COMMUNICATION

BIRD COMPOSITION, DIVERSITY AND FORAGING GUILDS IN AGRICULTURAL LANDSCAPES: A CASE STUDY FROM EASTERN UTTAR PRADESH, INDIA

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Bird composition, diversity and foraging guilds in agricultural landscapes: a case study from eastern Uttar Pradesh, India

Yashmita-Ulman & Manoj Singh

Abstract: Birds have a significant role in maintaining the ecological balance of agro-ecosystems. But yet there is no documentation related to bird diversity in the agricultural landscapes of eastern Uttar Pradesh. This study was conducted from March 2019 to February 2020 using a fixed radius point count method in Ayodhya district of eastern Uttar Pradesh. A total of 139 bird species belonging to 107 genera, 49 families and 15 orders were recorded from the study area. Passeriformes was the most dominant order with 28 families and 76 species. Accipitriformes and Muscicapidae were the most diverse families with 11 species each and RDI value of 7.91. Among the recorded bird species, 105 species (76%) were resident, 29 species (21%) were winter visitors and only 5 species (4%) were summer visitors. According to the feeding guilds, omnivores (46 species, 33%) were highly represented, followed by insectivores (31%), carnivores (25%), granivores (6%), frugivores (4%) and nectarivores (1%).

Keywords: Ayodhya, Avifauna checklist, community parameters, feeding guilds, relative diversity, species richness.
INTRODUCTION

Agriculture is the most dominant land use in the tropical and sub-tropical regions of the world. In India, nearly 60.45% of the total land is under agriculture (Anonymous 2021a). Even if the area under protected area is as small as 15.40% globally (Anonymous 2021b) and 5.00% (Anonymous 2021c) in India, the conservationists have always concentrated on natural forests or protected areas for species conservation. But lately, the focus has been slowly changing to conservation outside protected areas. Recent studies have highlighted the importance of human-dominated agroforestry systems and agricultural landscapes in conservation of common to globally concerned vertebrates and invertebrates (Athreya et al. 2010; Sundar & Subramanya 2010). Birds play a vital role in maintaining the ecological balance in agro-ecosystems (Haslem & Bennett 2008). An agricultural system provides food like grains, seeds, fruits, green vegetation, plants, grasses, insects, arthropods and rodents to the birds (O’Connor & Shrubb 1986; Asokan et al. 2009). Birds, therefore, play a dual role of pests by feeding on grains and seeds as well as of bio-control agents by feeding on insect pests of agricultural crops (Borad et al. 2000). Thus, they act as both friend and foe of farmers. In addition to this, birds also have functional roles of seed dispersal, pollination, scavenging, nutrient deposition etc. (Dhindsa & Saini 1994; Whelan et al. 2008; Sekercioglu 2012) making them beneficial to nature and thus humans. The occurrence of birds in agricultural systems is influenced by many factors such as the crop type, structural complexity, i.e., vertical stratification formed by the grasses, shrubs and trees, type of management and landscape composition (Taft & Haig 2006; Bruggisser et al. 2010; Wretenberg et al. 2010). Most of the agricultural lands are intermingled with agroforestry & horticultural trees, wetlands, remnant vegetation, natural forest fragments, grasslands and poultry farms influencing the bird diversity positively.

Uttar Pradesh is the top most producer of food grains in the country and also is one of the most intensively cultivated regions of the world (Ramankutty & Foley 1998). This State has undergone various developments and mechanizations in its farming systems due to rapid urbanization and industrialization. Some of them include excessive use of pesticides and fertilizers, intensive agriculture, very good network of irrigation etc. which have altered the agro-ecosystems as well as the bird composition. Some studies show evidences that the existence of birds in agricultural lands depends on low-intensity agricultural practices (Doxa et al. 2010). To study the impacts of agricultural mechanization on birds, it is important to first record the bird diversity present in this most dominant land use system of Uttar Pradesh. It is also important that the birds which act as bio-control agents and bio-indicators of the agro-ecosystems should be conserved in these landscapes. This study, therefore, aims to produce a checklist of birds associated with agricultural fields which can then be further used as a baseline for detailed investigation and research.

The avian diversity in agricultural landscapes has been studied by different authors in different states of India. Work has been done on bird composition and diversity in the agricultural fields of Punjab (Malhi 2006), Karnataka (Basavarajappa 2006), Maharashtra (Abdar 2014), West Bengal (Hossain & Aditya 2016), Uttarakhand (Elsen et al. 2016), Odisha (Mukhopadhyay & Mazumdar 2017), Telangana (Narayana et al. 2019) and Haryana (Kumar & Sahu 2020). Studies have also been conducted on bird diversity in paddy fields (Borad et al. 2000; Jayasimhan & Pramod 2019). Sundar (2006, 2009), Sundar & Subramanya (2010), Sundar & Kittur (2012, 2013) have studied bird composition in agricultural fields and their use by birds in western Uttar Pradesh. Studies have also been undertaken on bird diversity in wetlands and bird sanctuaries (Kumar & Kanaujia 2016; Mishra et al. 2020), and protected areas (Javed & Rahmani 1998; Iqubal et al. 2003, Khan et al. 2013) in Uttar Pradesh. However, there has been no study on the bird diversity in agricultural landscapes of eastern Uttar Pradesh. In this context, the present study is designed to document the bird species composition and diversity in the agricultural landscapes of Ayodhya district, eastern Uttar Pradesh.

MATERIALS AND METHODS

Study area

This study was conducted in five tehsils namely, Sohawal, Rudauli, Milkipur, Sadar and Bikapur of Ayodhya district, eastern Uttar Pradesh (Figure 1). The details of each tehsil are given in Table 1. Two study sites were chosen in each tehsil (Figure 1). Ayodhya district is situated between 26.7730 °N and 82.1458 °E. It has an elevation of 93 m above mean sea level and has an area of 2,764 km² (Anonymous 2021d). The net cultivated area in the district is 1,710 km² and the total forest area is 3,038 km² (Anonymous 2021d). The city of Ayodhya is situated on the banks of the river Saryu. The climate is humid subtropical (Kumar 2018) experiencing three major seasons, i.e., summers (March to June), rainy (July to October) and winters (November to February) (Sundar...
The district receives annual rainfall of 1,067 mm. The average temperature during summers is 32 °C and in winters is 16 °C (Anonymous 2021d). The area also experiences heat and cold waves at times (Kumar 2018). The topography of the district is plain. The soil varies from clay soil to sandy soil across the district and is suitable for raising horticultural and agricultural crops. Agriculture is dependent on rain, tube-wells and canals for irrigation. This region is inhabited by small, marginal and landless farmers. The main cropping system of the area is rice-wheat cropping system (Anonymous 2021d). *Saccharum officinarum* is the main cash crop grown which serves as the raw material for the jaggery and sugar industries in Sadar tehsil. Apart from this, crops like *Cajanus cajan*, *Vigna mungo*, *Vigna radiata*, *Cicer arietinum*, *Sorghum bicolor*, *Zea mays*, *Hordeum vulgare*, *Brassica* sp., vegetable (e.g., *Solanum tuberosum*), fruit crops (*Mangifera indica*, *Psidium guajava*) and fodder crops are also grown (Anonymous 2021d).

**Method**

In each tehsil, two sites were selected randomly. Bird surveys were conducted using fixed radius, point-count method (Bibby et al. 2000) in selected sites on a monthly basis between 0600h to 0830h from March 2019 to February 2020. In every tehsil, a transect of 1 km in length was laid in each of the two sites and five permanent point counts were marked at every 250 m distance on each transect. So, in each tehsil 10 point counts were marked, making a total of 50 point counts in Ayodhya district. The birds were recorded in 30 m radius from the point count. At every point count, a five minutes settling down time was given before recording the birds. Species were recorded for 10 minutes at every point count. Each point count was surveyed 24 times during the entire study period. Birds were recorded directly using a pair of field binoculars (Nikon 7x35). On sighting the birds, the species name, number of individuals and habitat were recorded. Birds flying across were not counted. The opportunistic counts during the other time of the day were also included. Bird identification was done following Grimmett et al. (2011). Praveen et al. (2020) was followed for the taxonomic position (order and family), common names and scientific names of species observed. According to the observations made in the field and following Ali & Ripley (1987), the species were also classified into six major feeding guilds, i.e., insectivorous (feeds exclusively on insects), carnivorous (feeds mainly on non-insect invertebrates and vertebrates), granivorous (feeds mainly on grains/seeds), frugivorous (feeds mainly on fruits), nectarivores (feeds mainly on nectar) and omnivorous (feeds on both plant and animal.
parts). The IUCN Red List (2021) was followed to compile the global population trend (decreasing, increasing, stable, unknown) of the recorded species.

Species richness was calculated as total number of bird species recorded in the study area.

The following community parameters were calculated using the below given formulae at each tehsil:

[i] Relative diversity of bird families (RDi) (Torres-Cuadros et al. 2007)

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

[ii] Shannon Weiner index (Shannon & Weiner 1963)

\[
H' = -\sum_{i=1}^{S} p_i \log_{10}(p_i)
\]

where, \( p_i \) is often the proportion of individuals belonging to the \( i^{th} \) species in the dataset and \( S \) is the species richness. The values usually lies between 1 and 4 where 1 shows less diversity and 4 shows high diversity.

[iii] Simpson’s index (Simpson 1949)

This was calculated according to Simpson (1949) to measure the concentration of dominance (CD) of bird species.

\[
CD = \frac{\sum_{i=1}^{S} (p_i)^2}{\sum_{i=1}^{S} p_i}
\]

where \( p_i \) is the proportion of the IVI of the \( i^{th} \) species and IVI of all the species (ni/N). The values of Simpson’s index is limited to 1 where 1 shows dominance by a single species.

[iv] Pielou’s evenness index (Pielou 1966)\( \frac{H'}{ \log_{10}(S) } \)

where \( H' \) is the Shanon Weiner diversity index and \( S \) is the total number of species. This index ranges from 0 (no evenness) to 1 (complete evenness).

[v] Sorensen’s similarity coefficient (Sorensen 1948)

\[
\text{Sorensen similarity coefficient} = \frac{2C}{A+B}
\]

where C is the number of species common to both sites, A is the total number of species in site A and B is the total number of species in site B. Sorensen’s coefficient gives a value between 0 and 1, the closer the value is to 1, the more the communities have in common.

RESULTS

A total of 139 species of birds belonging to 107 genera, 49 families and 15 orders were recorded from the study area (Table 2). Passeriformes was the most dominant order with 28 families and 76 species followed by Accipitriformes (1 family and 11 species) (Figure 2). Falconiformes and Bucerotiformes were the least dominant orders with one family and one species each (Figure 2). According to the residential status of the birds, 105 bird species (76%) were resident, 29 bird species (21%) were winter visitors and only 5 bird species (4%) were summer visitors (Figure 3). As far as the feeding guilds were concerned, six foraging guilds were found in the study area. Omnivores (46 species, 33%) were highly represented, followed by insectivores (31%) whereas, nectarivores (1 species, 1%) was the least represented guild (Figure 4).

Accipitridae and Muscicapidae were the most diverse families (11 species each, RDi= 7.91), followed by Ardeidae, Columbidae and Cuculidae (7 species each, RDi= 5.04). On the other hand, 18 families namely, Aegithinidae, Bucerotidae, Coraciidae, Dicaeidae, Dicruridae, Falconidae, Glareolidae, Gruidae, Monarchidae, Nectariniidae, Paridae, Railidae, Sittidae, Stenostiridae, Turdidae, Upupidae, Vangidae & Zosteropidae were least represented (1 species each, RDi= 0.72) (Table 3).

Sohawal tehsil had the highest species richness and Shannon-Weiner diversity index (133, 4.30), followed by Rudauli (126, 4.28), Milkipur (119, 4.25) and Bikapur (114, 4.23) (Table 4). Whereas the lowest species richness and Shannon-Weiner diversity index was found in Sadar (98, 3.86) (Table 4). The Simpson’s Dominance index indicated that all sites were highly diverse in terms of bird species and no single bird species was dominant (Table 4). The Pielou’s Evenness index was the highest in Bikapur (0.89), followed by Rudauli and Milkipur (0.88 each), Sohawal (0.87) and the lowest in Sadar (0.84).

This index highlighted that the bird communities in each tehsil was nearly even i.e. all the species were equally represented (Table 4). The Sorensen’s Similarity index indicated that all the sites were almost similar in diversity (Table 5). The highest similarity existed between the sites of Rudauli and Milkipur (0.94), followed by Sohawal and Rudauli (0.93) and the lowest similarity existed between the sites of Sohawal and Sadar (0.82) (Table 5).

Of the 139 species recorded, two species (1.44%) were ‘Endangered’, two species (1.44%) were ‘Vulnerable’, four species (2.88%) were ‘Near Threatened’ and the rest (131 species, 94.24%) were ‘Least Concern’ according to the IUCN Red List (Table 2). With regard to the global population trend, this area supported 66 globally stable bird species (48%), 31 globally decreasing species (22%), 28 globally increasing species (20%) and 14 species (10%) whose global population trend was unknown (Figure 5).

In addition to this, 15 species recorded from this area were listed in Appendix II of CITES and one species was under Appendix III of CITES (Table 2). According to the

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IWPA (1972), out of 139 species, 11 species were under Schedule I, one species was in Schedule V and the rest were in Schedule IV (Table 2).

**Table 1. General characteristics of the selected agricultural landscapes in Ayodhya District, eastern Uttar Pradesh, India.**

| Name of tehsil | Co-ordinates | Features |
|----------------|--------------|----------|
| Sohawal        | 26.694°N, 81.972°E | Rice-wheat cropping system along with mustard and sugarcane dominates in the area. The area has orchards of Mangifera indica. Trees of Eucalyptus sp. and Flectona grandis are planted on the field boundaries in agroforestry systems. The area has large to small sized wetlands. The main source of water is the tube wells. |
| Rudauli         | 26.698°N, 81.611°E | Rice-wheat is the major cropping system in this area. Mustard, vegetables, fruits are also grown in this area. The study area is adjacent to Rudauli Forest Reserve. Apart from this, the area has orchards and agroforestry systems in which Eucalyptus sp. is planted on the boundaries of the fields. It has very few small sized water bodies. Agricultural activities are dependent upon tube wells. |
| Milkipur       | 26.632°N, 81.910°E | Wheat, mustard, sugarcane, rice, bajra are grown in this area. This area has good patches of tall wooded trees, plantations, orchards, agroforestry systems, grasses and wetlands. The irrigation is done through canals and tube wells. |
| Bikapur         | 26.616°N, 82.194°E | Wheat, mustard and rice are the major crops grown in this area. There are some orchards and few small sized water bodies available in this area. Tube wells are used for irrigation purpose. |
| Sadar           | 26.793°N, 82.158°E | Wheat, rice and sugarcane are the major crops grown in this area. There are many jaggery and sugar industries located in this area. There are some orchards and wetlands available in this area. This area is mostly influenced by urbanization. |

**Figure 2. Composition of avian community in selected agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.**

**Figure 3. Seasonal status of avian species recorded from agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.**

**Figure 4. Guild-based classification of avian species recorded in agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.**

**Figure 5. Comparison of global status of avifaunal species recorded in selected agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.**

**DISCUSSION**

Agricultural landscape is the preferred habitat for 45% of the birds of the Indian subcontinent (Sundar & Subramanya 2010), however some species are known to visit this landscape only occasionally (Sekercioglu et al. 2012). This might be one of the reasons for finding 139 bird species in the agricultural landscapes of Ayodhya.
| Order/Family/Common name | Scientific name | Residential status | Feeding status | Conservation status | Global status | Sites | Image No. |
|--------------------------|-----------------|--------------------|----------------|--------------------|---------------|-------|-----------|
| Accipitriformes           |                 |                    |                |                    |               |       |           |
| Accipitridae (1)          |                 |                    |                |                    |               |       |           |
| 1 Black Kite              | Milvus migrans  | R                  | C              | LC                 | II            | I     | R         |
|                          | (Boddaert, 1783)|                    |                |                    |               |       |           |
| 2 Black-winged Kite       | Elanus caerules | R                  | C              | LC                 | II            | I     | R         |
|                          | (Desfontaines, 1789)|                    |                |                    |               |       |           |
| 3 Crested Serpent Eagle   | Spilornis cheela| R                  | C              | LC                 | II            | I     | R         |
|                          | (Latham, 1790)  |                    |                |                    |               |       |           |
| 4 Egyptian Vulture        | Neophron percnopterus | R       | C              | EN                 | II            | I     | R         |
|                          | (Linnaeus, 1758)|                    |                |                    |               |       |           |
| 5 Himalayan Vulture       | Gyps himalayensis| W                  | V              | C                  | NT            | II    | R         |
|                          | (Hume, 1869)    |                    |                |                    |               |       |           |
| 6 Indian Spotted Eagle    | Changa hastata  | R                  | C              | LC                 | II            | I     | R         |
|                          | (Lesoon, 1831)  |                    |                |                    |               |       |           |
| 7 Shikra                  | Accipiter badius| R                  | C              | LC                 | II            | I     | R         |
|                          | (Gmelin, 1788)  |                    |                |                    |               |       |           |
| 8 Short-toed Snake Eagle  | Circus gallicus | R                  | C              | LC                 | II            | I     | R         |
|                          | (Gmelin, 1788)  |                    |                |                    |               |       |           |
| 9 Steppe Eagle            | Aquila nipalensis| W                  | V              | C                  | EN            | II    | R         |
|                          | (Hodgson, 1833) |                    |                |                    |               |       |           |
| 10 Western Marsh-harrier  | Circus aeruginosus| W                  | V              | C                  | LC            | II    | R         |
|                          | (Linnaeus, 1758)|                    |                |                    |               |       |           |
| 11 White-eyed Buzzard     | Butastur teesa  | R                  | C              | LC                 | II            | I     | R         |
|                          | (Franklin, 1831)|                    |                |                    |               |       |           |
| Bucerotiformes            |                 |                    |                |                    |               |       |           |
| Bucerotidae (1)           |                 |                    |                |                    |               |       |           |
| 12 Indian Grey Hornbill   | Ocyrrhynchus bicornis| R        | O              | LC                 | -              | IV    | R         |
|                          | (Scopoli, 1786) |                    |                |                    |               |       |           |
| Caprimulgiformes          |                 |                    |                |                    |               |       |           |
| Apodidae (2)              |                 |                    |                |                    |               |       |           |
| 13 Asian Palm Swift       | Cypsiurus balasiensis| R       | I              | LC                 | -              | IV    | R         |
|                          | (Gray, 1829)    |                    |                |                    |               |       |           |
| 14 Indian House Swift     | Apus affinis    | R                  | I              | LC                 | -              | IV    | R         |
|                          | (Gray, 1830)    |                    |                |                    |               |       |           |
| Upupidae (1)              |                 |                    |                |                    |               |       |           |
| 15 Common Hoopoe          | Upupa epops    | R                  | O              | LC                 | -              | IV    | R         |
|                          | (Linnaeus, 1758)|                    |                |                    |               |       |           |
| Charadriiformes           |                 |                    |                |                    |               |       |           |
| Charadriidae (2)          |                 |                    |                |                    |               |       |           |
| 16 Red-wattled Lapwing    | Vanellus indicus| R                  | O              | LC                 | -              | IV    | R         |
|                          | (Boddaert, 1783)|                    |                |                    |               |       |           |
| 17 Yellow-wattled Lapwing  | Vanellus malabaricus| R       | C              | LC                 | -              | IV    | R         |
|                          | (Boddaert, 1783)|                    |                |                    |               |       |           |
| Glareolidae (1)           |                 |                    |                |                    |               |       |           |
| 18 Small Pratincole       | Glareola media  | R                  | I              | LC                 | -              | IV    | R         |
|                          | (Temminck, 1820)|                    |                |                    |               |       |           |
| Columbiformes             |                 |                    |                |                    |               |       |           |
| Columbidae (7)            |                 |                    |                |                    |               |       |           |
| 19 Eurasian Collared Dove | Streptopelia decaocto| R       | G              | LC                 | -              | IV    | R         |
|                          | (Frivaldszky, 1838)|                    |                |                    |               |       |           |

Table 2. Checklist and status of avifauna recorded in agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.
## Bird Composition, Diversity, and Foraging Guilds in Agricultural Landscapes: A Case Study

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### Table of Bird Species

| Order/Family/Genus | Scientific Name | Residential Status | Foraging Status | Global Status | Conservation Status |
|-------------------|-----------------|--------------------|-----------------|---------------|--------------------|
| **Cuculiformes**   |                 |                    |                 |               |                    |
| **Cuculidae**      |                 |                    |                 |               |                    |
| 31 Asian Koel      | Eudynamys scolopaceus | R O LC       |        | IV → √ √ √ √ √ |                    |
| 32 Common Hawk Cuckoo | Hierococcyx varius | R O LC       |        | IV → √ √ √        |                    |
| 33 Greater Coucal | Centropus sinensis | R O LC       |        | IV → √ √ √ √ √ |                    |
| 34 Grey-bellied Cuckoo | Cuculus microcarbo | SV I LC       |        | IV        |                    |
| 35 Indian Cuckoo | Clamator jacobinus | SV O LC       |        | IV → √ √ √ √ √ |                    |
| 36 Pied Cuckoo | Charadrius asiaticus | SV O LC       |        | IV → √ √ √ √ √ |                    |
| 37 Sirkeer Malkoha | Taccocua leschenaultii | R O LC       |        | IV → √ |                    |
| 38 Oriental Magpie | Cissa chinensis | R O LC       |        | IV        |                    |
| 39 Indian Robin | Erithacus rubecula | R O LC       |        | IV → √ √ √ √ √ |                    |
| 40 Grey Francolin | Ptilpitta araujoi | R O LC       |        | IV → √ √ √ √ √ |                    |

### Additional Information

- **Sites:** SHW RDL MWP BDP SDR
- **Image No.:** 1a 2a 2b 2c 2d 2e
- **References:** Linnaeus, 1766; Latham, 1790; Hermann, 1804; Gmelin, 1789; Scopoli, 1786;Lesson, 1830; Boddaert, 1783; Vahl, 1797; Stephens, 1815;
- **Conservation Status:** IUCN (2021) CITES (2012) IWPA (1972) SHW RDL MWP BDP SDR
| Order/Family/Common name | Scientific name | Residential status | Feeding status | Conservation status | Global status | Sites | Image No. |
|-------------------------|----------------|--------------------|---------------|--------------------|---------------|-------|-----------|
| **Gruiformes**<br>Gruidae (1) | | | | | | | |
| 41 Sarus Crane<br>(Linnaeus, 1758) | Antigone antigone | R O VU | - | IV ↓ | v v v v x | 3h |
| **Rallidae** (1) | | | | | | | |
| 42 White-breasted Waterhen<br>(Pennant, 1769) | Amaurornis phoenicurus | R O LC | - | IV ? | v v v v | v |
| **Passeriformes**<br>Acrocephalidae (2) | | | | | | | |
| 43 Blyth’s Reed Warbler<br>(Byth, 1841) | Acrocephalus dumetorum | WV O LC | - | IV ↑ | x v v x x | |
| 44 Booted Warbler<br>(Lichtenstein, 1823) | Iduna caligata | WV I LC | - | IV ↑ | x x x x v | |
| **Aegithinidae** (1) | | | | | | | |
| 45 Common Iora<br>(Linnaeus, 1758) | Aegithina tiphia | R O LC | - | IV ? | v v v v | |
| **Alaudidae** (4) | | | | | | | |
| 46 Ashy-crowned Sparrow-Lark<br>(Scopal, 1786) | Eremopterix grisaeus | R O LC | - | IV → | v v v v v | |
| 47 Bengal Bushlark<br>(Horsfield, 1840) | Mirafra assamica | R O LC | - | IV → | v v v v | |
| 48 Crested Lark<br>(Linnaeus, 1758) | Galerida cristata | R O LC | - | IV ↓ | v v v v | |
| 49 Sand Lark<br>(Byth, 1845) | Alauda arvensis | R O LC | - | IV → | v v v v | |
| **Campephagidae** (3) | | | | | | | |
| 50 Large Cuckoo Shrike<br>(Lesueur, 1831) | Coracina macrocorax | R I LC | - | IV ↓ | v v x x x x | |
| 51 Long-tailed Minivet<br>(Bangs & Phillips, 1914) | Pericrocotus phoeniceus | WV I LC | - | IV ↓ | v v x x x v | |
| 52 Small Minivet<br>(Linnaeus, 1766) | Pericrocotus rufescens | R I LC | - | IV ↓ | v v v v v | |
| **Cisticolidae** (4) | | | | | | | |
| 53 Ashy Prinia<br>(Sykes, 1832) | Prinia socialis | R I LC | - | IV → | v v v v | |
| 54 Common Tailorbird<br>(Pomatorhinus subrufus) | Orthotomus sutorius | R I LC | - | IV → | v v v v | |
| 55 Plain Prinia<br>(Sykes, 1832) | Prinia inornata | R I LC | - | IV → | v v v v | |
| 56 Zitting Cisticola<br>(Rafinesque, 1810) | Cisticola juncidis | R I LC | - | IV → | v v v v | |
| **Corvidae** (3) | | | | | | | |
| 57 House Crow<br>(Vieillot, 1817) | Corvus splendens | R O LC | - | IV → | v v v v | |
| 58 Common Tailorbird<br>(Pomatorhinus subrufus) | Orthotomus sutorius | R I LC | - | IV → | v v v v | |
| 59 Rufous Treepie<br>(Latham, 1790) | Dendrocitta vagabunda | R O LC | - | IV ↓ | v v v v | |
| Order/Family/Common name | Scientific name | Residential status | Conservation status | Global status | Site(s) | Image No. |
|--------------------------|-----------------|--------------------|--------------------|---------------|---------|-----------|
| Red-backed Shrike         | Lanius collurion (Linnaeus, 1758) | R | O | LC | - | V | V | V | V | V | V |
| Brown Shrike              | Lanius cristatus (Linnaeus, 1758) | R | O | LC | - | V | V | V | V | V | V |
| Long-tailed Shrike        | Lanius schach (Linnaeus, 1758) | R | O | LC | - | V | V | V | V | V | V |
| Wire-tailed Shrike        | Lanius swinhoei (Swinhoe, 1863) | R | O | LC | - | V | V | V | V | V | V |
| Indian Paradise-Flycatcher| Terpsiphone paradisi (Linnaeus, 1758) | R | O | LC | - | V | V | V | V | V | V |

**Scientific name**
- Dicaeum agile (Tickell, 1833)
- Dicrurus macrocercus (Vieillot, 1817)
- Euodice malabarica (Linnaeus, 1758)
- Amandava amandava (Linnaeus, 1758)
- Lonchura punctulata (Linnaeus, 1758)
- Hirundo rustica (Linnaeus, 1758)
- Hirundo paludicola (Vieillot, 1817)
- Hirundo daurica (Laxmann, 1769)
- Cecropis daurica (Laxmann, 1769)
- Petrochelidon fluvicola (Blyth, 1855)
- Hirundo smithii (Leach, 1818)
- Lanius vittatus (Valenciennes, 1826)
- Lanius cristatus (Linnaeus, 1758)
- Lanius schach (Linnaeus, 1758)
- Argya caudata (Dumont, 1823)
- Argya striata (Dumont, 1823)
- Argya earlei (Blyth, 1844)
- Terpsiphone paradisi (Linnaeus, 1758)
- Motacilla citreola (Pallas, 1776)
- Motacilla cinerea (Tunstall, 1771)
- Anthus rufulus (Vieillot, 1818)
- Motacilla flava (Linnaeus, 1758)
- Motacilla alba (Linnaeus, 1758)

**Conservation status**
- IUCN (2021)
- CITES (2012)
- IWPA (1972)
- SHW
- RDL
- MKP
- BKP
- SDR
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### Table of bird species

| Order/Family/Genus | Scientific name | Residential status | Global status | Feeding status | Conservation status IUCN (2021) | Conservation status CITES (2012) | Conservation status IWPA (1972) | Status | Location |
|--------------------|-----------------|-------------------|---------------|---------------|-------------------|-------------------------------|-------------------------------|-------|----------|
| Muscicapidae (11)  | White-browed Wagtail | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Black Redstart   | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Yellow-throated Longclaw | R | LC            | -             | IV                 |                               |                               |       |          |
|                    | Red-billed Starling | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Indian Robin     | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Oriental Magpie Robin | C            | LC            | -             | IV                 |                               |                               |       |          |
|                    | Tickell's Babbler | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Indian Robin     | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Siberian Rubythroat | R            | LC            | -             | IV                 |                               |                               |       |          |
|                    | Siberian Stonechat | R            | LC            | -             | IV                 |                               |                               |       |          |
|                    | Taiga Flycatcher | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Purple Sunbird   | N                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Black-hooded Oriole | O            | LC            | -             | IV                 |                               |                               |       |          |
|                    | Indian Golden Oriole | R           | LC            | -             | IV                 |                               |                               |       |          |
|                    | Common Jay       | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Greenish Woodpecker | R            | LC            | -             | IV                 |                               |                               |       |          |
|                    | House Sparrow    | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Indian Cuckoo    | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Yellow-throated Sparrow | R | LC            | -             | IV                 |                               |                               |       |          |
|                    | Common Waxwing   | W                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Scarlet-minivet  | R                | LC            | -             | IV                 |                               |                               |       |          |
|                    | Yellow Eagle     | R                | LC            | -             | IV                 |                               |                               |       |          |

Note: The table includes various bird species with their scientific names, residential status, global status, and conservation status. The table also indicates the status of each species across different conservation organizations and their locations.
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| Order/Family/Common name | Scientific name | Residential status | Feeding status | Conservation status | Sites |
|--------------------------|-----------------|--------------------|---------------|---------------------|-------|
| Order Pycnonotidae (2)   |                |                    |               |                     |       |
| 106 Red-whiskered Bulbul  | Pycnonotus jocosus (Linnaeus, 1758) | R O LC | - | LC | - | V V V V V |       |
| 107 Grey-faced Cuckoo-Thrush | Cuculus poliocephalus (Swainson, 1820) | R O LC | - | LC | - | V V V V V |       |
| Order Zosteropidae (1)   |                |                    |               |                     |       |
| 108 Indian White-eye     | Zosterops palpebrosus (Temminck, 1824) | R I LC | - | LC | - | V V V V V |       |
| Order Pelecaniformes Ardeidae (7) |   |                    |               |                     |       |
| 111 Cattle Egret         | Bubulcus ibis (Linnaeus, 1758) | R O LC | - | LC | - | V V V V V |       |

*Note: The table includes scientific names, residential status, feeding status, and conservation status for various bird species in agricultural landscapes. The table also indicates the number of sites where each species was observed (Sites No.).*
| Order/Family/Common name | Scientific name | Residential status | Feeding status | Conservation status | Global status | Sites | Image No. |
|--------------------------|----------------|-------------------|----------------|--------------------|---------------|-------|-----------|
|                         |                |                   |                |                    | LUCN (2021) | CITES (2012) | IWPA (1972) | SHW | RDL | MKP | BKP | SDR |
| Little Egret             | Egretta garzetta (Linnaeus, 1766) | R | C | LC | - | IV | ↑ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Purple Heron             | Ardea purpurea (Linnaeus, 1766) | R | C | LC | - | IV | ↓ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Ciconiidae (3)          |                |                   |                |                    |              |               |            |     |     |     |     |     |
| Asian Openbill           | Anastomus oscitans (Boddaert, 1783) | R | C | LC | - | IV | ? | ✓ | ✓ | ✓ | ✓ | ✓ | 2f |
| Painted Stork            | Mycteria leucocephala (Permar, 1769) | WV | C | NT | - | IV | ↓ | x | ✓ | x | x | x | 2d |
| Woolly-neck Stork        | Ciconia episcopus (Boddaert, 1783) | R | C | NT | - | IV | ↓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1h |
| Piciformes Picidae (3)   |                |                   |                |                    |              |               |            |     |     |     |     |     |
| Black-rumped Flueback    | Dinoxia benghalensis (Linnaeus, 1758) | R | O | LC | - | IV | → | ✓ | x | x | x | x |  
| Brown-capped Pygmy Woodpecker | Hancornia nanus (Vigors, 1832) | R | I | LC | - | IV | ↑ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Yellow-fronted Woodpecker | Leucopias mahattens (Latham, 1801) | R | O | LC | - | IV | → | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Ramphastidae (2)         |                |                   |                |                    |              |               |            |     |     |     |     |     |
| Brown-headed Barbet      | Palopago zeylanicus (Gmelin, 1788) | R | F | LC | - | IV | → | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Coppersmith Barbet       | Palopago haemacephalus (Huller, 1776) | R | F | LC | - | IV | ↑ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Pittaiformes Pittauilidae (3) |                |                   |                |                    |              |               |            |     |     |     |     |     |
| Alexandrine Parakeet     | Pittaualge eupatria (Linnaeus, 1766) | R | F | NT | II | IV | ↓ | ✓ | ✓ | ✓ | x | x | 2a |
| Plum-headed Parakeet     | Pittaualge cyanoccephala (Linnaeus, 1766) | R | F | LC | II | IV | ↓ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Rose-ringed Parakeet     | Pittaualge kramer (Scopoli, 1769) | R | F | LC | - | IV | ↑ | ✓ | ✓ | ✓ | ✓ | ✓ |  
| Strigiformes Strigidae (3) |                |                   |                |                    |              |               |            |     |     |     |     |     |
| Brown Fish Owl           | Ketupa zeylanica (Gmelin, 1788) | R | C | LC | II | IV | ↓ | ✓ | x | ✓ | ✓ | ✓ |  
| Mottled Wood Owl         | Arx aestival (Lesson, 1839) | R | C | LC | II | IV | → | ✓ | x | x | ✓ | ✓ |  
| Spotted Owlet            | Athene brama (Temminck, 1821) | R | C | LC | II | IV | → | ✓ | ✓ | ✓ | ✓ | ✓ |  

IUCN: International Union for Conservation of Nature and Natural Resources; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora; IWPA: Indian Wildlife Protection Act; R: Resident; WV: Winter Visitor; SV: Summer Visitor; C: Carnivorous; O: Omnivorous; I: Insectivorous; F: Frugivorous; G: Granivorous; N: Nectarivore; LC: Least Concern; EN: Endangered; VU: Vulnerable; NT: Near Threatened; CITES II: Appendix II species of CITES are the ones that are not necessarily threatened now with extinction but may become so unless trade is closely controlled; III: Appendix III species of CITES are those species which are already regulated for trade by the country and that needs the cooperation of other countries to prevent unsustainable and illegal exploitation; IWPA I: Schedule - I species of IWPA (high priority species); IV: Schedule - IV species of IWPA (relatively low priority species); V: Schedule - V species of IWPA (vermin - species which are harmful to crops, livestock and perceived as causing problems for the society); ?: Unknown; →: Stable; ↑: Increasing; ↓: Decreasing; SHW: Shihawa; RDL: Rudauli; MKP: Milkipur; BKP: Bikapur; SDR: Sadar; ✓: Species recorded in the site; ×: Species not recorded in the site.
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District, eastern Uttar Pradesh, India (Table 2). Similar studies in agricultural landscapes have reported 144 species in Burdwan, West Bengal (Hossain & Aditya 2016), 128 species in Nalgonda District, Telangana (Narayana et al. 2019) and 107 species in Assam (Yashmita-Ulman et al. 2021a). In India, Passeriformes is the most dominant order (Praveen et al. 2016) and was found to be the most dominant order with 28 families and 76 species (Figure 2) in this study also. This finding is also consistent with the study of Kumar & Sahu (2020). Most species that have been recorded during our study are residents followed by winter and summer visitors (Figure 3). Hossain & Aditya (2016) in West Bengal, Narayana et al. (2019) in Tamil Nadu and Kumar & Sahu (2020) in Haryana have also found that the majority of the birds recorded from agricultural landscapes were resident in nature, followed by winter visitors and summer visitors. Uttar Pradesh being a part of the Central Asian Flyway serves as a wintering site for the migratory birds travelling from northern part of Asia and parts of Europe. The migratory birds usually prefer areas having congenial environment, enormous food availability and safe and secure sites as wintering grounds (Mukhopadhyay & Mazumdar 2017). Most of the tehsils in Ayodhya district are blessed with seasonal and perennial wetlands that attract a large population of migratory birds (pers. obs.). This is one of the reasons for encountering such high numbers of migrants in the study area.

Six foraging guilds are found in the study area, omnivores being the most dominant (Figure 4). This result contradicts those of other studies (e.g., Narayana et al. 2019; Kumar & Sahu 2020) who have reported insectivores to be the most dominant feeding guild in agricultural landscapes. Out of all the avifauna recorded, 87 bird species (63%) were found in all the study sites, whereas 52 bird species (37%) are recorded only in some study sites (Table 2). The fact that the bird species observed in the study area were mainly omnivores and a majority of them were found in all the study sites, indicates that the bird species occurring in agricultural fields are generalists in nature. They might have adopted themselves to the instability of food (fields are cultivated only for some parts of the year) and therefore feed on both plant and animal matter. Family Muscicapidae is known to be the most diverse family in India (Manakadan & Pittie 2001) and our results also indicate that Muscicapidae along with Accipitridae are the most diverse families (11 species each, RDi= 7.91) (Table 3), conforming to this statement.

In the present study, Sohawal tehsil recorded the

| Avian family | Number of species recorded | Rdi value |
|--------------|-----------------------------|-----------|
| Accipitridae | 11                          | 7.91      |
| Muscicapidae | 11                          | 7.91      |
| Ardeidae     | 7                           | 5.04      |
| Columbidae   | 7                           | 5.04      |
| Cuculidae    | 7                           | 5.04      |
| Motacillidae | 6                           | 4.32      |
| Sturnidae    | 6                           | 4.32      |
| Hirundinidae | 5                           | 3.60      |
| Alaudidae    | 4                           | 2.88      |
| Cisticolidae | 4                           | 2.88      |
| Phylloscopidae| 4                          | 2.88      |
| Campephagidae| 3                           | 2.16      |
| Ciconiidae   | 3                           | 2.16      |
| Corvidae     | 3                           | 2.16      |
| Estrildidae  | 3                           | 2.16      |
| Laniidae     | 3                           | 2.16      |
| Leiothrichidae| 3                          | 2.16      |
| Picidae      | 3                           | 2.16      |
| Puffulidae   | 3                           | 2.16      |
| Strigidae    | 3                           | 2.16      |
| Acrocephalidae| 2                         | 1.44      |
| Alcedinidae  | 2                           | 1.44      |
| Apodidae     | 2                           | 1.44      |
| Charadridae  | 2                           | 1.44      |
| Meropidae    | 2                           | 1.44      |
| Oriolidae    | 2                           | 1.44      |
| Passeridae   | 2                           | 1.44      |
| Phasianidae  | 2                           | 1.44      |
| Placedidæ    | 2                           | 1.44      |
| Pycomotidae  | 2                           | 1.44      |
| Ramphastidae | 2                           | 1.44      |
| Aegithinidae | 1                           | 0.72      |
| Bucerotidae  | 1                           | 0.72      |
| Coraciidae   | 1                           | 0.72      |
| Dicerae      | 1                           | 0.72      |
| Dicruridae   | 1                           | 0.72      |
| Falconidae   | 1                           | 0.72      |
| Glareolidae  | 1                           | 0.72      |
| Gruidae      | 1                           | 0.72      |
| Monarchidæ   | 1                           | 0.72      |
| Nectarinidae | 1                           | 0.72      |
| Pandæ        | 1                           | 0.72      |
| Rallide      | 1                           | 0.72      |
| Sittidae     | 1                           | 0.72      |
| Stenostiride | 1                           | 0.72      |
| Turdide      | 1                           | 0.72      |
| Upupide      | 1                           | 0.72      |
| Vangide      | 1                           | 0.72      |
| Zosteropide  | 1                           | 0.72      |

Table 3. Relative diversity (Rdi) of various avian families in agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.
Table 4. Measurements of avian diversity and richness at agricultural landscapes of Ayodhya District, eastern Uttar Pradesh, India.

| Tehsil (Study sites) | Species richness | SWI | SDI | PEI |
|----------------------|------------------|-----|-----|-----|
| Sohawal              | 133              | 4.3 | 0.01| 0.87|
| Rudauli              | 126              | 4.28| 0.01| 0.88|
| Milkipur             | 119              | 4.25| 0.01| 0.88|
| Bikapur              | 114              | 4.23| 0.01| 0.89|
| Sadar                | 98               | 3.86| 0.03| 0.84|

Table 5. Sorensen’s Similarity Index of avian species between selected agricultural landscapes of Ayodhya district, eastern Uttar Pradesh, India.

| Tehsil (Study sites) | Sohawal | Rudauli | Milkipur | Bikapur | Sadar |
|----------------------|---------|---------|----------|---------|-------|
| Sohawal              | 0.00    |         |          |         |       |
| Rudauli              | 0.93    | 0.00    |          |         |       |
| Milkipur             | 0.92    | 0.94    | 0.00     |         |       |
| Bikapur              | 0.91    | 0.92    | 0.92     | 0.00    |       |
| Sadar                | 0.82    | 0.86    | 0.84     | 0.84    | 0.00  |

PEI—Pielou’s Evenness Index | SDI—Simpson’s Dominance Index | SWI—Shannon-Weiner Diversity Index.

highest species richness and Shannon-Weiner diversity index (133, 4.30) (Table 4). The bird species richness and community structure depends upon the availability of food, roosting and nesting sites (Narayana et al. 2019), anthropogenic pressure (Yashmita-Ulman et al. 2020), geographical area & size, topographical features & climatic conditions of the area. The agricultural fields in Sohawal offer food in the form of rice & wheat grains & mustard seeds from time to time. This tehsil also has a presence of very diverse habitats. It is interspersed by small to large water bodies, agroforestry systems (trees like Eucalyptus sp. or Tectona grandis) planted on farm bunds), plantations of Eucalyptus sp. or Tectona grandis and orchards of Mangifera indica or Psidium guajava making the landscape heterogeneous in nature. Due to this, the area offers very diverse food supply catering to the needs of birds belonging to different foraging guilds. Sundar and Kittur (2013) have reported that agricultural fields having wetlands in vicinity support diverse bird species. Yashmita-Ulman et al. (2018) have suggested that the presence of trees on bunds or blocks increases the bird diversity in agricultural fields. All these factors might have contributed to the bird diversity positively for this site to have a high bird diversity.

In the current study, the second highest species richness (126) is reported from Rudauli tehsil. The sites selected in Rudauli have Rudauli Reserve Forest in the vicinity and the agricultural fields have patches of trees either planted on bunds or in the form of orchards and plantations which might have influenced the bird diversity positively. Yashmita-Ulman et al. (2021b) in their study have concluded that agro-ecosystems in the vicinity of forests have higher diversity. But at the same time, these selected sites have very few water bodies which might have had a negative impact on the bird diversity. Bird species richness and diversity increase in accordance to presence of vegetation and water bodies (Shih 2018). All these might be the reasons of having a good bird diversity but not at par with Sohawal tehsil. On the other hand, Sadar tehsil mostly forms the heart of the Ayodhya city, having large areas occupied by buildings, settlements and industries. The study sites in this tehsil are, therefore, adversely affected by urbanization and higher anthropogenic disturbances. The urban development leads to habitat alteration thus reducing the availability of suitable habitats for birds (Mukhopadhyay & Mazumdar 2017). This might be the reason for finding the lowest bird diversity in Sadar (Species richness= 98, Shannon Weiner diversity index= 3.86) as compared to that of other selected sites.

Overall eight species of global conservation importance namely, Aquila nipalensis, Neophron percnopterus (Endangered), Antigone antigone, Clanga hastata (Vulnerable), Ciconia episcopus, Gyps himalayensis, Mycteria leucocephala, Psittacula eupatria (Near Threatened) have been reported in the study area (Table 2). This region also supported, 31 species (22%) whose global population trend is decreasing (Figure 5) and 16 species which came under Appendix II and Appendix III of CITES (Table 2). These findings are consistent with the study of Kumar & Sahu (2020). The agricultural lands with diverse species composition (Yashmita-Ulman 2021c), fruiting and flowering pattern (Yashmita-Ulman 2021a), structural diversity and management activities (Peterjohn 2003) prove as suitable breeding and foraging grounds for bird species. Many bird species such as Ploceus philippinus (Yashmita-Ulman et al. 2017) and Antigone antigone (Sundar 2009) are conserved in human-dominated landscapes due to the religious and traditional beliefs of the local communities. These beliefs immensely contribute in supporting species of conservation concern and species whose global population trend is decreasing in these agricultural landscapes.
CONCLUSION

The present study is the first documentation of the bird diversity found in agricultural landscapes of Ayodhya district, Uttar Pradesh. It is evident from this study that the agricultural landscapes are a potential habitat for the rare, globally threatened and near-threatened birds as well as various other migratory and resident birds. Thus, this paper lends an insight that agricultural landscapes can be harnessed for their conservation values. But such habitats are under constant threats due to anthropogenic activities. Therefore, such landscapes must be regularly assessed for their bird diversity and populations. Further detailed studies should be conducted to understand the factors influencing the diversity of birds in agricultural landscapes and the role these landscapes play in providing feeding, nesting, roosting and breeding sites for birds.

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Image 1a–h. a—Halcyon smyrnensis | b—Prinia inornata | c—Upupa epops | d—Dicrurus macrocerus | e—Saxicola maurus | f—Sitta castanea | g—Sturnus vulgaris | h—Antigone antigone & Ciconia episcopus. © Authors.
Image 2a–h. a—Psittacula eupatria | b—Alcedo atthis | c—Neophron percnopterus | d—Mycteria leucocephala | e—Treron phoenicopterus | f—Anastomus oscitans | g—Spilornis cheela | h—Accipiter badius. © Authors.
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