The spatial pattern of the black-billed magpie, *Pica pica*, contribution to predation risk on dummy nests

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A b s t r a c t. A three-year experimental study with artificial ground nests was carried out in a highly fragmented agricultural landscape in Southern Bohemia, Czech Republic, to examine whether population density or spatial distribution of active black-billed magpie (*Pica pica*) nests contributes to the pattern of predation on dummy nests. Out of the total of 335 dummy nests with a known fate, predators robbed 126 (37.6%). The population density of magpies did not affect nest predation significantly, while nests placed closer to active magpie nests were predated significantly more than distant nests in two out of the three years under study. Moreover, the distance to the nearest active magpie nest was found to be the most obvious factor affecting nest predation risk, among such factors as site, individual nest position, habitat type, distance to the nearest forest fragment, habitat diversity, nest concealment, distance to the nearest line habitat, and distance to a perch for avian predators. The study suggests that the spatial pattern of a dominant generalist predator can be a factor explaining the predation pattern on experimentally treated nests.

Introduction

Predation studies with real and artificial ground-nests demonstrate that predation pressure is generally high in landscapes with a substantial proportion of farmland (A n d r é n & A n g e l s t a m 1988, B a y n e & H o b s o n 1997). The diversity of predators, namely generalists such as corvids, is of great importance and increases as a forest landscape becomes proportionally balanced with open fields (A n d r é n 1992, H u h t a et al. 1996). The nest predation rate may be strengthened by higher fragmentation, edge proximity (G a t e s & G y s e l 1978, A n d r é n & A n g e l s t a m 1988, M a r t i n 1988, S m a l l & H u n t e r 1988, B u r g e r et al. 1994, S ö d e r s t r ö m et al. 1998, H u h t a et al. 1996) or availability of perches for avian predators (B e r g et al. 1992, V a l k a m a et al. 1999, S ö d e r s t r ö m et al. 1998). Nest visibility and height above the ground are also considered as relevant factors (M a r t i n & R o p e r 1988, W e i d i n g e r 2001) particularly in some types of habitat or for specific habitat structures (P i c m a n 1988, Y a h n e r et al. 1989, P a s i t s c h n i a k - A r t s & M e s s i e r 1996, P e s c a d o r & P e r i s 2001).

As S ö d e r s t r ö m et al. (1998) suggested, it is crucial also to identify the actual nest predator species in order to reach a deeper understanding of spatial variation in nest predation risk (see also A n d r é n 1992, V i c k e r y et al. 1992, O p e r m a n i s et al. 2001). However, direct identification of nest predators and detection of their home ranges raises many technical problems or is difficult and time consuming. Thus it is unusual in most nest predation studies to take the spatial distribution of any predator into consideration as a quantitative environmental factor.

The black-billed magpie (*Pica pica*) is a widely distributed generalist corvid species in farmlands throughout Europe. Its populations have increased in most European countries since the mid-1960s, leading to present densities in urban and rural habitats of between 0.04–42 pairs km^{-2} (B a e y e n s & J e r z a k 1997). The black-billed magpie shows a strong preference for agricultural land, where it may represent a key predator on dummy nests (A n d r é n 1992, S ö d e r s t r ö m et al. 1998). Also, at least one example demonstrates that predation on blackbird (*Turdus merula*) nests in small forest fragments within an agricultural landscape (in Denmark) may be increased by nearly 50% by the presence of a single breeding pair of black-billed magpies nearby (M ø l l e r 1988).

An experiment with dummy ground nests in this study was carried out in a highly fragmented agricultural landscape where the numbers of black-billed magpies has increased markedly since the first half of the 1980s (Š ť a s t n ý et al. 1997). The aim was to evaluate whether the density and/or spatial distribution of active black-billed magpie nests fits in a set of potential environmental factors that could threaten artificial nests, as might be expected (cf. L a h t i 2001) from its status as the dominant avian predator in this landscape.

Study Area

The study was conducted close to Písek, a town in Southern Bohemia, Czech Republic (49°15'N, 14°05'E, 370–400 m a.s.l.) between 1999 and 2001. The agricultural landscape under study consisted of fields (49%), meadows (18%), forest fragments (> 0.25 ha, 16%), margins of villages (9%), fishponds (5%), with marginal amounts of other habitats (shrubs, tree lines, roads; 3%).

The extent of particular managed fields (winter wheat, spring cereal, rape and maize as the main rotation crops) and meadows varied largely around a mean of 5.5 ha (median 2.2 ha). Most of the small forest fragments (40–50 years old) had a rich scrub layer bordered by various types of edges or ecotones (coniferous/deciduous shrubs or herbaceous strips). Pine *Pinus sylvestris*, spruce *Picea abies*, oak *Quercus* sp., poplar *Populus* sp. and willow *Salix* sp. represented the dominant forest species, but these species also occurred as solitary trees. The shrub layer was dominated by *Sambucus nigra*, *Prunus spinosa*, *Rosa canina*, *Crataegus monogyna*, *Corylus avellana*, *Frangula alnus*, *Padus racemosa* as well as saplings of all tree species mentioned above.

The remaining vegetation outside the fields and forests was usually reduced to narrow grassy strips dominated by *Arrhenatherum elatius*, *Dactylis glomerata* and *Calamagrostis epigejos,* mixed with other herbs (e.g. *Urctica dioica*), sparse shrubs or (fruit) trees. Most of these habitats have experienced marked changes over the last five decades as a consequence of lack of management such as regular grazing or mowing, which has resulted in places in thick growth.

Material and Methods

P o t e n t i a l   n e s t   p r e d a t o r s

Yearly estimates of breeding corvid populations between 1999 and 2001 in an area of 32 km^2 encompassing the study sites were as follows: Black-billed magpie 37–40 nests (1.2 pairs/km^{-2}), crows *Corvus corone* 5-11 nests (0.2–0.3 pairs/km^{-2}) and European jay *Garrulus glandarius* 13 nests (0.4 pairs/km^{-2}; M. Š á l e k , unpubl. data). As the European jay is inconspicuous, especially during the breeding period, its numbers may be slightly underestimated. Within the experimental sites, including the surrounding strip up to 150 m,

a total of 32 occupied black-billed magpie nests were located (Table 1) representing a site density of one to six pairs/km^{-2}.

Table 1. Number of black-billed magpies' territories (occupied nests) in particular experimental plots (I–IV) in 1999–2001.

Year / Plot	I	II	III	IV	Total
1999	3	4	2	2	11
2000	6	4	2	2	14
2001	2	1	2	2	7
Total	11	9	6	6	32

Moreover, marsh harrier *Circus aeruginosus*, black-headed gull *Larus ridibundus*, fox *Vulpes vulpes* and mustelids (martens *Martes* sp. and stoat *Mustela erminea*) were considered as potential nest predators with a wide and more regular distribution throughout the study area. Similarly, small mammals (voles *Microtus* sp., hedgehogs *Erinaceus* sp.), which rob nests elsewhere (e.g. Y a n e s & S u á r e z 1996, B u r e š 1997), were also abundant in the study area. However, fine scraps of eggshells, typical signs of egg predation by small mammals, were found only exceptionally on the treated nests, indicating probably only a minor contribution of small mammals to nest predation in this study (M. Š á l e k , unpubl. data).

Experimental design

Four separated plots (I–IV, 1 km^2 each) with different proportions of habitats (fields, meadows, shrubs, human settlements; see Table 2) were investigated. The distance between the two nearest and the furthermost plots was 1 km and 5 km, respectively. In order to avoid repeated success of corvids in locating a certain type of nest (e.g. M ø l l e r 1988), only 36 dummy nests were installed in each plot, with a regular pattern (6 × 6 nests) irrespective of the habitat. The distance of 150 m between each two nearest nests represents a low nest density of 1.2 ha^{-1}, which should not enhance the predation risk of the neighbours (R e i t s m a et al. 1990, R e i t s m a 1992, V i c k e r y et al. 1992). It also corresponds to the estimate of the home range size of black-billed magpies in an agricultural landscape in Denmark (~ 6 ha; M ø l l e r 1982). All trials started in April (1999: 18–19, 2000: 22–23, 2001: 28–29), at the beginning of the breeding season of most passerines in central Europe (C r a m p 1988).

The artificial ground nests with eggs of the japanese quail *Coturnix japonica* were set up. Each nest consisted of two eggs put in a small pit rounded by the boot and strewn with

Table 2. Habitat proportions (%) and number of forest fragments (n) in particular experimental plots (I–IV). The total areas of the study plots were identical (81 ha each).

Habitat / Plot	I	II	III	IV
Fields and meadows	77	94	75	95
Forest & shrubs	18	2	10	1
Human settlements	4	1	11	1
Other habitats	1	3	4	3
Total	100	100	100	100
Forest fragments (n)	10	2	2	0

a little dry plant material (if present) from the nest surroundings. Nests were placed in the vegetation or on soil, but always in accordance with the ambient habitat. However, nests were made as cryptically as possible to natural bird nests. Rubber boots were worn during installation to reduce any human scent. The nests were marked with a fresh stick within a 10 m radius in the field, and their positions were recorded on an aerial photo-map.

The fates of the nests were checked 12 days after installation (approximate incubation period of most passerines). Nests where at least one egg was missing, cracked or broken were considered as attacked (or visited) by a predator. Nests lost due to other reasons than predation (e.g. crushed by machinery, or not found at all) were excluded from the analysis.

The following parameters of nest positions were read from the digitized aerial orthophoto-maps (scale 1:10 000) or recorded directly in the field during nest installation: (1) Nest concealment subjectively on an ordinal scale as open nests (ground cover without vegetation), partially hidden nests (sparse or/and low vegetation) or fully hidden nests (dense crops or herbaceous covers and shrubs); (2) Habitat as field/meadow, unmanaged (idle) plant cover or forest fragment; (3) Habitat diversity around the nest up to 50 m (Shannon-Wiener diversity index H' according to K r e b s 1989); (4) Distance to the nearest perch for avian predators, i.e. any tree, shrub, power line, building, etc. being at least 3 m in height, regardless of its position in any habitat; (5) Distance to the nearest line such as a road, tree line, ditch or field edge; (6) Distance to the nearest edge of forest fragment; (7) Distance to the nearest nest occupied by a pair of black-billed magpies.

D a t a   a n a l y s i s

The pattern of nest fates (survived/predated) was analysed in a multiple logistic-regression model with the pooled set of all nests from all sites and years. The (explanatory) factors were: year, site, habitat, distance to the nearest forest fragment, habitat diversity, nest concealment, distance from the nearest line habitat, distance from a perch for avian predators, and distance from the nearest black-billed magpie nest. Since there were three repetitions of each nest position in the course of the three-years study, there was also an individual nest position implemented into the model.

The number of variables in the full model called for simplification. Therefore, the AIC (Akaike Information Criterion) was applied to leave out the factors which lowered the AIC. The AIC was estimated by stepwise selection of predictors using a Cp statistic from the intermediate results of the IRLS algorithm. The calculations were performed with S-Plus for Windows (S – P l u s 1999).

Results

Out of the total of 335 nests with a known fate included in the analysis, predators robbed 126 (37.6%; Table 3). The omission of most factors analysed in the model (site, habitat, distance from the nearest forest fragment, habitat diversity, nest concealment, distance from a perch for avian predators and nest position) minimized the AIC without changing the model significantly ($F_{286,330} = 1.223$, p = 0.1697). The resulting model includes three factors: year, distance to the nearest line habitat, and distance to the nearest magpie nest. When fitted last in the models, year and distance to the nearest line habitat were significant factors, while distance to the nearest magpie nest was a highly significant factor explaining the nest predation risk (Table 4). The model in which both distance from the nearest line and distance from the nearest magpie nest

were nested within the year explained more deviance than the non-nested model (P = 0.0015). The interactions "year x line" and "year x magpie nest" were significant ($F_{3,329}$ = 4.943, P = 0.0023 and $F_{3,326}$ = 4.191, P = 0.0063, respectively) while "line x magpie nest" was non-significant ($F_{1,331}$ = 0.521, P = 0.4708), indicating that both predation patterns in relation to distances to the nearest line habitat and to the nearest magpie nest differed from year to year.

Table 3. Number of analysed and predated nests (in parentheses) in the experimental plots (I–IV) and years (1999–2001).

Year / Plot	I	II	III	IV	Total
1999	24 (11)	34 (17)	32 (9)	33 (8)	123 (45)
2000	35 (15)	30 (8)	32 (6)	30 (13)	127 (42)
2001	24 (13)	11 (7)	25 (9)	25 (10)	85 (39)
Total	83 (39)	75 (32)	89 (24)	88 (31)	335 (126)

Table 4. Statistical significances of factors explaining the predation pattern on dummy nests when fitted last in the models. Omission of each of these factors led to a higher Akaike Information Criterion (AIC).

Factor	F-value	P
Year	$F_{2,330}$ = 3.330	0.0370
Distance to the nearest line habitat	$F_{1,330}$ = 6.396	0.0119
Distance to the nearest magpie nest	$F_{1,330}$ = 7.114	0.0080

The effect of distance from the nearest line habitat was of opposite direction in first two years, but was quite different in the third year – and therefore without any obvious biological interpretation (Fig. 1). In contrast, the results for the predation pattern in relation to the nearest magpie nest were consistent for the first two years, indicating that the dummy nests placed close to the active magpie nests were predated more often than the distant nests. However, no such pattern was detected in the third year of the study (Fig. 2). Predation pressure (rate of deprecated nests) was not found to be significantly affected by the number of nesting pairs of magpies within the site and year (Spearman's rank correlation: r_s = 0.066, n = 12, NS).

Discussion

The results may suggest that the dominant and most common avian nest predator in the area under study, the black-billed magpie, was also mostly responsible for the predation pattern on the treated nests (cf. A n g e l s t a m 1986). Although there is no direct evidence that the magpie visited the nests, the results of parallel installation of five cameras (Olympus AF-10) at artificial nests of this type repeatedly confirmed this corvid as a nest robber in the landscape surrounding the study plots in 1999 (M. Š á l e k , unpubl. results).

Non-significant influences of either habitat type, habitat diversity, nest concealment or distance from a perch for avian predators on the nest predation pattern could result from the fact that the study area is inhabited by a group of generalist predators with a wide range of foraging techniques and operating across various (micro)habitats. Also, their home ranges might be far larger than the small habitat fragments, and might stretch to different habitat types.

Some short-stalk swards and grassy strips along the fields, roads or ditches might provide higher quality foraging habitats than the interiors of managed fields (e.g., D e n y s & T s c h a r n t k e 2002, V i c k e r y et al. 2002) and could at least in some years be
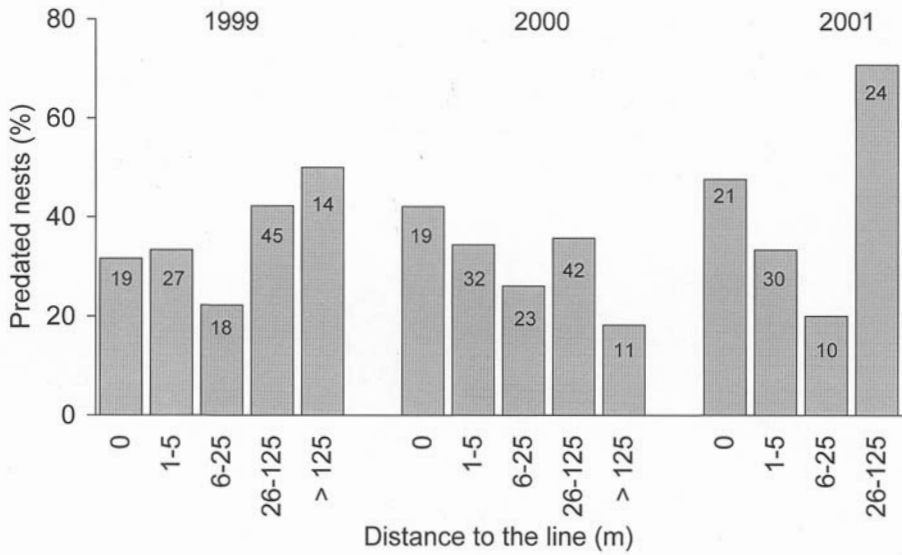
Fig. 1. Predation on dummy nests in relation to distance from the nearest line habitat during a three-year study. The numbers indicate sample sizes.
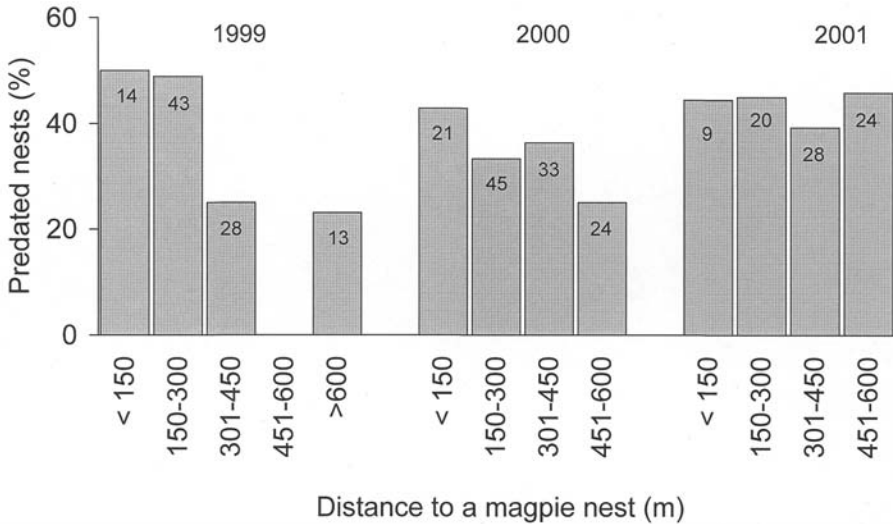

Fig. 2. Predation on dummy nests in relation to the distance to the nearest active magpie nest during a three-year study. The numbers indicate sample sizes.

inspected by omnivorous predators tending at such times to put stronger predation pressure on nests positioned closer to such lines. Opposite directions of the predation pattern in relation to the distance from the line habitat may be due to different dominant predators operating in the area in different years.

The black-billed magpie is a generalist predator of farmland that can exploit the food resources in any type of habitat possessing low vegetation and bare soil (A n d r é n 1992,

B a e y e n s & J e r z a k 1997), and the artificial nests could have been found by chance in the course of its feeding activities (A n g e l s t a m 1986). The only clear result of this study is that predation on artificial ground nests decreased with increasing distance from the nearest occupied nest of the black-billed magpie in two of the three years under study. This result corresponds with findings from Denmark, where blackbirds breeding in habitat patches with nesting black-billed magpies experienced higher nest predation rates than other blackbirds (M ø l l e r 1988). These results suggest that the predation risk increases where predators are searching for food more frequently, and indicate incidental rather than selective predation (V i c k e r y et al. 1992, S ö d e r s t r ö m et al. 1998).

L u g i n b u h l et al. (2001) pointed out that the relationship between corvid abundance and nest predation is scale-sensitive, and that the use of corvid density to assess the nest predation risk is not possible on the scale of plots of 0.5 to 1.0 km^2 (as shown also in this study), but rather on a broader landscape scale. However, G o o c h et al. (1991) did not find such a relationship between black-billed magpie densities and overall nest success for 15 songbird species throughout England, i.e. on a large landscape scale.

In conclusion, the spatial nest pattern of black-billed magpies was found to be a better predictor of nest predation risk than density of pairs. The results demonstrate that the search for habitat factors which determine the pattern of predation in a highly fragmented landscape may fail due to the distribution of a common generalist predator with no specific requirement for foraging sites. This overwhelmingly outweighs any other effect. Thus if possible, such a predator should be included as separate factor in analyses of nest predation.

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