Avian powerline mortalities, including Asian Houbaras *Chlamydotis macqueenii*, on the Central Asian flyway in Uzbekistan

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Avian mortalities from powerline collisions and electrocution are increasingly recognised as a significant problem for many different species (Bevanger 1998, Jenkins *et al* 2010, Martin & Shaw 2010, Loss *et al* 2014). Birds of prey and other thermal soarers are particularly vulnerable to electrocution (Janss 2000), whereas those susceptible to collisions are considered to have poor flying manoeuvrability due to high wing-loading, as in large waterfowl, cranes and bustards, with the latter two apparently finding lines hard to see owing to the position of their eyes and morphological constraints in the movement of the head (Bevanger 1998, Janss 2000, Martin & Shaw 2010, Rioux *et al* 2013). Rates of collision for Karoo *Heterotetrax vigorsii*, Kori *Ardeotis kori* and Ludwig's *Neotis ludwigii* Bustards in southern Africa have been estimated as 0.1–1.05 per km of surveyed powerline per year (Shaw 2013). Although such rates can seem low, when extrapolated across the vast distances powerlines can cover, the result can be a significant source of unnecessary anthropogenic mortality (Shaw 2013). Furthermore, shorter lengths of powerline placed in habitat with a high abundance of a vulnerable species can make a disproportionately large contribution to overall mortality, as seen in the Great Bustard *Otis tarda* population in easternmost Austria (Raab *et al* 2012).

Powerline extent and placement may combine to become especially acute along routes in which migrant birds concentrate for all or part of their journeys ('flyways'). The configuration of the Caspian sea in the west and the Pamir, Tien Shan and Hindu Kush ranges in the east has created such a flyway in Central Asia (aka Middle Asia), funnelling many populations of migrant birds through the deserts of southern Kazakhstan, Uzbekistan and Turkmenistan on their movements to and from their breeding and wintering ranges. The powerline issue has become increasingly focused in Kazakhstan, where the narrowest portion of the migration corridor begins to broaden, with several investigations reporting mortalities in as many as 37 species and electrocution rates as high as 7.6 birds/km of surveyed powerline in late summer (Lasch *et al* 2010, Pestov *et al* 2012, Voronova *et al* 2012). However, Uzbekistan and Turkmenistan have not been subject to formal study, even though they may be more important as they bestride the narrowest part of this flyway.

Our work in the flyway focuses on managing the globally Vulnerable Asian Houbara *Chlamydotis macqueenii* population that migrates to and breeds in the southern (Bukhara) sector of the Kyzylkum desert (*eg* Collar *et al* 2014, Koshkin *et al* 2014). The Bukhara district (Figure 1) represents about one sixth of the Kyzylkum desert contained within Uzbekistan, while as a whole Uzbekistan contains the southern half of the entire Kyzylkum desert with the north in Kazakhstan. It is predominantly a flat semi-desert consisting mainly of sparse shrub vegetation growing on consolidated and drifting sands and clay pans with variable gravel cover (Koshkin *et al* 2014). Our main aim in this pilot study was to establish whether powerlines were causing mortality to Asian Houbaras within the study area; however, we report on all mortalities found.

METHODS

A total of 240 km of powerlines, made up of 22 unique transects varying in length from 1–40 km, were surveyed by car between 29 March and 6 May 2014, covering the migration period for many species and the arrival and breeding period for the Asian Houbara, although probably too late to cover the main raptor migration period (pers obs). Vehicles with two observers drove under powerlines at no more than 20 km/h, with an observer scanning either side. Mortalities were observed either as carcasses or as bundles of feathers within the immediate area under and adjacent to the powerline. For each mortality, the GPS location and species was logged, along with (if possible) its sex, distance from pylon and scavenged status (no/yes/by what). Mortalities were collected to prevent double counting (two repeat transects were carried out 11 and 24 days after the first transect where mortalities occurred, but no further mortalities were found). It was not possible to age any dead birds. Causes of death were identified on the basis of circumstantial evidence. Electrocution—when bodies lay either below or close to the pylon (support structure), and the perpendicular distance from the powerline was small with no scatter of body feathers. Collision—when bodies lay at some point between the pylons and (due to momentum) had landed some metres beyond the powerline, with considerable loss of feathers. These interpretations can be confounded when scavengers move carcasses around.

Three types of powerline were encountered in the area: two types of high-voltage transmission line, with large metal pylons separated by a distance of 240 m and either three or six lines suspended between pylons (Plate 1a,b); and one type of low-voltage (6–10

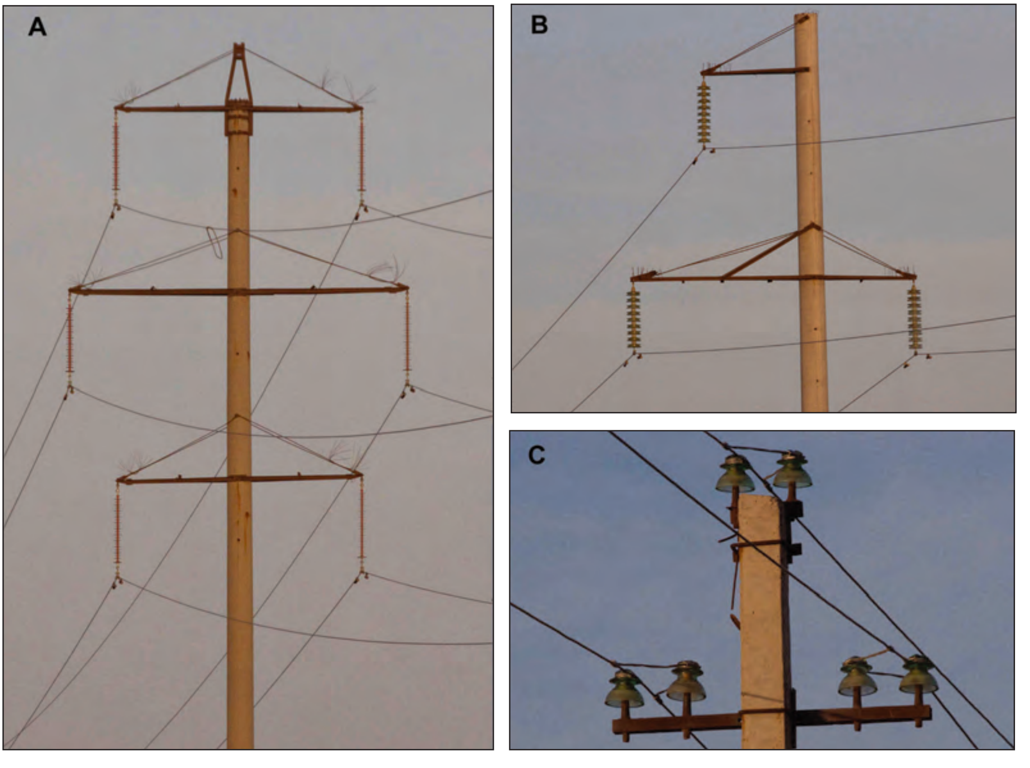

Plate 1. Powerline types surveyed in the Bukhara district, Uzbekistan: two types of high-voltage transmission line, suspension distance of 240 m (a,b); and low-voltage (6–10 kV) distribution line, suspension distance of 68 m (c). © *RJ Burnside*

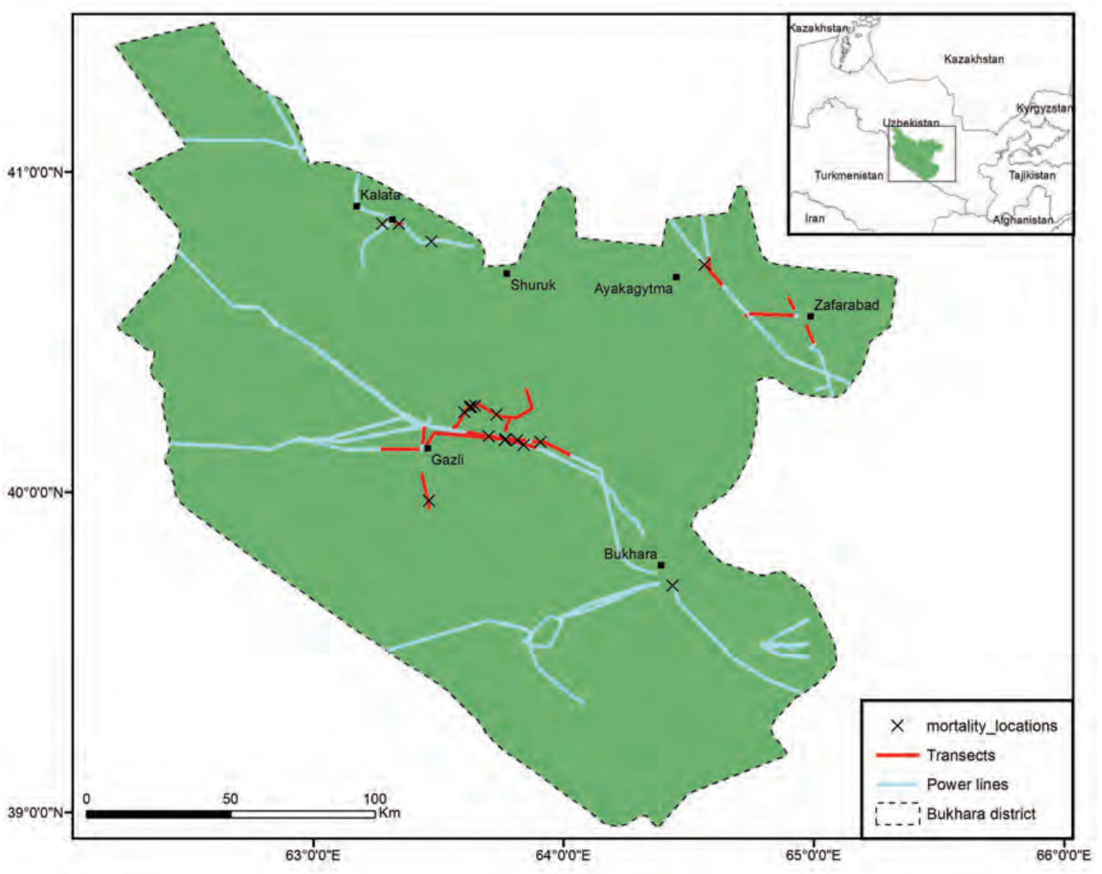

Figure 1. Map of study area showing digitised and field-recorded powerlines (blue lines, total length 1289 km) in Bukhara district, Uzbekistan. This is an incomplete coverage of powerlines, see methods. The location of powerline transects is overlaid in red and covers 240 km. Locations of mortalities are marked with x.

kV) distribution line, which had three lines closely suspended between pylons separated by 68 m. The latter type of distribution line was suspended on either wooden or concrete pylons with metal cross-arms and upright insulators (Plate 1c), of which the latter are considered to pose less risk of electrocution (Voronova *et al* 2012). We made a formal request for powerline infrastructure maps for Uzbekistan from the Uzbek authorities, but these are not publicly available. High-voltage lines are reported to cover 23 350 km in Uzbekistan (Newman & Nesbitt 2010) but we could find no reports for low-voltage lines. To estimate powerline coverage in Bukhara province, therefore, we digitised lines from Soviet-era topographic maps. However, besides being long out-of-date these maps were also missing smaller infrastructure. Nevertheless, using this resource (1097 km of powerlines digitised) and our opportunistic observations (192 km digitised) during other fieldwork, we mapped a total of 1289 km of powerlines (179 km of which are low-voltage distribution lines) and ran transects under 18.6% of them, sampling 114 km of the total low-voltage distribution lines (63.7%) and 126 km of the total high-voltage transmission lines (11.3%) (Figure 1).

The probability of finding a carcass under a powerline was calculated per 1 km length of transect using a generalised linear model (GLM) with a binomial error structure. We treated each 1 km unit surveyed as a binomial trial and coded finding a carcass as 1 and no carcass as 0, thus giving the probability of finding a carcass per km and confidence intervals based on the binomial distribution (Aebischer 1999). We also report on powerline mortalities not recorded on transects but encountered opportunistically or as part of an existing Asian Houbara long-term monitoring programme using Microwave Telemetry PTTs, with 24 wild adults monitored between October 2011 and October 2014. When a PTT-bird mortality occurred in the Bukhara study area, the location was visited to retrieve the PTT and establish a cause of mortality; therefore mortality date and location were known. If the location of a mortality was within 20 m of a powerline it was deemed as a mortality by collision. For only wild adult Houbaras, the monthly risk of collision with a powerline during the breeding and post-breeding period spent in Uzbekistan (1 April–1 October) was estimated. For each individual, we considered the total cumulative number of days monitored during this period and, using a binomial GLM (described above), treated each day as a trial where a powerline collision was coded as 1 and no collision as 0, thereby giving a daily probability of colliding with a powerline while in Uzbekistan, which was then extrapolated to give a monthly estimate calculated as $1-((1-\text{daily collision probability})^{30})$, and results are shown as percentages.

RESULTS

Nineteen avian mortalities were recorded involving 10 different species of predominantly large birds (Table 1). Fourteen mortalities were observed during transects (Table 1), giving a probability of finding one carcass in a 1 km section as 5.8% (95% CI 3.8–7.9%), although a seasonal rate of mortality cannot be estimated as the age could not be verified for most carcasses. In general, we concluded that the large raptors mostly died from electrocution, as many were found right under pylons of low-voltage distribution lines (Plate 2a), although some were farther away from the lines and might instead have been victims of collision (Plate 2b). The Asian Houbara remains observed during the transects under a high-voltage transmission line, being between pylons and away from the lines, were certainly the result of collision (Plate 2c, Table 1). Overall, mortalities of all species were distributed widely, although one 40 km stretch of distribution line yielded five mortalities (Figure 1). Opportunistic observation revealed an additional one Asian Houbara, one Steppe Eagle *Aquila nipalensis* and one Steppe Buzzard *Buteo buteo vulpinus* mortality on low-voltage transmission powerlines, while satellite PTTs disclosed two Asian Houbara mortalities, one wild adult female colliding with low-voltage distribution lines during post-breeding movements (Plate 2d) and one captive-bred female hitting a high-voltage transmission line during migration. Based on monitoring 24 wild adult Houbaras with a cumulative total of 5930 days monitored in Uzbekistan and one recorded powerline collision gives a monthly probability of hitting a powerline per individual of 0.51% ± 0.50% SE. Thus over the period 1 April–1 October, an individual had a 3.0% (95% CI: 0.0–9.0%) probability of powerline mortality. Houbaras seem relatively vulnerable to scavengers (usually confirmed as red fox *Vulpes vulpes*, by the presence of scats), as all evidence found consisted merely of remnants of feathers under the powerline, whereas eagle and buzzard carcasses were generally intact.

DISCUSSION

These results demonstrate that powerlines are a cause of mortality for several bird species in Uzbekistan. Quantifying how serious this mortality is will require considerably more work, but our provisional survey is likely to underestimate the true impact for several reasons. First and most importantly, disappearance of carcasses due to scavenging will negatively influence detection rates (*eg* Lehman *et al* 2007). Second, carcass detection will

Table 1. Powerline mortalities observed in the Bukhara district of Uzbekistan in spring 2014 from transects, PTT data and opportunistic observation. 'Powerline' denotes the type of powerline which caused the mortality: transmission line with three and six lines = TPL3 and TPL6; distribution line = DL. 'Method' denotes the method by which the mortality was observed: transect = T, satellite transmitter = PTT, opportunistic = O.

Date	Method	Powerline	Cause	Species
06/05/2014	T	TPL3	collision	Black-bellied Sandgrouse *Pterocles orientalis*
02/04/2014	T	DL	electrocution	Rough-legged Buzzard *Buteo lagopus*
10/04/2014	T	DL	electrocution	Rough-legged Buzzard *Buteo lagopus*
09/04/2014	T	TPL3	collision	Great Egret *Egretta alba*
03/04/2014	T	TPL3	electrocution	European Honey-buzzard *Pernis apivorus*
31/03/2014	T	TPL6	collision	Asian Houbara *Chlamydotis macqueenii*
31/03/2014	T	TPL3	uncertain	Common Kestrel *Falco tinnunculus*
10/04/2014	T	TPL3	collision	Common Quail *Coturnix coturnix*
13/04/2014	T	DL	electrocution	Steppe Buzzard *Buteo buteo vulpinus*
13/04/2014	T	DL	electrocution	Steppe Buzzard *Buteo buteo vulpinus*
02/04/2014	T	DL	electrocution	Steppe Eagle *Aquila nipalensis*
10/04/2014	T	DL	electrocution	Steppe Eagle *Aquila nipalensis*
10/04/2014	T	DL	uncertain	White-tailed Eagle *Haliaeetus albicilla*
10/04/2014	T	DL	electrocution	White-tailed Eagle *Haliaeetus albicilla*
30/12/2013	PTT	TPL6	collision	Asian Houbara *Chlamydotis macqueenii*
15/05/2014	PTT	DL	collision	Asian Houbara *Chlamydotis macqueenii*
12/06/2014	O	DL	collision	Asian Houbara *Chlamydotis macqueenii*
12/06/2014	O	DL	electrocution	Steppe Eagle *Aquila nipalensis*
12/06/2014	O	DL	electrocution	Steppe Buzzard *Buteo buteo vulpinus*

have been imperfect. Third, some birds are likely to have suffered injuries which allowed them to travel beyond the transect visibility width before killing them (Shaw 2013). Fourth, our transect selection may have missed clusters of mortalities such as observed along particular sections of powerlines in Kazakhstan (Lasch & Sadykulin 2012) where 300 birds along a single 100 km stretch have been reported (Moseikin 2003). It is highly likely that more bird species may also be affected. Currently, there is much uncertainty about the impact of powerlines in Uzbekistan (and the Central Asian flyway) owing to the unavailability of mapped powerline infrastructure and no large-scale multi-season studies incorporating scavenging experiments to adjust mortality estimates. However, in the first instance we can suggest that mortality occurs during both autumn and spring passage (losses in autumn may be higher owing to the presence and naivety of the summer's offspring). Further, several of the species susceptible to mortality are long-lived with low reproductive output. Given this, numbers of mortalities do not need to be high to have a detrimental effect on population stability when a species' demography is sensitive to small changes in adult survival (Combreau *et al* 2001).

Importantly we found that Asian Houbaras were susceptible to collision with both high- and low-voltage powerlines and that the monthly probability of an adult colliding with a powerline was non-trivial, with the possibility of 30 out of every 1000 individuals perishing in this way per season in Uzbekistan. The current male population in the study site is estimated around 2000 (MK unpublished data) which when extrapolated to include

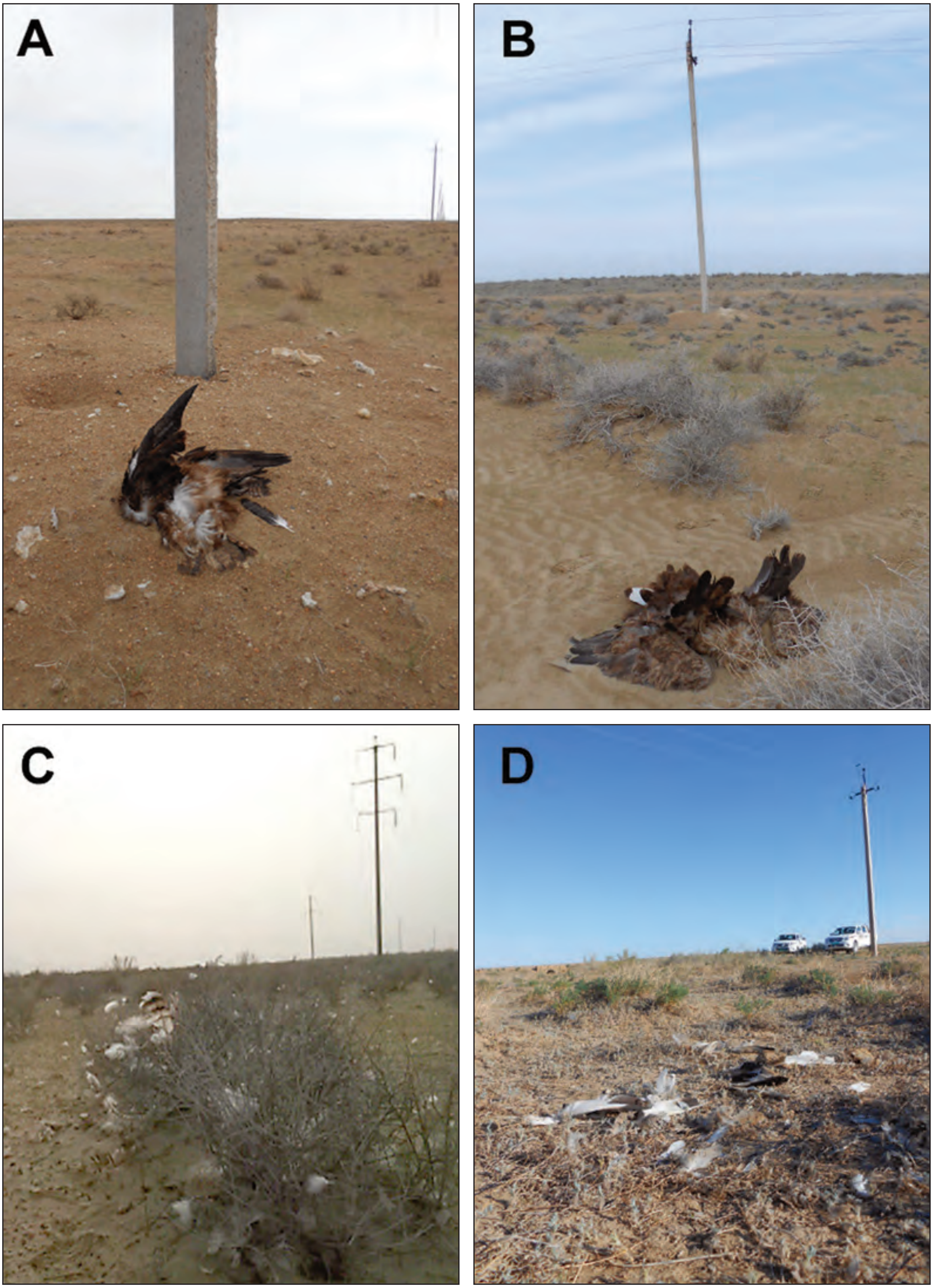

Plate 2. Powerline mortality photos Bukhara district, Uzbekistan: (a) Steppe Buzzard *Buteo buteo vulpinus* electrocuted on a low-voltage distribution line, 10 April 2014 (© *JM Herrero*); (b) White-tailed Eagle *Haliaeetus albicilla* killed on distribution lines but uncertain if by electrocution or collision, 10 April 2014 (© *JM Herrero*); (c) Feather remains caught in a shrub of an Asian Houbara *Chlamydotis macqueenii* killed by collision on high-voltage powerlines, 2 April 2014 (© *RJ Burnside*); (d) Feather remains of an Asian Houbara *Chlamydotis macqueenii* monitored with a satellite transmitter and killed by collision with low-voltage distribution lines, 15 May 2014 (© *RJ Burnside*).

females if the sex ratio was 1:1 (Combreau *et al* 2002) would give a total population of 4000, resulting in 120 birds lost/year (95% CI: 0–350 birds). Powerline collisions caused the deaths of at least three adult birds in the 2014 breeding season, and at least during the April–May fieldwork this was the only confirmed source of adult mortality in our study area over two consecutive years, although other sources of mortality like poaching and hunting occur in autumn (unpublished data). After hunting and poaching, therefore, powerlines are likely to be an important additional cause of mortality in the Asian Houbara. However, identifying causes of mortality is complicated because most mortalities for this species are likely to go unnoticed owing to an apparent high rate of scavenging in our study area, based on visitation of remains within three days of mortality of satellite tracked Houbaras.

None of the species recorded, with the exception of the Asian Houbara, is categorised as threatened under IUCN criteria. However, with continuing expansion of powerline infrastructure in Uzbekistan (Newman & Nesbitt 2010) and neighbouring countries, the risks to birds migrating through Central Asia are set to increase unless (1) the appropriate assessments of risks posed by powerlines when planning their placement are made, (2) the use of appropriately designed powerlines that mitigate the risk of electrocution/collision becomes mandatory (this would be beneficial to energy companies as it reduces the risk of damage to lines and blackouts) and (3) existing lines running through important habitats are fitted with the appropriate insulation and bird flight deflectors.

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REFERENCES

Aebischer, NJ. 1999. Multi-way comparisons and generalized linear models of nest success: extensions of the Mayfield method. *Bird Study* 46: 22–31.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electric power lines. *Biological Conservation* 86: 67–76.

BirdLife International. 2014. *Country profile: Uzbekistan*. www.birdlife.org/datazone. [Downloaded 3 November 2014]

Collar, NJ, PM Dolman, KM Scotland & ARH Swash. 2014. *The houbara in Uzbekistan*. Emirates Bird Breeding Center for Conservation, Abu Dhabi.

Combreau, O, F Launay & M Lawrence. 2001. An assessment of annual mortality rates in adult-sized migrant Houbara Bustards (*Chlamydotis undulata macqueenii*). *Animal Conservation* 4: 133–141.

Combreau, O, J Qiao, M Lawrence, X Gao, J Yao, W Yang & F Launay. 2002. Breeding success in a Houbara Bustard *Chlamydotis undulata macqueenii* population on the eastern fringe of the Jungar Basin, People's Republic of China. *Ibis* 144**:** E45–E56 [Online].

Janss, GFE. 2000. Avian mortality from power lines: A morphologic approach of a species-specific mortality. *Biological Conservation* 95: 353–359.

Jenkins, AR, JJ Smallie & M Diamond. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263–278.

Koshkin, MA, NJ Collar & PM Dolman. 2014. Do sheep affect distribution and habitat of Asian Houbara *Chlamydotis macqueenii*? *Journal of Arid Environments* 103: 53–62.

Lasch, MV & RF Sadykulin. 2012. Comparing the rate of bird mortality caused by electrocution in the Astrakhan and the Atyrau districts, Russia–Kazakhstan. *Raptors Conservation* 24: 98–103.

Lasch, U, S Zerbe & M Lenk. 2010. Electrocution of raptors at power lines in Central Kazakhstan. *Waldökologie* Online 9: 95–100.

Lehman, RN, PL Kennedy & JA Savidge. 2007. The state of the art in raptor electrocution research: a global review. *Biological Conservation* 136: 159–174.

Loss, SR, T Will & PP Marra. 2014. Refining estimates of bird collision and electrocution mortality at power lines in the United States. *PLoS ONE* 9: e101565.

Martin, GR & JM Shaw. 2010. Bird collisions with power lines: failing to see the way ahead? *Biological Conservation* 143: 2695–2702.

Moseikin, VN. 2003. *The operation and construction of fatal power lines continues in Russia and Kazakhstan*. Abstract. World Conference on Birds of Prey, Budapest, May 2003.

Newman, JR & SA Nesbitt. 2010. *Potential for collisions and electrocutions associated with the proposed Talimarjan transmission line project, Uzbekistan*. http://uz.denemetr.com/tw_files2/urls_2/88/d-87163/7z-docs/1.pdf. [Downloaded 10 November 2014]

Pestov, MV, FA Saraev & MK Shalharov. 2012. Assessing the impact of power lines in the medium voltage range on birds of the Atyrau district in Kazakhstan. *Raptors Conservation* 24: 104–117.

Raab, R, C Schütz, P Spakovszky, E Julius & CH Schulze. 2012. Underground cabling and marking of power lines: conservation measures rapidly reduced mortality of West-Pannonian Great Bustards *Otis tarda*. *Bird Conservation International* 22: 299–306.

Rioux, S, J-PL Savard & AA Gerick. 2013. Avian mortalities due to transmission line collisions: a review of current estimates and field methods with an emphasis on applications to the Canadian electric network. *Avian Conservation & Ecology* 8: 7.

Shaw, JM. 2013. *Power line collisions in the Karoo: Conserving Ludwig's Bustard*. PhD Thesis. University of Cape Town, South Africa.

Voronova, VV, GI Pulikova, KK Kim, EV Andreeva, VR Bekker & T Aitbaev. 2012. The impact of power lines on bird mortality in central Kazakhstan. *Raptors Conservation* 24: 52–60.

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