Ravens, *Corvus corax* (L. 1758), nesting on high-voltage transmission line pylons in Croatia

Ivančica Jurčević Agić

Department of Biology, J.J. Strossmayer University of Osijek, Trg Lj. Gaja 6, HR-31000 Osijek, Croatia
Corresponding author : Ivančica Jurčević Agić, e-mail : ijurcevi@ffos.hr

ABSTRACT. This paper presents the first data on the occurrence of nesting of ravens *Corvus corax* on transmission line pylons in south-eastern Europe, based on research in Croatia. Field-work was carried out in the period 1995-2001, in the area of eastern Croatia. By 2001, 93 breeding pairs of ravens were nesting on pylons over the 380 km length of transmission lines under observation, comprising 14 surveyed routes. The breeding population increased over the period of seven years to a population density of 2.45 pairs per 10 km of the line, which is the highest recorded in the world, for ravens breeding on electricity pylons. Ravens breeding in eastern Croatia often leave a particular pylon and/or change the nest position on the pylon in a subsequent year. Evidence suggested that some ravens may disintegrate their nests on the pylons, after their young have fledged.

KEY WORDS : Raven, nesting, Croatia, pylons.

INTRODUCTION

Over the past 50 years, electric power-lines have been a conspicuous part of the landscape of industrialized countries. These lines and supporting structures are known to cause wildlife mortality, especially in birds, and in recent decades this has been increasingly documented throughout the world (O'NEIL, 1988; FERRER et al., 1991; BEVANGER, 1994; BROWN & DREWIEN, 1995; NEGRO & FERRER, 1995). However, data on the utilization by birds of these structures as nest supports are not as abundant (INFANTE & PERIS, 2003).

Raven breed almost throughout the west Palearctic, except in certain densely-settled and cultivated regions (CRAMP & PERRINS, 1994). The raven is typically a forest-habitat nesting species, but a new nesting mode on high-voltage pylons has appeared as a relatively recent phenomenon in Europe. The first such cases were reported in the early 1960s from the European part of Russia (BEDNORZ, 2000), in 1969 from Great Britain (RATCLIFFE, 1997), in 1970 from Germany (STEGEMANN, 1971), in 1979 from the Vojvodina province of Yugoslavia (ZAKINSZKI, 1982), and in 1981 from Poland (BEDNORZ, 2000). In Croatia the first record of a raven's nest on a transmission-line pylon was in 1988, in eastern Slavonia (J. MIKUSKA, pers. comm.). Outside Europe this way of nesting has also been reported from North America (WHITE & TANNER-WHITE, 1988; STEENHOF et al., 1993).

The only extensive investigation of raven nesting on transmission lines in Europe was carried out in Poland, NE Europe (BEDNORZ, 2000). The purpose of the study reported in this paper, carried out in SE Europe, was to precisely determine ravens' utilisation of power-line supports as nest-sites in agricultural and forested lowland of eastern Croatia, and to assess the type of poles used, breeding density and distribution patterns.

MATERIAL AND METHODS

Eastern Croatia is a lowland continental region, covering 11090 km^2, with a population density of 78.2 inhabitants per km^2. The climate is continental, with an average temperature of minus 1^{o}C in January, the coldest month, and 22^{o}C in the warmest month, July. The mean annual precipitation is 652-754 mm. The landscape of the region is predominantly agricultural, and forests cover about 30%.

The research was carried out between 1995 and 2001. Field-work started at the end of January and proceeded till the beginning of May each year with the exception of 1998. Observations were performed using 8x30 and 10x50 binoculars and a 16-48x zoom telescope, from a vehicle and on foot. A laser range-finder (Bushnell 400) was used for measuring the height of each nest above ground. Because of the specific nesting mode on the high-voltage pylons, the line transect method (BIBBY et al., 1993) was applied instead of the standard census method of counting. Transect routes followed the existing transmission lines in the study area. Based on a map of existing power-lines supplied by the utility company in the region, transects were made on 23 transmission lines in the major part of the region. However, because of damage to some of these lines incurred during the Homeland War, complete data were available from the utility company for only 14 of these lines. Thus, although additional data on nesting were obtained, only those results that pertain to those lines for which all necessary information was available, were used for statistical calculations. Pylons are made of reinforced concrete along one of the transmission lines, while the pylons of the remaining 22 power lines are a steel-latticed type. In the base of every pylon is an identification tag with the name of the transmission line and ordinal number of the pylon. Thus, every raven nest was given its own 'address and home number', which was useful for the field-research.

Since calculated variables did not indicate normal distribution (TRIOLA, 1989), the relationship between nesting pairs of ravens and transmission line pylon types was analysed using statistical data analyses according Kruskal-Wallis test (HEATH, 1995).

RESULTS

In the first year of study (1995), 30 breeding pairs of ravens were found along 190 km of transmission lines. Total length of the regularly observed lines increased in the successive years, as did the number of ravens' nests that I found. In 1996, 61 breeding pairs were noted over 320 km of line, in 1997, 73 pairs over 330 km of line, and in 1999, 74 pairs over 330 km of line. Raven nests were not counted in 1998. In the breeding season of 2000, only a third of the regularly observed transmission line routes were checked. Thus, the low number of nests recorded in 2000 (29) cannot be interpreted as a decrease in the breeding population. In the last year of study 93 breeding pairs were found on a total of 380 km of power lines in eastern Croatia (Table 1).

During the seven-year study period (observations made in six of those years), raven nests were found on pylons of 23 power lines in the study area. Ravens nested on five different pylon types (Fig. 1). The majority of the nests (71.74%) were built on the type B, which is the commonest type in the area. They were followed by the type C (15.45% of the nests), type D (10.16%), type A (2.43%) and type E (0.22%). The pylons of A, B and C type have three consoles, while type E has two consoles in the upper part of the pylon. With regard to the console on which the raven pair built the nest, upper, middle and lower positions were distinguished. During the study period, ¾ of the nests were built on the upper position of the pylons, while ¼ was built on other positions. Pylons of type D have no consoles, and the nests were built on one or the other side of the crosswise beam. Orientation of the nest was classified as 'southern' or 'northern' with regard to the cardinal point where the settled side of the beam was directed. The majority of the nests (69.57%) were built on the north side of crosswise beams.

Density of raven nesting on transmission lines in the study area ranged from 1.58 pairs per 10 km of line (1995) to 2.60 pairs (2000). Only lines that were surveyed completely (from the first to the last pylon) have been included in density calculations. The breeding density and population size increased from year to year (Table 1).

Only 14 years passed from the appearance of the first raven nest on a transmission line pylon (1988 year - J.MIKUSKA, pers.comm.) to the time when numerical stability was reached (93 pairs in 2001 year). The mean population density over the whole period is 2.16 pairs per 10 km of the line (Table 1), i.e. raven nests were, on average, situated on every 5 km of the line. Although the density of breeding pairs of ravens was higher on medium-voltage transmission lines than on high-voltage lines (Table 2, comparing only pylon type B), the difference was not statistically significant (Kruskal-Wallis test : $H = 4.551$; $p > 0.05$).

The height of occupied pylons ranged from 24.60 m to 36.55 m, mean of 28.71m. The height of raven nests on pylons ranged from 18.57 m to 30.10 m, mean of 24.74 m. Ravens built their nests at from 69% to 91% of the pylon's height, at 85.55% on average.

Ravens breeding in eastern Croatia often abandoned the pylon, and/or changed the nest position on the pylon in the next year. Ravens moved from one to the first nearby pylon in 66% of cases, two pylons further in about 25%, and three pylons further in 8% of cases (Fig. 2). Removal to the fourth pylon away was noticed only once. Among 212 pylons settled by ravens, during the study period 50% were occupied only in one year. Only 2.8% of raven pairs nested on the same pylon each year over the whole six-year period. Thus, ravens nesting on electricity pylons in eastern Croatia are not faithful to one, chosen pylon.

An observation in May 2000 suggested that ravens may destroy their nests on the transmission line pylons. About a week after the young birds had left the nest, an adult raven was seen holding a twig in the beak beside the nest remains (J. MIKUSKA, pers. comm.). In 2001 I checked a few more transmission lines where raven nestings had been reliably confirmed in the previous year. I found no nests nor nest remains. A week later, while observing the same power lines, I found three current year nests, two of which were already completed. The Croatian Electricity Company affirmed that neither protection nor renovation work had been done on those pylons in the investigated period, so human intervention was not responsible for the nest destruction. Although the study area is open agricultural landscape, there are no strong autumnal or winter winds that might have caused the nest disappearance. Further investigations of this phenomenon are needed.

TABLE 1

Distribution of raven nests on different types of transmission-line pylons in eastern Croatia during the period 1995-2001 (no data for 1998).

Year	No. of controlled lines	Length of controlled lines (km)	No. of breeding pairs	Total No. of pylons	Frequency of occupied pylons (%)	No. of breeding pairs /10 km of the line
1995	6	189.98	30	578	5.19	1.58
1996	10	320.41	61	941	6.48	1.90
1997	11	330.89	73	972	7.51	2.21
1999	11	330.89	74	972	7.91	2.24
2000	3	111.49	29	327	8.88	2.60
2001	14	380.24	93	1,143	8.33	2.45
					7.30 = Avg	2.16 = Avg

TABLE 2

Distribution of raven breeding population on electricity pylons in eastern Croatia during the 1995-2001 period (no data for 1998).

Pylons type	Voltage (kV)	Avg No. of pairs	Total No. of pylons	Frequency of occupied pylons (%)	Length of line (km)	Avg No. of pairs /10 km of the line
A	110	2.2	102	2.16	31.46	0.7
B	220 110 35	6.50 6.73 2.87	65 687 158	10 7.82 7.58	26.35 232.21 43.14	2.47 2.77 2.53
C	2x110	11.5	131	8.78	47.08	2.54

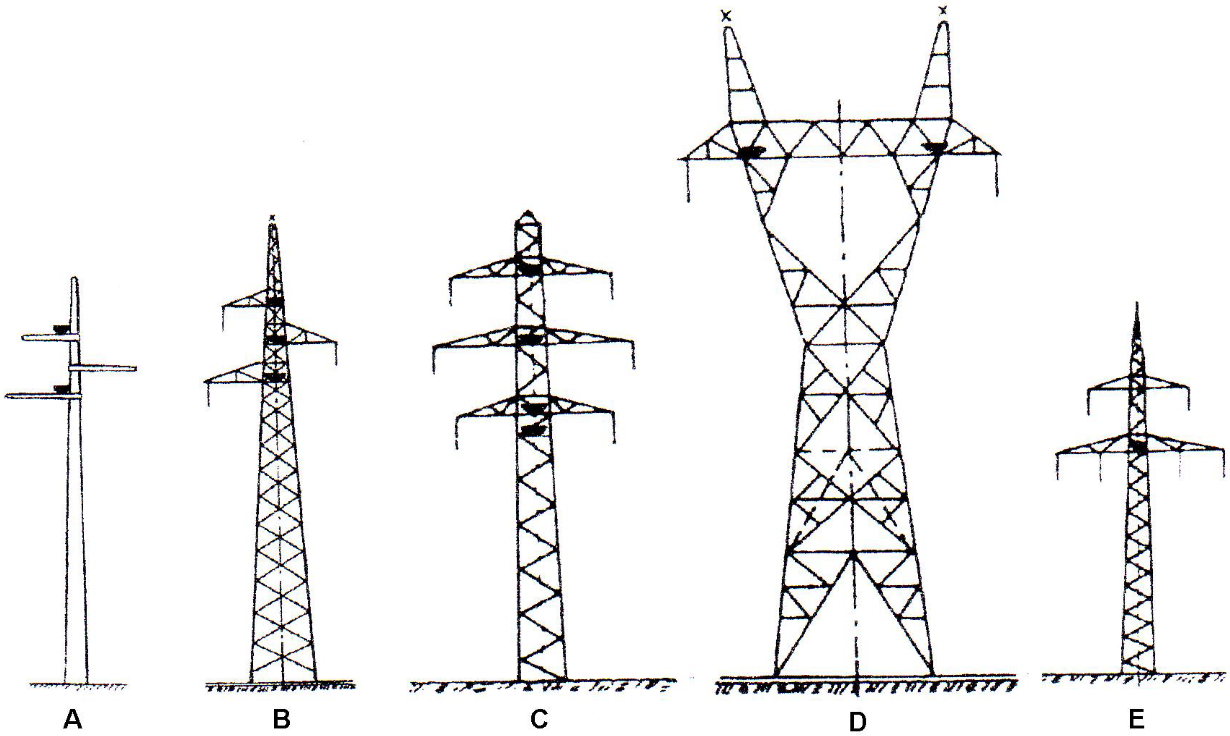

Fig. 1. – Types of pylons with raven nests, and nest location sites on the pylons in eastern Croatia over the period 1995-2001.

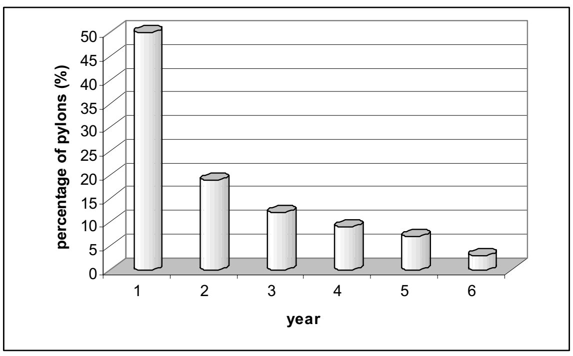

Fig. 2. – Percentage of pylons occupied for a given number of years during the period 1995-2001 (no data for 1998).

DISCUSSION

Infrastructural objects with linear direction, such as highways, power transmission lines or railway tracks, modify ecosystems, whether through simple habitat conversion or through the creation of habitat edge, resulting in either population declines or increases (KNIGHT et al., 1995). Although these energy and transportation conveyance systems are commonplace in the world, their impacts on vertebrate populations are poorly understood (KNIGHT & KAWASHIMA, 1993; STEENHOF et al., 1993; BEDNORZ, 2000). Ravens live commensally with humans, and are capable of population increases and distributional changes, responding to perturbations in the man-made landscape (KNIGHT et al., 1995).

Ravens nesting on electricity pylons in Croatia were recorded only in the eastern region. There have been no reports of this way of nesting in other regions of the country (KRALJ, 1997; LUKAČ, 1998). It has to be emphasized that under similar ecological conditions in neighbouring Hungarian steppe, a total of only 100 breeding pairs of ravens has been noticed (HARASZTHY, 1984), while my research has shown that in eastern Croatia more than 100 pairs of ravens were nesting just on transmission line pylons. Forests in this region of Croatia have their own breeding population of ravens, too.

Studies of distribution patterns of raven population nesting on rocks and trees showed that among 27 investigated European regions, high population density (17-21 pair/100 km^2) has been recorded only in three regions (NOGALES, 1994). A single North American study noted 72.6 pairs/100 km^2, which is the highest known density for the species (NOGALES, 1994). The breeding density recorded on El Hierro (35 pairs/100 km^2) is the highest in any island ecosystem and the second highest recorded anywhere in the species range (NOGALES, 1994).

The only reported data in Europe are on the average number of breeding pairs nesting on pylons in Wielkopolska region in Poland, which is 0.6 pairs per 10 km of the line (BEDNORZ, 2000). In the States of Idaho and Oregon (USA) it was on average 1.3 pairs per 10 km of the line over a 596 km long section (STEENHOF et al., 1993). The average number of raven breeding pairs on electricity pylons in eastern Croatia reached 2.45 pairs per 10 km of the line by 2001 (this study). This number is 3.6 times higher than in Poland and 1.7 times higher than in the USA, and is the highest recorded on any transmission lines within the world range of the species.

Nest distribution is significantly affected by food availability. At least 70% of the nests in Wielkopolska region were built near farms, slaughterhouses, communal waste dumps and nearby to heavy-traffic roads (BEDNORZ, 2000). Higher density of breeding ravens in eastern Croatia was also noticed near a hog-breeding farm, cattle-breeding farms and near a slaughterhouse.

KNIGHT et al. (1995) suggested that land-use patterns influence raven numbers. They found that ravens are more abundant in urban and suburban areas in irrigated farmlands, because of the greater abundance and availability of food sources. While an animal component to the diet is essential from a bioenergetics' point of view, herbaceous elements represent only complementary food sources for ravens (NOGALES & HERNANDEZ, 1994).

In contrast to literature data, ravens nesting on electricity pylons in Croatia often left the pylon in the following year and/or changed the nest position on the pylon, but the pair still remained in their breeding area. Results of observations in Wielkopolska region indicate that ravens are faithful to once-chosen pylons. Among 175 pylons occupied by the ravens in the years 1996-1998, seventy-seven (44%) were occupied for all three years, and in 66 cases the nest were built not only on the same pylon, but on exactly the same spot. In Poland the most common reason for birds leaving pylons unoccupied in a following year was disturbance caused by protection and renovation works on those pylons (BEDNORZ, 2000). The same author also mentioned five cases of occupation of the same pylon for 11 to 13 years in Poland.

Disappearance of raven nests from transmission line pylons in eastern Croatia, in conjunction with re-building in the following breeding season, is in contrast to the literature data. BIBBY et al. (1993) suggested that raven nests on trees last for a few breeding seasons. Nests are frequently re-used, often over many years (CRAMP & PERRINS, 1994). In the Berlin area in Germany, 60% of 75 nests over 10 years were new, while 40% were refurbished old ones. New nests were usually built on top of the previous year's nest (SÖMMER, 1991).

There are several possible reasons for the disappearance of nests from pylons : humans, wind or the ravens themselves. Humans and strong winds probably play only a small part in the destruction of nests on pylons. KNIGHT & KAWASHIMA (1993) found that the beams and lattice work of power-line pylons help to anchor the nest and secure it against extreme winds. Nest destruction by humans is less possible where nests are placed on pylons, than on forest trees. The most probable cause of disappearance of ravens' nests in Croatia is destruction by ravens themselves after their young have left the nest. Bird nests are rich in ectoparasites (WIMBERGER, 1984; HEEB et al., 2000), therefore building a new nest every year may lower the possibility of ectoparasites attacking the nestlings.

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