

Research Article

Avian Diversity and Abundance of Taunsa Barrage Ramsar Site in Punjab, Pakistan

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The study of avian species diversity and abundance at the Taunsa Barrage Ramsar site was carried out from September 2019 to March 2020. Taunsa Barrage is an important wetland for international and local migratory birds, including waterfowls, waders, and long-distance migrant avifauna. Data were collected by direct counts made on four-point transects representing a disturbance gradient due to humans and different habitats. Species diversity indices, analysis of variance (ANOVA), and other statistical methods were used to analyze data. A total of 150 avian species of 19 orders and 53 families were recorded. These included 66 migrant species and 84 resident species. The spotting of ten globally threatened species also highlights the importance of wetland for avian species. On average, 1511 ± 373 (mean \pm SD) species of birds were recorded every month. Shannon's diversity index indicated that Transect Point 2 had higher species diversity ($H' = 3.779$), followed by Transect Points 3, 4, and 1 ($H' = 3.769$, $H' = 3.491$, and $H' = 3.457$, respectively). Evenness index showed that birds evenly distributed in September ($E = 0.5584$) than November ($E = 0.3109$). ANOVA showed a significant difference ($F = 4.800$, $df = 3$, $P = 0.002$) of avian diversity and abundance among the transect points. But there was no statistically significant interaction between months ($F = 1.23$, $df = 6$, $P = 0.233$). The results showed that the Taunsa Barrage Ramsar site harbors plenty of resident migratory and threatened bird species. Hence, it is important to protect its habitat and need to protect avian diversity by overcoming major threats.

1. Introduction

Birds are a key component of the world's ecosystems [1]. Wild birds are present worldwide, from pole habitats to the equator habitats [2]. They are essential for continuing ecological circles, particularly in the food chain ranging from consumers to top predators [3]. They are extremely

vulnerable to climate change, and even minor temperature changes disturb their distribution and diversity [4]. Therefore, their diversity plays a vital role as environmental indicators in evaluating the quality of habitats and the state of our natural world [5]. In 1958, Taunsa Barrage was built to maintain a discharge of up to 1,000,000 cusecs on an Indus River [6]. First time at upstream of the

barrage, the wildlife sanctuary was established in 1972 of 65.6 km² area [7].

Variable climate patterns in Pakistan result in diverse wetlands and classified into different wetlands. Wetlands serve as a transitional area between land-based and water ecosystems where water-levels are normally at or close to the land's surface [8]. Wetland habitats are important for biodiversity genetic variations and evolution [9]. Bird communities are a vital part of the wetland ecosystems. Wetland habitats provide vital wintering, staging, and breeding sites for various water birds [10]. Bird diversity and abundance depend on wetland characteristics such as food availability, water quality, wintering, and breeding grounds [11]. Wetland provides a suitable habitat for biodiversity like birds, mammals, amphibians, fish, reptiles, and plants [12]. Therefore, wetlands are distinctive biological communities supporting plant and animal diversity [13].

Species diversity and abundance are equally key factors for improving the ecosystem [14]. Patterns of avian diversity and composition are the outcomes of evolutionary, historical, and environmental processes [15]. Assessment of bird communities has become a useful tool in biodiversity conservation and finding measures for the conservation of high human pressure areas [16]. However, monitoring the abundance of bird species provides useful information, widely used in bird conservation and management of threatened and endangered species [17]. Moreover, seasonal bird monitoring is equally important to finding dynamic bird movement in specific habitats [18].

Biodiversity monitoring at the Ramsar site provides valuable information on biodiversity, wetland quality, and economic importance. This information can develop wetland policies and conservation strategies [19]. Wetland avifauna species are virtuous ecological pointers indicating the condition of wetlands, and these are the source of unifying factors among countries through migration around the world. Birds are useful environmental indicators, helping us find important places and can provide a useful sign of how well the country's ecosystems offer benefits to people. Thus, ornithological research and monitoring of wetland biodiversity are essential ecological tools that provide valuable information for sustainable environments and climate change worldwide [20].

The study was planned to observe species diversity and abundance of wild birds at Taunsa Barrage (a Ramsar site). The avifauna of the Taunsa Barrage Ramsar site has been studied earlier by several researchers (Akbar et al. [21–25]). The authors have already reported a preliminary systematic checklist of 171 bird species found in TBWS [26]. Despite these works, a few areas of the Ramsar site were unattended; therefore, the present study was undertaken. This study comes with further additions and information on the relative abundance and seasonal status of migratory birds, focusing on raptors' diversity and distribution status. The purpose of this study was to identify the current diversity of birds, major threats, and threatened bird species. However, the assessment of bird population status and trends from the Taunsa Barrage Ramsar site deserves the utmost significance for bird conservation. This study also carries great impor-

tance for wetland management and bird conservation, especially the migratory birds.

2. Materials and Methods

2.1. Study Area. Taunsa Barrage (a Ramsar site) is located on the Indus River in south-western Punjab. Geographically, it is situated between 30°30'46" North latitudes and 70°50'57" East longitudes, with an altitude of 139 m (Figure 1). The area is Tehsil Kot Addu of Pakistan's District Muzaffargarh, Punjab province. It takes its name from a city called Taunsa Sharif, located about 30 km from the barrage. Taunsa Barrage was built over five years (1953–1958) on the River Indus. It was declared a Wildlife Sanctuary in 1978 with 6,576 hectares. In 1996, Taunsa Barrage was designated as a Ramsar site covering 16,000 hectares [27, 28]. Taunsa barrage wildlife sanctuary (TBWS) was renotified in 2004 with an extended area (Akbar et al. [21]). The sanctuary area covers 9 km upstream and 3 km downstream from the barrage [29].

This wetland provides a suitable habitat for biodiversity, including plants, birds, mammals, fishes, amphibians, and reptiles. This site is linked to the Indus flyway and provides an ambient environment for migratory bird survival. The Wildlife Sanctuary supports a rich variety of wildlife, including 253 avian species, 5 large mammals, 21 small mammals, 3 amphibians, 17 reptiles, and 67 fish species (Akbar et al. [21]). The sanctuary is also rich in plant species, with 120 species having been documented [30]. The study area qualifies as an Important Bird and Key Biodiversity Area because it owns a globally threatened species [31]. Threatened species like the Hog Deer, Indus Dolphin, Smooth-coated Indian Otter, Marbled Teal, and Pond Spotted Turtle. Taunsa Barrage Ramsar site is also an important breeding location for water birds such as Pheasant-tailed Jacana, Lesser Whistling-Duck, and Ruddy Crake (Akbar et al. [21]). The area supports a variety of bird species and provides critical breeding, staging, and wintering grounds for various water birds [23].

Its climate is arid with particularly hot summer seasons and mild winters. The average lowest temperature is between 5 and 6°C in January, while extreme is between 41 and 43°C in June. Annual rainfall average is between 150 and 400 mm and relative humidity of 25–85%. Wind speed stays at 15–30 km/h and shoots up to 30–35 km/h with dust storms and haze during summer. Wind direction is from north to south or northwest to southeast [28].

2.2. Methods. The fieldwork (from Sep-2019 to Mar-2020) was based on the direct observation method [32]. Point transect sampling was selected to count and record all birds seen or heard and birds in flight. A total of four-point transects were made to study the diversity and abundance of birds (see Table 1). Locations of these transects were selected to cover all wetland habitats (see Figure 1). Bird surveys were carried out between early mornings (30 min after dawn) and until three hours after sunrise [33]. Bird count data was taken in two sessions. The first session was from early morning to 9 or 10 AM when bird activity declined. The



FIGURE 1: Map showing location of Taunsa Barrage Ramsar site and selected study sites for monitoring avian species.

TABLE 1: Details of study sites selected for surveying birds of Taunsa Barrage Ramsar site.

Transect Name	Coordinates at start	Coordinates at end	Length (km)	Description
TP.1	30.51012 N 70.83167 E	30.49578 N 70.82864 E	1.5 km	Basti Faqir Wali, fruit gardens, crops cultivated land, & high human disturbance
TP.2	30.51871 N 70.84099 E	30.51277 N 70.82479 E	1.5 km	Fishponds, crops cultivation area, & low human disturbance
TP.3	30.51735 N 70.85597 E	30.52997 N 70.86243 E	1.5 km	Bund tract, crops cultivation area during dry season, wintering area for water birds, lotus growing area, & very low human disturbance
TP.4	30.51992 N 70.87608 E	30.53320 N 70.87644 E	1.5 km	Left Marginal Bund (LMB), wintering area for water birds, crops cultivation area, & medium human disturbance

second session was from mid-day or from 4 to 6 PM, as this is the period when most raptors and other birds are active.

All the surveys were conducted by foot. Point transects during the morning and evenings were considered by individual surveys. Binoculars of ZEISS, 10 × 42 were used to observe the birds. GPS map 62 was used to record the coordinates of transects and species location. A Nikon D90 (70-300 mm lens) camera was used to take the birds' photos. Birds were identified by using field guides ([34]: [35–41]). The status of residential, migratory, terrestrial, and water birds was assessed with the help of field guides. Photos of the birds taken from field surveys were identified and verified by the field guides.

2.3. Data Analysis. All the collected field work data of birds were processed using MS excel 365. MS excel 365 was used to calculate individuals' mean values, standard deviation, and standard error values. PAST version 2.17C software [42] analyzed diversity indices (Dominance, Simpson, Shan-

non, and Evenness) and Bray-Curtis cluster analysis. The maximum count of individuals was taken per month and transect, from September 2019 until March 2020. The mean number of avian species and individuals recorded during the study period from four study sites was compared using One-Way ANOVA.

3. Results

3.1. Bird Monitoring Frequency. A total of 62 surveys were conducted from September 2019 to March 2020 to monitor bird diversity and abundance at four transects. Maximum surveys (14) were conducted in September, while the minimum (6) in March. The four study sites were selected to evaluate bird abundance; maximum surveys (21) were undertaken at Transect Points 1 and 2 while the minimum (6) at Transect Point 4. The study sites were monitored based on the weekly schedule. Under fieldwork plan, some surveys were not conducted due to weather conditions.

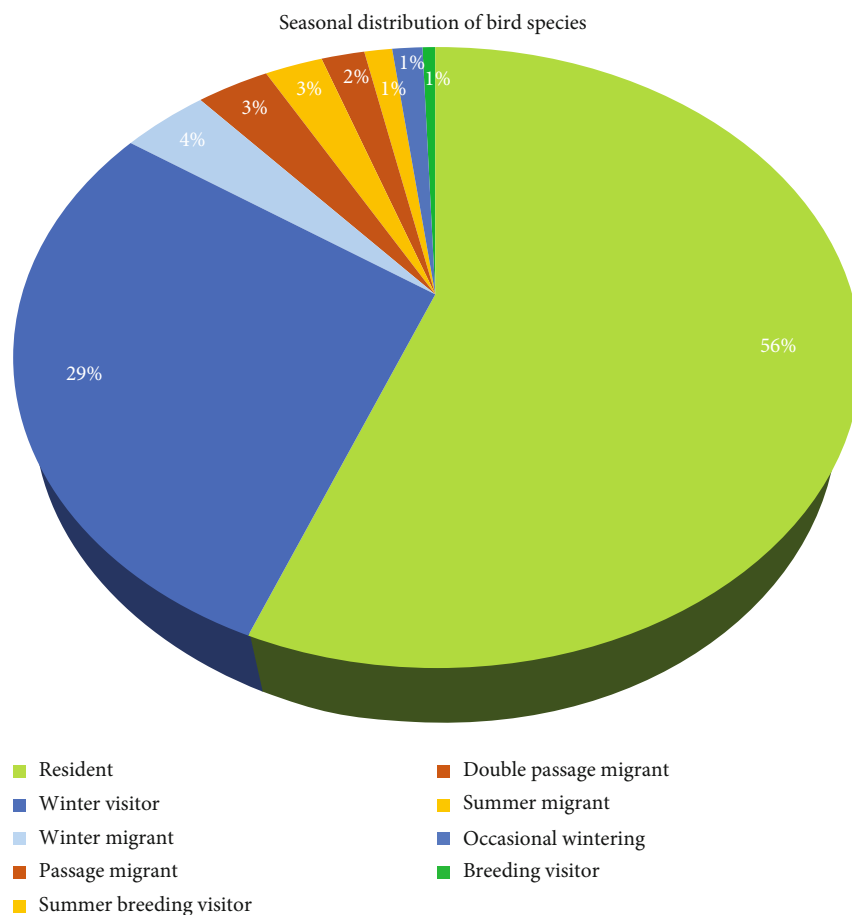


FIGURE 2: Percentage composition of species occurring in study area according to seasonal distribution status.

Because of weather conditions, monitoring frequency was reduced to 6 visits at Transect Point 4.

3.2. Bird Species Composition. A total of 150 avian species of 19 orders and 53 families were recorded during Sep-2019 to Mar-2020. Order Passeriformes has the highest diversity (57 species from 23 families), followed by Charadriiformes (21 species from 6 families), Accipitriformes (14 species from 2 families), Anseriformes (12 species from single-family), Pelecaniformes (11 species from 2 families), Coraciiformes (5 species from 3 families), Piciformes, Gruiformes, and Suliformes (4 species from 2 families), Columbiformes (4 species from single-family), Cuculiformes and Falconiformes (3 species from single-family), Strigiformes (2 species from single-family), Podicipediformes, Galliformes, Psittaciformes, Phoenicopteriformes, Bucerotiformes, and Caprimulgiformes one species from single-family. Accipitridae, Ardeidae, and Anatidae were the leading families represented by 13, 11, and 10 species at the family level, respectively. Families Accipitridae (9%), Anatidae (8%), and Ardeidae (7%) had the largest number of bird species, while families Alaudidae (1.33%) and Recurvirostridae (0.66%) had the smallest number of bird species.

At the species level, little cormorant (*Microcarbo niger*), common starling (*Sturnus vulgaris*), common myna (*Acridotheres tristis*), house crow (*Corvus splendens*), sind spar-

row (*Passer pyrrhonotus*), cattle egret (*Bubulcus ibis*), black kite (*Milvus migrans*), and common pochard (*Aythya ferina*) had the highest number of individuals during the study period. Few species were recorded only in a single month during the study period, and some rare species (few in numbers) were recorded. Barred buttonquail (*Turnix suscitator*), pied cuckoo (*Clamator jacobinus*), steppe eagle (*Aquila nipalensis*), peregrine falcon (*Falco peregrinus*), and short-toed eagle (*Circetus gallicus*) were observed only once throughout the study period. Out of the total avian species, 56% species were residents, 29% winter visitors, 4% winter migrants, 3% passage migrants, 3% summer breeding visitors, 2% double passage migrants, and 1% species summer migrants, occasional wintering, and breeding visitors (Figure 2).

3.3. Bird Species Abundance. The maximum number of individual birds' $N = 10845$ (including unknown species) with an average abundance of 1549 ± 410 (mean \pm SD) were recorded from September 2019 to March 2020. A total of 10575 individual birds representing 150 known avian species were recorded. The average abundance (mean \pm SD) of 150 bird species was 1511 ± 373 (mean \pm SD) during the study period. Month-wise variation in average bird abundance was high during the November month with $1874 (24 \pm 58)$ and least during the February month with $1024 (15 \pm 28)$.

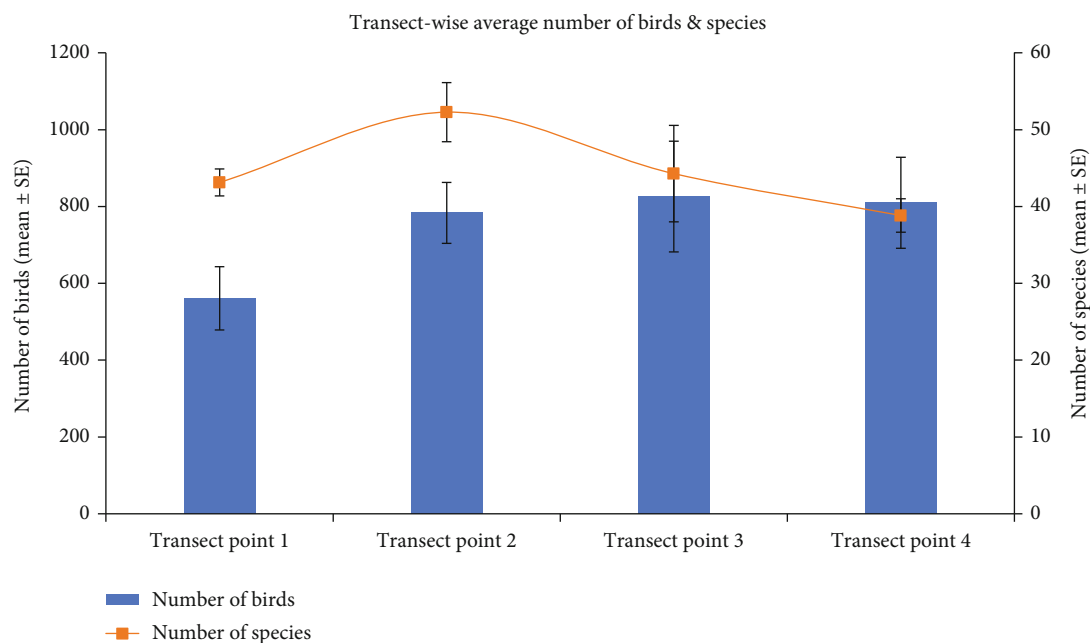


FIGURE 3: Monthly average number of bird species and individuals showing the highest values at Transect Points 2 and 3 recorded during Sep-2019 to Mar-2020.

Species richness was high during the October month ($n = 100$) and least during the February month ($n = 67$). The total average bird species richness was 80 ± 11.95 (mean \pm SD) during the study period.

Avian species diversity and abundance in the area was typically dispersed among the four transects. Transect wise variation in the average bird abundance was high at Transect Point 3 with 5782 (826 ± 144) and least at Transect Point 1 with 3927 (561 ± 82). Species richness was high at Transect Point 3 (108) and least at Transect Point 1 (74). The average species richness (mean \pm SD) was high at Transect Point 2 with 52.28 ± 3.85 and least at Transect Point 4 with 38.83 ± 2.16 .

The average number of birds and species was varied between all transects. At Transect Point 1, the average number of birds and species was 561 ± 43.14 (mean \pm SD), and at the other three transects, it was 783.57 ± 52.28 , 826 ± 44.28 , and 809.83 ± 38.83 , respectively, (Figure 3). Based on species richness, Transect Point 2 was found to be dominant with 45 families and 18 orders, followed by the Transect Point 3 with 42 families and 17 orders, Transect Point 1 with 40 families and 16 orders, and less Transect Point 4 with 37 families and 14 orders.

3.4. Avian Diversity. The species diversity index fluctuated from $H' = 3.989$ (October) to $H' = 3.189$ (November). The Shannon-Weiner diversity index revealed that the highest diversity of birds was observed during October month ($H' = 3.989$), followed by the September, December, January, February, March, and November, i.e., 3.95, 3.68, 3.50, 3.41, 3.45, and 3.18, respectively, (Figure 4). The highest species evenness of birds was observed during September ($e^{H/S} = 0.55$), while the lowest was during the November

month ($e^{H/S} = 0.31$). The Shannon-Weiner diversity index revealed that the highest diversity of birds was observed at Transect Point 2 ($H' = 3.779$), followed by the Transect Points 3, 4, and 1, i.e., 3.769, 3.491, and 3.457, respectively (Figure 5). Based on the diversity, species evenness has shown variation among transects with values of 0.4285 (TP 1), 0.4129 (TP 2), 0.401 (TP 3), and 0.390 (TP 4). The Simpson index (1- D) revealed 0.954, 0.964, 0.960, and 0.94 for Transect Points 1, 2, 3, and 4, respectively, suggesting that Transect Points 2 and 3 had the highest avian species diversity (Tables 2 and 3).

3.5. Globally Threatened Species. A total of 150 bird species consisting of 140 Least Concern and 10 species were found to globally threatened and near threatened in the study area. According to the IUCN Red List 2021-3, six species Ferruginous Duck (*Aythya nyroca*), Eurasian Curlew (*Numenius arquata*), Northern Lapwing (*Vanellus vanellus*), River Tern (*Sterna aurantia*), Oriental Darter (*Anhinga melanogaster*), and Rufous-vented Prinia (*Prinia burnesii*) were identified as Near Threatened (NT). In contrast, Common Pochard (*Aythya ferina*) and Greater Spotted Eagle (*Aquila clanga*) were recognized as Vulnerable (VU) and Black-bellied Tern (*Sterna acuticauda*) and Steppe Eagle (*Aquila nipalensis*) as Endangered (E) species (Figures 6–9) (Table 4).

3.6. Analysis of Variance (One-Way ANOVA). The month-wise analysis (One-way ANOVA) did not yield any significant ($p < 0.05$) differences in bird diversity among months from September 2019 to March 2020 ($df = 6$, $F = 1.34$, $p = 0.233$). Although species composition contrasted between the months during the study period, significant differences were not found between months and years. Year-wise analysis showed that the difference was not statistically significant

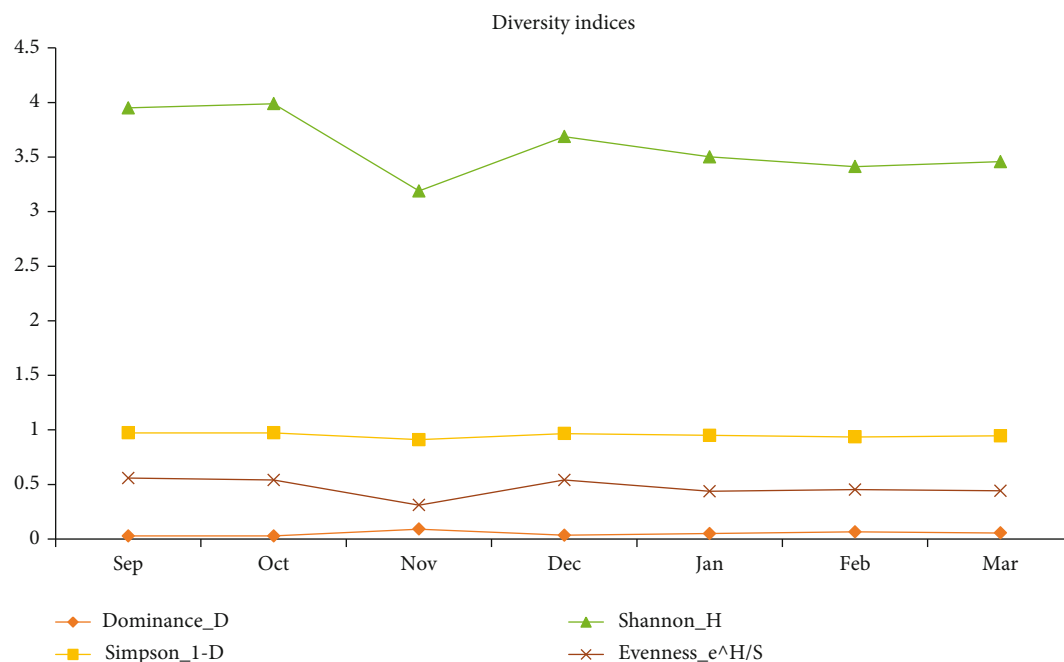


FIGURE 4: Monthly variations in species diversity indices from Sep-2019 to Mar-2020.

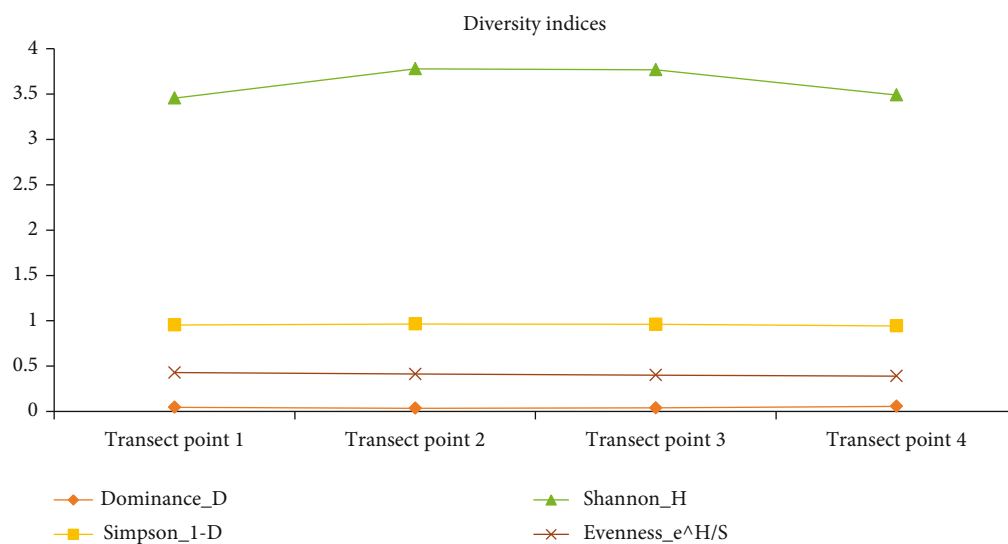


FIGURE 5: Transect-wise variations in species diversity indices during Sep-2019 to Mar-2020.

TABLE 2: Month-wise species abundance, richness, and species diversity indices from Sep-2019 to Mar-2020.

Month	No. of species	No. of individuals	Dominance (D)	Simpson (1-D)	Shannon (H')	Evenness ($e^{H/S}$)	Margalef
September	93	1958	0.0274	0.9726	3.95	0.5584	12.14
October	100	1785	0.02745	0.9725	3.989	0.5402	13.18
November	78	1830	0.09029	0.9097	3.189	0.3109	10.25
December	74	1179	0.0343	0.9657	3.688	0.5399	10.32
January	76	1604	0.04987	0.9501	3.502	0.4368	10.16
February	67	1024	0.06513	0.9349	3.412	0.4526	9.522
March	72	1195	0.05517	0.9448	3.458	0.4411	10.02
Grand total	150	10575	0.02932	0.9707	4.08	0.3945	15.99

TABLE 3: Transect-wise species abundance, richness, and species diversity indices during Sep-2019 to Mar-2020.

Diversity indices	Transect Point 1	Transect Point 2	Transect Point 3	Transect Point 4	Total
No. of species	74	106	108	84	150
No. of individuals	3926	5336	5665	4702	19629
Dominance (D)	0.04546	0.03531	0.03963	0.05665	0.03349
Simpson ($1-D$)	0.9545	0.9647	0.9604	0.9434	0.9665
Shannon (H')	3.457	3.779	3.769	3.491	3.919
Evenness ($e^{H/S}$)	0.4285	0.4129	0.4011	0.3908	0.3356
Brillouin	3.414	3.734	3.725	3.45	3.899
Menhinick	1.181	1.451	1.435	1.225	1.071
Margalef	8.821	12.23	12.38	9.816	15.07
Equitability_J	0.8031	0.8103	0.8049	0.788	0.7821
Fisher_alpha	12.94	18.75	18.93	14.53	22.09
Berger-Parker	0.1049	0.09033	0.1271	0.1808	0.09567
Chao-1	78.2	109.3	113.6	84.55	153.5

FIGURE 6: *Sterna acuticauda* (EN), breeding adult, January 2020 (photo by Muhammad Zeshan Haider).FIGURE 7: *Sterna aurantia* (NT), breeding adult, January 2020 (photo by Muhammad Zeshan Haider).

($df = 1$, $F = 2.51$, and $p = 0.11$). However, the analysis showed a nonsignificant interaction between year and month. The transect-wise analysis of variance showed that avian diversity varies significantly ($p < 0.05$) across the four transects (Figure 10). The analysis revealed significant differences ($F = 4.800$, $df = 3$, $p = 0.002$) in bird diversity across four different transects during the study period. Cluster analysis (Figure 11) shows the avian similarity of the four

FIGURE 8: *Aquila clanga* (VU), immature, December 2019 (photo by Muhammad Zeshan Haider).FIGURE 9: *Aquila nipalensis* (EN), immature, January 2020 (photo by Muhammad Zeshan Haider).

study sites in which TP3 and TP4 formed the first clade, which means that these transects shared mostly the same avifaunal species. These transects (3 and 4) have the highest similarity percentage, 72.5%. TP1 and TP2 habitats are less related to TP3 and TP4, with a percentage similarity of 60%.

TABLE 4: List of globally threatened species recorded from Taunsa Barrage Ramsar site from Sep-2019 to Mar-2020.

S. no.	Common name	Scientific name	IUCN status
1	Common pochard	<i>Aythya ferina</i>	VU
2	Ferruginous duck	<i>Aythya nyroca</i>	NT
3	Eurasian curlew	<i>Numenius arquata</i>	NT
4	Northern lapwing	<i>Vanellus vanellus</i>	NT
5	River tern	<i>Sterna aurantia</i>	NT
6	Black-bellied tern	<i>Sterna acuticauda</i>	EN
7	Greater spotted eagle	<i>Aquila clanga</i>	VU
8	Steppe eagle	<i>Aquila nipalensis</i>	EN
9	Oriental darter	<i>Anhinga melanogaster</i>	NT
10	Rufous-vented prinia	<i>Prinia burnesii</i>	NT

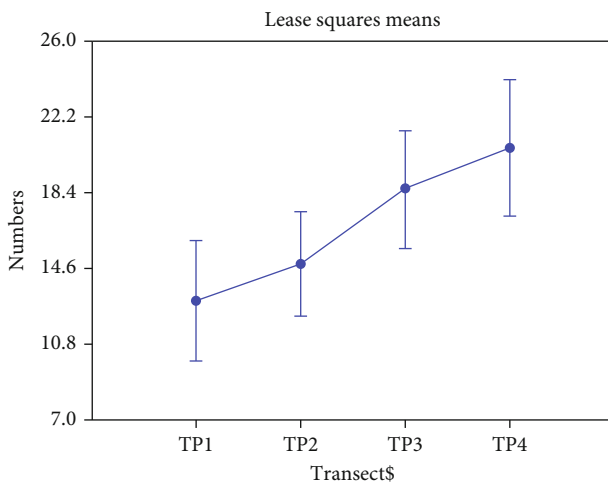


FIGURE 10: Transect-wise analysis of variance.

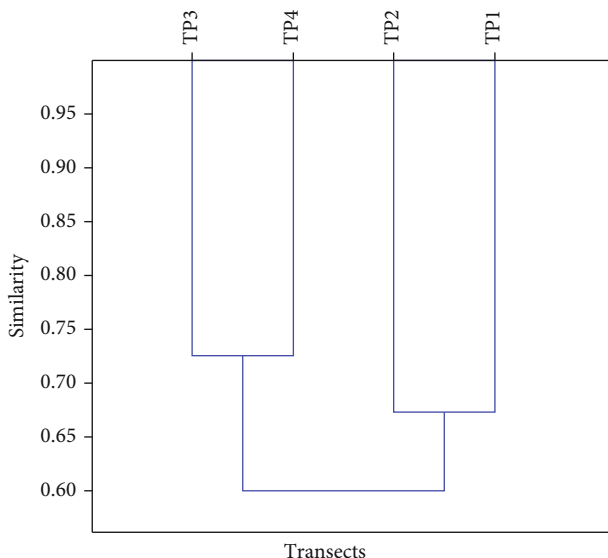


FIGURE 11: Transect Bray-Curtis cluster analysis.

4. Discussion

The present study was conducted to monitor bird diversity and abundance at Taunsa Barrage Ramsar site. Species richness and abundance has been the aim of many birds monitoring studies [43–45]. During the current study, 150 avian species of 19 orders and 53 families were observed (see Table 5). Biodiversity monitoring at the Ramsar site provides valuable information on biodiversity, wetland quality, and economic importance. This information can be used to develop wetland policies and conservation strategies [19]. Our results showed that Taunsa Barrage is an important wetland harboring a rich diversity of avian species. The study revealed that Taunsa Barrage Ramsar site is rich in avifaunal diversity as the value of the Shannon index ranges from 3.18 to 3.98, which is also supported by Bibi [26]; Bibi and Ali [24]. Our results are consistent with the other studies conducted for diversity and abundance [46–48].

The current study showed that little cormorant was found more dominant with relative abundance of 10.59%, followed by common starling (5.47%), house crow (4.14%), sind sparrow (3.87%), cattle egret (3.73%), common myna (3.49%), black kite (3.21%), and common pochard (3.03%). The dominance of these species could be brought by high encounter rates and the presence suitable habitats on Taunsa Barrage wetland. The availability of food and favorable habitat makes some birds with a more abundance in the area [49]. Some other species such as barred buttonquail, pied cuckoo, peregrine falcon, steppe eagle, and short-toed snake eagle were observed only once throughout the study period.

Out of the total bird species, 4 species (2 VU and 2 E) were recorded during the study period. The spotting of globally threatened species highlights the importance of Taunsa Barrage as an important wetland for bird species. Black-bellied tern (E), steppe eagle (E), common pochard (VU), and greater spotted eagle (VU) were regularly found at study site 3 (TP.3). This study site had a lowest human disturbance, wintering area, and feeding grounds for birds especially waterfowls and migratory birds. These results are consistent with the work of Mishra et al. [11] who stated that bird diversity and abundance depend on wetland characteristics such as food availability, quality of water, wintering, and breeding grounds. These findings also supported by the previous study conducted at Taunsa Barrage Wildlife Sanctuary [24, 26]. We also documented other threatened species (NT) such as ferruginous duck, Eurasian curlew, northern lapwing, river tern, oriental darter, and rufous-vented prinia.

The present study duration restricted to seven months' majority in winter season. Most of the bird species coming into the winter season in the study area were observed such as black-throated thrush, common kestrel, Eurasian curlew, Eurasian hobby, Eurasian sparrowhawk, Eurasian wryneck, grey-necked bunting, northern lapwing, and steppe eagle. Some winter visitor species such as waterfowls, cranes, and waders stay at the study site over winter until late February. These winter migratory bird species exhibit a distinct species-specific pattern for arrival at and departure from the Taunsa Barrage wetland. The arrival of these bird species

TABLE 5: Checklist of birds of Taunsa Barrage Ramsar site.

S. no.	Order name	Family name	Common name	Scientific name	IUCN status	Seasonal status
1	Galliformes	Phasianidae	Grey francolin	<i>Francolinus pondicerianus</i>	LC	R
2	Charadriiformes	Turnicidae	Barred buttonquail	<i>Turnix suscitator</i>	LC	R
3			Greylag goose	<i>Anser anser</i>	LC	WM
4			Ruddy shelduck	<i>Tadorna ferruginea</i>	LC	WM
5			Gadwall	<i>Anas strepera</i>	LC	WV
6			Eurasian wigeon	<i>Anas penelope</i>	LC	WV
7			Mallard	<i>Anas platyrhynchos</i>	LC	WV
8	Anseriformes	Anatidae	Common teal	<i>Anas crecca</i>	LC	WV
9			Garganey	<i>Anas querquedula</i>	LC	SPM/APM
10			Northern pintail	<i>Anas acuta</i>	LC	WV
11			Northern shoveler	<i>Anas clypeata</i>	LC	WV
12			Common pochard	<i>Aythya ferina</i>	VU	WV
13			Ferruginous duck	<i>Aythya nyroca</i>	NT	WV
14			Tufted duck	<i>Aythya fuligula</i>	LC	WV
15			Eurasian wryneck	<i>Jynx torquilla</i>	LC	WV
16	Piciformes	Picidae	Yellow-crowned woodpecker	<i>Dendrocopos mahrattensis</i>	LC	R
17			Black-rumped flameback	<i>Dinopium benghalense</i>	LC	R
18		Megalaimidae	Coppersmith barbet	<i>Megalaima haemacephala</i>	LC	R
19	Bucerotiformes	Upupidae	Common hoopoe	<i>Upupa epops</i>	LC	R
20		Coraciidae	Indian roller	<i>Coracias benghalensis</i>	LC	R
21			Common kingfisher	<i>Alcedo atthis</i>	LC	R
22	Coraciiformes	Alcedinidae	White-throated kingfisher	<i>Halcyon smyrnensis</i>	LC	R
23			Pied kingfisher	<i>Ceryle rudis</i>	LC	R
24		Meropidae	Green bee-eater	<i>Merops orientalis</i>	LC	R
25			Pied cuckoo	<i>Clamator jacobinus</i>	LC	BV
26	Cuculiformes	Cuculidae	Asian koel	<i>Eudynamis scolopaceus</i>	LC	SM
27			Greater coucal	<i>Centropus sinensis</i>	LC	R
28	Psittaciformes	Psittaculidae	Rose-ringed parakeet	<i>Psittacula krameri</i>	LC	R
29	Caprimulgiformes	Apodidae	Little swift	<i>Apus affinis</i>	LC	R
30	Strigiformes	Strigidae	Indian scops owl	<i>Otus bakkamoena</i>	LC	R
31			Spotted owlet	<i>Athene brama</i>	LC	R
32			Rock pigeon	<i>Columba livia</i>	LC	R/WM
33	Columbiformes	Columbidae	Laughing dove	<i>Streptopelia senegalensis</i>	LC	R
34			Red collared dove	<i>Streptopelia tranquebarica</i>	LC	SBV
35			Eurasian collared dove	<i>Streptopelia decaocto</i>	LC	R
36		Gruidae	Demoiselle crane	<i>Anthropoides virgo</i>	LC	APM
37	Gruiformes		Common moorhen	<i>Gallinula chloropus</i>	LC	R
38		Rallidae	White-breasted waterhen	<i>Amaurornis phoenicurus</i>	LC	R
39			Common coot	<i>Fulica atra</i>	LC	WV
40			Common snipe	<i>Gallinago gallinago</i>	LC	WV
41			Eurasian curlew	<i>Numenius arquata</i>	NT	WV
42			Common redshank	<i>Tringa totanus</i>	LC	WV
43			Common greenshank	<i>Tringa nebularia</i>	LC	WV
44		Scolopacidae	Green sandpiper	<i>Tringa ochropus</i>	LC	WV
45	Charadriiformes		Common sandpiper	<i>Actitis hypoleucos</i>	LC	WV
46			Little stint	<i>Calidris minuta</i>	LC	WV
47			Temminck's stint	<i>Calidris temminckii</i>	LC	WV
48		Jacaniidae	Pheasant-tailed jacana	<i>Hydrophasianus chirurgus</i>	LC	SBV
49		Charadriidae	Little ringed plover	<i>Charadrius dubius</i>	LC	WV
50			Northern lapwing	<i>Vanellus vanellus</i>	NT	WV
51			Red-wattled lapwing	<i>Vanellus indicus</i>	LC	R

TABLE 5: Continued.

S. no.	Order name	Family name	Common name	Scientific name	IUCN status	Seasonal status
52			White-tailed lapwing	<i>Vanellus leucurus</i>	LC	WV
53			Black-headed gull	<i>Larus ridibundus</i>	LC	WV
54			Caspian tern	<i>Hydroprogne caspia</i>	LC	R
55			River tern	<i>Sterna aurantia</i>	NT	R
56		Laridae	Little tern	<i>Sternula albifrons</i>	LC	SBV
57			Black-bellied tern	<i>Sterna acuticauda</i>	EN	R
58			Whiskered tern	<i>Chlidonias hybrida</i>	LC	SPM/APM
59		Recurvirostridae	Black-winged stilt	<i>Himantopus himantopus</i>	LC	R
60		Pandionidae	Osprey	<i>Pandion haliaetus</i>	LC	WV
61			Black-winged kite	<i>Elanus caeruleus</i>	LC	R
62			Black kite	<i>Milvus migrans</i>	LC	R
63			Brahminy kite	<i>Haliastur indus</i>	LC	R
64			Short-toed snake eagle	<i>Circaetus gallicus</i>	LC	R
65			Eurasian marsh-harrier	<i>Circus aeruginosus</i>	LC	WV
66			Shikra	<i>Accipiter badius</i>	LC	R
67	Accipitriformes	Accipitridae	Eurasian sparrowhawk	<i>Accipiter nisus</i>	LC	WV
68			Oriental honey-buzzard	<i>Pernis ptilorhynchus</i>	LC	WV
69			White-eyed buzzard	<i>Butastur teesa</i>	LC	R
70			Common buzzard	<i>Buteo buteo</i>	LC	WV
71			Long-legged buzzard	<i>Buteo rufinus</i>	LC	WV
72			Greater spotted eagle	<i>Aquila Clanga</i>	VU	WV
73			Steppe eagle	<i>Aquila nipalensis</i>	EN	WV
74			Common kestrel	<i>Falco tinnunculus</i>	LC	WV
75	Falconiformes	Falconidae	Eurasian hobby	<i>Falco subbuteo</i>	LC	WV
76			Peregrine falcon	<i>Falco peregrinus</i>	LC	WV
77	Podicipediformes	Podicipedidae	Little grebe	<i>Tachybaptus ruficollis</i>	LC	R
78		Anhingidae	Oriental darter	<i>Anhinga melanogaster</i>	NT	R
79			Little cormorant	<i>Microcarbo niger</i>	LC	R
80	Suliformes	Phalacrocoracidae	Indian cormorant	<i>Phalacrocorax fuscicollis</i>	LC	R
81			Great cormorant	<i>Phalacrocorax carbo</i>	LC	R
82			Little egret	<i>Egretta garzetta</i>	LC	R
83			Grey heron	<i>Ardea cinerea</i>	LC	WV
84			Purple heron	<i>Ardea purpurea</i>	LC	R
85			Great egret	<i>Casmerodius albus</i>	LC	R
86		Ardeidae	Intermediate egret	<i>Mesophoyx intermedia</i>	LC	R
87	Pelecaniformes		Cattle egret	<i>Bubulcus ibis</i>	LC	R
88			Indian pond-heron	<i>Ardeola grayii</i>	LC	R
89			Black-crowned night-heron	<i>Nycticorax nycticorax</i>	LC	R
90			Cinnamon bittern	<i>Ixobrychus cinnamomeus</i>	LC	R
91			Great bittern	<i>Botaurus stellaris</i>	LC	WM
92		Threskiornithidae	Eurasian spoonbill	<i>Platalea leucorodia</i>	LC	WM
93	Phoenicopteriformes	Phoenicopteridae	Greater flamingo	<i>Phoenicopiterus roseus</i>	LC	R
94			Isabelline shrike	<i>Lanius isabellinus</i>	LC	WM
95		Laniidae	Bay-backed shrike	<i>Lanius vittatus</i>	LC	R
96			Long-tailed shrike	<i>Lanius schach</i>	LC	R
97		Corvidae	Rufous treepie	<i>Dendrocitta vagabunda</i>	LC	R
98	Passeriformes		House crow	<i>Corvus splendens</i>	LC	R
99	Passeriformes	Oriolidae	Eurasian golden oriole	<i>Oriolus oriolus</i>	LC	PM
100		Dicruridae	Black drongo	<i>Dicrurus macrocercus</i>	LC	R
101		Vangidae	Common woodshrike	<i>Tephrodornis pondicerianus</i>	LC	R
102		Turdidae	Black-throated thrush	<i>Turdus atrogularis</i>	LC	WM

TABLE 5: Continued.

S. no.	Order name	Family name	Common name	Scientific name	IUCN status	Seasonal status
103		Muscicapidae	Red-breasted flycatcher	<i>Ficedula parva</i>	LC	PM
104			Bluethroat	<i>Luscinia svecica</i>	LC	WV
105			Indian robin	<i>Saxicoloides fulicatus</i>	LC	R
106			Black redstart	<i>Phoenicurus ochruros</i>	LC	WV
107		Muscicapidae	Common stonechat	<i>Saxicola torquata</i>	LC	R
108			Pied bushchat	<i>Saxicola caprata</i>	LC	R
109			Variable wheatear	<i>Oenanthe picata</i>	LC	R
110			Desert wheatear	<i>Oenanthe deserti</i>	LC	WV
111			Rosy starling	<i>Pastor roseus</i>	LC	DPM
112			Common starling	<i>Sturnus vulgaris</i>	LC	WV
113		Sturnidae	Common myna	<i>Acridotheres tristis</i>	LC	R
114			Bank myna	<i>Acridotheres ginginianus</i>	LC	R
115			Plain Martin	<i>Riparia paludicola</i>	LC	R
116		Hirundinidae	Barn swallow	<i>Hirundo rustica</i>	LC	W
117			Wire-tailed swallow	<i>Hirundo smithii</i>	LC	SM
118			White-eared bulbul	<i>Pycnonotus leucotis</i>	LC	R
119		Pycnonotidae	Red-vented bulbul	<i>Pycnonotus cafer</i>	LC	R
120		Pellorneidae	Rufous-vented prinia	<i>Prinia burnesii</i>	NT	R
121			Rufous-fronted prinia	<i>Prinia buchanani</i>	LC	R
122			Yellow-bellied prinia	<i>Prinia flaviventris</i>	LC	R
123		Cisticolidae	Plain prinia	<i>Prinia inornata</i>	LC	R
124			Graceful prinia	<i>Prinia gracilis</i>	LC	R
125			Common tailorbird	<i>Orthotomus sutorius</i>	LC	R
126		Zosteropidae	Indian white-eye	<i>Zosterops palpebrosus</i>	LC	R
127			Lesser whitethroat	<i>Sylvia curruca</i>	LC	WV
128		Sylviidae	Yellow-eyed babbler	<i>Chrysomma sinense</i>	LC	R
129		Phylloscopidae	Common chiffchaff	<i>Phylloscopus collybita</i>	LC	WV
130			Common babbler	<i>Turdoides caudata</i>	LC	R
131		Leiothrichidae	Striated babbler	<i>Turdoides earlei</i>	LC	R
132			Jungle babbler	<i>Turdoides striata</i>	LC	R
133			Crested lark	<i>Galerida cristata</i>	LC	R
134			Oriental skylark	<i>Alauda gulgula</i>	LC	R
135		Nectariniidae	Purple sunbird	<i>Cinnyris asiaticus</i>	LC	R
136			House sparrow	<i>Passer domesticus</i>	LC	R
137		Passeridae	Spanish sparrow	<i>Passer hispaniolensis</i>	LC	DPM
138			Sind sparrow	<i>Passer pyrrhonotus</i>	LC	R
139			White wagtail	<i>Motacilla alba</i>	LC	WV
140			White-browed wagtail	<i>Motacilla maderaspatensis</i>	LC	R
141			Citrine wagtail	<i>Motacilla citreola</i>	LC	WV
142		Motacillidae	Yellow wagtail	<i>Motacilla flava</i>	LC	DPM
143			Paddyfield pipit	<i>Anthus rufulus</i>	LC	R
144			Tawny pipit	<i>Anthus campestris</i>	LC	R
145			Tree pipit	<i>Anthus trivialis</i>	LC	SBV
146			Black-breasted weaver	<i>Ploceus benghalensis</i>	LC	R
147		Ploceidae	Streaked weaver	<i>Ploceus manyar</i>	LC	R
148			Baya weaver	<i>Ploceus philippinus</i>	LC	R
149		Estrildidae	Scaly-breasted munia	<i>Lonchura punctulata</i>	LC	R
150		Emberizidae	Grey-necked bunting	<i>Emberiza buchanani</i>	LC	W

LC: least concerned; VU: vulnerable; NT: near threatened; E: endangered; R: resident; WV: winter visitor; WM: winter migrant; W: wintering; PM: passage migrant; DPM: double passage migrant; SBV: summer breeding visitor.

further adds to the increase in diversity and abundance of total avifaunal population in the study area. These winter birds that migrate from the North (mainly from Russia) have been frequently visiting Taunsa Barrage [25].

Out of total species, 19 species of raptors (Birds of Prey) were recorded during the present study. Bibi [26] recorded 16 raptor species from TBWS during 2009-2011. The following 8 raptor species such as common kestrel, Eurasian hobby, Eurasian sparrowhawk, Indian scops owl, peregrine falcon, white-eyed buzzard, short-toed snake eagle, and steppe eagle were not recorded by Bibi [26]. The Indian scops owl and Eurasian hobby raptor species are new records from the Taunsa Barrage. During this study, 11 species of raptors were found to be winter visitors and 8 species were residents. The maximum number of individuals of raptor species was 966 which were of Black Kite, and the minimum number of individuals observed was 1 of Eurasian sparrowhawk, peregrine falcon, steppe eagle, and short-toed snake eagle.

The annual bird population trends at TBWS were observed from 2008 to 2014 by Bibi et al. [23]. The latter authors observed a decreasing trend of 14 bird species and an increasing trend of 157 bird species from 2008 to 2014. Among the 14 species, the white-backed vulture, greater painted snipe, Pallas's fish eagle, and imperial eagle species were not documented during the current study. The previous study confirmed the rarity of white-backed vulture and imperial eagle (100% decline) in the study area. No records of their occurrence in the study area were found during the present study. Even interviews with local peoples revealed that these species had not visited the Ramsar site during the current study period, mainly due to habitat loss, chemical poisoning, trapping of birds, and hunting. Bibi et al. [23] found that alteration in the habitat, illegal hunting, and grazing had decreased the avifauna species population of the area. Their study confirmed that avian heritage of this wetland is under threat due to increased anthropogenic activities resulting in habitat destruction and fragmentation/deforestation.

Khaliq *et al.* [25] reported that the population of 4 species such as oriental darter, Eurasian wigeon, pheasant-tailed jacana, and black-tailed godwit at TBWS were decreasing trend. During the present study, one species (black-tailed godwit) was not recorded and the other three were recorded in few numbers. Black-tailed godwit species were also not recorded in the Taunsa Barrage by Ali *et al.* [22]. Results of the current study confirmed the rarity of these birds in the study area. Ghalib *et al.* [50] carried out a study on birds of KPAC, Sindh, during September 2012 to March 2013. Their study period (September to March) is similar to the present study. Ghalib *et al.* [50] recorded 207 avian species belonging to 15 orders and 38 families.

Bibi and Ali [24] reported Shannon-Wiener and Simpson's diversity values of 3.39 and 0.93, respectively, in the same study area (TBWS). In our study, higher diversity index values at Transect Points 2 and 3 revealed that species composition and diversity of birds at these sites were more diverse and distributed. At these sites, the level of human disturbance was low. Avian diversity and richness in TP 2

and 3 were high, because at these sites the human disturbances were very low and a safe place for bird feeding and other activities. Diversity and species richness in TP 1 and 4 were low due to anthropogenic activities and hunting at these sites. At these sites, the level of human disturbance was high. However, Transect Points 1 and 4 had the lowest species richness and diversity. The results of ANOVA revealed that there were no statistically significant differences across the months because this study restricted to winter season. Mean values of the total number of individuals were recorded during September 2019 to March 2020 ($df = 6$, $F = 1.34$, $p = 0.233$) indicating no significant change month wise in bird diversity. The mean values of total individuals documented at four transects ($F = 4.800$, $df = 3$, $p = 0.002$) were significantly different ($p < 0.05$). The ANOVA results showed that there were significant variances in bird diversity across four different transects during the study period.

5. Conclusion

Our study concluded that Taunsa Barrage wetland is very important to avian communities. Bird species richness, diversity, and abundance were compared in four different transects of the Taunsa Barrage Ramsar site. A total of 150 bird species were recorded belonging to 19 orders and 53 families. Shannon winner diversity index and evenness values revealed a more diverse and evenly distributed bird assemblage during September and October month. Similarly, higher diversity index values at Transect Points 2 and 3 revealed that species composition and diversity of birds at these sites were more diverse and distributed. More bird diversity was found in the low and medium human disturbance study sites. However, assessment of bird population status and trends from the Taunsa Barrage Ramsar site deserves the utmost significance for bird conservation.

Data Availability

All data created during this research will be available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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