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RETURN RATES OF ALUMINUM VERSUS PLASTIC LEG BANDS FROM ELECTROCUTED HARRIS'S HAWKS (*PARABUTEO UNICINCTUS*)

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Ecological research programs investigating dispersal, migration, habitat selection, social structure, survival, reproductive success, and population size depend on the ability to identify individual study animals on multiple occasions (Bibby et al. 2000). Leg bands often are used to facilitate the identification of individual birds and more than one million birds, including numerous raptors, are marked annually in North America with aluminum leg bands (USGS 2008). In the United States, aluminum is also used in overhead electric systems because of its strength, low resistance, long life, and relatively low cost (APLIC 2006).

Raptors often perch on overhead electric structures where they risk electrocution (APLIC 2006, Lehman et al. 2007, Dwyer and Mannan 2007) or injury from electric shock (Morrow and Morrow 2003, Dwyer 2006). These events occur when a raptor simultaneously contacts two or more differentially energized conductors, and the probability of simultaneous contact increases with increasing body size (APLIC 2006). Thus, small birds perched on a power line are not electrocuted because they are in contact with only one conductor, which does not create an alternative pathway of lower resistance for the electric current to follow.

Harness and Wilson (1998) found that radio-transmitter antennas on falconry birds may increase electrocution risk by contacting conductors that a bird would otherwise have avoided. We speculated that encircling a raptor's leg in the favored material of electric transmission may have a similar effect. Human electrocution victims often show very little or no external trauma over most of the body, but metal on the person (e.g., jewelry, zippers, etc.) can become heated during electrocution and leave corresponding and diagnostic burns (Wetli et al. 1999, DiMaio and DiMaio 2001). Thus, we also speculated that, even if aluminum leg bands did not contribute to electrocution, burns associated with bands may serve as effective diagnostic indicators of electrocution.

To assess these possibilities, we fitted Harris's Hawks (*Parabuteo unicinctus*) with either aluminum or plastic leg bands and compared differences in the cause of death for recovered birds, and burns on electrocuted birds.

METHODS

We banded Harris's Hawks in Tucson, Arizona, U.S.A. from 1 February 2003 through 31 May 2004, and searched for carcasses from 1 February 2003 through 1 February 2008. Tucson is a city and suburban assemblage of about 1000 km^2, which supported a growing population of 900 000 to one million people during this study (Pima Association of Governments 2008). This area is served by more than 111 000 overhead utility poles that shuttle more than 2500 MW of electricity during peak usage (J. Sheehey pers. comm.).

We searched for Harris's Hawk nests as part of a larger study investigating the relationship between electrocution risk and proximity of power poles to nests (Dwyer and Mannan 2007), and used a bal-chatri trap (Bub 1978) to capture Harris's Hawks within nesting territories.

We identified captured birds as juvenile (no adult flight feathers present), subadult (a mix of juvenile and adult flight feathers present), and adult (no juvenile flight feathers present; Wheeler and Clark 1995). We sexed birds by mass (females >923 g, males <803 g; Dawson and Mannan 1991b). To verify that plastic bands would be retained, we fitted the first 10 hawks we caught with a USGS aluminum lock-on band on one leg and a uniquely coded 10-mm, high-wrap-around, Darvic plastic band (Haggie Engraving, Crumpton, MD U.S.A.) on the other leg. We then resighted these individuals within their territories for 18 mo and found that all plastic bands were retained for the duration of the study. After double-banding the first 10 hawks, we randomly assigned either a metal or plastic band to each bird caught thereafter.

From the time each nest was discovered until 8 wk after young had fledged, we searched for electrocuted hawks within a 7.6-m radius (Harness 2000, Dwyer and Mannan 2007) around the bases of particularly dangerous poles within 300 m of Harris's Hawk nests. Electrocution is more likely for a given species when individuals perch on poles where differentially energized, exposed conductors occur closer together than the wrist-to-wrist span of that species (APLIC 2006). Harris's Hawks have a wrist-to-wrist span of ca. 60 cm (APLIC 2006) and we identified poles with <60 cm of separation between conductors as particularly dangerous (Dwyer and Mannan 2007).

We also notified area residents, birdwatchers, falconers, wildlife rehabilitators, and county, state, and federal personnel of our interest in recovering dead raptors, and encouraged them to contact us if they discovered the carcass of any

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large bird. We diagnosed electrocutions as described by Haas (1993), Burke et al. (2002), and Koumbourlis (2002). We diagnosed hawks found dead and burned at the base of dangerous power poles as electrocuted, and hawks found dead and unburned at the base of dangerous power poles as suspected electrocutions. We recorded cause of death as ''undetermined'' if we found a carcass at the base of a dangerous pole, but the carcass was too decomposed to diagnose a cause of death, or if we found a bird away from a pole and without burns. Thus, some birds with undetermined causes of death also may have been electrocuted, but we chose to be conservative in this assessment.

We conducted all statistical analyses using JMP 7.0 (SAS Institute Inc., Cary, NC U.S.A.).

RESULTS

We banded 89 Harris's Hawks and monitored an average of 6.0 poles per nest (SD = 3.08) at 32 nests. We recovered 23 (26%) carcasses, including one carcass we found while searching beneath dangerous poles within 300 m of nests. The remaining 22 mortalities were reported to us by human residents, either directly or through the Arizona Game and Fish Department or Tucson Electric Power Company.

We recovered 3 of 10 (30%) birds fitted with aluminum and plastic leg bands, 10 of 41 (24%) birds wearing aluminum bands only, and 10 of 38 (26%) birds wearing plastic bands only. Twelve recovered birds were electrocuted, four were suspected to have been electrocuted, and one was found dead in a closed, medium-sized Havahart® mammal trap (Woodstream Corporation, Lititz, PA U.S.A.). We could not determine the cause of death for the remaining six birds. Of the 12 birds found electrocuted, six had a plastic band only, five had a metal band only, and one had both. Birds wearing only a metal band were not more likely to be found electrocuted than birds wearing only a plastic band, whether suspected electrocutions were excluded ($\chi^2 = 0.0$, df = 1, $P = 0.886$) or included ($\chi^2 = 0.0$, df = 1, $P = 0.865$).

We banded 44 males and 45 females, and recovered five (12%) male and 18 (40%) female carcasses. Two males and 10 females were electrocuted. Females were more likely to be found dead, in general ($\chi^2 = 10.0$, df = 1, $P = 0.002$), and to be found electrocuted, in particular ($\chi^2 = 6.4$, df = 1, $P = 0.011$).

We banded 30 juvenile Harris's Hawks, 25 subadults, and 34 adults. Two of the 23 banded Harris's Hawks we found dead were juveniles, four were subadults, and 17 were adults. Of the 12 Harris' Hawks we found electrocuted, two were juveniles, one was a subadult, and nine were adults. Harris's Hawks in complete adult plumage were more likely to be found dead ($\chi^2 = 18.4$, df = 2, $P < 0.001$) and electrocuted ($\chi^2 = 8.4$, df = 2, $P = 0.015$) than hawks in other plumages.

None of the bands on the carcasses of either confirmed or suspected electrocuted hawks showed evidence of having served as a conduit for electric current (i.e., no leg bands or adjacent tissues were melted or burned). Rather, all of the electrocuted birds had burns on the soles and toes of their feet, near the distal ends of their wing bones, or both.

DISCUSSION

The electrocution of raptors is an ongoing problem and the effectiveness of mitigation efforts has not been clearly determined (Lehman et al. 2007). Previous reviews have demonstrated that across species larger raptors tend to be at greater risk of electrocution, and that within species females tend to be at greater risk than males, probably also due to their larger size (APLIC 2006, reviewed in Lehman et al. 2007). We did not investigate more than one species in this study, but we did find that female Harris's Hawks, particularly adult females, were at greater risk of electrocution than other sex-age classes. Harris's Hawks in Tucson live in social groups of up to seven individuals (Dawson and Mannan 1991a). Because dominant adult females can prevent subordinates from accessing nests or fledglings, adult females sometimes accept prey from group mates away from young birds and then deliver it to nestlings and fledglings. In many cases, these prey transfers occur on power poles (J. Dwyer unpubl. data). Thus, adult females may participate in substantially more prey transfers on dangerous power poles and be electrocuted. Many studies also indicate higher risk of electrocution for young birds, probably due to their poorly developed motor skills (APLIC 2006, Lehman et al. 2007). Although this pattern was not evident in this study, we previously reported such for this population (Dwyer and Mannan 2007).

We also found that adult Harris's Hawks, particularly females, were more likely to be found dead regardless of the agent of mortality, and that the public reported nearly all of our carcasses. This may indicate that large, boldly patterned adult females are more obvious to untrained laypersons than smaller adult males or more cryptically colored juveniles. Thus, efforts to include the public in raptor electrocution studies can increase overall detection probabilities dramatically, but some mechanism of gauging detection by sex-age class should be incorporated.

We did not find burns around leg bands, so deliberately examining this area of carcasses may not result in diagnoses of electrocution in cases where burns are not evident elsewhere. It is encouraging, however, that leg bands did not appear to increase the risk of electrocution to Harris's Hawks and, therefore, that banding can continue to be a useful tool for this species without increasing the risk of electrocution-related trauma.

TASA DE RECAPTURA DE ANILLAS DE ALUMINIO Y ANILLAS DE PLÁSTICO EN INDIVIDUOS ELECTROCUTADOS DE *PARABUTEO UNICINCTUS*

RESUMEN.—En estudios de aves rapaces, la habilidad para identificar individuos correctamente es facilitada por la

utilización de anillas de aluminio. Debido a que las aves rapaces generalmente descansan sobre líneas eléctricas, las anillas de aluminio pueden contribuir al riesgo de electrocución, o pueden servir como indicadoras de electrocución en cadáveres intactos. Para comprobar estas posibilidades, marcamos 89 individuos de *Parabuteo unicintus* en Tucson, Arizona, U.S.A. con anillas de aluminio o de plástico y comparamos las heridas y causas de muerte en 23 individuos recogidos. No encontramos diferencia en la tasa de electrocución en 41 individuos marcados con anillas de aluminio y 38 individuos marcados con anillas de plástico, y no encontramos quemaduras en las anillas o en las patas alrededor de las anillas. En general, las hembras y los adultos fueron más propensos a ser encontrados muertos por electrocución. Nuestros datos no apoyan la hipótesis de que las anillas de aluminio aumentan el riesgo de electrocución de las rapaces, pero sí concuerdan con otros estudios que identifican al sexo y la edad como factores de riesgo.

[Traducción del equipo editorial]

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