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DENSITY AND DIVERSITY OF BIRDS IN THE AGRICULTURAL LANDSCAPE OF POTHWAR PLATEAU, PAKISTAN

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ABSTRACT

Due its unique topography and climatic conditions Pothwar plateau of Pakistan is famous for hosting important floral and faunal diversity of Pakistan but no report is available on the current status and population dynamics of bird species in this area. In this study the number and species richness of birds associated with different agricultural landscapes on the plateau were estimated. The study was conducted in 4 selected study sites (10 x 10 ha each) based on monthly visual surveys over 2 years. Two of the sites were drier where wheat and groundnut were the main crops whereas the other two sites were located close to rain water ponds where wheat, maize and millet were cultivated. A total of 29 bird species were recorded, of which 24 were residents while the remaining 5 were winter visitors. Both bird density and species richness decreased during summer (May-July) at all sites across the 2 years. Comparing sampling sites on the basis of cropping system and water availability showed that more bird species, especially the over-wintering species, were found at sites close to water resources. Thus the higher number of species in areas with a wheat-maize/millet cropping system was probably due to water availability.

Key words: Bird density, Bird diversity, Birds in croplands, Species richness.

INTRODUCTION

The Pothwar plateau of Pakistan is characterized by low fertility, rugged topography and unpredictable rainfall pattern. Climatically, it is a sub-tropical, sub-humid zone. The principal crop is wheat cultivated with either maize and millet or groundnut (Arif and Malik, 2009). Fast growing trees and shrubs are usually planted along the crop field boundaries for browse and fodder which also provide nesting sites for many species of birds (Nizami *et al*., 2004; Hussain *et al*., 2009). In agricultural landscapes, habitat heterogeneity is defined by wild vegetation along field boundaries which contributes towards increased avian diversity (Lee and Martin, 2017). In Europe, management strategies for bird conservation on agriculture land have been linked to efforts for increasing non-crop vegetation along the fields (Whittingham *et al*., 2009; Wuczynski, 2016). Such features exist on the Pothwar plateau mainly to stop soil erosion due to rain-water.

The bird species of the plateau include mostly residents, but some are summer breeding visitors whereas others are winter visitors (Roberts, 1992; Qaisrani, 2006). No comprehensive account of birds associated with the vegetation of the plateau is available. In this study we link habitat characteristics to estimates of population sizes of bird species (in the term of the number and species richness) associated with the different cropping systems.

MATERIALS AND METHODS

Study site: The present study spanned four districts viz: Rawalpindi, Attock, Jhelum and Chakwal (Figure 1). Pothwar plateau has an area of ~ 13,000 km^2 and elevation ranges from 305 - 610 m (Nadeem *et al*., 2012). Climate is semi-arid to humid with summer temperature range of 15-40 ^{o}C while the range of winter temperature is 4-25 ^{o}C (Hussain *et al.*, 2003).

Roberts (1992) reported that 24 bird species are associated with agricultural landscape of Pothwar plateau. Among these, insectivorous passerines dominated the avian community. Similarly, Maan and Chaudhry (2001) observed 24 species of birds in Rawalpindi and 25 in Attock and found that residential avifauna of the plateau are oriental in region. However, Qaisrani (2006) in a field trip listed 77 species of birds in this plateau, many of these being occasional visitors.

Study plan: Traditionally 2 types of cropping systems are present in this region i.e. wheat-groundnut at drier with hard soil locations and wheat-maize/millet in areas of loamy soil and having relatively more rainfall. The latter areas have relatively more standing water available in shape of rain water ponds. This study was designed to compare these 2 major agricultural systems, by regularly visiting two sites within each system and surveying bird densities as well as vegetation cover (Table 1). Each site with wheat-maize/millet cropping system had a single rain water pond measuring 150 x 70m approx. and 120 x 80m approx. with water available all around the year as water access point. At each selected site, an intact area of

10 × 10 ha was chosen to sample. The selected areas were visited on a monthly basis over a period of 2 years (July 2012 to June 2014). One site was located in district Attock, another in district Rawalpindi and the remaining 2 in district Chakwal.

Habitat analysis: Habitats of the four study sites were evaluated in terms of following variables.

A) Substrate/soil type: Classified as sandy (gritty with large particles), silt (soft with medium sized particles) and/or hard (rocky soil).
B) Cropping pattern: Two major cropping patterns were classified as wheat-maize/millet and wheat-groundnut.
C) Water availability: The presence of water body e.g. small ponds and streams if any was recorded.
D) Area under cultivation (%): The percentage of area under crop cultivation within each study site was estimated.

Species richness and abundance of birds: Bird densities were estimated using the point count method (Bibby *et al*., 1992). At each study site 12 permanent points were marked to take the repeated observations monthly. The effective observation radius for point count was fixed as 20 m in a pilot study given the terrain, topography, vegetation structure and number of birds to be recorded. Distance between adjacent points was fixed to 50 m to avoid overlapping.

All 48 point count locations (4 sites × 12 points at each site) were surveyed once every month for 2 years (July 2012 to June 2014), adding up to a total of 1152 point counts. At each point, after an initial settling time of one minute, observations were taken for 10 minutes. All birds viewed on the ground or in vegetation were identified and wherever possible sexed, and flock size was recorded. Avifauna was identified with the help of binoculars and field guides (Ali and Ripley, 1987; Grimmett *et al*., 2008). The status of species as resident or migrant was determined after Roberts (1992).

The monthly record of bird abundance was categorized into five seasons namely winter (December to February), spring (March to April), summer (May to mid-July), monsoon (mid-July to August) and fall (September to November). To mark a clear distinction between summer and monsoon data, observations for July were taken after mid of the month for both the years. Monthly species diversity for each site was estimated using the Shannon–Wiener (*H′*) Diversity Index

$$H' = -\Sigma\, pi \log pi$$

Where p_i is the proportion of total sample belonging to the ith species.

Species richness across the sites was calculated by Menhinick's Index (D) following Magguran (2004).

$$D = \frac{s}{\sqrt{N}}$$

Where s is number of species in the sample and N is the number of individual organisms in the sample.

Analysis: All data were log transformed to meet the assumption of normality. In current study, two sites (I + IV) had water resource and wheat-maize/millet cropping system while the other two sites (II + III) were without water and had wheat-groundnut cropping system. Effect of water and cropping system variability on bird abundance were tested statistically. Yearly difference in bird records was compared using paired t-test for independent samples. The bird abundance across the two agricultural systems was compared using 2 sample t-tests for paired comparison, based on averages and sums within sites. The resultant 2 degrees of freedom (for t tests) implies relatively low power since the data appeared to be consistent, so P values < 0.1 were interpreted. Avian species richness across the four sites was compared using chi-square test based on species counts. The chi-square test used species as the replicate. The difference in bird density across the four sites was compared by repeated measures ANOVA using month as replicate.

RESULTS

Bird data: Twenty-nine bird species (see Table 2, where scientific names are given) were recorded in total. Twenty-five were Passeriformes, 2 species Coraciiformes and 1 species each in the Columbiformes and Falconiformes. Twenty-four species were resident while the remaining 5 were winter visitors (Table 2). The number of resident and migratory species observed during the study period is presented in Figure 2. Migrants were few and the large differences were in residents, which were therefore expected to drive any patterns.

Year-wise differences in bird abundance: Total number of birds recorded at all the four sites in first year of study (2012) was 2526 which was almost similar to record of 2416 in the second year (2013). There was non-significant difference between these figures (paired t-test, using month as replicate, $t_{11} = 0.43$, $P = 0.67$).

Seasonal differences: Only 6 species (house sparrow, green bee-eater, red vented bulbul, Himalayan bulbul, common myna and Eurasian collared dove) were observed every month at every site.

At all the study sites both bird numbers and species richness decreased during summer i.e. May to mid-July (Figures 3 and 4). When avian species richness was compared with temperature data across the study period, it was found that temperature and the number of species observed in every month were strongly negatively correlated (each month averaged across the 2 years, N = 12 months, r = -0.90, $P < 0.001$) indicating decline in bird species richness with rise in temperature. Bird density

also decreased with rise in temperature at all sites (r = -0.88, $P < 0.001$). The relationship between diversity of bird species and their numbers with rainfall was also negative, but weaker than temperature (r = -0.47, $P = 0.12$ and r = -0.19, $P = 0.56$, respectively).

Site differences: Study sites differ in total bird numbers recorded, using month as replicate in repeated measures ANOVA ($P < 0.001$). Shannon-Weiner diversity indices separately for each year i.e. year I was July 2012 to June 2013 and year II was July 2013 to June 2014 are in Table 3. The lowest diversity index was recorded for Site III because the house sparrow was so dominant at this site.

Avian abundance was compared with respect to agricultural practices. In this test sites I and IV were compared (by sample t-test on log transformed data of bird numbers recorded) to sites II and III ($t_2 = 1.085$, P = 0.391). There was no significant difference in bird numbers between the sites that were drier or wetter. In particular, sites II and IV had very similar numbers.

Despite similarity in numbers, about 75% more species of birds were present in sites that were in close proximity to water resources viz: Site I and IV, cf. those that were not (Table 3). All species present in the drier sites were also recorded in the wetter sites, but the wetter sites had an additional 14 species never observed in the drier sites. A chi-square goodness of fit test comparing species richness across the four sites approached the statistical significance at $P < 0.1$ ($\chi^2_3 = 6.94$, P = 0.074). There was no difference in the number of resident species between the wetter and drier sites ($t_2 = 0.783$, P = 0.515). More migratory species were present in the wetter sites and the difference between the sites approached the statistical significance ($t_2 = 3.577$, P = 0.07).

Table 1. Description of the selected sampling sites for birds' records in the agricultural landscape of Pothwar Plateau, Pakistan.

Site No.	Site Name and Location	GPS location*	Elevation* (m above sea level)	Cropping system	Substrate type	Water resource available?	Area under cultivation (%)
I	Thatti Gujran (Fatehjang, Attock)	N 33˚32.915 E 072˚49.194	477	Wheat-millet/maize	Silt loam	Present	80
II	Koont (Gujjar Khan, Rawalpindi)	N 33˚07.365 E 073˚00.541	534	Wheat-groundnut	Hard soil	Absent	75
III	Shah Syed Billu (Choa Saden Shah, Chakwal)	N 32˚48.333 E 072˚57.393	537	Wheat-groundnut	Hard soil	Absent	60
IV	Prem Nagar Faqiran (Balkassar, Chakwal)	N 32˚56.591 E 072˚33.727	392	Wheat-millet/maize	Silt loam	Present	75

*GPS Location and elevation were taken at the centre of the site.

Table 2. Records of bird species observed during July 2012 to June 2014 at the 4 selected sites of Pothwar Plateau, Pakistan.

Order*	Common Name	Scientific Name	Family	Status**	Proportion*** (%)
Falconiformes	Red headed merlin	*Falco chicquera*	Falconidae	Resident	3.45%
Columbiformes	Eurasian collard dove	*Streptopelia decaocto*	Columbidae	Resident	3.45%
Coraciiformes	Indian roller	*Coracias benghalensis*	Coraciidae	Resident	6.89%
	Green bee-eater	*Merops orientalis*	Meropidae	Resident	
Passeriformes	Golden oriole	*Oriolus oriolus*	Oriolidae	Resident	86.21%
	Ashy drongo	*Dicrucus leucophaeus*	Dicuridae	Resident	
	Indian tree magpie	*Dendrocitta vagabunda*	Corvidae	Resident	
	Singing bush lark	*Mirafra cantillans*	Alaudidae	Resident	
	Eastern calandra lark	*Melanocorypha bimaculata*	Alaudidae	Migrant	
	Rufous tailed finch lark	*Ammomanes phoenicura*	Alaudidae	Resident	
	Common lark	*Alauda arvensis*	Alaudidae	Migrant	
	Grey crowned prinia	*Prinia cinereocapilla*	Cicticolidae	Resident	
	Ashy prinia	*Prinia socialis*	Cicticolidae	Resident	
	Himalayan bulbul	*Pycnonotus leucogenys*	Pycnonotidae	Resident	
	Red vented bulbul	*Pycnonotus cafer*	Pycnonotidae	Resident	
	Indian tailor bird	*Orthotomus sutorius*	Cicticolidae	Resident	
	Yellow browed leaf warbler	*Phylloscopus humei*	Sylviidae	Migrant	
	Common whitethroat	*Sylvia communis*	Sylviidae	Migrant	

Cont'd.

Large grey babbler	*Turdoides malcolmi*	Leiothrichidae	Resident
Common myna	*Acridotheres tristis*	Sturnidae	Resident
Himalayan thrush	*Myophonus caeruleus*	Turdidae	Resident
Black redstart	*Phoenicurus ochruros*	Turdidae	Migrant
Pied bushchat	*Saxicola caprata*	Turdidae	Resident
House sparrow	*Passer domesticus*	Passeridae	Resident
Yellow throated sparrow	*Petronia xanthocollis*	Passeridae	Resident
Baya weaver	*Ploceus philippinus*	Ploceidae	Resident
White wagtail	*Motacilla alba*	Motacillidae	Resident
Common chaffinch	*Fringilla coelebs*	Fringillidae	Resident
White capped bunting	*Emberiza stewarti*	Emberizidae	Resident

*Order arrangement follows Birdlife International (2013) **After Roberts (1992) ***Proportion of species in the given order

Table 3. Total number of birds of different species observed during July 2012 to June 2014 at the four selected sites of Pothwar plateau, Pakistan.

	Site I	Site II	Site III	Site IV
No. of birds observed	1576	1298	865	1203
No. of species observed	25	15	10	18
No. of migratory species observed	5	2	1	3
Menhinick's Index (D)	0.63	0.42	0.34	0.52
Shannon-Weiner Index (Year I)	2.35	2.08	1.85	1.95
Shannon-Weiner Index (Year II)	2.77	2.09	1.82	2.34

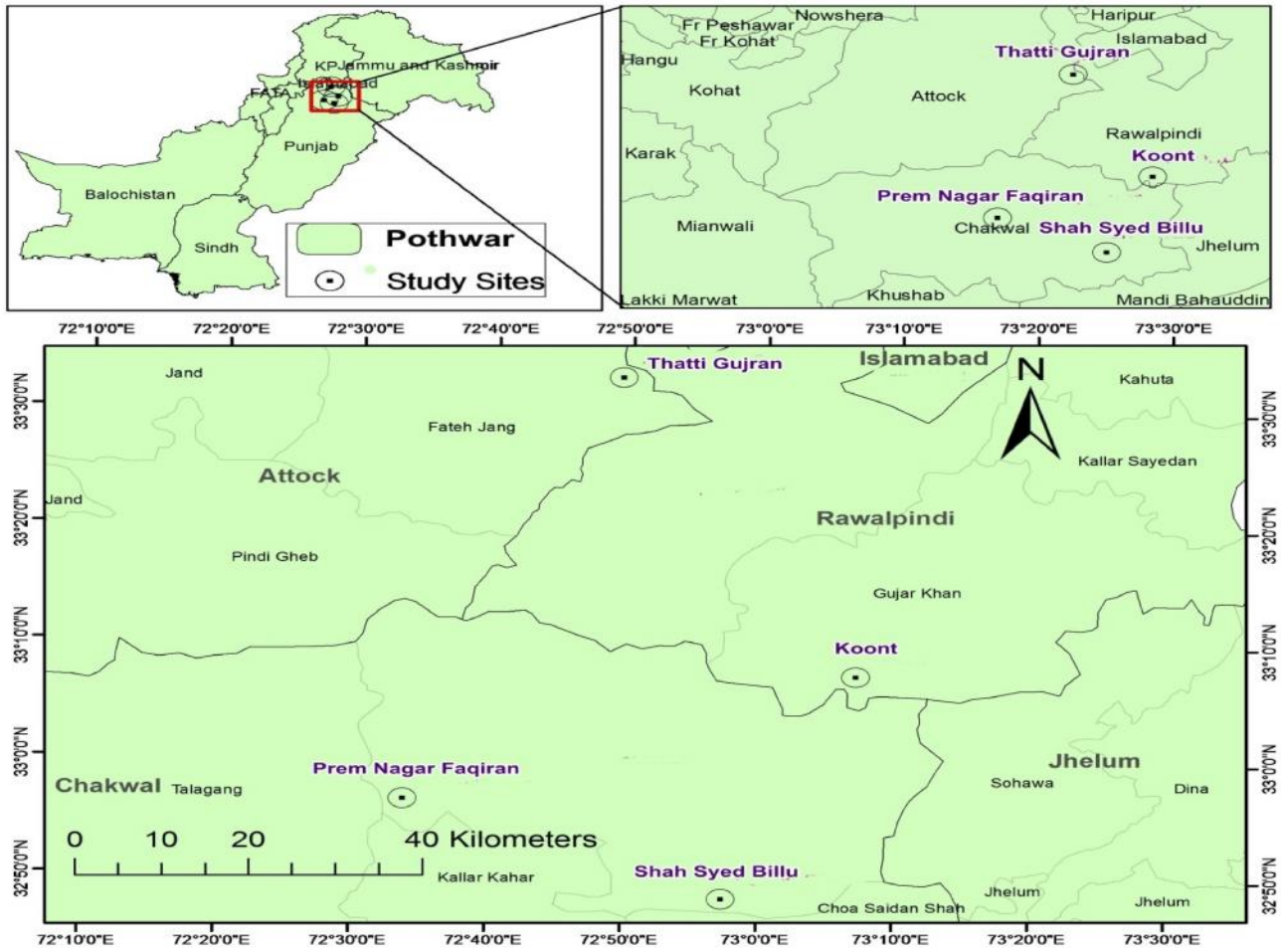

Figure 1. Map of Pothwar plateau, Pakistan showing the locations of selected study sites.

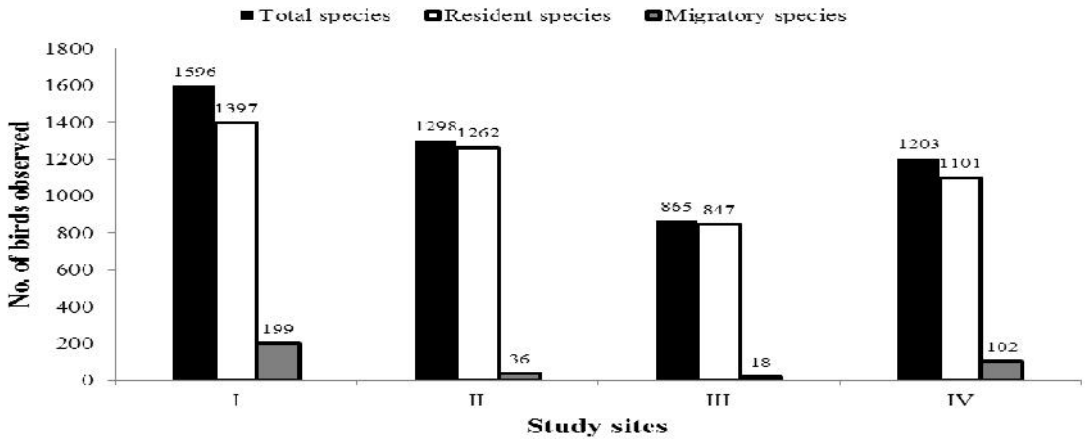

Figure 2. The total number of birds of resident and migratory species observed during July 2012 to June 2014 at each of the 4 selected sites of Pothwar plateau, Pakistan.

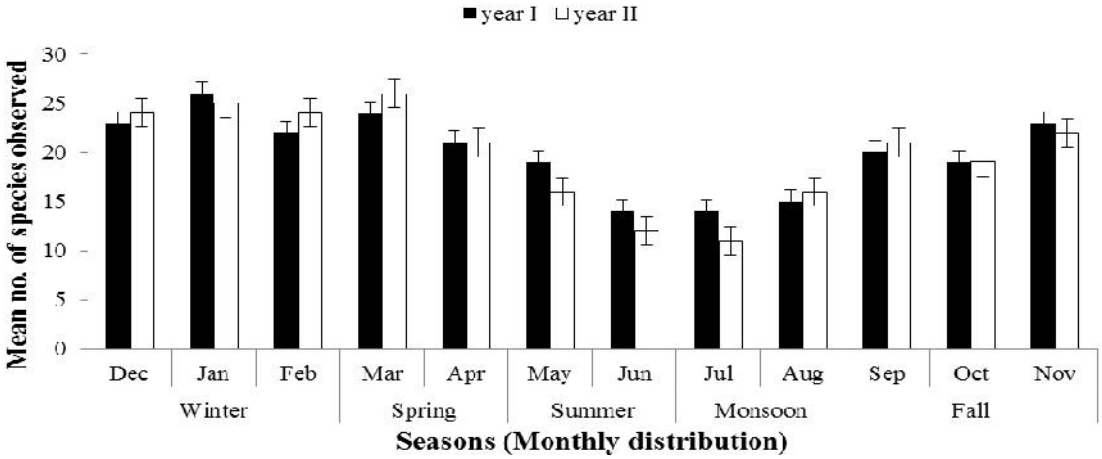

Figure 3. Mean number of birds (X + SE) observed each month during July 2012 to June 2014 at the 4 selected sites of Pothwar plateau, Pakistan.

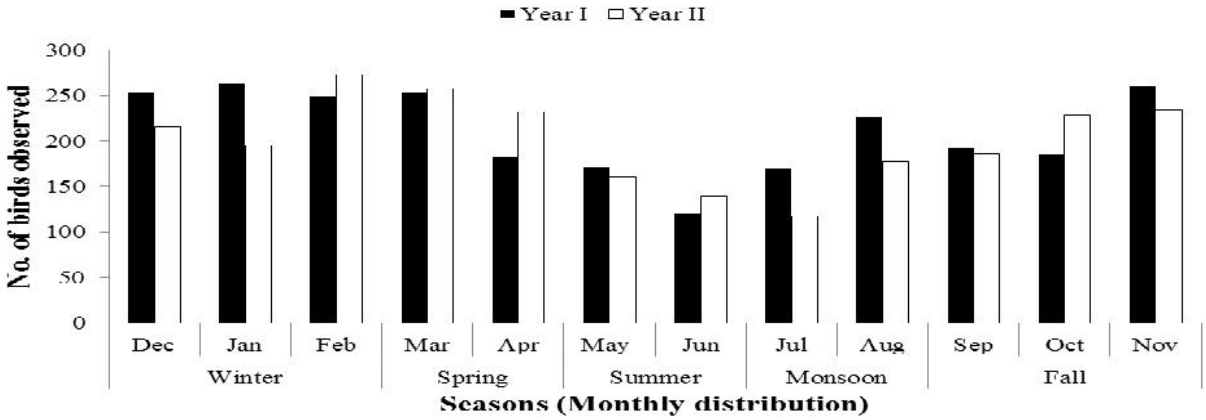

Figure 4. Mean number of species observed each month during July 2012 to June 2014 at the 4 selected sites of Pothwar plateau, Pakistan.

DISCUSSION

In Pakistan, few studies exist about population status and significance of birds in agro-ecosystems and no studies have so far been conducted on the habitat, population status and avian species richness in this particular region. This study set out some preliminary information on population status and diversity of bird species utilizing the agricultural landscape of the Pothwar plateau. Habitat availability in robust ecosystems affects

bird populations (Javed and Kaul, 2002) and agricultural landscapes provide habitat to important avifauna (Munoz-Saez *et al*., 2017). Because of limited habitat availability to species in such cropping systems, agriculture interventions profoundly affect the management and sustainability of bird populations (Laxmi *et al*., 2013). Results show that croplands of Pothwar plateau offer good habitat for the relatively few terrestrial bird species that are adapted to utilize farmland. For example, the house sparrow comprised almost one-third (31.86%) of all individuals observed, probably because of food through agriculture. The house sparrow, green bee-eater, red vented bulbul, Himalayan bulbul, common myna and Eurasian collard dove were widespread and common species occurring in all the four study sites. Pothwar plateau is located in foothills of Himalayas. Kopij (2018) also found that in foothill farmlands of southern Africa, certain granivorous birds dominate. Wilson *et al*. (2017) also reported that croplands of Canada have low avian diversity but bird abundance in such crop agriculture does not decline implying tolerance of certain species to agroecosystems.

Other studies have shown that avian species richness does not increase in diversified agroecosystems rather in agricultural systems few granivorous and omnivorous species dominate bird communities (Tonglei and Guo, 2013; Calamari *et al*., 2018a). Although no baseline data are available but agriculture in Pothwar region may well have increased the total number of species in this arid region, by adding some agricultural species without losing natives.

More species of birds were observed in the wetter study sites with wheat-millet/maize cropping system which also held more cultivated land (Table 1), but this is largely a consequence of migrants (Table 3). It is perhaps most likely that water resources support the cropping system and consequently the birds. Surmacki (2005) also reported that crops close to water access harbor rich invertebrate populations because of edge effect and thus more birds are concentrated in such regions since foraging of farmland avifauna near these edges not only reduces energy needed in food search but also decreases risk of predation. Although trees and shrubs provide nesting and perching sites to birds, the vegetation data showed that the wetter sites (i.e. Site I and IV) had fewer shrubs. Thus the higher numbers may be attributed to the fact that the birds were attracted to crop grains and insects in the crops for feeding, and they used the nearby wild vegetation for nesting and perching that had less human intervention. Studies in agro ecosystems of India reported that shrubs attract more birds by providing food resources to them (O'Connor and Shrubb, 1986; Dhindsa and Saini, 1994) but this did not seem to be a major driver of species richness patterns. Similarly, Redlich *et al*. (2018) found that in certain agroecosystems of Germany with small field size and more non-crop habitat, avifauna was benefitted by utilizing non-crop resources.

The 25 species of passerine birds reported in this study differ somewhat from the previously reported 24 species by Roberts (1992). Several species e.g. red-winged lark (*Mirafra erythroptera*), grey-winged blackbird (*Turdus boulboul*), ashy-grey wren warbler (*Prinia hodgsonii*), hogson's wren warbler (*Prinia cineveocapilla*), lesser whitethroat (*Sylvia curruca*), crested black tit (*Parus melanolophus*), thick-billed flower-pecker (*Dicaeum agile*), willow sparrow (*Passer hispaniolensis*), Indian silver bill (*Eodice malabarica*) and spotted munia (*Lonchura punctulata*) were not recorded in this study whereas 11 new passerine species were identified. This deviation could be attributed to the fact that the rarer species were infrequent, over-looked and their habitat might have been changed (e.g. Qaisrani, 2006). In addition, this study focused only on the croplands with traditional cropping pattern and irrigated plantations or fruit orchards etc. were not studied.

It is evident that strategies for effective conservation are governed by local landscape features and characteristics (Fischer *et al*., 2008; Ranganathan *et al*., 2010). Agricultural landscapes are dynamic due to variations in annual crop distribution patterns, climate, vegetation cover, land use and productivity (Borges *et al*., 2017; Calamari *et al*., 2018b) In the present study, it was found that there were more species and more numbers of birds in the wetter sites so species availability was probably because of water availability because agricultural practices are driven by rain water availability in such arid areas. Thus water availability was driving more birds. Although different agriculture systems can sustain communities that are of very high value for biodiversity conservation, the comparison of sites on the basis of agricultural practices makes it clear that local conditions also govern the avian community structure.

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