Ann. Zool. Fennici 38: 131–138 ISSN 0003-455X
Helsinki 26 June 2001

Proximity of raven (*Corvus corax*) nest modifies breeding bird community in an intensively used farmland

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Received 20 March 2000, accepted 20 November 2000

Tryjanowski, P. 2001: Proximity of raven (*Corvus corax*) nest modifies breeding bird community in an intensively used farmland. — *Ann. Zool. Fennici* 38: 131–138.

In this paper I tested the hypothesis that areas around nests of raven *Corvus corax* built on electricity pylons in an intensively used farmland are avoided by small birds as their nest sites. Birds were counted along 13 transects (length 1000 m, width 200 m) starting from pylons with raven nests, as well as 13 control transect lines which started from pylons without any nests. These two types of transects did not differ with respect to the number of recorded bird species. However, the proximity of raven nests positively affected the total density of bird species, including skylark *Alauda arvensis*, the most abundant bird species. Neither the presence of raven nests nor control pylons influenced the number of breeding bird species along 100-m sections of the transect. Total density of breeding birds decreased with the increasing distance from raven nests, whereas it increased with the distance from control pylons. Contrary to expectations, these results indicate the positive impact of raven presence on breeding bird community in an open farmland. I suggest that breeding of birds near raven nests is an antipredator adaptation against nest-robbing by other predators.

Introduction

Predation has long been recognised as a potentially important factor organising bird communities, also in farmlands (Yanes & Oñate 1996, Newton 1998, Tryjanowski 2000a). Predation risk affects birds' foraging behaviour (review in Lima & Dill 1990), their daily routines of reserve accumulation (Lilliendahl 1998), concealment behaviour (Sodhi 1991, Rytkönen & Soppela 1995), and abundance near raptor nests (Geer 1978, Sodhi *et al.* 1991, Suhonen *et al.* 1994, Norrdahl & Korpimäki 1998). So far two hypotheses have been put forward to explain the observation that bird abundance is lower in the vicinity of raptor nest than farther away: (a) such a pattern may be a result of predation on birds breeding near a raptor nest, and (b) potential prey species avoid breeding near a raptor. However, these explanations come from the studies of a relation between small breeding passerines and birds of prey hunting adults: tits and sparrowhawk *Accipiter nisus* (Geer 1978), small forest passerines and merlin *Falco columbarius* (Meese & Fuller 1987), and small farmland passerines and kestrel *Falco tinnunculus* (Suhonen *et al.* 1994, Norrdahl & Korpimäki 1998).

So far no studies on the effect of corvids' nests on breeding birds have been conducted, although corvids may be one of the most important predators in farmland areas (Andrén 1992). In the breeding season the diet of raven *Corvus corax* includes bird eggs (Gaston & Elliot 1996, Ratcliffe 1997). In addition, ravens may actively hunt fledglings and adults of many bird species (Ratcliffe 1997, Hendricks & Schlang 1998). If a raven has a negative impact on birds nesting nearby, then open areas around its nest, which represent the main feeding site of the species (Zawadzka 1996, Ratcliffe 1997), should be avoided as breeding places (cf. Suhonen *et al.* 1994, Norrdahl & Korpimaki 1998). On the other hand, breeding near predator nests may sometimes increase nest survival. It has been shown that fieldfares *Turdus pilaris* breeding close to merlins (Wiklund 1982) and curlews *Numenius arquata* near the kestrel nests (Norrdahl *et al.* 1995) had a lower predation risk than those farther away. Both associations have antipredator character, and serve primarily to protect nests against main nest predators, e.g. hooded crow *Corvus corone cornix*.

In this study I examine whether the presence of raven nests affects habitat selection, species composition and density of breeding bird community in an open farmland area.

Material and methods

The study was conducted during the breeding season 1999 in Wielkopolska province, western Poland (52°N, 16°E). Mainly cereals and sugar beets were cultivated in the fields (for further details, *see* Tryjanowski 1999), and power lines (110 kV and 220 kV) were common throughout the farmland habitat.

In Poland, ravens formerly bred on trees, mainly pines (Kulczycki 1973), but in the mid-1980s they started to build their nests on electricity pylons (Bednorz 1991). I checked some potential nest sites (pylons) located in an intensively used farmland near Poznań, which probably holds an important part of the European raven population nesting on electricity pylons (Bednorz 2000).

In birds large-scale manipulations of predation pressure in the field are often difficult to perform, as birds are very mobile and enclosures cannot be used (Suhonen *et al.* 1994). I solved this problem by utilising the dependence of breeding ravens on pylons located in an open farmland. Thirteen treatment transects (length 1000 m, width 200 m) were selected to include a raven pair breeding on an electricity pylon 220 kV. Thirteen comparable transects situated at least 1000 m from the nearest raven nest, which also started from a pylon (without any nest) were chosen as controls. Observation of the hunting behaviour of breeding ravens showed that the birds foraged mainly within 700 m of their nest. Hence, control transects were situated outside the hunting area of nesting ravens. Using several criteria, I chose study areas to be as similar as possible. I compared the proportion of arable fields (especially fallow lands), water and tree covered areas as a critical determinant of breeding bird density and species evenness in Wielkopolska (Tryjanowski 1999). Areas with high and low potential raven impact were similar with respect to habitat distribution (Table 1). Generally, study methods were very similar to those used by Suhonen *et al.* (1994), and Norrdahl and Korpimäki (1998).

As a census method I used a line transect. The treatment transects started from pylons with raven nests, whereas the corresponding control lines started from similar pylons situated > 1000 m from the closest raven nest. Both treatment and control transects were arranged perpendicularly to the power line with study pylons. I walked 1000-m lines directly from the pylons and recorded all birds seen or heard within 200 m of the line and grouped them in ten distance classes (0–100, 101–200 m, etc.). Similarly to Norrdahl and Korpimäki (1998), I followed the recommendations of the standard line transect method by Järvinen and Väisänen (1976). Each line was counted twice in the breeding season; the first census was conducted between 8–15 April, and the second one between 17–20 May. All counts were made during the first 5 hours after sunrise in fair weather. I censused treatment and control transects pairwise on the same morning, varying the order of censusing at random. I excluded migratory or non-breeding flocks ($n > 2$) of birds from the analysis (a total of ten flocks including starlings *Sturnus vulgaris* (3), swallows *Hirundo rustica* (3), jays *Garrulus glandarius* (1), sparrows *Passer domesticus* (1), white storks *Ciconia ciconia* (1) and herring gulls *Larus argentatus* (1)).

All breeding species in the study area start to breed later than ravens, mainly in the time when ravens feed their nestlings (Bednorz 2000; P. Tryjanowski unpubl. data).

Similarly to Norrdahl and Korpimäki (1998), I assumed that predation risk should increase towards the raven nest, and it was measured as the distance to the nearest pylon with nest. Because bird density was very low within a 100-m section of a transect line (2-ha plot), I pooled data from all 13 lines (separately for April and May counts) and used each 100-m section as an independent observation for statistical testing (Spearman rank correlation). I assessed the influence of control pylons in a similar way. I applied repeated ANOVA to test for the effect of predation risk and season (April and May) on the density and number of breeding birds species using the index of habitat diversity as covariate. The index of habitat diversity (Shannon diversity index) for each study plot was calculated using the formula: $H' = -\sum p_i \times \ln(p_i)$, with p_i being the proportion of habitat in category i (Ludwig & Reynolds 1988), including fields, fallow lands, areas covered with trees and shrubs, and water. All p-values in significance tests are two-tailed.

Results

High vs. low raven activity areas

A total of 27 bird species were recorded on the transects with raven nests, whereas on the control transects, 31 species were found (Table 2). This difference was not statistically significant ($\chi^2 = 0.28$, df = 1, $p = 0.600$). The main factor affecting the number of species was habitat diversity (Table 3, $p < 0.0001$) while the presence of ravens ($p = 0.549$) and time of census ($p = 0.097$) were not important.

A total of 984 breeding pairs of birds were recorded during censuses (Table 1). The number of birds did not correlate with the habitat diversity ($p = 0.582$), but the effect of raven presence ($p < 0.002$) and the time of census was strong ($p < 0.0001$). The most abundant bird species

Table 1. Habitat characteristics of transect line (length 1000 m) in open agricultural area. Lines in treatment areas started from raven nest, whereas control lines were at least 1000 m from the nearest raven nest. Values are presented as means per transect area (20 ha) with standard deviation (SD). None of the differences was statistically significant (Mann-Whitney *U*-test).

Variable	Treatment		Control		*U*	*P*
	Mean	SD	Mean	SD		
Habitat diversity[1)]	0.93	0.73	0.90	0.93	80.0	0.82
Percentage of cover						
Arable fields	0.95	0.06	0.94	0.11	77.0	0.70
Fallow lands	0.04	0.06	0.04	0.11	69.5	0.43
Water	0.00	0.01	0.01	0.02	54.0	0.08
Trees	0.02	0.01	0.01	0.01	55.0	0.11

[1)] Shannon diversity index within a 20 ha study plot: $H' = -\sum p_i \times \ln(p_i)$, where p_i is the proportion of habitat in category *i*.

Table 2. Number of pairs of breeding species near (*N*) and far (*F*) from raven nest during April (A) and May (M) transect counts.

No.	Species	*N*		*F*		Total
		A	M	A	M	
1	*Alauda arvensis*	222	132	181	100	635
2	*Motacilla flava*	8	37	8	34	87
3	*Miliaria calandra*	23	14	17	15	69
4	*Emberiza citrinella*	11	10	11	9	41
5	*Sylvia communis*	2	8	0	8	18
6	*Motacilla alba*	6	4	5	1	16
7	*Acanthis cannabina*	2	3	3	4	12
8	*Emberiza schoeniclus*	2	1	7	2	12
9	*Anthus pratensis*	9	1	0	1	11
10	*Fringilla coelebs*	2	0	5	1	8
11	*Turdus merula*	4	1	0	1	6
12	*Acrocephalus palustris*	0	3	0	3	6
13	*Sturnus vulgaris*	2	1	1	1	5
14	*Passer montanus*	4	1	0	0	5
15	*Carduelis carduelis*	0	2	1	2	5
16	*Cuculus canorus*	0	5	0	0	5
17	*Anas platyrhynchos*	0	0	3	1	4
18	*Carduelis chloris*	0	1	1	2	4
19	*Coturnix coturnix*	0	3	0	1	4
20	*Saxicola rubetra*	0	4	0	0	4
21	*Perdix perdix*	0	0	1	2	3
22	*Emberiza hortulana*	0	2	0	1	3
23	*Sylvia atricapilla*	0	0	1	1	2
24	*Lanius excubitor*	0	0	1	1	2
25	*Crex crex*	0	1	0	1	2
26	*Luscinia megarhynchos*	0	1	0	1	2
27	*Parus major*	1	0	0	0	1
28	*Erithacus rubecula*	1	0	0	0	1
29	*Upupa epops*	1	0	0	0	1
30	*Phasianus colchicus*	0	0	1	0	1
31	*Vanellus vanellus*	0	0	1	0	1
32	*Oriolus oriolus*	0	0	0	1	1
33	*Pica pica*	0	0	0	1	1
34	*Acrocephalus scirpaceus*	0	0	0	1	1
35	*Acrocephalus schonebanus*	0	0	0	1	1
36	*Oenanthe oenanthe*	0	0	0	1	1
37	*Columba palumbus*	0	0	0	1	1
38	*Phylloscopus collybita*	0	1	0	0	1
39	*Phoenicurus phoenicurus*	0	1	0	0	1
	No. of pairs	300	237	248	199	984
	No. of species	16	22	17	29	

were: skylark *Alauda arvensis*, yellow wagtail *Motacilla flava*, corn bunting *Miliaria calandra* and yellowhammer *Emberiza citrinella*. They constituted 84.6% of the whole assemblage, and were much more abundant than the remaining species. Raven's presence positively influenced the number of skylarks ($p = 0.006$) but did not affect the number of the three other most abundant species (in all cases $p < 0.68$). The number of corn bunting was influenced primarily by the habitat diversity, while the number of yellow

Table 3. Results of repeated ANOVA for the effect of raven nest proximity on the number of species, total breeding density of all species, and breeding density of the chosen species. Habitat diversity (Shannon diversity index) was used as covariate.

Source	df	*F*	*p*
Species			
Raven	1	0.2	0.63
Habitat diversity	1	8.3	0.011
Season	1	5.9	0.023
Raven × Season	1	0.0	0.79
All birds			
Raven	1	8.1	0.582
Habitat diversity	1	0.2	0.68
Season	1	21.1	0.0001
Raven × Season	1	0.3	0.60
Skylark			
Raven	1	5.0	0.035
Habitat diversity	1	6.6	0.013
Season	1	131.0	0.0001
Raven × Season	1	0.1	0.74
Yellow Wagtail			
Raven	1	0.2	0.671
Habitat diversity	1	0.1	0.74
Season	1	16.7	0.0004
Raven × Season	1	0.4	0.51
Corn Bunting			
Raven	1	0.0	0.98
Habitat diversity	1	11.4	0.0039
Season	1	4.0	0.057
Raven × Season	1	0.3	0.59
Yellowhammer			
Raven	1	0.0	0.97
Habitat diversity	1	1.8	0.26
Season	1	0.9	0.35
Raven × Season	1	0.1	0.75

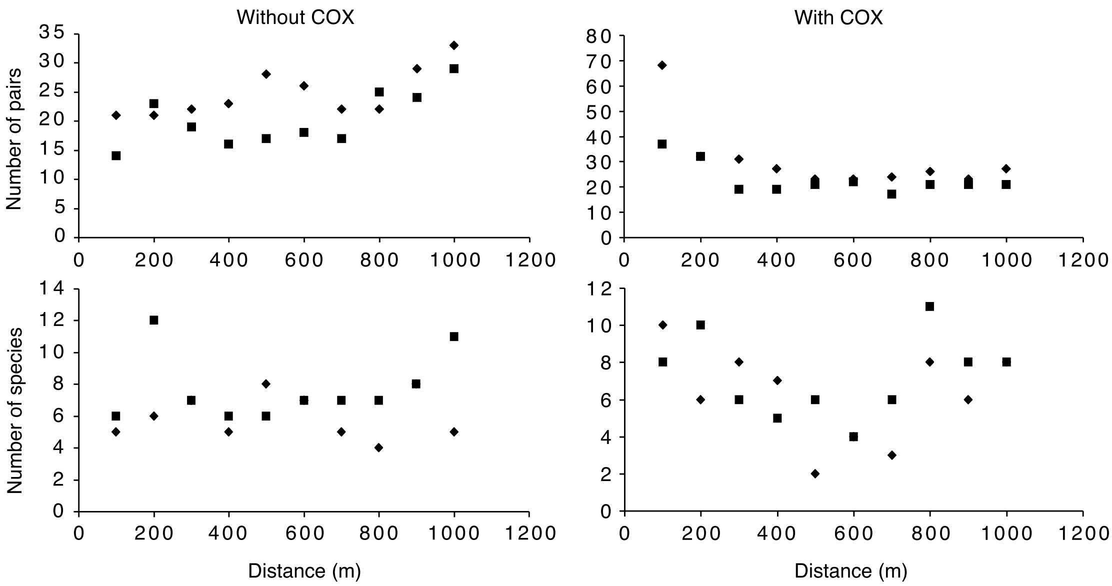

Fig. 1. Number of pairs and number of bird species at different distances from raven nests (left-hand panels) and from control pylons (right-hand panels). The dots refer to April censuses, squares to May censuses.

wagtail by the date of transects. No significant correlation was found between the number of yellowhammers and the analysed factors.

Line transect counts

Neither the presence of raven nests nor the control pylons influenced the number of breeding species in the consecutive 100-m sections of the transect during both (April and May) counts ($r_s < 0.40$ in all cases, $p > 0.25$ in all cases, n = 10 in each case; Fig. 1). The total bird density decreased with the distance from a pylon to a raven nest. This relationship was significant only for April counts (r_s = –0.63, n = 10, p = 0.049), although in May its direction remained the same, the coefficient was also negative (r_s = –0.33, n = 10, p = 0.36). In contrast, the density of birds increased with the distance from the control pylons, both in April and May (r_s = 0.751, p = 0.012 and r_s = 0.663, p = 0.037, respectively, n = 10 in both cases). Differences in the total breeding density resulted mainly from variability in the number of skylark, the most abundant bird species. The density of skylark declined with the distance from a raven pylon, both in April and May (r_s = –0.96, p = 0.0001 and r_s = –0.73, p = 0.016, respectively, n = 10 in both cases). The density of the three other most abundant species did not change with the increasing distance from both control and raven pylons (r_s between –0.43 and + 0.37, Fig. 2).

Predators near and far from raven nest

During the transect counts, I observed a total of 12 bird species, which are potential predators of adult birds and/or their clutches and broods. They were as follows: buzzards *Buteo buteo* (5 observations), kestrels (3), marsh harriers *Circus aeruginosus* (2), and single individuals of red kite *Milvus milvus*, hen harrier *Circus cyaneus*, goshawk *Accipiter gentilis*, lesser spotted eagle *Aquila pomarina*, hobby *Falco subbuteo*, great grey shrike *Lanius excubitor*, jay *Garrulus glandarius*, magpie *Pica pica*, and hooded crow. Predators were recorded 12 times on the treatment transects and 7 times on the control transects. This difference was not statistically significant (χ^2 with Yates correction = 0.24, p = 0.62).

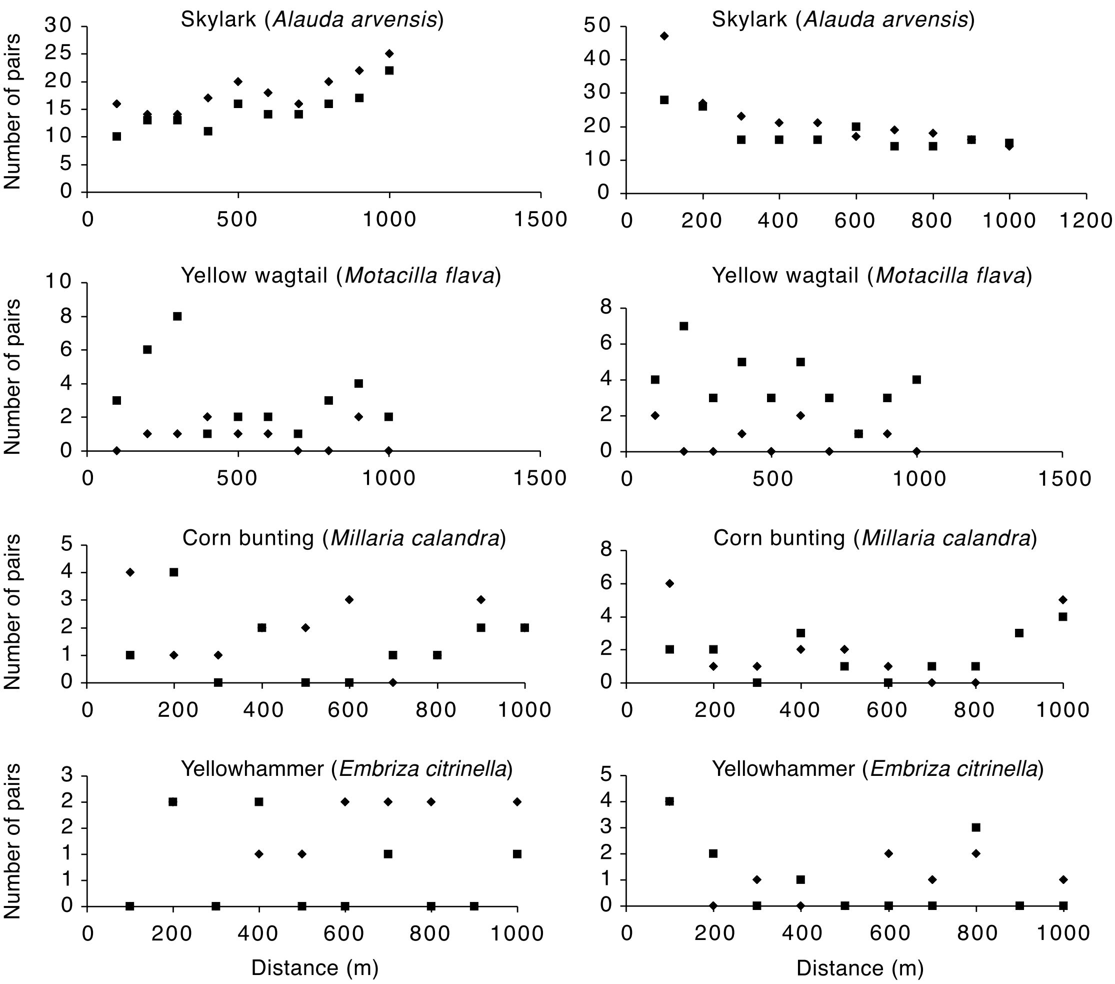

Fig. 2. Density of the skylark, yellow wagtail, corn bunting and yellowhammer at different distances from raven nests (left-hand panels) and from control pylons (right-hand panels). Sample size for all species in censuses is given in Table 1. The dots refer to April censuses, squares to May censuses.

Discussion

Various parameters of the breeding bird communities differed considerably with the distance from the raven nests built on the electricity pylons in an open farmland area. Especially the total density of all the breeding species and the density of skylark were higher on the treatment transects as compared with the control transects located far from the raven nests. Both values decreased with the distance from the pylons with the raven nests. The presence of raven did not negatively affect the number of any breeding species. These results suggest that raven proximity has a positive influence on a breeding bird community in an open farmland. It seems that the main factor responsible for nesting of birds near raven nests is the antipredator behaviour of this species. The raven actively attacks predators within its territory, including other corvids (Ratcliffe 1997). Also in the study area I observed ravens attacking other bird species. The number of predators within the raven territories and near the control pylons did not differ significantly, although the latter value was higher. However, it should be emphasised that a predator is easier to notice when it is mobbed by ravens than during foraging in the area. Therefore, I suggest that birds benefit from breeding near ravens through a reduced nest predation risk. The earlier study by Ellenberg and Dreifke (1992) also showed that the antipredator aggression of nesting ravens resulted in a lower goshawk-related predation on nests of other corvids. Likewise, Norrdahl *et al.* (1995) reported that kestrels protected curlew nests against nest predators, and small passerines: yellow wagtail and meadow pipit *Anthus pratensis* have been found to benefit by nesting in association with Lapwings *Vanellus vanellus* (Eriksson & Götmark 1982). Similarly, Dyrcz *et al.* (1981) found that nesting of "timid" waders in the vicinity of "bold" ones was an antipredator adaptation against nest-robbing.

Electricity pylons built in an open farmland countryside serve as artificial perches: places of resting and searching for prey by various bird species, including nest predators and predators of fledglings and adults (Wolff *et al.* 1999, P. Tryjanowski unpubl. data). Therefore, breeding birds should avoid the vicinity of pylons (Lima & Dill 1990). The distribution of birds along control transects found in this study is consistent with this idea: The total density of the breeding birds, as well as the density of skylark grew up with the increasing distance from the control pylons. Similar distribution of breeding small birds, resulting from the presence of kestrel nests was found in a Finnish open farmland (Suhonen *et al.* 1994, Norrdahl & Korpimäki 1998).

Apart from the presence of ravens, the structure of breeding bird communities in farmlands was also influenced by other factors. The most important one was the habitat diversity, which affected the number of breeding species and the total density of birds. The effect of the habitat diversity on breeding bird communities is widely known (Wiens 1989), and has been documented also for bird communities in farmlands of Central Europe (Tryjanowski 1999). The other studied factor, season, strongly affected the number of skylarks and yellow wagtails and hence (those two species were most abundant) also the total density of breeding birds. In the case of skylark, the effect of season reflects seasonal decline in the activity of this species, whose males cease singing and defending their territories in May (Tryjanowski 2000b). The number of yellow wagtails was much higher in May than in April, when only single individuals came back from winterings.

In conclusion, apart from the habitat diversity and seasonal changes, the presence of ravens was an important factor in organising a breeding bird community in large agricultural fields. We may expect that the effect of raven on breeding birds will intensify as more and more ravens select open farmlands as their nesting sites (Bednorz 2000).

Acknowledgements

I would like to thank J. Bednorz for fruitful discussion on the raven, P. Śliwa for help in the field, and L. Halupka, A. Surmacki, L. Kuczyński and J. Suhonen for comments on an earlier version of this paper.

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