Relative Abundance and Census Indices of Migratory Ducks along Selected Water Bodies in District Banu of Khyber Pakhtunkhwa (KP), Pakistan

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Ducks have adopted webbed feet and wide bills in communal which sponsor them to move far and wide without any restrictions in wetlands and investigation of food in water or marshy and muddy areas. Current research work aimed to assess the diversity of migratory duck species and estimate their population indices in the district of Banu Khyber Pakhtunkhwa (KP), Pakistan. Field and Social surveys were conducted at seven sites along different water bodies in the study area. Point and line transect methods were used to collect the data. Certain indices were used to calculate the species diversity. Reported species were identified using different published morphometric keys and field guides. A total of ten species of migratory ducks belonging to the Family were reported. Mallard Duck and Marbled Duck were reported as the most dominant and least dominant species respectively. Genus *Anas* and Genus *Marmaronetta* were reported as the most dominant and least dominant Genera respectively. River Kurram 24.10% (n=113), was reported as the most dominant water body to individuals reported there. The total census density of species showed a value of 0.377 birds per km^2. The present study shows that most people hunt for fun and are involved in illegal poaching and hunting, which is reported as one of the main threats to their diversity. Other threats include deforestation and loss of habitat, which need special attention from the wildlife department.

Keywords: Banu, Hunting, Species Richness, Ducks

Introduction:

Avian biodiversity is an extremely important component of our planet for contributing numerous services to an ecosystem like seed dispersal, aesthetic beauty, biological control, and environmental cleaners [1][2] Indo-Pak subcontinent illustrates a total of 2060 species of birds [3] Whereas the land of Pakistan shows 729 different species of birds belongs to 272 genera [4][5] A huge number of birds following the waterbodies of Pakistan to pass to their destinations in the Indian subcontinent in search of suitable feeding grounds [6] International Migratory Bird Route Number 4 also called Green Route or more commonly Indus Flyway providing attractive stopovers for guest birds in Subcontinent [5] Houbara bustards, Cranes, Teals, Pintails, Mallards, Geese, Spoonbills, Waders, and Pelicans are the major species of birds that migrate from Siberia to Pakistani region. These birds' species use the wetlands and water bodies of Pakistan for food, shelter, and breeding. Along with these birds, numerous species of Anatids (Ducks, Geese, and Swans) visit Pakistan every winter (mostly at the start of winter) [7] Duck is the communal name for numerous species in the waterfowl family, this family also includes geese and swans. Up till now a total of 37 species of waterfowls have been reported in Pakistan of which 29 species are migratory ducks reported so far, while the remaining contribute to Geese and Swans [3] These birds have webbed feet and wide bills common which subsidize them move everywhere freely in wetlands and search of food in water or marshy or muddy areas [8] Ducks (Family Anatidae) are well-studied and common worldwide, and many are important game species [9] Anatidae taxa are distributed worldwide, except for the Antarctic region. In terms of Ornithology the male individual of a duck is called Drake while the female individual is called Hen [10]. A broadly accepted organization of classification divides the Family Anatidae (ducks, geese, and swans) into three subfamilies, 13 tribes, 43 genera, and 148 species [11]. Ducks are generally further divided into three major groups, dabbling ducks (shallow-water), diving ducks, and perching ducks, based on their behaviors and feeding practices [12] It is asserted that modern Anatids advanced from the old world bird Presbyornis which was one of the first Anatids, and is well-thought-out as the lineages of all Anatids [13]. Migration is most important event in the lives of ducks for completion of one annual life cycle, for this purpose a large number of ducks migrate from central Asian countries and Europe towards wetlands of Pakistan [14]. They follow an Indus Flyway to come in to Pakistan [15][16]. The flyway is recycled by a huge number of ducks species such as Mallard, Shoveler, Gadwall, Common Teal, Pintail, Garganey plus internationally endangered species by IUCN such as White-headed Duck (*Oxyura leucocephala*) [17][18]. Anatids (Ducks) are commonly acknowledged as waterfowl because they characteristically spend ample time sitting on the water, and their bodies are fit for an extreme water life [19]. Migratory ducks face several threats due to which their Figure is declining, major threats to the diversity of these migratory ducks are illegal hunting and poaching worldwide, particularly for food and sports [20][21].

The avian fauna of the Province of KP, Pakistan is very diverse but likely to be declining due to ground hunting and trapping of various bird species, especially the migratory bird species. A total of 456 different bird species have been reported in the KP [22] of which nearly six species are rare, along with 25 species of ducks that have also been reported so far from the Province of KP, Pakistan [6][23]. District of Banu, located on the southern belt of the province of KP is an example of such a region, having a dense flora and fauna and, lying north of the Indus with an area of 1,227 km^2. The research area is located at a distance of 370 km from the capital city of Pakistan and 199 km away from the capital city of the province of KP. River Kurram and River Tochi originate in the hills of Waziristan which are the enormous resources of water in District Banu. Along with these water bodies, some other water tributaries and wetland wetland areas are also located in the district, such as Baran Lake, Kasho Algad, and Lorha Nala. (As shown in Figure 1). The wetlands are considered supermarkets due to the presence of a wide

range of flora and fauna [24][25], which is why these water bodies also host a lot of birds every year.

Objective:

The current research area has not been studied before, therefore the current research work is, an effort to document the status, diversity, and indices of migratory ducks in District Bannu, province of Khyber Pakhtunkhwa, Pakistan.

Novelty Statement:

This study represents the first comprehensive investigation of the diversity, relative abundance, and population indices of migratory ducks in District Bannu, Khyber Pakhtunkhwa, Pakistan. Unlike previous studies, this research uniquely combines field observations, census data, and statistical diversity indices (e.g., Shannon-Weiner, Richness, and Evenness) to provide a detailed ecological profile of migratory ducks in an understudied area. Furthermore, it identifies specific threats to migratory duck populations, such as illegal hunting and habitat degradation, while highlighting key water bodies like River Kurram as dominant habitats. This focused exploration not only addresses gaps in local biodiversity data but also contributes valuable insights for conservation strategies in this ecologically significant region.

Methodology:

Study Area Specification:

The current research work was performed in Bannu, a southern district of the province of KP & Division of northern Pakistan. The district of Bannu, lying north of the Indus with an area of 1,227 km^2. District Bannu has dense flora and fauna and has GPS coordinates of 32º 59' 11.99" N and 70º 36' 11.99 " E. The research area has extremely warm and cold climatic conditions in summer and winter respectively. The summer days range from May till mid-August. June is regarded as the hottest month. In July and August, the climate is hot but moist. In summer days the temperature goes up to 48°, while in winter days the temperature falls up to 22°. December is the coldest month in the research area. River Kurram and River Tochi originate in the mountains of Waziristan which are the massive resources of water in District Bannu. Both rivers enter the district in the North West and unite near Lakki Marwat and from there flow to South East and join the Indus River in the South of Isa Khel. (As shown in Figure 1).

Field Visits:

Seven observation sites were fixed along different water bodies in the research area for observations of migratory ducks. The observations were made for a fixed time (early morning and evening) every month in such a way that the sun was always at the back of the observer. GPS points (GPS coordinates) (As shown in Figure 1), were also recorded at each of the observation points.

Data Collection/ Birds Estimation or Census:

Data were collected through the use of point and line transect methods during the period from October 2019 to March 2020. The duck individuals were detected by using binoculars (10 X 60, Make: Pentax) and field guidebooks [26]. A count or Census was made for many individuals of each species. Visits to feeding grounds were also made during special feeding seasons as this method was earlier used by [27]. Data sheets were used to record observations. For categorizing the residential status, IUCN categories like WV (winter visitor), R (Resident), and SV (Summer Visitor), were based on their detection season earlier used by [26] with certain modifications. Birds are very subtle to anthropogenic activities which is why the researchers try to keep a proper distance from the birds during observations. Doubt and double count in the area were avoided.

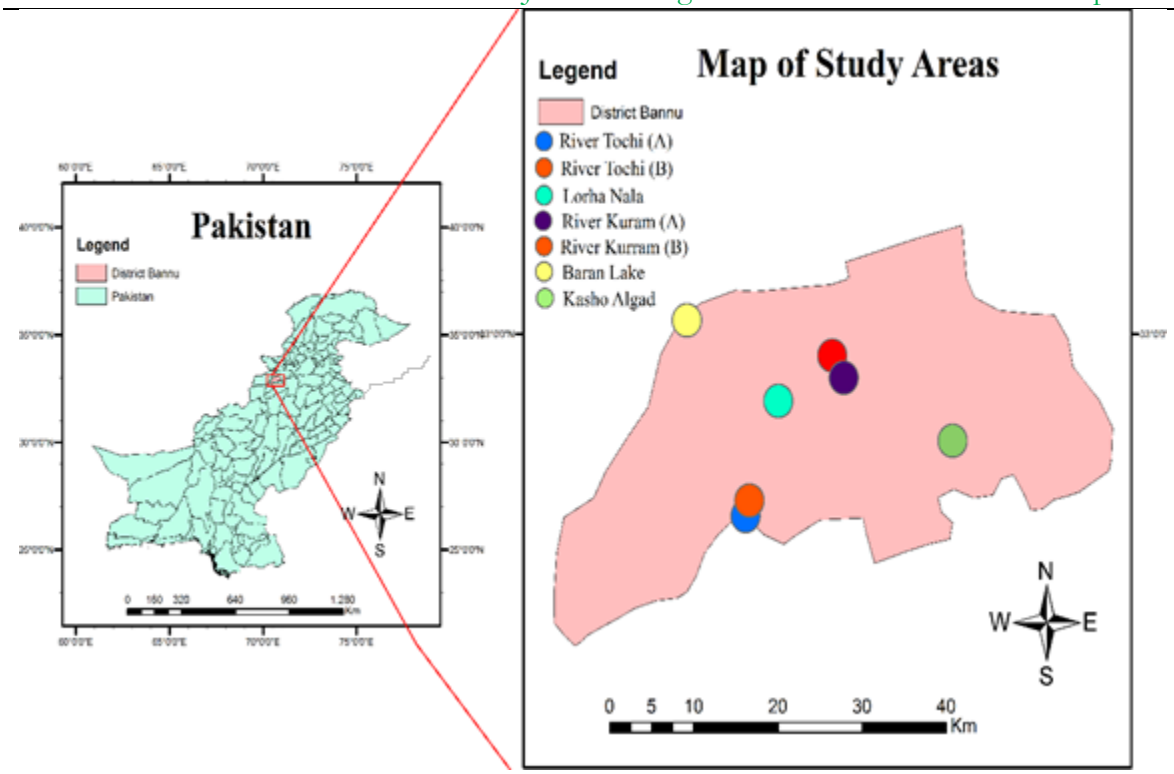

Figure 1: Map of the Area locating the Selected Observation Sites

Identification of Species:

The observed individuals were identified either visually (based on the size and shape of the bird's body, wings, head, feet, beak, flying characteristics, acts, and colors of feathers) or by their calls, or identified by referencing the field guides of [11][28], were used. Focus Group Discussions (FGDs) were conducted to document the population dynamics, Census Index, Relative abundance, and threats to the population of duck species in addition to direct observations.

Statistical Analysis:

The diversity of duck species was determined by using different indices (Relative Abundance, Census Index, Diversity Index, Richness Index, and Evenness Index). The following measures of abundance were calculated using the various formulae:

The relative abundance of each bird species was estimated through the formula as;

$$Relative\ Abundance: \frac{\text{Total no. of individuals of one species}}{\text{Total no. of individuals of all species}} \times 100$$

Population Dynamics of observed species were noted on a monthly basis. The Census index of every species was calculated to find out the approximate population of every species per km^2 in a study area. For this purpose, the total surveyed area was determined through the GPS technique.

$$Census\ Index: \frac{\text{Total no. of individuals of one species}}{Total\ Area\ Surveyed(1227km2)}$$

Shannon-Weiner diversity Index [29] was used to calculate the species diversity for the total area surveyed. The diversity of each species was calculated using [30]. The equation for the index is given below:

$$\text{Diversity Index: } H = -\Sigma (Pi \ln Pi)$$

Where H is the amount of diversity in a particular ecosystem or habitat, Pi represents the relative abundance of species to the total population, and 'ln Pi' is the natural logarithm of it. A well-known richness index was employed known as (Pielou, 1966) which is calculated as:

Richness Index: R= S – 1/ ln (n)

Where R is the Richness of species, S is the number of species and n is the number of Individuals representing the sample.

Evenness Index used in the current research work is the one used by (Ludwig et al., 1988). It is calculated as:

Evenness Index: e = H / ln S

Where H is the Shannon-Weiner Diversity Index and S is the total number of species in the sample. Diversity, Richness, and evenness were calculated using SPDIVERSE software which is designed by [31].

The distribution of observed species was determined through categories like WV (winter visitor), R (Resident), and SV (Summer Visitor), based on their detection seasons. Feeding Habits of all reported species were assessed based on their food preferences as suggested by [32]. The status of reported species was determined through the Checklist of IUCN i.e. EN, CN, EX, VU, LC. Threats to the population of migratory ducks were determined through the distribution of semi-structured questionnaires among hunters and the conduction of social meetings with the local farmers, hunters, and wildlife staff of the research area.

Flow Chart of Methodology:

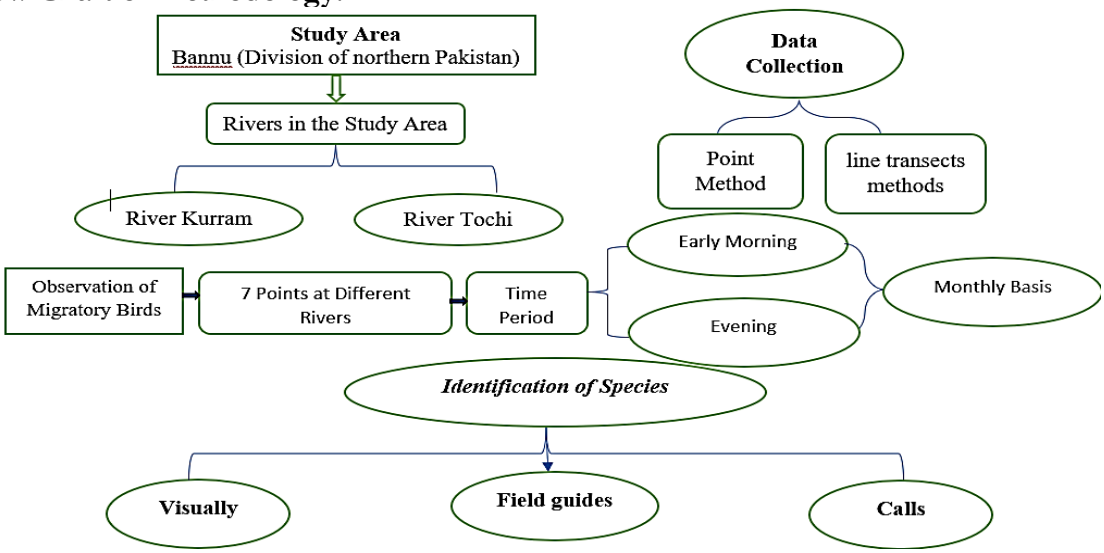

Figure 1 a. Flow of the study diagram

Results:

In the present research work the population count of migratory ducks at District Bannu was carried out for the period of six months from October 2019 to March 2020. Migratory Ducks species varied both in numbers and Diversity. A total of 469 ducks individuals were counted that belonged to 10 species, 6 genera, 1 family, and 1 order during the period from October 2019 to March 2020. (As shown in table 2) Species observed during current research work include Mallard, Pintail, Common Teal, Ruddy Shelduck, Garganey, Shoveler, Gadwall, Eurasian Wigeon, Marbled Duck, and Common Pochard (As shown in Figure 2).

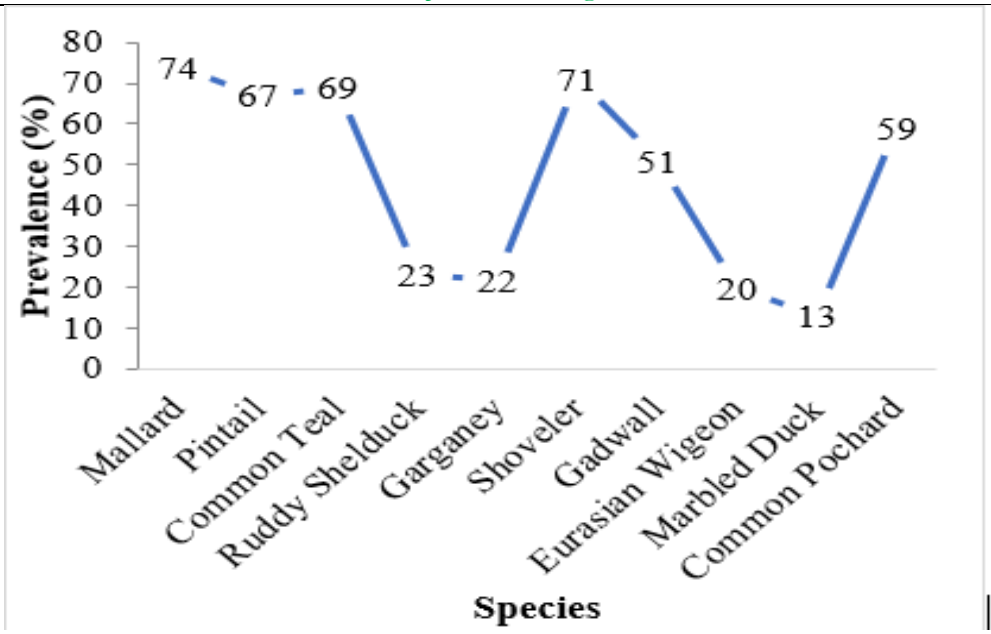

Figure 2. Species Wise Population of Ducks

Well-marked seasonal variation in the migratory duck population was recorded during the current study period. The highest number of duck species (9) was found in March 2020 (As shown in Table 3). Monthly records of the duck population exhibited a peak in duck population (142 individuals of different species) in November 2019 whereas the lowest count (11 individuals of different species) was observed in January 2020 (As shown in Table 3).

Table 3: Population Count, Abundance, and Census Indices of Reported Species

	Months				2019			2020		
Species	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Total**	**Mean ± S.E**	**Relative Abundance**	**Census Index (Density of ducks/km^2)**
Mallard	16	31	0	0	19	8	74	11.6 ± 12.07753	15.77%	0.060
Shoveler	11	21	1	8	0	30	71	8.2 ± 11.7204	15.13%	0.057
Common Teal	17	27	0	0	20	5	69	12.8 ± 11.39737	14.71%	0.056
Pintail	15	9	0	3	27	13	67	10.8 ± 9.641922	14.28%	0.054
Gadwall	0	25	5	0	14	7	51	8.8 ± 9.607289	10.87%	0.041
Garganey	11	6	2	0	2	1	22	4.2 ± 4.131182	4.69%	0.017
Common Pochard	30	0	5	0	15	9	59	10 ± 11.40906	12.57%	0.048
Ruddy Shelduck	5	16	0	0	2	0	23	4.6 ± 6.274286	4.90%	0.018
Eurasian Wigeon	16	0	0	0	3	1	20	3.8 ± 6.314006	4.26%	0.016
Marbled Duck	0	7	0	0	1	5	13	1.6 ± 3.060501	2.7%	0.010

The relative abundance was calculated for each species. The Mallard Duck was reported as the most dominant species 15.77% (n=74), while the Marbled Duck 2.7% (n=13) was reported as the least dominant species in the current research work (As shown in Table 2: Figure 2). Genus *Anas* was reported as the most dominant Genus 44.7% (n=210), while Genus *Marmaronetta* was reported as the least dominant Genus 2.7% (n=13) (As shown in Table 2, Figure 3).

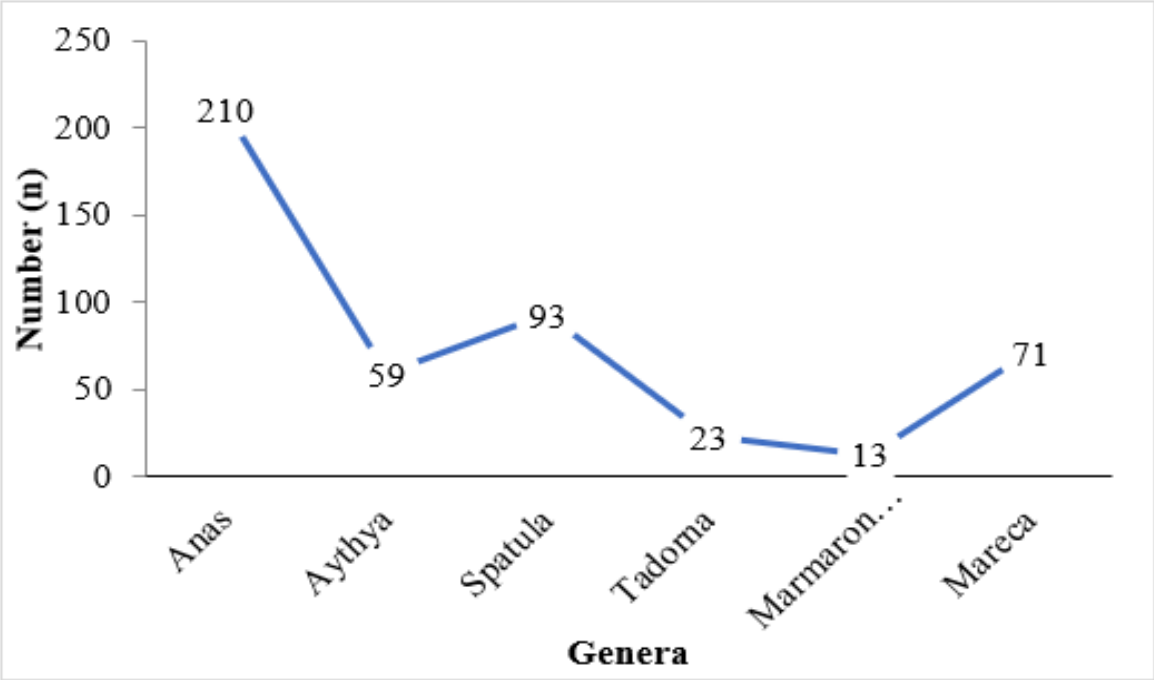

Figure 3. Genera Wise Population of Ducks

In current research work, seven sites were fixed for migratory ducks census along different water bodies in the research area. One site along Baran Lake, two sites at River Tochi, two sites at River Kurram, one site at Lorha Nala, and one site at Kasho Algad were fixed (Shown in Figure 1). River Kurram 24.10% (n=113), was reported as the most dominant water body with the highest number of duck species reported there, followed by River Tochi 23.68% (n=111), Kasho Algad 20.25% (n=95), Lorha Nala 16.84% (n=79) and Baran Lake 15.13% (n=71) (As shown in Table 1 & 4, Figure 1).

Table 1 Analysis of Figure 2

Category	Value
Mean	46.9
Standard Error	7.770957327
Median	55
Mode	N/A
Standard Deviation	24.57392475
Sample Variance	603.8777778
Kurtosis	-2.031964921
Skewness	-0.307533145
Range	61
Minimum	13
Maximum	74
Sum	469
Count	10

Table 4. Description of Observation sites along different water bodies in a research area

S. No	Site No	Water Body	U\C	Tehsil	GPS Coordinates	Observed Individuals (Site Wise)	Observed Individuals (Water Body Wise)
1.	Site 1	River Tochi	Jani Khel	Baka Khel	N 36º 34' .052" E 64º 83' .007" 42N	34	River Tochi=111 Percentage=23.68 %
2.	Site 2	River Tochi	Jani Khel	Baka Khel	N 36º 33' .888" E 64º 89' .046" 42N	77	
3.	Site 3	Lorha Nala	Mandan	Bannu	N 36º 44' .996" E 65º 10' .082" 42N	79	Lorha Nala=79 Percentage=16.84 %
4.	Site 4	River Kurram	Shahbaz Azmat Khel	Bannu	N 36º 49' .331" E 65º 69' .096" 42N	85	River Kurram=113 Percentage=24.10 %
5.	Site 5	River Kurram	Shahbaz Azmat Khel	Bannu	N 36º 48' .829" E 65º 76' .022" 42N	28	
6.	Site 6	Baran Lake	Maman d Khel	Baka Khel	N 36º 53' .591" E 64º 01' .038" 42N	71	Baran Lake=71 Percentage=15.17 %
7.	Site 7	Kasho Algad	Sirki Khel	Domel	N 36º 42' .155" E 66º 89' .065" 42N	95	Kasho Algad=95 Percentage=20.25 %

Current Research work suggested that all the reported species were winter visitors to the area, spend winter here, and go back to breeding grounds at the end of winter (As shown in Table 1). Feeding Habits of all the reported species were also determined which shows that only two species i.e Mallard and Gadwall are Herbivorous (20%), while the rest of the species are Omnivorous (80%), in their diet patterns (As shown in Table 2: Figure 4).

Table 2. Hierarchal Classification of Migratory Ducks of Research Area

S. No	Order	Family	Sub Family	Genus	Species	Common Names	IUCN Status	Distribution	Feeding Habit
1.	Anseriformes	Anatidae	Anatinae	*Anas*	*platyrhynchos*	Mallard	LC	WV	Herbivore
2.					*acute*	Pintail	LC	WV	Omnivore
3.					*crecca*	Common Teal	LC	WV	Omnivore
4.				*Tadorna*	*ferruginae*	Ruddy Shelduck	LC	WV	Omnivore
5.				*Spatula*	*querquedula*	Garganey	LC	WV	Omnivore
6.					*clypeate*	Shoveler	LC	WV	Omnivore
7.				*Mareca*	*falcate*	Gadwall	LC	WV	Herbivore
8.					*Penelope*	Eurasian Wigeon	LC	WV	Omnivore
9.				*Marmonetta*	*angustirostris*	Marbled Duck	VU	WV	Omnivore
10				*Aythya*	*ferina*	Common Pochard	VU	WV	Omnivore

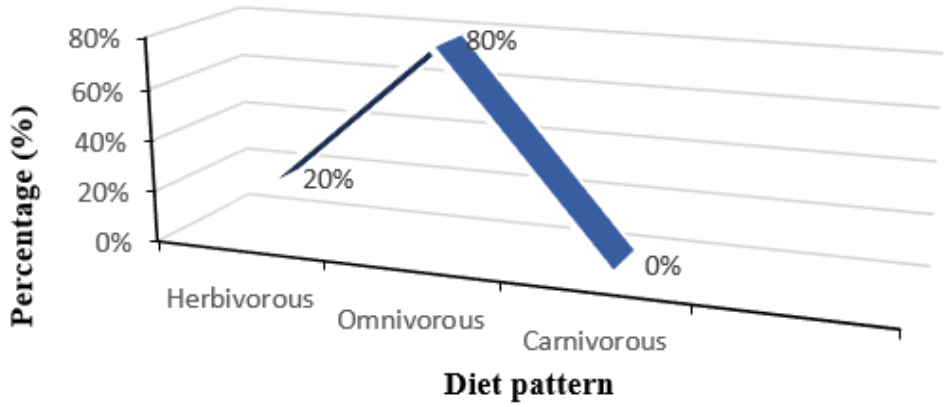

Figure 4. Diet Pattern of Reported Species

The total area surveyed was calculated by using GIS techniques. The total area surveyed was 1227 km^2, this was done to calculate the density of each duck species visiting the research area, as the total census density of duck species was calculated which shows the value of 0.377 birds per km^2. Shannon-Weiner Diversity Index was calculated (2.164) to find out the species diversity for the total area surveyed (shown in Table 5)

Table 5. Summary of Different Analysis at the Research Area

Analysis	From October 2019 to March 2020
Total Area Surveyed (km^2)	1227 km^2
Total Ducks Population	469
Number Of Species	10
Census Index	0.377 birds per km^2
Shannon-Weiner Diversity Index	2.164
Richness Index	1.463
Evenness Index	0.940
Most Dominant Specie	Mallard (15.77%)
Least Dominant Specie	Marbled Duck (2.7%)
Most Dominant Genus	*Anas* (44.7%)
Least Dominant Genus	*Marmaronetta* (2.7%)
Most Dominant Month Population Wise	142 individuals of different species in November 2019
Least Dominant Month Population Wise	11 individuals of different species in January 2020
Most Dominant Water Body Count Wise	River Kurram 24.10% (n=113)
Least Dominant Water Body Count Wise	Baran Lake 15.17% (n=71)

Species richness (1.463) and Evenness Index (0.940) of species in the research area were also calculated (Details in Table 4). Furthermore, the status of reported species was also noted (AS shown in Table 2). The distribution of all the reported species shows that all species were winter visitors to the research area (As shown in Table 2). In current research work, the researcher also observed threats to the diversity of migratory ducks, and a major threat to their diversity is Illegal hunting other minor threats are deforestation, loss of habitats, and use of pesticides. Hunting was considered the main threat to the Diversity of migratory ducks in the research area (Shown in Figure 5).

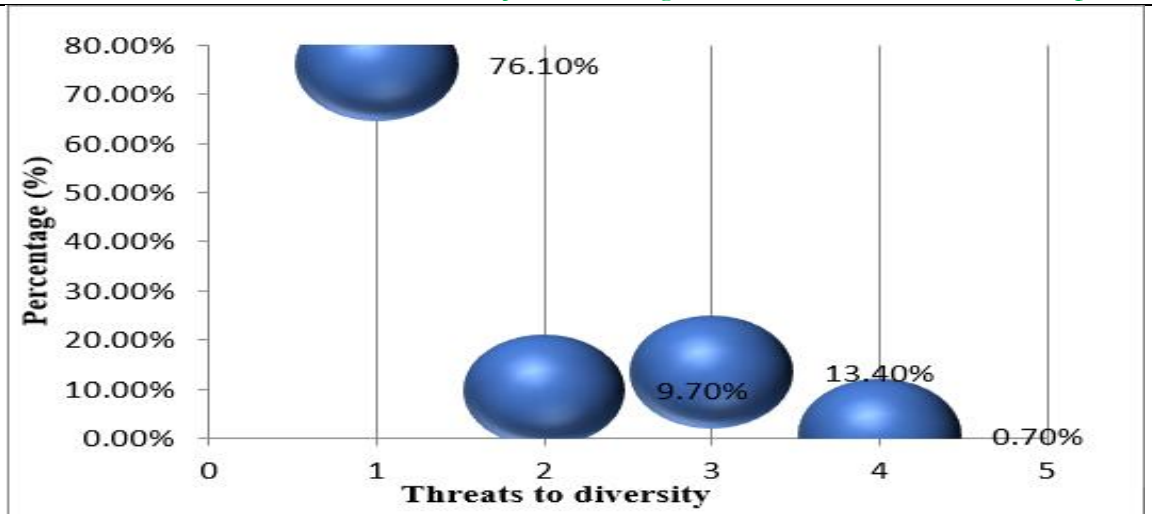

Figure 5. Threats to Diversity of Migratory Ducks

Species Identified Through Vision:

The Species Identified through Vision in the present study were Mallard, Pintail, Ruddy Shelduck, Garganey, Shoveler, Common Teal, and Eurasian Wigeon.

Species Identified Through Call:

The Species Identified through the Calls Method in the present study were Mallard (familiar "quack" sound), Common Teal (whistling calls), Eurasian Wigeon (distinctive "whee-oo" call), Pintail (soft whistles and trills), and Ruddy Shelduck (loud, honking call).

Species Identified Through Field Guide:

The Species Identified through the field guide in the present study were Marbled Duck**,** Gadwall**,** Shoveler**,** Garganey (needs subtle seasonal and plumage distinctions)**,** and Common Pochard.

Discussion:

Satisfactory climatic conditions and favorable feeding and breeding sites in a particular area indicate the occurrence of migratory birds in that area. Several research studies show that migration of birds to different areas occurs due to accessibility of food, seasonal variations [33] and to escape from threats of predation [34][1].

Due to the presence of a variety of wetland ecosystems including lakes, rivers, streams, and marshy areas, the research area is considered to be a hotspot for migratory ducks and other water birds and these wetlands offer winter staging ground and refuge to migratory ducks. The migratory ducks start arriving in the area in October and return to their breeding destinations in April. District Bannu is not being sufficiently protected and is therefore under threat. Hunting and shooting of migratory ducks reach maximum as the arrivals and departure starts in the area ultimately affecting the migratory ducks population.

Current research work depicts the diversity of migratory ducks in district Bannu. During current research work, a total of 10 species of migratory ducks were observed on different water bodies. These species are Mallard, Shoveler, Pintail, Common Teal, Ruddy Shelduck, Garganey, Gadwall, Eurasian Wigeon, Marbled Duck, and Common Pochard. These all species are winter visitors to the research area. The most common pathway used by migratory ducks is the Indus Fly Zone through which they enter Pakistan during autumn migration, and then scatter in different water bodies i.e River Kabul, River Indus, River Kurram, etc., and follow the same pathway during spring migration whenever they go back to their breeding grounds.

[35] counted 2312 individuals of migratory ducks comprised of four species at Rawal Lake Islamabad, while [14] counted 585 individuals of migratory ducks comprised of 12 species at the same site which shows a huge decrease in the population of ducks. [32] reported 34 species of waterfowl in them 28 are ducks species from Pakistan of which 17 are winter visitors in the

salt range. [5] reported 32 species of Order Anseriformes in them 27 are ducks species from Pakistan of which 14 occur in the Salt Range during winter months.

The study conducted by [36] on the coastal wetland complex of Karachi shows similarities to current research work in seven species of migratory ducks, but three species are not reported in current research work i.e Tadorna tadorna, Melanita fusca, Mergus serrator. [3] reported twelve species of migratory ducks from Mangla Dam which shows similarities in nine species with current research work except for three species i.e. Falcated Teal, Spot-Billed Duck, and Ferruginous Duck. [6] reported a pair of white-headed ducks *(Oxyura leucocephala)* a globally threatened (Endangered) duck species, which was observed at Uchalli wetland complex in the year 2017 which is not reported/observed during current research work.

In comparison with the study conducted by [24], the species with the highest census index in our research work was Mallard (0.060 birds per km^2), while the species with the highest census index in their research work was Common Pochard (6.91 birds per km^2). [23] conducted research work on the Birds' fauna and certain Parameters of water at Mangla Wetland, Azad Kashmir and they reported ten species of migratory ducks, the three species are not reported in our current research work i.e Tufted Duck, Ferruginous Duck, and Common Shelduck.

Ali et al., 2017 conducted research work on the Avifauna Diversity along the coastline of Bhanbhore District Thatta Province of Sindh, Pakistan. They reported a total of 51 bird species of which migratory ducks contribute to 8 species i.e. Common Pochard, Common Teal, Eurasian Wigeon, Gadwall, Garganey, Mallard, Northern Pintail, and Shoveler. Northern Shoveler was considered as the species with the highest population (75 individuals), in continuation with their study all the species of migratory ducks were also reported in our research work except for two species i.e Marbled Duck and Ruddy Shelduck which were not reported in their research work.

In current research work, the River Kurram is regarded as the most dominant water body to the number of individuals of ducks because it is a huge water body flowing through the whole district of Bannu, and most of the migratory ducks used to follow them to enter to Pakistan from Afghanistan. In connection to this Baran Dam was regarded as the least dominant water body to the number of ducks population because nowadays the Baran Dam is going through the process of re-construction That's why the water level in the dam is very low so most of the migratory ducks avoid to stay here.

According to the Province of KP, Wildlife, and Biodiversity (Protection, Preservation, Conservation, and Management) Act 2015, the following species of migratory ducks are allowed to hunt under special hunting licenses/permits; Northern Pintail, Common teal, Mallard, Gadwall, Eurasian Wigeon, Garganey, Shoveler, Common pochard, White-eyed Pochard, and Tufted duck. It shows that without a special hunting permit/license hunting of migratory ducks is considered illegal. In current research work, ten duck species are reported. According to *"The IUCN Red List of Threatened Species"* among these reported ten duck species only two species i.e. Common pochard and Marbled duck are Vulnerable because the population of these two species are decreasing gradually. While the rest of the eight reported species are the least concerned, they are still independent of conservation.

Conclusion and Recommendations:

From the current study, it was concluded that ten species of migratory ducks were reported with which the highest relative abundance was recorded for the Mallard duck while the lowest was recorded for the marbled duck. Furthermore, there are several threats to these migratory birds such as loss of habitat and intense hunting, which causes serious decline in their numbers. These threats should be controlled in time otherwise they may cause the extinction of these species.

It is the extreme need of time to ensure the conservation of migratory ducks in the research area. For this purpose, some challenging steps are needed for the protection of their territories.

The government, Wildlife Department, and different Wildlife protection agencies can play a major role in the conservation of bird species in the natural environment. The following steps should be immediately implemented for migratory duck conservation:

1. Proper monitoring of the diversity of migratory ducks for their protection.
2. To avoid Human intervention there should be a ban on the entrance of the public to the territories of ducks.
3. People should be aware of the importance of ducks in the environment and also implement a strict ban on the illegal hunting of ducks.

Acknowledgement:

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