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MEASUREMENT OF DIVERSITY INDICES OF AVIAN COMMUNITIES AT TAUNSA BARRAGE WILDLIFE SANCTUARY, PAKISTAN

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ABSTRACT

The study was conducted to measure bird species diversity at Taunsa Barrage Wildlife Sanctuary from 2009 to 2011. The objective of the study was to identify avian diversity and main threats to them in the sanctuary. Data were collected by direct census method. In total, 58,598 bird species belonging to 53 families and 171 species were recorded. Density of the birds was 6.9 birds per hectare. Shannon-Weiner Diversity Index (H´) was 3.39, whereas Simpson's Diversity Index (D) was 0.93. According to local occurrence status, there were 12 species ranked as very abundant, 19 abundant, 62 very common, 16 common and 41 fairly common. There were, however, 7 species, in each category, recorded as uncommon, rare and very rare. Seasonal occurrence observed for different bird species revealed; year- round residents 42%, summer breeders 7%, winter migrants 38% and passage migrants 13%. Five dominant species with their relative abundance included; *Fulica atra* (13.3), *Bubulcus ibis* (12.28), *Egretta garzetta* (11.46), *Aythya ferina* (8.9) and *Corvus splendens* (5.8). A decreasing population trend in 14 species was found by regression analysis. Main threats identified to survival of birds were; habitat degradation, pesticide usage and illegal hunting. The species richness and composition are important parameters for stability and functioning of an ecosystem, therefore, there is urgent need to protect avian diversity by protecting natural habitat of the area.

Key words: Avian diversity, seasonal occurrence, diversity index, Taunsa Barrage Wildlife Sanctuary.

INTRODUCTION

Pakistan harbors a wide range of ecosystems which in turn catches the attention of a diverse avifauna to exploit their resources (Khan *et al*., 1996). More than 650 species of birds have been reported in the country and their occurrence in three zoogeographical zones (Oriental, Palaearctic and Ethopian region) is unique in the world (Grimmett *et al*., 2001; Mirza and Wasiq, 2007). Species diversity is an important component of the health of an ecosystem. Among species, birds have an important place because they are visible and highly valued by humans. Birds, furthermore, play an informational role in attracting public attention to natural habitat. The abundance and diversity of avian species, therefore, in a specific habitat could serve as a useful barometer of the ecological status of that habitat. Ecologically, birds are of tremendous importance as they are important pollinators and play a key role in seed dispersal. Indus flyway, for instance, provides food and shelter for millions of migratory and resident birds.

The Indus River is one of the major routes of migratory birds. Taunsa barrage, therefore, has been declared as a Wildlife Sanctuary. This sanctuary forms an important wintering area for water bird and breeding area for several species, while staging area for certain cranes and water birds (Omer and Saeed, 2006). The birds are bio-indicators of ecosystem, as they represent the ecological conditions of the area affected by changes and variation of the environment. In looking for patterns among bird communities, the relative distribution (evenness) of birds in adding up their species richness, diversity indices were calculated for avifauna by combining two years observation. The Shannon-Wiener diversity index is a heterogeneity measure that incorporates species richness and evenness (Hollenbeck and Ripple, 2007). Relative to other diversity indices, such as Simpson's index, it is considered sensitive to the addition of rare species (Krebs, 1989). The aim of the study was to measure bird species diversity at Taunsa Barrage Wildlife Sanctuary, by measuring the species richness, evenness, Simpson index and Shannon-Weiner Diversity Index.

MATERIALS AND METHODS

Study Area: The study was conducted at Taunsa Barrage Wildlife Sanctuary, situated in district Muzaffargarh at River Indus in Southern Punjab, falls between 30º 30´ latitudes and 70º50 longitudes; with an altitude of 137m. It is one of the most important wetland sites in this region and one of 42 wildlife sanctuaries of the Punjab, Pakistan. Its status as a Ramsar site (Ramsar site # 817) lends its international recognition as a designated wetland site of ecological importance. Initially, 16,000 hectares were included in the protected area (Omer and Saeed,

2006). Since its declaration, the Sanctuary has been re-notified many times; the last on December 10, 2004, with its total area of 2,834 hectare, that reduced to 43% of the original area. The climate of Taunsa Barrage is dry subtropical with relative humidity of 25 to 85%, and annual rainfall of 200 to 450 mm. The average temperature observed in January was 4.5°C to 5.5°C, whereas in June it ranged from 42°C to 45°C (Shelly, 2011). The dominant forest vegetation observed along river side includes, *Dalbergia sissoo, Acacia nilotica, Prosopis cineraria, Cynodon dactylon, Panicum antidotale, Pisum arvense* and *Populus euphratica* in association with *Tamarix dioica* (Bibi *et al*., 2013). The site forms a very important wintering area for waterbirds, support fisheries worth up to 5 million annually. The study site provides excellent opportunities for scientific research and education.

METHODOLOGY

Point Count: Points were selected at upstream and downstream of Taunsa Barrage to observe, count and identify bird species with the help of binocular and spotted scope (Haldin and Ulfvens, 1987). Field observations were performed from 2009 to 2011 with 30 days interval. Surveys were carried out early in the morning from 06:30 to 10:00 h and in the late afternoon from 04:00 to 06:00 h. Unscrupulous observations were also added to the list to prevent missing of any species during the survey period. Surveys were conducted on foot and by boat. Photography of birds was done by using Nikon Digital SLR camera with 300 and 500 zoom lenses.

Species Evenness and Richness: Species diversity increases with the complexity of habitat. This diversity considers both the richness and evenness of species. Evenness is a measure of the relative abundance of different species making up the richness of an area. This evenness is an important component of diversity indices (Hill, 1973; Turchi *et al*., 1995; Leinster and Cobbold, 2012) and expresses evenly distribution of the individuals among different species.

Shannon-Weiner Index: Species evenness, richness, and diversity indices as Shannon-Weiner (Shannon and Weaver, 1949) and Simpson Index (Simpson, 1949) were used to evaluate the bird species diversity. Shannon-Weiner Index assumes that individuals are randomly sampled from an independent large population and all the species are represented in the sample. Shannon diversity is very widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001). It was calculated in order to know the species diversity in different habitat (Hutchison, 1970) based on the abundance of the species by the following formula: $\mathbf{H' = - [\sum Pi \ln Pi]}$

Where, H´ = Diversity Index; Pi = is the proportion of each species in the sample; lnPi = natural logarithm of this proportion

The presence of one individual of a species is not necessarily indicative of the species being present in a large number. The value of Shannon Weiner Diversity Index usually falls between 1.5 and 3.5, only rarely it surpasses 4.5. A value near 4.6 would indicate that the numbers of individuals are evenly distributed between all the species.

Simpson Index (D): It measures the probability that two individuals randomly selected from a sample will belong to the same species. Simpson gave the probability of any two individuals drawn from noticeably large community belonging to different species. It has been measured by the given formula:

$$D = 1-\{\sum n (n-1) \,/\, N (N-1)\}$$

n=the total number of birds of a particular species
N= the total number of birds of all species
The correlation between birds species and time period (years) was investigated by simple linear regression trend line. Population trend line series was ran by using bird density as the dependent variable, while month's independent variables.

Local Occurrence Status: For describing frequency of occurrence and comparative abundance, the terms described by Bull (1974) were followed. The bird species found more than 1000 individuals per day in the locality were termed as very abundant, those between 200 to 1000 individuals were termed as abundant, and those found between 51 to 200 individuals were termed as very common, whereas those found between 21 to 50 individuals were considered as common species. Bird species, similarly, were termed as fairly common having population seven to 20 individuals per day, whereas those observed between one to six individuals were named as uncommon. Correspondingly, birds with one to six individuals per season were described as rare. On the other hand, bird species having infrequent occurrence were termed as very rare species.

RESULTS AND DISCUSSION

Taunsa Barrage Wildlife Sanctuary has a rich diversity of birds, with a combination of water birds, raptors, forest, mountain and desert dwellers. In total, 58,598 birds belonging to 53 families and 171 species were recorded.

Evenness of birds species compares the similarity of the population size of each of the species which recorded in 2009 to 2010 was 0.3 and 3.33 in 2009 to 2011; while species richness was n =165 in 2009 to

2010 and n =170 in 2010 to 2011. Shannon-Weiner diversity index value encountered avifauna was estimated to be 3.03 in 2009 to 2010 and 3.33 in 2010 to 2011. Simpson's Diversity Index is a calculation of variety which takes into records both richness and evenness. It has been a useful tool to understand the profile of biodiversity across study area. This diversity index value encountered avi-fauna was estimated to be 0.928 was same in 2009 to 2010 and 2010 to 2011. Density of birds recorded 5.7 birds per hectare in 2009 to 2010 and 6.26 birds per hectare in 2010 to 2011 (Table 1).

Table 1: Diversity of avian-fauna of Taunsa Barrage Wildlife Sanctuary.

Diversity Index	Years	Results
Shannon Weiner Index		H´
	2009-2011	3.39
	2009-2010	3.31
	2010-2011	3.33
Simpson Index		D
	2009-2011	0.934
	2009-2010	0.928
	2010-2011	0.928
Species evenness		E
	2009-2011	0.3088
	2009-2010	0.699
	2010-2011	0.71
Census Index (birds per hectare)		**C.I**
	2009-2011	6.902
	2009-2010	6.26
	2010-2011	5.74
Species richness		**r**
	2009-2011	171
	2009-2010	165
	2010-2011	170

Note: H´= Shannon-weiner diversity Index; D= Simpson Diversity Index; E= Evenness; C.I = Census Index; r= Species richness

As Simpson Diversity Index has swift convergence to limit diversity value for minor sample size, therefore, is principally suitable for rapidly evaluating regions for conservation (Lande *et al*., 2000). The observed 110 species during 2008 at Taunsa Barrage Wildlife Sanctuary belongs to 45 families including 66 resident species, 8 breeding resident, 34 winter visitor and only two summer visitors (Ali *et al*., 2011). The commonly applied diversity indices form ratios of absolute to the highest range possible (Peet, 1975). The result showed that estimated avian diversity from 2009 to 2012 (171 species) was greater than previously conducted studies in 2002 (Ali, 2006) and 2008 (Ali *et al*., 2011). Therefore, it could never approach near possible occurrence data of species published in books of various authors (Robert, 1991, 1992; Mirza and Wasiq, 2007; Grimmett *et al*., 2008). It might need a decade to observe full range of species of the birds. The Shannon-Weiner Diversity Index which specifies the comparative occurrence of many species; was used to associate species abundance and relative richness amongst species (Whittaker, 1977; Barbour *et al*., 1998). As the value of Shannon-Weiner Diversity Index (2009 to 2011) calculated was near to 4.6, which predicts that the numbers of individuals of all species were evenly distributed in study area. Ali (2006) recorded 127 species (6972 individuals) of birds from TBWS, with Shannon-Weiner Diversity Index value 3.99 that support present findings. Species recorded in 2008 at Taunsa Barrage Wildlife Sanctuary was 110 belonged to 45 families while with 66 resident species, 8 breeding resident, 34 winter visitor and only two summer visitors (Ali *et al*., 2011). In total 129 birds species comprised of three endemics, two globally threatened and 21 palaearctic migrants were identified (Aynalem and Bekele, 2008).

Relative abundance of birds was also calculated, and Table 2 shows the most dominant species of the birds in the area. The relative abundance of bird species might be related to the availability of food, habitat condition and breeding season of the species.

Table 2: Five dominant species of birds recorded at TBWS 2009 to 2011.

S. No.	Scientific and common name	Relative Abundance
1	*Fulica atra* (Eurasian Coot)	0.13311
2	*Bubulcus ibis* (Cattle Egret)	0.12287
3	*Egretta garzetta* (Little White Egret)	0.11469
4	*Aythya ferina* (Common Pochard)	0.089
5	*Corvus splendens* (House Crow)	0.058

The divergent seasonality of rainfall and seasonal variation in the plenty of food resources end result in seasonal changes in the species abundance of birds (Gaston *et al*., 2000; Karr and Roth, 1971). The allocation and abundance of numerous bird species are determined by the composition of the vegetation that forms a major element of their habitats. As vegetation changes along multifaceted biological and environmental gradients, a particular bird species can appear, increase or decrease in number, and vanish as the habitat changes (Lee and Rotenberry, 2005).

In regression analysis, there were 157 species with increasing trend that represents the number of species increasing with the change in years. However, in 14 species namely Little Cormorant (*Microcarbo niger*), Grey Heron (*Ardea cinerea*), Gadwall (*Anas strepera*), Garganey (*Anas querquedula*), Red-crested Pochard (*Netta rufina*), White-backed Vulture (*Gyps africanus*),

Marsh Harrier (*Circus aeruginosus)*, Common Buzzard (*Buteo buteo*), Long-legged Buzzard (*Buteo rufinus*), Merlin (*Falco columbarius*), Greater Painted-snipe (*Rostratula benghalensis*) and Black Drongo (*Dicrurus macrocercus*) a decreasing trend was found. As ecosystem stability depends on species richness and composition, therefore a decline in bird's diversity will lead to successive changes in properties of natural environment. Ecosystem management, however, need to improve understanding of the consequences of decline in avian diversity.

The species that best fit in the trendline included *Recurvirostra avosetta, Eremoptrrix grisea, Lanius vittatus, Streptopelia tranquebarica* and *Sylvia curruca*. Local occurrence status (Table 3) of birds' species of Taunsa Barrage Wildlife Sanctuary was recorded as shown below.

Table 3: Categories of occurrence status of avian diversity recorded at TBWS.

Status	Number of species
Very abundant	12
Abundant	19
Very common	62
Common	16
Fairly common	41
Uncommon	7
Rare	7
Very rare	7

Seasonal occurrence of avifauna of TBWS recorded during 2009 to 2011 was found as summer breeder 7%, winter migrant 38%, year round resident 42%, and 13 % passage migrant Biologist believes that food abundance has an important determinant of winter abundance and distribution of migratory birds, including shorebirds (Hockey *et al.,* 1992).

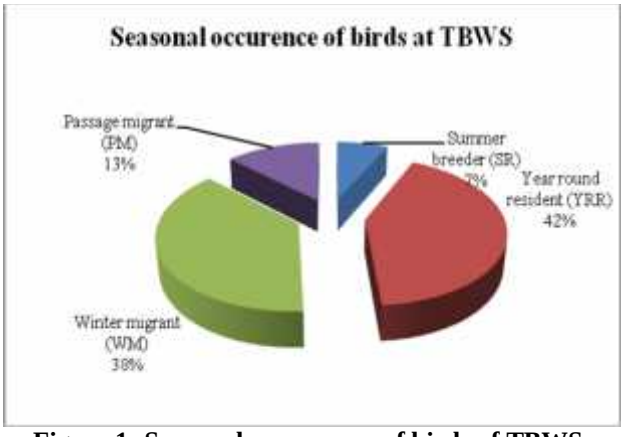

Figure 1: Seasonal occurrence of birds of TBWS.

In present study, maximum observed species were *Phalaerocorax carbosinensis* (4395), *Fulica atra* (2440), *Anas crecca* (998), *Larus michahellis* (952) and *Haematopus ostralegus* (938). The top five maximum counted bird species in 2001 to 2002 were *Pelecanus crispus* (1244), *Phoenicopterus roseus* (1242), *Larus michahellis* (1018), *Phalaerocorax carbosinensis* (785) and *Larus ridibundus* (723) (Ali, 2006). The most observed species of birds in 2008 to 2009 includes *Bubulcus ibis* (5240), *Egretta garzetta* (3150), *Egretta alba* (1670), *Hirundo rustica* (702) and *Riparia paludicola* (660) (Ali *et al*., 2011).

In the same way in 2009 to 2011 least observed species of birds were *Buteo buteo* (n=1), *Haliaeetus leucoryphus, Aquila rapax, Aquila heliacal, Sterna hirundo, Alcedo atthis, Tyto alba* two individuals in each respectively. However, least observed species in 2001 to 2002 were *Circus aeruginosus, Haliaeetus leucoryphus, Buteo buteo, Aquila rapax, Perdix perdix, Falco babylonicus, Gallinula chloropus, Gallinago gallinago, Eudynamys scolopacea, Saxicola caprata, Lanius vittatus, Falco concolor, Sylvia deserti* and *Lanius vittatus* only one individual in each (Ali, 2006). Correspondingly, the least observed bird species during 2008 to 2009 included *Anhinga melanogaste, Circus aeruginosus, Accipiter badius, Aquila nipalensis, Falco tinnunculus, Hydrophasianus chirurgus, Recurvirostra avosetta, Charadrius alexandrinus, Calidris minuta, Tringa stagnatilis, Tringa nebularia, Tringa glareola, Sterna acuticauda, Psittacula eupatria, Eudynamys scolopaceus, Athene brama, Alcedo atthis, Dinopium benghalense, Dendrocopos assimilis, Calandrella brachydactyla, Calandrella raytal, Anthus rufulus, Motacilla cinerea, Pycnonotus leucogenys, Phoenicurus ochruros, Saxicola torquatu, Orthotomus sutorius, Sylvia curruca, Cinnyris asiaticus, Oriolus oriolus, Lanius schach* and *Dendrocitta vagabunda* two individuals in each species, respectively (Ali *et al*., 2011).

Threats to Avifauna Observed at the Site: Following threats has been observed at TBWS for the avifauna (Table 4).

Threats	Intensity		
	High	Medium	Low
Habitat destruction	✓		
Hunting and fishing	✓		
Poverty	✓		
Unawareness		✓	
Grazing		✓	

Habitat destruction: The harvesting and utilization of the natural resources by human beings is the leading cause of habitat destruction. The expansion of agricultural fields in the close vicinity of TBWS is

causing much severe structural threats to biodiversity especially by creating disturbance to avifauna. The construction of dams, towns and agriculture development are the main cause of habitat destruction.

Hunting and fishing: Fishing practices and unlawful hunting by local community creates interruption in feeding and breeding of birds. For instance drowning of ducks in fishing nets has already been reported by Scott (1989). Hunting causes a severe disturbance in wildfowl and due to these disturbances ducks especially and other bird species in general shift their feeding and resting places or times (Khan, 1992).

Poverty: One of the foremost threats to biodiversity reduction in the study area was poverty. In the surroundings of TBWS, 35% households were extremely poor, 5% ultra poor, 3% poor, 17% medium and 40% were non poor. These communities were heavily depends upon biodiversity for their persistence and wellbeing.

Unawareness: Peoples of TBWS were mostly illiterate (64%) and only 17% (Primary to metric level) was literate. Due to high illiteracy rate local communities were unaware about the importance of wild fauna and flora and have no idea about sustainable management. Cause of illiteracy was observed institutional deficiency, as two primary and one middle school was working in the study area. Due to high poverty, villagers were unable to bear expenditure and send their children to other cities to educate them.

Grazing: The main human induced factors include grazing of livestock, hunting, agriculture, unchecked fisheries and encroachment of land near the sanctuary area. Livestock grazing has been an important issue for the management of TBWS. As the local community of TBWS was totally (100%) dependent on sanctuary for livestock grazing. Over grazing, results in flushing of nests by rain due to availability of less hay material for nesting birds. Unavailability of hay causes exposure which allows the birds of prey to approach the eggs or chicks of breeding birds (Khan, 1992). Free roaming of livestock in the sanctuary area was a great threat for the survival of birds' species.

It is concluded from the present study that there is a major decline in 14 avian species in the area. The main identified causes of this decline were habitat destruction, unawareness and poverty of the local communities. For the stability and proper functioning of the ecosystem, species richness and composition occupies a prominent place. There is an urgent need, therefore, to safeguard avian diversity by protecting natural habitat of the protected area.

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