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Original article

Impact of wind turbines on birds: a case study from Gujarat, India

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ABSTRACT

Rising generation costs, shortage of fuel sources and high environmental costs have raised serious concerns about the sustainability of conventional power generation methods. In this context, the wind-based power generation is gaining prominence, as an alternate source of renewable energy. Globally, India is at fifth position in wind power generation with an installed capacity of 14550 MW. However, based on recent reports from certain parts of the world, there is also a growing concern on the environmental impacts of wind turbines on birds. The present field study was conducted to evaluate these impacts in an Indian context. We have been studying the birds from a wind farm in Kutch District, Gujarat, India since September 2011 and our preliminary results of the past one year study is presented here. We used line transect method to estimate the bird species composition and standardized visual search methods to record the fatalities of birds caused by turbines. During the study span, 139 bird species were recorded which include eight *Near threatened* species as per IUCN Red list. Totally six bird fatalities were recorded as a result of collisions with the wind turbines. Preliminary findings of this study confirm the possible impact of wind turbines on birds in Kutch region.

1. Introduction

Wind-generated electricity is renewable and generally considered environmentally clean, and recent technological advances and tax subsidies have allowed commercial wind generation to compete with energy produced from fossil fuels and nuclear power (Gipe, 1995; Redlinger *et al*., 2002). Harnessing wind energy is an affordable form of power generation that is pollution-free with relatively less environmental impacts. These advantages have lead to a dramatic increase in its popularity in recent years and have resulted in the proliferation of wind farms around the world (Osborn *et al*., 2000).

In India, several wind farms are already working or under are construction especially in those areas with wind resource is plentiful. Often, suitable areas tend to occur offshore or onshore in coastal areas, on ridges and mountains, in open agricultural areas and other open habitats. Many of these areas contain sensitive habitats and/or bird species, which heighten the importance of assessing the effects of wind energy projects. As of 31 March 2011 the installed capacity of wind power in India was 14550 MW, mainly spread across Tamil Nadu (6007MW), Maharashtra (2310.70 MW), Gujarat (2175.60 MW), Karnataka (1730.10 MW), Rajasthan (1524.70MW), Madhya Pradesh (275.50 MW), Andhra Pradesh (200.20 MW), Kerala (32.8 MW), Orissa (2MW), West Bengal (1.1 MW) and other states (3.20 MW). It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012. Wind power accounts for 6% of India's total installed power capacity, and it currently generates 1.6% of the country's power.

Bird fatalities caused by human-made infrastructures (power lines, communication towers, wind turbines) are widely reported from around the world (Erickson *et al*., 2005; Manville, 2009). Wind farms affect birds mainly through collision with turbines and associated power lines (Drewitt and Langston 2006; Lekuona & Ursua 2007) or disturbance displacement (Drewitt and Langston, 2006). Observed impacts vary geographically due to varying topography, habitat, weather conditions, flyways, species diversity and species abundance (GAO, 2005). Some recent studies suggest insignificant threats to wildlife from commercial wind-generated electricity relative to other anthropogenic structures (such as buildings and automobiles) and energy sources (NRC, 2007; Sovacool, 2009).

Nowadays, there is abundant literature on the impact and mortality of birds and caused by wind turbines in different countries like USA, UK, Canada, New Zealand, Ireland, Denmark, Spain, Belgium and Australia (Leddy *et al*., 1999; Howe *et al*., 2002; Percival, 2003; Jain, 2005; Barclay *et al*., 2007; Everaert and Stienen, 2007; Miller, 2008; Cryan and Barclay, 2009; Powlesland, 2009; Sharp, 2010; Graham and Hudak, 2011). Nevertheless, the impact of wind farms on birds in from the Indian context is very less studied with almost no scientific literature available on this topic. Hence, in this paper we provided preliminary data on avifaunal composition around wind farm locations and the impact of wind farms on birds.

2. Materials and methods

The present study was carried out 51 wind turbine locations covering four villages namely, Vandhiya, Modpar, Lakhapar and Jangi about 20km to the south-east of Samakhiyali, Bhachau Taluk, Kutch District, Gujarat, India (Fig. 1) between September 2011 and July 2012. Total land area covered is about 127 acres and the wind turbines were located in agricultural lands, un- irrigates lands and coastal line (Fig. 2, 3). The wind farms are situated between 23°15´5.18 and 23° 11´21.72 N and 70° 30´8.68 and 70°38´24.68 E with the mean sea level of 8 to 30m. The study area is flat terrain with scanty vegetation, agricultural fields, human settlements, waste lands and several water-bodies of varying sizes. The study area is also close to the vast expanse of Little Rann of Kutch and the Wild Ass Sanctuary area situated towards its southern border. Bajra *Pennisetum americanum,* Ground nut *Arachis hypogeal,* Cotton *Gossypium herbaceum,* Sorghum *Sorghum bicolour* etc., are the major cultivated crops in the study area. The study area has a characteristic dry and hot climate. The hot and humid climate occurs during July to September and cold and dry climate occurs between October and February. The average temperature during hottest months ranges from 17.6 to 39.5 °C and the annual rainfall varies from a few mm to 900mm the average being 400 mm. This area has the history of earthquakes and the seismicity of the area is coming under the very high damage risk zone categorized as Zone-V with seismic intensity of MSK-IX or more on the Medvedev-Sponheuer-Karnik scale.

Bird surveys using the line transect method of Gaston (1975) was done to estimate the species composition in the study site. The survey was carried out in four different transects (3km) including one transect on shore line. All census operations were carried out immediately after sunrise, from 05:30 to 08:30 hrs. Transects were walked at a

rate of 0.75 to 1.00 km/hr. The bird species name, number of individuals and their activities were recorded during the transect walks.

In order to record the mortality of birds at turbine sites, searches for fatalities were conducted at each of the turbines. At each wind turbine, 100m transect in four directions were walked and bird carcasses encountered were recorded (Orloff and Flannery, 1992; Anderson *et al*., 1999). When a carcass was found, data such as species, sex, distance to the closest turbine, kind of injuries and estimated time of death were recorded (Orloff and Flannery, 1992; Christensen *et al*., 2003).

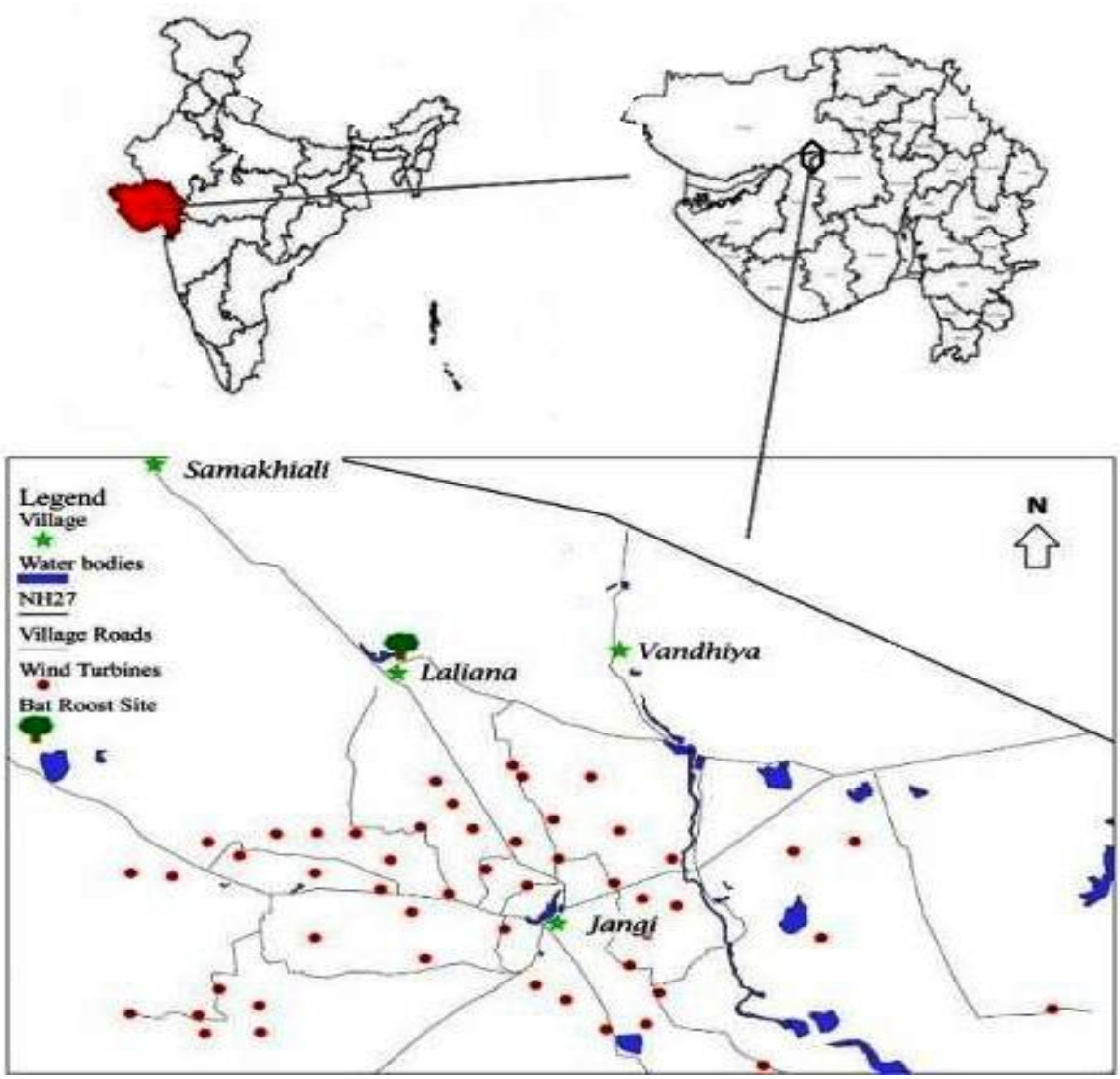

Fig.1. Map of India and Gujarat showing study site.

3. Results

During the study span, 139 bird species belonging to 45 families and 16 orders were observed in and around wind turbine locations (Appendix-1). Among the 16 orders, Passeriformes dominated the list with 43species followed by Charadriiformes with 26 species; Ciconiiformes with 20 species; Coraciiformes with 8 species; Colubmiformes with 7 species; Anseriformes with 6 species; Falconiformes and Gruiformes with 5 species each, Pelicaniformes, Cuculiformes and Galliformes with 4 species each; Apodiformes with 3 species; Podicipediformes, Psittaciformes, Piciformes and Strigiformes with one species each. Most of the family contained 2-3 species.

Maximum percent occurrence was found in the Families: Ardeidae (7.91%), Scolopacidae (7.91%), Laridae (6.47%) and Columbidae (4.32%) respectively. Of all bird species, 48.2% species were resident, 20.1% were resident with local movements, 15.8% were resident with winter migrants, 12.2% were winter migrants and 3.6% were winter migrant and passage migrant.

Fig. 2. View of wind turbines located in the study area.

Out of 139 species recorded, Darter *Anhinga melanogaster*, Lesser Flamingo *Phoenicopterus minor*, Oriental White Ibis *Threskiornis melanocephalus*, Black-tailed Godwit *Limosa limosa*, Black-bellied Tern *Sterna acuticauda*, European Roller *Coracias garrulous,* Eurasian Curlew *Numenius arquata* and Painted Stork *Mycteria leucocephala* are listed as *Near Threatened* (IUCN 2008) and the Indian Peafowl *Pavo cristatus*, Black-shouldered Kite *Elanus caeruleus*, Black Kite *Milvus migrans*, Shikra *Accipiter badius*, Eurasian Sparrow hawk *Accipiter nisus*, Western Marsh-Harrier *Circus aeruginosus* and Eurasian Spoonbill *Platalea leucorodia* are included in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Corvus sp.

Cattle Egret *Bubulcus ibis*

Blue Rock Pigeon *Columba livia*

Fig. 3. Evidence of wind turbine mortalities/injuries of birds.

During the study time we found six bird carcasses namely that of Blue Rock Pigeon *Columba livia* and *Corvus* sp., Spotted Dove *Streptopelia chinensis,* Cattle Egret *Bubulcus ibis*, Eurasian Collared Dove *Streptopelia decaocto* and an unidentified Egret sp. on our mortality search transects. Crashed birds were found from 20 m to 120 m

away from turbines, and the mean distance was 59 m (Table 1). One House Crow, Egret sp., Eurasian Collared Dove and Spotted Dove probably crashed a few weeks earlier, because only remains were found (wing bones and feathers). However, the Cattle Egret presumably crashed with a turbine blade a few days before the bird was found. It was partially devoured by some scavenger as evidenced from stained wings and beaks. One Blue Rock Pigeon was injured by few hours before the bird was found. The bird was alive but severely injured in eyes and wings. However all crashed birds were common species under the category *Least Concern* (IUCN 2008).

Table 1
List of bird collision recorded in the study site

Species	Condition	Distance from nearest turbine (m)
Blue Rock Pigeon	Intact (injured)	20
Corvus sp.	Feathers and bones	55
Egret sp.	Feathers only	25
Eurasian Collared Dove	Feathers only	55
Spotted Dove	Feathers only	80
Cattle Egret	Scavenged	120

4. Discussion

The development of wind-energy is a vital component of the India-wide objective to increase the proportion of energy derived from renewable sources, thus helping to reduce the emission of greenhouse gases. However, wind energy production itself is not without its share of impacts on the environment. Considering the current pace and scale of wind power development proposals, combined with the poor understanding of their impacts, it is a cause for concern. One of the main areas of concern is the potential impact of wind farms on birds. Many of the studies carried out on collision mortality, displacement, barrier effects and direct habitat loss caused by wind farms are either inconclusive, due in part to inadequate study methods or indicate effects that are not significant for a given species, site and season, such incomplete and partial assessment results may lead to inadequate environmental impact assessments of future wind energy developments. Indeed, the relatively few studies that do indicate a significant impact are a clear warning that the inappropriate location of a wind farm can adversely affect wild bird populations significantly. The potential implications of wind farms for birds are of even greater concern when considering the scale of current applications and the possibility of the effects of individual wind farms interacting to produce much larger cumulative impacts on bird populations. Hence there is a pressing need for more information on the range of potential impacts of wind farms, from across landscapes and seasons.

The high avian species-richness recorded from the study area is due to the presence of diverse habitat types and to the fact that it is located along the major, western Indian migratory flyway of birds. Based on the results of preliminary study, the operation of wind turbines has an impact on some of the birds present in the region. However the magnitude of impact is too less compared to the reports from wind farms in various other parts of the world (Pedersen and Poulsen, 1991; Muster *et al*., 1996). In general, previous studies suggest that the frequency of avian collisions with wind turbines is low, and the documented impact of wind power on bird populations today is negligible (Erickson, 2001; de Lucas *et al*., 2004; Walker *et al*., 2005; Madders and Whitfield, 2006). The effects of a wind farm on birds depend on a wide variety of factors such as the characteristics and location of the wind farm, topography, habitat of the surrounding land and species present (Percival, 2000; Hoover and Morrison, 2005). The average number of collision fatalities in different European wind farms varies between a few birds per turbine per year up to 64 birds per turbine per year (Langston and Pullan, 2003). Also within a wind farm the impact can strongly differ between individual turbines, indicating that 'site selection' can play an important role in limiting the number of collision fatalities.

There are major gaps in our knowledge with regard to impacts of Indian wind farms on birds. For example, it is not known to what extent each species is prone to wind farm development (collision, disturbance), which species are suffering collision fatalities, which routes are taken by migrants, how fixed these routes are in relation to varying weather conditions and time of travel and the extent to which each species is able to avoid collision with turbines.

5. Conclusion

In conclusion, the preliminary findings of this study confirm the possible impact of wind turbines on birds. However, the actual effect of wind farm on bird populations requires a regular long term monitoring study. While additional data such as bird fatality rate (carcasses/turbine/year), mortality rate during migration, breeding or wintering season and across various weather conditions will be needed to establish actual impacts of wind farms that would help us to prioritize future studies.

APPENDIX-I

List of bird species recorded in the study site during the study period.

English Name	Scientific Name	Status
Order: Podicipediformes		
Family: Podicipedidae		
LITTLE GREBE	*Tachybaptus ruficollis* (Pallas, 1764)	R/LM
Order: Pelecaniformes		
Family: Phalacrocoracidae		
LITTLE CORMORANT	*Phalacrocorax niger* (Vieillot, 1817)	R/LM
INDIAN SHAG	*Phalacrocorax fuscicollis* (Stephens, 1826)	R/LM
GREAT CORMORANT	*Phalacrocorax carbo* (Linnaeus, 1758)	R/WM
Family: Anhingidae		
DARTER	*Anhinga melanogaster* (Pennant, 1769)	R/LM
Order: Ciconiiformes		
Family: Ardeidae		
LITTLE EGRET	*Egretta garzetta* (Linnaeus, 1766)	R/LM
WESTERN REEF-EGRET	*Egretta gularis* (Bosc, 1792)	R/LM
GREY HERON	*Ardea cinerea* (Linnaeus, 1758)	R/WM
PURPLE HERON	*Ardea purpurea* (Linnaeus, 1766)	R/LM
BLACK-CROWNED NIGHT HERON	*Nycticorax nycticorax* (Linnaeus, 1758)	R/LM
LARGE EGRET	*Casmerodius albus* (Linnaeus, 1758)	R/LM
MEDIAN EGRET	*Mesophoyx intermedia* (Wagler, 1829)	R/LM
CATTLE EGRET	*Bubulcus ibis* (Linnaeus, 1758)	R/LM
INDIAN POND HERON	*Ardeola grayii* (Sykes, 1832)	R/LM
LITTLE GREEN HERON	*Butorides striatus* (Linnaeus, 1758)	R
GREAT BITTERN	*Botaurus stellaris* (Linnaeus, 1758)	WM
Family: Ciconiidae		
PAINTED STORK	*Mycteria leucocephala* (Pennant, 1769)	R/LM
ASIAN OPENBILL-STORK	*Anastomus oscitans* (Boddaert, 1783)	R/LM
WHITE-NECKED STORK	*Ciconia episcopus* (Boddaert, 1783)	R/LM
Family: Threskiornithidae		
ORIENTAL WHITE IBIS	*Threskiornis melanocephalus* (Latham, 1790)	R/LM
BLACK IBIS	*Pseudibis papillosa* (Temminck, 1824)	R/LM
GLOSSY IBIS	*Plegadis falcinellus* (Linnaeus, 1766)	R/WM
EURASIAN SPOONBILL	*Platalea leucorodia* (Linnaeus, 1758)	R
Family: Phoenicopteridae		
GREATER FLAMINGO	*Phoenicopterus ruber* (Linnaeus, 1758)	R/LM
LESSER FLAMINGO	*Phoenicopterus minor* (Geoffroy, 1798)	R/LM
Order: Anseriformes		
Family: Anatidae		
COMB DUCK	*Sarkidiornis melanotos* (Pennant, 1769)	R/LM
LESSER WHISTLING DUCK	*Dendrocygna javanica* (Horsfield, 1821)	R/LM
GARGANY	*Anas querquedula* (Linnaeus, 1758)	WM
SPOT-BILLED DUCK	*Anas poecilorhyncha* (J.R. Forester, 1781)	R/LM
NORTHERN SHOVELLER	*Anas clypeata* (Linnaeus, 1758)	WM

English Name	Scientific Name	Status
COMMON TEAL	*Anas crecca* (Linnaeus, 1758)	WM
Order: Falconiformes		
Family: Accipitridae		
SHIKRA	*Accipiter badius* (Gmelin, 1788)	R
EURASIAN SPARROWHAWK	*Accipiter nisus* (Linnaeus, 1758)	R/WM
WESTERN MARSH HARRIER	*Circus aeruginosus* (Linnaeus, 1758)	WM
BLACK KITE	*Milvus migrans* (Boddaert, 1783)	R/WM
BLACK-SHOULDERED KITE	*Elanus caeruleus* (Desfontaines, 1789)	R
Order: Galiformes		
Family: Phasianidae		
COMMON QUAIL	*Coturnix coturnix* (Linnaeus, 1758)	WM/PM
GREY FRANCOLIN	*Francolinus pondicerianus* (Gmelin, 1789)	R
JUNGLE BUSH QUAIL	*Perdicula asiatica* (Latham, 1790)	R
INDIAN PEAFOWL	*Pavo cristatus* (Linnaeus, 1758)	R
Order: Gruiformes		
Family: Gruidae		
DEMOISELLE CRANE	*Grus virgo* (Linnaeus, 1758)	WM
Family: Rallidae		
COMMON COOT	*Fulica atra* (Linnaeus, 1758)	R/WM
COMMON MOORHEN	*Gallinula chloropus* (Linnaeus, 1758)	R/WM
PURPLE MOORHEN	*Porphyrio porphyrio* (Linnaeus, 1758)	R/LM
WHITE-BREASTED WATERHEN	*Amaurornis phoenicurus* (Pennant, 1769)	R
Order: Charadriiformes		
Family: Charadriidae		
RED-WATTLED LAPWING	*Vanellus indicus* (Boddaert, 1783)	R/LM
YELLOW-WATTLED LAPWING	*Vanellus malabaricus* (Boddaert, 1783)	R/LM
LITTLE RINGED PLOVER	*Charadrius dubius* (Scopoli, 1786)	WM
KENTISH PLOVER	*Charadrius alexandrines* (Linnaeus, 1758)	R/WM
BLACK-WINGED STILT	*Himantopus himantopus* (Linnaeus, 1758)	R/LM
Family: Burhinidae		
GREAT STONE-PLOVER	*Esacus recurvirostris* (Cuvier, 1829)	R/LM
Family: Scolopacidae		
BLACK-TAILED GODWIT	*Limosa limosa* (Linnaeus, 1758)	WM
SPOTTED REDSHANK	*Tringa erythropus* (Pallas, 1764)	WM
COMMON REDSHANK	*Tringa totanus* (Linnaeus, 1758)	R/WM
MARSH SANDPIPER	*Tringa stagnatilis* (Bechstein, 1803)	WM
COMMON SANDPIPER	*Actitis hypoleucos* (Linnaeus, 1758)	R/WM
GREEN SANDPIPER	*Tringa ochropus* (Linnaeus, 1758)	R /WM
WOOD SANDPIPER	*Tringa glorioles* (Linnaeus, 1758)	WM
TEREK SANDPIPER	*Xenus cinereus* (Guldenstadt, 1774)	WM/PM
EURASIAN CURLEW	*Numenaus arquata* (Linnaeus, 1758)	WM
RUFF	*Philomachus pugnax* (Linnaeus, 1758)	WM/PM
LITTLE STINT	*Calidris minuta* (Leisler, 1812)	WM
Family: Laridae		
PALLAS'S GULL	*Larus ichthyaetus* (Pallas, 1773)	WM
BLACK-BELLIED TERN	*Sterna acuticauda* (J.E. Gray, 1831)	R
BLACK-NAPED TERN	*Sterna sumatrana* (Raffles, 1822)	R
COMMON TERN	*Sterna hirundo* (Linnaeus, 1758)	R/WM
RIVER TERN	*Sterna aurantia* (J.E. Gray, 1831)	R/WM
LITTLE TERN	*Sterna albifrons* (Pallas, 1764)	R/WM
GULL-BILLED TERN	*Gelochelidon ninotica* (Gmelin, 1789)	R/WM
WHISKERED TERN	*Chlidonias hybridus* (Pallas, 1811)	R/WM

English Name	Scientific Name	Status
BLACK TERN	*Chlidonias niger* (Linnaeus, 1758)	WM/PM
Order: Columbiformes		
Family: Pteroclididae		
CHESTNUT-BELLIED SANDGROUSE	*Pterocles exustus* (Temminck, 1825)	R
Family: Columbidae		
BLUE ROCK PIGEON	*Columba livia* (Gmelin, 1789)	R
LITTLE BROWN DOVE	*Streptopelia senegalensis* (Linnaeus, 1766)	R
RED COLLARED-DOVE	*Streptopelia tranquebarica* (Hermann, 1804)	R
SPOTTED DOVE	*Streptopelia chinensis* (Scopoli, 1786)	R
EURASIAN COLLARED DOVE	*Streptopelia decaocto* (Frivaldszky, 1838)	R
ORIENTAL TURTLE DOVE	*Streptopelia orientalis* (Latham, 1790)	R
Order: Psittaciformes		
Family: Psittacidae		
ROSE-RINGED PARAKEET	*Psittacula krameri* (Scopoli, 1769)	R
Order: Cuculiformes		
Family: Cuculidae		
BRAINFEVER BIRD	*Hierococcyx varius* (Vahl, 1797)	R/WM
PIED CRESTED CUCKOO	*Clamator jacobinus* (Boddaert, 1783)	R/WM
ASIAN KOEL	*Eudynamys scolopacea* (Linnaeus, 1758)	R
GREATER COUCAL	*Centropus sinensis* (Stephens, 1815)	R
Order: Strigiformes		
Family: Strigidae		
SPOTTED OWLET	*Athene brama* (Temminck, 1821)	R
Order: Apodiformes		
Family: Apodidae		
ASIAN PALM SWIFT	*Cypsiurus balasiensis* (J.E. Gray, 1829)	R
HOUSE SWIFT	*Apus affinis* (J.E. Gray, 1830)	R
Family: Hemiprocnidae		
CRESTED TREE SWIFT	*Hemiprocne coronata* (Tickell, 1833)	R
Order: Coraciiformes		
Family: Alcedinidae		
LESSER PIED KINGFISHER	*Ceryle rudis* (Linnaeus, 1758)	R
WHITE-BREASTED KINGFISHER	*Halcyon smyrnensis* (Linnaeus, 1758)	R/LM
Family: Meropidae		
BLUE-TAILED BEE-EATER	*Merops philippinus* (Linnaeus, 1766)	R/WM
CHESTNUT-HEADED BEE-EATER	*Merops leschenaulti* (Vieillot, 1817)	R
SMALL BEE-EATER	*Merops orientalis* (Latham, 1801)	R
Family: Coraciidae		
INDIAN ROLLER	*Coracias benghalensis* (Linnaeus, 1758)	R
EUROPEAN ROLLER	*Coracias garrulous* (Linnaeus, 1758)	WM/PM
Family: Upupidae		
COMMON HOOPOE	*Upupa epops* (Linnaeus, 1758)	R/WM
Order: Piciformes		
Family: Capitonidae		
COPPERSMITH BARBET	*Megalaima haemacephala* (P.L.S. Müller, 1776)	R
Order: Passeriformes		
Family: Alaudidae		
ASHY-CROWNED SPARROW LARK	*Eremopterix grisea* (Scopoli, 1786)	R
BENGAL BUSH-LARK	*Mirafra assamica* (Horsfield, 1840)	R
COMMON CRESTED LARK	*Galerida cristata* (Linnaeus, 1758)	R
RUFOUS-TAILED FINCH-LARK	*Ammomanes phoenicurus* (Franklin, 1831)	R
GREAT HOOPOE-LARK	*Alaemon alaudipes* (Desfontaines, 1789)	R

English Name	Scientific Name	Status
Family: Hirundindae		
RED-RUMPED SWALLOW	*Hirundo daurica* (Linnaeus, 1771)	R/WM
WIRE-TAILED SWALLOW	*Hirundo smithii* (Leach, 1818)	R/WM
Family: Laniidae		
BAY-BACKED SHRIKE	*Lanius vittatus* (Valenciennes, 1826)	R
BROWN SHRIKE	*Lanius cristatus* (Linnaeus, 1758)	R
Family: Dicruridae		
ASHY DRONGO	*Dicrurus leucophaeus* (Vieillot, 1817)	WM
BLACK DRONGO	*Dicrurus macrocercus* (Vieillot, 1817)	R
WHITE-BELLIED DRONGO	*Dicrurus caerulescens* (Linnaeus, 1758)	R
Family: Artamidae		
ASHY WOOD-SWALLOW	*Artamus fuscus* (Vieillot, 1817)	R
Family: Sturnidae		
BRAHMINY STARLING	*Sturnus pagodarum* (Gmelin, 1789)	R
ROSY STARLING	*Sturnus roseus* (Linnaeus, 1758)	WM
BANK MYNA	*Acridotheres ginginianus* (Latham, 1790)	R
COMMON MYNA	*Acridotheres tristis* (Linnaeus, 1766)	R
Family: Corvidae		
HOUSE CROW	*Corvus splendens* (Vieillot, 1817)	R
JUNGLE CROW	*Corvus macrorhynchos* (Wagler, 1827)	R
INDIAN TREEPIE	*Dendrocitta vagabunda* (Latham, 1790)	R
Family: Pycnonotidae		
RED-VENTED BULBUL	*Pycnonotus cafer* (Linnaeus, 1766)	R
WHITE-EARED BULBUL	*Pycnonotus leucotis* (Gould, 1836)	R
Family: Timaliinae		
COMMON BABBLER	*Turdoides caudatus* (Dumont, 1823)	R
WHITE-HEADED BABBLER	*Turdoides affinis* (Jerdon, 1847)	R
Family: Turdinae		
PIED BUSHCHAT	*Saxicola caprata* (Linnaeus, 1766)	R
INDIAN ROBIN	*Saxicoloides fulicata* (Linnaeus, 1776)	R
ORIENTAL MAGPIE ROBIN	*Copsychus saularis* (Linnaeus, 1758)	R
Family: Sylviinae		
COMMON TAILORBIRD	*Orthotomus sutorius* (Pennant, 1769)	R
ASHY PRINIA	*Prinia socialis* (Sykes, 1832)	R
JUNGLE PRINIA	*Prinia sylvatica* (Jerdon, 1840)	R
PLAIN PRINIA	*Prinia inornata* (Sykes, 1832)	R
Family: Motacillidae		
PADDY-FIELD PIPIT	*Anthus rufulus* (Vieillot, 1818)	R
GREY WAGTAIL	*Motacilla cinerea* (Tunstall, 1771)	WM
LARGE PIED WAGTAIL	*Motacilla maderaspatensis* (Gmelin, 1789)	R
YELLOW WAGTAIL	*Motacilla flava* (Linnaeus, 1758)	R
Family: Dicaeidae		
THICK-BILLED FLOWERPECKER	*Dicaeum agile* (Tickell, 1833)	R
TICKELL'S FLOWERPECKER	*Dicaeum erythrorhynchos* (Latham, 1790)	R
Family: Nectariniidae		
PURPLE SUNBIRD	*Nectarinia asiatica* (Latham, 1790)	R
PURPLE-RUMPED SUNBIRD	*Nectarinia zeylonica* (Linnaeus, 1766)	R
Family: Passerinae		
HOUSE SPARROW	*Passer domesticus* (Linnaeus, 1758)	R
Family: Ploceidae		
BAYA WEAVER	*Ploceus philippinus* (Linnaeus, 1766)	R
Family: Estrildidae		

English Name	Scientific Name	Status
BLACK-HEADED MUNIA	*Lonchura malacca* (Linnaeus, 1766)	R
WHITE-THROATED MUNIA	*Lonchura malabarica* (Linnaeus, 1758)	R

R: Resident; WM: Winter migrant; LM: Local migrant; PM: Passage migrant.

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References

Anderson, R., Morrison, M.L., Sinclair, K., Strickland, D., 1999. Studying wind energy/bird interactions: a guidance document. National Wind Coordinating Committee, Washington, D.C., USA.

Barclay, R.M.R., Baerwald, E.F., Gruver, J.C., 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Can. J. Zool. 85, 381-387.

Christensen, T.K., Clausager, I., Petersen, I.K, 2003. Base-line investigations of birds in relation to an offshore wind farm at Horns Rev, and results from the year of construction. Report to National Environmental Research Institute. Roskilde, Denmark.

Cryan, P.M., Barclay, R.M.R., 2009. Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. J. Mammal. 90(6), 1330-1340.

de Lucas, M., Janss, G. & Ferrer, M. (2004). The effects of a wind farm on birds in a migration point: the Strait of Gibraltar. Biodiversity Conser., v.13, pp. 395-407.

Drewitt, A.L., Langston, R.H.W., 2006. Assessing the impacts of wind farms on birds. Ibis 148, 29-42.

Erickson, W.P., Johnson, G.D., Young, D.P., 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSW-GTR-191, Washington, D.C., USA.

Erickson, W.P., Johnson, G.D., Strickland, M.D., Young, D.P., Sernka, K.J., Good, R.E., 2001. Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee Resource document.

Everaert, J., Stienen, E.W. M., 2007. Impact of wind turbines on birds in Zeebrugge (Belgium). Biodiv. Conser. 16, 3345-3359.

GAO., 2005. US Government Accountability Office, Wind power: Impacts on wildlife and government responsibilities for regulating development and protecting wildlife. US Government Accountability Office, Report GAO-05-906, Washington, DC.

Gaston, A.J., 1975. Estimating bird population. J. Bombay Nat. Hist. Soc. 72, 271-283.

Gipe, P., 1995. Wind energy comes of age. John Wiley and Sons, Inc., NY.

Graham, T.L., Hudak, P.F., 2011. Potential Hazards of Wind Energy for Rare, Threatened, and Endangered Birds and Batsin Texas. Int. J. Environ. Res. 5(4), 917-922.

Hoover, S.I., Morrison, M.L., 2005. Behavior of Red-tailed Hawks in a wind turbine development. J. Wildl. Manage. 69, 150-159.

Howe, R.W., Evans, W., Wolf, A.T., 2002. Effects of wind turbines on birds and bats in northeastern Wisconsin. University of Wisconsin-Green Bay, Green Bay, USA.

Jain, A.A., 2005. Bird and bat behavior and mortality at a northern Iowa wind farm. Ph. D. Dissertation, Iowa State University, Ames, Iowa, USA.

Langston, R.H.W., Pullan J.D., 2003. Wind farms and birds: an analysis of the effects of wind farm on birds, and guidance on environmental assessment criteria and site selection issues. Report written by Birdlife International on behalf of the Bern Convention. Council Europe Report T, PVS/inf.

Leddy, K.L., Higgins, K.F., Naugle, D.E., 1999. Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands. Wilson Bull. 111, 100-104.

Lekuona, J.M., Ursua, C., 2007. Avian mortality in wind power plants of Navarra (Northern Spain).). *In*: Proceedings of Birds and Wind Farms, M. de Lucas, G.F.E. Janss and M. Ferrer (Eds.), Quercus, Madrid.

Madders, M,. Whitfield, D.P., 2006. Upland raptors and the assessment of wind farm impacts. Ibis 148, 43-56.

Manville, A.M., 2009. Towers, turbines, power lines, and buildings – steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. *In:* Proceedings of 4th International Partners in Flight Conference, C.J. Ralph and T.D. Rich (Eds.), McAllen, TX.

Miller, A., 2008. Patterns of avian and bat mortality at a utility scaled wind farm on the southern high plains. Master Degree Dissertation, Texas Tech University.

Musters, C.J.M., Noordervliet, M.A.W., Ter Keurs, W.J., 1996. Bird casualties caused by a wind energy project in an estuary. Bird Study 43, 124-126.

NRC., 2007. National Research Council Environmental impacts of wind-energy projects. National Academies Press, Washington, DC.

Orloff, S., Flannery, A., 1992. Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas. California Energy Commission, CA.

Osborn, R.G., Higgins, K.F., Usgaard, R.E., Dieter, C.D., Neiger, R.G., 2000. Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. Am. Midl.Nat. 143, 41-52.

Pedersen, M.B., Poulsen, E., 1991. Impact of a 90m/2MW wind turbine on birds: Avian responses to the implementation of the Tjaereborg wind turbine at the Danish Wadden Sea. Danske Vildtundersøgelser Hæfte, Denmarks.

Percival, S.M., 2000. Birds and wind turbines in Britain. Britain Wildl. 12, 8-15.

Percival, S.M., 2003. Birds and wind farms in Ireland: A review of potential Issues and Impact Assessment. Durham, UK.

Powlesland, R.G. 2009. Impacts of wind farms on birds: a review. Department of Conservation, Wellington, New Zealand.

Redlinger, R.Y., Andersen, P.D., Morthorst, P.E., 2002. Wind Energy in the 21st Century: Economics, Policy, Technology and the Changing Electricity Industry. Palgrave Publishers, Basingstoke.

Sharp, A., 2010. Briefing note on the effects of wind farms on bird and bat populations. Department of Environment and Heritage, Govt. of South Australia.

Sovacool, B.K., 2009. Contextualizing avian mortality: A preliminary appraisal of bird and bat fatalities from wind, fossil-fuel, and nuclear electricity. Energy Policy, 37, 2241-2248.

Walker, D., McGrady, M., McCluskie, A., Madders, M., McLeod, D.R.A., 2005. Resident Golden Eagle ranging behaviour before and after construction of a wind farm in Argyll. Scot. Birds 25, 24-40.