Research Article

To Assess the Diversity and Abundance of Seasonal Migratory Waterbirds at Chashma Lake, Pakistan

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Abstract | The present study was conducted to estimate various species of Avifauna found at Chashma Lake during winters (2017-2018 and 2018-2019). As the birds are the best indicators for environmental changes, the migratory bird's fauna was observed from September to March 2017-2019. The line-transect method was used to explore the avifauna diversity at the study site. 16371 individuals were observed belonging to 11 families belonging to approximately 38 species during the present study. The relative abundance was found to be 1, the Shannon-wiener diversity index (H´) was calculated as 3.43, the Simpson index (D) was 0.96, and the Evenness was 0.35. Little Cormorant (*Microcarbo niger*), Gadwall (*Mareca streper)*, Great Cormorant (*Phalacrocorax carbo*) were found as the dominant species with the relative abundance of 0.07, 0.07 and 0.06, respectively. As migratory birds indicate a freshwater ecosystem, healthy bird species indicate a healthy habitat, while declining bird populations indicate degraded habitat. Studies concluded that the diversity of migratory birds is decreasing at Chashma Lake due to deforestation and illegal hunting leading to habitat degradation, so there is a dire need to protect avifauna diversity for the proper functioning and stability of an ecosystem.

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1. Introduction

Wetlands are the regions of soil covered by water. It is present near the soil surface around the year or differs for varying periods. Wetlands are essential for continuing the country's natural resources, such as surface, shallow or deep groundwater, fisheries, and sea animals and wildlife (Latif *et al*., 2010). The birds which inhabit and are dependent on wetland directly or indirectly for feeding, breeding, nesting, or roosting are commonly called water birds or wetland birds (Harisha, 2016). Waterbirds represent a crucial indicator of a taxon in wetland ecosystems. These wetlands are vital habitats for birds for various purposes like foraging, roosting and courtship behaviour (Wang *et al*., 2020). Wetlands support the highest number of waterbirds during the winter (Mishra *et al*., 2020). Aquatic avian fauna occupies a unique position in a marine ecosystem. They have an aesthetic role and occupy a very special place in the food chain (Bhatnagar *et al*., 2008). The water-dependent Avifauna and their habitat are adversely affected by various factors like scarcity of food, hunting, and poaching (Vishwakarma *et al*., 2020). 225 wetlands are found in Pakistan, and it is also blessed with the most extensive canal systems of the

world-class (Ali *et al*., 2017). Chashma is a shallow lake and wetland of international importance (Ayyub *et al*., 2018). This Wetland site is located in the Indus Monsoon Forest southwest of District Mianwali (25 Km away), Punjab Province in Pakistan. Large Barrage on the Indus River with a series of dams or flood bunds makes the wetland of Chashma, which is further divided into five lakes, each of up to 250 hectares in area. The wetland has also been declared as Ramsar Site (Brohi *et al*., 2017).

In search of suitable climatic conditions, several birds migrate from one region to another and pass through Pakistan. Pakistan presents practical and eye-catching wetlands that house different migratory Avifauna that migrate in the winter season annually. a Tremendous amount of migratory birds visits Chashma lake during the winter season (like waterfowl's population). Birds migrate to redirect themselves to areas where a surplus of resources is available to increase breeding chances (Pandey *et al*., 2020).

Pakistan is located in South Asia at a latitude of 30.3753°N and a longitude of 69.3451°E. It serves as a crossroads for various migratory species, connecting them to the West and East flying pathways of Asia and Africa, respectively. The Indus Flyway, which stretches from the Karakoram to the Indus delta (in the south) and provides appealing stopovers for migratory birds (Umar *et al*., 2018), is also known as the International Migratory Bird Route Number 4 (The Green Route). Every year, tens of hundreds of waterfowls come to Pakistan this route. Significant migratory waterfowls include ducks, flamingoes, pelicans, cranes, and shorebirds (Khalique *et al*., 2012).

To avoid harsh winters, many birds travel from Central Asia and Europe to Pakistan's marshes (Altaf *et al*., 2013). Pakistan is one of the countries that hosts around 400 migratory avifauna each year who travel a tough 4500 mile journey. By these marshes, these birds spend about 4-5 months in Pakistan. These birds arrive in Pakistan from September to November via the Indus flyway, passing via the Karakorum and Suleiman mountain ranges on their way to the Indus River delta near the Arabian Sea, where they stay until February or March before returning to their breeding grounds (Umar *et al*., 2018).

The marshes of Pakistan are home to many migrating waterfowl species from Siberia and Russia (Ali *et al*., 2011). Long-distance migrants account for 30% of avian species in Pakistan, while Oriental or Palearctic species account for 43% of breeding birds and 27% of winter visits (Ali *et al*., 2017).This study investigated migratory waterbird species' abundance, distribution, and diversity in Chashma lake at Indus river Pakistan. This study has been conducted to categorize and draw attention to Pakistan's aquatic migratory birds' ecological concerns.

Current studies aimed to identify the following essential parameters that affect the avifauna diversity of Chashma Lake during the winter season between September to March. These parameters are the effect of anthropogenic activities on Avifauna diversity during the winter season, the population structure of migratory birds in response to habitat utilization, the effect of vegetation composition on the diversity of Avifauna.

2. Materials and Methods

2.1 Study area

The study was conducted at Chashma Lake, established in 1971. Chashma lake is situated in the Indus Monsoon Forest at 25 km in Mianwali in Punjab province from Mianwali to road of Dera Ismail Khan between latitude 32°11'43" and 32°38'25" N and longitude 71°23'53" and 71°45'40" E on the left bank of the river Indus. Chashma lake is a multipurpose wetland with 33,082 hectares, and it was declared as a Ramsar site. This wetland was also reported as a wildlife sanctuary in 1974. The climatic conditions of the Chashma area are semi-arid, hot in summers that is the temperature in June is 41°C and cold in winters that are in January is 4.5 °C. The cool air masses blow southward in the winter season from central Asia. This Lake serves as a first staging ground for many winter aquatic and migratory birds, especially winter. Annual relative humidity ranges from 22-85%, and the annual rainfall ranges from 300-500 mm. The variation in pH values ranges from 6.5 to 7.2.

2.2 Data collection

This survey was carried out during the winter season to study the arrival and departure of winter aquatic waterbirds at the Chashma wetland. Surveys were conducted on a seasonal basis (from September 2017 to March 2019) because, during this period, the temperature of this area becomes cool and provides the best habitat for migratory birds to migrate over there.

An observer surveyed at dawn from 6:00 am to 9:00 am, i.e., hours after sunrise and dusk from 4:00-6:00 pm after the sunsets. During this period, birds were inactive condition, and their activities like feeding are at their peak. Migratory waterbird begins to arrive at Chashma lake in mid of September and migration commence again in the March of the following year, and then they migrate to another region. One season field data was collected by using the "Line Transect Method" of sampling, used for estimating unknown population size, i.e., "N" by walking distance "L" across the nonintersecting or non-overlapping area or tract. The survey was conducted by walking along with the Lake buds and booting along with the pond areas. The birds were identified, count, and observe through binocular (42x). The photographs of these birds were captured with Nikon D7200 (150 – 160 mm lens). For the accurate identification of birds, we used the best book titled "Birds of Pakistan" by Richard Grimmet, Tom Roberts and Tim Inskipp.

2.3 Data analysis

The data was first analysed on an MS Excel sheet, and then statistical SPSS software was used to assess it.

The following parameters were calculated using the data:

2.4 Relative abundance

The relative abundance of bird species per habitat was determined using:

Relative abundance

$$(R.A) = n/N \quad \ldots(1)$$

$$= n(\text{Total \# of birds of particular species})$$

$$N(\text{Total \# of all birds species})$$

2.5 Bird species diversity

S.W.I (Shannon-Weiner Index) (H') was calculated to observe the species diversity (Hutcheson, 1970) in accordance with prevailing species abundance by the Shannon and Weaver (1949) formula:

$$H' = -[\Sigma Pi * LN(Pi)]$$

Where; H'= Diversity Index; Pi= proportion of each species in the sample and LN (Pi) + natural logarithm of this proportion.

The similarity of the population size of each species represented the Evenness of bird's species.

The ratio of the observed diversity of Avifauna to maximum diversity was calculated by using the equation.

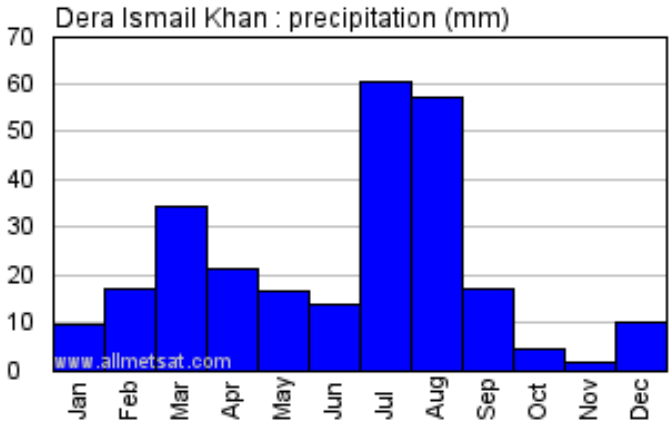
$$J = \frac{H'}{H\max}/$$

Where; H'= Shannon wiener diversity index and Hmax= natural log of a total # of species.

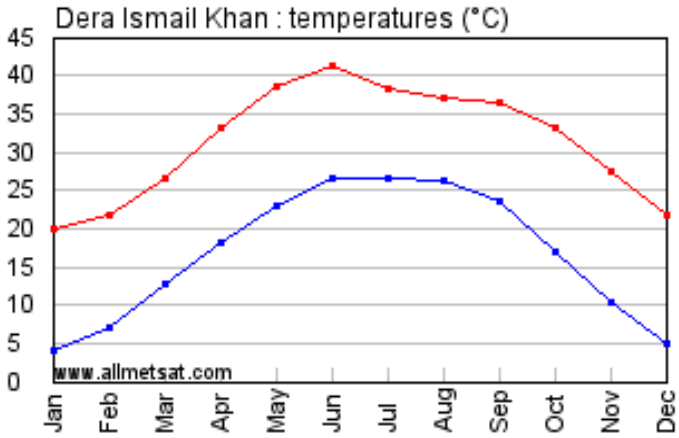
Simpson Index (D) calculates the probability of two individuals selected from noticeably large communities belonging to various avian species (Simpson, 1949). The formula measuring Simpson Index is as follows:

$$D = 1 - \frac{\Sigma n(n-1)}{N(N-1)}$$

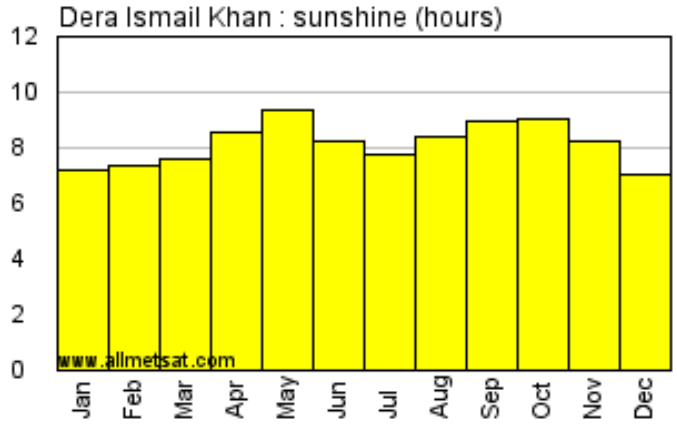
Where; n= total # of birds of a particular species, and N= total # of birds of all species.



Average Annual Temperatures in Dera Ismail Khan, Pakista



Average Annual Precipitation in Dera Ismail Khan, Pakistan



Average Monthly Sunshine in Dera Ismail Khan, Pakistan

3. Results and Discussion

Several water bird watching surveys were carried out to record the winter avian fauna migratory birds at the Chashma lake during the winter season. The different waterfowl species were recorded on the lake/wetland from September 2017 to March 2018 and September 2018 to 2019 (Table 1). During the present study, 16371 individuals from different waterfowls species were sighted on the lake/wetland (Figure 1). A total of 8290 individual birds belonging to 38 species, 11 families were counted during 2017 to 2018, whereas in 2018 to 2019, 8081 birds were counted to 38 species, 11families (Table 1). The relative abundance of each bird species was calculated (Table 1). The little cormorant (584) was the most abundant species (0.07) in 2017-2018, while from 2018 to 2019, the most abundant species was great Gadwall (588), with a relative abundance of 0.07. The total close lot of 2017-18 is one, whereas the total relative abundance of 2018-2019 is 1 (Table 1). The total # of wild bird species found were 1637 individuals belonging to 38 species and 11 Families. Wards method of the bird species at Chashma lake shown in (Figure 2).

The order anseriformes were observed to be the dominant order represented by 11 species from the anatidae family. Order pelecaniformes was in the second rank, including six species from one family, ardeidae, and one other family member, threskiornithidae. Order charadriiformes are represented by five species. Simultaneously, the lowest orders were Ciconiiformes, including one species from the Ciconiidae family, Charadriiformes, including one species from the Jacanidae family. In the Chashma lake wetland, water birds belonging to different species were observed to have relative abundance. One total number of birds belonging to other species is 16371 species. (Figure 3) represented Scatter plots of the bird species at Chashma lake. The lowest close quantity (0.0043) was recorded for spoonbill with just 72 individuals sighted from 2017-18 and 2018-19. The total number of individuals during the period from September 2017 to March 2018 and September 2018 to March 2019 was 16371, with the relative abundance of 1, Shannon-wiener index 3.43, Simpson index 0.96 as shown in Table 1 and Evenness 0.35.

Table 1: Total number of water birds at chasma lake from 2017-2019.

Family	Species name	Total	n/N	H	D
Anatidae	Bar-headed goose	340	0.02	-0.08	0.0004
	Common teal	652	0.04	-0.13	0.0016
	Common shelduck	344	0.02	-0.08	0.0004
	Common pochard	682	0.04	-0.13	0.0017
	Gadwall	1153	0.07	-0.19	0.0050
	Eurasian wigeon	756	0.05	-0.14	0.0021
	Ferruginous duck	288	0.02	-0.07	0.0003
	Mallard	551	0.03	-0.11	0.0011
	Northern pintail	786	0.05	-0.15	0.0023
	Ruddy shelduck	230	0.02	-0.06	0.0002
	Shoveler	314	0.02	-0.08	0.0004
Ardeidae	Cattle egret	718	0.04	-0.14	0.0019
	Grey heron	306	0.02	-0.07	0.0003
	Indian pond heron	529	0.03	-0.11	0.0010
	Intermediate egret	667	0.04	-0.13	0.0017
	Little egret	258	0.01	-0.07	0.0002
	Purple heron	218	0.01	-0.06	0.0002
Ciconii-dae	White stork	235	0.01	-0.06	0.0002
Jacanidae	Pheasant tail Jacana	122	0.01	-0.04	0.0001
Laridae	Black headed gull	332	0.02	-0.08	0.0004
	Great black headed gull	116	0.01	-0.04	0.00004
	Indian river tern	209	0.01	-0.06	0.0002
	Herring gull	278	0.01	-0.07	0.0003
	Grown head gull	247	0.06	-0.06	0.0002
Phalacro-coridae	Little cormorant	1157	0.07	-0.19	0.0050
	Great cormorant	1123	0.07	-0.18	0.0047
Podicipe-didae	Black-necked grebe	431	0.03	-0.10	0.0007
	Great crested grebe	169	0.01	-0.05	0.0001
	Little grebe	682	0.04	-0.13	0.0017
Recurvi-rostridae	Black winged stilt	129	0.01	-0.04	0.0001
	Avocet	254	0.06	-0.06	0.0002
Rallidae	Common coot	653	0.04	-0.13	0.0016
	Moor hen	236	0.01	-0.06	0.0002
Scol-opacidae	Common sand piper	200	0.01	-0.05	0.0001
	Green shank	145	0.01	-0.04	0.0001
	Little stint	458	0.03	-0.10	0.0008
	Red shank	332	0.02	-0.08	0.0004
Thre-skiornith-idae	Spoon bill	71	0.0043	-0.02	0.00001
		16371	1	3.43	0.96

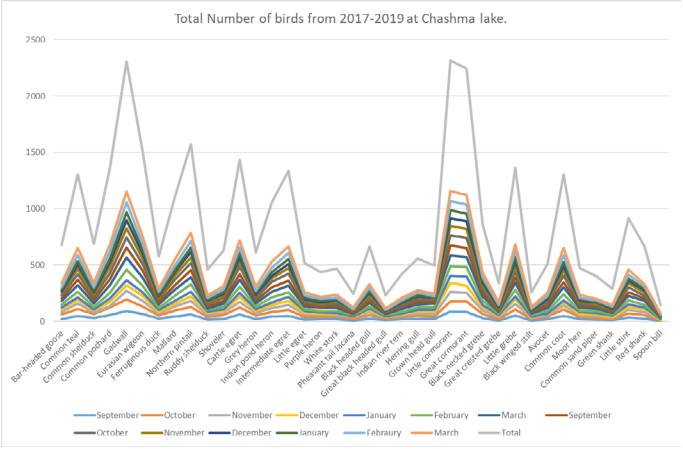


Figure 1: Total Number of birds from 2017-2019 at Chashma lake.

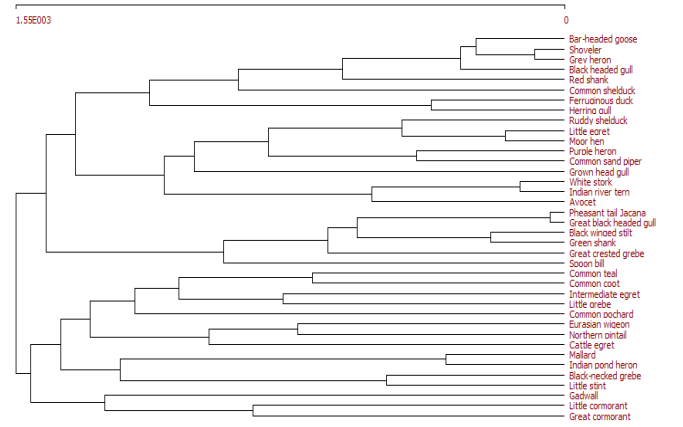


Figure 2: Wards method of the bird species at Chashma lake.

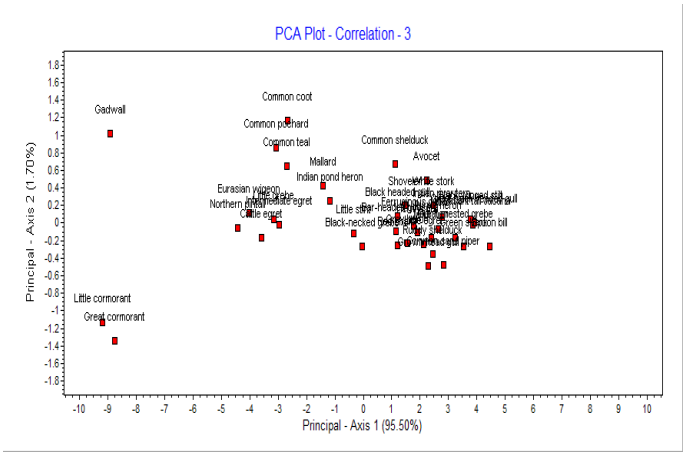


Figure 3: Scatter plots of the bird species at Chashma lake.

3.1 Relative abundance of waterbirds at Chashma lake

Detail of the relative abundance of waterbird species observed at Chashma lake is presented in Table 1. The dominant bird species of our study area were little cormorant, gadwall, great cormorant, northern pintail, eurasian wigeon, cattle egret, common pochard, little grebe, intermediate egret, and common coot with the numbers 1157, 1153, 1123, 786, 756, 718, 682, 682, 667, 653 with the relative abundance 0.07, 0.07, 0.06, 0.04, 0.04, 0.04, 0.04, 0.04, 0.03, respectively. The bird's species with the lowest number was 71, with a relative abundance of 0.004 for spoonbill.

3.2 Shannon-wiener index of water birds at Chashma lake

Detail of the Shannon-wiener index of waterbird species observed at Chashma lake is presented in Table 1. The dominant bird species of our study area were Little Cormorant, Gadwall, Great cormorant, Northern pintail, Eurasian wigeon, Cattle egret, Common pochard, little grebe, Intermediate Egret, and common coot with the numbers 1157, 1153, 1123, 786, 756, 718, 682, 682, 667, 653 with the Shannon-wiener index -0.19, -0.19, -0.18 -0.15, -0.14, -0.14, -0.13, -0.13, -0.13 and -0.13, respectively. The bird's species with the lowest number was 71, with the Shannon-wiener index -0.02 for spoonbill.

3.3 Simpson index of water birds at Chashma lake

Simpson index of waterbird species observed at Lake (Table 1) showed that the dominant bird species from the study area included little cormorant, gadwall, great cormorant, northern pintail, Eurasian wigeon, cattle egret, common pochard, little grebe, intermediate egret, and common coot with the number 1157, 1153, 1123, 786, 756, 718, 682, 682, 667, 653 with the Simpson index 0.0049, 0.0049, 0.0047, 0.0023, 0.0021, 0.0019, 0.0017, 0.0017, 0.0016 and 0.0015, respectively. The bird's species with the lowest number was 71, with the Simpson index 0.00001 for spoonbill.

It is of the utmost importance to determine and understand the habitat avian community parameters in habitat relevance and productivity that a better plan can be made to enhance population and conserve their habitat. As habitat loss and degradation is a major anthropogenic factor, the bird population has decreased. Chashma barrage provides a habitat for many migratory birds. It contains many species of waterbirds during the winter season. Different bird species belonging to other families migrate toward the Chashma barge for feeding, breeding, and raising their young's. The line transects method was used to determine the diversity of waterbird species in the Chashma barrage. Waterbirds are an important part of wetland ecosystems, having both direct and indirect effects on them (see Comin *et al.*, 2000).

The conservation of wintering aquatic bird species relies heavily on Chashma Lake. The rich diversity of waterbirds observed in this study was discovered using the line transect method at Chashma Lake in Dera Ismail Khan, Pakistan. During the study period, a total of 38 bird species were identified. Little cormorant, Gadwall, and Great cormorant were the most common birds. All of the migratory waterfowls in the area belonged to different families.

The species evenness, relative abundance, Shannon-wiener index (H), and Simpson index (D) was also observed during present studies for waterfowl species observed at Chashma lake. From the study area recorded, the Shannon-wiener diversity index was 3.43072841, Simpson diversity index 0.961876446, Evenness 0.353564268. The results of this study are nearly identical to those of (Ali *et al*., 2011) at the Taunsa Dam, a wildlife sanctuary in Punjab, Pakistan. They stated that the Shannon Weiner Diversity Index values are typically between 1.5 and 3.5; however, under rare circumstances, it may exceed 4.5. Following others result, the Evenness of bird's species was recorded by Bibi for Avifauna diversity at Chashma lake from 2009 to 2010 was 0.3 and 3.33 in 2009 to 2011; Shannon-Weiner Diversity Index (H´) was 3.39, whereas Simpson's Diversity Index (D) was 0.93 (Bibi and Ali, 2013). while the calculated value for species evenness of waterfowl by us from (2017-2019) was 0.35, Shannon wiener index was estimated as 0.43 and Simpson index was 0.35.

The common Coot in 2015 by Brohi was counted 32860, Little Cormorant (1025), Cattle Egret (62), Gray Heron (139), at Chashma Barrage (Brohi and Asim, 2017) while during current observation at Chashma Lake Common Coot was relatively less as 653. Little Cormorant (1157), Cattle Egret was 718, and Gray Heron was 306. This explains waterfowl population has decreased, and one cause is due to over and illegal hunting. Wildlife Research Institute, Gatwala, Faisalabad, conducts waterfowl surveys annually (Akbar *et al*., 2009).

The period of our study is 2018-2019, during the winter season from September to March. By comparing the total number of birds in 2017-2018 and 2018-2019, we mainly found the same results that are 8290 in 2017-2018 and 8081 in 2018-2019, with 16371 from the year 2017-2019. According to our findings, the family Anatidae was dominant over the other families representing 11 bird species that correspond with Akbar *et al*., 2009. According to Akbar *et al*. 2009, During the survey, the Anatidae family was found to be the most diverse, with thirteen species accounting for 59.29% of the total bird fauna in the studied area (Akbar *et al*., 2009).

The dominant number of bird species is 1157, for little cormorant in our two-year study period. According to Brohi and Asim, 2017 the total number for little cormorant is 1025 (Brohi and Asim, 2017), primarily similar. The number of Gadwall, i.e., Relatively double that is 3672 according to (Brohi and Asim, 2017) compared to our findings that are 1153. Let's compare the total annual population of the Avifauna of Chashma lake with (Brohi and Asim, 2017) of the year 2017. It indicates a decline in the diversity of Chashma lake's Avifauna.

Ecosystem management, however, needs to improve understanding of the consequences of the decline in avian diversity (Bibi and Ali, 2013). Wetlands are biologically very productive and supply food for a wide range of local and migratory water birds. The supply of feeding and roosting habitat is critical for migratory species, which travel thousands of kilometres in certain situations (Ali *et al*., 2011). We observed a total 16371 of water birds belonging to 38 species and 12 families. While the most significant population (43910) of migratory waterbirds was observed at Chashma Barrage in 2017 (Brohi and Asim, 2017). 110 bird species at Taunsa Barrage Wildlife Sanctuary, in which 34 were winter visitors. Ali *et al*. (2011) as Robert (1991, 1992) studied the birds of Pakistan. A total of 120 species; 46 species were winter visitors, Grimmett *et al*. (1998) out of 101 species of birds, 35 were recorded as winter visitors. A biologist believes that food abundance has an essential determinant of winter abundance and distribution of migratory birds, including shorebirds (Hockey *et al*., 1992).

The interactions between aquatic birds and these settings are still a mystery (Kushlan, 1989; Colwell and Taft, 2000). Because of the range of microhabitats, such as exposed mudflats, emergent marshes, and deep water, topographically varied wetlands sustain more waterbird species (Colwell and Taft, 2000).

3.4 Threats to avifauna observed at study site

Illegal Hunting, Trapping, Habitat Loss, and

Degradation threaten the bird's species at Chashma lake.

Conclusions and Recommendation

Present studies to observe the avifauna diversity at Chashma lake and from our research, it has been concluded that as the migratory season starts in September to October, the number of birds increases at Chashma wetland and when the severe winters at the end of December to the start of February their number tend to decrease. The studies also concluded that at the end of February to March, their number again increases. It has been indicated that they are ready to move to their following migratory site through International Migratory Bird Route Number 4, also called Green Route, to leave the Chashma wetland. During our observation, the most dominant bird species were Little Cormorant, Gadwall, Great cormorant due to their plenty of food availability such as crustaceans, insects, and fishes at the study site. The little cormorant and excellent cormorant feed on fish. In contrast, the gadwall feed on insects and crustaceans, and the most diminutive bird species was the spoonbill belonging to the family Threskiornithidae because of natural habitat destruction. Especially in the winter, Pakistan once supported the vast population of winter waterfowls, but during the twentieth century, their number decreased.

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Novelty Statement

Two years of research from 2017-2019 provided the valued information about Avifauna present by the highest number of the bird species of Little Comorant ,Gadwall and Great Cormorant and Spoon Bill with the lowest numbers.

Author's Contribution

Mr. Inam Ullah accomplished fieldwork for data collection. Mrs Ruqia Bibi and Miss Najam Un Nisa evaluated the data and prepared the results. Sania Komal, Hafiza Nimra Ghani Qureshi, Maryam Safdar, Hafiza Hina Jameel, Saman Gul, Sania Saeed participated in typing of the manuscript. All authors proofread before approval of the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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