

EFFECTS OF POWER LINES ON A WHITE STORK *CICONIA CICONIA* POPULATION IN CENTRAL SPAIN

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SUMMARY.—*Effects of power lines on a White Stork Ciconia ciconia population in central Spain.*

Aims: The aims of this article are 1) to study the effect of mortality at power lines on a White Stork population and 2) to know which are the risky factors on both collision and electrocution incidents in a humanised area.

Location: Study area was located at South-eastern Madrid (600 m a.s.l.), in Central Spain.

Methods: The area was surveyed between early December 1999 and late November 2000 to estimate monthly population of Storks presents at the study area. Twelve different power line sections and 129 steel power poles were surveyed monthly to study mortality by collision and electrocution. To control for underestimated collisioned and electrocuted casualties we calculated correction index. Correlation analysis, chi-square test, principal components analysis and logistic regression were used to test that 1) the mortality at power lines was related with population size in the area; 2) there are differences among mortality by lines type and poles type; 3) mortality by collision was related with environmental variables around power lines; and 4) environmental parameters influences electrocution risk on pylons.

Results: We found that ca. 1% present population during postbreeding migration died on powerlines and 7% population did during prebreeding migration and wintering season. Deaths were nearly anecdotal during breeding season. Collision with wires and electrocution on pylons were both associated with rubbish dumps selection as foraging habitat. Annual mortality rates of collision (3.9 birds/km) and electrocution (0.39 birds/pylon) were the highest rates never found in Spain. Mortality on power lines was a density-independent limiting factor of this White Stork population. Collisions with transmission lines were significantly higher than those with distribution lines, though our mortality rate in distribution lines was also higher than other regions. More than 70% collisions occurred in <1 km far away of the nearest rubbish dumps. Pylons of distribution lines with both elevated and horizontal conductors were the most dangerous. Selection of nearer pylons to rubbish dumps as roosting site during postbreeding and wintering season caused the highest annual electrocution rate found in Spain.

Conclusions: We conclude that White Storks mortality caused nowadays by interaction with power lines is not additional to natural mortality of the species during dangerous periods as emancipation or migration and it is compensated by use of rubbish dumps as foraging habitat in Spain which also dilute the effects of other natural mortality factors. However, deaths because of utility structures could have higher incidence on future White Storks population dynamics if availability of rubbish dumps disappeared. Preventive measurement must to be developed by power companies to prevent incidents in feeding, breeding and roosting areas. Companies would also prevent possible outages following incidents eliminating or marking wires <1 km away to rubbish dumps, to prevent collision incidents, and insulating or changing the design of pylons with elevated and horizontal conductors <2 km away to dumps.

Key words: White Stork, *Ciconia ciconia*, population, collision, electrocution, powerlines

RESUMEN.—*Efectos de los tendidos eléctricos sobre una población de Cigüeña Blanca Ciconia ciconia en la España central.*

Objetivos: Los objetivos de este trabajo son 1) estudiar el efecto de la mortalidad producida por tendidos eléctricos en una población de Cigüeña blanca y 2) conocer cuales son los factores de riesgo de colisiones y electrocuciones en un área humanizada.

Localidad: El estudio se llevó a cabo en el suroeste de Madrid (600 m s.n.m.) en el centro de España.

Métodos: Se realizaron itinerarios mensuales durante el periodo comprendido entre diciembre de 1999 y noviembre de 2000 para estimar la población de cigüeñas presente en el área de estudio. Paralelamente, se muestrearon mensualmente 12 tramos de líneas eléctricas y 129 apoyos del tendido para estimar la mortalidad por colisión y electrocución. Con el objeto de no subestimar el número de bajas se han aplicado índices de co-

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rección. Se han utilizado análisis de correlación simple, test de la chi-cuadrado, análisis de componentes principales y regresión logística para comprobar que 1) hay relación entre la mortalidad producida por tendidos eléctricos y el volumen de población presente en un área; 2) existen diferencias en la mortalidad producida según tipos de tendidos eléctricos y tipos de apoyos; 3) la mortalidad por colisión se relaciona con las variables ambientales en el entorno de los tendidos donde se produce; y 4) los parámetros ambientales influyen en el riesgo de electrocución de los apoyos del tendido eléctrico.

Resultados: Las líneas eléctricas ocasionaron la muerte de al menos el 1% de la población durante la migración postnupcial y del 7% de las cigüeñas presentes durante la migración prenupcial y la invernada, mientras que durante la reproducción las muertes por esta causa fueron anecdóticas. Tanto las colisiones contra los conductores como las electrocuciones sobre apoyos eléctricos se asociaron a la selección de los basureros como hábitat de alimentación, encontrando los índices de mortalidad anual más altos de España (3,9 cigüeñas/km de línea y 0,39 cigüeñas/apoyo de tendido). Las colisiones contra las líneas de transporte de electricidad fueron significativamente más elevadas que contra los tendidos de distribución, aunque el índice de mortalidad para estas últimas líneas fue también más alto que el encontrado en otras regiones. Más del 70% de estos incidentes se produjeron en un radio de menos de 1 km de basureros de poblaciones humanas. La electrocución se produjo sobre todo en apoyos con aisladores rígidos o en cadena de amarre usados como dormitorios en el entorno de los basureros durante la migración postnupcial y la invernada.

Conclusiones Concluimos que actualmente la mortalidad de Cigüeñas Blancas asociada a tendidos eléctricos no es aditiva a la mortalidad natural de la especie durante periodos críticos como la emancipación o la migración, siendo compensada por la alimentación en basureros. Sin embargo, esta mortalidad podría ser importante en el futuro si desaparece la disponibilidad de estos medios. Las compañías eléctricas deberían desarrollar medidas preventivas para reducir los incidentes mortales y los cortes del suministro eléctrico sustituyendo o eliminando los cables del tendido en un radio de 1 km en torno a los basureros y aislando o sustituyendo el diseño de los apoyos con aisladores rígidos o en cadena de amarre situados en un radio de 2 km.

Palabras clave: Cigüeña Blanca, *Ciconia ciconia*, población, colisión, electrocución, tendidos eléctricos.

INTRODUCTION

Mortality on power lines results in the deaths of thousands of birds in the world each year and it is a conservation problem for many bird species (Janss, 2000). Electrocution on pylons appears to be the major cause of casualties, but collisions with wires also cause many bird deaths (Bevanger, 1998; Bevanger & Broseth, 2001; Janss, 2000). Both electrocutions and collisions are also a problem for the energy supply authorities due to possible outages following incidents (Bevanger & Broseth, 2001). The design of power lines and pylons are related with the risk of death from electrocution, being especially dangerous metal pylons (see Janss, 2000 for a review). Moreover, bad weather conditions and poor visibility increase the possibility of collision and electrocution accidents (Renssen *et al.*, 1975; APLIC, 1994, 1996).

Studies evaluating the impacts of casualties caused by power lines are most often conducted by means of systematic searches under wires and pylons (Bevanger, 1999). However, the evaluation of the effects on bird populations has not been carried out due to the lack of demographic data concerning wild populations (Bevanger, 1998, 1999).

The White Stork *Ciconia ciconia* is a suitable species to investigate the effects of power lines on population dynamics. Storks are common victims of both electrocution and collision (Riegel & Winkel, 1971; Oatley & Rammensmayer, 1988) because they perch on elevated sites, such as pylons, for both breeding and roosting. Furthermore, they are flocky ground feeders and are often exposed to risk by daily flock movements between feeding and breeding or roosting areas (Schierer, 1987; Janss, 2000). Mortality because of power lines on White Storks in Spain seems to be concentrated in postbreeding migration affecting both local and migrating populations (Gómez-Manzaneque, 1995; Gómez-Manzaneque & Cantos, 1995). These authors found that 57% ringed storks electrocuted in Spain had European origin.

The aims of this paper are 1) to study the effect of mortality by power lines on a White Stork population and 2) to know which are the risk factors on both collision and electrocution incidents at a humanised area in Central Spain, where the population has increased 170% during last ten years (SEO/BirdLife, 1994; Fernández-Cruz & Garrido, 2001).

MATERIAL AND METHODS

The study area is located at South-eastern Madrid (600 m a.s.l.), in Central Spain. This area concentrated 436 breeding pairs of White Storks during the study period (Fernández-Cruz & Garrido, 2001). Native Mediterranean forest (*Quercus* spp.) has been deeply transformed into intensified dry and irrigation farming crops, grazing lands for cattle and intensive gravel extraction. There were also three major human rubbish dumps in the area including the one serving Madrid City. Storks selected rubbish dumps as main foraging habitat throughout the year, concentrating important both migrating and wintering populations (Fernández-Cruz & Garrido, 2001) The climate is Mediterranean, with an average annual temperature of 13-15°C, warm and dry summers, and low precipitation (450-600 mm) (Nicolas *et al.*, 1979).

The area was surveyed between early December 1999 and late November 2000 to estimate monthly population presents at the study area by using two established transects according to the dispersal of storks from the roosting and breeding sites. The total length of survey routes was 348 km. Transects were driven by car and carried out once a month, during early morning and late afternoon, in accordance with

periods of maximum feeding activity. This method underestimates White Stork population during breeding season (February to June) because breeding pairs take turns to look after eggs and chicks at the nest and only one adult fly to the foraging sites. Due to this fact, we have estimated population size as the number of breeding pairs in the study area (436 pairs, 872 individuals; Fernández-Cruz & Garrido, 2001).

Twelve different power line sections were surveyed monthly at the study area (25.7 km): 19.8 km were distribution lines and 5.9 km were transmission lines with earth wire. All sections were situated in potential foraging habitats of storks and close to breeding and roosting sites. To study collision mortality, during the surveys a zone of 50 m wide centered along the power line was covered by two people, one by side of line (Bevanger, 1999). The base of 129 steel power poles (73 with suspended insulators, 49 with horizontal ones and seven with elevated ones, Fig. 1) was checked for electrocution casualties within a 15 m radio according to Bevanger (1999). Dead storks were collected monthly for preventing duplication of data on subsequent searches. To control for underestimated collided casualties we calculated a correction index according to Bevanger (1999). This index estimates the real number of mortalities (RNM) according to the observed

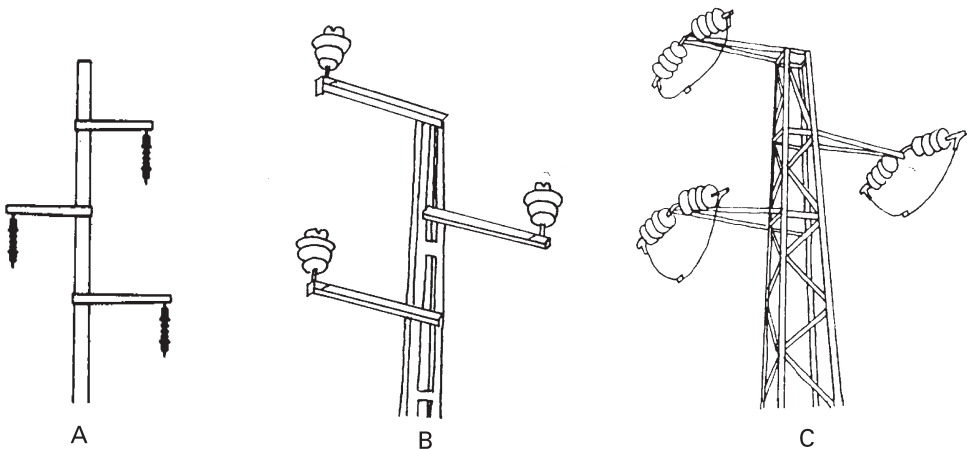


FIG. 1.—Types of power poles: A, pole with suspended conductors; B, pole with elevated conductors; C, pole with horizontal conductors (from Ferrer, 1996).

[Tipos de apoyos eléctricos: A, apoyo con aisladores suspendidos; B, apoyo con aisladores rígidos; C, apoyo con aisladores en cadena de amarre (extraído de Ferrer, 1996).]

number of mortalities (ONM) and its is calculated by the expression $RNM = [1/(pob \times pnb \times pp \times pdb)] \times ONM$, where *pob* is the proportion of observed dead birds according to a previous experiment of artificial placing of dead birds; *pnb* is the proportion of non-eliminated dead birds by scavengers according to a previous study of elimination; *pp* is the proportion of suitable area to be prospected; and *pdb* is the proportion of located collided storks in the prospected area. We calculated RNM, *pob*, *pnb* and *pp* monthly by surveyed sections. We considered *pdb* as the highest value (75%) according to Alonso & Alonso (1999a), to avoid overestimation of the real number of mortalities. We calculated monthly RNM/km of power line, which is the most suitable index to estimate the real importance of collision mortality (Bevanger, 1999).

Similarly, according to Bevanger (1999), in electrocutions studies $RNM = 1/(pnb) \times ONM$. We calculated monthly *pnb* and annual *pnb* was equal to one; so, ONM indicated the actual number of mortalities. We calculated monthly RNM/pylon, which is the most suitable index to estimate the actual importance of electrocution mortality (Bevanger, 1999).

We correlated monthly electrocuted storks, monthly collided ones and total dead ones with monthly population of White Storks present in the study area by means of Pearson correlation. We transformed our data according to Fowler & Cohen (1993) because of their non-normal distribution.

Chi-square tests were performed to analysed differences between classes (lines type and poles type) according to Fowler & Cohen (1993).

We considered nine environmental variables about power line sections to characterise mortality by collision: TH, mean trees height (m) in a 50 m circle around the power section; TC, percentage of surface covered by trees in a 50 m circle around the power line section; RBD, central distance (km) of power line section to the nearest rubbish dump; WTD, central distance (km) of power line section to the nearest wetland; FD, central distance (km) of power line section to the nearest foraging site non-rubbish dump and non-wetland; FRD, central distance (km) of power line section to the nearest forest; RD, central distance (km) of power line section to the nearest river; ND, central

distance (km) of power line section to the nearest nesting site; RSD, central distance (km) of power line section to the nearest roosting site. We performed a Principal Components Analysis (PCA) after varimax rotation of the components to reduce redundancy of these variables. We correlated the principal components with collisions (RNM/km) throughout the year by power line section by means of Pearson correlation (Abraira & Pérez de Vargas, 1996). The data were transformed according to Fowler & Cohen (1993).

We used forward stepwise logistic regression model with removal testing based on the probability of the Wald statistic (Hosmer & Lemeshow, 1989) to determine the effects of environmental parameters on the electrocution risk on pylons. We considered presence or absence of electrocutions as dependent variable and variables listed in Table 1 as independent ones. Finally, we also observed the efficiency of bird deterrents observed at sampled pylons.

RESULTS

Monthly numbers of White Storks feeding in the study area and mortality on power lines are summarised in Table 2. Seasonal changes in stork abundance clearly reflect dispersal and postbreeding migration. Numbers increased progressively showing a peak in August and then a sharply decline. Numbers stabilised during the autumn and winter, corresponding to local and foreigner wintering population. Numbers were also lower in spring, during the breeding season, increasing after June likely due to juveniles. We estimated 101 collided storks and located 51 electrocuted ones through the year. Number of casualties was not related to the number of storks in the study area ($r = -0.13$, $P > 0.05$, $n = 12$ months), either by collision ($r = 0.43$, $P > 0.05$, $n = 12$ months) either by electrocution ($r = -0.37$, $P > 0.05$, $n = 12$ months). Mortality was concentrated both during peak of postbreeding migration (July-August) and during wintering season and prebreeding migration (October-February). However, ca. 1% of present storks died during postbreeding migration, while 5-7% population did during winter (Table 2). Mortality was nearly anecdotal during breeding season (February-June).

TABLE 1

Independent variables used in the logistic regression model to study electrocutions on pylons.
 [Variables independientes utilizadas en el modelo de regresión logística para estudiar la electrocución en apoyos eléctricos.]

Definition [Definición]
Electrocution risk of pylon, considering dangerous poles those with horizontal and elevated conductors and non-dangerous ones those with suspended conductors (Ferrer, 1996) (see Fig. 1) [Apoyos con riesgo de electrocución, considerando apoyos peligrosos aquellos con aisladores en cadena de amarre o rígidos, y no peligrosos aquellos con aisladores suspendidos (Ferrer, 1996) (ver Fig. 1)]
Stork's nest present or absent on pylon [Presencia o ausencia de nidos de Cigüeñas en los apoyos]
Mean trees height (m) in a 50 m circle around the pylon [Altura media de los árboles en un radio de 50 m alrededor del apoyo]
% of surface covered by trees in a 50 m circle around the power section [% de superficie cubierta por árboles en un radio de 50 m alrededor de la línea eléctrica]
Distance (km) to the nearest rubbish dump [Distancia (km) al basurero más cercano]
Distance (km) to the nearest wetland [Distancia (km) a la zona húmeda más cercana]
Distance (km) to the nearest foraging site non-rubbish dump and non-wetland [Distancia (km) al lugar más cercano de búsqueda de alimento que no sea un basurero o una zona húmeda]
Distance (km) to the nearest forest [Distancia (km) al bosque más cercano]
Distance (km) to the nearest river [Distancia (km) al río más cercano]

Collision with power lines

We estimated 3.9 annual collided Storks/km line. During the year of study mortality was significantly higher in transmission lines (8.1 Storks/km) than in distribution ones (2.7 Storks/km) ($\chi^2 = 33.54$, $df = 1$, $P < 0.001$). However, deaths were concentrated during summer and winter, affecting principally to migrant and wintering birds (ca. 1 Stork/km by month; Table 2). During the rest of the year, casualties by collision were very low.

The PCA of environmental variables of power line sections extracted three components (Table 3). RNM/km was only related with PC 2 ($r = 0.56$, $P < 0.05$, $n = 12$ power line sections), which was loaded heavily by distance to nearest rubbish dump (RBD), distance to nearest nesting site (ND), and distance to nearest roosting site (RSD). PC 2 was related

positively with ND and RSD and negatively with RBD (Table 3). Therefore, collisions increase in power line sections close to rubbish dumps and they decrease in power line sections close to nesting and roosting sites. Also, we found that 71.3% ($n = 72$) of collisions occurred less than one Km far from nearest rubbish dump.

Electrocution on pylons

We located 51 electrocuted storks all year-round, 49 (96.1%) on distribution lines pylons. 70.6% ($n = 36$) electrocutions occurred on poles with horizontal conductors, 17.6% ($n = 9$) on poles with elevated ones and 11.8% ($n = 6$) on pylons with suspended conductors. We found electrocuted four ringed storks, one from local origin, two from Holland and one from

TABLE 2

Monthly results of foraging and breeding Storks (*) census and monthly dead storks on power lines, by both electrocution and collision, during December 1999–November 2000 in the study area (Central Spain). Percentage of monthly deaths is also shown.

[Resultados mensuales de los censos de Cigüeñas alimentándose y reproduciéndose (*) y de cigüeñas muertas por colisión y electrocución en tendidos eléctricos obtenidos durante el periodo comprendido entre diciembre de 1999 y noviembre de 2000 en el área de estudio. También se indica el porcentaje de población muerta mensual.]

	Number of Storks [Número de Cigüeñas]	Electrocuted Storks (ES)		Real number of collided Storks (RNM)		Total dead Storks by power lines [Número de Cigüeñas muertas en tendidos]	% dead population [% de la población muerta]
		Total [Total]	ES/pylon [ES/apoyo]	Total [Total]	RNM/km [RNM/km]		
December [diciembre]	612	20	0.15	23	0.89	43	7.00
January [enero]	532	5	0.04	25	0.97	30	5.64
February [febrero]	872	3	0.02	2	0.08	5	0.01
March [marzo]	872*	1	0.01	0	0.00	1	< 0.01
April [abril]	872*	1	0.01	2	0.08	3	< 0.01
May [mayo]	872*	0	0.00	0	0.00	0	0.00
June [junio]	872*	0	0.00	0	0.00	0	0.00
July [julio]	2032	5	0.04	20	0.79	25	1.23
August [agosto]	2610	1	0.01	25	1.01	26	1.00
September [septiembre]	1425	2	0.02	4	0.97	6	0.42
October [octubre]	590	7	0.05	0	0.00	7	1.19
November [noviembre]	282	6	0.05	0	0.00	6	2.13

Germany. Electrocutions were concentrated during the summer and winter, especially on December (Table 2).

We estimated 0.39 electrocuted storks per pylon during the studied year (0.60 electrocuted storks per pylon with elevated conductors, 0.58 per pylon with horizontal ones and 0.09 per pylon with suspended ones). Mortality was significantly higher than total dead storks per pylon on poles with elevated conductors ($\chi^2 =$

14.5, $df = 1$, $P < 0.001$) and with horizontal ones ($\chi^2 = 22.9$, $df = 1$, $P < 0.001$), and it was significantly lower on pylons with suspended conductors ($\chi^2 = 41.8$, $df = 1$, $P < 0.001$).

Logistic regression model did not include any environmental parameter which can explain the electrocution risk on pylons. Finally, we found five electrocuted storks (9.8%) on pylons with artificial T-perches and one (2.0%) on a pole with pointed perch deterrent.

TABLE 3

Results of the PCA on environmental variables around power line sections to characterise mortality by collision. Components loadings for principal components ones, two and three after Varimax rotation are shown (* $P < 0.001$).

[Resultados del análisis de componentes principales con rotación Varimax realizado sobre las variables ambientales medidas en torno a los tramos de líneas eléctricas muestreados para caracterizar la mortalidad por colisión (* $P < 0,001$).]

Variables [Variables]	Principal component [Componente principal]		
	Factor 1	Factor 2	Factor 3
TH	-0.845*	-0.015	-0.141
TC	-0.825*	0.304	-0.019
RBD	0.152	-0.875*	0.377
WTD	0.073	0.099	-0.931*
FD	0.414	-0.153	0.753*
FRD	0.784*	0.466	0.182
RD	0.689	0.668	-0.102
ND	0.043	0.915*	-0.172
RSD	0.193	0.812*	0.477
Explained variance [Varianza explicada]	39.1%	30.6%	15.6%
Eigenvalue [Autovalor]	3.52	2.75	1.40

DISCUSSION

White Storks mortality on power lines seems to act both on local and foreign individuals during migration and wintering season. Less than 1% breeding population was affected by collisions with power lines and electrocutions on pylons, while 1-7% migrating and wintering population died by incidents on power lines, especially on December. This mortality can be underestimated and it would have been acting on populations during the last years (Gómez-Manzanaque, 1995; Janss, 2000; Garrido *et al.*, 2001). In fact, ringed electrocuted storks found in our study area seem to show that their power lines are a sink for Spanish and foreign populations, as it happen in other parts of Spain (Gómez-Manzanaque, 1995; Gómez-Manzanaque & Cantos, 1995) and Africa (Rooyen & Ledger, 1999). Moreover, rates of collision (3.9 Storks/km) and electrocution deceases (0.39 Storks/pylon) represent the highest rates never found in Spain (2.16 Storks/km power line in Alonso & Alonso, 1999a; less 0.01 Storks/pylon in Janss & Ferrer, 1999; 0.09 birds/pylon in Janss & Ferrer, 1999; 0.20 birds/pylon in Mañosa, 2001; last two rates included rest of bird species). According to Garrido *et al.* (2001)

power lines casualties would be the main cause of death in adult and juvenile storks and they would not act selectively on population but randomly (see also Bevanger, 1999). The results of this study also show that mortality on power lines is a independent of density limiting factor for White Stork populations and it only acts significantly on migrating storks and probably local yearlings.

Our results indicate that technical characteristics of power lines are the principal factors related to accidents by both collision and electrocution. Transmission lines are especially dangerous to storks, and another birds, because they have undetectable earth wires (Ferrer, 1996; Alonso & Alonso, 1999a, 1999b; Bevanger, 1999; Bevanger & Broseth, 2001). However, in our area, mortality rate in distribution lines without earth wire (2.7 Storks/km) is also higher than in other areas (Alonso & Alonso, 1999a). Environmental parameters did not increase risk of collisions except distance to rubbish dumps. In our study area, local and migrating stork populations depended on rubbish dumps to forage due to the low availability of alternative foraging sites (Fernández-Cruz & Garrido, 2001). In such places the storks form flocks of thousands of individuals. Moreover,

storks are flockly ground feeders and are often exposed to risk of collisions by means of daily flock movements between feeding—nearly exclusively rubbish dumps, and breeding or roosting areas (Janss, 2000). Thus, flock travels to and from rubbish dumps continuously increasing the risk of collisions.

On the other hand, storks perched on pylons for breeding and roosting (Janss, 2000; Fernández-Cruz & Garrido, 2001) and electrocution risk was only affected by the kind of pylons where storks perched. Distribution lines pylons with both elevated and horizontal conductors were the most dangerous, while those of transmission lines or with suspended conductors did not affect mortality. Other studies on bird electrocution have showed similar results (Ferrer, 1996; Bevanger, 1999; Janss & Ferrer, 1999; Mañosa, 2001). Our results indicate that breeding storks nesting on pylons did not show high risk of electrocution, because ca. 25% breeding population nested on them (Fernández-Cruz & Garrido, 2001) and there were few electrocutions during breeding season (February to June). Moreover, mortality usually occurred during the beginning of reproduction. This would indicate that when storks begin to construct new nests they have more chances of touching conductors and being electrocuted. Nevertheless, old nests act as natural isolating because the presence of wood, though in rare occasions they can be burnt by electricity (Fernández-Cruz & Garrido, 2001). On the other hand, many nests are constructed on transmission lines pylons where electrocution risk is lower (Bevanger, 1999). Nonetheless, during postbreeding and wintering season storks selected pylons as roosting sites located less than 2 km far from the nearest rubbish dumps (Fernández-Cruz & Garrido, 2001). Storks perched on pylons of distribution lines with elevated and horizontal conductors had high risk of electrocution. Aggregations of storks in these roosting sites caused the highest annual electrocution rate found in Spain (Janss & Ferrer, 1999; Mañosa, 2001).

Electrocutions always are mortal accidents and birds can not learn of experience (Bevanger, 1999). Therefore, electrocutions occurred during all no-breeding period, when adult and young storks used roosting sites. Thus, electrocutions were more frequent in December because storks were more dependent of rubbish

dumps than the rest of the year, increasing the risk of perching on close power lines (Fernández-Cruz & Garrido, 2001).

On the other hand, our results seem to show that power lines affect mainly juveniles and migrants which are the individuals affected by natural mortality as well (Newton, 1998). Therefore, we can conclude that White Storks mortality caused by interaction with power lines is not additional to natural mortality during emancipation or migration. Mortality due to power lines is compensated by use of rubbish dumps as foraging habitat in Spain which also dilute the effects of other natural mortality factors (Garrido & Sarasa, 2000). In this context, actual deaths due to utility structures could have higher incidence on future White Storks population dynamics if availability of rubbish dumps disappears. Thus, preventive measurement should be developed by power companies to prevent incidents in foraging, breeding and roosting areas. To prevent possible outages following incidents, companies should eliminate or mark wires within an area of 1 km far from rubbish dumps. Pylons should be insulated or designed with elevated and horizontal conductors within an area of 2 km far from dumps. In addition, our study has demonstrated that artificial T-perches and pointed perch deterrents are not absolutely efficient methods to prevent stork electrocutions. We think that our results can be extrapolated to other humanised areas of Spain where White Stork populations are dependent of rubbish dumps as a foraging habitat.

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