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## Community structure of birds in wheat crop fields of Central Gujarat

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### Abstract

The study on avian community structure utilizing wheat (*Triticum aestivum* L.) fields was conducted in Matar and Thasra Tahsils of central Gujarat during winter (*rabi*) season of year 2007-2008. Avian species richness, community structure, species diversity, and guild structure of bird were worked out during early (sowing and germination stage), and late stages (vegetative stage and crop maturing stages) using variable distance line transect census method.

During entire cropping season, total 80 species of birds were recorded from the study area starting from Germination to the milking stage of crop growth. Total 72 species in early period of growth and 63 species in later stage of wheat crop growth were recorded. Over all relative abundance of birds in wheat fields was as follow: Cattle Egret (50.91%) followed by Yellow Wagtail (22.81%), Glossy Ibis (6.47%), Black Drongo (15.31%), Indian Ring Dove (3.93%). In early growth stage, Cattle Egret (50.71%) was dominant species followed by Yellow Wagtail (24.71%), Glossy Ibis (6.52%), Indian Ring Dove (3.91%) and Red-wattled Lapwing (3.49%). In later growth stage, Cattle Egret (44.64%) was dominant species followed by Black Drongo (12.82%), Barn Swallow (9.42%), Indian Blue Peacock (8.12%) and Bank Myna (6.49%).

The importance of wheat fields as foraging habitat of birds requires consideration because this habitat will persist, and possibly increase, in the region. The wheat field supports about 20% of the total species recorded in the central Gujarat suggesting that wheat growing area is useful habitat to manage and conserve the birds in the region. On other side, dominancy of insectivorous birds in wheat crop fields needs to be highlighted as regulator of insect pests in crop fields.

**Keywords:** Birds community, wheat, Gujarat, guild, biodiversity, agriculture, *Triticum aestivum*

### Introduction

The rice (*Oriza sativa*) – wheat (*Triticum aestivum*) cropping system, which covers an area of 10 million ha, is the major cropping sequence in most parts of India and contributes 85% of total cereal production in India<sup>[1]</sup>. Both transplanted and direct seeded rice are cultivated under rain-fed conditions during south-west monsoon season (June–October). Wheat is generally cultivated during the dry winter season (November–April) and irrigated with groundwater. Growth and development of both rice and wheat crops depend on rainfall and weather variability which plays a significant role<sup>[2]</sup>.

The Indian subcontinent (including the countries like Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka) has experienced extensive cropland intensification during the 20<sup>th</sup> century, with cultivated crops being the dominant land use presently<sup>[3, 4]</sup>. The region has the highest cropland cover per unit area in Asia<sup>[3]</sup> with wheat being the most important crop in terms of geographical coverage with over 26.07 million ha under this crop covering nearly 70% of the total land area of winter crop<sup>[5, 6]</sup>. Most of the wheat of this region is produced in India with 22% of the country's wheat being produced in the Indo-Gangetic flood plains<sup>[7]</sup>. In addition to this extensive cultivation, the region houses India with the second-largest and fastest growing human population globally<sup>[1, 3]</sup>. Protected Areas form less than 5% of the total geographical area in the Indian subcontinent<sup>[8]</sup> and cultivated areas are the predominant land use<sup>[6]</sup>.

Despite the obvious human pressure on the landscape, the region is home to 1,299 species of resident and migratory birds<sup>[8]</sup>. The information on the importance of wheat fields to birds from India and other parts of the world is not documented till date. There is little information from the Indian subcontinent on their role in sustaining bird diversity<sup>[8]</sup>. In this paper, we have described the bird biodiversity in relation to different growth stage of wheat crop growth in the central Gujarat and provide a community and guild structure of birds observed in wheat fields.

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Furthermore, we review published information on birds in wheat fields from the region and highlight gaps in information. Finally, the importance of wheat fields for bird conservation and bird fauna as crop pest regulator is discussed.

### Materials and Methods

Study was conducted during winter season (rabi) of the year 2006-07 and 2007-08 in wheat growing region of central Gujarat, located mainly within the Matar and Thasra Tehsil of Kheda district, Gujarat, India. In this study area, primary agricultural production included Paddy (*Oryza sativa*), Wheat (*Triticum aestivum*) and forage crops. Most crop fields on study regions were tilled for rabi season in November-December and sown in month of December.

The birds were surveyed with variable distance line Transect count method<sup>[10]</sup>. During early winter season, we established transect route of 1 km length with effective strip width of 0.2 km, along wheat growing region. Two transects in each tehsil were marked and surveyed periodically over different growth stage of crop i.e. early (vegetative) and late (reproductive and harvesting) stage, Transects were repeated twice in each growing stage, starting from 50% fields were sown in the landscape. The observations were noted on sighting of bird/s. The bird species and its number, details of microhabitat were recorded. Guild association on the basis of food types was derived through information gathered while long term monitoring of different food types utilizing by species in the region. Total 12 foraging guilds of different food types were defined (Table 1). The species were marked with their guild association on the basis of food type they utilize. Also, the species were marked with their guild association on the basis of their Residential Status in the Gujarat<sup>[11]</sup>. Species were marked as regularly using wheat fields, or ecotonal species that use wheat fields bordering their preferred natural habitat. The data were analyzed to work out species richness, frequency of occurrence and relative abundance to document avian community structure of wheat crop agro-ecosystem of the region. We referred the species distribution from<sup>[8]</sup> and nomenclature follows the most recent recommendations by BirdLife International (2018)<sup>[12]</sup>.

### Results and Discussion

In year 2007, total 64 species of birds were recorded from the study area starting from germination to the harvesting stage of crop growth. Total 53 species during the period of early growth stage (germination to tillering); 38 species during later growth stage (Stem elongation, Booting, Heading & flowering to Milky stages) were observed. During early growing season of crop, Cattle Egret was dominant bird species in the community with 31.43% of Relative abundance followed by Glossy Ibis (20.20%), Eurasian Collared Dove (10.83%), and Laughing Dove (4.91%) (Table 2). During later growth stage, Cattle Egret was dominant in bird community with Relative abundance of 33.33% followed by Bank Myna 11.02%, Black Drongo 7.44% and Laughing Dove 6.06% (Table 2).

In year 2008, thirty nine species of birds were observed utilizing wheat fields in the study area. During early growing season of crop Cattle Egret was dominant species in the community with 53.81% of Relative abundance followed by Yellow wagtail (32.81%), Red-naped Ibis (2.37%), Red-wattled Lapwing (3.07%), and Black Drongo (4.11%) (Table 2). During later crop growth also, bird community was

dominated by Cattle Egret (35.48%) followed by Barn Swallow (13.36%), Black Drongo (11.98%) and Indian Peafowl (11.52%).

During two years, total 80 species of birds were recorded from the study area, starting from germination to the milky stage of crop growth. This constitutes 20% of the total species recorded in Kheda and Anand district. Total 72 species in early period of growth and 63 species in later stage of wheat crop growth were observed. Overall relative abundance of birds species observed in wheat fields was as follow: Cattle Egret (50.91%) followed by Yellow Wagtail (22.81%), Glossy Ibis (6.47%), Black Drongo (15.31%), Laughing Dove (3.93%)(Figure 1). Further, bird communities using various locations for foraging and nesting within wheat fields in Central Gujarat is presented diagrammatically (Figure 2).

We investigated guild structure, on basis of food type and migrant status, of birds utilizing wheat fields. We recognized total 12 guilds based on food type and 5 guilds on the basis of residential status of the species in Gujarat (Table 3). Out of these twelve food type guilds, the guild of birds using insect as food was dominant by frequency (48.75%) as well as by abundance (68.03%). The birds feeding on animal matter was represented by 82.50% frequency and 92.45% by abundance; whereas birds feeding on plant matter was represented by, 17.50% frequency and 7.57% by abundance in the guild structure of wheat crop fields. The birds feeding on animal matter was dominant in guild structure. Out of five residential status guild, Resident breeding (RB) guild was dominant: nearly 72% by frequency as well as by abundance. Migrant birds were represented as 22% in the guild. The wheat field supported five IUCN red listed threatened species, namely Black-headed Ibis, Greater Spotted Eagle, Painted Stork, Sarus Crane and Woolly-necked Stork.

Our results show that birds were abundant in wheat fields, in particular for insectivorous and granivorous birds, In past, a few studies highlighted depredation of some bird species on wheat crop<sup>[13, 14, 15, 16, 17]</sup>. However, very little is known about the avian community of agricultural landscape in India. The number of birds using wheat fields varied with the wetness of the fields and the growth stage. Stubble and recently sown fields were used more by larks, doves and pipits, and replaced by waterbirds (sandpipers, herons, ibises and stilt) when the fields were irrigated<sup>[18, 19]</sup>. In general, species richness displayed a bimodal pattern being highest in early growing season and when the wheat crop was matured. A diurnal bimodal pattern of diversity is also known to exist during the day with species richness peaking at early mornings and late evening<sup>[20]</sup>. Several studies suggested that bird composition (abundance and species) were affected by agricultural land cover and various species could persist within agroecosystems<sup>[21]</sup>.

The importance of wheat fields as foraging habitat of birds requires special consideration because this habitat will persist, and possibly increase, in the region. The wheat field supported about 20% of the total species recorded in the central Gujarat suggesting that wheat is a useful habitat to manage and conserve the birds in the region. Productivity of agricultural landscape is much higher than any other natural ecosystem<sup>[22]</sup>. That is the reason why birds of diverse feeding habits are attracted to the landscape. Unfortunately, avian community studies in agricultural landscape are lacking.

On other side, there is a need to highlight dominance of insectivorous birds in wheat crop fields to manage insect pest in crop field. Several studies have already suggested that

insectivorous birds can be effective for controlling crop pests [23]. The role of birds in natural regulation of a polyphagous lepidopteran pest - *Helicoverpa armigera* in wheat crop was documented in Gujarat and opined that the birds preferred to feed on insects rather than maturing wheat grains [23].

There is need to design and manage agricultural landscapes to host wild biodiversity with neutral or even positive effects on agricultural production and livelihoods. Innovative

practitioners, scientists and indigenous land managers are adapting, designing and managing diverse types of 'ecoagriculture' landscapes to generate positive co-benefits for production, biodiversity and local people. To promote farming communities for conserving biodiversity in their crop fields and for conserving other ecosystem services using management practices that also conserve biodiversity [25].

**Table 1:** Categories of guild association of bird species in the wheat crop ecosystem

Guild name	Definition
<b>Food Type</b>	
Aquatic Inverts	May include aquatic insects, crayfish, shrimp, snails, bivalves, etc.
Birds	Includes birds and their eggs.
Carrion	Dead and putrefying flesh.
Fish	Includes fish, their fry, and eggs.
Fruit	Includes fruit and berries.
Greens	May include leafy parts of both aquatic and terrestrial plants, and bulbs.
Insects	May include insects, spiders, mites, land snails, slugs, worms, millipedes, etc.
Nectar	The sugar
Nuts	A type of fruit with one seed and a hard woody outer layer (e.g., acorns and beechnuts).
Seeds	Includes grains, sunflower seeds, conifer seeds, etc.
Small Mammals	
Small Verts	Includes reptiles (e.g., lizards, snakes) and amphibians (e.g., salamanders, frogs), small mammals (e.g. rodents)
<b>Resident Status</b>	
Migratory (M)	Species migratory to Gujarat state
Resident (R)	Species resident to Gujarat state but no breeding record
Resident + Migratory (R,M)	Species resident (R) to Gujarat but in addition migratory population visit during migratory season
Resident Breeding (RB)	Species Resident and regularly breeding in Gujarat state
Species Resident Breeding + Migratory (RB, M)	Species Resident breeding (RB) in Gujarat state but in addition migratory population visit during migratory season
<b>Threat Status (IUCN)</b>	
Least Concern	Lowest risk (Does not qualify for a more at-risk category; widespread and abundant taxa are included in this category.)
Not rare	
Near threaten	Likely to become endangered in the near future
Vulnerable	High risk of endangerment in the wild

**Table 2:** Bird Abundance (%) in wheat crop agro ecosystem of central Gujarat

Sr. No.	Common name	Scientific name	IUCN Threat category	Residential Status	Year 2007			Year 2008			Overall
					Late	Early	Total	Late	Early	Total	
1	Ashy Prinia	<i>Prinia socialis</i> Sykes, 1832	LC	RB	0.83	0.00	0.13	0.00	0.00	0.00	0.04
2	Ashy-crowned Sparrow-Lark	<i>Eremopterix griseus</i> (Scopoli, 1786)	LC	RB	0.00	0.00	0.00	0.00	0.02	0.02	0.01
3	Asian Openbill	<i>Anastomus oscitans</i> (Boddaert, 1783)	LC	RB	0.28	0.40	0.38	0.00	0.00	0.00	0.12
4	Bank Myna	<i>Acridotheres ginginianus</i> (Latham, 1790)	LC	RB	11.02	0.00	1.70	0.00	1.75	1.60	1.63
5	Barn Swallow	<i>Hirundo rustica</i> Linnaeus, 1758	LC	M	0.00	0.00	0.00	12.61	0.00	1.09	0.75
6	Baya Weaver	<i>Ploceus philippinus</i> (Linnaeus, 1766)	LC	RB	4.41	1.00	1.53	0.00	0.00	0.00	0.47
7	Bay-backed Shrike	<i>Lanius vittatus Valenciennes, 1826</i>	LC	RB	0.00	0.00	0.00	0.43	0.00	0.04	0.03
8	Black Drongo	<i>Dicrurus macrocercus Vieillot, 1817</i>	LC	RB	7.44	0.80	1.82	11.30	3.98	4.62	3.76
9	Black Redstart	<i>Phoenicurus ochruros</i> (Gmelin, 1774)	LC	M	0.00	0.15	0.13	0.00	0.00	0.00	0.04
10	Black-breasted Weaver	<i>Ploceus benghalensis</i> (Linnaeus, 1758)	LC	RB	0.00	0.00	0.00	3.26	0.47	0.71	0.49
11	Black-headed Bunting	<i>Emberiza melanocephala</i> Scopoli, 1769	LC	M	0.55	0.20	0.25	0.00	0.00	0.00	0.08
12	Black-headed Ibis	<i>Threskiornis melanocephalus</i> (Latham, 1790)	NT	RB	0.00	3.71	3.14	0.00	0.02	0.02	0.98
13	Black-winged Kite	<i>Elanus caeruleus</i> (Desfontaines, 1789)	LC	RB	0.00	0.00	0.00	0.22	0.02	0.02	0.01
14	Black-winged Stilt	<i>Himantopus himantopus</i> (Linnaeus, 1758)	LC	RB	0.00	0.15	0.13	0.00	0.00	0.00	0.04
15	Bluethroat	<i>Luscinia svecica</i> (Linnaeus, 1758)	LC	M	0.00	0.05	0.04	0.00	0.00	0.00	0.01
16	Brahminy Starling	<i>Sturnia pagodarum</i> (Gmelin, 1789)	LC	RB	1.10	0.50	0.59	0.00	0.00	0.00	0.18
17	Bronze-winged Jacana	<i>Metopidius indicus</i> (Latham, 1790)	LC	RB	0.28	0.20	0.21	0.00	0.00	0.00	0.07
18	Brown Rock Chat	<i>Oenanthe fusca</i> (Blyth, 1851)		RB	0.55	0.00	0.08	0.00	0.00	0.00	0.03
19	Cattle Egret	<i>Bubulcus ibis</i> (Linnaeus, 1758)	LC	RB	33.33	31.43	31.72	33.48	51.65	50.08	44.45
20	Citrine Wagtail	<i>Motacilla citreola</i> Pallas, 1776	LC	M	0.00	1.70	1.44	0.00	0.00	0.00	0.44
21	Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i> (Ehrenberg, 1833)	LC	RB,M	0.28	0.00	0.04	0.00	0.00	0.00	0.01
22	Common Babbler	<i>Turdoides caudate</i> (Dumont, 1823)	LC	RB	3.31	0.65	1.06	0.00	0.00	0.00	0.33
23	Common Hoopoe	<i>Upupa epops</i> Linnaeus, 1758	LC	RB,M	0.00	0.25	0.21	0.00	0.00	0.00	0.07
24	Common Myna	<i>Acridotheres tristis</i> (Linnaeus, 1766)	LC	RB	0.55	0.00	0.08	1.74	1.60	1.61	1.14
25	Common Pigeon	<i>Columba livia</i> Gmelin, 1789	LC	RB	0.00	0.15	0.13	0.00	0.31	0.28	0.23
26	Common Quail	<i>Coturnix coturnix</i> (Linnaeus, 1758)	LC	R,M	0.00	0.00	0.00	0.00	0.08	0.08	0.05
27	Common Stonechat	<i>Saxicola maurus</i> (Pallas, 1773)	NR	M	0.83	0.05	0.17	0.00	0.00	0.00	0.05
28	Common Tailorbird	<i>Orthotomus sutorius</i> (Pennant, 1769)	LC	RB	0.55	0.00	0.08	0.00	0.00	0.00	0.03

29	Crested Lark	<i>Galerida cristata</i> (Linnaeus, 1758)	LC	RB	0.00	0.10	0.08	0.43	0.00	0.04	0.05
30	Eurasian Collared Dove	<i>Streptopelia decaocto</i> Frivaldszky 1838	LC	RB	4.68	10.83	9.88	1.09	0.53	0.58	3.43
31	Eurasian Marsh Harrier	<i>Circus aeruginosus</i> (Linnaeus, 1758)	LC	M	0.00	0.00	0.00	0.22	0.00	0.02	0.01
32	Glossy Ibis	<i>Plegadis falcinellus</i> (Linnaeus, 1766)	LC	RB,M	0.00	20.20	17.09	6.52	0.02	0.58	5.65
33	Greater Short-toed Lark	<i>Calandrella brachydactyla</i> (Leisler, 1814)	LC	M	0.00	0.90	0.76	0.00	0.00	0.00	0.23
34	Greater Spotted Eagle	<i>Aquila clanga Pallas</i> , 1811	VU	M	0.00	0.00	0.00	0.00	0.02	0.02	0.01
35	Green Bee-eater	<i>Merops orientalis</i> Latham, 1802	LC	RB	0.00	0.05	0.04	0.00	0.39	0.36	0.26
36	Grey Francolin	<i>Francolinus pondicerianus</i> (Gmelin, 1789)	LC	RB	1.38	0.10	0.30	0.00	0.12	0.11	0.17
37	Grey Wagtail	<i>Motacilla cinerea</i> Tunstall, 1771	LC	M	0.00	0.60	0.51	0.00	0.00	0.00	0.16
38	Greylag Goose	<i>Anser anser</i> (Linnaeus, 1758)	LC	M	0.00	0.10	0.08	0.00	0.00	0.00	0.03
39	House Crow	<i>Corvus splendens</i> Vieillot, 1817	LC	RB	0.55	0.90	0.85	3.70	0.04	0.36	0.51
40	House Sparrow	<i>Passer domesticus</i> (Linnaeus, 1758)	LC	RB	1.10	0.50	0.59	0.00	0.08	0.08	0.18
41	Indian Peafowl	<i>Pavo cristatus</i> (Linnaeus, 1758)	LC	RB	0.00	0.00	0.00	10.87	0.27	1.18	0.82
42	Indian Pond Heron	<i>Ardeola grayii</i> (Sykes, 1832)	LC	RB	1.65	0.45	0.64	0.43	0.70	0.68	0.66
43	Indian Robin	<i>Saxicoloides fulicatus</i> (Linnaeus, 1766)	LC	RB	0.00	0.05	0.04	0.22	0.00	0.02	0.03
44	Indian Roller	<i>Coracias benghalensis</i> (Linnaeus, 1758)	LC	RB	0.00	0.00	0.00	2.17	0.14	0.32	0.22
45	Intermediate Egret	<i>Egretta intermedia</i> Wagler, 1829	NR	RB	0.00	0.00	0.00	2.17	0.31	0.47	0.33
46	Jungle Babbler	<i>Turdoides striata</i> (Dumont, 1823)	LC	RB	1.38	0.25	0.42	0.00	0.00	0.00	0.13
47	Knob-billed Duck	<i>Sarkidiornis melanotos</i> (Pennant, 1769)	LC	RB	0.00	0.10	0.08	0.00	0.00	0.00	0.03
48	Large Grey Babbler	<i>Turdoides malcolmi</i> (Sykes, 1832)	LC	RB	4.13	3.46	3.56	0.00	0.31	0.28	1.29
49	Large-billed Crow	<i>Corvus macrorhynchos</i>	LC	RB	0.55	0.05	0.13	0.00	0.06	0.06	0.08
50	Laughing Dove	<i>Spilopelia senegalensis</i> (Linnaeus, 1766)	LC	RB	6.06	4.91	5.09	0.00	0.00	0.00	1.56
51	Little Cormorant	<i>Microcarbo niger</i> (Vieillot, 1817)	LC	RB	0.00	0.00	0.00	0.00	0.02	0.02	0.01
52	Little Egret	<i>Egretta garzetta</i> (Linnaeus, 1766)	LC	RB	0.00	0.35	0.30	0.00	0.00	0.00	0.09
53	Long-tailed Shrike	<i>Lanius schach</i> Linnaeus, 1758	LC	RB	0.28	0.00	0.04	0.00	0.00	0.00	0.01
54	Oriental Magpie-Robin	<i>Copsychus saularis</i> (Linnaeus, 1758)	LC	RB	0.00	0.10	0.08	0.00	0.02	0.02	0.04
55	Oriental Skylark	<i>Alauda gulgula</i> Franklin, 1831	LC	R	0.28	1.65	1.44	0.00	0.00	0.00	0.44
56	Paddyfield Pipit	<i>Anthus rufulus</i> Vieillot, 1818	LC	R	0.55	0.15	0.21	0.00	0.00	0.00	0.07
57	Paddyfield Warbler	<i>Acrocephalus agricola</i> (Jerdon, 1845)	LC	M	0.28	0.00	0.04	0.00	0.00	0.00	0.01
58	Painted Stork	<i>Mycteria leucocephala</i> (Pennant, 1769)	NT	RB	0.00	0.00	0.00	2.17	0.16	0.34	0.23
59	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i> (Scopoli, 1786)	LC	RB	0.28	0.00	0.04	0.00	0.00	0.00	0.01
60	Pied Bush Chat	<i>Saxicola caprata</i> (Linnaeus, 1766)	LC	M	0.00	0.05	0.04	0.00	0.00	0.00	0.01
61	Plain Prinia	<i>Prinia inornata</i> Sykes, 1832	LC	RB	0.00	0.10	0.08	0.00	0.00	0.00	0.03
62	Purple Heron	<i>Ardea purpurea</i> Linnaeus, 1766	LC	RB	0.00	0.05	0.04	0.00	0.00	0.00	0.01
63	Purple Sunbird	<i>Cinnyris asiaticus</i> (Latham, 1790)	LC	RB	0.55	0.15	0.21	0.00	0.00	0.00	0.07
64	Red Collared Dove	<i>Streptopelia tranquebarica</i> (Hermann, 1804)	LC	RB	1.38	0.80	0.89	0.00	0.00	0.00	0.27
65	Red-napped Ibis	<i>Pseudibis papillosa</i> (Temminck, 1824)	LC	RB	1.10	3.61	3.22	3.70	2.30	2.42	2.67
66	Red-vented Bulbul	<i>Pycnonotus cafer</i> (Linnaeus, 1766)	LC	RB	0.55	0.25	0.30	0.00	0.00	0.00	0.09
67	Red-wattled Lapwing	<i>Vanellus indicus</i> (Boddaert, 1783)	LC	RB	2.75	3.56	3.44	0.43	2.98	2.76	2.97
68	Rose-ringed Parakeet	<i>Psittacula krameri</i> (Scopoli, 1769)	LC	RB	0.28	0.35	0.34	0.22	0.00	0.02	0.12
69	Rosy Starling	<i>Pastor roseus</i> (Linnaeus, 1758)	LC	M	4.13	0.00	0.64	0.00	0.00	0.00	0.20
70	Ruff	<i>Philomachus pugnax</i> (Linnaeus, 1758)	LC	M	0.00	0.20	0.17	0.00	0.00	0.00	0.05
71	Sarus Crane	<i>Grus antigone</i> (Linnaeus, 1758)	VU	RB	0.00	0.00	0.00	2.39	0.58	0.73	0.51
72	Southern Coucal	<i>Centropus (sinensis) parroti</i>		RB	0.28	0.00	0.04	0.00	0.02	0.02	0.03
73	Southern Grey Shrike	<i>Lanius meridionalis</i> Temminck, 1820	NR	RB	0.00	0.00	0.00	0.22	0.02	0.04	0.03
74	Spotted Dove	<i>Spilopelia chinensis</i> (Scopoli, 1786)	LC	RB	0.00	1.05	0.89	0.00	0.00	0.00	0.27
75	Sykes's Lark	<i>Galerida deva</i> (Sykes, 1832)	LC	RB	0.00	0.20	0.17	0.00	0.00	0.00	0.05
76	White Wagtail	<i>Motacilla alba</i> Linnaeus, 1758	LC	M	0.55	0.50	0.51	0.00	0.00	0.00	0.16
77	White-breasted Waterhen	<i>Amaurornis phoenicurus</i> (Pennant, 1769)	LC	RB	0.00	0.45	0.38	0.00	0.00	0.00	0.12
78	White-throated Kingfisher	<i>Halcyon smyensis</i> (Linnaeus, 1758)	LC	RB	0.00	0.10	0.08	0.00	0.04	0.04	0.05
79	Woolly-necked Stork	<i>Ciconia episcopus</i> (Boddaert, 1783)	VU	RB	0.00	0.00	0.00	0.00	0.16	0.15	0.10
80	Yellow Wagtail	<i>Motacilla flava</i> Linnaeus, 1758	LC	M	0.00	1.35	1.15	0.00	30.89	28.22	19.92

Table 3: Guild structure of birds in wheat crop fields of central Gujarat (N=80)

Guild	Species richness	Occurrence (%)	Abundance (%)
<b>Food Type</b>			
<b>Animal matter</b>			
Aquatic Invertebrates	8	10.00	1.47
Carrion	2	2.50	0.59
Insects	39	48.75	68.03
Insects & seeds	9	11.25	21.92
Small Vertebrates	8	10.00	0.44
Animal matter Total	66	82.50	92.45
<b>Plant matter</b>			
Fruit	1	1.25	0.12
Greens	4	5.00	0.89
Nectar	1	1.25	0.07
Seeds	8	10.00	6.49
Plant matter Total	14	17.50	7.57
<b>Migrant Status</b>			
Migratory (M)	17	21.25	22.16
Resident (R)	2	2.50	0.51
Resident + Migratory (R,M)	1	1.25	0.05

Resident Breeding (RB)	57	71.25	71.57
Species Resident Breeding + Migratory (RB, M)	3	3.25	5.73
<b>Threat Staus (IUCN)</b>			
Least Concern	72	90.00	97.78
Not rare	3	3.75	0.41
Near threaten	2	2.50	1.21
Vulnerable	3	3.75	0.62

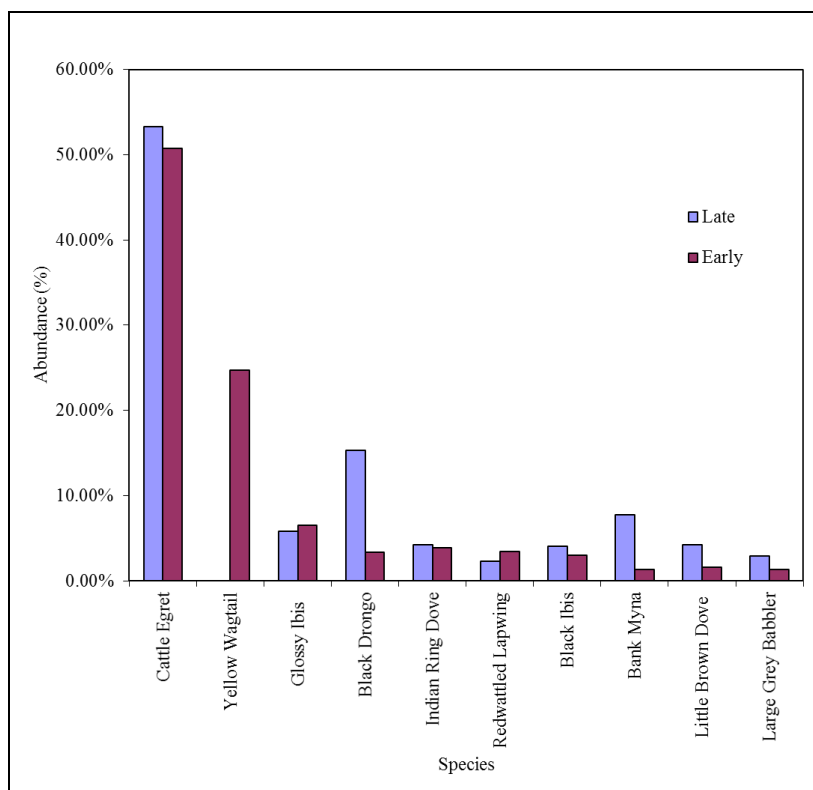


Fig 1: Most abundance of bird species and its abundance in wheat crop fields.

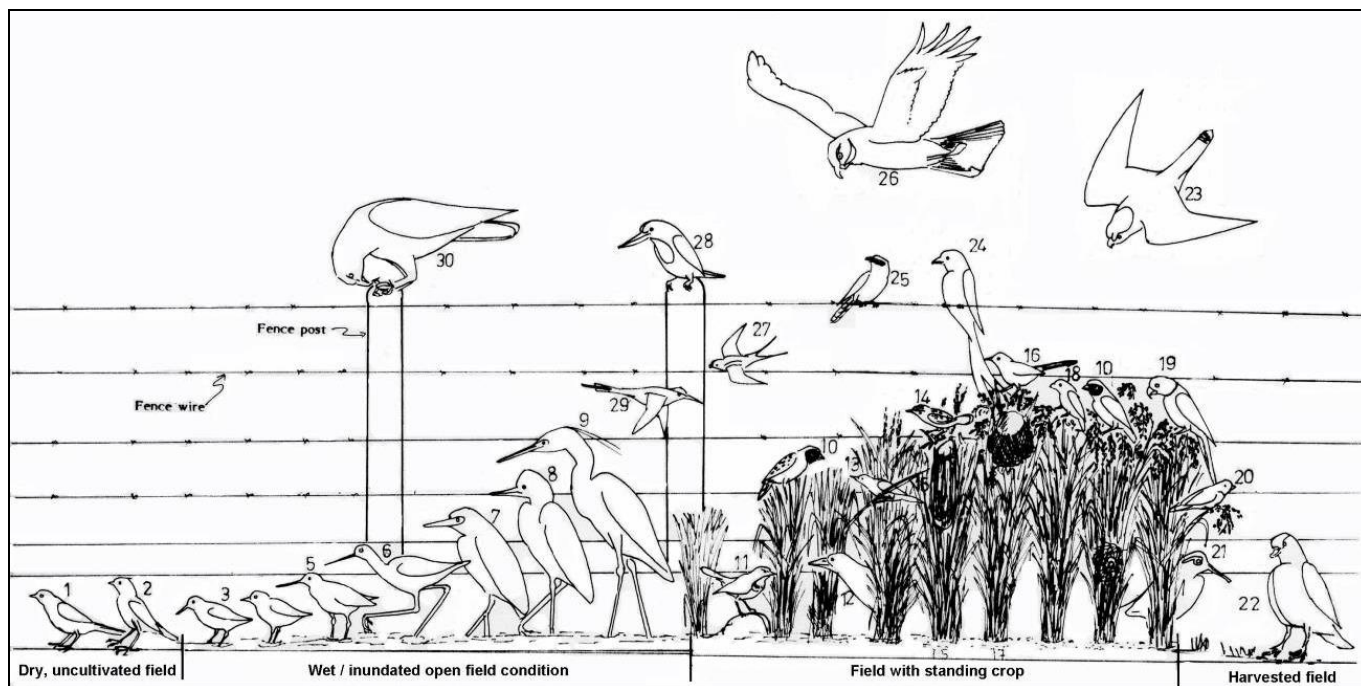


Fig 2: Diagrammatic representation of bird communities using various locations for foraging and nesting within wheat fields in Central Gujarat district, Gujarat (modified from Subramanya & Veeresh, 1998). Key to bird species 1. Paddyfield Pipit, 2. Greater Short-toed Lark, 3. Red-wattled Lapwing, 4. Ruff, 5. Grey Francolin, 6. Black-winged Stilt, 7. Indian Pond Heron, 8. Cattle Egret, 9. Little Egret, 10. Baya Weaver, 11. Black-breasted Weaver, 12. Red-napped Ibis, 13. Paddyfield Warbler, 14. Ashy Prinia, 15. Common Stonechat, 16. Plain Prinia, 17. Plain Prinia Nest, 18. Indian Silverbill 19. Rose-ringed Parakeet, 20. House Sparrow, 21. Jungle Babbler, 22. Common Pigeon, 23. Red-necked Falcon, 24. Black Drongo, 25. Long-tailed Shrike, 26. Eurasian Marsh Swallow, 27. Barn Swallow, 28. White-breasted Waterhen, 29. Green Bee-eater, 30. Black-winged Kite

## Conclusion

The region is clearly in need of focused applied research in order to better understand how birds and wheat fields are interacting, and given that rice-wheat cropping systems are here to stay, to understand how to improve cultivation practices to improve conditions for bird diversity. Specifically, we list aspects of research and conservation that should be taken up on a priority basis for the region given the present status of information and ongoing research; 1) Bird and habitat information; 2) Agrochemical impacts on birds and their natural habitats; 3) Restoration of habitat and socio-economic assessments; 4) Multiple-use rice-wheat cropping system, 5). Agricultural landscapes to be designed and managed to host wild biodiversity with neutral or even positive effects on agricultural production and livelihoods.

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