



The Diversity and Spatial Distribution of Birds in a Moderately Developed Urban Habitat of Gulabpura, Rajasthan, India

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Abstract

Urbanization is a phenomenon directly related with development. The outcomes of unplanned development appear as deformed and unsustainable ecosystems. We studied the bird community composition of various habitats around an urbanized domain from year 2011 to year 2013. The birds of four different habitats namely Open cultivation, Urban, Aquatic and Parks and grassland patches were recorded using line transect and call note methods. Total 129 birds of 48 families have been recorded out of them 44 were migratory and 85 were resident. Urban habitat had least number of birds and open cultivation area had highest number of birds. The maximum numbers of birds were omnivorous guild followed by insectivorous and carnivorous guild. 15 bird species among 129 were urban dependent, 24 species were urban semi-dependent and 89 were urban independent. Sorenson's biodiversity index was calculated to know the community overlapping but no considerable similarity was revealed besides between urban habitat and park and grassland patch habitat.

Keywords: Development, guild, open cultivation, sorenson's, urban dependent.

Introduction

Birds are the group of feathered vertebrates and contribute in various ecological functions occupying a wide range of positions in ecosystem¹. These are important indicators of inhabited area² and the potential umbrella group of species for biodiversity conservation³. The reaction of birds to the change in their habitat is very rapid due to their high mobility⁴, so being an essential ecological tool, the study of avifaunal diversity acts as a significant indicator to evaluate various habitats qualitatively as well as quantitatively⁵.

Urbanization is a universal phenomenon and its negative effects on biodiversity in terms of habitat fragmentation, habitat loss, destruction of both native and migratory species are slowly being understood^{6,7,8}. Increasing population and development exerts pressure on the resources of urban areas. Not only the abundance but the type of resources upon which birds survive, such as food, water, perches, roosts and nesting sites, should also change greatly with development^{9,10}. The alarming scenario of urbanization can be viewed from the fact that about 3% of the Earth's surface is occupied by buildings and other urban structures¹¹. The distribution and diversity of birds in urban area have been studied across the globe including India¹²⁻¹⁹ and all concluded that human disturbance and urbanization affect bird diversity.

Gulabpura (25.902879°N, 74.660726°E.) is a town of Bhilwara district of mid- southern Rajasthan. The climate is dry and typical as of Rajasthan state of India. The average minimum and maximum temperature is 11⁰C and 41⁰C respectively with

average annual rainfall of 615 mm. The monsoon is the only period of rain and it is from June to September. High temperature in summer and low rainfall makes climate overall dry. The vegetation of the area is chiefly of thorny type characterized by *Prosopis cineraria*, *Ziziphus mauritiana*, *Acacia nilotica*, excessively grown *Prosopis juliflora* but also have a considerable population of trees like *Azadirachta indica* and *Delbergia sissoo*.

Industrialization in textile, plastic manufacturing and mining field has generated employment opportunities in the town for last few years. It is exerting pressure on the resources of the urban area. The population is although not very high but the density has grown up to 2,267.9¹ people per square km. The boundaries of human settlements are increasing continuously and new residential colonies are being established on agriculture land. On one hand, it is opening new avenues of livelihood for the society but on the other hand habitat destruction and fragmentation due to the unplanned development and actively growing *Prosopis juliflora*, may produce new problems for the natural environment and the animals specially birds in the near future. Due to urbanization and industrialization, disappearance of traditional values and natural resources, people's attitude and socio-cultural practices are also rapidly changing which mostly degrade many sacred groves²⁰ and surrounding habitats. So the current study was taken to know the present status of diversity and distributive pattern of the birds along various habitats of the town and to infer the effect of urbanization on the bird. No work has been done on the birds of this area including the district so far so the data would also be the baseline for future studies.

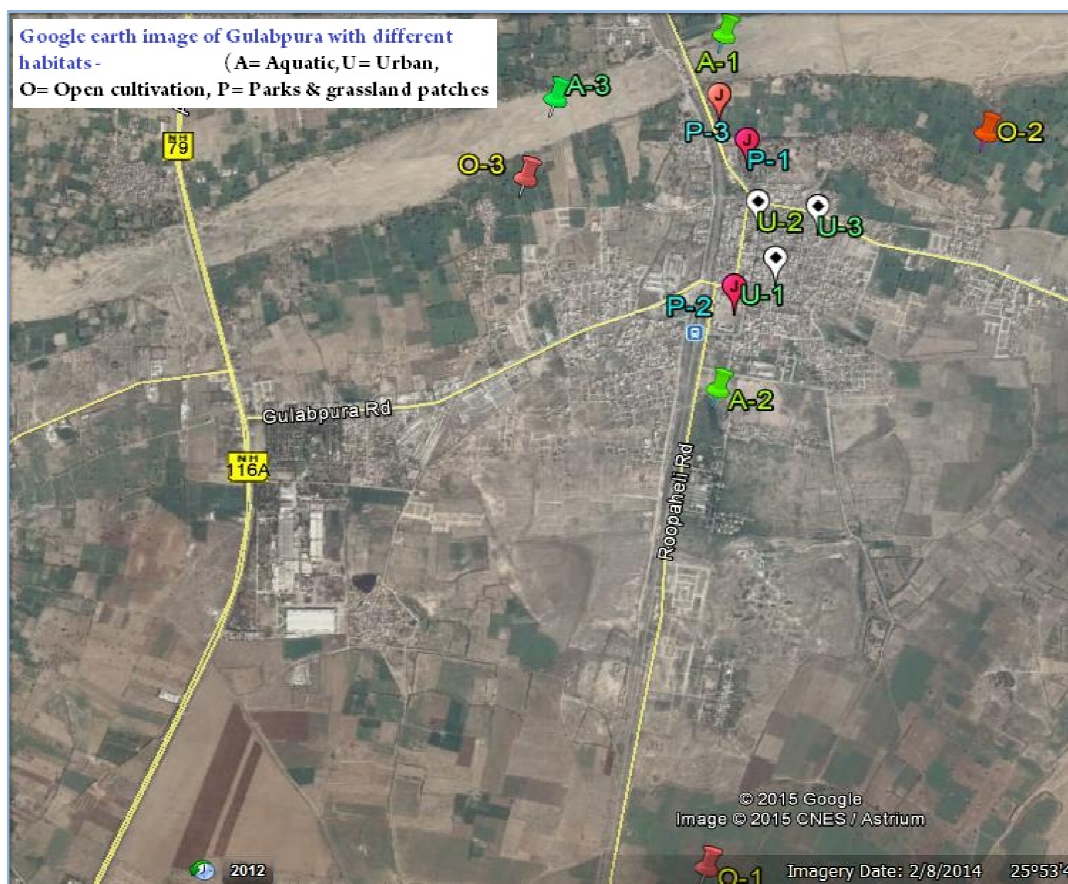


Image-1
Google earth image showing habitats of the study area

Material and Methods

The study was accomplished in and around Gulabpura town of Rajasthan state from January 2011 to December 2012. Twelve sites belonging to four different habitats were selected for surveying the birds. The study area distinctively has four types of habitats: Three seasonal wetlands (A), Urbanized area (U), Open cultivation area including pasture land (O) and Public parks and seasonal patches of grassland (P). Three sites in each of the habitat were selected for data collection, thus total 12 points were selected. Data were collected in early morning hours from 7.00 to 9.00 in winters and 6.00 to 8.00 in summers in every three months time, so total twelve visits of each site were made.

Line transect method²¹ was followed to study the birds. Transects of different lengths according to the habitat type were laid. The length was 500 m in urban area and Parks, 800 m in wetland area and 1000 m in Open cultivation area. The transects of open agriculture land were not straight because the route in this habitat was undulating. Walking on the transect with uniform pace the birds seen at 50 meters on both side of the transect were recorded or photographed using Celestron binoculars (8x42) and Canon 550D SLR camera with 75-300

mm zoom lens. Call notes of birds were also used for locating and identifying birds. The birds were identified and listed using field books²². The birds were also categorized by trophic guilds based on Ali and Ripley²³ and field observations. The residential status of the birds was categorized as “winter migratory”, “summer migratory”, “resident” and “passage migratory”. The birds those were seen regularly in the study area were categorized as “resident”; birds encountered only in winter and summer seasons were kept under “winter migratory” and “summer migratory” and birds encountered only once or twice during the study period were considered as “passage migratory”.

The birds were also classified on their dependence on urban area. Birds those were always sighted in urban area were classified as urban dependent, the birds those come to the urban area for foraging purposes and nest here occasionally were classified as urban semi-dependent and the birds usually avoid urban areas for fulfilling their life requirements were put into category of urban independent birds.

Sorenson’s coefficient (C) was calculated to understand the community overlapping or similarity of avian species composition of different habitats using formula $2a / (2a+b+c)$ Where ‘a’ is the number of species shared by the habitats, ‘b’ is

the number of species in habitat one and 'c' is the number of species in habitat two²⁴. The value of coefficient (C) is between 0 to 1, where 0 shows total dissimilarity and 1 shows total similarity. The different values between 0 and 1 indicate the degree of similarity.

Results and Discussion

Total 129 birds of 48 families have been recorded during the study, 44 out of them were migratory and 85 birds were resident, table-1. The maximum number of birds belong to family Anatidae (n=10) and Scolopacidae (n=10) followed by Muscicapidae (n=9), Ardeidae (n=6) and Motacilidae (n=6). Three among the total bird species, Painted Stork (*Micreopus leucocephalus*), Black headed Ibis (*Threskiornis melanocephalus*) and River Tern (*Sterna aurantia*) were Near Threatened and one species Woolly-necked Stork (*Ciconia episcopus*) was under vulnerable category in IUCN redlist 2015.

Maximum avian richness was found in open cultivation area (n=81) and Muscicapidae (n=9) was the largest bird community. The urban area had least avian richness (n=30) consists mainly of family Sturnidae (n=5) Columbidae (n=3) and Cisticolidae (n=3). Third maximum bird species were recorded at Public parks and the seasonal grassland patches (n=58). The bird community of this habitat comprised mainly of Sturnidae (n=5), Muscicapidae (n=5), Motacilidae (n=5), Cuculidae (n=4) and Columbidae (n=3). Aquatic habitat had avian richness of (n=51) birds. The Maximum part of bird species belongs to family Anatidae (n=10) and Scolopacidae (n=10).

As far as guild concern table-2 and figure-1 shows the distribution of birds according to their feeding guild in different habitats of study area. The most abundant feeding guild was omnivorous (n=48, 37.21%). In Open cultivation area the chief feeding guild was Omnivorous (n= 32, 39.51%) and Insectivorous (n=28, 34.57%). The same i.e. Omnivorous (n=11, 36.67%) and Insectivorous (n=8, 26.67%) were the principal feeding guild of the Urban habitat. In Public parks and patchy grassland habitat the maximum birds were associated with Insectivorous feeding guild (n=23, 39.66%), followed by Omnivorous (n=22, 37.93%) and the major feeding guild of the aquatic bird community was Omnivorous (n=19, 37.25%), Carnivorous (n=18, 35%) and Insectivorous (n=14, 27.45%).

In context of urban dependence 15 bird species were categorized as urban dependent. 24 species were urban semi-dependent out of which maximum no of birds were from Timallidae (n=3), Cisticolidae (n=3) followed by Accipitridae (n=2), Ardeidae (n=2) and Muscicapidae (n=2). 89 bird species of total birds were urban independent as they fulfill their requirements from the habitat other than urban.

Among all habitats the number of birds in the urban area was least and maximum number of the birds was in the open cultivation area. The urbanized area has maximum bird species

abundance but minimum richness. Blair²⁵ and Salahudeen et.al.¹⁷ suggested that the human disturbance negatively affect the richness and diversity of birds. We had the same observations that the both number and richness of birds was least in urban area because of the disturbance made by various human activities. Some birds were found to look for their food and nesting sites in urban localities but majority of birds avoid this disturbance. Not all birds avoided the urban habitat but the birds, familiar with human activities and get adequate food and shelter here tended to stay. The birds didn't like human disturbance or got insufficient food in urban areas, were found to spend their time in other habitats having no or insignificant human interruptions, such as open cultivation fields or the transition area between the two. In our study, the maximum birds were present in the less disturbed open cultivation area. The Urbanized areas lack suitable vegetation patches, shrubs and canopy cover that limit the density and variety of food, placement of nests, predator avoidance and escape¹⁵ so usually avoided by the birds but the open cultivation area due to least human disturbance, food availability, variety of nesting sites and ecologically better conditions supports a big number of bird species. The supporting factors motivated the birds of this area to avoid urban penetration and make them urban-independent. Thus it became evident that the habitat quality has strong influence on bird population²⁶. In the same way the birds of wetlands rarely move to urban and fulfill their daily requirements from their aquatic habitat so the greater mass of these birds were classified as urban-independent. A few birds of them were categorized as urban semi-dependent such as Black headed Ibis, *Threskiornis melanocephalus* and Pond Heron, *Ardeola grayii* which were foraging in sewage flow of urban areas. Shikra, *Accipiter badius*, Black-shouldered Kite, *Elanus caeruleus* and Owls were also kept in this category of urban semi-dependent birds due to their presence in the urban locations having nests of sparrows, mynas and other small birds looking for prey.

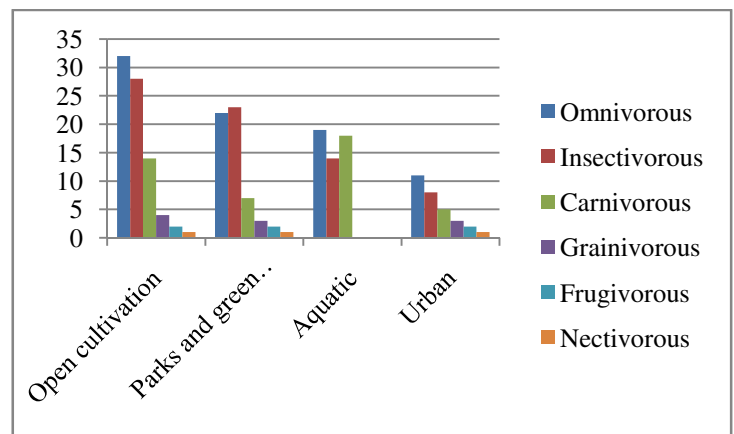


Figure-1
 Birds associated with different feeding guilds in different habitats

Table-1
The birds in various habitats of the urban area of Gulappura (Rajasthan)

Families	Common name	Zoological Name	Habitat	Residential status	Feeding guild	Urban dependance	
Phasianidae	Grey Francolin	<i>Francolinus pondicerianus</i>	O	R	Omnivorous	No	
	Rock Bush Quail	<i>Perdicula argoondah</i>	O	R	Omnivorous	No	
	Jungle Bush Quail	<i>Perdicula asiatica</i>	O	R	Omnivorous	No	
	Red Jungle fowl	<i>Gallus gallus</i>	U	R	Omnivorous	Yes	
	Indian Peafowl	<i>Pavo cristatus</i>	U,O,P	R	Omnivorous	SD	
Anatidae	Painted francolin	<i>Francolinus pictus</i>	O	R	Omnivorous	No	
	Lesser Whistling Duck	<i>Dendrocygna javanica</i>	A	R	Omnivorous	No	
	Knob-billed Duck	<i>Sarkidiornis melanotos</i>	A,O	R	Omnivorous	No	
	Ruddy Shelduck	<i>Tadorna ferruginea</i>	A	M	Omnivorous	No	
	Eurasian Wigeon	<i>Anas penelope</i>	A	M	Omnivorous	No	
	Spot-billed Duck	<i>Anas poecilorhyncha</i>	A	R	Omnivorous	No	
	Northern Shoveler	<i>Anas clypeata</i>	A	M	Omnivorous	No	
	Northern Pintail	<i>Anas acuta</i>	A	M	Omnivorous	No	
	Garganey	<i>Anas querquedula</i>	A	M	Omnivorous	No	
	Common Teal	<i>Anas crecca</i>	A	M	Omnivorous	No	
	Gadwall	<i>Anas strepera</i>	A	M	Omnivorous	No	
	Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	A	R	Carnivorous	No
	Ciconiidae	Painted Stork	<i>Mycteria leucocephala</i>	A	R	Carnivorous	No
		Woolly-necked Stork	<i>Ciconia episcopus</i>	A	R	Carnivorous	No
	Threskiornithidae	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	A,O	R	Carnivorous	SD
Indian Black Ibis		<i>Pseudibis papillosa</i>	O	R	Carnivorous	No	
Glossy Ibis		<i>Plegadis falcinellus</i>	O	R	Carnivorous	No	
Ardeidae	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	A	R	Carnivorous	No	
	Indian Pond Heron	<i>Ardeola grayii</i>	A,U	R	Carnivorous	SD	
	Cattle Egret	<i>Bubulcus ibis</i>	A,O	R	Carnivorous	SD	
	Grey Heron	<i>Ardea cinerea</i>	A	R	Carnivorous	No	

Families	Common name	Zoological Name	Habitat	Residential status	Feeding guild	Urban dependance
	Intermediate Egret	<i>Mesophoyx intermedia</i>	A	R	Carnivorous	No
	Little Egret	<i>Egretta garzetta</i>	A	R	Carnivorous	No
Pelecanidae	Great White Pelican	<i>Pelecanus onocrotalus</i>	A	M	Carnivorous	No
Phalacrocoracidae	Little Cormorant	<i>Phalacrocorax niger</i>	A	R	Carnivorous	No
Accipitridae	Shikra	<i>Accipiter badius</i>	U,O,P	R	Carnivorous	SD
	Black-winged Kite	<i>Elanus caeruleus</i>	O,P	R	Omnivorous	SD
Rallidae	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	A,O	R	Omnivorous	No
	Common Moorhen	<i>Gallinula chloropus</i>	A	R	Omnivorous	No
	Eurasian Coot	<i>Fulica atra</i>	A	M	Omnivorous	No
Burhinidae	Great Thick-knee	<i>Esacus recurvirostris</i>	A	R,	Carnivorous	No
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	A	R	Omnivorous	No
	Pied Avocet	<i>Recurvirostra avosetta</i>	A	PM	Insectivorous	No
Charadriidae	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	A,O	R	Insectivorous	No
	Red-wattled Lapwing	<i>Vanellus indicus</i>	A,O,P	R	Omnivorous	SD
	Little Ringed Plover	<i>Charadrius dubius</i>	A	M	Carnivorous	No
	Kentish Plover	<i>Charadrius alexandrinus</i>	A	M	Carnivorous	No
Rostratulidae	Greater Painted-Snipe	<i>Rostratula benghalensis</i>	A,P	M	Omnivorous	No
Scolopacidae	Common Snipe	<i>Gallinago gallinago</i>	A	M	Insectivorous	No
	Black-tailed Godwit	<i>Limosa limosa</i>	A	M	Omnivorous	No
	Common Redshank	<i>Tringa totanus</i>	A	M	Insectivorous	No
	Green Sandpiper	<i>Tringa ochropus</i>	A	M	Insectivorous	No
	Wood Sandpiper	<i>Tringa glareola</i>	A	M	Insectivorous	No
	Marsh Sandpiper	<i>Tringa stagnatilis</i>	A	M	Insectivorous	No
	Common Sandpiper	<i>Actitis hypoleucos</i>	A	M	Insectivorous	No
	Little Stint	<i>Calidris minuta</i>	A	M	Insectivorous	No
	Ruff	<i>Philomachus pugnax</i>	A,O	M	Omnivorous	No
	Common Greenshank	<i>Tringa nebularia</i>	A	M	Insectivorous	No

Families	Common name	Zoological Name	Habitat	Residential status	Feeding guild	Urban dependance
Laridae	River Tern	<i>Sterna aurantia</i>	A	R	Carnivorous	No
Columbidae	Common Pigeon	<i>Columba livia</i>	U,O,P	R	Grainivorous	Yes
	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	U,O,P	R	Grainivorous	Yes
	Red Collared Dove	<i>Streptopelia tranquebarica</i>	O	R	Grainivorous	SD
	Laughing Dove	<i>Streptopelia senegalensis</i>	U,O,P	R	Grainivorous	Yes
Psittacidae	Rose-ringed Parakeet	<i>Psittacula krameri</i>	U,O,P	R	Frugivorous	Yes
Cuculidae	Jacobin Cuckoo	<i>Clamator jacobinus</i>	O,P	SM	Insectivorous	No
	Common Hawk Cuckoo	<i>Hierococcyx varius</i>	O,P	SM	Omnivorous	No
	Common Koel	<i>Eudynamis scolopaceus</i>	U,O,P	R	Omnivorous	SD
	Southern Coucal	<i>Centropus sinensis</i>	U,O,P	R	Omnivorous	SD
Tytonidae	Barn Owl	<i>Tyto alba</i>	U,O,P	R	Carnivorous	SD
Strigidae	Spotted Owlet	<i>Athene brama</i>	U,O,P	R	Carnivorous	SD
Caprimulgidae	Indian Nightjar	<i>Caprimulgus asiaticus</i>	O,P	R	Insectivorous	No
Apodidae	Little Swift	<i>Apus affinis</i>	U,O,P	R	Insectivorous	Yes
Coraciidae	Indian Roller	<i>Coracias benghalensis</i>	O	R	Carnivorous	No
	Eurasian Roller	<i>Coracias garrulus</i>	O	PM	Carnivorous	No
Alcedinidae	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	A	R	Carnivorous	No
	Pied Kingfisher	<i>Ceryle rudis</i>	A	R	Carnivorous	No
Meropidae	Green Bee-eater	<i>Merops orientalis</i>	O,P	R	Insectivorous	SD
Upupidae	Common Hoopoe	<i>Upupa epops</i>	O	R	Insectivorous	No
Bucerotidae	Indian Grey Hornbill	<i>Ocyrceros birostris</i>	O,P	R	Omnivorous	No
Ramphastidae	Coppersmith Barbet	<i>Megalaima haemacephala</i>	U,O,P	R	Omnivorous	No
Picidae	Lesser Golden-backed Woodpecker	<i>Dinopium benghalense</i>	O,P	R	Insectivorous	No
Campephagidae	Large Cuckoo-shrike	<i>Coracina macei</i>	O	R	Insectivorous	No
	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	O	R	Insectivorous	No
Laniidae	Isabeline Shrike	<i>Lanius isabellinus</i>	O	M	Carnivorous	No

Families	Common name	Zoological Name	Habitat	Residential status	Feeding guild	Urban dependance
	Bay-backed Shrike	<i>Lanius vittatus</i>	O,P	R	Carnivorous	No
	Long-tailed Shrike	<i>Lanius schach</i>	O,P	R	Carnivorous	No
	Southern Grey Shrike	<i>Lanius meridionalis</i>	O,P	R	Carnivorous	No
Dicruridae	Black Drongo	<i>Dicrurus macrocercus</i>	U,O,P	R	Insectivorous	SD
Corvidae	Rufous Treepie	<i>Dendrocitta vagabunda</i>	O,P	R	Omnivorous	No
	House Crow	<i>Corvus splendens</i>	U,O,P	R	Carnivorous	Yes
Hirundinidae	Wire-tailed Swallow	<i>Hirundo smithii</i>	O,P	R	Insectivorous	No
	Dusky Crag Martin	<i>Ptyonoprogne concolor</i>	U,O	R	Insectivorous	Yes
	Red-rumped Swallow	<i>Cecropis daurica</i>	O	R	Insectivorous	No
	Streak-throated Swallow	<i>Petrochelidon fluvicola</i>	O	R	Insectivorous	NO
Alaudidae	Singing Bushlark	<i>Mirafra cantillans</i>	O	R	Omnivorous	No
	Oriental Skylark	<i>Alauda gulgula</i>	O	R	Omnivorous	No
	Indian Bush-Lark	<i>Mirafra erythroptera</i>	O	R	Omnivorous	No
	Ashy-crowned Sparrow-Lark	<i>Eremopterix grisea</i>	O	R	Omnivorous	No
Cisticolidae	Ashy Prinia	<i>Prinia socialis</i>	U,O,P	R	Insectivorous	SD
	Plain Prinia	<i>Prinia inornata</i>	U,O,P	R	Insectivorous	SD
	Common Tailorbird	<i>Orthotomus sutorius</i>	U,P	R	Insectivorous	SD
Sylviidae	Common Lesser Whitethroat	<i>Sylvia curruca</i>	U,O,P	M	Insectivorous	No
	Clamorous Warbler	<i>Acrocephalus stentoreus</i>	P	M	Insectivorous	No
	Common Chiffchaff	<i>Phylloscopus collybita</i>	O	M	Insectivorous	No
	Sulphur-bellied Warbler	<i>Phylloscopus griseolus</i>	P	R	Insectivorous	No
Pycnonotidae	Red-vented Bulbul	<i>Pycnonotus cafer</i>	U,O,P	R	Frugivorous	Yes
maliidae	Yellow-eyed Babbler	<i>Chrysomma sinense</i>	O,P	R	Omnivorous	No
	Common Babbler	<i>Turdoides caudate</i>	O,P	R	Omnivorous	SD
	Large Grey Babbler	<i>Turdoides malcolmi</i>	O,P	R	Omnivorous	SD

Families	Common name	Zoological Name	Habitat	Residential status	Feeding guild	Urban dependance
	Jungle Babbler	<i>Turdoides striata</i>	O,P	R	Omnivorous	SD
Sturnidae	Bank Myna	<i>Acridotheres ginginianus</i>	U,O,P	R	Omnivorous	Yes
	Common Myna	<i>Acridotheres tristis</i>	U,O,P	R	Omnivorous	Yes
	Asian Pied Starling	<i>Gracupica contra</i>	U,O,P	R	Omnivorous	Yes
	Brahminy Starling	<i>Sturnus pagodarum</i>	U,O,P	R	Omnivorous	Yes
	Rosy Starling	<i>Pastor roseus</i>	U,O,P	M	Omnivorous	SD
Muscicapidae	Bluethroat	<i>Luscinia svecica</i>	O,P	M	Insectivorous	No
	Oriental Magpie-Robin	<i>Copsychus saularis</i>	O,P	R	Insectivorous	SD
	Indian Robin	<i>Saxicoloides fulicatus</i>	O,P	R	Insectivorous	SD
	Black Redstart	<i>Phoenicurus ochruros</i>	O,P	M	Insectivorous	No
	Common Stonechat	<i>Saxicola torquatus</i>	O	M	Insectivorous	No
	Pied Bushchat	<i>Saxicola caprata</i>	O	M	Insectivorous	No
	Desert Wheatear	<i>Oenanthe deserti</i>	O	M	Insectivorous	No
	Brown Rock Chat	<i>Cercomela fusca</i>	U,O,P	R	Insectivorous	Yes
	Red-breasted Flycatcher	<i>Ficedula parva</i>	O,P	WM	Insectivorous	No
Nectariniidae	Purple Sunbird	<i>Cinnyris asiatica</i>	U,O,P	R	Nectivorous	SD
Passeridae	House Sparrow	<i>Passer domesticus</i>	U,O,P	R	Omnivorous	Yes
Ploceidae	Baya Weaver	<i>Ploceus philippinus</i>	O	R	Omnivorous	No
Estrildidae	Indian Silverbill	<i>Lonchura malabarica</i>	O,P	R	Omnivorous	No
Motacillidae	Yellow Wagtail	<i>Motacilla flava</i>	A,P	M	Insectivorous	No
	Citrine Wagtail	<i>Motacilla citreola</i>	A,P	M	Insectivorous	No
	Grey Wagtail	<i>Motacilla cinerea</i>	A,P	M	Insectivorous	No
	White wagtail	<i>Motacilla alba</i>	A,P	M	Insectivorous	No
	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	A,P	M	Omnivorous	No
	Paddyfield Pipit	<i>Anthus rufulus</i>	O	R	Insectivorous	No

A= Aquatic; O= Open cultivation; U=Urban; P= Public parks and seasonal grassland patches; M=Migratory; R= Resident; PM=Passage Migratory; WM=Winter Migratory; SD= Semi-dependent

Table -2
Feeding guilds of the birds according to the habitat type

Feeding guild	No of bird species	% in total no. of bird species	Aquatic (% in the birds of the habitat)	Urban (% in the birds of the habitat)	Open (% in the birds of the habitat)	Parks (% in the birds of the habitat)
Omnivorous	48	37.21%	37.25%	36.67%	39.51%	37.93%
Insectivorous	44	34.11%	27.45%	26.67%	34.57%	39.66%
Carnivorous	30	23.26%	35.29%	16.66%	17.28%	12.07%
Grainivorous	4	3.10%	00%	10%	4.93%	5.17%
Frugivorous	2	1.55%	00%	6.66%	2.46%	3.44%
Nectivorous	1	0.77%	00%	3.33%	1.23%	1.72%

The chief urban-dependent birds in our study belong to family Sturnidae, Columbidae, Passeridae, and Corvidae. These birds were closely associated with human population and stay in the urban area in remarkable diversity. The possible reasons of their high diversity in urban area were their dependence primarily on the left-over of food disposed in open areas around the residences, restaurants and grain-shops. The roadside vegetation also helped them in terms of getting food besides other daily activities including roosting and foraging. People also feed the birds in temples or around their homes due to spiritual values in culture. All these factors motivated the birds to remain around human dwellings. Indian Rock Pigeon, Columba livia dominated all other species in urban habitat followed by Common Myna, *Acridotheres tristis* and House Sparrow, *Passer domesticus*. The birds of family Cisticolidae were recorded from the trees and shrubs of the lawns of the houses. The maximum numbers of urban independent birds were from open cultivation and aquatic habitat (figure-2) as these had the potential to support birds in a complete way. The omnivorous guild superseded other guild in all habitats besides public parks. Insectivorous birds stood first in public parks due to the supportive conditions like high humidity, presence of grasses, flowering plants and decorative lights at night which ensures availability of insect food for insect-eating birds. The noticeable bird diversity in this habitat confirmed that the vegetation cover, water and food are deciding factors for birds. Kim et.al.¹⁴ also concluded similar results that if water resources and the multiple vegetation structure, are maintained then, the small patches (parks and seasonal grassland here) can be valuable to support bird diversity rather than the large habitat.

We calculated Sorenson's index to know the similarity in bird communities among different habitats of the study area. The insignificant values of the index were concluded as dissimilarity of species composition among the habitats. The value of the index for open cultivation and park habitat was higher (S=0.413) than others, indicated some resemblance in bird composition and ecological conditions of the two habitats. Urban and Park habitat (S=0.388) and the Urban and Open

cultivation area (S=0.327) are next two habitats showing a little overlapping in bird community. The urban and aquatic habitats (S=0.02) clearly showed strict dissimilarity in their bird types and ecological factors.

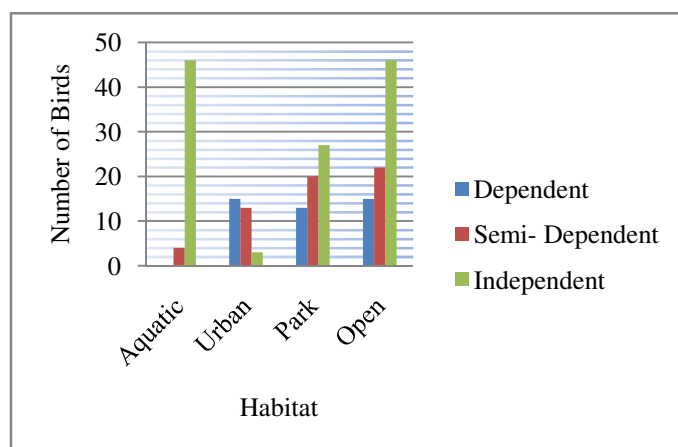


Figure-2
 The urban dependence of the birds of different habitats

The study revealed that the urbanization posing serious threats to the biodiversity of this area. Habitat fragmentation due to the unplanned residential colonies, reducing agricultural land and habitat degradation due to water and land pollution were the principal problems of the area. Besides, the upcoming hazard to the biodiversity was identified as the exorbitantly growth of Vilayati Babool, *Prosopis juliflora*. It's growth was maximum in the pasture land otherwise it was growing more or less everywhere. Sajeev et al.²⁷ concluded that dense impenetrable thickets of *Prosopis juliflora* pose serious threat to native flora and fauna as it can dry out the soil and compete with other plants for water so this species should be checked in the context of global environment change wherein the resilience of native species would be compromised. The effect of urbanization was also seen on the behavior and type of nesting materials used by the birds. The birds of the urban area prefer threads, papers, light plastic items, safety pins, polythene and clothe as nesting

material in addition to grasses. These birds were likely to adjusting and making themselves more and more familiar to the humans so as to get easy food. For this purpose the birds were compromising with their natural behavior of feeding, nesting and other activities as we found a large number of Black Drongos, *Dicrurus macrocercus* and Rosy Starlings, *Sturnus roseus* feeding on the waste-remains of snacks at a shop in urban area.

Table-3
Sorenson's index for different habitats of the study area

Habitat	A	U	O	P
A	1.0	0.02	.095	0.11
U	-	1.0	0.327	0.338
O	-	-	1.0	0.413
P	-	-	-	1.0

Conclusion

Urbanization is an impact and aspect of development. It affects not only the diversity but the behavior of the birds also. Increasing population is leading to destroy the natural habitats of animals that can move the birds permanently from that habitat. Planned human settlements, plantation in pasture land and around industries, developing small green area as gardens and public parks, eradication of *Prosopis juliflora*, water harvesting and arousing awareness in people towards environment may some steps that can secure the future of the biodiversity of this area.

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