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Avian Diversity in Agricultural Landscapes of District Panipat, Haryana, India

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ABSTRACT

Agricultural landscapes provide a variety of habitats and support rich diversity of avifauna. Field surveys were conducted from April 2015 to March 2016, following point-transect and direct observations to document diversity and temporal variation of avifauna in agricultural landscapes of Panipat district of Haryana. A total of 99 bird species under 44 families and 15 orders were recorded, of which 79 were residents, 14 were winter migrants and 6 were summer migrants. Bird species richness was highest for the order Passeriformes (46), followed by Pelecaniformes (15) and rest 13 orders. Ardeidae was the most diverse family in the study area. Most bird species were insectivorous (34) followed by carnivorous (26), omnivorous (24), granivorous (9), frugivorous (5) and nectarivorous (1). Species richness, abundance, diversity and evenness differed significantly ($P< 0.05$) between seasons as well as among habitats. Four species are listed as Near Threatened in IUCN Red List. Moreover, five species having a globally declining population trends were frequently observed in the study area. This emphasizes that study sites are crucial habitat for bird species of conservation priorities. The present study is expected to provide a baseline for future research on management and conservation of existing avian species in agricultural landscapes.

Key words: Avian, diversity, species richness, agricultural landscape, conservation

INTRODUCTION

Birds are potential ecological indicators of integrity and stability of ecosystem structure and functions (Lawson *et al.*, 1998; Gregory *et al.,* 2008). Species composition in bird communities depends on the available resource and varies with the landscapes across large geographical areas. Characteristic bird assemblage in landscapes enables predictions about the ecological health and possible deviations in the ecosystem functions (Whelan *et al*., 2008; Sekercioglu, 2012). Birds are key component of an agro-ecosystem and often execute varied functional roles as pollinators, seed dispensers, 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 considered a good indicator of overall biodiversity in agricultural landscapes (Malhi, 2006; Birasal, 2014).

Birds are known to play a dual role as pests and as biological control agents of insect pests in agro-ecosystems (Ali, 1949; Dhindsa & Saini, 1994; Bianchi *et al*., 2006). 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 arthropods and rodents (Dhindsa & Saini, 1994; Asokan *et al*., 2010). In agricultural landscapes most bird species are insectivorous and have a potential check on harmful insects thereby are beneficial to agriculturists (Asokan *et al*., 2010; Narayana *et al*., 2015). Therefore, these insectivorous birds need to be encouraged and conserved in the agricultural landscape by use of proper management practices (Malhi, 2006; Narayana *et al*., 2015). However, only limited information is available on the species diversity of the pests and beneficial birds from agricultural fields in India (Dhindsa & Saini, 1994; Hossain & Aditya, 2016).

The state of Haryana in India, in the last few decades, has witnessed tremendous changes in its agro-ecosystem owing to massive deforestation, intensive agriculture and its mechanization, excessive use of pesticides and fertilizers along with rapid urbanization and industrial growth. All these anthropogenic activities have resulted in several ecological changes in the agro-ecosystems, which in turn have greatly affected the bird fauna of the state. There is a need to study the community structure and species diversity of birds of agro-ecosystems in order to investigate the impact of changing natural habitat and agricultural practices (Mallik *et al*., 2015). Assessment of bird assemblages is thus being emphasized for monitoring ecosystem conditions and functions (Bradford *et al*., 1998; Browder *et al*., 2002). Information on species richness and community structure of birds will enable conservation planning for sustaining birds without interfering with the objective of intensive agricultural practices (Dhindsa & Saini, 1994; Sundar & Kittur, 2013). Panipat is one of the

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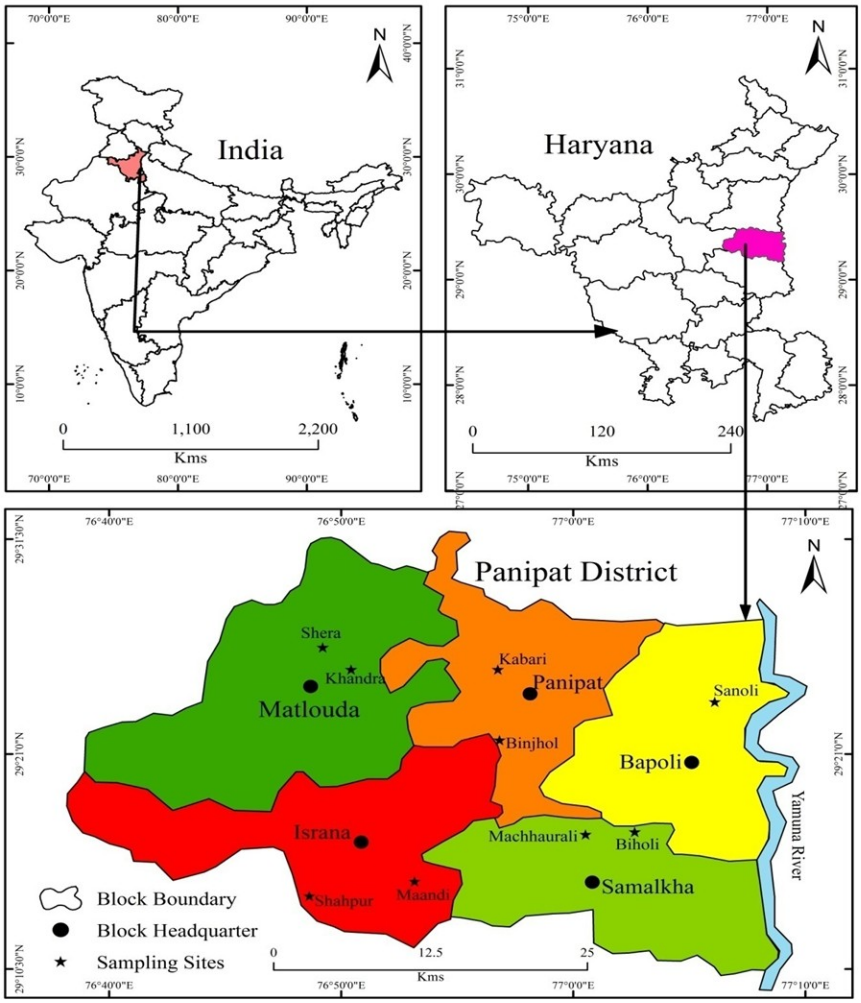

Figure 1. Map of study area of Panipat, Haryana, India with location of study sites

agriculturally advanced districts of the state of Haryana, India. Consequently, there is no data available on the bird diversity in agricultural landscapes of the Panipat district. In this context, the present study made an attempt to record avifaunal diversity in agricultural landscapes of district Panipat, Haryana.

MATERIALS AND METHODS

Study Area

The present study was conducted in all the five development blocks (Panipat, Samalkha, Israna, Bapoli and Madlauda) of district Panipat(29^0 09' to 29^o 27'N and 76^o 38' to 77^o 09' E), Haryana in northern India, taking at least two study sites in each development block (Figure 1). It covers an area of 1268 km^2. Net area sown in the district is 93000 ha which constitutes 71% of the total area. Agricultural activities of the district are dependent on tubewells 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. Sunflower and sugarcane are also being grown in the study area as cash crops. 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^o C in summer and as low as 3^o C in winter. The average annual rainfall in the district is 467 mm.

Data Collection

Field surveys were conducted at two-week intervals in all the study sites from April 2015 to March 2016, employing the point-transect method (Sutherland, 2006). One km transect was laid at each study site and at every 200 m distance one point was marked and the birds species were recorded in 20 m radius, and each point location was surveyed 24 times during the entire study period. On arrival at a survey point, an initial five-minute settling-down period was used prior to counting the birds, and 10 -20 mins were spent at each point surveying the birds. Birds were counted directly, aided by field binocular (Nikon 8 x 40), during hours of peak activity 06:00 to 10:00 h and 16:00 to 18:00 h. In addition to these regular surveys, opportunistic records of birds at other times were also included to document a comprehensive checklist. Birds were identified using field guides (Ali &Ripley, 1987; Grimmett *et al*., 2011). Taxonomic position (Order and family), common and scientific names of recorded species were accorded following Praveen *et al*. (2016). Based on their seasonal dispersal pattern in the study area, birds were classified as resident, summer visitor and winter visitor (Grimmett *et al*., 2011). 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, rare (RA) - sighted on less than 19.9% of field visits. For determination of the feeding guilds, foraging birds were observed with the help of binoculars in the study area. Feeding guilds were classified on the basis of direct observations and available literature (Ali & Ripley, 1987). Conservation status of recorded bird species was assessed following International Union for Conservation of Nature (IUCN, 2019). The global population trend of the species obtained from the Red List of IUCN (2019) was compared with its local status in the study area.

Data Analysis

Species richness was estimated by recording the number of bird species encountered in the study area. Species diversity was calculated using Shannon–Wiener's index (H) as

$$H = -\sum_{i=1}^{S} pi \ln pi$$

Where, H is index of species diversity, pi is the proportion of the total sample belonging to the *i*th species and S is the total number of species in the community.

Evenness index (E) was estimated using the following formula:

E= H/ ln S,

Where, H is Shannon-Wiener's diversity index and S is species richness.

The relative diversity (RDi) of bird families was calculated using the following formula as per 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 habitats 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 habitats , b is number of species recorded in the first habitat only and c is the number of species recorded only in the second habitat.

Two-way analysis of variance (ANOVA) was used to analyse the effect of two variables i.e. season and habitat. Where statistically significant differences have been found, we did pair wise multiple comparisons (Tukey's HSD test) to evaluate differences among the five habitat types at 5% level of significance.

RESULTS AND DISCUSSION

A total of 99 species of birds belonging to 80 genera, 44 families and 15 orders were recorded during the study period (Table 1).The study area supports about 19% of bird species recorded from Haryana (Kalsi *et al*., 2019), and 8% of species reported from India (Praveen *et al*., 2016). The rich avian assemblage in the agricultural landscapes can be corroborated with the varied micro-habitats that appear to provide abundant food resources and suitable roosting or nesting sites for migratory and resident species. The observed richness of bird species is comparable with earlier studies conducted in different agro-ecological regions of India. For example, Malhi (2006) recorded of 128 bird species from agricultural habitat and other associated sub-habitats of Punjab. Gupta and Singh (2014) recorded 79 species from agricultural landscape in Yamuna Nagar district of Haryana. Abdar (2014) observed 97 species of birds from agricultural areas of Western Ghats, Maharashtra. Narayana *et al*. (2015) recoded 104 species from Nalgonda district of Telegana. Hossain and Aditya (2016) recoded occurrence of 144 bird species from agricultural landscapes of Burdwan, West Bengal. Order Passeriformes (46 species) had the highest species representation followed by Pelecaniformes (15) and rest 13 orders. According to Praveen *et al*. (2016), passerines (order Passeriformes) constitute the most predominant avian taxon in India. In terms of families, Ardeidae was the most diverse family in the study area (8 species, RDi = 8.08) followed by Motacillidae (6 species RDi = 6.06). Moreover, 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 = 1.01; Table 2). Muscicapidae is the largest bird family in India (Manakadan and Pittie, 2001). However, several studies have also found Ardeidae to be the most diverse bird family, particularly in agricultural landscapes, sub-urban areas and wetlands in India (Basavarajappa, 2006; Gupta & Singh, 2014, Dal &Vaghela, 2015; Mukhopadhyay & Mazumdar, 2017). Among the recorded species in different agricultural landscapes of the study area, 36 species (36.36%) were common to all the five habitats, while 63 species (63.63%) were spotted at some specific habitats. The similarity in species composition of bird assemblage as measured by Jaccard's similarity index, among the five selected agricultural landscapes is shown in Table 3. These results revealed that Panipat and Israna block (0.676) showed maximum similarity in bird communities, while species similarity of Bapoli with Madlauda was recorded to be minimum (0.518). This highest species similarity recorded between Panipat and Israna landscapes might be attributed to habitat similarity. Habitat proximity and similarity have been reported to determine species diversity and similarity of birds among habitats (Tubelis & Cavalcanti, 2001; Zeleke *et al*., 2015; Andrade *et al*., 2018).

Of the total 99 bird species, 79 (79.79%) were residents, 14 (14.14%) winter migrants and 6 (6.06%) were summer migrants. Species richness, abundance, diversity and evenness of birds differed significantly ($P < 0.05$) between seasons as well as among habitats (Table 4). This significantly higher species richness, species diversity and abundance of birds registered during the winter season compared to summer season might be related with arrival of more migratory birds (Rajashekara

Table 1. List of bird species recorded from agricultural landscapes of District Panipat, Haryana, India

Order/Family	Common and Scientific names	Dispersal status	Feeding guild	Local status	Habitat					IUCN status	Global trend
					PA	SA	IS	BA	MA		
Order: Galliformes											
Phasianidae	Indian Peafowl *Pavo cristatus*	R	O	CO	+	+	+	+	+	LC	→
	Black Francolin *Francolinus francolinus*	R	O	UC	-	+	-	+	+	LC	→
	Grey Francolin *Francolinus pondicerianus*	R	O	FC	-	+	+	-	-	LC	→
Order: Phoenicopterifomes											
Podicipedidae	Little Grebe *Tachybaptus ruficollis*	R	C	UC	-	+	-	+	-	LC	↓
Order: Columbiformes											
Columbidae	Rock Pigeon *Columba livia*	R	G	CO	+	+	+	+	+	LC	↓
	Eurasion Collared Dove *Streptopelia decaocto*	R	G	FC	-	+	+	+	-	LC	↑
	Spotted Dove *Spilopelia chinensis*	R	G	FC	+	+	+	+	+	LC	↑
	Laughing Dove *Streptopelia senegalensis*	R	G	CO	+	+	+	+	+	LC	→
	Yellow-legged Green Pigeon *Treron phoenicopterus*	R	F	UC	+	+	-	+	-	LC	↑
Order: Caprimulgiformes											
Apodidae	Indian House Swift *Apus affinis*	R	I	UC	-	+	-	+	-	--LC	↑
Order: Cuculiformes											
Cuculidae	Greater Coucal *Centropus sinensis*	R	O	CO	+	+	+	+	+	LC	→
	Pied Cuckoo *Clamator jacobinus*	S	I	UC	+	+	-	+	-	LC	→
	Asian Koel *Eudynamys scolopaceus*	R	O	FC	+	+	-	+	-	LC	→
	Drongo Cuckoo *Surniculus lugubris*	S	I	RA	-	+	-	+	-	LC	↓
	Common Hawk Cuckoo *Hierococcyx varius*	S	I	RA	-	+	-	+	-	LC	→
Order: Gruiformes											
Rallidae	White-breasted Waterhen *Amaurornis phoenicurus*	R	O	CO	+	+	+	+	+	LC	?
	Purple Swamphen *Porphyrio porphyrio*	R	O	FC	-	+	-	-	+	LC	?

Table 1 continued in next page

Order: Pelecaniformes											
Ciconiidae	Painted Stork *Mycteria leucocephala*	W	C	RA	-	+	-	+	-	NT	↓
	Asian Openbill *Anastomus oscitans*	W	C	RA	-	+	-	+	-	LC	?
	Black-necked Stork *Ephippiorhynchus asiaticus*	W	C	RA	-	+	-	+	-	NT	↓
Ardeidae	Black-crowned Night Heron *Nycticorax nycticorax*	R	C	UC	-	-	+	+	-	LC	↓
	Indian Pond Heron *Ardeola grayii*	R	C	CO	+	+	+	+	+	LC	?
	Cattle Egret *Bubulcus ibis*	R	C	CO	+	+	+	+	+	LC	↑
	Grey Heron *Ardea cinerea*	R	C	RA	-	-	-	+	-	LC	?
	Purple Heron *Ardea purpurea*	R	C	RA	-	+	-	-	-	LC	↓
	Great Egret *Ardea alba*	W	C	UC	-	+	-	+	-	LC	?
	Intermediate Egret *Ardea intermedia*	W	C	UC	+	+	+	+	+	LC	↓
	Little Egret *Egretta garzetta*	R	C	UC	-	+	-	+	-	LC	↑
Threskiornithidae	Black-headed Ibis *Threskiornis melanocephalus*	R	C	UC	+	-	+	+	-	NT	↓
	Indian Black Ibis *Pseudibis papillosa*	R	C	CO	+	+	+	+	+	LC	↓
	Glossy Ibis *Plegadis falcinellus*	R	C	UC	+	+	+	+	+	LC	↓
Phalacrocoracidae	Little Cormorant *Microcarbo niger*	R	C	FC	+	+	-	+	-	LC	?
Order: Charadriiformes											
Recurvirostridae	Black-winged Stilt *Himantopus himantopus*	R	C	CO	+	+	+	+	+	LC	↑
Charadriidae	Little Ringed Plover *Charadrius dubius*	W	C	UC	-	+	-	+	-	LC	→
	Red-wattled Lapwing *Vanellus indicus*	R	C	CO	+	+	+	+	+	LC	?
Jacanidae	Pheasant-tailed Jacana *Hydrophasianus chirurgus*	S	O	RA	-	+	-	+	-	LC	↓
Scolopacidae	Common Sandpiper *Actitis hypoleucos*	W	I	CO	+	-	+	-	-	LC	↓
	Common Redshank *Tringa totanus*	W	C	FC	-	+	+	+	+	LC	?
Order: Accipitriformes											
Accipitridae	Black-winged Kite *Elanus caeruleus*	R	C	UC	+	-	-	-	+	LC	→
	Shikra *Accipiter badius*[*]	R	C	FC	+	+	+	+	+	LC	→
	Brahminy Kite *Haliastur indus*	R	C	RA	+	+	-	+	-	LC	↓
	Black Kite *Milvus migrans*	R	C	FC	+	-	+	-	+	LC	?

Table 1 continued in next page

Order: Strigiformes											
Strigidae	Spotted Owlet *Athene brama*	R	C	FC	+	+	+	+	+	LC	→
Order: Bucerotiformes											
Bucerotidae	Indian Grey Hornbill *Ocyceros birostris*	R	O	FC	+	+	+	+	-	LC	→
Upupidae	Common Hoopoe *Upupa epops*	R	O	CO	+	+	+	+	+	LC	↓
Order: Piciformes											
Picidae	Lesser Golden-Backed Woodpecker *Dinopium benghalense*	R	I	RA	+	-	-	+	-	LC	→
Ramphastidae	Brown-headed Barbet *Psilopogon zeylanicus*	R	F	FC	+	+	+	+	-	LC	→
	Coppersmith Barbet *Psilopogon haemacephalus*	R	F	FC	+	+	+	+	-	LC	↑
Order: Coraciiformes											
Meropidae	Green Bee-eater *Merops orientalis*	R	I	CO	+	+	+	+	+	LC	↑
Coraciidae	Indian Roller *Coracias benghalensis*	R	I	FC	+	+	-	+	-	LC	↑
Alcedinidae	White-throated Kingfisher *Halcyon smyrnensis*	R	C	CO	+	+	+	+	+	LC	↑
Order: Psittaciformes											
Psittaculidae	Alexandrine Parakeet *Psittacula eupatria*	R	F	RA	+	+	-	+	-	NT	↓
	Rose-ringed Parakeet *Psittacula krameri*	R	F	CO	+	+	+	+	+	LC	↑
Order: Passeriformes											
Campephagidae	Long-tailed Minivet *Pericrocotus ethologus*	W	I	UC	+	-	-	+	-	LC	↓
Oriolidae	Eurasian Golden Oriole *Oriolus oriolus*	S	O	RA	+	-	-	+	-	LC	→
Dicruridae	Black Drongo *Dicrurus macrocercus*	R	I	CO	+	+	+	+	+	LC	?
Laniidae	Bay-backed shrike *Lanius vittatus*	R	I	FC	-	+	+	+	+	LC	→
	Long-tailed Shrike *Lanius schach*	R	I	FC	+	+	+	+	+	LC	?
Corvidae	RufousTreepie *Dendrocitta vagabunda*	R	I	CO	+	+	+	+	-	LC	↓
	House crow *Corvus splendens*	R	O	CO	+	+	+	+	+	LC	→
	Large-billed Crow *Corvus macrorhynchos*	W	O	UC	+	+	+	+	+	LC	→
Nectariniidae	Purple Sunbird *Cinnyris asiaticus*	R	N	FC	+	+	+	+	+	LC	→
Ploceidae	Black-breasted Weaver *Ploceus benghalensis*	R	G	UC	+	-	-	+	-	LC	→
	Streaked Weaver *Ploceus manyar*	R	G	UC	-	+	+	+	-	LC	→
	Baya Weaver *Ploceus philippinus*	R	G	FC	+	+	+	+	+	LC	→

Table 1 continued in next page

Estrildidae	Indian Silverbill *Euodice malabarica*	R	G	FC	-	+	-	+	+	LC	→
	Scaly-breasted Munia *Lonchura punctulata*	R	G	FC	+	+	+	+	+	LC	→
Passeridae	House Sparrow *Passer domesticus*	R	O	UC	+	+	+	+	+	LC	↓
Motacillidae	Paddyfield Pipit *Anthus rufulus*	R	I	UC	-	+	-	+	+	LC	→
	Western Yellow Wagtail *Motacilla flava*	W	I	UC	+	+	+	+	-	LC	↓
	Grey Wagtail *Motacilla cinerea*	W	I	FC	+	+	+	+	+	LC	→
	Citrine Wagtail *Motacilla citreola*	W	I	FC	+	-	+	+	-	LC	↑
	White-browed Wagtail *Motacilla maderaspatensis*	R	I	FC	+	+	+	+	+	LC	→
	White Wagtail *Motacilla alba*	W	I	FC	+	+	-	+	-	LC	→
Alaudidae	Crested Lark *Galerida cristata*	R	O	RA	-	+	-	-	+	LC	↓
Cisticolidae	ZittingCisticola *Cisticola juncidis*	R	I	FC	-	+	-	+	-	LC	↑
	Ashy Prinia *Prinia socialis*	R	I	FC	+	+	+	+	+	LC	→
	Plain Prinia *Prinia inornata*	R	I	FC	+	-	+	+	+	LC	→
	Common Tailorbird *Orthotomus sutorius*	R	I	FC	+	+	+	+	+	LC	→
Acrocephalidae	Paddyfield Warbler *Acrocephalus agricola*	S	O	RA	-	-	+	-	+	LC	↓
Hirundinidae	Redrumped Swallow *Cecropis daurica*	R	I	UC	+	-	-	-	-	LC	→
	Wire-tailed Swallow *Hirundo smithii*	R	I	CO	+	+	+	+	+	LC	↑
	Barn Swallow *Hirundo rustica*	R	I	RA	-	+	-	+	-	LC	↓
	Plain Martin *Riparia paludicola*	R	I	RA	+	+	-	-	-	LC	↓
Pycnonotidae	Red-vented Bulbul *Pycnonotus cafer*	R	O	CO	+	+	+	+	+	LC	↑
Sylviidae	Lesser Whitethroat *Sylvia curruca*	W	O	UC	-	-	-	+	-	LC	→
Zosteropidae	Oriental White-eye *Zosterops palpebrosus*	R	I	UC	-	+	-	+	-	LC	↓
Leiothrichidae	Large Grey Babbler *Argya malcolmi*	R	O	FC	+	+	+	+	+	LC	→
	Common Babbler *Argya caudata*	R	O	FC	-	+	+	-	-	LC	→
	Jungle Babbler *Turdoides striata*	R	O	FC	+	+	-	+	+	LC	→
Sturnidae	Asian Pied Starling *Gracupica contra*	R	O	FC	+	+	+	+	+	LC	↑
	Brahminy Starling *Sturnia pagodarum*	R	O	UC	+	+	-	+	+	LC	?
	Common Myna *Acridotheres tristis*	R	O	CO	+	+	+	+	+	LC	↑
	Bank Myna *Acridotheres ginginianus*	R	I	FC	+	+	+	+	-	LC	↑
	Indian Robin *Saxicoloides fulicatus*	R	I	FC	+	+	-	+	+	LC	→
Muscicapidae	Oriental Magpie Robin *Copsychus saularis*	R	I	FC	+	+	+	+	-	LC	→
	Bluethroat *Cyanecula svecica*	W	I	RA	+	+	+	+	-	LC	→
	Pied Bushchat *Saxicola caprata*	R	I	CO	+	+	+	+	+	LC	→
	Brown Rock Chat *Oenanthe fusca*	R	I	CO	+	+	+	+	+	LC	→

R-Resident, S-Summer migrant, W-Winter migrant, C-Carnivorous, F-Frugivorous, G-Grainivorous, I-Insectivorous, N-Nectarivorous,
O- Omnivorous, CO-Common, FC-Fairly common, UC-Uncommon, RA-Rare, PA-Panipat, SA-Samalkha, IS- Israna, BA-Bapoli, MA-Madlauda, +- Presence of species in the habitat, -- Absence of species in the habitat, IUCN-International Union for Conservation of Nature,
LC- Least Concern, NT- Near Threatened, →-Stable, ↓- Decreasing,↑- Increasing, ?-Unknown

Table 2. Relative diversity index (RDi) of bird families in agricultural landscapes of District Panipat, Haryana, India

Bird families	Number of species	Relative diversity index (RDi)
Ardeidae	8	8.08
Motacillidae	6	6.06
Columbidae, Cuculidae, Muscicapidae	5	5.05
Accipitridae,Cisticolidae, Hirundinidae, Sturnidae	4	4.04
Phasianidae,Ciconiidae, Threskiornithidae,,Corvidae, Ploceidae, Leiothrichidae	3	3.03
Rallidae,Charadriidae, Scolopacidae, Ramphastidae,Psittaculidae, Laniidae, Estrildidae	2	2.02
Podicipedidae, Apodidae, Phalacrocoracidae, Recurvirostridae, Jacanidae, Strigidae, Bucerotidae, Upupidae, Picidae, Meropidae, Coraciidae, Alcedinidae, Campephagidae, Oriolidae, Dicruridae, Nectariniidae, Passeridae, Alaudidae, Acrocephalidae, Pycnonotidae, Sylviidae, Zosteropidae	1	1.01

Table 3. Jaccard's similarity index (C_j) for bird communities in different agricultural habitats of the study area

Habitat	Panipat	Samalkha	Israna	Bapoli	Madlauda
Panipat	-	0.612	0.676	0.640	0.583
Samalkha	-	-	0.585	0.670	0.543
Israna	-	-	-	0.595	0.672
Bapoli	-	-	-	-	0.518

& Venkatesha, 2014). Species richness of resident birds showed no significant variation between seasons and remained same during the study period. The winter migratory birds start appearing at study area from October, reached a peak in the month of January, then start declining and leave the agricultural landscapes by March, flying back to their breeding grounds.

Species richness (65.67 ±4.46) and species diversity (3.77 ±0.05) at Bapoli block was significantly higher than that of remaining agricultural habitats except at Samalkha (Tukey's HSD test, $P< 0.05$) as shown in Table 4. However, species evenness was recorded to be maximum (0.93±0.03) in the Madlauda landscape and it was significantly ($P< 0.05$) higher than that of the remaining landscapes except Israna. From the observations it is evident that the species richness and diversity of the birds varied within the geographical area considered in the present study. The difference in bird diversity across different habitats might be associated with availability of food, roosting and nesting sites, predation pressure and disturbance (Hossain & Aditya, 2016). Crop composition and farming intensity also influence the species richness and abundance of birds in the agricultural fields (Cunningham *et al*., 2013; Malik *et al*., 2015). The highest richness and diversity recorded in the Bapoli block compared to other landscapes could be due to habitat heterogeneity. The patches of tall wooded trees, scrub and bushy type stumpy vegetation, grasses and the wetlands (river Yamuna) around the agricultural fields contributed to the heterogeneity of landscape, and augmented resource variety to sustain different bird species. In contrast, agricultural landscape of Madlauda being in the vicinity of industrial area (Thermal Power Plant of Panipat) showed lowest species richness (Hossain & Aditya, 2016).

The quality and quantity of food available is the key factor that determines the spatio-temporal distribution and relative abundance of birds in a given habitat (Rajashekhra & Venkatesha, 2014; Mukhopadhyay & Mazumdar, 2017). As far as foraging habits of birds in the study area are concerned, six major feeding guilds were identified (Figure 2). Majority of the bird species were insectivorous (34) followed by carnivorous (26), omnivorous (24), grainivorous (9), frugivorous (5) and nectarivorous (1). The results of present study are in consistent with previous records that insectivore is the dominant feeding guild in agricultural landscapes in India (Rajashekhra & Venkatesha, 2014; Narayana *et al*., 2015). Majority of insectivorous birds belonged to Motacillidae (6 species) and Muscicapidae (5 species). The characteristic bird assemblages in agricultural landscapes of Panipat, India also reflect possible variation in their ecological roles, feeding habits and resource utilization pattern. Most bird species in agricultural landscapes were insectivorous, indicating rich abundance of insects there. These insectivorous birds play a crucial role in the biological control of various insect pests thriving in agriculture, horticulture and forests (Mahabal, 2005; Thakur *et al*., 2010). The indiscriminate use of chemical insecticides and pesticides in agricultural fields could have severe ecological consequences and a grave effect on the avifauna of the study area. Hence, these insectivorous bird species should be conserved in the agricultural landscapes by use of appropriate management practices (Malhi, 2006; Narayana *et al*., 2015).

Among the recorded avifauna, Painted Stork (*Mycteria leucocephala*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Oriental White Ibis (*Threskiornis melanocephalus*) and Alexandrine Parakeet (*Psittacula eupatria*) are near threatened species, while

Table 4. Temporal variation in species richness, abundance, diversity and evenness of avifauna in the study area

Habitat		Diversity indices (mean± SE)			
		Number of birds	Species richness	Diversity	Evenness
Panipat	Summer	189.17 ±21.18	51.67 ±2.58	3.58 ±0.09	0.91 ±0.02
	Winter	251.00 ±35.35	56.50 ±3.45	3.72 ±0.08	0.92 ±0.01
	Both	220.08^{c} ±42.60	54.08^{c} ±3.85	3.65^{bc} ±0.11	0.92^{bc} ±0.02
Samalkha	Summer	244.33 ±35.12	60.50 ±1.64	3.70 ±0.07	0.90 ±0.01
	Winter	307.50 ±37.72	67.17 ±2.93	3.76 ±0.07	0.89 ±0.01
	Both	275.92^{b} ±47.91	63.83^{ab} ±4.15	3.73^{ab} ±0.07	0.90^{de} ±0.01
Israna	Summer	159.33 ±23.03	47.00 ±1.79	3.50 ±0.10	0.91 ±0.02
	Winter	234.67 ±33.74	52.50 ±1.64	3.73 ±0.10	0.94 ±0.01
	Both	197.00^{cd} ±48.02	49.75^{d} ±3.31	3.62^{cd} ±0.15	0.93^{ab}±0.03
Bapoli	Summer	287.00 ±38.12	62.00 ±1.41	3.75 ±0.04	0.91 ±0.01
	Winter	355.50 ±39.27	69.33 ±3.08	3.79 ±0.05	0.89 ±0.00
	Both	321.25^{a} ±51.39	65.67^{a} ±4.46	3.77^{a} ±0.05	0.90^{d} ±0.01
Madlauda	Summer	136.17 ±28.75	44.33 ±2.80	3.44 ±0.11	0.91 ±0.02
	Winter	225.33 ±35.28	47.67 ±1.75	3.69 ±0.06	0.96 ±0.01
	Both	180.75^{de} ±55.77	46.00^{e} ±2.83	3.57^{cde} ±0.16	0.93 ^{a}±0.03
ANOVA F-value	Season	69.35	79.00	50.54	13.94
	Habitat	36.91	153.50	13.39	14.75
P-value	Season	0.00*	0.00*	0.00*	0.00*
	Habitat	0.00*	0.00*	0.00*	0.00*

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

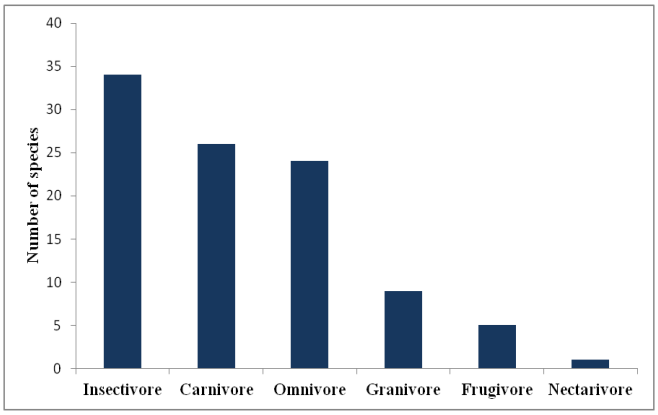

Figure 2. Feeding guilds of bird species recorded in agricultural landscapes of district Panipat, Haryana, India

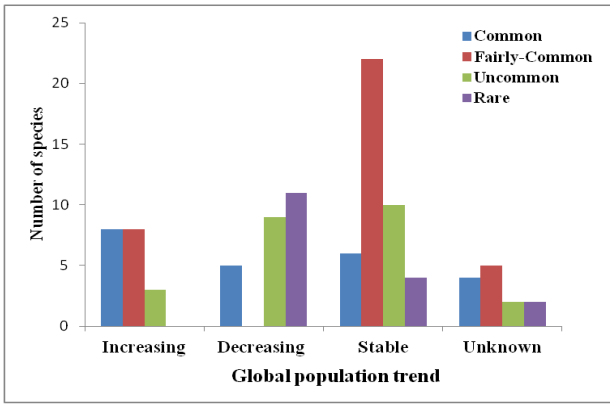

Figure 3. Comparison of local status of avian species in selected agricultural landscapes of District Panipat with its IUCN global population trend.

the remaining 99 species are categorized as least concern in the Red List of IUCN (2019). Data on local abundance revealed that 23 species were common, 35 species were fairly common, 24 species were uncommon and 17 species were rare in the study area. When this local status was compared with global population trend of the species, it was found that five species having a globally declining population trends (Rock Pigeon, Indian Black Ibis, Common Sandpiper, Common Hoopoe and Rufous Treepie) were recorded to be common in our study area (Figure 3), which indicates that suitable resources for these avian species are still available in these agro-ecosystems. These species must be prioritized for regular and long-term monitoring from a global bird conservation perspective.

Documentation of the species richness and composition of birds in a particular landscape is crucial to assess its ecological importance. Species-specific roles and ecological services facilitate prioritization of the steps towards conservation of the bird species and sustenance of the ecosystem services, which in Indian context are far from being complete (Dhindsa & Saini, 1994; Sundar & Kittur, 2013; Hossain & Aditya, 2016). In this context, the present study is the first scientific documentation of the assemblage and richness of avian species in agricultural landscapes of district Panipat, Haryana.

CONCLUSION

From the present study, it can be concluded that the selected agricultural landscapes support a rich diversity of

avifauna including resident and migratory species as well as species on conservation priorities. Our findings on avian diversity can be used as a baseline for further research on conservation and management of existing bird species in agricultural landscapes. Long-term monitoring of bird species should be continued in the study area, focusing on seasonal abundance, habitat use, nesting and breeding ecology, to supplement holistic approach of conservation and management strategies for sustenance of ecosystem services derived from birds.

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REFERENCES

Abdar, M.R. 2014. Seasonal diversity of birds and ecosystem services in agricultural area of Western Ghats, Maharashtra state, India. Journal of Environmental Science, Toxicology and Food Technology 8(1): 100-105.

Ali, S. 1949. Bird friends and foes of the cultivator. Indian Farming 10: 385-387.

Ali, S. and Ripley, S.D. 1987. Handbook of the Birds of India and Pakistan. Oxford University Press, Delhi.

Andrade, R., Batemana, H.L., Franklinb, J. and Allen, A. 2018. Waterbird community composition, abundance, and diversity along an urban gradient. Landscape and Urban Planning 170: 103-111.

Asokan, S., Ali, A.M.S. and Manikannan, R. 2010. Foraging behavior of selected birds in Cauvery Delta region of Nagapattinam District, Tamil Nadu, India - a preliminary study. Journal of Threatened Taxa 2(2):690-694.

Basavarajappa, S. 2006. Avifauna of agro-ecosystems of Maidan area of Karnataka. Zoos' Print Journal 21 (4): 2217-2219.

Bianchi, F.J.J.A., Booij, C.J.H. and Tscharntke, T. 2006. Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. Proceedings of the Royal Society B 273: 1715-1727.

Birasal, N.R. 2014. Agricultural ecosystem: an encouraging field for ornithologists. Journal of Biodiversity and Endangered Species 2:1.

Bradford, D.F., Franson, S.E., Neale, A.C., Heggem, D.T., Miller, G.R. and Canterbury, G.E. 1998. Bird species assemblages as indicators of biological integrity in Great Basin Rangeland. Environmental Monitoring and Assessment 49: 1-22.

Browder, S.F., Johnson, D.H. and Ball, I.J. 2002. Assemblages of breeding birds as indicators of grassland condition. Ecological Indicators 2: 257-270.

Cunningham, S.A., Attwood, S.J., Bawa, K.S., Benton, T.G., Broadhurst, L.M., Didham, R.K., McIntyre, S., Perfecto, I., Samways, M.J., Tscharntke, T. and Vandermeer, J. 2013. To close the yield-gap while saving biodiversity will require multiple locally relevant strategies. Agriculture, Ecosystems & Environment 173: 20-27.

Dal, P. and Vaghela, A.K. 2015. Preliminary survey of avifaunal diversity around Shetrunji River, Dhari, India. Journal of Biology and Earth Sciences 5(1): 19-24.

Dhindsa, M.S. and Saini, H.K. 1994. Agricultural ornithology: an Indian perspective. Journal of Bioscience 19(4): 391-402.

Gregory, R.D., Vorisek, P., Noble, D.G., Strien, A.V., Klvanova, A., Eaton, M., Meyling, A.W.G., Joys, A., Foppen, R.P.B. and Burfield, I.J. 2008. The generation and use of bird population indicators in Europe. Bird Conservation International 18 (Supplement 1): S223-S244.

Grimmett, R., Inskipp, C. and Inskipp, T. 2011.Birds of the Indian Subcontinent. Oxford University Press &Christopher Helm, London.

Gupta, N. and Singh, N. 2014. The abundance of avifauna in an agricultural landscape: a benefit of community conservation initiatives in Haryana, India. Indian Journal of Science and Technology 7 (4): 537-541.

Hossain, A. and Aditya, G. 2016. Avian diversity in agricultural landscape: records from Burdwan, West Bengal, India. Proceedings of Zoological Society 69(1): 38-51.

International Union for Conservation of Nature (IUCN). 2019. The IUCN red list of threatened species. www.iucnredlist.org (assessed on 30/07/2019).

Kalsi, R.S., Sharma, S.C. and Choudhary, J.R. 2019. Birds of Haryana. Unique Publications, Panipat, India.

Lawson, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., Hodda, M., Holt, R.D., Larsen, T.B., Mawdsley, N.A., Stork, N.E., Srivastava, D.S. and Watt, A.D. 1998. Biodiversity inventories, indicator taxa, and effects of habitat modification in tropical forest. Nature 391: 72-76.

MacKinnon, J. And Phillipps, K. 1993. A Field Guide to the Birds of Borneo, Sumatra, Java and Bali, the Greater Sunda Islands. Oxford University Press, Oxford.

Mahabal, A. 2005. Aves. Pp. 275-339. In: Fauna of Western Himalaya. (ed. The Director). Zoological Survey of India, Kolkata.

Mallik, A., Chand, D.S., Singh, A. and Parida, S.P. 2015. Studies on avifauna diversity of agronomy field of O.U.A.T campus, Bhubaneswar, India. Current Life Sciences 1(2): 46-57.

Malhi, C.S. 2006. Status of avifauna in agricultural habitat and other associated sub-habitats of Punjab. Environment and Ecology 24 (1):131-143.

Manakadan, R. and Pittie, A. 2001. Standardised common and scientific names of the birds of the Indian subcontinent. Buceros 6(1): 1-37.

Mukhopadhyay, S. and Mazumdar, S. 2017.Composition, diversity and foraging guilds of avifauna in a suburban area of southern West Bengal, India. Ring 39: 103-120.

Narayana, B. L., Rao, V.V. and Pandiyan, J. 2015. Avifaunal diversity in different croplands of Nalgonda district, Telangana, Southern India. International Journal of Current Research 7(7): 17677-17682.

Praveen, J., Jayapal, R. And Pittie, A. 2016. A Checklist of the birds of India. Indian Birds 11(5&6): 113-172.

Rajashekara, S. and Venkatesha, M.G. 2014. Insectivorous bird communities of diverse agro-ecosystems in the Bengaluru region, India. Journal of Entomology and Zoology Studies 2(5): 142-155.

Sekercioglu, C.H. 2012. Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. Journal of Ornithology 153 (Supplement 1): S153-S161.

Sundar, K.G. and Kittur, S. 2013. Can wetlands maintained for human use also help conserve biodiversity? Landscape-scale patterns of bird use of wetlands in an agricultural landscape in north India. Biological Conservation 168: 49-56.

Sutherland, W.J. 2006. Ecological Census Techniques: A Handbook. Cambridge University Press, New York.432 pages.

Thakur, M.L., Mattu, V.K., Lal, H., Sharma, V.N., Raj, H. and Thakur, V. 2010. Avifauna of Arki Hills, Solan (Himachal Pradesh), India. Indian Birds 5: 162-166.

Torre-Cuadros, M.D.L.A.L., Herrando-Perez, S. and Young, K.R. 2007. Diversity and structure patterns for tropical montane and premontane forests of central Peru, with an assessment of the use of higher-taxon surrogacy. Biodiversity Conservation 16: 2965-2988.

Tubelis, D.P. and Cavalcanti, R.B. 2001.Community similarity and abundance of bird species in open habitats of a central Brazilian Cerrado. Ornitologia Neotropical 12: 57-73.

Whelan, C.J., Wenny, D.G. and Marquis, R.J. 2008. Ecosystem services provided by birds. Annals of the New York Academy of Sciences 1134: 25-60.

Zeleke, A., Gadisa, T. and Gebremichael, G. 2015. Diversity and relative abundance of bird species of Sheko District, Bench Maji zone, Southwest Ethiopia. International Journal of Development & Research 5: 3975-3979.