Avian mortalities from two wind farms at Kutch, Gujarat and Davangere, Karnataka

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Abstract

Wind power is renewable and helps to reduce the greenhouse gas emission from the energy sector; however, it also has undesirable impacts on environment. Studies from Europe and USA report negative impact of wind farms on wildlife, especially on birds. India, the fourth largest producer of wind energy and also a mega bio-diverse country has very little information on this issue. Here, we report bird collisions from two wind farms: one at Kutch, Gujarat in western India and another from Davangere, Karnataka in southern India. A total of 47 bird carcasses belonging to at least 11 species in three-year period were reported from Kutch and seven carcasses of at least three species in one-year period were recorded at Davengere wind farms. The estimated annual bird mortality rate for Kutch was 0.478 birds/ turbine and for Davengere it was 0.466 birds/turbine.

Key words: wind turbines, bird collisions

Introduction

Wind power is one of the fastest growing renewable energy sector in the world[1]. India is the fourth largest producer of wind energy with an installed capacity of 32,280 MW as of March 2017, with a target of 60 GW by 2022[2]. Tamil Nadu, Maharashtra, Gujarat, Rajasthan and Karnataka are the leading states where most wind turbines are installed[2]. Although wind power is considered as a green energy source, there are negative impacts of wind farms reported on wildlife [3]. Wind farms affect terrestrial mammals [4] and reptiles [5], but the most affected groups are birds and bats [6,7]. The rotating blades of the wind turbine causes bird collisions [8]. Apart from bird collision which is considered as major impact of the wind turbine, other noted negative impacts includes displacement of birds from the turbine area [9], changes in territorial behaviour of birds due to turbine noise[10] and habitat alteration[6].

This issue came to light after large scale raptor mortality was documented at the Altamount pass, USA in the 1990[11]. Since then bird mortality at wind farms has been extensively studied in Europe and North America[8,12,13] but remains poorly studied in Asia[14,15]. In India, there have been few studies on effect of wind farms on bats and birds. The existing two studies are from Maharashtra and Gujarat[16,17]. Considering the rich diversity of avifauna with 554 Important Bird Area (IBA) spread all across the country[18], the rapid increase of wind turbines[1] are in need of investigation for their possible impacts on native avifauna.

The present study investigated bird collisions with wind turbines at two wind farms; one is located at Samakhiali region of Kutch district in Gujarat and the other in Harapanahalli region of Davangere district in Karnataka. Both wind farms are located in entirely different habitats;

Samakhiali a coastal area located close to Little Rann of Kutch and Harapanahalli a hilly area in Central Karnataka. The specific aim of this study was to document avian collisions and to provide an estimate of the annual mortality rate for these two wind farms.

Study Area

Samakhiali, Gujarat

This wind farm is located in Samakhiali region of the Kutch district (between 23°15' 5.18" N and 23° 11' 21.72" N to d 70° 30' 8.68" E and 70° 38' 24.68" E). The high winds and flat terrain close to the Arabian Sea make it a suitable location for wind power generation and has resulted in large number of wind turbines being setup in this area since 2003. This wind farm comprises of about 200 turbines and covers ~120 sq.km area and the majority of the turbines were of 1.8 MW capacities with 95 m hub height and a rotor diameter of 100 m.

The area is generally dry and arid, dotted with many seasonal wetlands. Barren lands with the invasive tree *Prosopis juliflora* predominate the landscape, with a small number of rain-fed agricultural fields. Most of the rainfall is received during July to September. Kutch district has four Important Bird and Biodiversity Areas[18] of which, the Wild Ass Wildlife Sanctuary (Little Rann of Kutch) is close to the study area and few turbines are located ~200 m from the sanctuary boundary. The region is also a stopover site for birds migrating thorough Central Asian Flyway (CAF), that makes it a bird rich area with 174 species of birds (Observations by SRK and AMSA). We selected 59 turbines for the carcass search of which 51 turbines belongs to a private wind farm company which requested this study. Remaining eight turbines were selected on the basis of easy access from the road. However, the selected turbines were scattered across the wind farm in different habitats like agricultural fields, barren land and close to saltpans.

Harapanahalli, Karnataka

This wind farm is located at Harapanahalli region of Davangere district (between $14^{0}45'$ 11.57" to $14^{0}53'$ 23.78" N, and longitudes $75^{0}47'$ 36.75" to $75^{0}50'$ 54.47"). The selected wind farm has 24 wind turbines located in 56 sq.km area. All the turbines are of 1.5 MW capacities, with 78 m hub height and a rotor diameter of 82 m. This study was conducted on the request of private windfarm company hence all the turbines (24) belongs to that company were selected for the study. There are about 75 wind turbines located 10 km from the present location which is not covered in the study. The wind farm is a part of 'Hyarada Block-C Reserved forests' a dry deciduous forest surrounded by human settlements. The elevation ranges from 500m to 800 m. This area is dominated by *Ziziphus mauritiana* and *Terminalia crenulata.* This area also has many small wetlands within the 5 km radius of the wind farm and the Tungabhadra River flows about 12 km west of the study area. The study area has a rich avifaunal diversity with about 115 species of birds (personal observations by VA, PRA & RJ).

Methods

Carcass search

Carcass surveys were conducted at selected 59 turbines from October 2011 to July 2014 at Samakhiali. Totally, 23 cycles of search were conducted at each turbine. The average gap between two consequent searches is 40.5 days. In Harapanahalli wind farm, nine cycles of searches were conducted in 24 wind turbines from January 2014 to February 2015 with an average gap of 40 days.

At both wind farms, 130 m radial area around each selected turbine was searched by slowly walking along a spiral path outwards from the centre [12]. On most occasions, two persons surveyed

Samakhiali wind farm, whereas one person searched for carcass at Harapanahalli. The time spent on searching a turbine site was approximately 30-40 minutes. When a carcass or feather and bone remaining (featherspots[19]) was found, data on species, condition of carcass and distance to the turbine base was recorded. Bird nomenclature was followed as in Praveen *et al.* [20] . The study covered both migratory (October to March) and non-migratory (April- September) period of birds. There was not much difficulty in locating the carcasses at both wind farms, hence the detection probabilities for both the wind farms were assumed as '1' i.e. the observer could detect all the carcasses which are available below turbine during search. The injuries seen in some carcasses (like broken leg, injuries on head, broken wing) revealed that death is caused by collision of birds with the wind turbine. Most of the existing studies have not put effort in determining the cause of death of the birds recorded below wind turbines, as the probability of natural deaths within the search area was not significant[19,21].

Scavenger Removal Test

Bird carcasses following collisions may be scavenged by dogs, jackals, and other scavenger species between two consequent searches. The major scavengers seen in the study area during our surveys include Bengal Monitor (*Varanus bengalensis),* Golden Jackal *(Canis aureus)* and domesticated dog (*Canis familiaris*). This bias can be corrected using scavenger removal tests. It determines the average number of days that a bird carcass remains in the search area below turbine before being removed by scavengers[22]. We used 10 bird carcasses belonging to 10 different species (3 fresh; 7 old/scavenged carcasses with only feathers and bones) for this test from Samakhiali wind farm. The smallest species used was Black Drongo *Dicrurus macrocercus* and Largest was Dalmatian Pelican *Pelecanus crispus* (See table 1 for species used for carcass test). No statistical test was performed to assess the role of body size in scavenger removal due to low sample size.

Only two carcasses were used from Harapanahalli Wind farm (See table 1). The mean length of time a carcass remained on a plot (T) was calculated based on the following equation [12,22].

$$\mathbf{T = \Sigma ti / S}$$

where, **ti** is the total length of time a carcass remained on site, **S** is the total number of carcasses planted for the study.

The estimated number of annual fatalities of the wind farms (M) calculated for the Samakhiali and Harapanahalli wind farms separately using the following formula[23],

$$\mathbf{M} = \frac{\mathbf{N \times I \times C}}{\mathbf{k \times T}}$$

Where, **N** is the total number of turbines, **I** is the interval between searches in days, **C** is the total number of carcasses found, **k** is the number of turbines sampled, and **T** is the mean length of time carcasses remained on site before being scavenged. The mortality rates per turbine estimated by dividing the **M (**estimated number of annual fatalities of the wind farms**)** with number of turbines present.

Results

Samakhiali Wind farm

In total, 47 bird mortalities belonging to 11species (8 resident and 3 winter visitors) including globally threatened Dalmatian Pelican (Vulnerable) and Near-threatened Painted Stork were recorded[31] (Table 1). Eurasian Collared Dove had maximum number of collisions (10 individuals), followed by Rock Pigeon (6 individuals.), Common Kestrel, Cattle Egret and House Crow each with four mortalities. In all, five carcasses were identified to family level (Accipitridae) and eight carcasses could not be identified to family level as they were scavenged beyond recognition. Among the 47 mortalities, 43 were recorded in migratory season (from October to March) and 4 were recorded in non-migratory season (from April to September). Of the 59 turbines searched, 37 turbine locations had bird carcasses recorded. All the carcasses were recorded within 80 m from the base of the turbine and maximum numbers of carcasses (21) were recorded within 20 m from the base of the turbine (Figure 1).

The simple average of bird collision for 59 turbines was 0.27 birds/turbine/year. The estimated annual mortality rate using the scavenger removal formula was 0.47 birds/turbine/year (over two years and 10 months). Three fresh carcasses (Pallid Scops Owl; Rock Pigeon and Cattle Egret) and seven scavenged carcasses (only feathers were remaining) found during search were left as such for the scavenger removal test. On an average the fresh carcasses remained intact in the field for 1.3± .57 (SD) days. However, the feathers of carcasses lasted for 23.7 ± 13 (SD) days. Since most of our records of carcasses were from feather remains, we used 23.7 days as the residence time for the estimation of annual mortality rate. However, there are chances that fresh carcasses might have been carried away entirely by scavengers without trace and it is likely that smaller birds may disappear entirely in short period of time.

Harapanahalli wind farm

In all, seven bird mortalities belonging to at least three species were recorded (average 0.29 birds/year/turbine). The bird carcasses observed included Indian Pitta, White-throated Kingfisher, Little Swift, one unidentified raptor (Family: Accipitridae) and two other unidentified taxa (Table 1). In all, four carcasses were recorded in migratory season and three in non-migratory season. None of the species recorded was listed as threatened by IUCN. Among the three species, one species Indian Pitta is a winter visitor and other two were resident to the study area. All bird carcases were recorded within 60 m from the base of turbine (Average: 21.5m) (Figure 2). Two fresh carcasses (Indian Pitta and Little Swift) were left in the field and monitored daily for the scavenger removal rate estimation. The mean length of time a carcass remained on a plot (T) was 2.5 days. The estimated annual bird mortality rate for Harapanahalli wind farm is 0.466 birds/turbine (1.5 MW capacity).

Discussion

Our study documented mortality of birds owing to collision with wind turbines from two wind farms one at Samakhiali and another Harapanahalli. The number and species of birds involved in collisions were different. No common species were observed in Samakhiali and Harapanahalli wind farm mortalities. However, the family Accipitridae was found to be affected in both the wind farms and also from another existing study in India[16]. Raptor mortalities were also reported from other bird collision studies from USA, UK and Europe[8,13]. Apart from Raptors, Eurasian Collared Dove and Rock Pigeon were killed in more numbers at Samakhiali wind farm. Similar to this observation, high number of Rock Pigeon mortalities was reported from many wind farms in the USA[8]. The water bird mortalities at Samakhiali could be due the presence of numerous wetlands within the wind farm. Similarly, the collision of Indian Pitta in forested area of Harapanahalli shows that the collisions mainly depend on the bird composition present at the wind farm.

At Samakhiali, most of the carcasses were recorded during the migratory season when the area is extensively used by migratory birds. Apart from this, resident birds also faced mortality in winter, this suggest the role of other parameters such as climatic conditions in determining bird mortalities for instance it is reported that bad weather condition can cause high bird mortalities[12]. Although the estimated annual mortality rate for Samakhiali was 0.47 birds/ turbine/year (over two years and 10 months) this estimation could be lower as smaller carcasses could have been removed by scavenger and this bias of carcass size is not accounted in our estimation. The fresh carcasses we planted for bias correction test were removed in about two days, hence, in future studies more frequent searches (minimum weekly twice) will give a better understanding of the mortality patterns. There is a further chance that the estimated mortality rate presented in this paper may be on the lower side because we assumed searcher efficiency as 01 (100 %). The mortality rates reported in other existing studies from other countries showed large variation for eg. from 0 to 64 birds/ turbine annually among wind farms[13]. Studies that shows high mortality rates includes report of 64.26 birds/turbine/year at El Perdón, Spain[13,24], 54 birds/turbine/year in Solano county, USA[8] and 35 birds/turbine/year in Boudewijnkanaal te Brugge, Belgium[25]. In contrast to such high records of bird mortalities, studies conducted at Green Mt, Searsburg and IDWGP Algona, USA reported zero bird mortality[8].

Species affected also vary based on the geographical and climatic features. More than the number of birds killed, the type of species getting killed is of concern. Raptors are the most affected group of birds worldwide by the wind turbines and the present study is yet another proof of this. The long-term impacts of the wind farm on raptors are of greater concern, because they produce few offspring and have a long-life expectancy and occupy top of the food chain[26]. A study conducted in Spain[27] showed that wind farms are a serious threat to the long living raptors as it decreases survival rates of this species and increases the chance of extinction.

Apart from the direct collisions, the displacement of bird species from wind turbine should also be taken into consideration[9]. For instance, the wind turbines installed on the habitat of critically endangered species such as Great Indian Bustard *Ardeotis nigriceps* may seriously affect the very survival of these bird species mediated through habitat alteration. In Harapanahalli, we found, the roads were constructed on many small hillocks and these hilltops were flattened for the turbine installation. This led to the extensive destruction of the vegetation cover of the area otherwise a dry deciduous forest a habitat for many bird species.

Considering the increased power consumption in India, the renewable sources of power production has to be tapped but the impacts on the avifauna should also be borne in mind. The present studies indicate the potential impacts of wind turbines on the birds. There are various mitigation measurements followed in some places, which includes automatic shutdown of turbines whenever a high-risk situation occurs (e.g. bird flocks approaching the high collision risk zone) or restriction of its operation during certain times of the day or seasons when bird activity is high in the area. Increasing wind turbine visibility for the birds using appropriate methods, placing bird deterrents and habitat management, including creation of alternative feeding areas[28], can also be helpful in mitigation of impacts by wind farms. Further large-scale experimental data is needed to confirm the effectiveness of these practices in mitigating wind farm bird collisions. We strongly recommend detailed bird monitoring studies before the installation of wind turbines. Careful selection of wind farm sites based on avifaunal importance of these sites and implementation of appropriate management and mitigation options can definitely help to reduce the impacts of wind farms on birds to a large extent.

Acknowledgements:

We are grateful to M/s Genting Energy Pvt. Ltd., CLP Wind Farms (India) Ltd and Vestas, Pvt. Ltd. for their financial and logistical support for the study. We are thankful to the Director; SACON for his continuous support and encouragement. SRK is grateful to Director, BNHS for the support provided. We are thankful to Neha Sinha, BNHS for help in improving the language in earlier version of this manuscript.

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Table-1. List of bird collisions at Samakhiali wind farm (Between October 2011 and July 2014; from 59 turbines locations; 23 rounds of searches) and Harapanahalli wind farm (Between January 2014 and February 2015 from 24 turbines), (R-Resident; WV-Winter Visitor; LC-Least Concern; NT-Near Threatened; VU-Vulnerable). The number of carcasses used for scavenger removal test is given in the parenthesis.

Family	Common name	Scientific Name	Resident Status	IUCN Status	No. of bird mortalities	
					Samakhiali	Harapanahalli
Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*	R	LC	1	-
Ardeidae	Cattle Egret	*Bubulcus ibis*	R	LC	4(1)	-
Dicruridae	Black Drongo	*Dicrurus macrocercus*	R	LC	1(1)	-
Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	R	LC	1	-

Ciconiidae	Painted Stork	*Mycteria leucocephala*	R	NT	1	-
Columbidae	Rock Pigeon	*Columba livia*	R	LC	6(1)	-
Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	R	LC	10(1)	-
Corvidae	House Crow	*Corvus splendens*	R	LC	4	-
Falconidae	Common Kestrel	*Falco tinnunculus*	WV	LC	4(1)	-
Pelecanidae	Dalmatian Pelican	*Pelecanus crispus*	WV	VU	1(1)	-
Strigidae	Pallid Scops Owl	*Otus brucei*	WV	LC	1(1)	-
Alcidinidae	White-throated Kingfisher	*Halcyon smyrnensis*	R	LC	-	1
Apodidae	Little Swift	*Apus affinis*	R	LC	-	1
Pittidae	Indian Pitta	*Pitta brachyura*	WV	LC	-	2
Unidentified raptors of Family Accipitridae					5 (2)	1
Other unidentified taxa					8	2
Total					47	7

Figure 1. Distances from the base of turbine at which carcasses were recorded in Samakhiali (surveyed between October 2011 and July 2014; from 59 turbines locations)

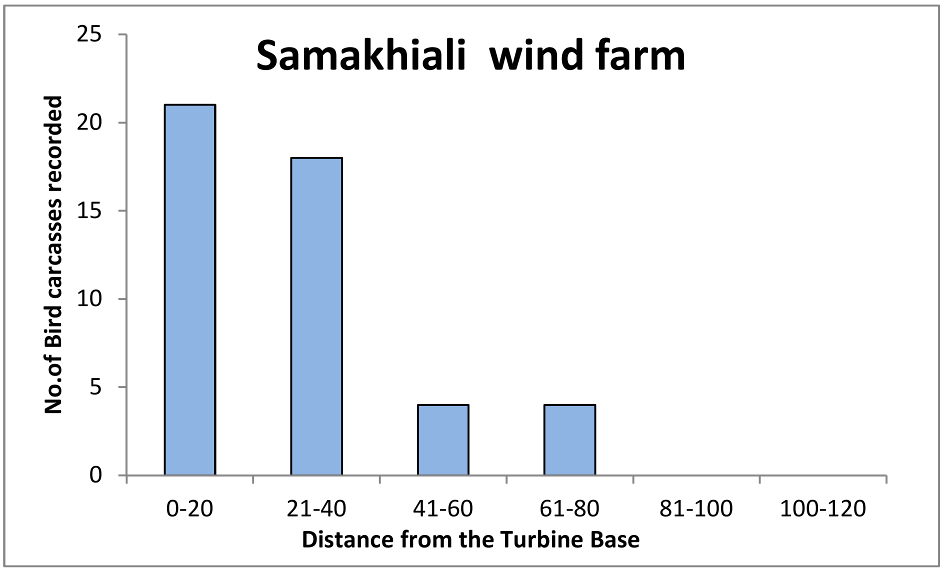

Figure 2. Distances from the base of turbine at which carcasses were recorded in Harapanahalli wind farms (surveyed between January 2014 and February 2015 from 24 turbines)