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Impact of Wind Energy Projects on Bird Migration, Gabel Al-Zeit - Eastern Desert, Egypt

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ABSTRACT

Wind farms along bird migration routes may be very hazardous. During the spring migration season in 2020, a study on the collision of bat and bird species was carried out on the KFW 240 MW (120 WTGs) wind farm. Direct inspections by searchers and unsystematic line transect searches with autos were used in the carcass searches technique. To examine the collected data, the GenEst estimator was used. During a systematic search, six bird carcasses/remains were discovered, three of which belonged to migratory soaring birds (MSB) with the least concern status. During the unsystematic search, two MSB and one Passerine carcasses were discovered, but no bat carcasses were found as collision victims. Furthermore, no bird or bat carcasses were detected beneath the high voltage powerlines that run parallel to the wind farm. Carcass persistence trials revealed that MSB lasted 23.92 days while little passerines lasted 3 days. The detection probability for all decay types was 87.2, 93.3 % for MSB, and 41.9 % for tiny Passerines. Moreover, the final fatality estimation for the plant and its structures was 0.084 MSB fatality/ turbine/ season, 0.166 Passerine/ turbine/ season.

Keywords: Fatality estimator; GenEst, Renewable energy; Soaring Birds; Turbine's collisions.

INTRODUCTION

Wind energy is one of the most effective and competitive methods for reducing emissions in the power sector and producing clean energy. In general, wind energy is one of the least greenhouse gas-intensive power sources available globally (Steffen *et al.* 2004; Katzner *et al.*, 2016); additionally, with the Kyoto Protocol signed in 2002, wind energy was first exposed to a broad spectrum of public stakeholders (Springer 2002).

Wind energy is one of the most climate-, health-, and environmentally friendly energy sources available (Jeremy *et al.*, 2014; Gibson *et al.*, 2017; Baidya Roy, 2011). Nonetheless, wind farms can have a negative impact on biodiversity, particularly on bird and bat species of high conservation concern (Schuster *et al.*, 2015; De Vos *et al.*, 2014), including direct collision mortality (Rosen, 2003; Getachew 2016; Frick *et al.*, 2017), indirect mortality (Arnett *et al.*, 2007; Strickland *et al.*, 2011), barrier effects to movement, and habitat degradation or loss (Dre (Getachew & Ayalew, 2016).

Collision with anthropogenic facilities such as wind farms, communication towers, and aircraft is great conservation concern for bats and birds (Kunz *et al.*, 2007; Zimmerling *et al.*, 2013; Erickson *et al.*, 2014 & McClurea *et al.*, 2018; Korner-Nievergelt *et al.*, 2013). Recently, wind turbines are the world's new apex predators, wiping out hawks, buzzards, and most carnivorous birds at the top of the food pyramid (Thaker *et al.*, 2018; McClurea *et al.*, 2018).

Egypt has excellent wide regimes, notably in the Suez Gulf, where the average wind speed is 10.5 m/sec. The wind energy resource is available in large regions on the Nile banks in the Eastern Desert and some parts of Sinai. In February 2008, the Supreme Council of Energy in Egypt approved an ambitious plan to satisfy 20% of the generated electricity by renewable energies by the second decade of the twentieth century, including 12% from wind energy, i.e, reaching more than 7200 MW grid-connected wind farms, which will have a positive impact on the environment, represented by saving around 4.25 million T.O.E. and reduce the emission of about 10 million TCo2 (NREA statistics).

Egypt occupies the northeastern part of the African continent and is geologically divided into different eight ecogeographical regions (Riad, 2019; Riad and Mahmoud 2020), it is of critical importance for bird migration as it is located on the only land bridge between the Eurasian and African landmasses that links breeding grounds in Europe and Asia with wintering areas in Africa (Bergen 2007; Bergen 2013; CarlBro 2010). The Gulf of Suez area lies at the heart of the Rift Valley / Red Sea Flyway and at its narrowest points that include several bottlenecks, which are internationally recognized as Important Bird and Biodiversity Areas (IBAs). These are Gebel El Zeit, Suez, Ain Sukhna, and the Qaa' plain. Egypt's Important Bird Areas (Baha El Din, 1999), where millions of birds from about 200 species travel each year from their breeding sites in Eurasia to Sub-Saharan Africa, where they spend the winter before returning the following spring. (Moreau, 1972; Riad *et al.*, 2019; Riad, 2020). On the other hand, previous studies recorded 22 bat species in Egypt (Wassif 1995). These migrants face very harsh conditions as they cross large areas of unfavourable habitats, such as deserts and open seas, without the possibility of feeding or drinking. Most of the species, particularly smaller ones, perform direct and active flights, selecting the most direct route between the breeding and the wintering grounds (Tesfahunegny *et al.*, 2020).

The effects of wind energy development on subtler aspects of bird and bat responses such as physiological changes that lead to mistrust and stress reactions are unknown (Tesfahunegny *et al.*, 2020). Still the wind energy facilities in Egypt in their infancy, and consequently, there has been little research into the impact on birds and bats.

Three wind energy plants with a combined capacity

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of 580 MW are already in operation in the Gulf of Al-Zeit area. This research will focus on one of them, the Gabel Al-Zeit KFW 240 MW (120 WTGs) wind farm project, which was constructed by the New and Renewable Energy Authority (NREA) and funded through government cooperation with European Development Partners, EDPs. This comprises Germany's Development Bank (KFW), the European Investment Bank (EIB), and European Development Partner EU in the Gulf of Suez. Also, other new projects are currently producing energy, and other is under construction for both the Egyptian, international private and governmental sectors; thus, continuous assessment of wind turbine impact on wildlife especially birds and bats life is urgently needed. Therefore, the curent study aims to assess bats and avian fatality monitoring during the operation of the RASOD system in the KFW wind farm project at Gabel Al-Zeit, Eastern desert, Egypt.

MATERIALS AND METHODS

Study area

The KFW Gabel El-Zeit Wind-farms is a 240 MW wind farm comprising 120 Gamesa wind turbines of the G80 model (2 MW each) sited in the Eastern Desert, 5 km away from the western coast of the Suez Gulf (approximate coordinates of the central area of the wind farm: N 28° 09’10.74’’ E 33° 09′17.44’’), is located ca. 4.5 km to the west of the Hurghada-Suez motorway, ca. 10 km to the west of the port and town of Ras Shukeir (Fig. 1). Along the eastern side of the wind farm there is a high-voltage 220 kV power line. The wind farm encompasses an area of approximately 37 km^2. In its maximum length, it reaches 8.9km (north-south) and its maximum width of 6.5 km (east-west). The wind turbines were disposed along seven parallel rows, distanced nearly 1,300 m apart, and following an approximate southwest-northeast aligned layout (Fig. 2). Each row, of varying length (1.6 km to 6 km), comprises between seven and 23 turbines approximately 270 m apart. The turbine’s hub is 60 m in height and the blade’s length is 40 m. Hence, the swept area of the blades extends from 20 m to 100 m above ground level. In addition, other wind farms were constructed to the south and southeast of the wind farm (Fig. 2), and to the N/NW.

The terrain is mostly flat, undulating on the eastern side but increasingly rugged towards the west, where altitude reaches 150 m. Several low-altitude hilly ridges (200-300 m) separate the wind farm from the Red Sea Mountain chain, where the most prominent mountain in the region, Gabel Gharib, stands at an altitude of 1,453 m about 20 km west of the wind farm. Several wadis (dry river valleys) intersect the area draining occasional floodwaters coming from the Red Sea Mountain chain towards the gravel and pebble plains to the east, including the large mudflats of Sabkhet Ras Shukeir with its pools of hyper-saline water and saltmarshes. The wind farm is set in a hyper-arid desert. The soil is mostly covered by gravel with sandy patches and has very little vegetation cover with only a few scattered bushes and grasses mainly restricted to the intersecting wadis.

Technical field survey

The study was conducted during the implementation of the RASOD program at the KFW wind farm. The Radar-Assisted Shutdown on Demand (RASOD) system is a hybrid shutdown on-demand setup primarily dependent on field observers' manual observations, with the aid of radar detection.

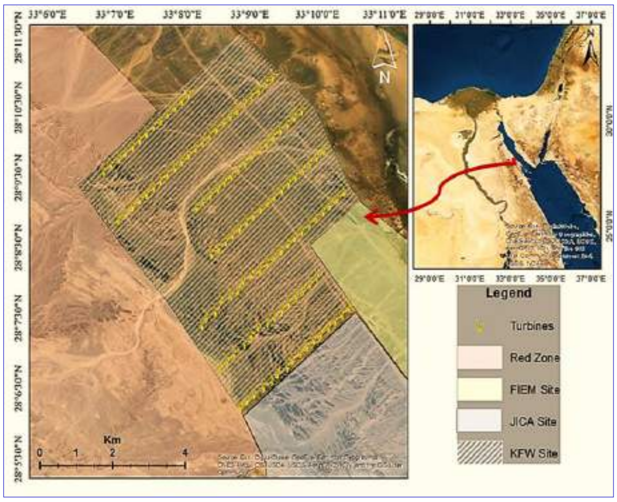

Figure (1): Googol map of KFW (Kreditanstalt für Wiederaufbau, Institute for Reconstruction) wind farm project area, Gabel Al-Zeit, Eastern desert, Egypt. Source: IGN, and the GIS User Community.

Figure (2): Map of wind farm showing the location of sampled carcass search plots, and car search transect under high voltage powerlines. Source: IGN, and the GIS User Community.

According to Strickland *et al.* (2011), a technical field survey approach was established to monitor mortality, from 2nd March to 8th May 2020, to cover the bird and bat causalities near KFW station's wind turbines and power cables. For each search plot, the linear transect procedure was utilised to conduct a systematic search under 72 turbines, approximately 187 % (75 m) of the length of each turbine blade, to produce a search plot (150 X 150m) in 10m apart transects. Furthermore, an unsystematic carcass search was conducted using a car to scan the remaining turbines (48 turbines).

A total of 235 trials were conducted to assess the searcher's efficacy in locating bird carcasses using decoys of various sizes. A total of 235 trials were conducted to assess the searcher's efficacy in locating bird carcasses using decoys of various sizes. Carcass persistence trials were conducted utilising wild bird fatalities discovered by systematic and unsystematic cadaver searches, as well as a fresh Steppe Buzzard carcass discovered crashed under a power wire far from the location. The persistence data from the neighbouring FIEM windfarm was also used to predict carcass persistence with a bigger sample size under comparable conditions.

Statistical analysis

The advanced GenEst (Generalized Mortality Estimator, version 1.4.4, 2020) programme was applied. This package is intended for assessing data related to estimating bird or bat fatalities at renewable-energy projects (Dalthorp *et al.*, 2018). GenEst contains tools for assessing searcher efficiency, carcass persistence, and other detection probability factors from experimental field trials (Simonis *et al.*, 2018).

RESULTS

During the study period, 576 systematic turbine mortality monitoring surveys were conducted covering 9 searches (the last two weeks merged in one search cycle) for each of the 72 sampled turbines within 9 weeks of monitoring. In addition, 54 unsystematic car transects covered the whole station 9 times during the survey period. Nine fresh carcasses of birds and no carcasses were observed beneath all turbines. The most abundant birds were white stork, and the remaining were evenly distributed between raptors and non-soaring birds. Most soaring bird fatalities were recorded in late spring, while passerine fatalities were in early spring (Table 1).

Persistence was assessed on seven MSB fatalities and five tiny passerine fatalities. The carcass trials of the MSBs revealed that not all carcasses vanished during the observed period, with two White Stork, one Black Kite, and one Lesser Spotted Eagle cadaver remaining until May 18th. Small passerines vanished within 8 days of arrival. The four primary curve fitting models that were utilised are depicted in Figure (3). Based on model comparison, the lognormal model (lognormal; l ~ Species Group; s ~ constant: AICc = 60.96, ΔAICc=3.24) provided the best match. As a result, Table (2) shows the median CP estimations and 90 percent confidence ranges for median persistence.

The overall combined detection probability was 87.2%; where searchers detected 205 surrogates out of the 235. Most of the undetected samples were for those placed in difficult ground visibility conditions. For GenEst model, the selected model was based on size predictor variable (p ~ Size; k fixed at 0: AICc= 181.89, ΔAICc= 0) (Fig. 5).

For this season work of 7 days search interval, the estimated generic detection probability for MSB was 0.933 [0.799 - 0.962], and for small passerine was 0.419 [0.242 - 0.606] (Fig. 5). The current search interval is good for MSB detection (93%) but is too long for the low persisting small Passerines. The fatality estimation using GenEst estimator was modeled based on species group carcass observation variable. Figure 6 show fatality estimation for the spring 2020 season. The calculated mortality accounts for 0.084 [0.025 - 0.147] MSB fatality /turbine/season, 0.166 [0.036 - 0.439] Passerine/turbine/season, and an overall mortality rate using combination of different carcass types and search efficiencies accounts for 0.248 [0.095-0.526] bird fatality / turbine/ season.

DISCUSSION

Wind farms have the same effects as the world's apex predators, which exterminate eagles, hawks, and predatory avian types at the top of the food chain (Thaker *et al.*, 2018). They are disrupting links of feeding/roosting/nesting areas. It also affects bats

Table (1): Carcasses observed during the systematic and unsystematic search at KFW windfarm during Spring, 2020.

Detected Bird	Scientific name	Turbine	Track down day	Disappeared Day
Reed Warbler	*Acrocephalus scirpaceus*	13	March 14th	8th
White Stork	*Ciconia Ciconia*	29	March 15th	11th
Black Kite	*Milvus migrans*	14	March 28th	50th
Bee-eater	*Merops apiaster*	109	April 9th	1st
Whinchat	*Saxicola rubetra*	109	April 16th	1st
Lesser Spotted Eagle	*Aquila pomarine*	48	April 30th	25th
Reed Warbler	*Acrocephalus scirpaceus*	60	March 14th	2nd
White Stork	*Ciconia Ciconia*	87	April 25th	25th
White Stork	*Ciconia Ciconia*	87	April 25th	25th

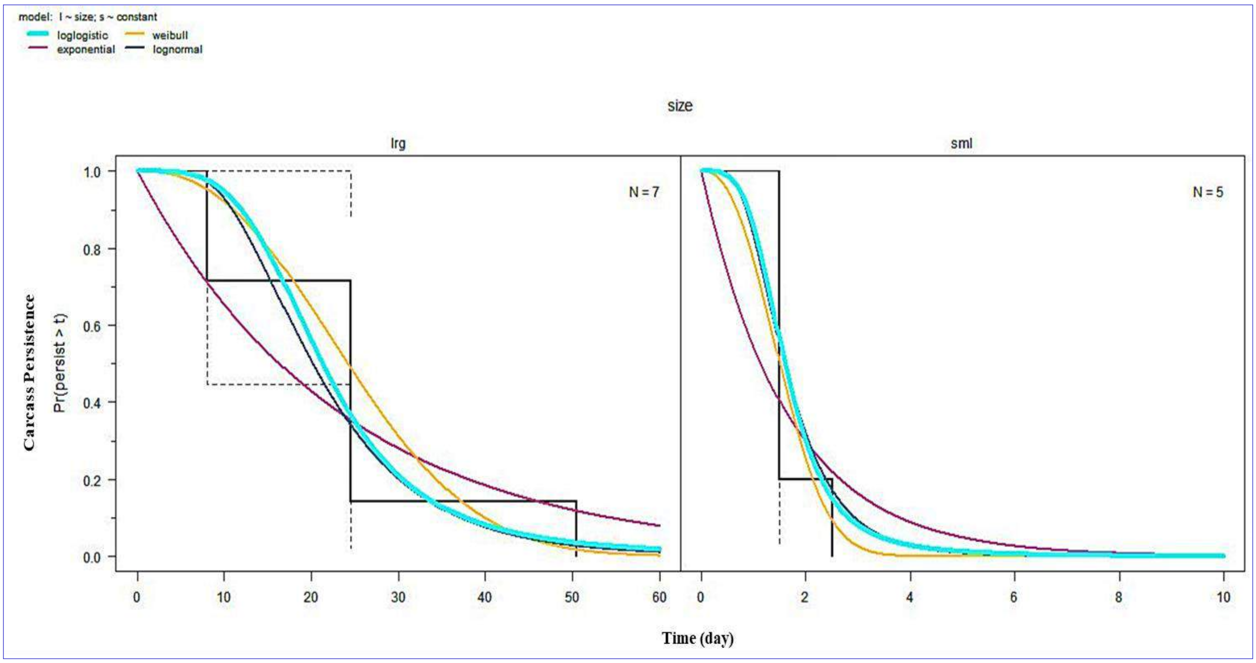

Figure (3): Carcass persistence for Migratory Soaring Birds (MSB) and non-MSB during time period of 60 days used for the trials.

and birds because they need places with high wind speed to help them fly with less energy consumption. The KFW wind farm placed within one of the major bottlenecks: the Sinai/Gulf of Suez «bridge» in Egypt, (Porter, 2005). This is probably the second most important flyway in the world concerning the total number of migratory soaring birds, following the Gulf of Panama in the Americas (Zalles & Bildstein, 2000). The rotating blades of a moving turbine frequently kill bats and birds at varying rates because they are a source of attraction for a variety of reasons. As a result, the more turbines with longer blades there are the more bats and birds that can collide with them during wind farm crossings (Erick-son *et al.,* 2014). Internal haemorrhaging induced by pressure drop behind the rotor blades is another cause of death (Arnett and Baerwald, 2013; Arnett, 2012; European Commission, 2011). Wind farms not only cause bird and bat mortality, but they also cause habitat loss as trees are cut down to clear the land (Tesfahunegny *et al.*, 2020).

Table (2): Estimated median for Migratory Soaring Birds (MSB) and 90 percent confidence intervals for median persistence, location (*l*), and scale parameters (*s*).

Measured parameter	MSB	Non-MSB
Sample size	7	5
Median CP [90% CI]	23.92 [11.08-51.62]	3.03 [1.39 - 6.60]
Median *l* [90% CI]	3.18 [2.40-3.94]	1.11 [0.33-1.88]
Median *s* [90% CI]	1.05 [0.67-1.64]	1.05 [0.67-1.64]

Since bats and soaring birds have low natural reproduction rates and mortality, increased wind power in vulnerable areas may endanger some species (De Lucas *et al.,* 2012). Aside from collision fatality, the presence/noise of turbines may deter birds and bats from foraging, reproducing, and nesting in areas near wind turbines (Arnett *et al.,* 2011). There is some evidence that wind turbines may impede the mov-ement of birds and bats. Birds and bats may fly near the wind turbines rather than between them. The level of displacement of flying birds and bats, as well as their ability to adapt for increased energy expenses, will determine whether this is an issue (National Research Council, 2007; McClurea *et al.,* 2018). The cumulative consequences of big wind farm install-ations may be significant if bird and bat movements are disrupted as a result. Bird displacement from offshore and onshore projects has been well docu-mented in only a few studies and for a few species up to now. (Steffen *et al.,* 2004; Roscioni *et al.,* 2013; Erickson *et al.,* 2014). This may lead to the interference of ecological links between feeding, breeding, and roosting areas.

For birds, it is important to understand flight corridors and establish spatial buffers away from these areas or provide corridors between the clusters of turbines aligned with main flight trajectories for species to fly through (Drewitt and Langston, 2006). Bats also move along linear structures such as rivers and river valleys (Furmankiewicz and Kucharska, 2009). Wind turbine collisions do not appear to be ran-dom incidents. Bird and bat species are likely drawn to turbines either directly because turbines resemble roosting locations (Cryan *et al.,* 2014) or indirectly because turbines attract insects that birds and bats feed on (Rydell *et al.*, 2010a, 2010b).

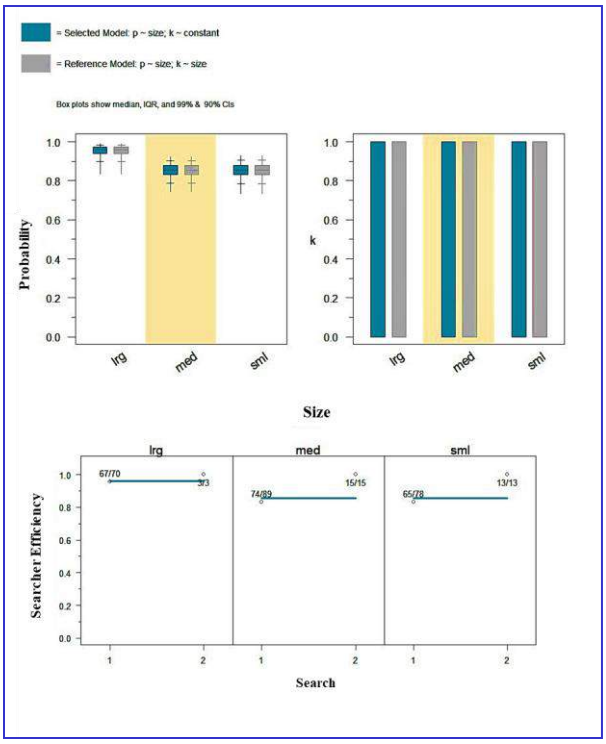

Figure (4): Box plot showing the searcher efficiency based on size of decoys.

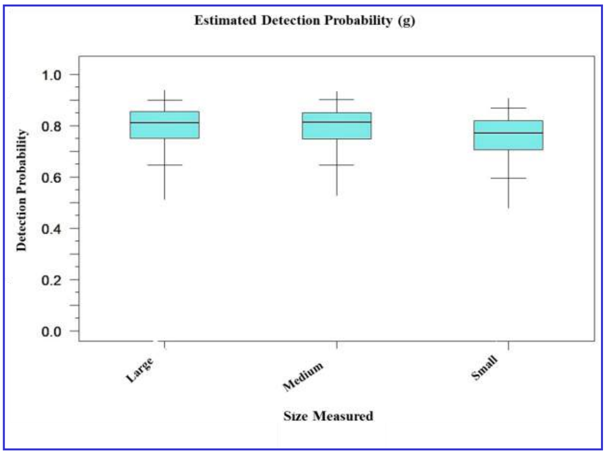

Figure (5): Estimated detection probability for the combination between species groups and measured size.

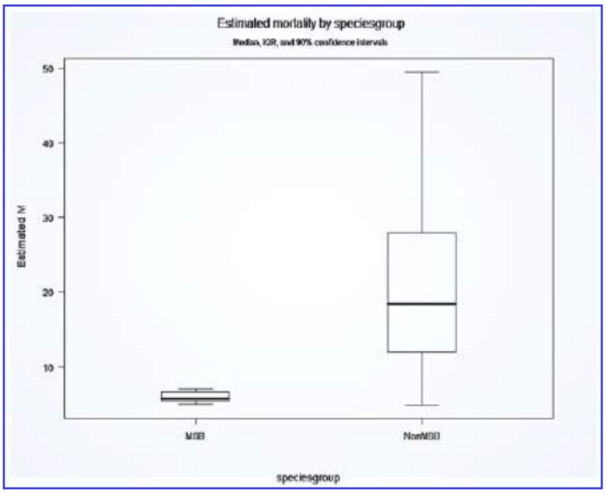

Figure (6): Estimated mortality by species group during spring of 2020, the study time period.

Nine bird individual species were collision victims due to the KFW wind farm in our study. previous literature shows that terrestrial wind farms have documented the highest collision risk of Accipitriformes/Accipitridae (raptors and birds of prey) (Thaxter *et al.*, 2017). On the contrary, our study showed that Ciconiidae had the highest rates of collision in the study area. Among other orders/families, Accipitriformes Accipitres-Accipitridae (hawks, buzzards, and eagles), Columbiformes-Columbidae (pigeons, doves), Passerifor-mesCorvidae (crows) were also vulnerable.

Although there was less variation in predicted mortality of bird and bat species, some were associated with relatively high rates of collision because bad weather is always expected in the spring season in the study area. White storks are relatively frequent fatalities, particularly in KFW wind farm where these species are more common during migration season since there was near the near crossing area of the Gulf of Suez on the migration route to Europe. Weather patterns may influence bat fatalities in wind farms. The estimated total number of bird and bat fatalities at wind energy facilities is likely several orders of magnitude lower than other leading anthropogenic sources of bird and bat mortality (Powlesland, 2009; Thaker *et al.*, 2018). The relationship between bird and bat behavior and collision risk, especially near the rotor swept area, is complex to understand. Certain species that forage for prey near turbines appear to have higher fatality rates, while other species that actively fly around wind turbines (pigeons, doves, and crows) appear to avoid collisions with turbines (Johnson *et al.*, 2016).

Despite the great success in using the Shutdown on-demand with RADAR (RASOD) implemented by the Egyptian government authorities, the little experience of some migratory soaring birds with bad weather is expected to be one of the main factors responsible for the high collision rates on the KFW wind farm. Globally, hundreds of millions of birds die each year in collisions with manmade structures, including glass windows and buildings, communication towers, and wind turbines (Vié *et al.*, 2009; Turner *et al.*, 2007).

Although no bats were killed on the KfW wind farm, experts believe collision mortality at wind energy plants to be one of the most serious threats to bat populations in developed countries (Barclay *et al.*, 2007; Colby *et al.*, 2009). In addition, bat mortality at wind turbine generators is always of greater magnitude than avian mortality (Kunz *et al.*, 2007; Arnett *et al.*, 007). The SOD program followed in the KfW wind farm during the spring migration season was effective in reducing the number of birds exposed to direct collision with the blades during the diurnal migration.

Finally, the cumulative effects of the KFW wind farm on migratory birds are definitely acceptable. While wind farms pose a hazard to birds, bats, and other endangered animals. Wind turbine mitigation techniques such as raising the cut-in speed and SOD at key hours allow for considerable reductions in bird fatalities. Also, due considerations for birds must continue to be implemented in the planning and operation of wind turbines to develop environmentally sustainable wind energy facilities, consequently, standardization of assessment protocols for all wind energy facilities in this important area for bird migration.

CONCULSION

Wind energy development endangers bats and birds, and many migratory bird species are on the point of extinction. Migratory bird mortality can be reduced greatly by mitigation techniques such as shutdown on demand for active wind farms which considered as resendable solution. Although the combined effects of birds and bats may be plainly acceptable but their population repercussions are unlikely. As a result, it is advised that pro-wind farms be avoided in areas with a high population of sensitive species. As far as possible, reduce building in the zone that has been affected by pre-construction monitoring and testing operations and installations.

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تأثير مشاريع طاقة الرياح على هجرة الطيور، جبل الزيت ـ الصحراء الشرقية ـ مصر

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الملخـص العـربي

تعتبر مصر ثاني أكبر مسار لهجرة الطيور في العالم لما تتميز به كموقع استراتيجي جغرافي. ولجود مزارع الرياح في مناطق مسارات هجرة الطيوراصبحت تمثل خطراً جزئياً على الهجرة. في هذه الدراسة، أجريت دراسة عن اصطدام أنواع الخفافيش والطيور في مزرعة الرياح KFW240 " ميجاوات " والتي تحتوي على 120 مروحة رياح خلال موسم الربيع لهجرة الطيور. استخدمت تقنية البحث المقطعية النظامية للبحث عن الجثث من قبل الباحثين وغير النظامية باستخدام السيارات. تم استخدام مقدر GenEst لتحليل البيانات التي تم جمعها. وقد اكتشفت ستة جثث او بقايا طيور أثناء البحث المنهجي، ثلاثة منها تنتمي إلى الطيور الحوامة المهاجرة(MSB) ، كلها في حالة "أقل قلق" طبقاً للاتحاد الدولي لحفظ الطبيعة. بينما تم اكتشاف جثتين من الطيور الحوامة المهاجرة وجثة واحدة من الغير حوامة أثناء البحث غير المنهجي. بالإضافة إلى ذلك، لم يتم ملاحظة أي جثث من الخفافيش كضحايا للاصطدام. ايضا، لم يتم العثور اي جثث للطيور أو الخفافيش تحت خطوط الضغط العالي لنقل الكهرباء المحاذية لمزرعة الرياح. أظهرت تجارب ثبات الذبيحة 23.92 يومًا لـجثث الطيور الحوامة المهاجرة و3 أيام لجثث الطيور غير الحوامة الصغيرة. كان احتمال الكشف 87.2٪ لجميع أنواع العلامات المستخدمة، واحتمال الكشف عن الطيور الحوامة المهاجرة كان 93.3٪، و41.9٪ للطيور غير الحوامة الصغيرة. بالإضافة إلى ذلك، كان تقدير الوفيات النهائي للمنشأة والهياكل المرتبطة بها 0.084 طائر حوام / توربين / موسم، 0.166 طائر غير حوام / توربين / موسم.