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Review Article

Fragmented Landscapes as Refuge for Forest Birds in Pakistan and India: A Systematic Review

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ABSTRACT

Fragmented landscapes in human-dominated areas could provide habitat for birds. We performed a systematic review of the occurrence of forest birds in urban green spaces, residential/commercial areas, and agricultural lands in India and Pakistan. We identified 101 forest bird species in 10 studies, including 65 year-round residents and 36 migratory birds. Ninety-five of the selected bird species were found in urban green spaces, 91 in agricultural lands, and 72 species in residential/commercial areas. Our findings underscore that many species can utilize trees in urban green spaces and associated fragmented areas, emphasizing the importance of these habitats for a variety of bird species. This review identifies bird species that could benefit from the conservation of trees and forest fragments in human-dominated landscapes in India and Pakistan.

INTRODUCTION

The average human population in developing countries is increasing rapidly and half of the world population is now living in the cities. The report projections state that the current 7.88 billion population on Earth will increase to 8.5 billion by 2030, 9.7 billion in 2050, and 11.2 billion in 2100 (World Population Prospects, Population Division, United Nations, 2022). The process of human development changes natural landscapes into agricultural and urbanized areas, impermeable ground layers, hydrological process disruptions, exotic vegetation growth followed by a rise in human population, and altered energy and nutrient flows (Menon and Rangaswamy, 2016). Declining biodiversity in cities is mostly associated with habitat alteration, especially vegetation cover and structural changes due to urbanization (Sadam *et al*., 2021).

The rapid expansion of urban and rural areas has had profound effects on natural ecosystems and biodiversity worldwide, and it has affected the distribution of birds (Archer *et al*., 2019). Human-dominated areas are highly modified and fragmented habitats that affect the types of birds that occur in cities (Grimm *et al*., 2008; Aronson *et al*., 2014; Venter *et al*., 2016). In many developing countries, some wildlife and birds survive outside protected areas on farmlands, pasture lands, and urban areas (Bolwig *et al*., 2006). Land transformation poses significant challenges for wildlife, including forest birds (Lampila *et al*., 2005), as their habitat are increasingly fragmented and transformed, and depending on how these areas are designed and managed, only certain species utilize these areas (Hostetler and Holling, 2000; Zaman *et al*., 2023).

Forest birds, especially those living in and around the human-dominated areas are among the taxa that are most at risk from land transformation because they depend on good forest habitats for breeding, food, and shelter (Blair, 1996; Kang *et al*., 2015). Because forest birds have specific ecological niches and environmental needs, they face several challenges as their natural habitats become urbanized (Blair, 1996; Lepczyk *et al*., 2017). However, human-dominated environments and urban green spaces have the potential to function as essential resources and refuges for some bird species, assisting in their survival (Chace and Walsh, 2006).

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Forest birds are important for pollination, seed dissemination, and pest management (Whelan *et al*., 2008). Their presence in urban and rural areas can promote avian diversity and improve human well-being by adding aesthetic and recreational value (Shochat *et al*., 2006). Forest birds also act as environmental quality indicators and can promote an understanding of the ecological integrity of cities (Clergeau *et al*., 2001). We focused on forest birds because most cities have the ability to conserve and plant trees in urban areas. Further, most urban bird surveys are done in parks and residential areas that contain trees (Hostetler and Holling, 2000; Lepczyk *et al*., 2017). To plan for the conservation of urban forest birds in human-dominated landscapes, conservationists must first understand which forest bird species can be found in cities and agricultural spaces. With such knowledge, it makes it possible to recognize priority species and their unique habitat needs, enabling targeted conservation efforts (Clergeau *et al*., 2001).

The prime objective of the current study is to determine the forest bird species of India and Pakistan that are potentially adapted to urban environments while maintaining their wilderness ranges because they are somehow vulnerable to rapid changes in the urban environment. The result of this review provides a list of forest birds that could utilize urban environments, helping in the decision-making process for avian conservation.

MATERIALS AND METHODS

Systematic review

We carried out a systematic review of peer-reviewed studies of urban forest birds surveyed in urban and rural areas that contained trees and/or small forest fragments. The objective was to create a list of birds that are known to consistently use urban or rural areas that are highly fragmented. The geographic focus was India and Pakistan. These countries share about 3323 km of border length starting from Gujrat/Sindh to Kashmir (Pakistan, 2016). Both countries have been facing issues of uncontrolled urbanization since the start of the 21st century and both of them share the same zoogeographic region i.e. Indomalayan realm and have similar climatic conditions along with many cultural similarities along the borders (Bibi and Métais, 2016). Most of the mountain ranges, plane areas, deserts, and even coastal areas are shared in both of these countries. That is why they share over 70% of flora and fauna (Pakistan- Himalayas, Karakoram, Indus, Britannica, n.d.). We looked for bird studies that were conducted in urban and suburban areas with urban tree canopies and in rural areas that had forest fragments embedded in an agricultural matrix. We considered birds that were either year-round residents or migrants that were using the habitat as a stopover or winter habitat. We focused on these taxa: Accipitridiformes, Anseriformes, Apodiformes, Bucerotiformes, Charadriiformes, Ciconiformes, Columbiformes, Coraciiformes, Cuculiformes, Falconiformes, Gruiformes, Passeriformes, Pelecaniformes, Piciformes, Psittaciformes, Strigiformes, and Suliformes.

Literature search strategy

An online literature search was performed on articles published from 2000 to 2023 in English. Only original research articles were included in the review and we excluded editorials, comments, and opinion essays. To be included in this review, the research articles had to have reported bird species abundance/presence and were analyzed within urban/rural forest fragments either in the form of urban parks or small forest patches and/or surveys in residential/commercial areas. To identify appropriate articles, we identified a series of keywords and used these as a search string in the Web of Science© online database and Science Direct. We developed our systematic review following the protocol suggested by the Collaboration for Environmental Evidence (CEE, 2013), using the population-intervention-comparator-outcomes (PICO) framework. This framework utilizes a combination of words that maximizes the discovery of relevant articles. This search strategy corresponded to the following: (a) Population – descriptors of those objects of study such as urban forest birds, (b) Interventions - aspects influencing these objects defined such as forest fragment, pocket park, urban trees, (c) Comparator- descriptors of the interventions identified such as fragment size, small fragment, large fragment, and (d) Outcomes- descriptors of outcomes related to objects with identified interventions such as occurrence, abundance, density. Additionally, we also included the words India and Pakistan to define the geographical scope of the review. Likewise, we used the words identified in the previous step to build a search string using Boolean operators like “AND” to link the groups of words between and “OR” to link those words inside of each search. We also used the string the symbol * to find words that have some suffix o prefix commonly used but with a similar meaning (e.g., urban* = urbanization or *urban=suburban). Additionally, we also included in the string the Boolean operator “NOT” linked to broader topics such as climate change and other study topics not considered for this review.

Article selection

Based on the literature identified in the first step, we developed a list of articles considered suitable for inclusion

in the review. We reviewed titles, abstracts, and the full text to determine relevant studies. We screened titles and abstracts of articles discovered through the scientific search engines and rated each as either "0" (not useful) or "1" (potentially useful). For those that received a "1," we read the full text. We considered articles with forest bird records in urban/rural forest fragments or residential commercial areas with trees in the Indo-Pak subcontinent.

Information extraction, analysis, and synthesis

We reported the total number of articles selected for this review and information on the year of publication and country of study. Additionally, from these articles, we constructed a list of all birds that are known to consistently use urban or rural areas that are highly fragmented. Forest birds made the list when they were reported in at least two articles and had a minimum of five individuals seen in a study. For each species, we provided the following: (a) the English common name and scientific name of each selected bird following the taxonomic classification, (b) existing sites associated with the reporting time and dates, (c) the Method used to count the bird population, and (d) the urban/rural green spaces where the forest birds occurred in at least two decades.

RESULTS

We found a total of 127 possible bird studies in India and Pakistan in human-dominated landscapes, but only 10 studies met our criteria where we were able to generate a list of forest birds reported in and around urban habitats like urban green spaces, agricultural lands, and residential/commercial areas (Supplementary Table I). Of these 10 studies, 3 studies included all three habitats, 3 studies included residential areas and agricultural lands, 2 of the studies just reported birds' density in urban green spaces and residential areas while 1 study just reported urban green spaces, and 1 reported residential areas. Green spaces are areas that have scattered trees in high human areas and some portions covered by small forest fragments. Overall, most studies were published in the last 10 years (80%) with 5 studies in Pakistan and 5 studies in India (Supplementary Table I).

We documented a total of 101 bird species considered to be utilizing trees in human-dominated landscapes. We found 95 bird species (94%) reported in urban green spaces. Out of these 95 species, 65% were primary residents, 23% were winter migrants, 5% were summer breeders, and 7% of the species were considered to be partially resident and winter migrants in the Indo-Pak subcontinent (Table I).

Table I. List of 101 forest bird species in this review identified as users of fragmented landscapes in human dominated areas of India and Pakistan.

S. No.	Order/ Common name (Scientific name)	Migratory/ resident status	Urban green spaces	Agri-cultural lands	Residential/ commercial areas	References
Order: Accipitridiformes						
1	Shikra (*Accipiter badius*)	Resident	✓	✓	✓	2,6,8
2	Northern goshawk (*Accipiter gentilis*)	Winter migrant	✓	✓	-	2,9
3	Common buzzard (*Buteo buteo*)	Winter migrant	✓	✓	✓	1, 2
4	Long-legged buzzard (*Buteo rufinus*)	Winter migrant	✓	✓	-	1, 2
5	Brahminy kite (*Haliastur indus*)	Resident	✓	✓	-	2, 8
6	Black kite (*Milvus migrans*)	Resident	✓	✓	✓	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
7	Tawny eagle (*Aquila rapax nipalensis*)	Winter migrant	✓	✓	✓	1, 2
8	Crested honey buzzard (*Pernis ptilorhynchus*)	Winter migrant	✓	✓	✓	1, 2, 8
Order: Anatoidea						
9	Ruddy shelduck (*Tadorna ferruginea*)	Winter migrant	✓	✓	-	1, 2
10	Common shelduck (*Tadorna tadorna*)	Winter migrant	✓	✓	-	1, 2, 8
Order: Apodiformes						
11	House swift (*Apus affinis*)	Resident	✓	✓	✓	2, 4, 6, 8, 9

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S. No.	Order/ Common name (Scientific Name)	Migratory/ resident status	Urban green spaces	Agri-cultural lands	Residential/ commercial areas	References
12	Asian palm swift (*Cypsiurus balasiensis*)	Resident	✓	✓	✓	6, 8
Order: Bucerotiformes						
13	Common hoopoe (*Upupa epops*)	Resident	✓	✓	✓	1, 2, 3, 4, 8, 9
Order: Charadriiformes						
14	Wood sandpiper (*Tringa glareola*)	Winter migrant	✓	-	-	1, 2, 7
15	Common greenshank (*Tringa nebularia*)	Winter migrant	✓	-	-	2, 1
16	Green sandpiper (*Tringa ochropus*)	Winter migrant		-	-	1, 2, 7
17	Marsh sandpiper (*Tringa stagnatilis*)	Winter migrant		✓	-	1, 2, 7
Order: Ciconiiformes						
18	Painted stork (*Mycteria leucocephala*)	Resident	✓	-	-	1, 2
19	Open-billed stork (*Anastomus oscitanas*)	Resident	-	✓	✓	6, 8
Order: Columbiformes						
20	Indian ring dove (*Streptopelia decaocto*)	Resident	✓	✓	✓	1, 2, 8, 9, 10
21	Oriental turtle dove (*Streptopelia orientalis*)	Winter migrant	✓	✓	✓	1, 5
22	Little brown dove (*Streptopelia senegalensis*)	Resident	✓	✓	✓	1, 2, 3, 4, 9, 10
23	Red turtle dove (*Streptopelia tranquebarica*)	Summer breeder	✓	✓	✓	1, 4
24	Yellow-footed green pigeon (*Treron phoenicoptera*)	Resident	✓	✓	✓	2, 4, 6, 9, 10
Order: Coraciiformes						
25	Indian roller/blue jay (*Coracias benghalensis*)	Resident	✓	✓	✓	1, 2, 3, 8,
26	European roller (*Coracias garrulous*)	Passage migrant	✓	✓	✓	1, 2
27	Green bee-eater (*Merops orientalis*)	Resident/ winter migrant	✓	✓	✓	2, 3, 5, 6, 8, 9, 10
28	Indian grey hornbill (*Ocyceros birostris*)	Resident	✓	✓	✓	4, 9
Order: Cuculiformes						
29	Common crow pheasant (*Centropus sinensis*)	Resident	✓	✓	✓	1, 2, 6, 8, 9, 10
30	Asian koel (*Eudynamus scolopacea*)	Summer breeder	✓	✓	✓	1, 3, 4, 6, 8, 9
Order: Falconiformes						
31	Red necked falcon (*Falco chicquera*)	Resident	✓	✓	-	1, 2
Order: Gruiformes						
32	White-breasted waterhen (*Amaurornis phoenicurus*)	Resident	✓	✓	✓	1, 2, 3, 4, 6, 7, 8
Order: Passeriformes						
33	Bank myna (*Acridotheres ginginianus*)	Resident	✓	✓	✓	1, 2, 3, 6, 8, 9, 10
34	Common myna (*Acridotheres tristis*)	Resident	✓	✓	✓	1, 2, 3, 6, 8, 9, 10
35	Blyth's reed warbler (*Acrocephalus dumetorum*)	Summer breeder	✓	✓	✓	1, 2, 8
36	Moustached sedge warbler (*Acrocephalus melanopogon*)	Winter migrant	-	✓	-	1, 2
37	Small skylark (*Alauda gulgula*)	Winter migrant	✓	✓	✓	1, 2
38	House crow (*Corvus splendens*)	Resident	✓	✓	✓	1, 2, 3, 4, 6, 8, 9, 10

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S. No.	Order/ Common name (Scientific Name)	Migratory/ resident status	Urban green spaces	Agri-cultural lands	Residential/ commercial areas	References
39	Rufous tree pie (*Dendrocitta vagabunda*)	Resident	✓	✓	✓	1, 2, 3, 4, 5, 6, 8, 9, 10
40	Forest wagtail (*Dendronanthus indicus*)	Winter migrant	✓	✓	-	2, 8
41	Black drongo/king crow (*Dicrurus macrocercus*)	Resident	✓	✓	✓	1, 2, 3, 4, 5, 6, 8, 9, 10
42	Red-headed bunting (*Emberiza bruniceps*)	Winter migrant	✓	✓	-	1, 2
43	Red-breasted flycatcher (*Ficedula parva*)	Winter migrant	✓	✓	✓	1, 2
44	Long-tailed shrike (*Lanius schach*)	Resident	✓	✓	✓	2, 3, 4, 8
45	Bay-backed shrike (*Lanius vittatus*)	Resident	✓	✓	✓	2, 4
46	Indian silverbill (*Lonchura malabarica*)	Resident	✓	✓	-	1, 2
47	Blue throat (*Luscinia svecica*)	Winter migrant	✓	✓	-	2, 4, 8
48	Purple-rumped sunbird (*Nectarinia asiatica*)	Resident	✓	✓	✓	1, 2, 3, 5, 6, 9
49	Golden oriole (*Oriolus oriolus*)	Summer breeder	✓	✓	✓	1, 2, 4, 6, 8
50	Common tailorbird (*Orthotomus sutorius*)	Resident	✓	✓	✓	1, 2, 6, 8
51	House sparrow (*Passer domesticus*)	Resident	✓	✓	✓	1, 2, 3, 6, 8, 10
52	Small minivet (*Pericrocotus cinnamomeus*)	Resident	✓	✓	-	2, 9
53	Long-tailed minivet (*Pericrocotus ethologus*)	Resident	✓	✓	-	1, 2
54	Greenish warbler (*Phylloscopus trochiloides*)	Winter migrant	✓	✓	✓	2, 8
55	Baya weaver (*Ploceus philippinus*)	Resident	✓	✓	✓	1, 2, 3, 8, 10
56	Yellow-bellied prinia (*Prinia flaviventris*)	Resident	-	✓	✓	2, 8
57	Red-vented bulbul (*Pycnonotus cafer*)	Resident	✓	✓	✓	1, 2, 3, 5, 6, 8, 9, 10
58	White-eared bulbul (*Pycnonotus leucotis*)	Resident	✓	✓	✓	2, 9
59	White-browned fantail flycatcher (*Rhipidura aureola*)	Resident/ winter migrant	✓	✓	✓	1, 2, 4
60	Lesser whitethroat (*Sylvia curruca*)	Winter migrant	✓	✓	-	1, 2
61	Lesser/common woodshrike (*Tephrodornis pondicerianus*)	Resident	✓	✓	✓	1, 2
62	Asian paradise-flycatcher (*Terpsiphone paradise*)	Summer breeder	-	✓	-	2, 8
63	Common babbler (*Turdoides caudatus*)	Resident	✓	✓	✓	1, 2
64	Striated babbler (*Turdoides earlei*)	Resident	✓	✓	✓	1, 2, 3, 10
65	Oriental white-eye (*Zosterops palpebrosus*)	Resident	✓	✓	✓	2, 8, 5
66	Common iora (*Aegithina tiphia*)	Resident		✓	✓	5, 8
67	Greater short-toed lark (*Calandrella brachydactyla*)	Winter migrant	✓	✓	-	1, 2
68	Purple sunbird (*Cinnyris asiaticus*)	Summer breeder	✓	✓	✓	8, 10
69	Oriental magpie robin (*Copsychus saularis*)	Resident	✓	✓	✓	4, 6, 8, 9, 10
70	Yellow bellied flower pecker (*Dicaeum melanoxanthum*)	Resident	✓	-	✓	5, 9
71	Ashy drongo (*Dicrurus leucophaeus*)	Resident	-	✓	✓	6, 8
72	Asian pied starling (*Gracupica contra*)	Resident	✓	✓	✓	8, 10
73	Black-naped monarch (*Hypothymis azurea*)	Resident		-	-	8, 9

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S. No.	Order/ Common name (Scientific Name)	Migratory/ resident status	Urban green spaces	Agri-cultural lands	Residential/ commercial areas	References
74	Black-headed munia (*Lonchura atricapilla*)	Resident	✓	✓	✓	8, 9
75	Black hooded oriole (*Oriolus xanthornus*)	Resident	✓	✓	✓	6, 8, 9
76	Great tit (*Parus major*)	Resident		✓	✓	1, 5, 8, 9
77	Whiskered bulbul (*Pycnonotus jocosus*)	Resident	✓	✓	✓	6, 8, 9, 10
78	White-cheeked bulbul (*Pycnonotus leucogenys*)	Resident	✓	✓	✓	1, 5
79	Asian pied starling (*Sturnus contra*)	Winter migrant		✓	✓	3, 6, 8, 9
80	Jungle babbler (*Turdoides striata*)	Resident	✓	✓	✓	1, 2, 3, 5, 6, 8, 9, 10
81	Orange headed thrush (*Zoothera citrina*)	Winter migrant	✓	✓	-	6, 8
	Order: Pelecaniformes					
82	Grey heron (*Ardea cinerea*)	*Ardea cinerea*	✓	✓	-	1, 2
83	Purple heron (*Ardea purpurea*)	*Ardea purpurea*	✓	✓	-	1, 8, 2
84	Indian pond heron (*Ardeola grayii*)	*Ardeola grayii*	✓	✓	✓	1, 2, 3, 4, 6, 7, 8,
85	Cattle egret (*Bubulcus ibis*)	*Bubulcus ibis*	✓	✓	✓	1, 2, 3, 4, 6, 7, 8
86	Little egret (*Egretta garzetta*)	*Egretta garzetta*	✓	✓	✓	1, 2, 3, 6, 7, 8
87	Intermediate egret (*Egretta intermedia*)	*Egretta intermedia*	✓	✓	✓	1, 2, 7
88	Little cormorant (*Microcarbo niger*)	Resident	✓	-	✓	2, 8
89	Great Indian cormorant (*Phalacrocorax carbo*)	Resident	✓	-	-	2, 7, 8
90	Night heron (*Nycticorax nycticorax*)	Resident	✓	✓	✓	1, 4, 6, 8
Order: Piciformes						
91	Yellow crowned woodpecker (*Dendrocopos mahrattensis*)	Resident	✓	✓	-	2, 9
92	Black-rumped flameback (*Dinopium benghalense*)	Resident	✓	✓	✓	2, 3, 4, 6, 8, 9,
93	Coppersmith barbet (*Megalaima haemacephala*)	Resident	✓	✓	✓	2, 4, 6, 8, 9
94	Blue throated barbet (*Megalaima asiatica*)	Resident	✓	✓	✓	6, 8
95	Brown-headed barbet (*Megalaima zeylanica*)	Resident	✓	-	-	9, 10
Order: Psittaciformes						
96	Large Indian parakeet (*Psittacula eupatria*)	Resident	✓	✓	✓	1, 2, 5, 8, 9
97	Rose-ringed parakeet (*Psittacula krameri*)	Resident	✓	✓	✓	2, 4, 6, 8, 9, 10
Order: Strigiformes						
98	Spotted little owlet (*Athene brama*)	Resident	✓	✓	✓	1, 2, 3, 4, 6, 8, 9
Order: Suliformes						
99	Darter (*Anhinga melanogaster*)	Winter migrant	✓	✓	✓	1, 2, 6, 8
Order: Suliformes						
100	Indian cormorant (*Phalacrocorax fuscicollis*)	Resident	✓	-	-	7, 8
101	Little cormorant (*Phalacrocorax niger*)	Resident	✓	✓	✓	1, 6

1. Altaf *et al*. (2018); 2. Riaz *et al*. (2020); 3. Zaman *et al*. (2023); 4. Sidra *et al*. (2013); 5. Naithani and Bhatt (2012); 6. Sengupta *et al*. (2014); 7. Rajpar *et al*. (2019); 8. Pal *et al*. (2019); 9. Khera *et al*. (2009); 10. Tiwary and Urfi (2016).

We found 91 (90%) species in agricultural lands. Out of which 72% of species were primarily year-round residents to the reported areas, 22% were winter migrants and seventy-two species (71%) were reported in residential/commercial areas. Out of these, 9 species were winter migrants, 5 of them were only summer breeders,

5 species were partial resident and winter migrants and the remaining 53 bird species were year-round residents in India and Pakistan (Table I). With a total of 101 bird species identified from 17 orders, Passeriformes exhibited the highest diversity of bird species than the other orders in all three habitats with 47 species in cultivated lands, 45 species in green spaces, and 37 species in residential and commercial areas (Table I). The second largest number of species belonged to Pelecaniformes, and then Accipitridiformes. This diversity emphasizes that human-dominated areas contain possible habitats for a wide array of bird species, including both residents and migratory visitors.

DISCUSSION

The list of 101 forest bird species spans across several genera. Notably, large species such as shikra (*Accipiter badius*) and Northern goshawk (*Accipiter gentilis*) occurred in fragmented areas with trees. Also, migratory species were sighted, such as wood sandpiper (*Tringa glareola*) and common greenshank (*Tringa nebularia*); human-dominated areas can provide stopover and wintering habitats along bird migratory flyways (Archer *et al*., 2019; Xu *et al*., 2021). However, not all residential landscapes are created equal. Managing the quality and quantity of urban vegetation is key to creating good breeding and stopover habitat within the built environment and native vegetation can increase native bird diversity (Schneider and Miller, 2014). As observed in one of the review studies, greater bird densities and diversities were discovered in residential areas with higher vegetation cover (Sengupta *et al*., 2014).

Our study results are similar to several review studies of North and South America. In a study of Neotropical migrant birds in South America (Amaya-Espinel and Hostetler, 2019), researchers found that small forest patches and urban tree cover provided some migrants with stopover and wintering habitats. Another study found that certain interior-forest specialists, which are defined as being dependent on extensive forest expanses for successful breeding, utilized small forest fragments in both urban and rural settings and tree canopies within suburban residential areas as crucial stopover sites during migration seasons (Archer *et al*., 2019). However, some migrating species may primarily forage or take shelter near the centers of forest patches; Dawson and Hostetler (2010) found several migrant species that avoided the edges of forest patches, indicating that the interior of these small urban forest fragments may hold significance for these species. Further, Buron *et al*. (2022) demonstrated that birds that primarily foraged under the tree canopy typically utilized urban forest patches more than residential treed areas. Additionally, remnant forest patches, located next to developments, are still utilized by migrating and resident bird species (Hostetler *et al*., 2005). Overall, studies have suggested that both city trees in residential areas and forest fragments in and around cities can provide habitat for different types of forest birds (Archer *et al*., 2019).

Synanthropic species, or urban dwellers, are birds that can effectively take advantage of human-caused changes and disruptions in an urban environment (Fischer *et al*., 2015). The presence of forest generalist species in urban environments of India and Pakistan, such as the house crow (*Corvus splendens*) and common myna (*Acridotheres tristis*), highlights their adaptability to cities, exploiting food waste generated by humans (Marzluff *et al*., 2012; Tariq *et al*., 2024). Other resident species like the house swift (*Apus affinis*) and Indian ring dove (*Streptopelia decaocto*) also demonstrate successful adaptation to human-dominated landscapes (Pal *et al*., 2019). Despite crows being seen in cities, a significant decline in the urban population of house crows has been observed (Radadia, 2013). Factors contributing to this decline could be due to the reduction of trees (Marzluff *et al*., 2001), crowded and heavily built-up areas (Bernat-Ponce *et al*., 2018), toxicity in urban environments (Benmazouz *et al*., 2021; Seress and Liker, 2015), and fluctuations in food availability (Mustafa *et al*., 2015). This decline in crows since 2011 suggests the vulnerability of synanthropic species in the urban areas of India and Pakistan, underscoring the complex interactions between urbanization and bird ecology.

For forest birds in cities, it is important to conserve forest fragments and trees as cities expand. Developers and city planners must take into account design, construction, and post-construction factors to promote the long-term health of trees and forest patches (Hostetler, 2012). For example, construction practices such as parking heavy machinery in forested areas, failure to protect root zones of trees with proper fencing, and failure to recognize and remove invasive vegetation transported from other areas can greatly reduce the ability of trees to survive and forested areas to retain plant and animal diversity (Hostetler, 2012). Further, nearby residents may impact conserved areas through pollution, exotic animals, and the spreading of invasive plants. Conserving forest patches within an urban area can have limited effects on biodiversity when steps are not taken to ensure its biological integrity. Without long-term management, urban forest patches can become ecological traps-habitats that an organism might favor despite increased livelihood of species mortality and decline (Battin, 2004).

It's important to note that while this review lists forest birds seen in urban and fragmented rural areas of Pakistan

and India, the mere presence of a species does not guarantee thriving populations or long-term persistence. Factors such as disease, competition, pollution, and predation can adversely affect certain species (Wilson *et al*., 2019). However, these lists serve as a starting point for identifying local species of concern and potential conservation. City planners can then collaborate with ecologists to assess population vitality and conduct further research on breeding success and foraging availability in fragmented and residential areas. While areas with trees could become bird habitats, potential threats to city birds must be carefully addressed through conservation measures and sustainable urban planning (Hostetler, 2012; Wilson *et al*., 2019).

DECLARATIONS

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During the preparation of this work, the authors used Chat GPT to enhance the Grammar and readability of the article. After using this service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Supplementary material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.pjz/.....

Statement of conflict of interest

The authors have declared no conflict of interest.

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