












## Research Article

# Diversity, Abundance, and Distribution of Avifauna in District Jhang, Pakistan

Ahmad Zaman <sup>1</sup>, Azhar Rafique <sup>1</sup>, Asma Ashraf <sup>1</sup>, Muhammad Shahid Mahmood <sup>2</sup>,  
Nazia Nahid <sup>3</sup>, Farhat Jabeen <sup>1</sup>, Salma Sultana <sup>1</sup>, Tayyaba Sultana <sup>1</sup>, Sultan Ali <sup>2</sup>,  
S. M. Neamul Kabir Zihad <sup>4</sup>, and Shaikh Jamal Uddin <sup>5</sup>

<sup>1</sup>Department of Zoology, Government College University Faisalabad, Punjab 38000, Pakistan

<sup>2</sup>Institute of Microbiology, University of Agriculture Faisalabad, Punjab 38000, Pakistan

<sup>3</sup>Department of Bioinformatics & Biotechnology, Government College University Faisalabad, Punjab 38000, Pakistan

<sup>4</sup>Department of Pharmacy, State University of Bangladesh, Dhaka 1205, Bangladesh

<sup>5</sup>Pharmacy Discipline, Life Science School, Khulna University, Khulna 9208, Bangladesh

Correspondence should be addressed to Azhar Rafique; [azharrafique96@gmail.com](mailto:azharrafique96@gmail.com) and Shaikh Jamal Uddin; [uddinsj@yahoo.com](mailto:uddinsj@yahoo.com)

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The present study was conducted from March 2021 to February 2022 in the Thal desert and Trimmu barrage of district Jhang located in the Punjab province of Pakistan to find out the diversity, abundance, and distribution of birds. The point count method was used for the Trimmu barrage, and the line transect method was used for the collection of data in the Thal desert area. We recorded 31,696 individuals belonging to 67 species of birds from two distinct types of habitats (Thal desert and Trimmu barrage) of district Jhang. Among these species, 39 species were residents, 18 species were winter visitors, 9 species were summer breeders, and a single species (Terek sandpiper) was a passage migrant. Highly significant differences ( $X^2 = 14979.7$ ,  $df = 11$ , and  $P < 0.01$ ) were observed in the abundance of birds between both habitats on every month. From the Thal desert area, 12,905 individuals belonging to 45 species were identified while 18,791 individuals from 58 bird species were observed in the Trimmu barrage, with 36 bird species among 67 species being common at both habitats. The most dominant species of the Trimmu barrage were the common pochard, little grebe, common coot, cattle egret, gadwall, little egret, red-wattled lapwing, and common teal. On the other hand, the Indian roller, common quail, cattle egret, common myna, and Indian kite were found to be the most common species in the Thal desert. The most notable feature of the present study is the identification of *Xenus cinereus* (Terek sandpiper) and *Ammomanes phoenicura* (rufous-tailed lark) in district Jhang as both species had no previous record in the study area. The Trimmu barrage was the more diverse and abundant site compared to the Thal desert as it provides both terrestrial and aquatic habitats for birds. The study determined that more varieties in the habitat and thermal changes affect the diversity, abundance, and distribution of birds.

## 1. Introduction

Deserts are low average annual rainfall areas usually containing 100 millimeters (less than 4 inches) or less rain per year. A desert is considered to be one of the most susceptible ecosystems in the world to climate change. Increasing temperature, declining rainfall, and a high level

of atmospheric CO<sub>2</sub> are expected to highly affect the structure and function of desert ecosystems intensively disturbing desert-inhabiting birds [1]. The present research investigated diversity, abundance, and distribution of avian fauna in terrestrial and semiaquatic types of habitats including the Thal desert and Trimmu barrage of district Jhang.

Birds are valuable components of the world desert and aquatic habitats; i.e., they play a key role in maintaining the stability and inherent functions of dwelling ecosystems. On top of that, birds amuse humans with their behaviour, beautiful colors, and songs [2]. Insectivorous birds eliminate vectors of various diseases, and scavenger birds such as *Corvus albus* (pied crow) as well as vultures serve as decomposers [3]. Birds are one of the most significant contributors to seed dispersion and pollination along with disease control [4].

Small rodents which cause incalculable damage to crops are controlled by birds such as the kestrel and barn owl [5]. Desert birds (desert wheatear, common quail, and Indian golden oriole), have behavioural adaptations such as the tendency to survive in unfavourable conditions. This behaviour allows these birds to move from less productive sites to more productive sites. Some birds such as the burrowing owl use the burrows of rodents during the mid-hot day to avoid very high temperatures. The majority of desert birds frequently feed on ants, very rarely seen by other temperate-region birds. Most birds such as the Asian koel, striated babbler, common myna, bank myna, and baya weaver show a seasonal feeding behaviour according to the availability of food [6]. Since Pakistan is the 5<sup>th</sup> largest populous country in the world, this overpopulation imposes some detrimental threats ranging from loss of habitat to extinction to avian diversity due to deforestation, agricultural expansion, urbanization, industrialization, change in desert ecosystems (human settlement, plantations, and agricultural practices), and habitat loss [7].

Deserts are the result of erratic climatic changes. Deserts contain scarcity of surface water which directly affects species richness because just like other organisms, water is the basic requirement for the survival of birds [8]. The total number of bird species across the globe is 9042 while 2700 avian species have been reported from Asia [9]. Pakistan harbours a diverse avian fauna due to its geographical structure that encompasses diversity of habitat, i.e., forest habitat, desert habitat, and aquatic habitat, and is home to more than 750 species of birds including 105 water bird species [10]. Previous reports show that wetlands and riverine systems are some of the best sites for wintering and migratory birds [11]. Wetlands are transitional areas between aquatic and terrestrial ecosystems. Pakistan has one of the largest irrigation systems in the world representing 225 wetland sites. Pakistan contains 43% endemic bird species, 30% of species are long-distance migrant, and 27% of species are winter visitors [12]. The Thal desert area and Trimmu barrage support a huge number of residents as well as migratory birds such as the houbara bustard, cuckoos, and quails. Some of these birds travel from central Asia during the winter season to avoid harsh climatic conditions [13]. The study area Trimmu barrage is an important wetland site for migratory and endemic species of birds. The barrage area is a complex of aquatic and terrestrial ecosystems and provides an ideal habitat for a vast variety of migratory and endemic avian fauna [14]. The Thal desert is spread across the districts of Jhang, Layyan, Bhakkar, Khushab, and Mianwali. The most prominent feature of this desert is the dunes [15]. The Thal

desert area of district Jhang is approximately 120 km. Athara Hazari is the most dominant tehsil of district Jhang contributing to 80 percent (100 km) of the desert area. On one side, the district contains an open desert ecosystem while, on the other side, it contains flowing water in the form of the river Chenab and river Jhelum. The union of both these rivers contains a huge reserve of water in the form of the Trimmu barrage. Both rivers merge at Athara Hazari and then originate from Trimmu barrage as a single Chenab river. Despite this fact, the study area (Jhang) is one of the dominant avian regions of Pakistan due to two very distinct types of habitat. Three major threats have been observed in the study area. The natural desert ecosystem is being converted by irrigation systems; hunting on a large scale which has been adopted as a profession, even though the Thal area has been declared as a game reserve by the government of Punjab (Pakistan); and disturbance by visitors especially at Trimmu barrage. Regional study for the determination of avian diversity in these areas is highly warranted and pivotal for the conservation of the bird species [16]. However, urbanization resulting in commercial farming [17] has been a permanent factor endangering the wildlife. Abouelela et al. [18] has reported the transformation in anatomical and histological features of cats. Different types of bacterial, protozoal, and parasitic infections emerging in food animals, mainly chicken, pork, sheep, and goat [19], and companion animals, i.e., dog and cats, ultimately pose a very high risk on the wild bird population, which may get infected through exposure to them [20].

The present study was conducted in the Thal desert area and Trimmu barrage of district Jhang to determine the diversity, abundance, and distribution of avian fauna in one of the richest biodiversity regions of Pakistan. The current survey is the second and recent research in the Thal desert area of district Jhang, as the first study was conducted in 2009. The combined research of both habitats (Thal desert and Trimmu barrage) is the first ever attempted.

## 2. Materials and Methods

**2.1. Study Area.** This study was carried out in district Jhang, Punjab, Pakistan, located between 31.1929°N and 72.2364°E and covers an area of 6162 km<sup>2</sup>. Two habitats, namely, Thal Desert and Trimmu barrage, were selected to determine the avian diversity, abundance, and distribution at different parts of the district.

**2.1.1. Trimmu Barrage.** Trimmu barrage is located in tehsil Jhang, 21 km from Jhang city. It comprises both aquatic and terrestrial habitats. The dominant flora encompasses *Acacia nilotica*, *Albizia lebeck*, *Ficus religiosa*, *Eucalyptus camaldulensis*, and *Dalbergia sissoo*. Ground vegetation comprised *Chenopodium album*, *Malva parviflora*, *Medicago polymorpha*, *Alhagi maurorum*, and *Melilotus indica*. Aquatic plants comprised *Hydrilla verticillata*, *Vallisneria spiralis*, *Nymphaea lotus*, and *Saccharum bengalense*, etc. The head pond area of Trimmu barrage is 3680.43 acres. The peripheral region of the river Jhelum and river Chenab flowing through district Jhang contains very fertile land for the cultivation of wheat, rice, corn, and sugar cane.

**2.1.2. Athara Hazari Thal Desert.** It is a barren area with harsh weather conditions that spreads across the districts of Jhang, Layyan, Bhakkar, Khushab, and Mianwali. It has been declared a game reserve since 1974 by the government of Punjab. Athara Hazari is the major Thal desert area which constitutes 80% (100/120 km) of the Thal desert in district Jhang. The current study on the Thal desert was conducted in Athara Hazari tehsil. About 85% of the area of this desert is nonirrigated. The only nonirrigated cultivated crop is chick pea (*Cicer arietinum*) which is grown in winter and fully depends on rain. It is one of the major sources of food and shelter for migratory and local birds. The noncultivated flora include *Prosopis cineraria*, *Tamarix aphylla*, *Prosopis juliflora*, *Salvadora oleoides*, *Acacia jacquemontii*, *Capparis aphylla*, and *Calligonum polygonoides*.

**2.2. Field Survey.** This survey was conducted throughout the year from March 2021 to February 2022 to find out the diversity and abundance of migratory and local birds. This was done on a monthly basis from sunrise to sunset (full day) to explore every possible opportunity. Thus, the study hours were limited not only to dawn and dusk. During each month for the two sampling sites (Trimmu barrage and Thal desert), each site was visited consecutively on a separate day. Two visits were done each month, while the area was visited 24 times during the whole study period. The point count method was used to determine the bird diversity and abundance in Trimmu barrage. The survey points include river banks, island, and surroundings fields. Ten point counts were established randomly in each survey point. The total number of point counts was 30 over the strip of 5 kilometers. The minimum distance between two point counts was a 250-meter radius [13]. The head pond area was visited by using a wooden boat while the marginal bunds were visited by foot to observe the avian fauna. Both direct and indirect methods were used for the collection of data. The direct method included field area observation by experienced observers while, indirectly, the information was gained from local people and hunters. Birds were enumerated by using a pair of binoculars and a spotted scope while a camera was used to photograph the birds for later identification. For identification of avian fauna, various practical guides were consulted [21, 22].

By following Mola et al. [11], the line transect method was used for observing the birds of the wetland area of the Thal desert. Since the Thal desert contains a uniform type of habitat due to very little vegetation, birds are easily visible. Two transect lines were arranged, and the length of each transect line was 20 km. Keeping in mind the topography of the study area, the transect lines were isolated from each other at a distance of 200 to 250 meters.

**2.3. Data Analysis.** For statistical analysis, the Minitab software was used. The Shannon-Weiner index was calculated to find out the diversity of birds in the sampling area. The Shannon-Wiener diversity index ( $H$ ) was calculated to point out both species richness (the number of species in a given area) and their abundances. Its values normally ranges

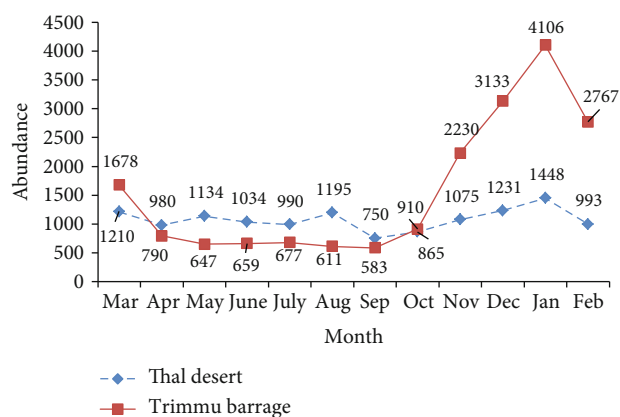


FIGURE 1: Comparison in abundance of birds at Trimmu barrage and Thal desert on monthly bases.

between 1.5 and 3.5. The level of significance was 0.05. The following formula was used for the Shannon-Wiener index.

$H = -\sum[(p_i) \cdot \log(p_i)]$ , where  $H$  is the Shannon wiener index,  $p_i$  is the proportion of individuals of the  $i$ -th species in a whole community, and  $\log$  is the natural logarithm.

Relative abundance =  $ni/N \times 100$ , where  $ni$  is the number of individuals of a single species and  $N$  is the total number of individuals of all the species.

One-way ANOVA and  $t$  test were used to compare the month-wise diversity and abundance of birds at both sampling sites.

### 3. Results

**3.1. Avian Fauna of District Jhang.** During the study, 67 bird species were identified from the two different sampling sites (Trimmu barrage and Thal desert) of district Jhang. The number of individual birds at Trimmu barrage was 18,791 while 12,905 individual birds were identified at the Thal desert. The most dominant order was Passeriformes representing 24 species of birds belonging to 13 families. The most common families were Accipitridae, Ardeidae, and Anatidae each representing 5 species. Fifty-eight species were observed at Trimmu barrage while 45 species were observed from the Thal desert area of district Jhang. Out of the 67 bird species, 36 species were common at both types of habitat. A total of 31,696 individual birds were observed at both sampling sites. Figure 1 represents the difference in the abundance of birds at both sites.

Highly significant differences ( $X^2 = 14979.7$ ,  $df = 11$ , and  $P < 0.01$ ) were observed in the diversity and abundance of birds overall between the Trimmu barrage and Thal desert area on a monthly basis (Table 1). The most prominent feature of the present study is the identification of *Xenus cinereus* (Terek sandpiper) and *Ammomanes phoenicura* (rufous-tailed lark) in district Jhang as both species have no previous record in the study area.

**3.2. Distribution Status of Avian Fauna in District Jhang.** As for the distribution of avian fauna, 39 species were resident, 18 species were winter visitors, 9 species were summer

TABLE 1: Month-wise analysis of variance (ANOVA) between sampling sites.

Source	Overall		Thal desert		Trimmu barrage	
	df	Mean squares	df	Mean squares	df	Mean squares
Month	11	14979.7**	11	553.49 <sup>NS</sup>	11	22223.8**
Error	910	4003.5	405	1639.46	493	5850.8
Total	921		16		504	

Key: NS: nonsignificant ( $P > 0.05$ ); \*significant ( $P < 0.05$ ); \*\*highly significant ( $P < 0.01$ ).

breeders, and a single species (Terek sandpiper) was a passage migrant.

**3.2.1. Resident Birds.** The birds which are found all year round in a particular area are called resident birds. The current study found 39 resident species in district Jhang of Pakistan, namely, *Streptopelia decaocto* (Eurasian collared dove), *Columba livia* (rock pigeon), *Gallinula chloropus* (common moorhen), *Amurornis phoenicurus* (white-breasted waterhen), *Dinopium benghalense* (black-rumped woodpecker), *Centropus sinensis* (greater coucal), *Himantopus himantopus* (black-winged stilt), *Vanellus indicus* (red-wattled lapwing), *Actitis hypoleucos* (common sandpiper), *Upupa epops* (Eurasian hoopoe), *Saxicola caprata* (Pied bushchat), *Saxicoloides fulicatus* (Indian robin), *Lanius schach* (long-tailed shrike), *Lanius excubitor* (great grey shrike), *Corvus splendens* (Indian house crow), *Corvus corax* (common raven), *Dendrocitta vagabunda* (Rufous treepie), *Dicrurus macrocercus* (black drongo), *Acridotheres tristis* (common myna), *Acridotheres ginginianus* (bank myna), *Pycnonotus cafer* (red-vented bulbul), *Motacilla alba* (white wagtail), *Galerida cristata* (crested lark), *Ammomanes phoenicurus* (rufous-tailed lark), *Argya earlei* (striated babbler), *Argya striatus* (jungle babbler), *Argya caudata* (common babbler), *Milvus migrans* (pariah kite), *Elanus caeruleus* (black-winged kite), *Bubulcus ibis* (cattle egret), *Egretta garzetta* (little egret), *Ardea intermedia* (intermediate egret), *Ardeola grayii* (Indian pond heron), *Ixobrychus sinensis* (yellow bittern), *Coracias benghalensis* (Indian roller), *Halcyon smyrnensis* (white-throated kingfisher), *Alcedo atthis* (common kingfisher), *Ceryle rudis* (pied kingfisher), and *Athene noctua* (little owl).

**3.2.2. Winter Visitors.** The study area hosted 18 species of visitor birds which migrated there after covering thousands of miles. These birds started to arrive in Pakistan during October and November from central Asian countries to avoid the intense cold. The frequent winter visitor species of district Jhang were identified as *Oenanthe deserti* (Desert wheatear), *Hirundo rustica* (common swallow), *Motacilla flava* (yellow wagtail), *Circus cyaneus* (hen harrier), *Aquila nipalensis* (steppe eagle), *Accipiter nisus* (Eurasian sparrowhawk), *Tachybaptus ruficollis* (little grebe), *Aythya ferina* (common pochard), *Anas crecca* (common teal), *Anas platyrhynchos* (mallard), *Anas strepera* (gadwall), *Anas penelope* (wigeon), *Fulica atra* (common coot), *Chlamydotis undulata* (houbara bustard), *Falco peregrinus* (peregrine falcon), *Coturnix coturnix* (common quail), *Phoenicopterus roseus* (greater flamingo), and *Charadrius dubius* (little ringed plover).

**3.2.3. Summer Breeders.** The 9 species of summer breeders in district Jhang were *Cinnyris asiaticus* (purple sunbird), *Hirundo smithii* (wire-tailed swallow), *Oriolus kundoo* (Indian golden oriole), *Ploceus philippinus* (baya weaver), *Merops orientalis* (green bee-eater), *Streptopelia tranquebarica* (red collared dove), *Clamator jacobinus* (Jacobin cuckoo), *Tockus nasutus* (grey hornbill), and *Eudynamis scolopacea* (Asian koel).

**3.2.4. Passage Migrant.** The single observed passage migrant species of the study area was *Xenus cinereus* (Terek sandpiper; Table 2).

**3.3. Bird Diversity at Trimmu Barrage.** The Trimmu barrage was a very dominant site with respect to avian fauna as it shows the features of both terrestrial and aquatic habitats. During the 12-month field survey, 58 species of birds were identified, and 18,791 individual birds were observed from terrestrial and aquatic habitats of Trimmu barrage. Common pochard (2332 individuals) was the most abundant species followed by little grebe (2327 individuals), common coot (1776 individuals), cattle egret (1281 individuals), gadwall (1270 individuals), little egret (956 individuals), red-wattled lapwing (488 individuals), and common teal (475 individuals). The least common bird species were the grey hornbill (6 individuals), hen harrier (12 individuals), Terek sandpiper (15 individuals), and crested lark (16 individuals). The highest relative abundance was noted for the common pochard (12.4%) followed by the little grebe (12.3%), common coot 9.5%, cattle egret (6.8%), gadwall (6.7%), little egret (5%), red-wattled lapwing (2.6%), and common teal (2.5%; Figure 2(a)).

The maximum number (4106) of bird individuals was observed during January followed by December (3133), February (2767), November (2230), March (1678), October (910), April (790), July (677), June (659), May (647), August (611), and September (583). The highest Shannon-Weiner diversity index (3.450) was recorded for January while the lowest was observed for September (2.901; Table 3). This huge population of birds observed in this area during winter months is due to the arrival of winter visitor birds. The highest diversity of avian fauna was also observed during December and January when 51 bird species were identified followed by February (48), November (47), March (45), April (43), July (40), June (38), and May (37).

The least number of species was observed during September and October when only 35 species were identified. During this part of the year, the summer breeders move back and winter visitors are yet to arrive. So bird diversity and

TABLE 2: Distribution of avian fauna of district Jhang.

	Order	Family	Scientific name	Common name	Status
1	Passeriformes	Nectariniidae	<i>Cinnyris asiaticus</i> (Latham, 1790)	Purple sunbird	SB
2		Muscicapidae	<i>Saxicola caprata</i> (Linnaeus, 1766)	Pied bushchat	R
3			<i>Oenanthe deserti</i> (Temminck, 1829)	Desert wheatear	WV
4			<i>Saxicoloides fulicatus</i> (Linnaeus, 1766)	Indian robin	R
5		Laniidae	<i>Lanius schach</i> (Linnaeus, 1758)	Long-tailed shrike	R
6			<i>Lanius excubitor</i> (Linnaeus, 1758)	Great grey shrike	R
7		Corvidae	<i>Corvus splendens</i> (Linnaeus, 1758)	Indian house crow	R
8			<i>Corvus corax</i> (Linnaeus, 1758)	Common raven	R
9			<i>Dendrocitta vagabunda</i> (Latham, 1790)	Rufous treepie	R
10		Dicruridae	<i>Dicrurus macrocercus</i> (Vieillot, 1817)	Black drongo	R
11		Sturnidae	<i>Acridotheres tristis</i> (Linnaeus, 1766)	Common myna	R
12			<i>Acridotheres ginginianus</i> (Latham, 1790)	Bank myna	R
13		Hirundinidae	<i>Hirundo rustica</i> (Linnaeus, 1758)	Common swallow	WV
14			<i>Hirundo smithii</i> (Leach, 1818)	Wire-tailed swallow	SB
15		Pycnonotidae	<i>Pycnonotus cafer</i> (Linnaeus, 1766)	Red-vented bulbul	R
16		Motacillidae	<i>Motacilla alba</i> (Linnaeus, 1758)	White wagtail	R
17			<i>Motacilla flava</i> (Linnaeus, 1758)	Yellow wagtail	WV
18		Oriolidae	<i>Oriolus kundoo</i> (Sykes, 1832)	Indian golden oriole	SB
19		Alaudidae	<i>Galerida cristata</i> (Linnaeus, 1758)	Crested lark	R
20			<i>Ammomanes phoenicura</i> (Franklin, 1831)	Rufous-tailed lark	R
21		Leiothrichidae	<i>Argya earlei</i> (Blyth, 1844)	Striated babbler	R
22			<i>Argya striatus</i> (Dumont, 1823)	Jungle babbler	R
23			<i>Argya caudata</i> (Dumont, 1823)	Common babbler	R
24		Ploceidae	<i>Ploceus philippinus</i> (Linnaeus, 1766)	Baya weaver	SB
25	Accipitriformes	Accipitridae	<i>Circus cyaneus</i> (Linnaeus, 1766)	Hen harrier	WV
26			<i>Milvus migrans</i> (Boddaert, 1783)	Pariah kite	R
27			<i>Aquila nipalensis</i> (Hodgson, 1833)	Steppe eagle	WV
28			<i>Elanus caeruleus</i> (Desfontaines, 1789)	Black-winged kite	R
29			<i>Accipiter nisus</i> (Linnaeus, 1758)	Eurasian sparrowhawk	WV
30	Pelecaniformes	Ardeidae	<i>Bubulcus ibis</i> (Linnaeus, 1758)	Cattle egret	R
31			<i>Egretta garzetta</i> (Linnaeus, 1766)	Little egret	R
32			<i>Ardea intermedia</i> (Wagler, 1827)	Intermediate egret	R
33			<i>Ardeola grayii</i> (Sykes, 1832)	Indian pond heron	R
34			<i>Ixobrychus sinensis</i> (Gmelin, 1789)	Yellow bittern	R
35	Coraciiform	Coraciidae	<i>Coracias benghalensis</i> (Linnaeus, 1758)	Indian roller	R
36		Alcedinidae	<i>Halcyon smyrnensis</i> (Linnaeus, 1758)	White-throated kingfisher	R
37			<i>Alcedo atthis</i> (Linnaeus, 1758)	Common kingfisher	R
38			<i>Ceryle rudis</i> (Linnaeus, 1758)	Pied kingfisher	R
39		Meropidae	<i>Merops orientalis</i> (Latham, 1801)	Green bee-eater	SB
40	Podicipediformes	Podicipedidae	<i>Tachybaptus ruficollis</i> (Pallas, 1764)	Little grebe	WV
41	Strigiform	Strigidae	<i>Athene noctua</i> (Scopoli, 1769)	Little owl	R
42	Columbiformes	Columbidae	<i>Streptopelia decaocto</i> (Frisvaldszky, 1838)	Eurasian collared dove	R
43			<i>Streptopelia tranquebarica</i> (Hermann, 1804)	Red collared dove	SB
44			<i>Columba livia</i> (Gmelin, 1789)	Rock pigeon	R
45			Anseriformes	Anatidae	<i>Aythya ferina</i> (Linnaeus, 1758)
46			<i>Anas crecca</i> (Linnaeus, 1758)	Common teal	WV
47			<i>Anas platyrhynchos</i> (Linnaeus, 1758)	Mallard	WV
48			<i>Anas strepera</i> (Linnaeus, 1758)	Gadwall	WV

TABLE 2: Continued.

Order	Family	Scientific name	Common name	Status
49		<i>Anas penelope</i> (Linnaeus, 1758)	Wigeon	WV
50	Gruiformes	<i>Fulica atra</i> (Linnaeus, 1758)	Common coot	WV
51		<i>Gallinula chloropus</i> (Linnaeus, 1758)	Common moorhen	R
52		<i>Amaurornis phoenicurus</i> (Pennant, 1769)	White-breasted waterhen	R
53	Otidiformes	<i>Chlamydotis undulata</i> (Jacquin, 1784)	Houbara bustard	WV
54	Falconiformes	<i>Falco peregrinus</i> (Tunstall, 1771)	Peregrine falcon	WV
55	Galliformes	<i>Coturnix coturnix</i> (Linnaeus, 1758)	Common quail	WV
56	Piciformes	<i>Dinopium benghalense</i> (Linnaeus, 1758)	Black-rumped woodpecker	R
57	Cuculiformes	<i>Centropus sinensis</i> (Stephens, 1815)	Greater coucal	R
58		<i>Clamator jacobinus</i> (Linnaeus, 1758)	Jacobin cuckoo	SB
59		<i>Eudynamis scolopacea</i> (Linnaeus, 1758)	Asian koel	SB
60	Phoenicopteriformes	<i>Phoenicopterus roseus</i> (Pallas, 1811)	Greater flamingo	WV
61	Charadriiformes	<i>Himantopus himantopus</i> (Linnaeus, 1758)	Black-winged stilt	R
62		<i>Vanellus indicus</i> (Boddaert, 1783)	Red-wattled lapwing	R
63		<i>Charadrius dubius</i> (Scopoli, 1786)	Little ringed plover	WV
64		<i>Xenus cinereus</i> (Guldenstadt, 1775)	Terek sandpiper	PM
65		<i>Actitis hypoleucos</i> (Linnaeus, 1758)	Common sandpiper	R
66	Bucerotiformes	<i>Upupa epops</i> (Linnaeus, 1758)	Eurasian hoopoe	R
67		<i>Tockus nasutus</i> (Linnaeus, 1766)	Grey hornbill	SB

Key: R: resident; SB: summer breeder; WV: winter visitor; PM: passage migrant.

abundance decreases. By comparing both study sites, during the months of April ( $t = 7.86$ ), May ( $t = 9.90$ ), June ( $t = 4.10$ ), July ( $t = 4.50$ ), August ( $t = 3.62$ ), December ( $t = 2.60$ ), and February ( $t = 6.81$ ), highly significant differences ( $P < 0.01$ ) were detected in the diversity of birds. Significant variations ( $P < 0.05$ ) were recorded in abundance as well as diversity during September ( $t = 1.98$ ) and November ( $t = 2.06$ ). Statistically nonsignificant differences ( $P > 0.05$ ) were noted during January ( $t = 0.00$ ), March ( $t = 1.28$ ), and October ( $t = 1.07$ ; Table 3). Table 4 briefly shows the diversity of birds at the Trimmu barrage of district Jhang.

**3.4. Bird Diversity at Thal Desert.** The most abundant species at the Thal desert with respect to the number of individuals were the Indian roller (1830), common quail (1122), cattle egret (939), green bee-eater (712), little egret (642), red-vented bulbul (594), common myna (482), Indian house crow (471), and Indian/pariah kite (461). The least common species were the crested lark (12 individuals), common kestrel (15 individuals), steppe eagle (41 individuals), red collared dove (48 individuals), and desert wheatear (50 individuals). The highest relative abundance was recorded for the Indian roller (14%) followed by the common quail (8%), cattle egret (7%), green bee-eater (5.5%), little egret (5%), red-vented bulbul (4%), common myna (3.71%), Indian house crow (3.6%), and Indian/pariah kite (3.5%; Figure 2(b)).

According to the distribution of avian fauna in the Thal desert area, 33 species were residents, 6 species were winter visitors, and six species were summer breeders. During the

month of January, bird abundance was at the peak level as 1447 individuals were observed followed by December (1231), March (1210), August (1195), May (1134), November (1075), June (1034), February (993), July (990), April (980), October (865), and September (750). Table 5 concisely elaborates the diversity and abundance of birds at the Thal desert of district Jhang.

Bird diversity was also at the top level during January when 38 species were observed followed by November and August (37 species each); December, February, March, and June (35 species each); and April, May, and July (34 species each). The least bird diversity level was recorded during September and October when only 32 species and 31 species were observed, respectively. The highest Shannon-Weiner diversity index (3.292) was noted for January while the lowest was for October (2.704; Table 3). Concerning the abundance of birds between the Thal desert and Trimmu barrage, significant difference ( $P < 0.05$ ) was observed for the months of April ( $t = 2.01$ ), May ( $t = 1.99$ ), July ( $t = 2.21$ ), and August ( $t = 2.22$ ). During the months of January, February, March, June, September, October, November, and December, no significant differences ( $P > 0.05$ ) were seen (Table 6 and Figure 1).

#### 4. Discussion

The current study was conducted on monthly bases in district Jhang to find out the diversity, abundance, and distribution of avian fauna. During the study, 67 species of birds were identified and 31,696 individual birds were observed



TABLE 3: Comparison in diversity between Thal desert and Trimmu barrage in different months by *t* test and Shannon diversity index.

Month	Thal desert			Trimmu barrage			<i>t</i> -value	<i>P</i> value
	S	H'	Var H	S	H'	Var H		
Mar	35	3.170	0.00051	45	3.207	0.00071	1.28 <sup>NS</sup>	0.100
Apr	34	2.910	0.00068	43	3.012	0.00072	7.86**	0.000
May	34	2.989	0.00102	37	2.990	0.00055	9.90**	0.000
June	35	3.090	0.00083	38	2.993	0.00092	4.10**	0.000
July	34	2.801	0.00074	40	2.991	0.00084	4.50**	0.000
Aug	37	3.119	0.00067	35	2.941	0.00076	3.62**	0.000
Sep	32	2.734	0.00096	35	2.901	0.00130	1.98*	0.024
Oct	31	2.704	0.00160	35	3.013	0.00162	1.07 <sup>NS</sup>	0.142
Nov	37	3.092	0.00136	47	3.264	0.00070	2.06*	0.020
Dec	35	3.179	0.00081	51	3.391	0.00049	2.60**	0.005
Jan	38	3.292	0.00093	51	3.450	0.00037	0.00 <sup>NS</sup>	0.500
Feb	35	3.067	0.00065	48	3.314	0.00054	6.81**	0.000
Total	45	3.342	0.00007	58	3.351	0.00007	0.77 <sup>NS</sup>	0.222

Key: S: number of species (richness); H': Shannon's diversity index; NS: nonsignificant ( $P > 0.05$ ); \*significant ( $P < 0.05$ ); \*\*highly significant ( $P < 0.01$ ).

from the two sampling areas (Trimmu barrage and Thal desert) of the district Jhang. From the Trimmu barrage, 18,791 individuals and 58 bird species were identified while 45 species and 12,905 individuals were observed from the Thal desert area. Among the 67 species, 39 species were residents and are found throughout the year, 18 species were winter visitors, 9 species were summer breeders, and a single species was a passage migrant. The most dominant order was Passeriformes.

Mahboob and Zaib-un-Nisa [14] conducted a 9-month survey at the same site (Trimmu barrage) during 2004-2005 and recorded 89 species of birds having 9699 individuals. Resident species were 52, winter visitors 29, summer breeders 4, and ordinary migrants were also 4. Comparison of both studies reveals that bird diversity has decreased while the number of individuals rose up. Our findings are similar to a previous study with respect to the distribution of birds as both studies share that December and January (winter season) were the most favourable time for the diversity and abundance of avian fauna. During the previous study, the green bee-eater was observed from December to August continuously, while during the current study, it was found from February to August only. No individual was observed during the winter months of December and January.

In the present study, 58 bird species and 18,791 individuals were observed from the Trimmu barrage. The most dominant species were the common pochard (2332 individuals) followed by the little grebe (2327 individuals), common coot (1776 individuals), cattle egret (1281 individuals), gadwall (1270 individuals), little egret (956 individuals), red-wattled lapwing (488 individuals), and common teal (475 individuals). Sixteen species of birds of the current study were similar to those of another previous survey. Khan et al. [13] did a field survey during 2018 at the Trimmu barrage and reported 11,556 individual birds belonging to 26

species. Both the studies have 16 common species. The common coot (7240 individuals) was the most common species of the 2018 survey followed by the common pochard (1102), northern shover (630), little grebe (495), common teal (311), black-winged stilt (258), and gadwall (193). The current survey identified these same species except for the northern shover but contradict with the diversity and abundance of avian fauna.

The present study confirmed that out of 58 bird species observed in the Trimmu barrage of district Jhang, 39 bird species were common at the Trimmu barrage and Taunsa barrage. Bibi et al. [23] conducted a study during 2008 at Taunsa barrage located in the Muzaffargarh district of Pakistan and recorded 171 species of birds. The most notable thing was the presence of various vulture species such as *Gyps bengalensis* and *Gyps africanus*. However, no vulture species was observed in present study. Secondly, in the Taunsa barrage survey, the population of the black drongo and gadwal was in a decreasing trend, but in the current study, the population of both species was increasing.

The current research evaluated that 30 species of the Trimmu barrage were similar to those of the Chashma barrage (Mianwali, Pakistan). Akbar et al. [24] investigated the diversity and abundance of the Chashma barrage (Mianwali, Pakistan) and recorded 533,965 individuals of 46 species. The most dominant species of the present study were also recorded from the study of the Chashma barrage, but their number of individuals was very high.

According to the present finding, the common fauna of the Trimmu barrage and Dhapchapak lake of Dera Ismail Khan (KPK, Pakistan) included the great egret and gadwal, Asian koel, Eurasian hoopoe, common kestrel, greater coucal, Indian roller, black drongo, purple sunbird, red collared dove, and Indian golden oriole. Najam-un-Nisa et al. [12] determined the bird diversity of the Dhapchapak lake of



TABLE 4: Diversity of birds at Trimmu barrage of district Jhang (March 2021–Feb 2022 survey on month bases).

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
1	<i>Cinnyris asiaticus</i>	Purple sunbird	0	21	17	12	35	8	0	0	0	0	0	0	93
2	<i>Saxicola caprata</i>	Pied bushchat	27	16	25	32	17	35	4	17	10	21	15	14	233
3	<i>Lanius schach</i>	Long-tailed shrike	12	5	28	4	0	24	5	0	2	2	15	3	100
4	<i>Lanius excubitor</i>	Great grey shrike	20	7	10	3	6	4	12	0	5	2	6	4	79
5	<i>Corvus splendens</i>	Indian house crow	32	39	35	17	11	20	13	14	20	25	10	21	257
6	<i>Dendrocitta vagabunda</i>	Rufous treepie	13	24	21	6	2	5	18	0	4	5	30	3	131
7	<i>Dicrurus macrocercus</i>	Black drongo	28	13	7	6	5	7	9	13	7	16	5	8	124
8	<i>Acridotheres tristis</i>	Common myna	42	21	30	33	43	9	16	26	20	18	27	12	297
9	<i>Acridotheres ginginianus</i>	Bank myna	18	10	9	6	7	0	11	13	0	4	5	3	86
10	<i>Hirundo rustica</i>	Common swallow	0	0	0	0	0	0	0	3	23	17	32	24	99
11	<i>Hirundo smithii</i>	Wire-tailed swallow	10	4	21	11	18	0	0	0	0	0	0	0	64
12	<i>Pycnonotus cafer</i>	Red-vented bulbul	28	15	23	31	20	16	10	19	26	34	21	25	268
13	<i>Motacilla alba</i>	White wagtail	34	12	6	11	1	7	11	10	18	30	42	15	197
14	<i>Motacilla flava</i>	Yellow wagtail	0	0	0	0	0	0	0	10	25	20	13		68
15	<i>Oriolus kundoo</i>	Indian golden oriole	0	0	25	14	18	1	0	0	0	0	0	0	58
16	<i>Galerida cristata</i>	Crested lark	3	2	0	0	4	1	0	0	1	3	1	1	16
17	<i>Ammomanes phoenicura</i>	Rufous-tailed lark	5	8	7	11	10	4	18	11	3	15	18	12	122
18	<i>Argya earlei</i>	Striated babbler	30	12	8	18	0	12	9	14	22	17	45	14	201
19	<i>Argya striatus</i>	Jungle babbler	27	15	17	27	30	17	10	5	31	33	48	40	300
20	<i>Argya caudata</i>	Common babbler	14	20	8	14	3	28	16	10	6	19	27	24	189
21	<i>Saxicoloides fulicatus</i>	Indian robin	5	3	13	0	8	5	3	0	1	4	6	2	50
22	<i>Circus cyaneus</i>	Hen harrier	0	0	0	0	0	0	0	0	3	4	5	0	12
23	<i>Milvus migrans</i>	Pariah kite	51	10	22	11	18	20	15	26	19	40	62	12	306
24	<i>Aquila nipalensis</i>	Steppe eagle	0	0	0	0	0	0	0	0	12	21	39	23	95
25	<i>Elanus caeruleus</i>	Black-winged kite	15	2	0	7	5	0	1	3	4	33	38	26	134
26	<i>Accipiter nisus</i>	Eurasian sparrowhawk	0	0	0	0	0	0	0	0	14	29	24	19	86
27	<i>Bubulcus ibis</i>	Cattle egret	112	81	55	80	51	49	67	72	104	210	275	125	1281
28	<i>Egretta garzetta</i>	Little egret	47	61	32	55	29	65	77	55	70	170	145	150	956
29	<i>Ardea intermedia</i>	Intermediate egret	15	10	11	0	4	18	0	20	14	7	18	12	129
30	<i>Ardeola grayii</i>	Indian pond heron	35	18	0	40	32	0	48	26	33	41	48	21	342
31	<i>Ixobrychus sinensis</i>	Yellow bittern	21	11	0	30	16	24	8	3	33	40	49	10	245
32	<i>Coracias benghalensis</i>	Indian roller	31	8	16	19	39	22	5	13	16	25	20	12	226
33	<i>Halcyon smyrnensis</i>	White-throated kingfisher	27	12	18	4	2	23	14	5	20	26	40	31	222
34	<i>Alcedo atthis</i>	Common kingfisher	4	7	0	3	9	2	5	3	0	1	2	3	39
35	<i>Ceryle rudis</i>	Pied kingfisher	2	5	6	10	7	11	20	4	0	5	1	0	71
36	<i>Merops orientalis</i>	Green bee-eater	51	30	27	29	41	31	18	0	0	0	0	10	237
37	<i>Anas penelope</i>	Wigeon	0	0	0	0	0	0	0	40	70	62	135	52	359
38	<i>Phoenicopterus roseus</i>	Greater flamingo	0	0	0	0	0	0	0	0	60	55	81	34	230
39	<i>Amaurornis phoenicurus</i>	White-breasted waterhen	30	39	27	40	55	19	28	38	15	26	36	17	370
40	<i>Vanellus indicus</i>	Red-wattled lapwing	41	23	37	19	48	42	51	22	30	45	59	71	488
41	<i>Himantopus himantopus</i>	Black-winged stilt	28	15	10	20	5	30	27	12	18	34	30	47	276
42	<i>Xenus cinereus</i>	Terek sandpiper	0	0	0	0	0	0	0	0	15	0	0	0	15
43	<i>Actitis hypoleucos</i>	Common sandpiper	16	7	5	0	5	12	4	1	10	6	24	17	107
44	<i>Charadrius dubius</i>	Little ringed plover	19	0	0	0	0	0	0	0	50	73	148	80	370

TABLE 4: Continued.

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
45	<i>Upupa epops</i>	Eurasian hoopoe	24	16	34	8	10	14	7	15	14	23	9	0	174
46	<i>Streptopelia decaocto</i>	Eurasian collared dove	17	10	19	15	5	11	8	18	9	12	10	16	150
47	<i>Aythya ferina</i>	Common pochard	230	40	0	0	0	0	0	0	366	541	780	375	2332
48	<i>Fulica atra</i>	Common coot	280	55	0	0	0	0	0	111	266	280	434	350	1776
49	<i>Tachybaptus ruficollis</i>	Little grebe	120	18	0	0	0	0	0	250	392	488	586	473	2327
50	<i>Anas strepera</i>	Gadwall	50	27	0	0	0	0	0	0	248	335	310	300	1270
51	<i>Anas crecca</i>	Common teal	11	0	0	0	0	0	0	0	45	104	205	110	475
52	<i>Anas platyrhynchos</i>	Mallard	20	0	0	0	0	0	0	0	60	75	66	80	301
53	<i>Athene noctua</i>	Little owl	11	6	4	5	12	9	3	8	1	2	3	0	64
54	<i>Falco peregrinus</i>	Peregrine falcon	0	0	0	0	0	0	0	0	0	4	15	20	39
55	<i>Columba livia</i>	Rock pigeon	12	14	5	2	7	0	3	7	0	6	4	8	68
56	<i>Tockus nasutus</i>	Grey hornbill	0	0	2	1	3	0	0	0	0	0	0	0	6
57	<i>Ploceus philippinus</i>	Baya weaver	0	0	2	3	8	6	0	0	0	0	0	0	19
58	<i>Gallinula chloropus</i>	Common moorhen	10	18	5	2	28	0	9	3	10	20	32	25	162
	Total		1678	790	647	659	677	611	583	910	2230	3133	4106	2767	18791

Dera Ismail Khan and observed 13,933 individuals belonging to 39 species of birds. The great egret and gadwal were the most abundant species. The least common species were the Asian koel, Eurasian hoopoe, common kestrel, greater coucal, Indian roller, black drongo, purple sunbird, red collared dove, and Indian golden oriole. We also recorded similar observation about the common kestrel, red collared dove, and Indian golden oriole as all the three species were fairly common while the rest of the species were common.

The current research determined that more diversity and abundance of birds was noted at the Trimmu barrage compared to the Keti Bunder wildlife sanctuary. However, the Trimmu barrage of district Jhang was less diverse than the Trimmu barrage overall. During the survey of birds at the Keti Bunder wildlife sanctuary (Thatta, Pakistan), 4280 individuals belonging to 49 bird species were identified [7].

The presently investigated 30 bird species of the Thal desert of district Jhang were also observed in the Australian desert. A study conducted in the Australian desert identified 28,000 individuals belonging to 91 bird species. It was pointed out that climatic changes and rainfall affect the diversity and abundance of avian fauna [8]. Sixty-one species of both studies were different which may be due to very different climatic and geographical conditions. Where the distribution of birds is concerned, 65% of bird species of our survey were residents. A similar type of distribution pattern was also observed by another survey which was done in the desert of northern Saudi Arabia. The survey recorded 131 species of birds. Most (70%) were residents while 30% were migratory [25]. In our research, the crested lark was among the least common bird species while the crested lark and hoopoe lark were the most abundant residential species in the desert of northern Saudi Arabia which may be due to different landscape types.

Twenty-five bird species of the Thal desert of district Jhang were also observed from the desert of Morocco.

Passeriformes was the most dominant order of our research with 31 bird species. A total of 130 species of birds were reported from the study of the Sahara desert (Morocco). Passeriformes with 68 bird species of 16 families was the most dominant order followed by Accipitriformes (13 species) and Charadriiformes with 6 species. Fringillidae with 280,520 individual birds was the most abundant family [16]. Avian diversity of wetlands in the Bahir Dar, Ethiopia was determined during wet and dry seasons. The field survey identified 96 species of birds in which 40 species were observed in the wet season and 13 species in the dry season while 43 species were common at both seasons [11].

According to present findings, the most common species of birds of the Thal desert were the Indian roller, common quail, cattle egret, little egret, red-vented bulbul, common myna, Indian house crow, and Indian/pariah kite. Mahboob et al. [15] conducted a study from December 2008 to November 2009 at the Thal desert of district Jhang to find out the diversity of birds. During the year-round survey, 2,550,219 individuals from 55 species of birds were reported. Among these bird species, 36 species were residents, 13 species were winter visitors, 6 species were summer breeders, while a single species was an ordinary migrant. Passeriformes was the most dominant order with 26 species. The common myna and house sparrow were the most abundant species. Both studies have similar findings, as the midwinter season (December and January) was the most dominant time for the diversity of avian fauna. The most distinguishing feature between both studies is the abundance of avian fauna. Previously, a total of 2,550,219 individual birds were identified while, in the present study, only 12,905 individuals of 45 species were observed. By comparing with other studies, the current recent study demonstrates that the diversity and abundance of avian fauna have been declining in district Jhang.

TABLE 5: Diversity of birds at Thal desert of district Jhang (March 2021–Feb 2022 survey on monthly bases).

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
1	<i>Chlamydotis undulata</i>	Houbara bustard	0	0	0	0	0	0	0	0	95	65	78	0	238
2	<i>Corvus corax</i>	Common raven	31	14	0	10	0	22	8	13	9	35	28	0	170
3	<i>Coturnix coturnix</i>	Common quail	0	0	0	0	0	0	68	190	121	248	380	115	1122
4	<i>Gracupica contra</i>	Asian pied starling	34	17	23	11	0	28	6	14	0	22	10	5	170
5	<i>Aquila nipalensis</i>	Steppe eagle	0	0	0	0	0	0	0	0	19	13	7	2	41
6	<i>Columba livia</i>	Rock pigeon	54	68	40	0	3	61	12	25	10	30	44	50	397
7	<i>Falco tinnunculus</i>	Common kestrel	0	0	0	0	0	0	0	0	7	0	3	5	15
8	<i>Pycnonotus cafer</i>	Red-vented bulbul	65	50	38	28	35	67	12	30	39	50	80	60	554
9	<i>Motacilla alba</i>	White wagtail	33	18	20	15	9	14	10	5	12	15	8	11	170
10	<i>Oriolus kundoo</i>	Indian golden oriole	0	0	12	35	48	45	0	0	0	0	0	0	140
11	<i>Galerida cristata</i>	Crested lark	4	2	1	0	0	0	1	0	3	0	1	0	12
12	<i>Ammomanes phoenicura</i>	Rufous-tailed lark	14	10	17	3	20	8	3	9	14	11	5	4	118
13	<i>Argya earlei</i>	Striated babbler	6	11	4	0	5	3	5	0	4	8	3	8	57
14	<i>Argya striatus</i>	Jungle babbler	25	15	16	9	6	4	0	3	2	10	5	9	104
15	<i>Milvus migrans</i>	Pariah kite	37	22	30	41	48	60	35	30	6	40	52	60	461
16	<i>Elanus caeruleus</i>	Black-winged kite	5	12	0	3	10	22	7	0	6	15	0	7	87
17	<i>Accipiter nisus</i>	Eurasian sparrowhawk	0	0	0	0	0	0	0	0	16	28	37	0	81
18	<i>Bubulcus ibis</i>	Cattle egret	130	65	48	34	66	87	100	47	105	123	91	43	939
19	<i>Egretta garzetta</i>	Little egret	40	31	25	100	58	125	80	20	67	30	37	29	642
20	<i>Ardeola grayii</i>	Indian pond heron	17	0	23	10	25	14	12	7	18	14	26	19	185
21	<i>Ixobrychus sinensis</i>	Yellow bittern	15	26	7	5	18	2	0	25	9	6	13	20	146
22	<i>Coracias benghalensis</i>	Indian roller	141	100	245	160	165	178	66	188	273	95	104	115	1830
23	<i>Halcyon smyrnensis</i>	White-throated kingfisher	27	11	25	15	0	12	15	8	18	20	16	24	191
24	<i>Merops orientalis</i>	Green bee-eater	100	140	170	122	78	65	37	0	0	0	0	0	712
25	<i>Amaurornis phoenicurus</i>	White-breasted waterhen	30	14	24	8	13	7	12	3	5	0	40	16	172
26	<i>Vanellus indicus</i>	Red-wattled lapwing	32	24	8	28	9	15	10	19	8	3	10	12	178
27	<i>Himantopus himantopus</i>	Black-winged stilt	0	2	11	5	30	5	17	6	10	25	32	20	163
28	<i>Actitis hypoleucos</i>	Common sandpiper	10	7	5	0	11	8	0	5	3	14	12	17	92
29	<i>Streptopelia tranquebarica</i>	Red collared dove	5	17	0	9	14	3	0	0	0	0	0	0	48
30	<i>Streptopelia decaocto</i>	Eurasian collared dove	60	37	40	55	45	20	15	17	38	32	46	53	458
31	<i>Dinopium benghalense</i>	Black-rumped woodpecker	26	15	19	15	0	8	10	4	1	8	3	7	116
32	<i>Centropus sinensis</i>	Greater coucal	20	31	35	15	7	10	12	9	14	0	8	10	171
33	<i>Clamator jacobinus</i>	Jacobin cuckoo	0	0	14	42	32	22	25	0	0	0	0	0	135
34	<i>Eudynamis scolopacea</i>	Asian koel	0	0	20	31	40	44	0	0	0	0	0	0	135
35	<i>Oenanthe deserti</i>	Desert wheatear	1	0	0	0	0	0	0	0	13	7	9	20	50
36	<i>Athene noctua</i>	Little owl	16	23	30	16	10	12	13	29	17	25	33	14	238
37	<i>Cinnyris asiaticus</i>	Purple sunbird	0	6	19	30	43	55	0	0	0	0	0	0	153
38	<i>Saxicola caprata</i>	Pied bushchat	42	30	20	33	11	5	19	15	27	45	40	50	337
39	<i>Lanius schach</i>	Long-tailed shrike	14	3	0	8	11	5	0	25	2	8	15	20	111
40	<i>Upupa epops</i>	Eurasian hoopoe	56	35	47	24	30	27	17	20	15	45	40	28	384
41	<i>Corvus splendens</i>	Indian house crow	28	40	26	47	38	55	42	39	30	44	34	48	471
42	<i>Dendrocitta vagabunda</i>	Rufous treepie	8	0	4	11	14	0	8	5	0	13	10	11	84
43	<i>Dicrurus macrocercus</i>	Black drongo	14	17	22	11	8	30	22	10	6	21	34	28	223

TABLE 5: Continued.

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
44	<i>Acridotheres tristis</i>	Common myna	55	48	46	38	20	32	47	34	25	53	40	44	482
45	<i>Acridotheres ginginianus</i>	Bank myna	15	19	0	7	10	15	4	11	8	10	14	9	122
	Total		1210	980	1134	1034	990	1196	750	865	1075	1231	1447	993	12905

TABLE 6: Comparison in abundance of birds between Thal desert and Trimmu barrage in different months by *t* test.

Month	Site	N	Mean	Std. deviation	<i>t</i> test for equality of means <i>T</i>	<i>P</i> value
Mar	S1	35	34.57	32.89	-0.27 <sup>NS</sup>	0.7915
	S2	45	37.29	53.17		
Apr	S1	34	28.82	28.75	2.01*	0.0483
	S2	43	18.37	16.42		
May	S1	34	33.35	46.89	1.99*	0.0500
	S2	37	17.49	12.09		
June	S1	35	29.54	34.15	1.97 <sup>NS</sup>	0.0532
	S2	38	17.34	16.55		
July	S1	34	29.12	30.70	2.21*	0.0304
	S2	40	16.93	15.40		
Aug	S1	37	32.30	36.97	2.22*	0.0295
	S2	35	17.46	14.31		
Sep	S1	32	23.44	24.31	1.31 <sup>NS</sup>	0.1944
	S2	35	16.66	17.77		
Oct	S1	31	27.90	44.49	0.17 <sup>NS</sup>	0.8633
	S2	35	26.00	44.76		
Nov	S1	37	29.05	50.25	-1.13 <sup>NS</sup>	0.2605
	S2	47	47.45	88.03		
Dec	S1	35	35.17	44.94	-1.29 <sup>NS</sup>	0.1997
	S2	51	61.43	114.10		
Jan	S1	38	38.11	62.43	-1.64 <sup>NS</sup>	0.1055
	S2	51	80.51	150.26		
Feb	S1	35	28.37	27.62	-1.63 <sup>NS</sup>	0.1067
	S2	48	57.65	103.35		
Total	S1	45	286.78	335.52	-0.43 <sup>NS</sup>	0.6693
	S2	58	323.98	501.74		

Key: S1: Thal desert; S2: Trimmu barrage; N: number of species; NS: nonsignificant ( $P > 0.05$ ); \*significant ( $P < 0.05$ ); \*\*highly significant ( $P < 0.01$ ).

## 5. Conclusion

District Jhang provides an ideal environment for birds due to a variety of habitats. The district contains a desert ecosystem, aquatic ecosystem, and agriculture land for the cultivation of a variety of crops which support the avian fauna. Only 12,905 individuals of 45 species were identified from the Thal desert, and 18,791 individuals of 58 species were observed from the Trimmu barrage. The current study results clearly indicate that the bird diversity has been dramatically decreased when we compared it with previous research conducted in this area. The reports from hunters and local villagers also support the results of the current

study. The winter migratory birds are especially vulnerable due to extreme hunting pressure by Arab as well as local hunters. Hunting, contamination of the aquatic ecosystem, and disturbance of the natural habitat are some major threats in the study area. The authors suggest that strict and immediate action is required in this matter to prevent the decline in the diversity and abundance of avian fauna. Awareness programs would be highly valuable for the conservation of avian fauna.

## Data Availability

Detailed data can be provided upon request.

## Ethical Approval

Permission for the bird survey was taken from the local district government and wildlife department.

## Disclosure

This study has been presented previously as a preprint at Research Square [26].

## Conflicts of Interest

The authors declare no conflicts of interest in regard to the publication of this article.

## Authors' Contributions

AZ conducted the field survey under the supervision of AR and MSM; AR and AA designed the study; FJ and TS helped in statistical analyses; AR, SS, and SA prepared the initial draft; and NN, SMNKZ, and SJU revised the manuscript.

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