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Avian Diversity around Indus River with Collision Prone Species Abundance at Proposed 765 KV Transmission Line

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ZA and MA conceptualized the study. ZA, UA, RA, IZ, MA and AB collected the data from the field. MA, ZA, RA, UA, AQ, and AB compiled and analyzed the data. MA, RA and UA drafted the manuscript. ZA and AQ reviewed and improved the manuscript.

Key words
Avian collision, Bird mortalities, Species abundance, Transmission lines, Indus River

ABSTRACT

A double circuit 765 kV Dasu Transmission Line (TL) of 250 kilometers length has been planned as Pakistan's first extra high voltage TL in the highlands. Collision risks for birds may be greatest around the Indus River and its tributaries. The study area is 7,951 km^2, stretching from the Dasu Hydropower Project in the north to the Islamabad West Grid Station in the south. Field surveys at 678 observation points were conducted from November 2017 to October 2018. A total of 38,939 birds were sighted, representing 215 different species. Tarbela Reservoir and the future Dasu dam site had the greatest abundance and diversity of avifauna. The number of individuals observed per survey peaked in November, at the height of fall migration; the secondary peak of back migration in March was much smaller. Most abundant species in the study area included Great Cormorant (*Phalacrocorax carbo*), Common Myna (*Acridotheres tristis*) and Carrion Crow (*Corvis corone*) with relative abundance 9.36, 6.58 and 5.73 respectively. Out of 215 species, 27 are collision-prone based on published reports or morphology. Natural birds and migratory sub-routes in the study area highlight the study's significance. Researchers might benefit from this research for similar studies in future developmental projects.

INTRODUCTION

Dasu Hydropower Project (DHP) is a major investment project proposed by the Government of Pakistan (GoP) to modernize and expand the energy sector of the country and to alleviate the shortage of electricity in Pakistan by generating clean and sustainable hydropower. DHP is a run of river project on the Indus River located seven km upstream of Dasu Town, District Kohistan, Khyber Pakhtunkhwa (KP). The site is 74 km downstream of proposed Diamer Basha Dam site and 350 km from Islamabad. DHP will have a total installed capacity of 5400 MW with 12 generating units and is among the priority projects under the National Power Policy 2013 and Vision 2025 of GoP. A 765 kV transmission line is proposed as part of DHP, which will generate 5400 MW of electricity which will be transmitted to National Grid in Islamabad through a 250 km long, 765 kV High Voltage Alternating Current, double circuit transmission line along Indus River which is known for the occurrence of endemic bird species and falls within important flyway routes for migratory birds. The proposed 765 kV transmission line corridor travels along the Indus and crosses the river seven times.

Transmission lines are high voltage power lines that range from 69 kilovolt (kV) to 765 kV. In these lines, electricity can travel through lines in both directions to balance the grid. Transmission lines are thicker than distribution lines, whose main purpose is to connect power plants and sub stations. The voltage range of distribution line is from 4kV to 69 kV (Jeffery, 2020). Transmission lines can have a significant bearing on the environment which has caused a prerequisite to study impacts, including bird interactions.

The risk of bird mortality from power line collision is a function of three interacting factors i.e., local avian population, environment of the area and the configuration/design of the power line (Bernardino *et al*., 2018; Rollan

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et al., 2010). In general, large, heavily bodied bird species are more susceptible and at greater risk to collision than smaller species (Rollan et al., 2010; Rubolini *et al*., 2005). In addition to the body size, the sensory perception, morphological feature, flight behavior, phenology and health of the birds are also contributing factors to collision. (Bernardino *et al*., 2018). Likewise, the species which tend to form large flocks and fly in groups are also at higher degree of collision risk (Drewitt and Langston, 2008; APLIC, 2012).

The environmental conditions of the site can have a profound impact at the resultant degree of collision risk. Power lines that pass through wetlands, coastal areas, extensive steppes and other major bird congregation habitats are considered to be the most hazardous (Andriushchenko and Popenko, 2012; Faanes, 1987). With respect to weather, low light, fog, rain, heavy wind and inclement weather exacerbate collision risk because power lines can become very difficult for an approaching bird to detect (Savereno *et al*., 1996). Most of the Avian collisions have been reported on high voltage power lines in the foraging and nesting areas of the bird population which are in the close proximity to the transmission lines especially near places used for taking off and landing (Quinn *et al*., 2011). In most documented collisions, it happens because the overhead transmission shield wire (OHSW) is smaller in diameter and is less visible to the bird (APLIC, 2012; Murphy *et al*., 2016).

Avian collision with overhead power lines is an ongoing concern in many countries across the globe (APLIC, 2012; Sporer *et al*., 2013) that may be an important source of mortality for certain species (Loss *et al*., 2014). Power lines are continuously expanding due to the increasing energy demands of growing and expanding communities, ultimately resulting in increased bird-transmission line interactions (Jenkins *et al*., 2010). Power lines can cause significant impacts on the environment both during construction and operation phases (Bagli *et al*., 2010). The most documented and confirmed impact is direct mortality of birds worldwide through collision and electrocution due to transmission lines and it may also impact threatened and endangered local populations negatively (Crowder, 2000; Drewitt and Langston, 2008; Shaw *et al*., 2010; Raab *et al*., 2012). The current study was planned to observe avian species in transmission line corridor and to enlist the collision prone species.

MATERIALS AND METHODS

Study site

The overall study area encompassed over 7,951 km^2, from Raikot Bridge in the North to West Islamabad Grid Station in the South (Fig. 1). The study area is rugged, with elevation ranging from 500 to 2,000 meters above sea level (masl), and diverse, comprising of six ecoregions and twelve unique land cover classifications. The National Transmission and Despatch Company's (NTDC) proposed 765kV, double circuit transmission line running from DHP located in district Kohistan of Khyber Pakhtunkhwa in the North to the Tarbela Reservoir in the South and adjoining mountainous areas at elevations up to 2,000 masl was considered to be main area of concern (Fig. 1).

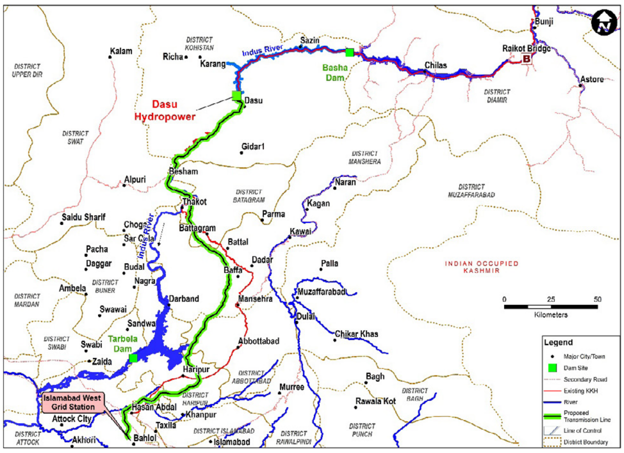

Fig. 1. Study area map (from Raikot to Tarbela reservoir).

Equipment

The equipment used for this study included a Garmin GPS map 76CSx, binoculars (Bushnell power view, 60 X 90 m, Harrier 65mm ED Spotting Scope and camera (Nikon p-900).

Avian surveys

Monthly avian surveys were conducted to obtain an account of the avian species in the study area (Fig. 2). Three primary sampling strategies were adopted including point counts, skyview surveys, and nocturnal surveys. A total of 678 points were surveyed in the 12 months from November 2017 to October 2018.

For the point count method (Verner, 1985), different vantage points were selected randomly during each survey, and observations were taken for fifteen minutes at each point. Nocturnal surveys were conducted to determine the presence of birds such as owls, nightjars and other nocturnal species. The skyview method was adopted to document raptor species and for that matter, the team members used binoculars, spotting scope and cameras at a specified location for one hour. The data were also collected throughout the day in order to completely survey the designated area within 8 to 10 days each month.

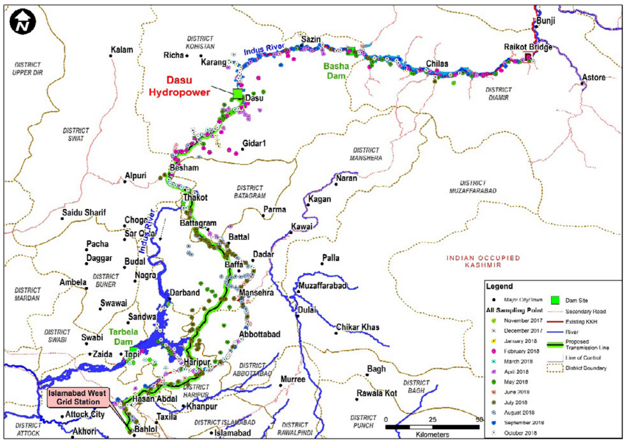

Fig. 2. Avifauna sampling points.

Shannon Weiner index

Shannon wiener index is famous for equalizing diversity among different ecological habitats. It is used to measure the diversity of species. It varies from 0 to 4. If the value of index is higher, it means that area/habitat will have the greater diversity. Species richness and evenness are required to calculate Shannon Wiener index. The land use classes extracted from Pakistan Forest Institute Land use in study area included agriculture land, alpine pasture, dry temperate, moist temperate, oak forest, rangeland, settlements, shrubs and bushes, snow and glaciers, sub-tropical broad leaved, sub-tropical chir pine and water bodies. Shannon wiener index was calculated for each habitat through following formula:

$$H' = -[\sum Pi \ln Pi]$$

Pi is the proportion of species relative to the total number of species, and lnPi is natural logarithm of this proportion.

RESULTS

In total, 215 avian species (Supplementary Table S1) were documented from a total of 678 observations during 12 months of field data collection. Birds observed during the survey belonged to 18 orders and 61 families. The maximum number of species belonged to the order Passeriformes, followed by Charadriiformes. A total of 38,939 individuals were observed across the study area. Most abundant species in the study area included great cormorant, common myna (*Acridotheres tristis*) and Carrion crow (*Corvis corone*) with relative abundance 9.36, 6.58 and 5.73, respectively

Tarbela Reservoir and the future Basha dam site were areas of greatest Avifauna abundance and diversity. The study revealed that important fall migration routes converge at Tarbela Reservoir, an important stopover for southern migration. The number of individuals observed per survey peaked in November, at the height of fall migration; the secondary peak in March was much smaller, reflecting a more diffused spring migration pattern. The diversity of bird species varied across the area with high numbers and diversity reflected in high Shannon-Weiner values near water such as the Tarbela Reservoir (Fig. 3). The body length was categorized as small (2-24cm), medium (24.1-42cm), large (42.1-82cm) and very large (82.1-182 cm). Out of 215, 115 species fell under the category of small while 59 were medium, 33 were large while 8 were very large (Fig. 4). The wing span was categorized into small (<15) medium (15-65 cm) and large (>65 cm). Out of total, 142 have small wing span while 39 species have medium and 34 species have large wing span (Fig. 5). Out of 215 avian species observed, 27 species (Table I) were determined to be collision prone (Fig. 6). Among collision prone species, 24 were least concern, one was near threatened (Ferruginous duck, *Aythya nyroca*) and two were vulnerable (common pochard (*Aythya ferina*) and Western tragopan (*Tragopan melanocephalus*). Collision- prone species accounted for 10% of the total observations. Most of the collision-prone species have strong associations with water habitats, and most of the point-count observations of collision-prone species were of ducks, geese, cormorants, and rails.

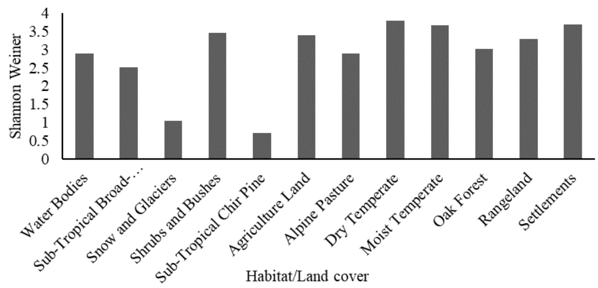

Fig. 3. Shannon-Wiener index by land cover.

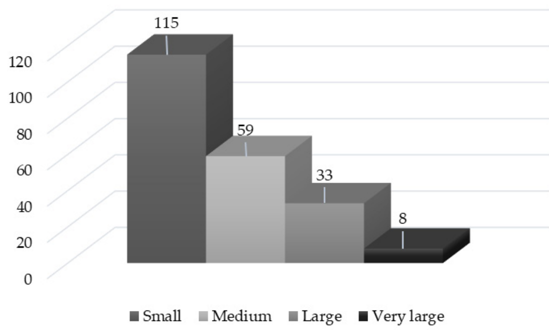

Fig. 4. Body length of avian species.

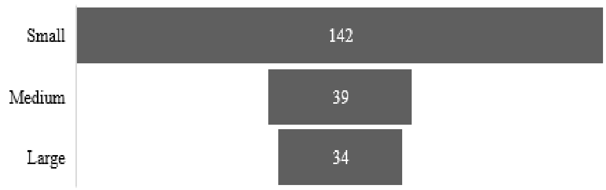

Fig. 5. Wing span of avian species.

Table I. Collision prone species.

S. No.	Scientific name	English name
1	*Amaurornis phoenicurus*	White-breasted waterhen
2	*Anas acuta*	Northern pintail
3	*Anas clypeata*	Shoveler
4	*Anas crecca*	Common teal
5	*Anas penelope*	Wigeon
6	*Anas platyrhynchos*	Mallard duck
7	*Anas strepera*	Gadwall
8	*Anser anser*	Graylag goose
9	*Anser indicus*	Bar- headed goose
10	*Aythya ferina*	Common pochard
11	*Aythya fuligula*	Tufted duck
12	*Aythya nyroca*	Ferruginous duck
13	*Buteo rufinus*	Long-legged buzzard
14	*Aquila nipalensis*	Steppe eagle
15	*Coturnix coturnix*	Common quail
16	*Fulica atra*	Eurasian coot
17	*Gallinago gallinago*	Common snipe
18	*Gallinula chloropus*	Moorhen/ waterhen
19	*Gelochelidon nilotica*	Gull-billed tern
20	*Himantopus himantopus*	Black-winged stilt
21	*Hieraaetus pennatus*	Booted eagle
22	*Phalacrocorax carbo*	Great cormorant
23	*Pucrasia macrolopha*	Koklass pheasant
24	*Circus aeruginosus*	Marsh harrier
25	*Tadorna ferruginea*	Ruddy shelduck
26	*Tragopan melanocephalus*	Western tragopan
27	*Troglodytes hiemalis*	Winter wren

DISCUSSION

Pakistan is a data deficient country for most of the avian species specially in the remote areas and where the developmental projects are expected in future. It is also difficult to estimate the mortalities due to collision with the high voltage transmission lines because of the known population of the collision prone avian species in project areas. This research was conducted to study the avian diversity along the proposed 765 kV extra high voltage transmission line at Indus Cascade. A total of 215 birds species were observed from the study area of 400km belt and from 678 observation points during 12 months (November 2017 to October 2018). A total of 38,939 individuals were observed and maximum number of species belonged to the order Passeriformes, followed by Charadriiformes. Mortalities due to collision are expected to be more during migration (southwards November and northwards March).

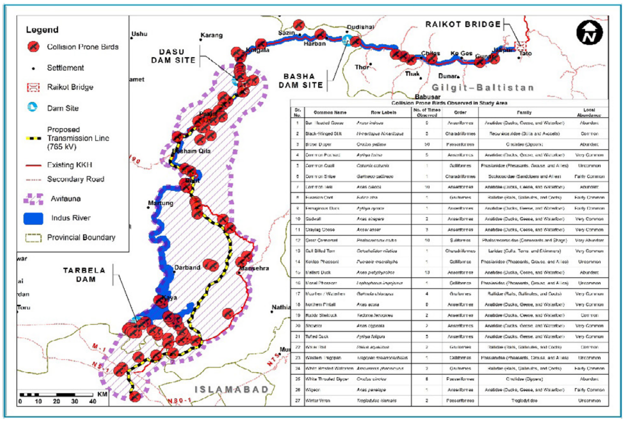

Fig. 6. Locations of collision prone species.

In the study area, 27 species were found to be collision prone. Among such species one was near threatened Ferruginous duck (*Aythya nyroca*) and two were vulnerable common pochard (*Aythya ferina*) and Western Tragopan. Ferruginous Duck has also been reported as collision prone by D'Amico *et al.* (2019). Some of the species in the collected data are rare or unidentified power-line collision sufferers, and exhibit morpho-behavioral traits that make these species not much susceptible to collisions. But, they commonly contain a threatened conservation status having high power-line density in their migratory routes. In such conditions, even infrequent collision events may cause significant consequences at the population level (D'Amico *et al*., 2018, 2019).

Among the sensitive species, Koklass pheasant *Pucrasia macrolopha*, Himalayan monal *Lophophorus impejanis*, and Western tragopan are range restricted (Grimmett *et al*., 2008). South of the Tibetan Plateau are known to be the wintering grounds of ruddy shelduck *Tadorna ferruginea* while the breeding grounds are the north of Himalayas mountain range. Considering this, it is possible that these species during migration (Parr *et al*., 2019) can collide with the structures like high voltage transmission lines in their migratory routes. According to Rioux *et al*. (2013) waterfowl, grebes, shorebirds and raptors are also more prone to the collision.

Among other species, common quail (*Coturnix coturnix*) is one of the collision prone species and it was found to be the most impacted species due to collision in a study conducted in Saudi Arabia (Shobrak, 2012). According to Mathiasson (1993), the susceptibility to bird collision can be due to poor lift capacity of the species and common quail can be considered one of the examples. Furthermore, among other factors the species vulnerability can be associated with exposure and susceptibility to collision. Moreover, studies suggested that birds with large wing span and body length for example, graylag goose (*Anser anser*), bar-headed goose (*Anser indicus*) and great cormorant are more prone to collision as compared to small birds. Vegetation density, cover, predation and terrain also contribute to bird collision susceptibility (Kerlinger and Curry, 2002; Osborn *et al*., 2000) such as in areas near Pattan, Besham and Dasu. Another research has revealed that the most collision prone species include large (Graylag goose, bar-headed goose) and habitat specialist (Western Tragopan) species (D'Amico *et al*., 2019).

After studying the avian diversity in the area, it is suggested that only a few species (Table I) can collide with the proposed transmission line and will cause outages. Not only the birds' life but the reliability of power supply can also be effected by usage of transmission lines for nesting and roosting by birds causing shutdowns and huge financial losses (Ding *et al*., 2021). Moreover, birds also defecate in a series of activities for example, nesting, laying eggs, brooding, resting, eating and fighting. High conductivity of bird droppings is an important factor causing streamer flashovers of high-voltage transmission line (Wang *et al*., 2018).

The natural presence of the birds and migratory sub-route of the Indus flyway in the proposed transmission line at upper Indus River highlights the importance of this study and the identified collision prone species along with other bird assemblages is an important beginning to invite conservationists and researchers to replicate such studies in other proposed developmental projects.

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Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20220507120544

Statement of conflict of interest

The authors have declared no conflict of interest.

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