Changes in density distribution of the Hooded Crow *Corvus corone cornix* and the Magpie *Pica pica* in Northern Italy

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Abstract - We describe the density distribution of breeding Hooded Crows and Magpies over 12,827 km² of planitial landscape, and we quantify the changes that have occurred since 1980. Nest were censused by means of winter roadside counts. We tested this technique by applying it to 12 sample zones where the breeding pairs had been censused during the preceding reproductive season, and we calculated a conversion index from winter nest counts to breeding densities. The breeding populations for the entire study area in 1994 increased by 107% of the 1980 population for the Hooded Crow and by 27% for the Magpie. Compared to 1980, the areas with high density of Hooded Crows in 1994 expanded north- and east-ward, while the distribution of the Magpie was similar to that in 1980. The density distributions of both corvids showed a clear structure with centers of abundance and with concentric bands of decreasing abundance, a pattern probably determined by gradients of environmental factors. However, the planitial landscape of our study area is very uniform, and there is no noticeable gradient to match the density variations between the two corvids; the variations therefore remain unexplained. The 1980 distribution patterns had suggested that predation or competition by Hooded Crows could limit Magpie distribution at a geographic scale, but the 1994 data do not confirm this hypothesis.

Introduction

We describe the density distribution of the nests of Hooded Crows *Corvus corone cornix* and of Magpies *Pica pica* in the central part of Northern Italy, and we identify the changes that have occurred since 1980, when the distribution was described, with similar methods, by Fasola and Brichetti (1983). Nest distribution was studied by means of winter roadside counts, when nests are easily spotted on leafless trees. We validate this technique, and we provide an index that converts from winter counts to nest densities during the preceding reproductive season. The research was enabled by the invaluable cooperation of 16 participants in the field surveys (see Acknowledgments). The Hooded Crow and the Magpie are highly plastic in their ecological adaptations (Rolando *et al.* 1993, Saino and Meriggi 1990), and they are widespread in northern Italy. However, their distribution is not uniform, and this unevenness is puzzling because the planitial landscape in Northern Italy is very homogeneous. We critically review the hypothesis by Fasola and Brichetti (1983) that the density distribution of the two corvids in northern Italy may be influenced by interspecific competition.

Study area and methods

We recorded Hooded Crow and Magpie nest distribution over 12,827 km², throughout the planitial part of the *Regione Lombardia* (Fig. 1). This study area is slightly smaller than the one censused by Fasola and Brichetti (1983), because some NW and SE parts of the former study area were not covered. The area is completely flat with a gentle south- and east-ward slope, it is northernly and southernly bound by the foothills of the Alps and the Appennine mountains, and it is intensively cultivated with maize, rice, wheat, poplar plantations and meadows. The landscape is uniform throughout the area, except for the local predominance of certain cultivations. Natural vegetation is scanty and mainly restricted to riversides.

Nest density was recorded by means of roadside counts conducted during the winter period; the technique was the same as that previously used by Fasola and Brichetti (1983) and by Fasola *et al.* (1985). Nest density distribution was recorded throughout the study area, from 15 November to 15 February, in the years 1993, 1994 and 1995, along a square grid of transect roads spaced approximately 10
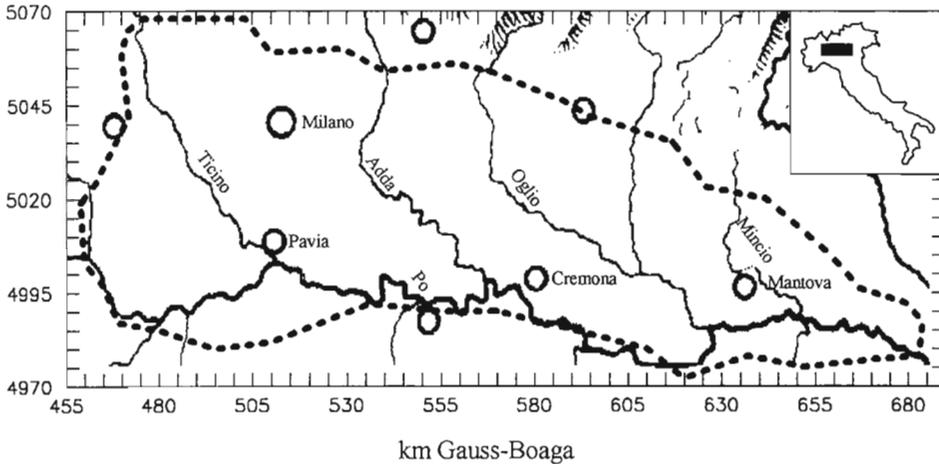
Figure 1. Study area and kilometric reference grid.

km from each other, for a total of 2,675 km of roads. The censuses were performed by 11 observers who adopted uniform techniques: driving along the survey roads, stopping every 0.5-1 km, scanning the landscape with binoculars, and marking a 100,000 scale map for all the Hooded Crow and Magpie nests identified on both sides of the road. From these maps, we calculated the number of nests per kilometer, and averaged the count for each 5 km tract of the transects. These values were converted to breeding pair densities, on the basis of the conversion index derived from the winter counts and from the estimates of the breeding densities, which were conducted in a number of sample areas (see below). To each 5 km transect, we assigned the Gauss-Boaga kilometric coordinates of its central point; from the estimated breeding pair densities, and using the graphic program SURFER, we derived the Hooded Crow and Magpie density distribution maps ("1994" maps in the Results). SURFER provides various techniques (Inverse Distance, the Kriging geostatistical technique, and Minimum Curvature) for the estimation of the distribution of a variable recorded at random points in a two-dimension space, but the output may differ greatly in relation to the technique and to the settings (Maurer 1994). We adopted Minimum Curvature, because it depicts the actual data with the least distortion, and because it is advisable when the data are evenly distributed throughout the study area, as in our case.

Again using SURFER, with exactly the same settings and over a coincident study area, we re-analyzed the nest distribution data collected by Fasola and Brichetti (1983) from 2,570 km of transect roads during the winters 1979-1982 and we derived another set of density distribution maps ("1980" maps in the

Results) to be compared with the 1994 maps.

The breeding populations for the entire study area were estimated by the measurement of the distribution maps for land surfaces with different densities (these measurements are an option provided by SURFER); by calculation of the current average density for each of these surfaces from the transect count data; by multiplication of each density by the corresponding surface, and by the summation the resulting numbers of nests.

We tested the efficacy of winter roadside censuses in the assessment of nest density by applying this technique to sample zones where pair density had been recorded during the preceding breeding season. The location of occupied and non-occupied nests was recorded on 10.000 scale maps during April and May in 1993 and in 1994, in 12 sample zones, each with surface area from 4 to 6 km², that were widely distributed throughout the study area. In December of each of the two given years, each sample zone was reassessed by another observer, who was not acquainted with the given sample zone. Each observer conducted 3-15 km of transect counts using the standard technique described above, and recorded nest locations on the 10.000 scale maps. From these repeated counts we estimated an index that converts from winter transect nest counts to breeding pair density.

Results

Validation of the winter census technique

We used the results of the winter and spring counts in the sample zones to calculate a conversion index, from the number of nests counted along the winter transects to the density of breeding pairs. This was possible only

for Hooded Crows, because Magpie density in the sample zones was too low.

A first estimate of the conversion index was obtained from the ratio "number of nests recorded along the winter transects : number of breeding pairs in spring". These two values were linearly related (r_{23}= 0.44, P<0.05), although with high residual variance (Fig. 2, which shows the values for the 12 sample zones in the 2 study years). The best-fit regression line between breeding pair density and number of nests recorded along the winter transects had a slope equal to 1.55, a value that was assumed as a first estimate for the conversion index.
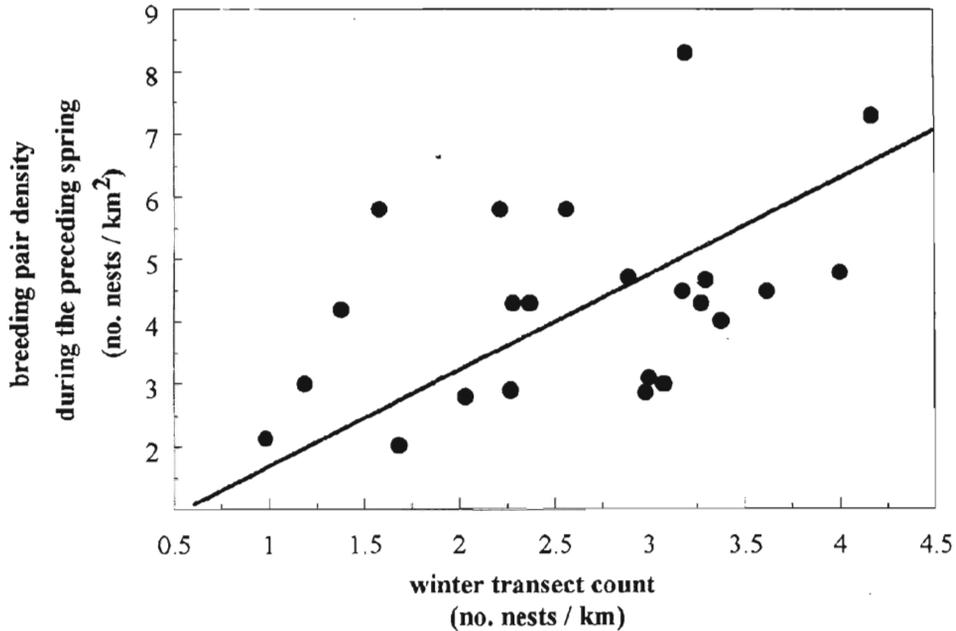
A second estimate of the index was based on the

Figure 2. Relationship between Hooded Crow breeding pair density, and number of nests counted from winter transects. The best-fit regression line is "pairs = 1.55 nests in winter".

distance of the nests from the transects. Winter nests locations were compared with those recorded in the spring. During the winter transect counts, the observers spotted 41.7% of the nests that had been recorded during the preceding spring within 300 m at both sides of the transect (Tab. 1). Another 39.7% of the spring nests were not recorded; this was due partially to the disappearance of some nests and to the falling of some trees, and partially to the overlooking of other nests. Conversely, 17.2% of the nests recorded in winter had not been spotted during the spring; most of these nests had surely been built after the peak breeding season in April and May when our breeding survey was conducted, and they were presumably attributable to late breeders or to replacement clutches. From the data in Tab. 1, we estimated a conversion index for Hooded Crows as follows:

1) the average distance of all the recorded nests from the winter transects (nests recorded at both counts, and nests recorded only in winter, Tab. 1) was 183 m,

Table 1. Correctness of nest species identification, and Hooded Crow nests recorded during the winter and the spring counts. The values are based on 1156 nests recorded in the 12 study zones.

	nests correctly attributed to their species		Hooded Crow nests (only those correctly attributed):		
	Magpie	Hooded Crow	recorded at both counts	recorded only in winter	recorded only in spring
total nests (%)	99,0	99,6	41.7	17.2	39.7
distance from transect (average in m)			229	128	159

therefore the average observation belt at both sides was 366 m

2) since in winter 39.7% of the spring nests were overlooked, but 17.2% other nests were recorded, the observation belt should be corrected to 366 *(1-0.397+0.172)= 283

3) for an effective 283-m-wide observation belt, the nest density in no./km^2 should be "no./km in winter /0.283", or "no./km in winter *3.53"

4) however, only 1 out of 2.3 of the nests present in spring had eggs or chicks, and the remaining nests were old, incomplete or non-used; therefore the conversion factor for "no. nests in winter/km of transect" into "no. breeding pairs/km^2" is 3.53/2.3= 1.54.

The conversion index deduced from the ratio "nests in winter / breeding pairs" (1.55), and that deduced from the nest distance (1.54), were both very close to the index (1.60) calculated by Fasola _et al._ (1985) with similar methods but from different data. We adopted the intermediate value, 1.55, as an index for converting the "no. nests/km in winter" into "no. breeding pair /km^2" in Hooded Crows. For the Magpie, no new

estimate was available, and we adopted the conversion index (0.80) estimated by Fasola _et al._ (1985). The lower value of the Magpie index is related to the higher number of non-occupied nests in this species; in our sample zones only 1 nest was occupied, on average, for every 3.8 nests present.

The observers correctly identified the species for over 99% of the nests in the 12 sample zones (Tab. 1). The performance of the 10 observers was measured as the ratio no. nests/km counted in winter-no. breeding pairs/km^2; no significant difference in observer performance emerged (ANOVA test based on the transects, from 3 to 8, censused by each observer in the sample zones, $F_9 = 0.28$, NS).

Density distribution

Fig. 3 and 4 depict the density distribution of the two species, as estimated from the winter counts and the conversion indexes. The maps for 1980 are in general similar, but in detail different from those produced by Fasola and Brichetti (1983), who interpolated intuitively the same density data that we have now mapped using an automatic algorhythm.
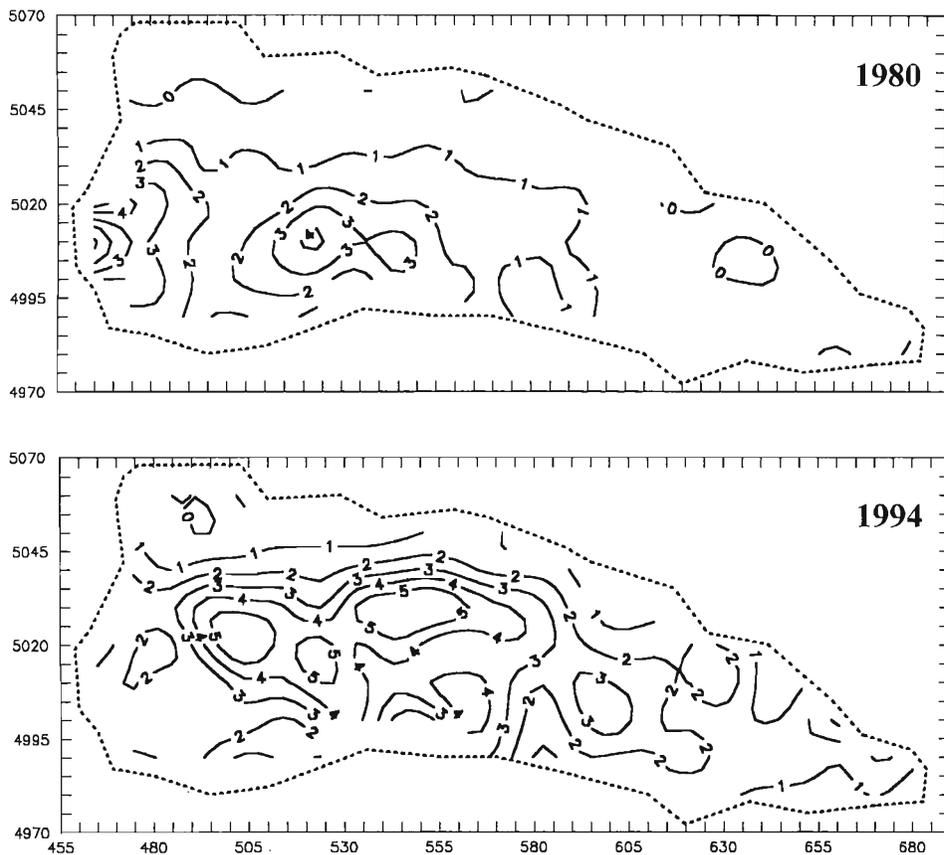

Figure 3. Hooded Crow density distribution. The isolines bound zones with density equal to or higher than a given value (no. pairs /km^2, scaled to unity).

The Hooded Crow (Fig. 3) in 1980 had its stronghold in the central and in the western parts of the study area, but at the northern and the eastern parts its density was very low or zero. In 1994, the areas of high density had expanded north- and east-ward, and only very small areas with zero density remained at the NW side of the study area.

The 1994 distribution of the Magpie (Fig. 4) was similar to that of 1980. Over most of the study area the densities were low. The boundaries of the 1994 zero density zones seem to differ greatly from those of the 1980 zones, but rather than to a real change, this is likely due to uncertain ties in the output of the graphic algorhythm when dealing with sparse presences. The zone of high density in the NW seemed to have slightly retracted in 1994, while the
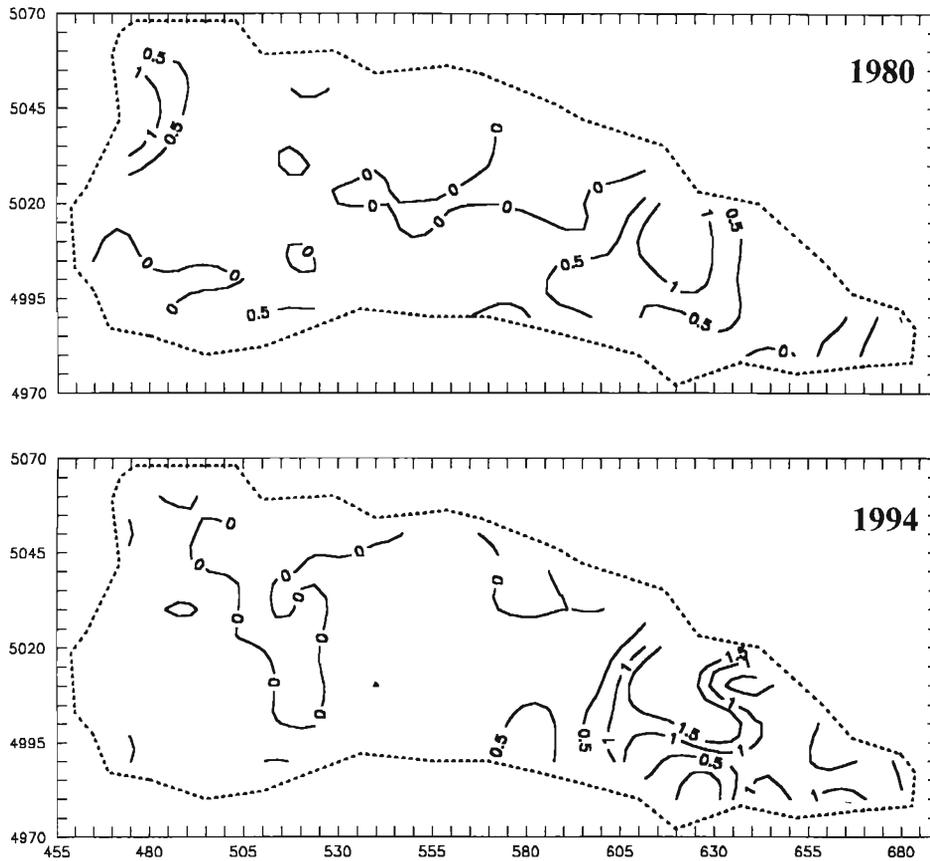

Figure 4. Magpie density distribution. The isolines bound zones with density equal to or higher than a given value (no. pairs /km², scaled to 0.5).

eastern zone of highest density had slightly expanded.

Breeding population

In comparison with the 1980 figures, the 1994 population of the two species (Tab. 2, 3) had increased by 107% for the Hooded Crow and by 27% for the Magpie, thanks to the increase in their maximum densities, and to the expansion of the surfaces with high densities around the traditional stronghold areas. The total number of individuals is certainly much higher than the number of breeders, since in our study

area only 30-40% of the Hooded Crows breed (Fasola *et al.* 1988, G. Bogliani pers. com.).

Discussion

The density distributions of both Hooded Crow and Magpie showed a clear structure with centers of abundance and with concentric bands of decreasing abundance. Such a pattern is common for the density distribution of animal species, and it is probably

Table 2. Estimate of the total breeding population of Hooded Crows for the entire study area.

	breeding pair density lower or equal to:							
	0	1	2	3	4	5	6	7
surfaces (km^2) in 1980	735	5709	3505	1727	1043	104	3	0
in 1994	81	1096	3246	3895	2041	1626	763	79
average density (pairs/km^2) in 1980		0.56	1.51	2.43	3.33	4.39	5.89	
in 1994		0.60	1.57	2.50	3.42	4.40	5.57	7.31
total number of nests in 1980				16630				
in 1994				34452				

Table 3. Estimate of the total breeding population of Magpies for the entire study area.

	breeding pair density lower or equal to:					
	0	0.5	1	1.5	2	2.5
surfaces (km^2) in 1980	1881	8347	1871	602	126	0
in 1994	1838	7856	1802	670	366	295
average density (pairs/km^2) in 1980		0.28	0.79	1.25	2.16	
in 1994		0.27	0.74	1.29	2.29	3.42
total number of nests in 1980			4885			
in 1994			6199			

determined by gradients of abiotic or biotic environmental factors. However, the planitial landscape of the study area is very uniform, and there are no noticeable habitat gradients which parallel the density variations of the two Corvids. Such variations therefore remain unexplained.

From the 1980 distribution data of Hooded Crows and Magpies in our study area, Fasola and Brichetti (1983) concluded that their partially complementary distributions could be due to their competitive or predatory interactions. Indeed, where the two species are syntopic, Magpie nests are frequently preyed upon by Hooded Crows, are placed far from Crow nests, and are located near buildings or roads presumably to limit Crow predation (Fasola et al. 1988).

However, the 1994 data do not confirm the idea that predation or competition by Hooded Crows limits Magpie distribution at geographic scale. First, the eastward expansion of the Hooded Crow in 1994 did not produce a corresponding decrease in the Magpie. Second, in 1980 the frequencies of the 5-km transects with given densities of Crows and Magpies showed a significant deviation from a random distribution, since the transects with high densities of both species were less frequent than expected (Fig. 3 in Fasola and Brichetti 1983). However, the 1994 data did not confirm this pattern, since the frequency distribution of the transects did not deviate significantly from random. It has repeatedly been confirmed that competition is pervasive in assemblages of similar species (Schoener 1983, Gurevitch et al. 1992), but Wiens (1989) warned that we should be cautious in adopting the "MacArthurian paradigm" that competition is a major determinant of species distribution at geographical scale.

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