Short Communications

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Perch Management May Reduce Raptor Electrocution Risk on Horizontal Post Insulators

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Abstract.—Raptor electrocutions on overhead power lines occur globally. To evaluate a mitigation strategy designed for horizontal post insulators, a common configuration in the 25–69-kV range, we quantified perching by two Great Horned Owls (*Bubo virginianus*) and seven Red-tailed Hawks (*Buteo jamaicensis*) on non-energized 25-kV and 69-kV horizontal post insulators installed below vertically mounted perch deterrents. We quantified how often and how long raptors perched on horizontal post insulators beneath perch deterrents, and how often and how long raptors simultaneously contacted both ends of horizontal post insulators, to simulate phase-to-ground electrical contacts. Across 900.0 min of video recordings, raptors usually perched at the distal end of the insulator away from the perch deterrent, but 56 of 1095 perches (5.1%) included at least some time perched below the perch deterrent ($\Sigma = 34.0$ min). We never observed any Great Horned Owls simultaneously contact both ends of an insulator. We observed three occurrences of Red-tailed Hawks simultaneously contacting both ends of an insulator (twice on the 25-kV insulator; once on the 69-kV insulator). We speculate that in the absence of the perch deterrents, raptors would have perched toward the center of horizontal post insulators with higher frequency, resulting in a greater frequency of bridging both ends of horizontal post insulators. On energized poles, such behavior would increase electrocution risk. This suggests that perch deterrents may reduce raptor electrocution risk on vertically configured power poles. This study should be repeated with a design that evaluates perching on horizontal post insulators with and without perch deterrents, with larger sample sizes, and with additional raptor species, particularly Golden Eagles (*Aquila chrysaetos*).

Key Words: *Red-tailed Hawk*; Buteo jamaicensis; *Great Horned Owl*; Bubo virginianus; *perch deterrent*; *rehabilitation*; *remote camera*; *trail camera*.

LA GESTIÓN DE POSADEROS PODRÍA REDUCIR EL RIESGO DE ELECTROCUCIÓN DE AVES RAPACES CON AISLADORES HORIZONTALES

Resumen.—La electrocución de rapaces en líneas eléctricas aéreas ocurre globalmente. Para evaluar una estrategia de mitigación diseñada para aisladores horizontales, una configuración común en el rango de

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25–69 kV, cuantificamos el comportamiento de dos individuos de *Bubo virginianus* y de siete individuos de *Buteo jamaicensis* al posarse en aisladores horizontales no energizados de 25 kV y 69 kV instalados debajo de inhibidores de posado montados verticalmente. Cuantificamos la frecuencia y el tiempo que estas rapaces se posaron sobre los aisladores horizontales debajo de los inhibidores de posado. También cuantificamos la frecuencia y el tiempo que contactaron simultáneamente ambos extremos de los aisladores horizontales para simular contactos eléctricos de fase a tierra. A lo largo de 900.0 min de grabaciones de vídeo, las rapaces se posaron habitualmente en el extremo distal del aislador, alejadas del inhibidor de posado, pero 56 de las 1095 observaciones (5.1%) incluyeron al menos algún tiempo posadas debajo del inhibidor de posado ($\Sigma = 34.0$ min). Nunca observamos ningún individuo de *B. virginianus* contactar simultáneamente ambos extremos de un aislador. Observamos tres casos de *B. jamaicensis* contactando simultáneamente ambos extremos de un aislador (dos veces en el aislador de 25 kV; una vez en el aislador de 69 kV). Especulamos que, en ausencia de los inhibidores de posado, las rapaces se hubieran posado con mayor frecuencia hacia el centro de los aisladores horizontales, resultando en una mayor frecuencia de puenteo de ambos extremos de los aisladores horizontales. En los postes energizados, este comportamiento aumentaría el riesgo de electrocución. Esto sugiere que los inhibidores de posado pueden reducir el riesgo de electrocución de las rapaces en los postes de energía configurados verticalmente. Este estudio debería ser repetido con un diseño que evalúe el posarse sobre aisladores horizontales con y sin inhibidores de posado, con mayores tamaños de muestreo, y con especies de rapaces adicionales, particularmente de *Aquila chrysaetos*.

[Traducción del equipo editorial]

The ongoing global expansion of overhead electric systems has made electric utility poles, pylons, and towers ubiquitous. Because overhead electric systems will continue to expand, effects to wildlife populations need to be considered so that mitigation of negative impacts can be developed and implemented (Smith and Dwyer 2016, Slater et al. 2020). Electrocutions occur when a raptor simultaneously contacts an uninsulated energized wire and another energized wire or grounded component, and the bird becomes part of an electrical circuit, resulting in an electrocution or electric shock injury (Avian Power Line Interaction Committee [APLIC] 2006, Dwyer 2006, Lehman et al. 2007, Kross 2014). Electrocutions have been implicated in population-level declines for Golden Eagles (*Aquila chrysaetos*) in the United States (US Fish and Wildlife Service [USFWS] 2016, Mojica et al. 2018), Spanish Imperial Eagles (*Aquila adalberti*) and Booted Eagles (*Hieraaetus pennata*) in Spain (González et al. 2007, López-López et al. 2011, Martínez et al. 2017), Eurasian Eagle-Owls (*Bubo bubo*) in Italy (Sergio et al. 2004), Saker Falcons (*Falco cherrug*) in Mongolia and China (Dixon et al. 2013), Egyptian Vultures (*Neophron percnopterus*) in Egypt (Angelov et al. 2013), Cape Vultures (*Gyps coprotheres*) in South Africa (Boschoff et al. 2011), and Tasmanian Wedge-tailed Eagles (*Aquila audax fleayi*) in Australia (Bekessy et al. 2009).

To address electrocution concerns, electric utilities design or modify power poles to reduce the likelihood of a raptor making simultaneous contact with an energized exposed wire and another energized or grounded component at a different electric potential (APLIC 2006). These electrocution mitigation strategies fall into three categories: separation, insulation, and redirection (Dwyer et al. 2017). Separation is accomplished by increasing the distance between conductive components, insulation is accomplished by covering energized components, and redirection is accomplished by installing equipment intended to modify how and where raptors perch. Redirection was widely used when raptor electrocutions were first identified as a conservation concern in the 1970s (APLIC 2006). Today, redirection is generally the least preferred electrocution mitigation strategy, though redirection remains useful in situations where neither separation nor insulation can be applied in a cost-effective manner (Dwyer et al. 2016a, 2016b).

Electric utilities generally seek to follow APLIC (2006) guidelines of creating 152 cm of horizontal separation between electrical components. This distance allows a Golden Eagle to spread its wings with minimal risk that more conductive areas (flesh) will simultaneously contact components on either side (APLIC 2006). Flight feathers may make contact, but because dry feathers are only slightly more conductive than air, the likelihood that a circuit involving the bird will be formed is low. Though generally useful, the 152-cm guideline may not be necessary on horizontal post insulators because if a bird is perched at the end of the insulator away from the pole, only half of the bird's wingspan is relevant when considering electrocution risk; the other half is away from the pole in open air. Horizontal post insulators support an energized exposed wire on one end separated by an epoxy or ceramic insulator from a grounded (and often bonded) base on the other end. Raptors occasionally perch on horizontal post insulators (APLIC 2006), and similar armless configurations (Fig. 1). A raptor making simultaneous contact with the energized and grounded ends can become a path for electric current, resulting in electrocution.

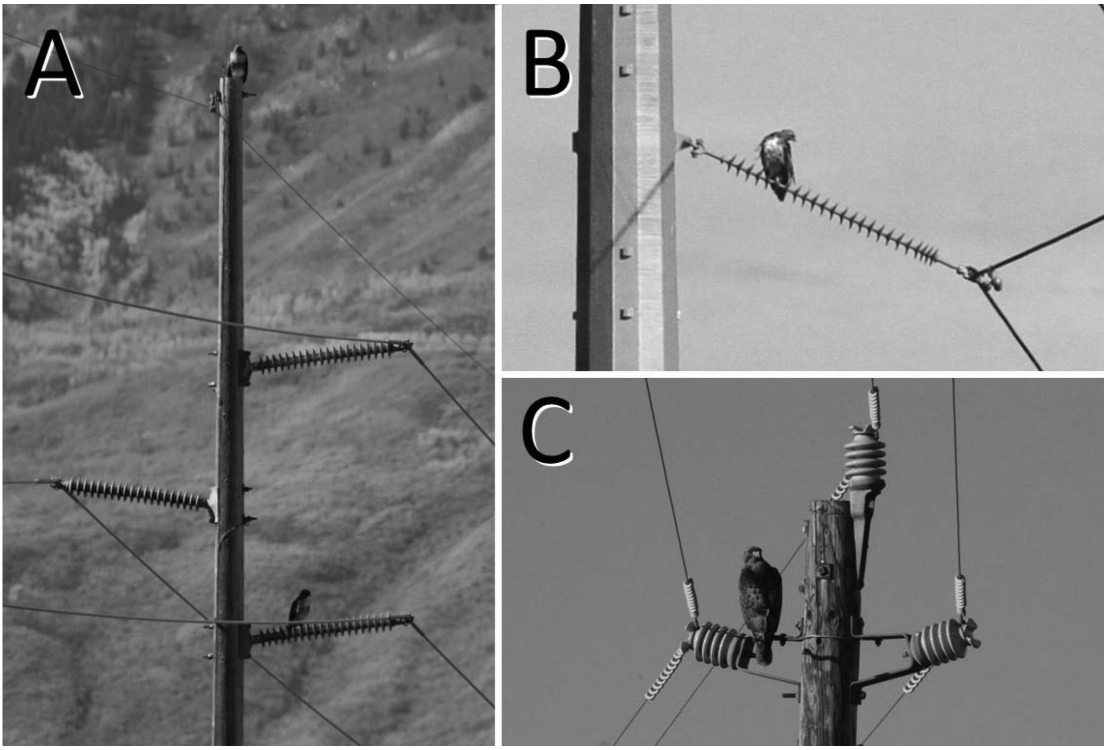

Figure 1. Examples of Red-tailed Hawks perched on armless configurations. (A) A Red-tailed Hawk perched on a horizontal post insulator; second Red-tailed Hawk perched at the top of the pole. (B) A Red-tailed Hawk perched on a strain insulator. (C) A Red-tailed Hawk perched on a horizontal post insulator bracket. Due to the lengths of the insulators in these photographs, only the Red-tailed Hawk in image C is at risk of electrocution on these configurations.

In this study, we assessed the effectiveness of a redirection strategy designed to mitigate raptor electrocution risk on horizontal post insulators. To our knowledge no study has previously focused on this configuration, though APLIC (2006) includes mention of 30 Golden Eagles electrocuted along approximately 32 km of a 69-kV line constructed with horizontal post insulator configurations. To begin addressing this knowledge gap, we quantified counts and durations of perching on horizontal post insulators when a perch deterrent was present.

METHODS

Due to the challenges associated with predictably observing perching on horizontal post insulators in the wild, and due to the danger to raptors involved in experimentally exposing raptors to high-voltage equipment, we conducted this study on non-energized model power poles within a flight enclosure at the Rocky Mountain Raptor Program (RMRP; Fort Collins, CO). The RMRP is a raptor rehabilitation facility that admits approximately 300 injured, ill, or orphaned wild raptors annually. All raptors included in this study were in captivity solely to facilitate recovery from injuries incurred in the wild. Because they were wild birds, we believe they responded to the presence of perch deterrents in ways consistent with what would occur in the wild. Upon successfully passing tests of their ability to hunt live prey, each raptor included in this study was released. Accordingly, throughout this study, we complied with ethical standards and institutional guidelines for ameliorating suffering in raptor rehabilitation in the United States (Miller 2000).

We installed two 4.0 m-tall non-energized model power poles inside a flight enclosure at the RMRP. The use of model poles in an enclosure allowed us to guide raptors into perching relatively frequently in a location where they only perch occasionally in the wild, and allowed us to evaluate an electrocution mitigation strategy without resorting to counting the carcasses of birds electrocuted in the wild, the most common mechanism of assessing retrofitting effectiveness. The flight enclosure was 12.2 m long, 6.1 m wide, and 5.5 m high. We removed all other perch structures from the enclosure. Each model pole supported two polymer horizontal post insulators, and each horizontal

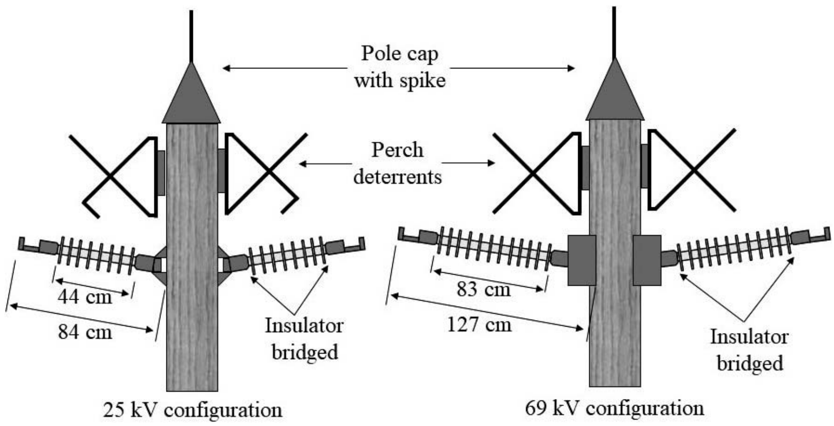

Figure 2. Overall length and insulator length of horizontal post insulators (not drawn to scale). The lower end of the perch deterrent on the 25-kV insulator bends toward the pole as required to maintain the minimum clearance required around the energized end of the insulator.

post insulator was paired with a vertically mounted X-type perch deterrent manufactured by Power Line Sentry (Fort Collins, CO). We chose this design because we found in preliminary observations that when a perch deterrent was absent from one of the horizontal post insulators, raptors perched almost exclusively on that insulator, preventing us from assessing perching on the insulator paired with the deterrent. Perch deterrents were installed by the manufacturer, with vertical separation between the insulators and the deterrents following the manufacturer's recommendations to ensure the deterrent would not compromise the air-gap around the insulator if this were an energized pole. We used screws to install the perch deterrents on wooden poles, though we could have installed them with straps to mimic installations on metal or fiberglass poles.

On one model pole, we installed horizontal post insulators rated for a 25-kV line. These were 84 cm long overall, including 44 cm of insulation between the two metal ends (Fig. 2). On the other pole, we installed horizontal post insulators rated for a 69-kV line. These were 127 cm overall, including 83 cm of insulation. We also installed a spiked pole cap on the top of each pole to increase the likelihood that raptors would perch on horizontal post insulators and not the pole tops.

We released a series of two Great Horned Owls (*Bubo virginianus*) and seven Red-tailed Hawks (*Buteo jamaicensis*) one at a time into the flight enclosure. Each bird remained in the enclosure for up to one week between May 2016 and March 2017. We studied Great Horned Owls and Red-tailed Hawks because these two species are frequently reported in studies of raptor electrocutions in North America (Harness and Wilson 2001, Dwyer and Mannan 2007, Lehman et al. 2010, Kemper et al. 2013). We used two M-990i motion-triggered game cameras (Moultrie Feeders, Calera, AL, USA) to enable continuous (24-hr) monitoring of each pole. Each camera was situated to monitor the horizontal post insulators on one pole and was set to record a 1-min video each time a raptor moved within the camera's field of view. We reviewed the entirety of each video to identify the frequency (counts) and duration (seconds) that the raptors perched on various parts of horizontal post insulators. We recorded time in seconds for precision, but report time in minutes for ease of understanding. Each time a raptor perched on a horizontal post insulator, we recorded the total duration of perching, the duration of any perching under the perch deterrent, and the duration of any simultaneous contacts with both ends of the insulator.

Ideally, one insulator on each pole would have been fitted with a perch deterrent (treatment), and one would not (control), to facilitate comparative statistical analyses. But as was previously noted, that approach was not practical in this study. Because we could not compare perching on model poles with and without perch deterrents, we instead report the occurrence (counts and duration in minutes) of Great Horned Owls and Red-tailed Hawks (1) perching on the insulator in general, (2) perching on the insulator below the perch deterrent specifically, and (3) making simultaneous contact with both ends of the insulator when perched on the insulators. This makes the number of birds observed ($n=9$) our sample size.

RESULTS

We recorded 900 min (15.0 hr) of videos showing Great Horned Owls ($n=2$ birds; 15 perches; 8 min) and Red-tailed Hawks ($n = 7$ birds; 1080 perches; 892 min) perched on horizontal post insulators on model power poles (Fig. 3). On the 25-kV insulator, 16 of 198 (8.1%) observed perches included at least some time ($\Sigma = 9.1$ min; $\bar{x} = 0.6$ min) perched below the perch deterrent. On the 69-kV insulator, 40 of 897 (4.5%) observed perches included at least some

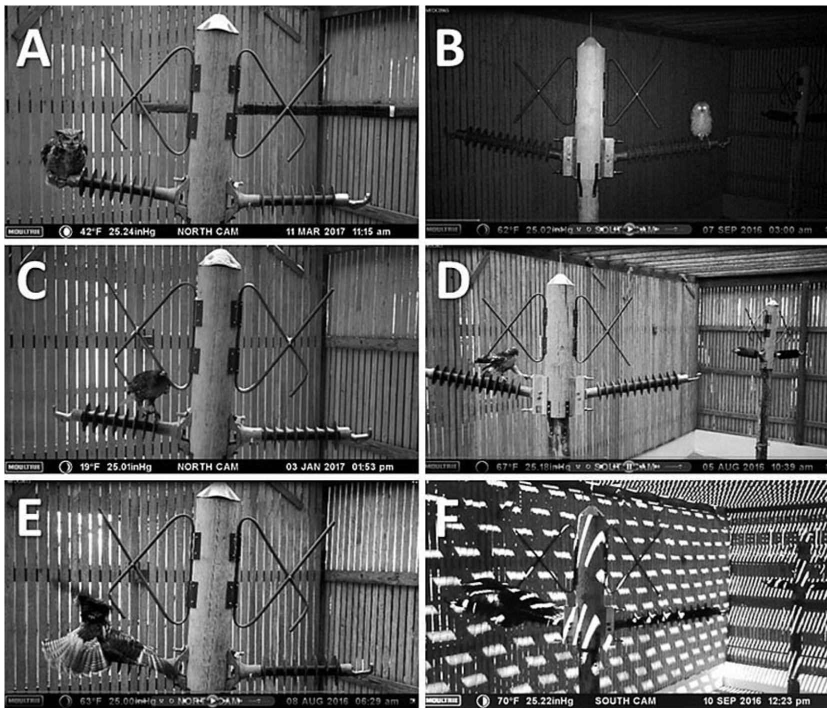

Figure 3. Raptor perch locations on horizontal post insulators relative to perch deterrents intended to prevent simulated simultaneous contact with energized and grounded ends of the insulators. (A and B) perching beyond the perch deterrent. (C and D) perching under the perch deterrent. (E and F) contacting both ends of the horizontal post insulator. (A, C, and E) 25-kV horizontal post insulator. (B, D, and F) 69-kV horizontal post insulator.

time ($\Sigma = 24.9$ min; $\bar{x} = 0.6$ min) perched below the perch deterrent. We did not observe any insulator bridging by Great Horned Owls. We observed three 1-sec occurrences of insulator bridging by Red-tailed Hawks; two of these were on the 25-kV insulator and one was on the 69-kV insulator.

DISCUSSION

We found that Great Horned Owls and Red-tailed Hawks perched on the portion of horizontal post insulators shielded by perch deterrents only 5% of the time even though on the 25-kV insulator, 60% of each insulator was below the perch deterrent, and on the 69-kV insulator, 45% of each insulator was below the perch deterrent. When perching on horizontal post insulators shielded by perch deterrents, raptors almost never contacted both ends of the insulators. When contact was made, it was fleeting wingtip contact made as birds spread their wings for balance while adjusting their stance on the horizontal post insulator. These observations lead us to believe that perch management may reduce raptor electrocution risk on horizontal post insulators. However, we do not know with certainty that this conclusion is correct because we did not compare perching on insulators with and without perch deterrents. For this reason, this research should be considered preliminary. Future research should duplicate this work with a study design that quantifies perching with and without perch deterrents, and with larger sample sizes. We also do not know if our findings on relatively narrow-edged polymer insulators will apply to more rounded-edged ceramic insulators which may be used in a different way by perching raptors. Inclusion of Golden Eagles (*Aquila chrysaetos*) in a future study would also improve confidence in our conclusions. Because Golden Eagles are larger than most other raptors, Golden Eagles are more likely than other raptor species to simultaneously contact pole-top components with different electric potentials (APLIC 2006, Mojica et al. 2018, Bedrosian et al. 2020).

Previous studies of perch deterrent use have yielded mixed results. For example, Slater and Smith (2010) found reduced perch frequency on a transmission line when all horizontal surfaces were fitted with spiked perch deterrents. Dwyer and Doloughan (2014) also found reduced perch frequency and perch duration on distribution poles when all horizontal surfaces were fitted with deterrents. In contrast, Prather and Messmer (2010) found little evidence that commercially available perch deterrents substantially reduced perching. The Prather and Messmer (2010) study did not install perch deterrents on all horizontal surfaces, however, because they also installed conductor covers, which raptors readily use for perching. Though not the intent of the study, Prather and Messmer (2010) demonstrated a crucial component of perch deterrent effects: if a combination of deterred surfaces and undeterred surfaces is created, raptors may be more likely to perch on the undeterred surfaces. This finding was supported by Dwyer et al. (2016a) who showed that careful and strategic use of deterrents on some parts of structures and not on others could direct raptors to perch in relatively safer locations on poles. Specific to horizontal post insulators, APLIC (1996) offered triangular perch deterrents mounted between conductor attachments as a mitigation approach, but APLIC (2006) later concluded that "because birds were still able to fit between the perch discourager and the conductor, the use of perch discouragers alone has been determined ineffective." Collectively, the mixed results associated with studies of perch deterrents underscores that deterrents are not an effective mitigation option in all situations, but rather (1) perch deterrents may be effective in some situations, and (2) failures of one type or arrangement of perch deterrents should not be taken to indicate their complete lack of utility.

In this study we evaluated perch deterrents on horizontal post insulators, but perch deterrents are not the only available solution to mitigate this electrocution risk on this configuration. Rather, at least five potential mitigation strategies exist: (1) Perch deterrents could be used as described here; (2) the energized ends of horizontal post insulators could be covered with insulation; (3) the grounded ends of horizontal post insulators could be covered with insulation; (4) the bases of the insulators could be ungrounded; and (5) oversized horizontal post insulators could be installed (APLIC 2006). The most effective solutions to raptor electrocutions on horizontal post insulators are likely removing grounding or increasing separation using oversized horizontal post insulators, but both solutions require engineering-based approaches that may not be practical on existing lines. Additionally, this will not be viable on existing metal poles, which are grounded. Insulation is an effective solution in some cases, but because insulation devices are typically manufactured to fit a range of configurations and voltages, insulation does not always fit specific insulator-conductor-voltage combinations (J. Dwyer unpubl. data) and can be dislodged. Redirection, as described herein may decrease the likelihood of phase-to-ground contact by raptors, and so offers a potential solution when other mitigation strategies are impractical or ineffective.

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