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Impact of zero tillage agriculture on the avian fauna in Ludhiana, Punjab

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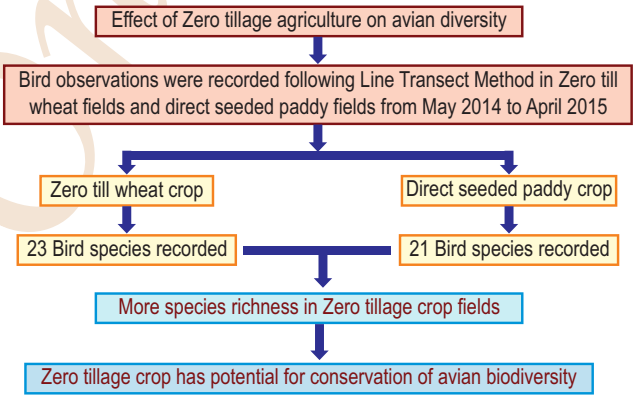
Abstract

Aim: Birds are excellent indicators of the state of a healthy environment and form an integral component of agricultural ecosystem. Rapid agricultural intensification leads to uniform habitat system resulting in decline of farmland bird diversity throughout the world. Birds are intimately related to agricultural habitat for their needs such as food, shelter and breeding places. Keeping this in mind, it was planned to study the effect of zero tillage agriculture on avian diversity to generate baseline data.

Methodology: Bird observations were recorded in zero till wheat fields and direct seeded paddy fields of Punjab Agricultural University (latitude 30° 54´147 N and longitude of 75° 47´ 642 E and 244 m above mean sea level), Ludhiana from May 2014 to April 2015. Line Transect Method was used for the survey of different bird species. Relative abundance (%) was calculated as: (ni/N) x 100, where ni is the number of birds of ith species and N is the total number of birds of all species.

Results: Species recorded in zero till wheat and direct seeded paddy crop was 23 and 21 respectively. Seven omnivore and five grainivorous bird species were recorded as overlapping species in zero till and direct seeded paddy crops. Highest value of species richness was recorded at ripening stage of zero till wheat crop. Results of the present study indicated that zero till wheat and direct seeded paddy attracts more bird species as compared to intensively cultivated paddy.

Interpretation: In the direct seeded paddy crop, species richness was highest both at seedling stage and reproductive stage. In zero till, farming stubbles and chaff from the previous crop remained undisturbed on soil surface, and undisturbed soil provided spilled grains, weed seeds, insects and small mammals to birds to feed on, so greater number of species was evident. From the present study, it is summarized that species abundance and species diversity was more in zero tillage crop fields as compared to intensively cultivated fields, which signifies that zero till farming has potential for conservation of avian biodiversity in a more sustainable way, while allowing the farmers to continue cropping in intensively cultivated agro-climatic zones.



Introduction

The avifauna of India includes around 1263 species (Praveen *et al*., 2016), majority of bird species are associated with agro-ecosystem for their survival and make some impact on such systems (Ali, 2002; Kler and Kumar, 2015). Punjab has rich avian fauna comprising 240 species of birds (Toor *et al.,* 1982). Cultural farming practices have major influence on the quality of wildlife habitat provided by croplands on the agricultural landscape (Best, 1985; Stefanova and Salek, 2013). Intensification of agriculture is considered to be responsible for decline of many bird species (Baillie *et al.,* 1997; Washburn *et al.,* 2016). So, it is important to consider how various tillage practices affect terrestrial wildlife such as birds in cropland situations (Lokemoen, 1997; Dyulgerova *et al.,* 2015). Zero tillage is concept of conservational agriculture and it is a way of growing crops from year to year without disturbing the soil through tillage (Erenstein, 2009). Change in cropping pattern affects the feeding and nesting preferences of Barn Owl population in Central Valley of California (Kross *et al.,* 2016). It is necessary to understand the importance of zero tillage cultivation to formulate bird conservation as well as management strategies. In view of the above, the present study was planned to determine the avian community structure in zero tillage crop fields of Punjab Agricultural University Ludhiana, Punjab, so as to generate data that would provide a baseline information for conservation of bird species.

Materials and Methods

The present study on avifauna was undertaken from May 2014 to April 2015 in zero tillage fields of wheat (PBW343; maturing duration 155 day; field area 1.5 hectare) and paddy (PR118; maturing duration 158 days, field area 1.5 hectare) located in Punjab Agricultural University, Ludhiana (latitude 30° 54´147 N and longitude of 75° 47´ 642 E and 244 m above mean sea level). Line Transect Method was used for the survey of different bird species (Verner, 1985). Identification of birds was based on the keys described by Ali (2002). Total numbers of bird species and their abundance were estimated. Relative abundance (%) was calculated as: (ni/N) x 100, where ni is the number of birds of ith species and N is the total number of birds of all species. Species diversity (H) was calculated by Shannon-Wiener index (Spellerberg and Fedor, 2003). Species diversity (H) and Species evenness (J) were calculated from bird abundance data (Krebs, 1985). Statistical method of Independent t-test was performed to find the difference between population of common bird species in zero till wheat and direct seeded paddy crops.

Results and Discussion

A total of 21 birds species were observed at different developmental stages of direct seeded paddy crop (Table 1). A total of sixteen birds were recorded at seedling stage; House crow, Asian pied starling and blue rock pigeon were the most represented in the bird population with 26.45%, 12.25% and 10.32% relative abundance, respectively (Table 1). House crow, common myna, cattle egret and red-wattled lapwing were noticed feeding on the insect and invertebrate prey. White-breasted kingfisher was solitary visitor and preyed on insects and small reptiles. It was observed that the collective relative abundance of three most abundant species namely House crow, Common myna and Black kite was recorded 52.16% at transplanting stage (Table 1). During the present study, House crow (21.42%) was recorded as most abundant species followed by Cattle egret (19%) and Black ibis (12%) at tillering stage (Table 1). House Crow, Black Ibis and Cattle Egret walked in group in search of the prey. Asian Pied Starling was noticed to feed upon plant and insects. There were recorded 16 and 15 species at reproductive stage and ripening stage, respectively. Collective relative abundance of three most abundant species namely House Crow, Common Swallow and Black Kite was recorded 50.63% at reproductive stage (Table 1).

Mixed flocks of House crow and common swallow were noticed hovering over the direct seeded paddy fields to attack the insect species on direct seeded paddy crop. Black Drongo was mostly noticed feeding on the flying insects. Common Swallow (27.11%) was recorded as the most abundant species followed by House Crow (18.22%) and Blue Rock Pigeon (14.66%) at ripening stage (Table 1). Grain ripening stage was inhabited by dominant group of omnivores of 6 species, followed by insectivores and grainivorous group of 4 species each. Small flocks of Blue Rock Pigeon and Ring Dove were noticed foraging on ripened grains which had fallen on the ground. Large flocks of Common Swallow were observed making aerial sallies over the ripened direct seeded paddy fields because of abundance of insect food on the direct seeded paddy crop. A total of 26 species of birds were observed during the present study (Table 6).

Shanon-Wiener index of bird diversity peaked at seedling stage of direct seeded paddy (2.36). The lowest species diversity was recorded at ripening stage (2.12) (Table 1). Evenness peaked at tillering stage of direct seeded paddy with highest value (0.91). The lowest species diversity was recorded at ripening stage (0.78) (Table 1).

At total of twenty three species were observed at different developmental stages of zero till wheat crop (Table 2). The data revealed that bird species richness at seedling stage was thirteen. House Crow (27.27%) was recorded as most abundant species, followed by Blue Rock Pigeon (17.04%), Common Swallow (10.22%), Cattle Egret (9.09%), Black Kite (7.95%) and Rose-ringed Parakeet (6.81%) (Table 2). Bird community comprised of sixteen species was recorded from the studied location at the tillering stage. House Crow was recorded as the most abundant bird species with relative abundance of 24.90%, followed by Blue Rock Pigeon (16.34%) and Rose-ringed

Table 1 : Bird community characteristics at different developmental stages in direct seeded paddy crop

Crop stages →	Seedling stage	Transplanting stage	Tillering stage	Reproductive stage	Ripening stage
Bird species ↓	Relative abundance (%)				
House Crow	26.45	17.39	21.42	22.36	18.22
Blue Rock Pigeon	10.32	_	5.71	_	14.66
Black Kite	4.51	13.04	9	13.15	12
Common Swallow	7.09	4.00	_	15.13	27.11
Cattle Egret	7.09	5.34	19	5.92	8
Rose-ringed Parakeet	3.22	13.00	7.14	12.5	2.66
Common Myna	8.38	21.73	7.14	3.94	6.22
Red-wattled Lapwing	4.51	4.25	8.57	4.60	1.77
Black Drongo	6.45	_	2.85	2.63	1.33
Asian Pied Starling	12.25	4.49	2.85	2.63	0.44
Ring Dove	2.58	2.17	_	2.63	2.22
Common Babbler	0.64	_	_	4.60	_
Alexandrine Parakeet	3.87	_	4.28	_	0.88
Black Ibis	_	_	12	1.31	0.88
Ashy Prinia	0.64	_	_	0.65	_
Jungle Babbler	_	12.04	_	1.31	0.88
Common Hoopoe	0.64	_	_	_	_
White-throated Munia	_	_	_	1.97	_
Red-vented Bulbul	_	2.17	_	_	_
Plain Prinia	_	_	_	1.31	2.66
White-breasted Kingfisher	1.29	_	_	_	_
Species Richness	16	11	11	16	15
Species Diversity	2.36	2.14	2.20	2.29	2.12
Species Evenness	0.85	0.89	0.91	0.82	0.78

Parakeet (11.28%) (Table 2). Cattle Egret, House Crow, Red-wattled Lapwing, Common Hoopoe, Bay-backed Shrike and Common Myna were noted feeding on the insects and soil invertebrates in zero till wheat fields. There were recorded 16 and 19 species at reproductive stage and ripening stage of zero till wheat crop. House Crow (17.85%) was recorded as most abundant at reproductive stage followed by Blue Rock Pigeon (15%) (Table 2). Common Swallow, Ashy Prinia, Common Hoopoe and Red-wattled Lapwing fed on plant, as well as ground insects. House Crow and Blue Rock Pigeon were recorded as abundant species at ripening stage of zero till wheat crop with relative abundance value of 21.43% and 15.70%, respectively (Table 2). House Crow, Blue Rock Pigeon and Rose-ringed Parakeet fed on the ripened wheat grains from the standing crop or were removed from the earheads.

Shanon-Wiener index of bird diversity peaked at seedling stage of zero till wheat and the lowest species diversity was recorded at tillering stage. Evenness was highest at reproductive stage (Table 2).

Eighteen species were recorded as common in both zero till wheat and direct seeded paddy crops. No significant difference was found in the population of common bird species which were recorded in both zero till wheat and direct seeded paddy crops (Table 3). Zero till wheat and direct seeded paddy crops were dominated by seven common omnivore birds (Table 4). Rich diversity of omnivore indicates the abundance of plant food and animal food available in zero till wheat and direct seeded paddy fields. Five common insectivore bird species fed on diverse insect species at different developmental stages of zero till wheat and direct seeded paddy crops (Table 4). Paddy field Pipit and Bay-backed Shrike were exclusive to direct seeded paddy crop, while Indian Robin and Plain Prinia were recorded feeding on the insects only in zero till wheat crop (Table 5). Five grainivorous species were found both in zero till wheat and direct seeded paddy crops (Table 4). It seems that zero till wheat and direct seeded paddy fields provided similar foraging opportunities to grainivorous birds. Black Kite was the common carnivore species in zero till wheat and direct seeded paddy. Great Grey Shrike and Indian Roller were found only in zero till wheat fields while White-breasted Kingfisher was noted in direct seeded paddy crop (Table 5). The presence of different bird species during different developmental stages of crop may be due to the simultaneous effect of field conditions, as well as crop stages.

Results of the present study indicated that zero till wheat and direct seeded paddy attracted more bird species as compared to intensively cultivated paddy. Kler and Singh (2007) reported nineteen bird species in intensively cultivated wheat fields of Punjab Agricultural University, Ludhiana. Kler (2010) observed fifteen bird species in intensively cultivated paddy fields

Table 2 : Bird community characteristics at different developmental stages of zero till wheat crop

Crop stages →	Seedling stage	Tillering stage	Reproductive stage	Ripening stage
Bird species ↓		Relative abundance (%)		
House Crow	27.27	24.90	17.85	21.46
Blue Rock Pigeon	17.04	16.34	15	15.70
Black Kite	7.95	8.17	11.42	4.71
Common Swallow	10.22	7.78	2.14	4.00
Cattle Egret	9.09	8.56	7.14	3.15
Rose-ringed Parakeet	6.81	11.28	14.28	9.42
Common Myna	2.27	7.39	9.28	7.85
Red-wattled Lapwing	_	5.83	7.14	5.28
Black Drongo	2.27	2.72	2.85	5.23
Asian Pied Starling	4.54	2.33	4.28	6.00
Ring Dove	3.40	0.38	1.42	6.28
Common Babbler	_	1.55	1.42	0.30
Alexandrine Parakeet	4.54	_	_	_
Black Ibis	_	_	1.42	_
Ashy Prinia	_	_	2.14	2.61
Jungle Babbler	3.40	_	_	1.00
Paddyfield Pipit	_	_	_	3.66
Common Hoopoe	_	0.77	0.71	0.52
White-throated Munia	_	_	1.42	0.50
Bay-backed Shrike	1.36	0.38	_	_
Great Grey shrike	_	1.16	_	_
Indian Roller	_	0.38	_	_
Indian Robin	_	_	_	1.57
Species Richness	13	16	16	19
Species Diversity	2.56	2.26	2.39	2.51
Species Evenness	0.82	0.81	0.86	0.85

Table 3 : Comparative statistical analyses of bird species observed both in zero till wheat and direct seeded paddy crops

Crops →	Wheat	Paddy
Bird species ↓		
House Crow	38.5±9.34	27.8±6.86
Blue Rock Pigeon	27.00±5.87	14.6±5.89
Black Kite	13.25±3.22	13.2±4.20
Common Swallow	10.25±3.54	19.4±11.16
Cattle Egret	11.75±3.47	10.6±2.61
Rose-ringed Parakeet	18.50±4.51	6.20±0.73
Common Myna	10.50±3.92	9.40±1.91
Red-wattled Lapwing	9.25±3.25	5.20±0.96
Black Drongo	5.75±1.75	3.80±1.68
Asian Pied Starling	7.00±1.73	5.60±3.38
Ring Dove	4.50±2.53	2.80±0.96
Common Babbler	1.75±0.85	1.40±1.16
Alexandrine Parakeet	1.00±1.00	2.20±1.11
Black Ibis	0.50±0.50	2.20±1.28
Ashy Prinia	2.00±1.22	0.20±0.2
Jungle Babbler	1.00±0.70	2.00±1.09
Common Hoopoe	1.00±0.40	0.20±0.2
White-throated Munia	2.25±1.31	0.60±0.6

*Significant difference of bird population at $p<0.05$ in wheat and paddy crops; values are mean of ±SE

Table 4 : Bird species recorded both in direct seeded paddy and zero till wheat crops

Insectivore	Granivore	Carnivore	Omnivore
Common Swallow	Blue Rock Pigeon	Black Kite	House Crow
Red-wattled Lapwing	Rose-ringed Parakeet	-	Cattle Egret
Black Drongo	Ring Dove	-	Common Myna
Common Hoopoe	Alexandrine Parakeet	-	Asian Pied Starling
Ashy Prinia	White-throated Munia	-	Common Babbler
-	-	-	Black Ibis
-	-	-	Jungle Babbler

Table 5 : Bird species observed exclusively in zero till wheat and direct seeded paddy crops

Wheat		Paddy	
Bird species	**Feeding habits**	**Bird species**	**Feeding habits**
Bay-backed Shrike	Insectivore	Red-vented Bulbul	Insectivore
Indian Robin	Insectivore	White-breasted Kingfisher	Carnivore
Indian Roller	Carnivore	-	-
Great Grey Shrike	Carnivore	-	-

Table 6 : Overall list of bird species recorded from zero till wheat and direct seeded paddy fields

Scientific name	Common name
Acridotheres tristis (Linnaeus)	Common Myna
Anthus rufulus (Vieillot)	Paddy field Pipit
Bubulcus ibis (Linnaeus)	Cattle Egret
Columba livia (Gmelin)	Blue Rock Pigeon
Coracias benghalensis (Linnaeus)	Indian Roller
Corvus splendens (Vieillot)	House Crow
Dicrurus macrocercus (Vieillot)	Black Drongo
Upupa epops (Linnaeus)	Common Hoopoe
Halcyon smyrnensis (Linnaeus)	White-breasted Kingfisher
Hirundo rustica (Linnaeus)	Common Swallow
Lanius excubitor (Linnaeus)	Great Grey Shrike
Lanius vittatus (Valenciennes)	Bay-backed Shrike
Lonchur amalabarica (Linnaeus)	White-throated Munia
Milvus migrans (Boddaert)	Black Kite
Prinia inornata (Gmelin)	Plain Prinia
Prinia socialis (Sykes)	Ashy Prinia
Pseudibis papillosa (Temminck)	Black Ibis
Psittacula eupatria (Linnaeus)	Alexandrine Parakeet
Psittacula krameri (Scopoli)	Rose-ringed Parakeet
Pycnonotus cafer (Linnaeus)	Red-vented Bulbul
Saxicoloides fulicata (Linnaeus)	Indian Robin
Streptopelia decaocto (Frivaldszky)	Ring Dove
Sturnus contra (Linnaeus)	Asian Pied Starling
Turdoides caudatus (Dumont)	Common Babbler
Turdoides striatus (Dumont)	Jungle Babbler
Vanellus indicus (Boddaert)	Red-wattled Lapwing

of Punjab Agricultural University. Urbanization, intensive agriculture, either crop production or pastoral-farming, have indirect negative effect on the bird population by reducing the quality and availability of food supplies and nesting sites (Rajashekara and Venkatesha, 2011, 2015; Verhulst *et al.,* 2004).

In zero till farming, stubbles and chaff from the previous crop remained undisturbed on soil surface, and undisturbed soil provided spilled grains, weed seeds, insects and small mammals to birds to feed on, so greater number of species was evident. O'Connor and Shrubb (1986) had emphasized that a diverse

community of species limited by food could exists only in habitat which could offer a diversity of foods. It was stated that ploughed fields may be preferred by many species as they hold readily accessible food resources (Wilson *et al.,* 1996; Stefanova and Salek, 2013; Washburn *et. al.,* 2016). In contrast, the loss of stubbles during winter, and a subsequent reduction in the availability of seed food is considered as an important factor in the decline of birds in croplands (Potts, 1997; Dyulgerova *et. al.,* 2015). Ploughed fields are avoided, probably because they provided little seed or invertebrate food with birds preferring those where the stubbles remains even when seed densities were higher in ploughed compared to uncultivated fields (Hart *et al.,* 2001). Some other workers have also reported that conservational agriculture is beneficial to birds while remaining economical to the farmers (Beecher, 2002; Dyulgerova *et al.,* 2015).

In the present study, exceptionally large flocks of Common Swallow were seen exclusively in zero till plots. Field *et al.* (2007) recorded 14,000 Starlings exclusively on two conservation tillage plots. From the present study, number of insectivore species was recorded highest among all the species that were observed in zero till wheat and direct seeded paddy. Holland (2004) stated that the conservational tillage attracts many species in cropland habitat as it provides seed food in winter and higher level of organic matter; and the higher level of organic matter and weeds encourage arthropods in summer.

In intensive cultivation, arthropods that are important dietary items for birds are also susceptible to tillage practices, e.g., Coleoptera, Diptera, Hymenoptera, Arachnida, Annelida and Molluska (Wilson *et al.,* 1999; Kross *et al.,* 2016). In United Kingdom, the occurrence of granivore birds was higher in conservation tillage established fields than fields established by ploughing across a range of crop types (Cunningham *et al.,* 2005). Kler (2008) found that the multi-layered crop vegetation at grain maturing stage of paddy had attracted birds belonging to both the insectivore and granivore groups.

From the present study, it is summarized that species abundance and species diversity was more in zero tillage crop fields as compared to intensively cultivated fields, which signifies that zero tillage cultivation method encourages bird population. It also revealed that zero till farming has potential to provide some of the benefits to birds while allowing farmers to continue cropping, thus suggesting that zero tillage cropping patron was more suitable for conservation of avian biodiversity in intensively cultivated agro-climatic zones of Punjab State.

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