NOTE BRÈVE

THE BLACK STORK *CICONIA NIGRA* IN NORTHERN ITALY: WHICH ENVIRONMENTAL FEATURES DOES THIS SPECIES NEED TO NEST?

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RÉSUMÉ. — *La Cigogne noire* Ciconia nigra *en Italie du Nord : de quel environnement cette espèce a-t-elle besoin pour nicher ?* — Il existe un besoin général de traiter le peu de données disponibles sur les espèces rares et menacées pour obtenir des indications significatives en vue de décisions politiques les concernant. Nous présentons ici une analyse de quelques données disponibles sur les besoins écologiques de la Cigogne noire dans le nord de l'Italie, en utilisant des analyses statistiques permettant d'extraire des informations significatives sur les préférences de l'espèce. La Cigogne noire recolonise l'Italie après plus d'un demi millénaire ; nous analysons les données sur l'utilisation de l'habitat et le choix du site de nid de trois couples suivis de 1994 à 2001. Il apparaît que ces couples ne requièrent pas surtout des forêts humides et de vieux grands arbres comme cela est souvent signalé mais préfèrent (1) des grandes surfaces collinéennes boisées, (2) des zones boisées non fragmentées, (3) un riche réseau hydrographique avec beaucoup de petits cours d'eau, (4) la présence de petites zones avec de fortes pentes, comme des petites falaises et ressauts rocheux. Les nids étaient toujours situés dans les zones avec le plus dense réseau hydrographique, dans lequel les adultes ne vont pas mais où les jeunes apprennent à rechercher leur nourriture sans avoir à aller loin du nid.

Conservation ecology and landscape planning usually can deal with many data from the community level (*e.g.*, Beja & Alcazar, 2003; Benayas & de la Montana, 2003; Kitahara & Watanabe, 2003) or using well known focal and umbrella species (*e.g.*, Coppolillo *et al.*, 2004; Roberge & Angelstam 2004) but in case of endangered and/or rare species, only few data could be available (*e.g.*, Bearzi *et al.*, 2003; Lovett-Doust *et al.*, 2003; Stringer *et al.*, 2003). In addition, in recent cases of arrival or spontaneous recolonization of new areas, species ecological requirements may be different from those known in other areas.

This is the case of the Black Stork, *Ciconia nigra* (Linnaeus, 1758), which became extinct as an Italian nesting bird, probably during the Middle Age, and naturally re-established successful breeding pairs since 1994 (Bordignon, 1995, 1999). In their analysis of the potentiality of the Italian area for all vertebrate species, Boitani *et al.* (2002) based their work on the Black Stork mainly on two variables: presence of (1) wet lowland woods with

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ponds where to feed and (2) old and large trees where to nest, as it was known from the literature but from other countries. These assumptions gave a high potential for this species to areas which are not used; moreover, the actually used area in Northern Italy resulted as not really potential, i.e. pointing to a discrepancy between previous knowledge and actual requirements. It is of pivotal importance to know which environmental features the Black Stork prefers, as it is one of the species which can drive the institution of Areas of Special Protections, by the EEC directives "Birds" 79/409/CEE and 91/244/CEE. The use of money for environment conservation in relation to this species has to be based on its actual requirements. Hence, the aim of this work is to clarify the environmental features which are actually needed by this charismatic species in its nesting area in Northern Italy. Moreover, due to the lack of available data on this rare species, we used resampling statistics (Manly, 1997), which can be a useful way to bypass the problem of few data in case of need of indications for political decisions about endangered species.

MATERIALS AND METHODS

We dealt with all the data regarding the presence of the Black Stork in Northern Italy during the breeding seasons since 1994. The area chosen by this species to breed was in the hills in Northern Piedmont, between Serra di Ivrea and Lago d'Orta, for an extension of 1 200 km^2 among the provinces of Biella, Novara and Vercelli. Presence of mixed woods in the area is dominant, while rural and urban settlements are patchy.

We georeferred all the presences of the Black Stork using ArcView 3.2 as GIS software with raster regional 1:10 000 maps CTR (Carta Tecnica Regionale) and delineated the minimum polygon, which resulted in an area of 800 km^2. We highlighted the hydrographical network, and divided it in 4 groups: (1) lentic water bodies, (2) main rivers, wider than 5 m, (3) intermediate streams, between 2 and 5 m wide, and (4) small streams, less than 2 m wide. Highlighting all the contour lines, we obtained a map of the slopes. We used the classes of the CORINE Land Cover Project to analyse land use in the area.

We analysed: (i) land use during foraging and (ii) during flight activities, (iii) kind of food, (iv) nest site choice, and (v) directions of movements to and from the nest.

We used two different theoretical models to analyse the different aspects of land use by the Black Stork: one for foraging areas, and one for nest site choice. In the former case, we had 28 foraging sites, and we tested whether some kind of water body were preferentially used. We measured the total lengths of the four groups (lentic, rivers, intermediate, and small streams) inside the polygon, then we counted the number of observable traits in each group. We evaluated these values by 100 field observations randomly chosen in the area, and an observable trait was defined as about 500 m for lentic water bodies and main rivers, 1/2 for intermediate streams, and 1/5 for small streams. With these values we weighted the potentialities of the area, and we evaluated how the observed data fitted these potentialities using a chi-squared test. Because of expected values lower than 5, P-value was computed by Monte Carlo simulation with 2 000 replicates. This was done by random sampling from the set of all contingency tables with given marginals (R Development Core Team, 2004).

The models for the nest site choice were obtained in a different way: they were based on actual data from the study area. We analysed three different aspects, length of the hydrographical network, slope, and CORINE Land Cover. We dealt with measures obtained from areas inside circles around the three known nests in the area (two from Bordignon (1999) and a new nest in 2001), and we used a radius of 850 m, that was half the distance between the two nearest nests. Then we measured the same features inside 50 not overlapping circles randomly distributed in all the study area, obtained with Point Randomizer by ArcView and we used these data to obtain the parameters mean (μ) and standard deviation (σ) of the model of the potentialities offered by the area. We checked the goodness of fit to normality of the data obtained from the 50 circles with a Kolmogorov-Smirnov test (Sokal & Rohlf, 1995), and all features resulted not significantly different from a normal distribution. We grouped all the 17 categories of CORINE Land Cover present in the area in 4 groups, urban, rural, woody, and open areas, but only rural and woody groups were sufficiently present to be normally distributed.

An indirect evidence of foraging habitats could be obtained in 2001 by observation of the kind of food adults brought to the nest, and by the analysis of remains in pellets and in the nest. Another indirect evidence of land use was obtained in 2001 by the analysis of the directions followed by adults leaving or arriving to the nest. Directions having a periodic distribution, the circular mean was calculated as a vector θ of length R. The vector is the mean direction and the length R expresses the dispersion from the mean: values of R near 1 indicate a distribution close to the mean, while values near 0 indicate a large dispersion of the observed directions.

We used Microsoft Excel® and R® for all the analyses.

RESULTS

Observations of the Black Stork in the study area during the breeding period started from about mid March (March 9th, 2001 the earliest one) and ended about mid August (August 29th, 1994 the latest one). During this period three nests were used (Tab. I).

TABLE I

Features of the three nesting sites of the Black Stork found in Northern Italy. Size of nest 1994 is from Bordignon (1995)

	nest 1994	nest 1997	nest 2001
Exposition	South-East	North-East	North-East
Altitude (m)	560	590	515
Position	on tree	on ground	on ground
Size (cm)	144*87	n.a.	230*170
Minimum distance in m from:			
asphalted roads	570	650	280
dirt roads	380	570	110
single buildings	400	680	1 000
urban settlements	1 500	1 300	1 600
electric lines	580	650	350
valley floor	4 100	690	250
mountain ridge	180	20	90
mountain peak	270	90	90
water body	30	90	50
nearest nest	9 100	1 760	1 760

Juveniles at the nest were fed mainly with fishes, and remains of fish bones were common in nests. Juveniles after leaving the nest used to feed also by themselves, and in the pellets produced by juveniles in this period we found remains of fishes, freshwater crayfishes *Austropotamobius pallipes*, diving beetles *Hydrous piceus*, dung beetles *Anoplotrupes stercorosus*, ground beetles, mainly *Pterostichus pedemontanus*, weevils, grasshoppers, green bugs, and spiders. Hence, not only food from water bodies, but also from dry ground.

Adults were always observed feeding in water bodies, without choosing preferentially any kind of water bodies (chi-squared test = 1.200, P = 0.769; Tab. II).

TABLE II

Expected distribution of the actual number of feeding observations of the Black Stork in different water habitats in the study area, based on different observable traits

	total length (m)	observed	expected
lentic water bodies	61 750	1	2.17
main rivers	130 691	3	4.59
intermediate streams	271 009	7	4.76
small streams	2 344 061	17	16.47

The 39 observations in flight far from the nest were not significantly related to particular habitats, and the Black Stork was observed also flying above large urban areas, as Borgomanero, Prato Sesia and Borgosesia.

Regarding nesting sites, slopes of the circles of 850 m radius around the nests were similar to those available in the area (Tab. III), but the slope of the points where the nests were localized on the ground were significantly more leaning than the slopes in the study area (nest 1997, slope 42.38°, P = 0.036; nest 2001, slope 43.37°, P = 0.030), while nest 1994, on a tree, was in a site with a non significantly different slope than the available slopes of the study area (25.08°, P = 0.396). The surface covered by woods and rural areas were similar to those available in the area too. Nests were located in areas with a dense hydrographical network, in two cases, nests 1997 and 2001, even significantly denser than the network available in the study area (Tab. III).

TABLE III

Significance of the features analysed in the circles of 850 m radius around the three nests of the Black Stork, based on the model originated from 50 randomly distributed circles in the study area. Bold numbers indicate the significant P-values, lower than 0.05

	μ	σ	nest 1994	nest 1997	nest 2001
hydrographical network (m)	8 679	3 658.9	12 871 P = 0.252	15 856 P = **0.049**	16 725 P = **0.028**
slope (°)	13.31	13.87	26.9 P = 0.72	21.8 P = 0.46	17.6 P = 0.68
rural areas (m^2)	502 053	527 546.1	254 199 P = 0.64	0 P = 0.34	0 P = 0.34
woodland (m^2)	1 216 119	573 493.8	1 426 195 P = 0.71	1 375 251 P = 0.78	1 581 431 P = 0.52

No particular direction was preferred by the Black Stork to and from the nest: the average movement was 105° 57', approximately East-South-East, but with R = 0.083, which means very scattered movements in almost all directions. No differences were evidenced, neither among periods, nor among time of the day.

DISCUSSION

While not shy during its flights, the Black Stork was very shy in the choice of both nesting sites and feeding areas, as previously known (Cramp, 1998; Jadoul, 1998). Both food remains, food brought to the juveniles, and observations of adults while feeding confirmed the preference for fishes and other animals as insects and crustaceans living in water bodies (Géroudet, 1978; Boano, 1992; Bordignon, 1995; Lorek & Tryjanowski, 1995; Görner *et al*., 1996; Cramp, 1998; Jadoul, 1998; Schneider-Jacoby, 1999; Kalocsa & Tamas, 2001; Mahieu, 2001). Foraging animals in the study area did not use preferentially any kind of water body, while in previous studies some preference was shown, either for small streams (Görner *et al*., 1996; Schneider-Jacoby, 1999), or for large water bodies such as lakes (Lorek & Tryjanowski, 1995). Juveniles started looking for food also in terrestrial habitats, as suggested by the presence of various insects in the two analysed pellets, confirming an old observation by Lopez Jurado *et al*. (1978).

As for the nesting site, our data and those from the literature suggested that nests located on the ground are larger than those on trees, as suggested by the comparisons with

data from other sources: between 130*80 cm and 130*115 cm on trees (Rodríguez De Los Santos *et al*., 1984; Dupuy, 1994) and about 200*200 cm on the ground (Rocca, 2002) (ANOVA on ellipse area of nests: $F_{1,4} = 242.29$, $p = 0.001$). All the nests in our study area were located in wide woodlands, and the absence of preferential directions supported the need for a wide woody area around the nest. The presence of a high surface of woods in all the circles suggests that un-fragmented woods are used. The preference of this species for wide and un-fragmented woodlands is already known (François *et al*., 1993; Dupuy, 1994; Görner *et al*., 1996; Libois & Jadoul, 1996; Fenyösi, 1998; Schneider-Jacoby, 1999; Mahieu, 2001; Sellis, 2001; Strazds, 2001; Rosenvald & Lõhmus, 2003), but an interesting result of our analysis is that inside the wide woodland of the study area, the Black Stork always preferred to nest in areas with a very dense hydrographical network, where surprisingly the adults were never observed. The presence of such a high density of water close to the nest may be required by the juveniles, which can find available preys without going too far from the nest during their first explorations; and we did often find juveniles feeding in these streams.

In conclusion, our analysis, based on resampling statistics approach, suggested that the Northern Italian breeding couples of the Black Stork do not chose areas with wet lowland woods and old, large trees, but (1) wide woody areas in hills, (2) un-fragmented woody areas, (3) rich hydrographical network, with many small streams, (4) presence of small areas with high slopes, like small cliffs and rock jumps.

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