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USE OF RAPTOR MODELS TO REDUCE AVIAN COLLISIONS WITH POWERLINES

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ABSTRACT.—We evaluated the use of raptor models to decrease bird mortalities caused by collisions with powerlines. One realistic statue of a Golden Eagle (*Aquila chrysaetos*) and two *Accipiter* silhouettes were placed on top of utility towers. Flight behavior of both resident and migrating birds near these power structures was compared to flight behavior we observed at towers where models were not installed. Overall, the number of flocks, number of crossings, and flight altitudes were not affected by the models. Our results indicated that the models did not in any way reduce the risk of collisions. Potential collision victims such as waterfowl, storks, and lapwings were generally indifferent to the models. Most reactions were shown by raptors primarily because the eagle model provoked abundant attacks. We felt that, due to the intensity of attacks on the eagle model, it may have actually increased the possibility of collisions by raptors with powerlines.

KEY WORDS: *avian collisions; mortality; avoidance models; powerlines.*

El uso de modelos de rapaces para reducir la colisión de aves con tendidos electricos

RESUMEN.—La eficacia de modelos de rapaces para disminuir la colisión de aves contra tendidos eléctricos fue comprobada. Un modelo realista de un águila real (*Aquila chrysaetos*) (estatua) y dos siluetas de halcones (*Accipiter* sp.) fueron colocados en lo alto de torres eléctricos. El comportamiento de las aves cerca del tendido fue comparado entre un tramo tratado y un tramo control y entre aves migratorias y residentes de dos áreas de estudio. En conjunto, el número de bandos, el número de cruces y la altura de vuelo fueron independientes de los tramos. Estos resultados indicaron que los modelos no cambiaron el comportamiento de las aves en la manera que pudiera reducir el riesgo de colisión. La composición de especies mostraba dependencia de tramos. Las potenciales víctimas de colisión en las áreas (aves acuáticas, cigüeñas, avefrías) parecían, en general, indiferentes ante los modelos. La mayoría de las reacciones fueron registradas en rapaces, porque el modelo de águila real provocó ataques de otras rapaces. Por ello, un mayor uso de los tramos tratados fue registrado. En consecuencia la probabilidad de una colisión podría incluso aumentar.

[Traducción de Autores]

Collisions with powerlines can be an important cause of death for some species of birds, especially those in unstable populations (Crivelli et al. 1988, Morkill and Anderson 1991). Species that fly in flocks (e.g., waterfowl) and species with high wing loading (e.g., storks [*Ciconia* spp.] and cranes [*Grus* sp.]) (Bevanger 1994, 1998) most frequently collide with and die at power structures. Measures tested to decrease collision mortality have mainly focused on the use of wire markers to increase the visibility of powerlines. Wire markers have been shown to reduce mortality by 50–80% (Alonso et al. 1994, Brown and Drewien 1995, Janss and Ferrer 1998).

In some areas where bird collisions are a problem, the use of models of raptors has been suggested as a useful mitigation measure. However, the effectiveness of these models in decreasing collisions has not been tested (Heijnis 1980, Brown 1993, APLIC 1996). If effective, they might have other applications such as at airports and along highway corridors where they might frighten birds away before collision accidents can become a problem (Solman 1973, Burger 1985, Hernandez 1988, Dolbeer et al. 1993, Work and Hale 1996). Habituation of birds to raptor models is a potential problem since it would make them only effective (Brown 1993) along migratory pathways where exposure to the models would only occur once or twice a year (Brown 1993, APLIC 1996).

We assessed the effectiveness of three different raptor models in reducing bird flights near power structures in two study areas. We discuss the effectiveness of these models in reducing collision mortality on powerlines for both migratory and resident birds.

METHODS

We used three models of raptors. Model A was a realistic statue of an "oversized" Golden Eagle (*Aquila chrysaetos;* height 70 cm, length 120 cm, about 130% of normal size) on a perch made of fiberglass. Models B and C were flat, brown and white silhouettes of *Accipiter*s made of wood. Model B simulated an *Accipiter* (height 30 cm, length 40 cm) on a perch and model C an *Accipiter* in flight (wingspan 105 cm, length 50 cm) (Heijnis 1980). The models were placed on top of powerpoles or other utility structures.

The first study area was in the south of Cádiz (southern Spain), near the Straits of Gibraltar, where large numbers of birds from Europe pass through when migrating to Africa (Bernis 1980, Finlayson 1992). The high-voltage powerline (400 kV) used was under construction and was without conductors or static wires (Fig. 1a, b). Towers were about 40-m high and about 400 m apart. We tested all three models in this migration area.

The second study area was in the Doñana National Park (southwest Spain). Two powerpoles were erected in marshland and scrub ecotone, where both wintering and breeding birds concentrated at the end of winter. The poles were not connected with any wire or conductor. The poles were about 10 m high and were 150 m apart, as in a distribution powerline (Fig. 1c). In this resident area only model A was tested.

Species we expected to be most susceptible to collisions in the study areas were waterfowl, pigeons (*Columba* spp.), White Storks (*Ciconia ciconia*) and Lapwings (*Vanellus vanellus*) (Fiedler and Wissner 1980, Bevanger 1994, Janss and Ferrer 1998).

Our observation periods were designed to coincide with periods when birds would be most abundant in each of the study areas. In the migration area, observations were made during the postnuptial migration period from 10 July–20 August 1996. In the resident area, observations were made from 12 February–13 March 1997. This period coincided with the end of the winter period and the start of the breeding period. All observations started immediately after the models were installed. Observations were made almost daily in sessions which lasted at least 2 hr (60 sessions on model A, 62 on models B and C in the migration area, and 24 sessions on model A in the resident area). Observation sessions covered all daylight hours and several sessions were conducted on the same day.

We analyzed the total number of flocks (i.e., bird groups) we observed because individuals in the same flock could not be considered as independent observations. Numbers of flocks were compared between utility towers with raptor models and adjacent towers where raptor models were not installed. Sections were further divided into subsections with one central tower and two lateral subsections which ended at the center of the spans (left and right from the tower subsection) (Fig. 1).

Using a telescope and binoculars, birds were recorded simultaneously at both types of sections from a fixed observation point centered between the two types of sections (approximately 200 m away). All birds and flocks that flew within 100 m of the structures were recorded For each observation of a bird or flock, we recorded the subsection where the bird came closest to the powerline, the flight altitude at this minimum distance, if the bird (flock) crossed the powerline, and any reactions to the raptor models (e.g., changes in flight direction or altitude either toward or away from the model, any aggressive behavior and vocal reactions). Three levels of flight altitude were recorded in the migration area: 0–20 m (under powerlines), 20–60 m (powerline level) and >60 m (above powerlines). Because utility towers differed in height in the resident area, flight altitude was assigned to two levels: 0–20 m (near poles) and >20 m (above poles).

In the resident area, observations recorded at the central subsections were omitted because of the small distance between the poles (Fig. 1). Observations in the treated sections where models B and C were placed, were compared with the same control section, which was situated in between both treated sections (Fig. 1b).

The number of flocks per subsection and per flight altitude category, and the number of flocks crossing vs. those not crossing over powerlines were compared using either chi-square or R $\times$ C tests of independence (Sokal and Rohlf 1995). This way we tested the homogeneity of the distribution of numbers (i.e., if proportions of birds near the towers were independent of treated and control sections). We used Yates's correction when necessary (Sokal and Rohlf 1995). Based on the experimental design (which had fixed control and treatment sections), we chose a significance level of $P < 0.01$. This way we lowered the probability of drawing wrong conclusions due to random effects. Although we planned to evaluate the use of the models to reduce collisions, we used two-tailed tests because we suspected that models could be both able to attract and scare off birds. Distributions of the number of flocks in tower subsections vs. lateral subsections (the sum of left and right) per taxonomic group, per flight altitude category and birds crossing sections vs not crossing sections were compared between treatments and controls. We analyzed the number of flocks independent of species as well as pooled by taxonomic groups (Appendix 1).

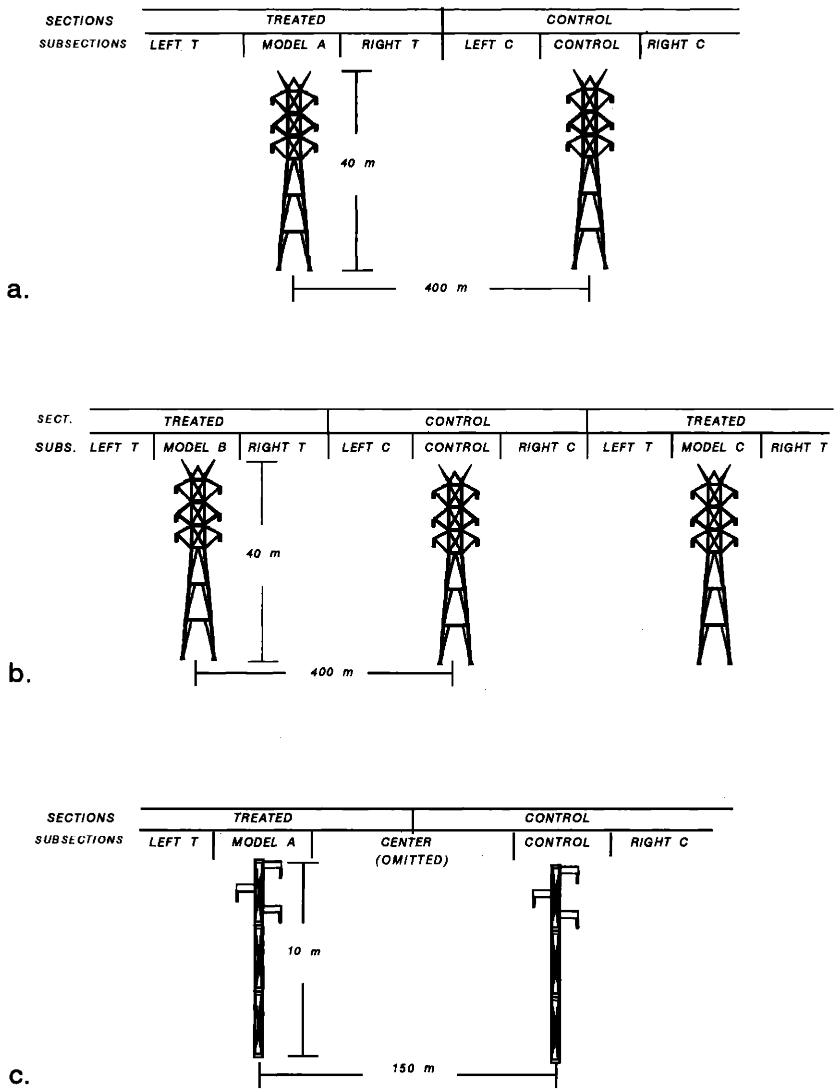

Figure 1. Experimental setting where raptor models were tested in reducing avian collisions with powerlines, (a) utility towers and study sections for model A in the migration area, (b) utility towers and study sections for models B and C in the migration area, and (c) powerpoles and study sections for model A in the resident area.

RESULTS

Model A in Migration Area. During 120 hr of observations, we recorded 466 flocks (2738 individuals) of 30 bird species that came within 100 m of the powerline sections (Table 1, Appendix 1). Number of flocks observed did not differ by subsections ($\chi^2 = 0.98$, df $= 1$, $P = 0.322$); however, species composition did differ by section ($\chi^2 = 119.00$, df $= 4$, $P < 0.001$). At sections where models were installed 41.9% of the birds observed were raptors (119 records) while, at sections without models, raptors represented only 20.9% of the birds observed (43 records). Flocks also used the second and third flight altitude categories (20–60 and >60 m) more frequently ($\chi^2 = 11.66$, df $= 2$, $P = 0.003$) at sections that were equipped with raptor models. All taxonomic groups tended to be more frequent in higher altitude levels, but this was not significant. Only Griffon Vultures (*Gyps fulvus*) were observed more frequently at flight level

Table 1. Number of flocks per taxonomic groups within 100 m of subsection of powerline tested. Flocks in lateral subsections (left and right) were summed (Lat A, B, C indicate the numbers in lateral subsections of models A, B and C, respectively; Lat X indicates the numbers in the lateral subsections of corresponding control sections). Species per group are indicated in Appendix 1.

MIGRATION AREA	MODEL A	LAT A	CONTROL	LAT X		
Ciconiiformes	20	34	15	14		
Vultures	10	14	19	24		
Raptors	79	40	19	19		
Gulls	3	5	1	0		
Other birds	31	36	20	34		
Passerines	3	9	10	4		
Corvids	0	0	1	2		
Total	146	138	85	97		
MIGRATION AREA	MODEL B	LAT B	CONTROL	LAT X	MODEL C	LAT C
Ciconiiformes	24	47	25	32	22	18
Vultures	9	6	8	20	13	15
Raptors	17	17	23	22	49	27
Other birds	10	4	22	24	48	33
Passerines	7	2	4	8	0	3
Corvids	0	0	1	1	0	1
Total	67	76	83	107	132	97
RESIDENT AREA	MODEL A	LAT A	CONTROL	LAT X		
Ciconiiformes	45	60	17	81		
Waterfowl	22	16	6	8		
Raptors	51	13	15	10		
Lapwings	21	19	31	23		
Other birds	4	1	4	0		
Corvids	20	4	5	5		
Total	163	113	78	127		

>60 m at sections with raptor models (83.3%) compared to sections without raptor models (53.5%, $\chi^2 = 4.74$, df = 1, $P = 0.030$). The number of flocks crossing vs. those not crossing was independent of section ($\chi^2 = 1.70$, df = 1, $P = 0.161$).

In 32 cases (6.9%), birds reacted to the models. Nearly all of the reactions were by raptors (90.6%). Fifteen of these we identified as "curiosity," 10 were "attacks," six were "vocal" reactions and one was "scared off." Black Kites (*Milvus migrans*) showed the highest reaction rate (33.8% of the records), followed by the Common Buzzard (*Buteo buteo*, 16.7%). There was no relationship between the number of days since the model was installed and the number of reactions per observation session (Spearman's $r_s = -0.18$, $P = 0.463$; $N = 18$). A Common Kestrel (*Falco tinnunculus*) actually perched twice in the tower with model A installed at a lower level and it was apparently not bothered by the model.

Models B and C in Migration Area. In 124 hr of observations, we recorded 562 flocks (4062 individuals) of 24 bird species within 100 m of the sections (Table 1, Appendix 1). As in the former case, number of flocks observed did not differ by subsection (model B, $\chi^2 = 0.33$, df = 1, $P = 0.565$; model C, $\chi^2 = 0.10$, df = 1, $P = 0.756$). Flocks per taxonomic group did differ by section for both models, but no clear pattern was shown (model B, $\chi^2 = 12.01$, df = 3, $P = 0.007$; model C, $\chi^2 = 13.17$, df = 3, $P = 0.004$). The number of flocks per flight altitude category also did not differ by section (model B, $\chi^2 = 2.15$, df = 2, $P = 0.341$; model C, $\chi^2 = 5.54$, df = 2, $P = 0.063$), nor did the proportions of flocks crossing vs. not crossing powerlines (model B, $\chi^2 = 4.34$, df = 1, $P = 0.037$; model C, $\chi^2 = 3.59$, df = 1, $P = 0.058$).

We felt that birds reacted to these models in only four cases (0.7%; three toward model C and one toward model B). These reactions were recorded for two raptors and two vultures and were classified either as "changes in flight direction" (three records) or "curiosity" (one record, model C). Three of these reactions were recorded on the first 2 d after the models were installed. The fourth reaction was recorded 7 d after installation.

Birds also perched on the utility towers with the models 10 times (five times near model B and five times near model C). These were kestrels (*Falco tinnunculus* and *F. naumanni*), Short-toed Eagles (*Circaetus gallicus*) and a Spanish Starling (*Sturnus unicolor*).

Model A in Resident Area. In 98 hr of observations, we recorded 481 flocks comprising 1288 individuals of 31 bird species (Table 1). The number of flocks observed varied between subsections ($\chi^2 = 22.14$, df = 1, $P = 0.001$). Over 33% of the observations were made at subsections with raptor models, while only 16.2% were recorded near control subsections. The number of flocks per taxonomic group also varied by section ($\chi^2 = 25.93$, df = 5, $P < 0.001$). Waterfowl, raptors and corvids were more often recorded near treated sections (13.8%, 23.2% and 8.7%, respectively) than near control sections (6.8%, 12.2% and 4.9%, respectively). Number of flocks was independent of altitude category ($\chi^2 = 5.34$, df = 1, $P = 0.021$). Flocks crossing vs. not crossing over powerlines was also independent of section ($\chi^2 = 1.74$, df = 1, $P = 0.187$).

In 59 cases (8.6%), we felt that a bird reacted to models. These reactions were mainly out of "curiosity" (21 records) but 19 birds were "scared off," 13 birds "attacked," and six showed "vocal reactions." Raptors seemed most curious or aggressive while waterfowl and storks were scared off by the model. Black Kites were recorded only four times near the structures equipped with models and in all of the cases the kite attacked model A. Marsh Harriers (*Circus aeruginosus*) approached model A 71.1% ($N = 31$) of the time it was observed. Both kites and harriers breed in the area. The Grey Heron (*Ardea cinerea*) was most frequently "scared off" (9.8%). Again, no correlation was found between the number of reactions and the days passed after the model was installed (Spearman's $r_s = -0.43$, $P = 0.086$, $N = 17$).

DISCUSSION

We found that the installation of raptor models on utility structures in Spain had no effect on decreasing the number of flocks or the types of birds that came near powerlines. Neither did we find that the number of birds in the highest flight altitude category increased over sections equipped with raptor models nor that there were fewer flocks that crossed over treated sections.

In general, raptors were responsible for the differences that we found. The eagle model (model A) had more effect on bird behavior (although not the intended effects) than the *Accipiter* silhouettes. This suggested that models designed to deter birds from approaching powerlines need to be as real as possible. Visible reactions toward the models such as attacks, curiosity or being scared off occurred only 10% of the time. Resident raptor species were more persistent in attacking models. Black Kites and Marsh Harriers had high reaction rates and we did not observe an accommodation toward the models. Although raptors are seldom recorded as collision casualties (Olendorff et al. 1981, Olendorff and Lehman 1986, Bevanger 1994), their reactions to the models suggested that models should not be used to deter raptors near powerlines because the possibility of collisions could actually increase. Based on our results, we concluded that the raptor models we tested would not reduce avian collisions with powerlines. None of the models had a significant effect in scaring off birds and, in the case of raptors, models even attracted birds toward the power structures.

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Appendix 1. Species observed in each taxonomic group for all experiments.

TAXONOMIC GROUPS	SPECIES
Ciconiiformes	*Ardea cinerea; Bubulcus ibis; Ciconia ciconia; Egretta garzetta; Platalea leucorodia*
Waterfowl	*Anas clypeata; Anas platyrhynchos; Anser anser; Himantopus himantopus; Limosa limosa; Numenius arquata; Tringa totanus*
Vultures	*Gyps fulvus*
Raptors	*Accipiter nisus; Athene noctua; Buteo buteo; Circus aeruginosus; Circus cyaneus; Circus pygargus; Circaetus gallicus; Falco naumanni; Falco peregrinus; Falco tinnunculus; Hieraaetus pennatus; Milvus migrans; Milvus milvus; Neophron percnopterus*
Lapwings	*Vanellus vanellus*
Gulls	*Larus cachinnans*
Other birds	*Apus apus; Apus caffer; Coccothraustes coccothraustes; Columba livia; Columba palumbus; Delichon urbica; Hirundo rustica; Lanius senator; Merops apiaster; Streptopelia turtur; Upupa epops*
Passerines	*Alauda arvensis; Carduelis cannabina; Carduelis carduelis; Galerida cristata; Miliaria calandra; Saxicola torquata; Sturnus unicolor; Sylvia melanocephala; Turdus merula*
Corvids	*Corvus corax; Corvus corone corone*