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Effects of Nest Box Installation on a Distribution Power Line: Increased Eurasian Kestrel Nesting, Reduced Electrocutions, and Reduced Electrical Faults

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Abstract.—Electrical pylons are frequently used by birds for perching, roosting, and nesting. These behaviors can lead to electrocutions, particularly when pylons are constructed of grounded concrete and steel crossarms, as they were in our study area near Arak, Iran. To address electrocutions of Eurasian Kestrels (*Falco tinnunculus*) and a variety of passerines nesting on a 20-kV distribution line, we documented construction and use of nests on pylons on a 34-km segment of power line in 2018. Following removal of nests by the electric utility operating the line, we installed nest boxes on pylons that previously supported nests, and in 2019 we documented use of those nest boxes. We predicted that after installation of nest boxes, numbers of Eurasian Kestrel nests would increase, and numbers of nests outside of nest boxes, avian electrocutions, and faults (electric current arcing from conductors to pylons) would decrease. All four predictions were validated. We documented 31 nests in 2018, including 3 Eurasian Kestrel nests. In 2019, we documented 6 nests outside of nest boxes, and 31 nests in nest boxes, including 16 Eurasian Kestrel nests. In 2018, we found 1 electrocuted Eurasian Kestrel, and 39 electrocuted passerines. In 2019, we found 3 electrocuted Eurasian Kestrels, 11 passerines, 2 Eurasian Eagle-Owls (*Bubo bubo*), and 1 Steppe Eagle (*Aquila nipalensis*). The rate of electrocutions per nest for Eurasian Kestrels decreased from 0.33 to 0.19, and the electrocution count for all birds decreased by 57.5%. Electrical faults, an indirect measure of potential avian electrocutions, decreased from 173 in 2018 to 120 in 2019. Although there is some risk that nest boxes on power poles could create ecological traps, our results suggest that in this study electrocutions and electrical faults were reduced, supporting conservation goals and electric power reliability goals while simultaneously reducing electric utilities' maintenance obligations.

Key Words: *Eurasian Kestrel*; Falco tinnunculus; *Iran*; *mitigation*; *nesting*; *power line*; *pylon.*

EFECTOS DE LA INSTALACIÓN DE CAJAS NIDO EN UNA LÍNEA DE DISTRIBUCIÓN ELÉCTRICA: AUMENTO DE LA ANIDACIÓN DE *FALCO TINNUNCULUS*, REDUCCIÓN DE ELECTROCUCIONES Y REDUCCIÓN DE FALLAS ELÉCTRICAS

Resumen.—Las torres eléctricas son frecuentemente usadas por las aves para posarse, dormir y anidar. Estos comportamientos pueden llevar a electrocuciones, particularmente cuando las torres son construidas con bases de hormigón y celosía de acero, como fueron en nuestra área de estudio cerca de Arak, Irán. Para

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evaluar las electrocuciones de *Falco tinnunculus* y de una variedad de paseriformes anidando en una línea de distribución de 20 kV, registramos la construcción y el uso de nidos sobre las torres a lo largo de un segmento de 34 km de una línea eléctrica en 2018. Tras la eliminación de los nidos por parte de los operadores de la línea, instalamos cajas nido en las torres que anteriormente albergaban nidos, y en 2019 registramos el uso de las cajas nido. Predijimos que tras la instalación de las cajas nido, el número de nidos de *F. tinnunculus* debería aumentar, y el número de nidos fuera de las cajas nido, las electrocuciones de aves y las fallas (arco eléctrico de corriente desde los conductores a las torres) deberían disminuir. Todas las predicciones fueron validadas. Registramos 31 nidos en 2018, incluyendo 3 nidos de *F. tinnunculus*. En 2019, registramos 6 nidos fuera de las cajas nido y 31 nidos en las cajas nido, incluyendo 16 nidos de *F. tinnunculus*. En 2018, encontramos 1 individuo de *F. tinnunculus* electrocutado y 39 paseriformes electrocutados. En 2019, encontramos electrocutados 3 individuos de *F. tinnunculus*, 11 paseriformes, 2 individuos de *Bubo bubo* y 1 individuo de *Aquila nipalensis*. La tasa de electrocución por nido para *F. tinnunculus* disminuyó de 0.33 a 0.19, y el conteo de electrocuciones para todas las aves disminuyó en un 57.5%. Las fallas eléctricas, una medida indirecta de potenciales electrocuciones de aves, disminuyó de 173 en 2018 a 120 en 2019. Aunque hay cierto riesgo de que las cajas nido en los postes eléctricos puedan convertirse en trampas ecológicas, nuestros resultados de este estudio sugieren que las electrocuciones y las fallas eléctricas se redujeron, apoyando los objetivos de conservación y los objetivos de sostenibilidad de las líneas eléctricas, reduciendo al mismo tiempo el compromiso de mantenimiento de los operadores eléctricos.

[Traducción del equipo editorial]

INTRODUCTION

Power lines are a ubiquitous part of the global landscape. They are widely distributed across all continents except Antarctica, and consequently, understanding and managing raptor interactions with power lines has become an important global conservation priority in Africa (Pretorius et al. 2016, Shaw et al. 2018), Asia (Kolnegari et al. 2018, Dixon et al. 2020), Australia (Bekessy et al. 2009, Fox and Wynn 2010), Europe (Bernardino et al. 2018, Demeter et al. 2018), North America (Bedrosian et al. 2020, Mojica et al. 2020), and South America (Galmes et al. 2018, Sarasola et al. 2020). Interactions between wildlife and power lines are generally perceived as negative, with electrocutions and collisions creating conservation concerns, and power outages and arcing creating reliability and fire-risk concerns (Guil et al. 2018, Dwyer et al. 2019). Population declines for a number of raptor species have been attributed to electrocutions (reviewed in Slater et al. 2020). Despite those concerns, power lines can also be beneficial for some species when pylons supporting the lines provide perching, roosting, and nesting opportunities for birds in landscapes that contain all the resources needed for survival and reproduction except a suitable nest substrate (Bevanger 1998, Infante and Peris 2003).

In some species and populations, the percentage of birds that breed on power structures has increased notably in recent years (Moreira et al. 2018), with nesting on power line infrastructure contributing substantially to overall productivity. For example, White Storks (*Ciconia ciconia*) in Spain and Ospreys (*Pandion haliaetus*) in Germany have greater reproductive success when nesting on power structures compared to birds nesting on natural substrates (Ferrer 2012). The difference in productivity may be attributable to the greater difficulty predators have climbing anthropogenic structures compared to natural structures, and the greater physical stability of anthropogenic structures reducing the likelihood that strong winds will collapse the substrate (Ferrer 2012). Nesting as a beneficial function of power lines is of particular value to wildlife in areas with few natural trees or with high rates of deforestation (Infante and Peris 2003, Voronova 2012, Moreira et al. 2018), such as in Iran where natural vegetation is decreasing due to long-term drought (Shamsipour et al. 2008).

Though nesting on power structures can be positive for the birds, unintended consequences of electrocutions, power outages, and fires can lead electric utilities to remove nests (Avian Power Line Interaction Committee [APLIC] 2006, Ferrer 2012). This can create tension between electric reliability obligations and conservation goals. To balance these competing needs, governments often regulate when nests may be removed. For example, in the United States and in parts of Spain, removal of nests containing eggs or young is prohibited unless a nest-specific exemption permit is secured (US Fish and Wildlife Service [USFWS] 2011, Ferrer 2012).

Nest relocation, an alternative to removal, usually involves creating a platform nearby and shifting the nest to that platform (APLIC 2006, Kemper et al. 2020). Either removal or relocation can be paired with nest deterrents to help encourage birds to move away from the original nest location (Ferrer 2012, Dwyer et al. 2015, Kemper et al. 2020). This combination of approaches can be quite successful. For example, in Portugal, installing nesting platforms to guide White Storks to safer locations on power pylons and installing nest deterrents to guide them away from dangerous parts decreased outages from 739 outages per 1000 nests in 1993 to a range of 9–93 outages per 1000 nests in recent years (Redes Energéticas Nacionais 2016).

In another example in Canada, provision of mobile nesting platforms allowed biologists to move Ferruginous Hawk (*Buteo regalis*) nests progressively farther from power lines over successive breeding seasons (Kemper et al. 2020).

Nest platforms are effective for many open-nesting species but are not effective for shifting nesting of cavity-nesting birds. Instead, nest boxes can be effective for cavity-nesting falcons, owls, bluebirds, swallows, chickadees, and wrens (APLIC 2006, Raudonikis and Morkunas 2018), and can have important conservation implications. For example, nest boxes are pivotal in Saker Falcon (*Falco cherrug*) conservation in Hungary, where about 75% of the population breeds in nest boxes on transmission towers (Fidlóczky et al. 2014). Attracting small birds to nest boxes installed on transmission structures (>60 kV) generally does not create conflicts between birds and power lines because the air gaps around energized equipment are large enough to prevent electrocutions (APLIC 2006, Ferrer 2012). In contrast, attracting birds to nest boxes installed on distribution structures may be problematic if the attracted birds are larger than the air gaps insulating energized equipment (Ferrer 2012, Voronova 2012, Demerdzhiev 2014). Because of potential unintended negative consequences associated with nest boxes on power lines, few conservation groups install nest boxes on power line rights-of-way, potentially missing important conservation opportunities.

Eurasian Kestrels (*Falco tinnunculus*) are generalist nesters, using cavity nests or open nests, or usurping Corvid nests (Shrubb 1993, Carrillo and Aparicio 2001). Despite their flexible nesting requirements, local populations of Eurasian Kestrels are often limited by nest-site availability, which contributes to their classification as Least Concern but decreasing (BirdLife International 2016). However, Eurasian Kestrels readily accept nest boxes (Cavé 1968), including nest boxes installed on electric pylons (Fargallo et al. 2001, Fay et al. 2019). Eurasian Kestrels also limit intraspecific nest defense to relatively small areas around nests (≤100 m; Cavé 1968) and regularly overlap hunting ranges with those of adjacent pairs (Riegert et al. 2007). Their hunting ranges are characterized by short, grassy vegetation with isolated tall perches, all of which are part of many power line rights-of-way. This combination of traits makes Eurasian Kestrels uniquely pre-adapted to benefit from nesting in power line rights-of-way if electrocution and electric fault risks can be minimized.

Considering the potential that nest boxes in power line rights-of-way have to contribute to Eurasian Kestrel conservation and given the absence of data on the effects of substituting nest boxes for existing nests on pylons, we developed this study to test four predictions. We predicted that after installation of nest boxes (1) the number of Eurasian Kestrel nests would increase, (2) the number of nests outside of nest boxes would decrease, (3) the number of avian electrocutions would decrease, and (4) the number of electrical faults (electric current arcing from conductors to pylons) would decrease. We believed that if these four predictions were supported, collectively they would support our hypothesis that installation of nest boxes could simultaneously meet electric utility goals for improving electric system reliability and meet conservation goals for reducing electrocutions.

Methods

We conducted our study on a 34-km segment of a 20-kV distribution line between Khomein and Arak, in Markazi Province, central Iran. The line was owned and operated by the Power Distribution Company of Markazi Province and was supported by approximately 450 concrete pylons spaced roughly 75 m apart. Separation between energized conductors and grounded steel crossarms was approximately 15–30 cm on each pylon (approximately 50-100% of the length of a Eurasian Kestrel) depending on configuration. Eight pylons supported three-phase transformers, which supplied 220 V electricity to residents. The remaining pylons were tangent (straight) or angle (corner) structures supporting only wires without any additional equipment. None of the pylons supporting the line we studied had been previously retrofitted to mitigate avian electrocution risks.

From March through September in 2018 and 2019, we surveyed the line weekly. During each survey, we identified all nests on pylons, identified the species associated with each nest, and searched for avian carcasses along the line. The Power Distribution Company of Markazi Province had a long-standing maintenance action of annual nest removal after each breeding season. This minimized the cumulative effects of nests on power delivery reliability. For this reason, all nests found each year were newly constructed during that breeding season, allowing us to definitively identify the species associated with each nest. To identify the species associated with each nest, when we observed a nest during a survey we paused survey progress until we observed a bird enter the nest. When different species entered the same nest during different surveys, we were able to infer interspecific turnover in nest occupancy.

Nests were removed from pylons by the Power Distribution Company of Markazi Province in October 2018. During November and December 2018, we installed nest boxes (Fig. 1) on each pylon that had supported a nest during the 2018 breeding season. Each nest box was constructed of untreated cypress (*Cupressaceae* family) boards cut to create a box 50 cm long × 50 cm deep × 40 cm tall, with a sloped roof (10°). Nest boxes included a 30-cm opening on one side, and a platform on that side to facilitate entry. We oriented nest boxes so the opening faced away from prevailing winds, which varied across our study area. We covered the floor of each nest box with a mixture of soft sand and clay (Fig. 1 inset) to mimic the floor texture of natural cavities, and to prevent eggs from rolling inside the nest box. We installed nest boxes on top of pylons. To do so, we constructed metal brackets designed

Figure 1. Nest box occupied by Eurasian Kestrels on a power line in central Iran. Inset: eggs and nestlings on a lining of sand and clay.

to be bolted into pre-existing holes in the pylons. Each bracket extended 40–60 cm above the top of the pylon. The exact extension above pylon tops varied because the pylons themselves varied.

To search for avian carcasses, we followed Ferrer (2012). Specifically, during each survey we drove the length of the power line, stopping at each pylon to inspect the pylon top and the ground within 7–8 m of the pylon base (Dwyer and Mannan 2007, Harness et al. 2013) for the presence of all or part of any avian carcasses. Based on previous study of avian carcasses found at the bases of grounded concrete pylons similar to those in our study area (Harness et al. 2013), we assumed all carcasses found at the bases of power poles were attributable to electrocution. We removed carcasses during each survey to prevent double-counting.

Quantification of total mortality with the greatest accuracy possible requires assessment of various biases (Ponce et al. 2010). Our goal in this study was not to quantify total numbers, so we did not assess these biases. However, we did use LineTroll R400D (Nortroll AS, Levanger) fault indicators to provide additional information. These devices monitor the electrical and magnetic fields around power lines, and report via an internal GSM (digital cellular) communication module when disruptions in these fields indicate that an electrical fault (i.e., a disruption in the flow of electricity) has occurred. Because there were no trees in contact with the power line, and because other sources of variation in electrical current such as lightning strikes create different types of aberrations, we were able to infer that faults indicated avian contacts. We deployed a total of 30 fault indicators. The fault indicators were installed in groups of three (one per conductor wire) at each of 10 locations.

We used chi-square tests of proportions to evaluate our predictions. To do so, we compared numbers of Eurasian Kestrel nests, nests outside of nest boxes, electrocutions, and faults in 2018 and in 2019 to the total number of pylons in our study area ($n = 450$). This approach assumed that each pylon was biologically independent because the analyses treated each pylon as statistically independent. We believe the assumption to be valid because Eurasian Kestrels defend only very small territories immediately around their nests (Cavé 1968). Consequently, events at one pylon (nesting, electrocutions, etc.) were not likely to have been substantially influenced by events at adjacent pylons. Correlations among response variables were likely however, so we applied a Bonferroni correction to our tests by dividing our initial critical level of $\alpha = 0.05$ by the number of tests conducted (four) to define a corrected critical level of $\alpha = 0.01$ as our threshold of statistical significance.

RESULTS

We recorded 31 nests in 2018; 26 Eurasian Magpie (*Pica pica*) nests, 3 Eurasian Kestrel nests, and 2 Rook (*Corvus frugilegus*) nests. Most nests were on crossarms (Fig. 2). Eurasian Magpies built 29 of these nests, but 3 of them were usurped by Eurasian Kestrels. We installed 31 nest boxes between the 2018 and 2019 breeding seasons. We recorded 37 nests in 2019. Of these, 31 were in nest boxes (all nest boxes were occupied), including 16 Eurasian Kestrel nests, and 15 Eurasian Magpie nests. Two of the Eurasian Kestrel nests were initially built by Eurasian Magpies. We also recorded 6 new Eurasian Magpie nests outside of nest boxes in 2019. Following installation of nest boxes, nests outside of nest boxes decreased by 80.6%, and the ratio of Eurasian Magpie nests to Eurasian Kestrel nests decreased from 9:1 to 2:1. In 2018, Eurasian Kestrels occupied 9.7% of nests (95% CI: 2.0–25.8%). In 2019, Eurasian Kestrels occupied 43.2% of nests (95% CI: 27.1–60.5%). In terms of our predictions, Eurasian Kestrel nests increased in 2019 ($\chi^2 = 9.09$, df $= 1$, $P = 0.003$) and nests outside of nest boxes decreased ($\chi^2 = 17.62$, df $= 1$, $P < 0.001$).

We recorded 57 electrocuted birds of seven species, including 40 birds in 2018 and 17 birds in 2019 (Table 1). Consistent with our predictions, avian electrocutions decreased in 2019 ($\chi^2 = 9.91$, df $= 1$, $P < 0.002$). Overall, electrocutions decreased by 57.5%. Electrocutions of Eurasian Kestrels increased from 1 to 3, but the ratio of electrocution fatalities in relation to the number of Eurasian Kestrel nests decreased from 0.33 to 0.19 electrocutions per nest. All electrocuted Eurasian Kestrels were juveniles. Also, in 2019 we documented two electrocuted Eurasian Eagle-Owls (*Bubo bubo*) and one electrocuted Steppe Eagle (*Aquila nipalensis*). The Eurasian Eagle-Owl electrocutions were both on pylons supporting or adjacent to nest boxes occupied by Eurasian Kestrels.

During the 2018 breeding season, fault indicators recorded 173 electrical faults. During the 2019 season, fault indicators recorded 129 electrical faults; a 25.4% decrease. As we predicted, electrical faults decreased in

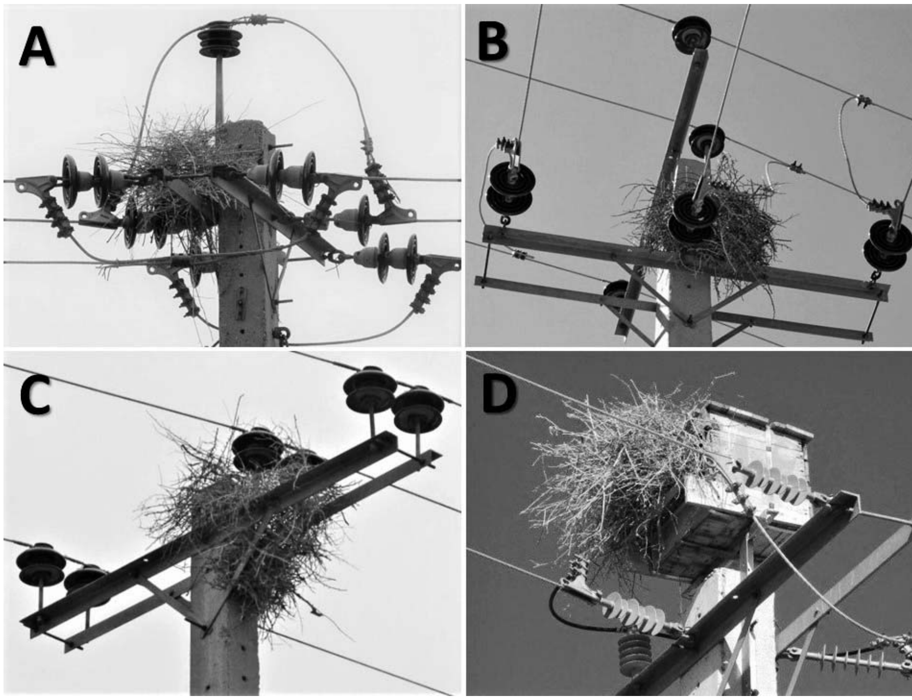

Figure 2. Nests constructed by Eurasian Magpies on electric pylons in central Iran, including on (A) horizontal insulators, (B) crossarms, (C) crossarm braces, and (D) inside a nest box.

2019 ($\chi^2 = 9.65$, df = 1, $P < 0.002$). All faults were momentary; none of the faults or electrocutions we documented resulted in power outages.

Discussion

We made four predictions prior to conducting this study. We predicted that installation of nest boxes would correlate with increased numbers of Eurasian Kestrel nests, decreased nests outside of nest boxes, decreased avian electrocutions, and decreased electrical faults. All four predictions were validated, supporting our hypothesis that installation of nest boxes could simultaneously meet conservation goals for reducing electrocutions and meet electric utility goals for improving system reliability.

Preventing avian electrocutions, and the faults (this study), outages (Dwyer 2004, Kemper et al. 2013), fires (Guil et al. 2018, Dwyer et al. 2019), and equipment damage (Kolnegari and Harness 2020) they can cause creates a unique situation where electric utilities and conservationists share common goals. In this study, we found new support for assertions in APLIC (2006) and Ferrer (2012) that installation of alternate nest sites, nest boxes in this case, can help meet goals of reducing electrocutions and faults. Specific to this study, nest boxes also appear to have facilitated an increase in the local Eurasian Kestrel population. Given that Eurasian Kestrels limit intraspecific nest defense to relatively small areas around nests (Cavé 1968), it may be that adding more nest boxes spaced regularly, rather than spaced based on previous use by Eurasian Magpies might further increase Eurasian Kestrel numbers.

We suggest three complementary and nonexclusive hypotheses for how installing nest boxes may have facilitated the reduction in numbers of electrocutions

Table 1. Counts of birds found electrocuted on a 34-km segment of 20-kV distribution line between Khomein and Arak, in Markazi Province, central Iran, in 2018 and 2019.

Species	Number of Birds Found Electrocuted	
	2018	2019
Eurasian Magpie (*Pica pica*)	17	5
Eurasian Kestrel (*Falco tinnunculus*)	1	3
Rook (*Corvus frugilegus*)	4	
Carrion Crow (*Corvus corone*)	7	2
European Starling (*Sturnus vulgaris*)	11	4
Eurasian Eagle-Owl (*Bubo bubo*)		2
Steppe Eagle (*Aquila nipalensis*)		1
Total	**40**	**17**

and electrical faults we observed. First, nests outside of nest boxes were substantially reduced, limiting the occurrence of electric current faulting from wires, through nests, to grounded pylons.

Second, birds often perched on the highest point on the pylon supporting a nest (M. Kolnegari and J. Dwyer unpubl. data). During the first year of our study, the highest points were the pylon tops themselves, and were often near conductors or jumpers (the small wires connecting equipment on a power pole). After we installed nest boxes, the boxes became the highest point on 31 pylons. Nest boxes substantially exceeded the height of energized wires, presumably separating perched birds from wires. Installing nest boxes may have affected reduction of electrocutions in two ways. Higher nest boxes (2a) may have enticed birds away from perching on structures without boxes, and (2b) may have enticed birds away from perching on crossarms where electrocution was more likely.

Third, installation of nest boxes correlated with differences in proportions of species making up the population of birds nesting on the power line. This likely also worked in two ways. (3a) The species nesting on the power line differed in average body size between years. On average, Eurasian Magpie body length is 30% larger than Eurasian Kestrel body length, and body length is a key parameter in defining electrocution risk (Ferrer and Hiraldo 1992, Infante and Peris 2003, Kemper et al. 2013). The 53.7% decline we observed in nesting by Eurasian Magpies, which are 43–46 cm long, and the 136.8% increase we observed in nesting by Eurasian Kestrels, which are 32–39 cm long, meant that the average size of nesting species, and thus the average likelihood of simultaneously contacting an energized wire and a grounded component, declined substantially. (3b) Given that electrocutions of Rooks, Carrion Crow (*Corvus corone*), and European Starlings (*Sturnus vulgaris*) declined by a total 72.7%, there may have been social-, competition-, or predation-related deterrence effects due to having a larger number of Eurasian Kestrels present in 2019.

Our findings may be useful in suggesting a new mechanism of reducing economic costs associated with power outages (Peretto 2010, Maricato et al. 2016), but electrocutions and electrical faults did persist at reduced levels after installation of nest boxes. Methods to prevent avian electrocutions and related faults and outages fall into three broad categories of isolation, insulation, and redirection (Dwyer et al. 2017). Isolation describes separating energized components from one another and from paths to ground by distances large enough to allow a bird to pass safely between components. This approach can be impractical on grounded distribution pylons. Insulation describes covering energized equipment with material intended to prevent the flow of electric current during incidental contact by birds (in this context insulation does not confer protection for humans). This approach is widely used by electric utilities globally. Redirection describes shifting where and how birds use pylons. The nest box strategy described herein is a type of redirection. Redirection often allows dangerous locations to persist on modified pylons because energized equipment remains exposed. We suggest that the most effective mechanism of preventing as many electrocutions as possible on the power line we studied, while simultaneously encouraging a Eurasian Kestrel population, would be a combination of covering conductors where they intersect pylons (insulation), and installing nest boxes (redirection). This combination approach would better protect kestrels, other raptors, and passerines from electrocution, while simultaneously utilizing a Eurasian Kestrel population to limit the Eurasian Magpie population, which would reduce the number of nests outside of nest boxes. In addition to addressing conductors, electrocution mitigation in our study area should also address energized equipment, such as arcing horns on transformers, where electrocutions often occur (Kolnegari and Harness 2020).

To our knowledge, Eurasian Magpies have not previously been reported breeding in nest boxes. We suspect the reason Eurasian Magpies bred in our nest boxes was that we included relatively large openings. Opening size could be reduced to test this hypothesis, but would likely result in additional nests outside of nest boxes, which could undermine one of the goals (reducing electrical faults) of the nest box strategy. For that reason, we suggest that if nest boxes are used in similar studies elsewhere, effects of nest box design on occupancy by birds other than kestrels be considered in the study design. Fault indicators should continue to be used because none of the electrocutions we documented caused outages. Overall, our results have implications for the management of nesting birds on the electricity distribution grid in Iran and elsewhere, such as in South Korea (Kim et al. 2019), where nests, some containing eggs or nestlings, are sometimes removed to address impacts to power reliability. Combinations of insulating energized equipment and providing nest boxes may allow electric utilities to move away from management practices that have direct mortality implications for avian populations. However, if the nest box approach is used elsewhere, we recommend careful monitoring because our study included only one breeding season of monitoring before and after nest boxes were installed, and that raptors other than Eurasian Kestrels were found electrocuted after installation of nest boxes.

We had not anticipated a change in the species of birds electrocuted after installing nest boxes, so we do not know why there were no raptors other than Eurasian Kestrels electrocuted in 2018, but two raptors other than Eurasian Kestrels electrocuted in 2019. Perhaps the raptors perceived potential prey items in nest boxes as more vulnerable than potential prey items in nests outside of nest boxes. If so, there is the potential that nest boxes created an ecological trap for avian nest predators such as the Eurasian Eagle-Owl. Ecological traps arise when the cues used by an animal to evaluate habitat are decoupled from the likely fitness implications (survival and reproduction) of occupying that habitat. For example, in Tucson, AZ, USA, Harris's Hawks (*Parabuteo unicinctus*) apparently use the high prey concentrations and high tree concentrations in urban areas as indicators of high quality habitat (Dwyer et al. 2020), but the hawks are unprepared by their evolutionary history to recognize the electrocution risk created by power poles in those urban landscapes (Dwyer 2009). This has led to reduced fitness (reduced survival) via the electrocution of numerous Harris's Hawks in breeding territories in urban Tucson (Dwyer and Mannan 2007). In another case, American Kestrels (*Falco sparverius*) breeding in nest boxes experienced higher levels of reproductive failure in proximity to high levels of vehicle traffic, and higher levels of reproductive success away from high levels of vehicle traffic (Strasser and Heath 2013). Ecological traps formed when nest boxes were located where habitat appeared to be of high quality but was actually unsuitable due to traffic noise.

In this study, following installation of nest boxes, a greater number of Eurasian Kestrels were electrocuted, but fewer Eurasian Kestrels were electrocuted per nest. This suggests that nest boxes were not operating as ecological traps for Eurasian Kestrels. Rather, the higher numbers of electrocutions and electrical faults in 2018 compared to 2019, indicates that the strength of the ecological trap associated with nesting on power lines without nest boxes exceeds the strength of the potential trap associated with nest boxes. This is true particularly because when nests outside of nest boxes become energized, all of the contents (eggs, nestlings, incubating birds) can be killed (M. Kolnegari and J. Dwyer unpubl. data). Constraining nesting to nest boxes as much as possible limits this greater impact. Information on breeding success would have been useful in evaluating an ecological trap hypothesis further. Unfortunately, we were unable to collect data on breeding success given our methodology. However, the fact that all nest boxes were occupied suggests that nest site availability limited the Eurasian Kestrel in our study area.

Artificial nesting sites such as those included in this study can be assessed for risks that they may create ecological traps (McClure et al. 2017). Future research could include quantification of productivity in a study such as ours and could contextualize that productivity and any associated mortality in an ecological trap hypothesis within the modeling framework described by McClure et al. (2017).

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