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RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Avian Diversity in Agricultural Mosaics in District Ludhiana, Punjab, India

Sandeep Kaur Thind, Charn Kumar, Amritpal Singh Kaleka 10.18805/ag.D-5611

ABSTRACT

Background: The birds constitute one of the most popular and easily recognizable groups of animals. They constitute the largest class of terrestrial chordates. The present paper deals with the documentation of number of avian species from agricultural mosaics in Ludhiana district of Punjab along with their residential and IUCN status 2020.

Methods: During the present study, periodic monthly as well as random surveys were conducted to document various bird species occurring in the study area from May 2016 to April 2019. The study area was categorized into agricultural, aquatic and forest habitats.

Result: A total of 173 species of birds referable to 17 orders and 56 families have been documented from the study area and identified on the basis of various morphological features and calls. During this study, maximum number of species have been recorded from agricultural habitat (118 species), followed by aquatic habitat (114 species) and the area covering the forest habitat and roadside plantations (71 species). However, some species have been found as common in these habitats.

Key word: Agricultural habitats, Aquatic habitats, Avian species, Forest habitats, Ponds.

INTRODUCTION

Being an agrarian state of India, Punjab has an area of 50,362 sq. kms and composed of 23 districts. After thorough scrutiny of literature, it has been observed that most of the works on avian documentation are from various wetlands especially the Ramsar sites and Shivalik foothills in the state. However, not much work has been done on avian diversity of agricultural mosaics including agricultural/rural/urban zone and village ponds and forest habitats of an area as such. Birds play a crucial role in many food webs of aquatic ecosystem and the birds are known as good 'bio-indicators' as they are very sensitive to minor environmental changes (Debnath *et al*. 2018). It needs to be mention here that the bird species dwelling in the state are mainly dependent on the agricultural profile of an area and have direct interaction with the agricultural crops and human habitations. Hence, an attempt has been made to explore the avian diversity of agricultural, aquatic and forest habitats of district Ludhiana. This district of Malwa region is centrally located district of Punjab and lies between latitude 30°55'N and longitude 75°54'E. It shares its boundaries with other districts including Jalandhar, SBS Nagar, Rupnagar, Moga, Ferozepur, Barnala, Sangrur and Fatehgarh Sahib. The cropping pattern, scattered patches of natural vegetation, water bodies and rural/urban areas presents a unique ecological system for exploring the associated avian diversity. The scattered works on the bird species of the study area are of Whistler (1919), Dhindsa *et al*. (1988), Kler (2006, 2009), Kler and Kumar (2015a, 2015b), Arora *et al*. (2016), Pannu and Kler (2018) and Sidhu *et al.* (2021).

MATERIALS AND METHODS

The monthly and opportunistic surveys were conducted in the study area from May 2016 to April 2019. For this purpose, the study area was categorized into three habitats namely agricultural habitat (Type 1), aquatic habitat (Type 2) and forest habitat and roadside vegetation (Type 3). All the birds seen, heard or in flight were recorded along with species name, number of individuals and habitat type. To avoid disturbance to the birds, Olympus 10X50 DPS binoculars were used to count the birds from some distance. A DSLR camera Canon 60d was used for the purpose of field photography. For documenting the bird species, Line transect method (Buckland *et al*., 2001) for agricultural and forest habitats and Point count method (Sutherland, 1996) for aquatic habitats was used. For identification of bird species, various field guides viz., Ali and Ripley (1987), Ali (2002), Grimmett and Inskipp (2010) and Grimmett *et al.* (2011) were used. Bird species were also assigned resident and migratory status as per Grimmett and Inskipp (2010) and IUCN Red list status 2020. The following parameters were also calculated:

(i) Relative diversity of bird families (RDi) (Torre-Cuadros *et al.,* 2007).

[1]Department of Zoology and Environmental Sciences, Punjabi University, Patiala-147 002, Punjab, India.
[2]Department of Biology, A.S. College, Khanna, Ludhiana-141 401, Punjab, India.

Corresponding Author: Amritpal Singh Kaleka, Department of Zoology and Environmental Sciences, Punjabi University, Patiala-147 002, Punjab, India. Email: apskaleka@gmail.com

How to cite this article: Thind, S.K., Kumar, C. and Kaleka, A.S. (2022). Avian Diversity in Agricultural Mosaics in District Ludhiana, Punjab, India. Agricultural Science Digest. DOI: 10.18805/ag.D-5611.

Submitted: 30-05-2022 **Accepted:** 21-09-2022 **Online:** 17-10-2022

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

(ii) Sorenson's similarity coefficient (Sorenson, 1948).

$$\text{Sorenson similarity coefficient} = \frac{2C}{A+B} \times 100$$

Where;
C= The number of species common at both sites.
A and B= The total number of species at site A and site B respectively.

RESULTS AND DISCUSSION

A total of 173 species of birds referable to 17 orders and 56 families have been recorded during the present study (Table 1). The order Passeriformes is found to be most dominant order (42.8% species) followed by Charadriiformes (10.4% species), Anseriformes (9.83% species), Pelecaniformes (5.78% species), Accipitriformes (4.6% species), Columbiformes and Coraciformes (4.05% species each), Gruiformes and Piciformes (2.89% species each), Sulliformes and Cuculiformes (2.31% species each), Galliformes, Psittaciformes and Strigiformes (1.73% species each), Ciconiformes and Bucerotiformes (1.16% species each) and Podicipediformes (0.58% species) (Fig 1). The family Anatidae has been observed as the most diverse family with 17 species (RDi=9.83) followed by families Muscicapidae and Scolopacidae with 10 species (RDi=5.78) and 9 species (RDi=5.2) respectively Table 2. The common species found in the study region mainly belongs to families such as Ardeidae, Anatidae, Accipitridae, Phasianidae, Rallidae, Recurvirostridae, Charadriidae, Columbidae, Psittacidae, Pycnonotidae, Nectariniidae, Sturnidae, Dicruridae and Corvidae.

As per Grimmett and Inskipp (2010), out of total 173 species, 103 species (59.5%) have been recorded as resident species, 57 species (32.9%) as winter migrants (WM), 7 species (4.05%) as summer migrants (SM) and 6 species (3.47%) as passage migrants (PM) (Fig 2). A considerable number of winter migrants (n=57) recorded from the study area may be attributed to geographic position of Punjab which occupies a strategic position in the migratory flyway of the birds (Toor *et al*., 1982). As per IUCN Red list 2020, the recorded species have also been categorized *i.e*., 1 species as "Vulnerable (VU)", 1 species as "Endangered (EN)" and 5 species as "Near Threatened (NT)". The remaining 166 species have been identified as "Least Concern (LC)".

The number of avian species recorded during the present study is more than the records in earlier reports. Whistler (1919) recorded 169 species of birds from Ludhiana

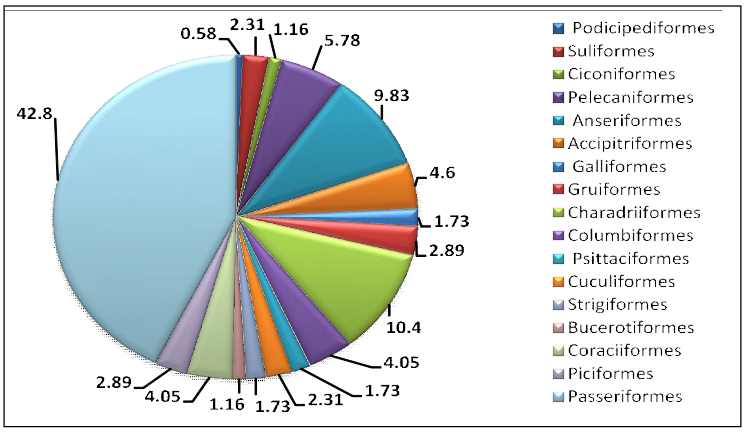

Fig 1: Percentage of order-wise representation of species recorded from the study area.

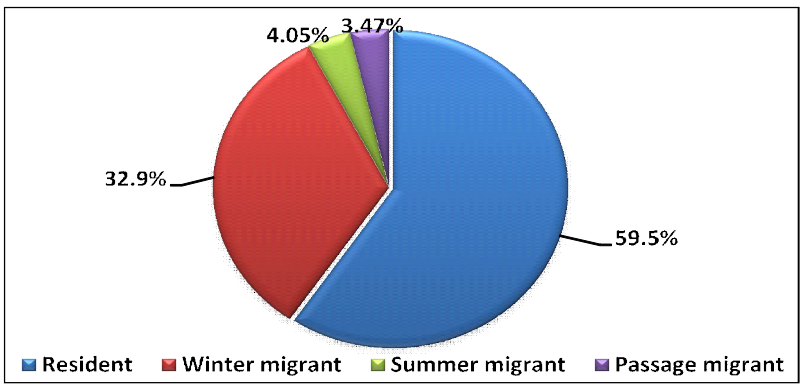

Fig 2: Percentage proportion of species with their resident or migrant status in the study area.

Table 1: List of avian species recorded from different habitats of the study area.

Common name	Scientific name	Agricultural habitat (Type 1)	Aquatic habitat *i.e.*, ponds, canals, Sutlej river (Type 2)	Forest habitat/ road side vegetation (Type 3)	Distribution and status in Punjab (Grimmett and Inskipp, 2010)	IUCN Red list status 2020
Little grebe	*Tachybaptus ruficollis* (Pallas, 1764)	A	P	A	CR	LC
Little cormorant	*Microcarbo niger* (Vieillot, 1817)	A	P	A	CR	LC
Indian cormorant	*Phalacrocorax fuscicollis* Stephens, 1826	A	P	A	NR	LC
Great cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	A	P	A	CR	LC
Darter	*Anhinga melanogaster* Pennant, 1769	A	P	A	LCR	NT
Asian woollyneck/ Woolly-necked stork	*Ciconia episcopus* (Boddaert, 1783)	A	P	A	NW	NT
Painted stork	*Mycteria leucocephala* (Pennant, 1769)	A	P	A	NR	NT
Great egret	*Ardea alba* Linnaeus, 1758	A	P	A	CR	LC
Grey heron	*Ardea cinerea* Linnaeus, 1758	A	P	A	CR	LC
Intermediate egret	*Ardea intermedia* Wagler, 1829	P	P	A	CR	LC
Purple heron	*Ardea purpurea* Linnaeus, 1766	P	P	A	NR	LC
Indian pond heron	*Ardeola grayii* (Sykes, 1832)	P	P	P	CR	LC
Cattle egret	*Bubulcus ibis* (Linnaeus,1758)	P	P	P	CR	LC
Little egret	*Egretta garzetta* (Linnaeus, 1766)	P	P	A	CR	LC
Black-crowned night heron	*Nycticorax nycticorax* (Linnaeus,1758)	P	P	A	CR	LC
Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)	P	P	A	NR	LC
Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)	P	P	A	NR	NT
Northern pintail	*Anas acuta* Linnaeus, 1758	A	P	A	NW	LC
Common teal	*Anas crecca* Linnaeus, 1758	A	P	A	CW	LC
Mallard	*Anas platyrhynchos* Linnaeus, 1758	A	P	A	NW	LC
Spot-billed duck	*Anas poecilorhyncha* Forster, 1781	P	P	A	CR	LC
Greylag goose	*Anser anser* (Linnaeus, 1758)	P	P	A	CW	LC
Bar-headed goose	*Anser indicus* (Latham, 1790)	P	P	A	LCW	LC
Common pochard	*Aythya ferina* (Linnaeus, 1758)	A	P	A	CW	VU
Tufted duck	*Aythya fuligula* (Linnaeus, 1758)	A	P	A	CW	LC
Lesser whistling duck	*Dendrocygna javanica* (Horsfield, 1821)	P	P	A	NW	LC
Eurasian wigeon	*Mareca penelope* (Linnaeus, 1758)	A	P	A	NW	LC
Gadwall	*Mareca strepera* (Linnaeus, 1758)	A	P	A	CW	LC
Red-crested pochard	*Netta rufina* (Pallas, 1773)	A	P	A	LCW	LC
Northern shoveler	*Spatula clypeata* (Linnaeus, 1758)	A	P	A	CW	LC
Garganey	*Spatula querquedula* (Linnaeus, 1758)	A	P	A	CP	LC
African comb duck	*Sarkidiornis melanotos* (Pennant, 1769)	A	P	A	NS	LC
Ruddy shelduck	*Tadorna ferruginea* (Pallas, 1764)	A	P	A	LCW	LC

Table 1: Continue....

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Common shelduck	*Tadorna tadorna* (Linnaeus, 1758)	A	P	A	NW	LC
Shikra	*Accipiter badius* (Gmelin, 1788)	P	P	P	CR	LC
Eurasian sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)	P	A	A	NW	LC
White-eyed buzzard	*Butastur teesa* (Franklin, 1831)	A	A	P	CR	LC
Black-winged kite	*Elanus caeruleus* (Desfontaines, 1789)	P	A	A	NR	LC
Black kite	*Milvus migrans* (Boddaert, 1783)	P	P	P	CR	LC
Egyptian vulture	*Neophron percnopterus* (Linnaeus, 1758)	P	P	A	NR	EN
Oriental honey buzzard	*Pernis ptilorhynchus* (Temminck, 1821)	P	A	P	LCR	LC
Crested serpent eagle	*Spilornis cheela* (Latham, 1790)	A	A	P	NR	LC
Common quail	*Coturnix coturnix* (Linnaeus, 1758)	P	A	A	CR	LC
Grey francolin	*Francolinus pondicerianus* (Gmelin, 1789)	P	A	P	CR	LC
Indian peafowl	*Pavo cristatus* Linnaeus, 1758	P	P	P	CR	LC
White-breasted waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	P	P	A	CR	LC
Common coot	*Fulica atra* Linnaeus, 1758	A	P	A	CR	LC
Common moorhen	*Gallinula chloropus* (Linnaeus, 1758)	A	P	A	CR	LC
Purple swamphen	*Porphyrio porphyrio* (Linnaeus, 1758)	A	P	A	CR	LC
Baillon's crake	*Zapornia pusilla* (Pallas, 1776)	A	P	A	NW	LC
Black-winged stilt	*Himantopus himantopus* (Linnaeus, 1758)	P	P	P	NW	LC
Pied avocet	*Recurvirostra avosetta* Linnaeus, 1758	A	P	A	NWP	LC
Little ringed plover	*Charadrius dubius* Scopoli, 1786	P	P	A	NW	LC
Yellow-wattled lapwing	*Vanellus malabaricus* (Boddaert, 1783)	P	P	A	NR	LC
Red-wattled lapwing	*Vanellus indicus* (Boddaert, 1783)	P	P	P	CR	LC
White-tailed lapwing	*Vanellus leucurus* (Lichtenstein, 1823)	A	P	A	NW	LC
Eurasian thick-knee	*Burhinus oedicnemus* (Linnaeus, 1758)	P	A	A	CR	LC
Pheasant-tailed jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	A	P	A	NR	LC
Common sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	A	P	A	NW	LC
Little stint	*Calidris minuta* (Leisler, 1812)	A	P	A	NW	LC
Ruff	*Calidris pugnax* (Linnaeus, 1758)	P	P	A	NP	LC
Temminck's stint	*Calidristemminckii* (Leisler, 1812)	A	P	A	NW	LC
Common snipe	*Gallinago gallinago* (Linnaeus, 1758)	P	P	A	NW	LC
Jack snipe	*Lymnocryptes minimus* (Brünnich, 1764)	A	P	A	NW	LC
Green sandpiper	*Tringa ochropus* Linnaeus, 1758	P	P	P	NW	LC
Wood sandpiper	*Tringa glareola* Linnaeus, 1758	P	P	A	NW	LC
Common redshank	*Tringa totanus* (Linnaeus, 1758)	A	P	A	NW	LC
Greater painted Snipe	*Rostratula benghalensis* (Linnaeus, 1758)	A	P	A	NW	LC
Rock pigeon/common pigeon	*Columba livia* Gmelin, 1789	P	P	P	CR	LC
Eurasian collared dove	*Streptopelia decaocto* (Frivaldszky, 1838)	P	P	P	CR	LC
Oriental turtle dove	*Streptopelia orientalis* (Latham, 1790)	P	P	A	NR	LC

Table 1: Continue....

Red turtle dove/red Collared dove	*Streptopelia tranquebarica* (Hermann, 1804)	P	A	A	CR	LC
Spotted dove	*Spilopelia chinensis* (Scopoli, 1786)	A	P	P	CR	LC
Laughing dove	*Spilopelia senegalensis* (Linnaeus, 1766)	P	P	A	CR	LC
Yellow-footed green pigeon	*Treron phoenicopterus* (Latham, 1790)	P	A	P	CR	LC
Rose-ringed parakeet	*Alexandrinus krameri* (Scopoli, 1769)	P	P	P	CR	LC
Plum-headed parakeet	*Himalayapsitta cyanocephala* (Linnaeus, 1766)	P	A	P	CR	LC
Alexandrine parakeet	*Palaeornis eupatria* (Linnaeus, 1766)	P	A	P	CR	NT
Greater coucal	*Centropus sinensis* (Stephens, 1815)	P	P	P	CR	LC
Jacobin cuckoo	*Clamator jacobinus* (Boddaert, 1783)	P	A	A	CS	LC
Asian koel	*Eudynamysscolopaceus* (Linnaeus, 1758)	P	P	P	NS	LC
Common hawk-cuckoo	*Hierococcyx varius* (Vahl, 1797)	P	A	A	NR	LC
Common barn owl	*Tyto alba* (Scopoli, 1769)	P	A	P	CR	LC
Spotted owlet	*Athene brama* (Temminck, 1821)	P	A	P	CR	LC
Eurasian eagle owl	*Bubo bubo* (Linnaeus, 1758)	P	P	A	NR	LC
Indian grey hornbill	*Ocyceros birostris* (Scopoli, 1786)	P	P	P	CR	LC
Common hoopoe	*Upupa epops* Linnaeus, 1758	P	P	A	CR	LC
Common kingfisher	*Alcedo atthis* (Linnaeus, 1758)	A	P	A	CR	LC
Pied kingfisher	*Ceryle rudis* (Linnaeus, 1758)	P	P	A	CR	LC
White-breasted kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	P	P	A	CR	LC
Green bee-eater	*Merops orientalis* Latham, 1802	P	P	P	CR	LC
Blue-tailed bee-eater	*Merops philippinus* Linnaeus, 1766	P	P	P	NS	LC
Indian roller	*Coracias benghalensis* (Linnaeus, 1758)	P	A	P	CR	LC
European roller/ eurasian roller	*Coracias garrulus* Linnaeus, 1758	P	A	A	NP	LC
Coppersmith barbet	*Psilopogon haemacephalus* (Müller, 1776)	P	A	P	CR	LC
Brown-headed barbet	*Psilopogon zeylanicus* (Gmelin, 1788)	P	A	P	CR	LC
Black-rumped flameback	*Dinopium benghalense* (Linnaeus, 1758)	P	A	P	CR	LC
Eurasian wryneck	*Jynx torquilla* Linnaeus, 1758	P	A	P	NW	LC
Indian pygmy woodpecker/ Brown-capped pygmy woodpecker	*Picoides nanus* (Vigors, 1832)	A	A	P	CR	LC
Wire-tailed swallow	*Hirundo smithii* Leach, 1818	P	P	A	CS	LC
Barn swallow	*Hirundo rustica* Linnaeus, 1758	P	P	A	CW	LC
Streak-throated swallow	*Petrochelidon fluvicola* (Blyth, 1855)	P	P	A	NR	LC
Paddyfield pipit	*Anthus rufulus* Vieillot, 1818	P	A	A	CR	LC
Long-billed pipit	*Anthus similis* Jerdon, 1840	P	P	A	NW	LC
Tree pipit	*Anthus trivialis* (Linnaeus, 1758)	P	A	A	NW	LC
Yellow wagtail	*Motacilla flava* Linnaeus, 1758	P	P	A	CW	LC
White wagtail	*Motacilla alba* Linnaeus, 1758	P	P	A	CW	LC

Table 1: Continue....

Grey wagtail	*Motacilla cinerea* Tunstall, 1771	P	A	A	NW	LC
Citrine wagtail	*Motacilla citreola* Pallas, 1776	P	P	A	CW	LC
White-browed wagtail	*Motacilla maderaspatensis* Gmelin, 1789	P	P	A	CW	LC
Red-vented bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	P	P	P	CR	LC
Common chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)	P	A	P	CW	LC
Sulphur-bellied warbler	*Phylloscopus griseolus* Blyth, 1847	P	A	P	NP	LC
Hume's leaf warbler	*Phylloscopus humei* (Brooks, 1878)	A	A	P	NW	LC
Grey-hooded warbler	*Phylloscopus xanthoschistos* (Gray, 1846)	P	A	P	NW	LC
Rufous-tailed shrike	*Lanius isabellinus* Ehrenberg, 1833	P	A	A	NW	LC
Long-tailed shrike	*Lanius schach* Linnaeus, 1758	P	A	P	CR	LC
Bay-backed shrike	*Lanius vittatus* Valenciennes, 1826	A	A	P	CR	LC
Blue whistling thrush	*Myophonus caeruleus* (Scopoli, 1786)	A	A	P	NW	LC
Black-throated thrush	*Turdus atrogularis* Jarocki, 1819	P	A	P	NW	LC
Asian paradise flycatcher	*Terpsiphone paradisi* (Linnaeus, 1758)	A	A	P	NS	LC
Oriental magpie robin	*Copsychus saularis* (Linnaeus, 1758)	P	P	P	CR	LC
Bluethroat	*Cyanecula svecica* (Linnaeus, 1758)	P	A	A	NW	LC
Verditer flycatcher	*Eumyias thalassinus* (Swainson, 1838)	A	A	P	NW	LC
Red-breasted flycatcher	*Ficedula parva* (Bechstein, 1792)	P	A	P	NW	LC
Brown rock chat	*Oenanthe fusca* (Blyth, 1851)	P	A	A	CW	LC
Black redstart	*Phoenicurus ochruros* (Gmelin, 1774)	P	P	P	CW	LC
Grey bushchat	*Saxicola ferreus* Gray, 1846	A	P	P	NW	LC
Pied bushchat	*Saxicola caprata* (Linnaeus, 1766)	P	P	P	CR	LC
Common stonechat	*Saxicola torquatus* (Linnaeus, 1766)	P	A	A	CW	LC
Indian robin	*Saxicoloides fulicatus* (Linnaeus, 1766)	P	P	P	CR	LC
Grey-headed canary flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)	A	A	P	NW	LC
Common babbler	*Argya caudata* (Dumont, 1823)	P	A	A	CR	LC
Striated babbler	*Argyaearlei* (Blyth, 1844)	A	P	P	NR	LC
Large grey babbler	*Argya malcolmi* (Sykes, 1832)	P	A	A	CR	LC
Jungle babbler	*Turdoides striata* (Dumont, 1823)	P	A	P	CR	LC
Yellow-eyed babbler	*Chrysomma sinense* (Gmelin, 1789)	P	P	A	CR	LC
Zitting cisticola	*Cisticola juncidis* (Rafinesque, 1810)	P	A	P	NR	LC
Common tailorbird	*Orthotomus sutorius* (Pennant, 1769)	P	P	P	CR	LC
Rufous-fronted prinia	*Prinia buchanani* Blyth, 1844	P	A	A	NR	LC
Yellow-bellied prinia	*Prinia flaviventris* (Delessert, 1840)	P	A	A	NR	LC
Plain prinia	*Prinia inornata* Sykes, 1832	P	P	P	NR	LC
Ashy prinia	*Prinia socialis* Sykes, 1832	P	P	A	CR	LC
Great tit	*Parus major* Linnaeus, 1758	A	P	A	CW	LC
Oriental white-eye	*Zosterops palpebrosus* (Temminck, 1824)	A	P	A	NR	LC

Table 1: Continue....

Purple sunbird	*Cinnyris asiaticus* (Latham, 1790)	P	P	P	CR	LC
Common rosefinch	*Carpodacus erythrinus* (Pallas, 1770)	P	A	P	NW	LC
Indian silverbill	*Euodice malabarica* (Linnaeus, 1758)	P	P	P	CR	LC
Scaly-breasted munia	*Lonchura punctulata* (Linnaeus, 1758)	P	P	A	CR	LC
Black-headed munia	*Lonchura Malacca* (Linnaeus, 1766)	P	A	A	NR	LC
Chestnut-shouldered petronia	*Gymnoris xanthocollis* (Burton, 1838)	A	A	P	CR	LC
House sparrow	*Passer domesticus* (Linnaeus, 1758)	P	P	P	CR	LC
Sind sparrow	*Passer pyrrhonotus* Blyth, 1844	P	A	A	LCR	LC
Black-breasted weaver	*Ploceus benghalensis* (Linnaeus, 1758)	P	A	A	CR	LC
Streaked weaver	*Ploceus manyar* (Horsfield, 1821)	P	P	A	CR	LC
Baya weaver	*Ploceus philippinus* (Linnaeus, 1766)	P	P	A	CR	LC
Bar-tailed treecreeper	*Certhia himalayana* Vigors, 1832	A	A	P	NW	LC
Common myna	*Acridotheres tristis* (Linnaeus, 1766)	P	P	P	CR	LC
Bank myna	*Acridotheres ginginianus* (Latham, 1790)	P	P	P	CR	LC
Asian pied starling	*Gracupica contra* (Linnaeus, 1758)	P	P	P	CR	LC
Brahminy starling	*Sturnia pagodarum* (Gmelin, 1789)	P	A	A	CR	LC
Common starling	*Sturnus vulgaris* Linnaeus, 1758	P	P	A	CW	LC
Eurasian golden oriole	*Oriolus oriolus* (Linnaeus, 1758)	P	P	A	CS	LC
Long-tailed minivet	*Pericrocotus ethologus* Bangs & Phillips, 1914	A	A	P	NW	LC
White-throated fantail	*Rhipidura albicollis* (Vieillot, 1818)	A	P	A	NR	LC
White-browed fantail	*Rhipidura aureola*Lesson, 1830	A	A	P	CR	LC
Black drongo	*Dicrurus macrocercus* Vieillot, 1817	P	P	P	CR	LC
Large-billed crow	*Corvus macrorhynchos* Wagler, 1827	P	A	P	CR	LC
House crow	*Corvus splendens* Vieillot, 1817	P	P	P	CR	LC
Rufous treepie	*Dendrocitta vagabunda* (Latham, 1790)	P	P	P	CR	LC
Red-headed bunting	*Emberiza bruniceps* Brandt, 1841	P	P	A	NP	LC
Ashy-crowned sparrow lark	*Eremopterix griseus* (Scopoli, 1786)	P	A	P	CR	LC
Crested lark	*Galerida cristata* (Linnaeus, 1758)	P	P	A	CR	LC

P- Recorded A; Not recorded.

Table 2: Relative diversity (RDi) of recorded avian families from the study area.

Name of order	Name of family	No. of species	RDi value
Podicipediformes	Podicipedidae	1	0.58
Suliformes	Phalacrocoracidae	3	1.73
	Anhingidae	1	0.58
Ciconiformes	Ciconidae	2	1.16
Pelecaniformes	Ardeidae	8	4.62
	Threskiornithidae	2	1.16
Anseriformes	Anatidae	17	9.83
Accipitriformes	Accipitridae	8	4.62
Galliformes	Phasianidae	3	1.73
Gruiformes	Rallidae	5	2.89
Charadriiformes	Recurvirostridae	2	1.16
	Charadriidae	4	2.31
	Burhinidae	1	0.58
	Jacanidae	1	0.58
	Scolopacidae	9	5.2
	Rostratulidae	1	0.58
Columbiformes	Columbidae	7	4.05
Psittaciformes	Psittacidae	3	1.73
Cuculiformes	Cuculidae	4	2.31
Strigiformes	Tytonidae	1	0.58
	Strigidae	2	1.16
Bucerotiformes	Bucerotidae	1	0.58
	Upupidae	1	0.58
Coraciiformes	Alcedinidae	3	1.73
	Meropidae	2	1.16
	Coraciidae	2	1.16
Piciformes	Megalaimidae	2	1.16
	Picidae	3	1.73
Passeriformes	Hirundinidae	3	1.73
	Motacillidae	8	4.62
	Pycnonotidae	1	0.58
	Phylloscopidae	4	2.31
	Laniidae	3	1.73
	Turdidae	2	1.16
	Monarchidae	1	0.58
	Muscicapidae	10	5.78
	Stenostiridae	1	0.58
	Leiotrichidae	4	2.31
	Sylviidae	1	0.58
	Cisticolidae	6	3.47
	Paridae	1	0.58
	Zosteropidae	1	0.58
	Nectariniidae	1	0.58
	Fringillidae	1	0.58
	Estrildidae	3	1.73
	Passeridae	3	1.73
	Ploceidae	3	1.73
	Certhiidae	1	0.58
	Sturnidae	5	2.89

Table 2: Continue....

Table 2: Continue....

	Oriolidae	1	0.58
	Campephagidae	1	0.58
	Rhipiduridae	2	1.16
	Dicruridae	1	0.58
	Corvidae	3	1.73
	Emberizidae	1	0.58
	Alaudidae	2	1.16

Table 3: Sorenson's similarity index (Q/S) to compare community structure of different habitats in the study area.

Compared habitats A vs B	Number of species			Sorenson's Quotient (%)
	A	B	Common (C)	
Type 1 vs Type 2	118	114	72	62.07
Type 1 vs Type 3	118	71	55	58.20
Type 2 vs Type 3	114	71	28	18.92

whereas Dhindsa *et al*. (1988) recorded 66 species from cultivated areas of the district. Kler along with her co-workers (2006-2015) compiled work on avian fauna of the district including 29 species (Kler, 2006), 97 species (Kler, 2009), 104 species (Kler and Kumar, 2015a) from different habitats of district Ludhiana. Kler and Kumar (2015b) recorded Tawny Eagle, Pallied Harrier, Paddyfield Warbler, Red-rumped Swallow and Rufous-bellied Babbler from Ludhiana which are not documented during present study. However, some other species such as Greylag Goose, Yellow-wattled Lapwing, White-tailed Lapwing, Jack Snipe, Yellow-eyed Babbler, Rufous-fronted Prinia, Yellow-bellied Prinia and Bar-tailed Treecreeper are the additional ones reported in the present study.

During present study, the maximum number of species is recorded from habitat Type 1 (n=118), followed by Type 2 (n=114) and Type 3 (n=71), however some species are found common in all the three habitats. Sorenson's similarity indicated that these habitats show some level of similarity in diversity (Table 3). The highest similarity has been found among agricultural and aquatic habitats (62.07%) followed by agricultural and forest habitats (58.20%) and lowest among aquatic and forest habitats (18.92%). It has been observed that the habitats with more similar structure and vegetation possess more common species *e.g*., in study area, the village ponds are mostly surrounded with agricultural fields and residential areas, hence, as many as 72 bird species are found common with agricultural habitats. Similarly, forest and aquatic habitats differs in structure and vegetation types, hence, only 28 common species are recorded among these habitats.

The conversion of forest lands or woody patches into agricultural areas is observed as one of the major consequences of green revolution which ultimately affected the avian species which prefer forest or undisturbed woody areas. This deforestation and conversion of forested lands is still under progress, due to which biodiversity of the state including avian diversity are under great impact. It has also been revealed during present study that the agricultural habitats exhibit more number of species than forest habitats in the study area. The study area also possesses more area under agriculture than forests as in other parts of the State which resulted in similar distribution pattern in the study area. While exploring the avian diversity, number of threats causing loss of various bird species in the study area has also been observed. These threats include mainly anthropogenic activities such as deforestation, extensive agriculture, excessive use of pesticides, urbanization *etc*. The anthropogenic activities at water bodies affect the distribution, foraging success, breeding success and ultimately the species richness. Beale and Monaghan (2004), Rees *et al*. (2005), Palacio-Nunez *et al*. (2007) and Thiollay (2007) also concluded similar results. In the study area, it has been observed that the water bodies such as village ponds and canals *etc*. are facing problems due to sewage disposal, garbage dumping and construction of cemented walls which ultimately cause disturbance to the birds inhabiting these water bodies. The encroachment of village ponds by some plant species such as Water Hyacinth *Eichhornia crassipes* also affects the presence of various bird species such as waders and herons etc. However, more individuals of Purple Moorhen and Black-winged Stilt are also recorded from such sites.

CONCLUSION

The avian documentation process not only includes the counting of number of individuals, but various environmental factors, anthropogenic activities and habitat characteristics of an area are also taken into account. The present study has been framed to document the avian diversity in different habitats of district Ludhiana to compile the detailed documentation in the study area. On the basis of present research findings, it has been observed the habitat destruction due to human activities is the main cause of biodiversity loss including avian species in the study area. Hence, assessing the relationship of a particular species with its habitat will help in planning conservation measures

and policies to protect natural habitats of wildlife and is necessary for its survival. While taking suitable steps for its protection, it is important to consider various threats to bird life in a study area. The present study forms the basis to recommend that the native plants must be grown as these plants help in maintaining the population of uncommon or rare bird species such as Common Barn Owl, Chestnut-shouldered Petronia, Golden Oriole and Alexandrine Parakeet. The dumping of garbage in fresh water bodies such as canals and ponds must be prohibited to attract the fresh water birds particularly the migratory birds. The efforts should be taken to restrict the infestation of weeds such as Water Hyacinth in water bodies as it affects the waterbirds preferring open water. Environmental awareness and educational programmes are also recommended to educate local people and farmers of the area about importance of different bird species to environment and agriculture.

Conflict of interest: None.

REFERENCES

Ali, S. (2002). The Book of Indian Birds. The Bombay Natural History Society, Bombay.13th Edition, 326.

Ali, S. and Ripley, S.D. (1987). The Compact Handbook of the Birds of India and Pakistan: Together with Those of Bangladesh, Nepal, Bhutan and Sri Lanka, Second Edition, Oxford University Press, New Delhi. 737.

Arora, A., Kumar, M. and Kler, T.K. (2016). Avian diversity in urban, periurban and rural residential areas of Ludhiana. Indian Journal of Applied Research. 6(2): 478-479.

Beale, C.M. and Monaghan, P. (2004). Human disturbance: people as predation-free predators? Journal of Applied Ecology. 41: 335-343.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. (2001). Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, Oxford, 432.

Debnath, S., Biswas, S. and Panigrahi, A.K. (2018). Present status and diversity of avian fauna in Purbasthali bird sanctuary, West Bengal, India. Agricultural Science Digest. 38: 95-102. DOI: 10.18805/ag.D-4711.

Dhindsa, M.S., Sandhu, J.S, Sandhu, P.S. and Toor, H.S. (1988). Roadside birds in Punjab (India): Relation to mortality from vehicles. Environmental Conservation. 15: 303-310. DOI: https://dx.doi.org/10.17582/journal.pjz/20190918070927.

Grimmett, R. and Inskipp, T. (2010). Birds of Northern India. Om Books International, New Delhi, 302.

Grimmett, R., Inskipp, C. and Inskipp, T. (2011). Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka and the Maldives. Christopher Helm, London. 528.

Kler, T.K. (2006). Avifaunal diversity in the different areas of Ludhiana city. Pestology. 30(7): 35-39.

Kler, T.K. (2009). Avian diversity observed in some agricultural habitats of Ludhiana, Punjab. Pestology. 33(10): 46-51.

Kler, T.K. and Kumar, M. (2015a). Prevalence of bird species in relation to food habits and habitat. Agricultural Research Journal, Punjab Agricultural University. 52(1): 50-53.

Kler, T.K. and Kumar, M. (2015b). Avian fauna in agricultural habitats of Punjab state. Agricultural Research Journal, Punjab Agricultural University. 52(3): 83-90.

Palacio-Nunez, J., Verdu, J.R., Galante, E., Jimenez-Garicia, D. and Olmos-Oropeza, G. (2007). Birds and fish as bioindicators of tourist disturbance in springs in semi-arid regions in Mexico: A base for management. Animal Diversity and Conservation. 30: 29-41.

Pannu, K.K. and Kler, T.K. (2018). To monitor the population of House Sparrow (*Passer domesticus*) in villages of district Ludhiana, Punjab. Journal of Entomology and Zoology Studies. 6(6): 1125-1128.

Rees, E.C., Bruce, J.H. and White, G.T. (2005). Factors affecting the behavioural responses of Whooper Swans (*Cygnus c. cygnus*) to various human activities. Biological Conservation. 121: 369-382.

Sidhu, S.K., Sekhon, G.S., Aulakh, R.K. and Kler, T.K. (2021). Prioritizing sustenance of village ponds for avian conservation: A case study from Punjab, India. Pakistan Journal of Zoology. 53(2): 1-8.

Sorenson, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Kongellege Danske Videnskabernes Selskab, Biologiske Skrifter. 5: 1-34.

Sutherland, W.J. (1996). Ecological Census Techniques: A Handbook. Cambridge University Press, Cambridge. 432.

Thiollay, J.M. (2007). Raptor communities in French Guiana: Distribution, habitat selection and conservation. Journal of Raptor Research. 41(2): 90-105.

Toor, H.S., Chakravarthy, A.K., Dhindsa, M.S., Sandhu, P.S. and Rao, A.P.K. (1982). A checklist of the birds of Punjab and Chandigarh. Bico Printers, Ludhiana, 37.

Torre-Cuadros, M.D.L.A.L., S. Herrando-Perez and Young, K.R. (2007). Diversity and structure patterns for tropical montane and premontane forests of central Peru, with an assessment of the use of higher taxon surrogacy. Biodiversity and Conservation. 16: 2965-2988. https://doi.org/10.1007/s10531-007-9155-9.

Whistler, H. (1919). Some birds of Ludhiana district Punjab. Journal of the Bombay Natural History Society.26: 585-598.