	UC	✓	✓	×	×	×	LC	↑
100	Pied Bushchat	*Saxicola caprata*	R	I	CO	✓	✓	✓	✓	✓	LC	→
101	Brown Rock Chat	*Oenanthe fusca*	R	I	CO	✓	✓	✓	✓	✓	LC	→

R—Resident | S—Summer migrant | W—Winter migrant | I—Insectivore | C—Carnivore | O—Omnivore | G—Granivore | F—Frugivore | N—Nectarivore | CO—Common | FC—Fairly common | UC—Uncommon | RA—Rare | PA—Panipat | SA—Samalkha | IS—Israna | BA—Bapoli | MA—Madlauda | IUCN—International Union for Conservation of Nature | LC—Least Concern | NT—Near Threatened | →—Stable | ↓—Decreasing | ↑—Increasing | ?—Unknown.

Analysis of data on relative diversity revealed that Ardeidae was the most diverse bird family in the study area (8 species, RDi = 7.92) followed by Muscicapidae (7 species, RDi = 6.93), Motacillidae (6 species, RDi = 5.94), while 22 families, Podicipedidae, Apodidae, Phalacrocoracidae, Recurvirostridae, Jacanidae, Strigidae, Bucerotidae, Upupidae, Picidae, Meropidae, Coraciidae, Alcedinidae, Campephagidae, Oriolidae, Dicruridae, Nectariniidae, Passeridae, Alaudidae, Acrocephalidae, Pycnonotidae, Sylviidae, and Zosteropidae, were poorly represented in the study area with a single species in each (RDi= 0.99; Table 3). Muscicapidae is the largest family of birds in India (Manakadan & Pittie 2001). In the study area, however, Ardeidae showed the highest diversity of species, followed by Muscicapidae. Nevertheless, several other studies have also found Ardeidae to be the most diverse avian family, particularly in agricultural habitats, urban areas, and wetlands in India (Basavarajappa 2006; Kumar 2006; Vijayan et al. 2006; Dal & Vaghela 2015; Mukhopadhyay & Mazumdar 2017). Of the total species identified, 35 species (34.65%) were recorded from all the five selected agricultural landscapes, but 66 species (65.34%) were spotted at some specific agricultural landscapes only. The similarity in species composition of birds as measured by Jaccard's index, between the five selected agricultural landscapes is shown in Table 4. These results revealed that Panipat and Israna blocks (0.685) showed a maximum similarity in bird communities, while species' similarity of Samalkha with Madlauda was recorded to be the minimum (0.487). The highest species similarity recorded between Panipat and Israna block might be attributed to landscape characteristics. Habitats with greater structural similarity tended to present similar bird communities (Tubelis & Cavalcanti 2001; Andrade et al. 2018).

In the study area, 77 species (76.23%) were residents, 18 (17.82%) were winter migrants, and 6 (5.94%) were summer migrants. The spotting of a considerable number of winter visitors can be attributed partly to the study area being on the Central Asian Flyway and serving as a wintering site for migratory birds that breed in the Palearctic region (Kumar et al. 2016). The highest number of bird species was recorded at Bapoli block (77), followed by Samalkha block (68), Panipat block (62), Israna block (56), and Madlauda block (51) as shown in Table 2. During the summer and winter seasons, 83 and 95 bird species were recorded respectively. Seventy-seven bird species were common to both seasons but six and 18 were exclusive to summer and winter seasons, respectively. The species richness of birds during summer and winter was significantly different ($F_{1, 50}$ = 93.35, $P < 0.05$) and also varied significantly among the five agricultural landscapes ($F_{4, 50}$ = 86.09, $P < 0.05$, Table 5). Average species richness of Bapoli block (65.50 ± 7.29) was significantly higher (Tukey's HSD test, all $P < 0.05$) than that of the remaining four agricultural landscapes. Species richness at Samalkha block (58.42 ± 5.81), however, showed non-significant differences ($P > 0.05$) with that of Panipat block (54.67 ±4.94). The species diversity of birds also varied significantly between the seasons ($F_{1,50}$ = 93.70, $P < 0.05$) as well as among the five landscapes ($F_{4,50}$ =126.29, $P < 0.05$). Mean species diversity of Bapoli block (3.78 ±0.04) was significantly higher than in the other four agroecosystems (Tukey's HSD test, all $P < 0.05$). But the average species diversity at Panipat block (3.58 ±0.05) did not differ significantly ($P > 0.05$) from that of Israna block (3.57 ±0.04) and Madlauda block (3.56 ±0.05). Species evenness differed significantly between the summer and winter seasons ($F_{1, 50}$ = 65.35, $P < 0.05$) and also among the five agroecosystems ($F_{4,50}$ =85.15, $P < 0.05$). Average species evenness at Madlauda block (0.95 ±0.01) was registered significantly higher than the remaining agroecosystems

Table 3. Relative diversity index (RDi) of various avian families in agricultural landscapes of district Panipat, Haryana, India.

Avian families	Number of recorded species	Relative diversity index (RDi)
Ardeidae	8	7.92
Muscicapidae	7	6.93
Motacillidae	6	5.94
Columbidae, Cuculidae	5	4.95
Accipitridae, Cisticolidae, Hirundinidae, Sturnidae	4	3.96
Phasianidae, Ciconiidae, Threskiornithidae, Corvidae, Ploceidae, Leiothrichidae	3	2.97
Rallidae, Charadriidae, Scolopacidae, Ramphastidae, Psittaculidae, Laniidae, Estrildidae	2	1.98
Podicipedidae, Apodidae, Phalacrocoracidae, Recurvirostridae, Jacanidae, Strigidae, Bucerotidae, Upupidae, Picidae, Meropidae, Coraciidae, Alcedinidae, Campephagidae, Oriolidae, Dicruridae, Nectariniidae, Passeridae, Alaudidae, Acrocephalidae, Pycnonotidae, Sylviidae, Zosteropidae	1	0.99

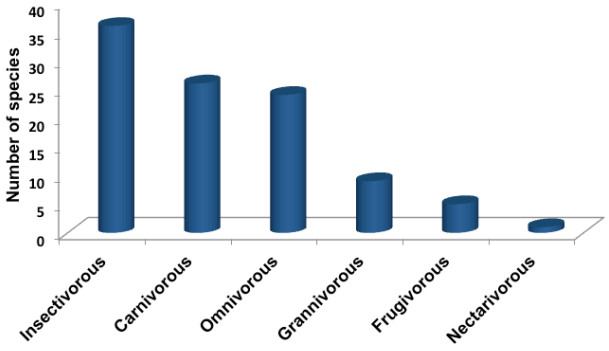

Figure 2. Feeding guilds of bird species recorded in agricultural landscapes of district Panipat, Haryana, India.

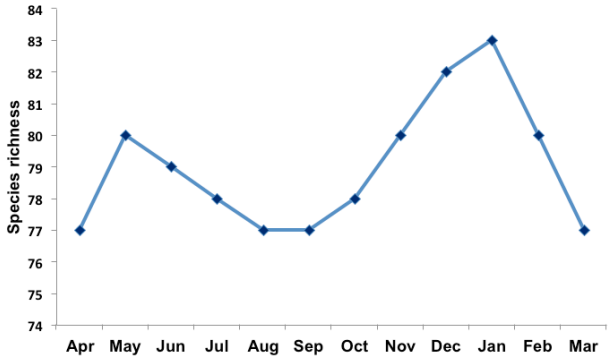

Figure 3. Monthly variations in overall species richness in all the selected agricultural landscapes of the study area during 2015–16.

(Tukey's HSD test, all $P < 0.05$). The average species evenness at Samalkha block (0.90 ±0.01) did not differ significantly ($P > 0.05$) from that of Bapoli block (0.90 ±0.02) and Panipat block (0.90±0.01). This relatively higher species richness, diversity and abundance of birds recorded during the winter (as compared to summer) might be due to the arrival of more migratory species during the winter season, and variation in habitat conditions (Kumar et al. 2016; Rajashekara & Venkatesha 2017). Bird species richness and community structure differ from region to region (Karr & Roth 1971; Pearson 1975; Richards 1996). From the observations it is evident that species richness and diversity of birds varied within the geographical area considered in the present study. This difference in bird diversity among the selected agroecosystems might be associated with availability of food, roosting and nesting sites, predation pressure and human disturbance (Hossain & Aditya 2016; Narayana et al. 2019). Crop composition and farming intensity also determine the species richness and abundance of birds in the agricultural landscapes (Cunningham et al. 2013). In the Bapoli block, the selected agricultural landscape was surrounded with patches of tall wooded trees, scrub and bushy type stumpy vegetation, grasses and the wetlands (river Yamuna) which provided a mosaic of habitats, leading to multiple and variety of the alternative food resources, and opportunities for microhabitat segregation for the birds and, thus, registered highest species richness and diversity (Hossain & Aditya 2016; Narayana et al. 2019). In contrast, agricultural landscape of Madlauda block being located in the vicinity of an industrial area (Thermal Power Plant of Panipat) was exposed to enhanced anthropogenic activities and adjacent land use alteration thus had the lowest species richness and diversity (Hossain & Aditya 2016). Human activities and their direct interference strongly disturb the avifauna (Hossain & Aditya 2016). This reflects that the basic requirements such as food, shelter, roosting and nesting sites for bird communities are not equally available in the different agricultural landscapes.

Monthly variations in species richness of birds in the study area are depicted in Figure 3. Overall, a maximum number of bird species was recorded in January (83 species), and minimum in August and September (77 species each). The variation in species richness could be related with the arrival of migratory species. It is evident from the figure that species richness of birds at study area begins to increase with the arrival of winter visitors. The winter migratory birds started appearing at study sites in October, gradually increased from November, reached a peak in the month of January, then started declining and leave the agricultural fields by April, flying back to their breeding grounds. Resident species were present throughout the year and showed no seasonal variation, but the migratory species (winter visitors and summer visitors) showed a definite species-specific pattern of arrival and departure from the study area. We observed that the majority of the winter migrants stayed in the agricultural fields from November to March. The summer visitors, including Pied Cuckoo, Drongo Cuckoo, Common Hawk Cuckoo, Pheasant-tailed Jacana, Eurasian Golden Oriole, and Paddy field Warbler were spotted during summer season (April–August) in the study area.

In this study, the recorded bird species were categorized into six major feeding guilds (Figure 2). This representation of major trophic guilds in the area indicated that the agricultural landscapes hold a wide variety of food resources for birds. The insectivore guild was the most abundant one with 36 species followed by carnivore (26), omnivore (24), granivore (9), frugivore (5) and nectarivore (1) guild. The results of the present study are consistent with the previously studied - that insectivore is the dominant feeding guild in agricultural

Table 4. Jaccard's similarity index (C_j) of bird species between selected agricultural landscapes of the study area.

Agricultural landscape	Panipat	Samalkha	Israna	Bapoli
Madlauda	0.547	0.487	0.671	0.488
Bapoli	0.616	0.611	0.602	
Israna	0.685	0.569		
Samalkha	0.604			

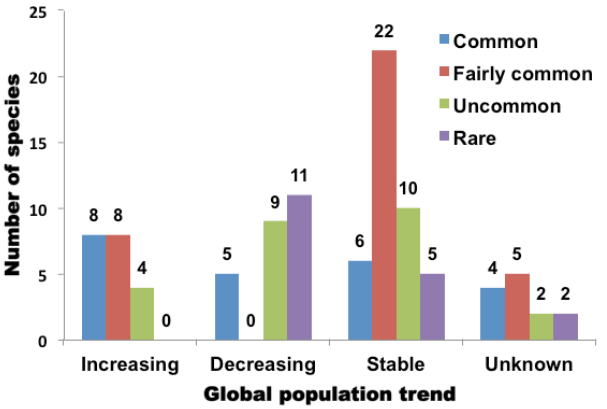

Figure 4. Comparison of local status of avifaunal species recorded in selected agricultural landscapes of the district Panipat, Haryana with its IUCN global population trend.

ecosystems in India (Dhindsa & Saini 1994; Narayana et al. 2019). Maximum insectivorous bird species belonged to Muscicapidae (7 species) and Motacillidae (6 species). The results of the current study also reflect possible variation in functional roles, feeding habits and resource utilization pattern of birds in the agricultural landscapes. Most bird species within the study area were insectivorous, indicating a rich abundance of insects here. Insectivorous birds play a crucial role in biological control of various insect pests thriving in agriculture, horticulture, floriculture, and forests (Mahabal 2005; Thakur et al. 2010). Indiscriminate use of chemical pesticides in the agricultural fields may have severe ecological consequences and a grave effect on the birds of the selected area. Insectivorous birds often consume insects contaminated with pesticides (Sánchez-Bayo et al. 1999), and thus these birds, being at a higher trophic level in food chain, are at a high risk of suffering from the toxic effects of bioaccumulation of such chemical pesticides (Sánchez-Bayo 2011).

Among the recorded avifauna, four species namely, Painted Stork *Mycteria leucocephala*, Black-necked Stork *Ephippiorhynchus asiaticus*, Oriental White Ibis *Threskiornis melanocephalus* and Alexandrine Parakeet *Psittacula eupatria* are Near Threatened species, while the remaining species are categorized as least concern species in the Red List of IUCN (2019). Assessment of local abundance revealed that 23 species were common, 35 species were fairly common, 25 species were uncommon and 18 species were rare in the study area (Table 2). When this local abundance status was compared with the global population trend of the species (Figure 4), we found that some species having a globally declining population trend were still common in the study area. Five species with globally declining population trends, Rock Pigeon *Columba livia*, Indian Black Ibis *Pseudibis papillosa*, Common Sandpiper *Actitis hypoleucos*, Eurasian Hoopoe *Upupa epops*, and Rufous Treepie *Dendrocitta vagabunda* were found to be common in our study area, which indicates that suitable resources for these avian species are still available in these agricultural landscapes. Hence, these species must be prioritized for regular and long-term monitoring from a global bird conservation perspective.

Birds are a good agency for dispersing seeds, pollinating plants, biological control of pests, and thus have a vital role in continuing the ecological cycle (Lawson et al. 1998; Gregory et al. 2008). Hence a decline in the diversity of birds may induce a cascading effect on the food chain, affecting multiple species and subsequently disrupting the species interactions and integrity of ecosystem functions (Whelan et al. 2008; Sekercioglu et al. 2012). Regular and long-term monitoring of avifauna is, therefore, an excellent means of keeping watch on ecosystem health. Assessment of the species richness and composition of birds in a particular landscape is a prerequisite to assess their ecological importance (Sekercioglu et al. 2012; Hossain & Aditya 2016; Mukhopadhyay & Mazumdar 2017). In this context the present study is the first scientific documentation of avifaunal diversity in the agricultural landscapes of the district Panipat, Haryana, India. The findings of the present study can be used as a baseline for further research on conservation and management of existing bird species in the agricultural landscapes. Regular and long-term monitoring of bird assemblages should be continued in the study area, emphasizing seasonal abundance, habitat use, nesting, feeding and breeding ecology to supplement a holistic approach to conservation and management strategies for sustenance of ecosystem services derived from the agricultural birds.

Table 5. Species richness, abundance, species diversity and species evenness of avifauna in the selected agricultural landscapes of the district Panipat, Haryana

Agricultural landscape		Diversity indices(mean± SE)											
		Species richness			Number of birds			Species diversity			Species evenness		
		Summer	Winter	Both	Summer	Winter	Both	Summer	Winter	Both	Summer	Winter	Both
Panipat		51.00 ±2.19	58.33 ±4.08	54.67^{bc} ±4.94	200.17 ±34.08	234.67 ±26.56	217.42^{abc} ±34.25	3.54 ±0.02	3.62 ±0.04	3.58^{c} ±0.05	0.90 ±0.00	0.89 ±0.01	0.90^{cde} ±0.01
Samalkha		54.00 ±2.00	62.83 ±4.83	58.42^{b} ±5.81	210.83 ±33.23	246.83 ±20.43	228.83^{ab} ±32.33	3.63 ±0.02	3.71 ±0.04	3.67^{b} ±0.05	0.91 ±0.00	0.90 ±0.01	0.90^{c} ±0.01
Israna		44.17 ±2.86	51.33 ±2.66	47.75^{d} ±4.58	164.17 ±23.96	205.17 ±23.27	184.67^{d} ±31.07	3.54 ±0.02	3.61 ±0.02	3.57^{cd} ±0.04	0.93 ±0.01	0.92 ±0.01	0.92^{b} ±0.01
Bapoli		59.50 ±3.02	71.50 ±4.64	65.50^{a} ±7.29	230.83 ±25.21	265.67 ±18.12	248.25^{a} ±27.73	3.75 ±0.02	3.81 ±0.03	3.78^{a} ±0.04	0.92 ±0.01	0.89 ±0.01	0.90^{cd} ±0.02
Madlauda		39.67 ±2.58	45.83 ±3.06	42.75^{e} ±4.20	155.50 ±36.78	209.50 ±25.17	182.50^{de} ±41.21	3.53 ±0.03	3.60 ±0.04	3.56^{cde} ±0.05	0.96 ±0.01	0.94 ±0.01	0.95^{a} ±0.01
ANOVA F-value	Season			93.35			32.30			93.70			65.35
	Landscape			86.09			13.05			126.29			85.15
P-value	Season			0.00*			0.00*			0.00*			0.00*
	Landscape			0.00*			0.00*			0.00*			0.00*

*-significant differences were found at 5% level of significance. Results in a column under various indices followed by different letters indicate significant differences among different agricultural landscapes at $P < 0.05$. Results in a column followed by same letters indicate non-significant differences among different agricultural landscapes at $P > 0.05$ (Two-way ANOVA and Tukey's HSD post-hoc test).

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