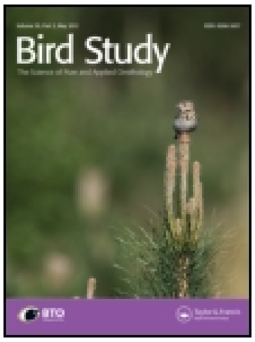

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SHORT REPORT

Breeding of Little Ringed Plovers *Charadrius dubius* in farmland: do nests in fields suffer from predation?

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Capsule Fishponds and fields were equally attractive for breeding plovers, although predation on nests was higher in fishponds and extremely low in fields.

Among the European charadriids, Little Ringed Plovers *Charadrius dubius* inhabit a wide range of habitats. Rivers with shingle beds and small islands are the most typical natural breeding habitat. The species also readily occupies various man-made habitats, such as drained ponds, gravel and sand pits, opencast mines and rubbish dumps (Cramp & Simmons 1983, Hagemeijer & Blair 1997).

Despite this variability, arable land is not known as a regular breeding habitat. According to Cramp & Simmons (1983), the species usually avoids regularly cultivated areas, and other studies mention fields only marginally (Osing 1993, Hagemeijer & Blair 1997). Although drained fishponds are a typical breeding habitat in the cultural landscape of Central Europe, this paper shows that at least in some regions, Little Ringed Plovers use bare fields for nesting.

The creation of large uniform fields has a detrimental effect on the populations of many species, including ground-nesting birds (Hagemeijer & Blair 1997, Vickery *et al.* 2002, 2004). The main threats include reduced food availability and the loss of habitats providing shelter, leading to increased predation risk to nests, adults and juveniles (Mason & MacDonald 2000, Eraud & Boutin 2002, Vickery *et al.* 2004). On the other hand, large and unfragmented habitat patches may be unattractive to some nest predators (Andrén 1995). However, there are no studies of predation of nests in extensive uniform patches of fields, a typical habitat of the Central European agricultural landscape (Tucker & Evans 1998).

The aims of this study were: (1) to test the hypothesis that predation is lower in uniform field habitats than in fishponds; (2) to ascertain to what extent fields are used by Little Ringed Plovers for nesting in a mosaic-like agricultural landscape where both fields and fishponds are available; and (3) to find out whether there is any indication that fishponds are more attractive than extensive field patches for breeding plovers.

The study was carried out in the Třeboň basin (Doudlebia, Czech Republic, 48°54′–49°10′N, 14°39′–14°56′E, total area 700 km^2). This is a flat landscape with numerous fishponds, which make up more than 10% of its area (a total of 465 fishponds covering 7450 ha). The region can be characterized as a mosaic of woods (about 45% of the area) and farmland habitats (30%) interspersed with wetlands (15%) (Albrecht 2003).

The fishponds in the Třeboň region are used mainly for intensive carp production. Each year, only a limited number of fishponds (less than 5% of the total area) are drained in the spring and are thus available to Little Ringed Plovers for nesting. Similarly, fields where bare ground is present in April and May (sown with maize, spring cereals, poppy, bean) are relatively rare, and are scattered throughout the area. Moreover, the location

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of suitable habitat patches changes from year to year. In this study, the category 'fields' also includes two sites with tree seedling nurseries and one harvested peat-bog (extensive habitat patches with scarce vegetation and limited water sources).

In each season in the period 1999–2003, breeding pairs of Little Ringed Plovers were searched for throughout the study area from April to June. As well as the cases where breeding was confirmed, plover pairs showing territorial or breeding behaviour repeatedly at the same site (within an interval of at least one week) were also considered to be breeding. Population size was assessed using data from the first half of May, a peak breeding period in the country (Hudec & Šťastný 2005).

For each nest we measured the distance to the nearest habitat edge (the same as the distance to the nearest potential perch, such as shrubs or poles, for avian predators), distance to water, vegetation coverage within 1 m from the nest, clutch size, and egg size. Timing of nesting was assessed using the flotation test (van Paassen *et al.* 1984). The estimated date when the first egg appeared in the nest was considered as the clutch initiation date. To correct for seasonal variations in the onset of breeding, the dates of clutch initiation in particular years were expressed as deviations from medians.

The nests were visited at ten-day intervals. The clutch was considered hatched when we found either hatchlings or adults rearing chicks in the nest or in its vicinity, or when only very small eggshell fragments were present on the bottom of the nest scrape. The clutch was considered depredated when large eggshell fragments were found (Green *et al.* 1987), or when the eggs disappeared before the expected date of hatching. The fledging success of particular breeding attempts was not quantified.

Adults were captured using funnel traps placed on the nest, and were individually marked with aluminium and colour rings. The sexes within the pair were identified by plumage pattern on the head and chest band (Cramp & Simmons 1983, Prater *et al.* 1997). We distinguished between second-year and older than second-year individuals based on the degree of wear of the primaries and by the coloration of the inner median coverts (Prater *et al.* 1997). To assess individual body condition, wing length (to the nearest millimetre) and weight (to the nearest 0.5 g) were taken. The width of the black forecrown was measured to the nearest 0.1 mm. Body condition and melanin-based plumage coloration were considered as indicators of the phenotypic quality of adult plovers (Bókony *et al.* 2003).

The nest attendance of colour-marked parents and the frequency of their changeovers at the nest were monitored from a car or from hides, using 12 × 50 binoculars or a 40 × 60 fixed telescope.

Population density was calculated from the pair numbers occupying the surveyed area of drained fishpond bottoms and fields potentially available for nesting. The daily nest survival and total hatching success (assuming 24 days of incubation) were calculated using the Mayfield method (Mayfield 1961, 1975, Hensler & Nichols 1981). The effects of habitat type (field or fishpond), timing of clutch initiation, distance to the nearest habitat edge/perch for predators, vegetation coverage and distance to water on daily nest survival (only hatched and predated nests were included in the analysis) were fitted by the generalized linear model (GLM) according to Aebischer (1999), using S-PLUS (1999). Statistical significance is based on Type III Sums of Squares. Chi-squared statistics were used as we ensured that the overdispersion of residual deviance was <1 (Crawley 2002).

Individual body condition was defined as the value of the regression residual from the relationship between weight and wing length, separately for males and females. Egg volumes were estimated according to Amat *et al.* (2001). Female reproductive effort was measured as a regression residual from the relationship between the total egg volume in a clutch and female weight (Galbraith 1988).

The total observation time of the incubation behaviour of parents varied between one and six hours for individual nests. The frequency of parent changeovers was fitted in GLM with binomial error (GLM_{binom}) and the total observation time and habitat type were used as explanatory variables. Nest attendance (percentage of time spent on incubation) of both parents during the observation period in fields and fishponds was compared using a non-parametric test.

Little Ringed Plover numbers declined from 30 to 18 pairs over the study period (five years), while the breeding density in the two habitats fluctuated from year to year (Table 1). The breeding density was consistently higher in fishponds than in fields (Wilcoxon's test for matched pairs: $z = 2.02$, $P < 0.05$).

Altogether, 57 nests in fishponds and 24 in fields were found. Hatching success did not differ from year to year (GLM_{binom}, $\chi^2_{4,77} = 8.39$, $P > 0.05$), and the data from all years were pooled for the subsequent analyses. The total hatching success differed strikingly between the habitats, being higher in fields than in fishponds (60.4% and 15.4%, respectively). Predation was the

Table 1. Habitat availability, numbers of breeding pairs and population densities for Little Ringed Plovers in two habitat types during the study period 1999–2003.

	1999	2000	2001	2002	2003
Fishponds					
Number of breeding pairs	22–24	16	13–14	19	11
Number of sites available	17	18	13	20	9
Total area of sites available (ha)	358.4	224.1	109.6	194.0	273.9
Breeding density (pairs/10 ha)	0.64	0.71	1.23	0.98	0.40
Fields					
Number of breeding pairs	6	9	10	3	7–8
Number of sites available	5	6	9	7	7
Total area of sites available (ha)	210.5	161.4	187.6	133.9	301.8
Breeding density (pairs/10 ha)	0.28	0.56	0.53	0.22	0.25
Total number of breeding pairs	28–30	25	23–24	22	18–19

Table 2. Description of habitat surrounding the nest and differences between the two habitat types.

Factor	Habitat[a]	Median	Range	Mann–Whitney *U*-test	*P*
Distance to the nearest habitat edge	1	20.0	5–100	169.0	<0.001
	2	70.0	15–300		
Vegetation coverage around nest	1	2.0	1–9	733.5	0.04
	2	1.0	1–4		
Distance to water	1	17.5	0–250	386.0	0.028
	2	55.0	0–500		

[a]1, Fishponds (n_1 = 52); 2, fields (n_2 = 22)

main cause of nest loss in fishponds (20 out of 41 lost nests, 48.8%), but no nest predation was recorded in fields. Other factors causing nest loss included flooding of nests due to changes in water level (14 out of 57 nests in fishponds, 0 in fields) and destruction by machinery (1 out of 57 nests in fishponds, 5 out of 24 nests in fields). Field and fishpond nests differed in many attributes (Table 2). However, the risk of nest predation could not be explained by any of the tested environmental factors once 'habitat type' was included in the model (partial effect of habitat type, $\chi^2_{1,68}$ = 13.2, P = 0.0003; partial effects of five other variables, all $\chi^2_{1,68} < 1.2$, $P > 0.3$).

In total, 35 males and 38 females were captured during incubation of the eggs. There appeared to be no evidence that birds of lower phenotypic quality inhabit fields. There was no difference in body condition between males and females breeding in fishponds and in fields (T = 1.10, df = 26, $P > 0.2$; T = 0.16, df = 32, $P > 0.5$, respectively). Similarly, there were no significant differences in the age of males and females between the habitats (2 × 2 contingency table, Yates corrected χ^2 = 1.61 and 0.01, n = 35 and 37, P = 0.2 and > 0.5, respectively), suggesting that more experienced (older) birds inhabited both habitats with the same intensity. Contrary to expectation, males in fields had a slightly wider forecrown than those in fishponds (T = 1.99, df = 26, P = 0.057), while no significant difference was found in females (T = 0.86, df = 26, P = 0.4). The timing of clutch initiation did not differ between the habitats (Mann–Whitney U = 757, n_1 = 56, n_2 = 23, $P > 0.2$).

Egg volume decreased during the breeding season ($\mathrm{GLM_{gauss}}$, $\chi^2_{1,69}$ = 9.05, P = 0.003), while the effects of habitat type and year were not significant ($\chi^2_{1,69}$ = 0.02, P = 0.9; $\chi^2_{4,69}$ = 8.47, P = 0.08, respectively), as were their interactions (season × habitat and season × year, P = 0.22 and P = 0.16, respectively). The reproductive effort of females did not differ between the habitats (t-test, t = 0.01, df = 31, $P > 0.5$).

Data on behaviour during incubation were collected for 18 pairs (12 in fishponds and 6 in fields), the total observation time being 69 hours. Frequency of changeovers at the nest was significantly lower in fields than in fishponds (medians of changeovers per hour = 2 and 5, respectively; $\mathrm{GLM_{binom}}$, $\chi^2_{1,15}$ = 15.08, P = 0.048), but the percentage of time spent on incubation by both parents did not differ between the habitats (Mann–Whitney U = 43, n_1 = 12, n_2 = 6, P = 0.5).

We found that hatching success of Little Ringed

Plovers was lower in fishponds than in fields, the main factor responsible for nest losses being predation. While no nests were depredated in fields, half of the clutch losses in fishponds were caused by predation. Despite the apparent differences in characteristics between the two habitats (Table 2), none of these factors proved to be related to nest predation risk. The high predation rate in fishponds could therefore be due to a non-random pattern of the activity of predators, which perhaps prefer fishpond margins to fields (see below), and may not be caused by any environmental characteristics of the nests themselves. It should be noted that only a few nests were placed less than 50 m from habitat margins in fields, which is the distance where predation intensity increases in many habitats (Paton 1994). By contrast, all fishpond nests can be considered 'edge nests'.

Because of the high availability of food (including fish carcasses) for various predators, the density of potential nest predators and incidental predation on nests are likely to be high around the shorelines of fishponds (Vickery *et al.* 1992). Moreover, the margins of fishponds may act as travel lines for some predators (Andrén 1995). In contrast, predators are assumed to be less frequent in uniform agricultural landscapes, where sources of animal food are rare (Andrén 1995). In accordance with this hypothesis, the frequency of occurrence of avian predators (mainly crows) recorded during observations of incubating adults was 0.67 individuals per hour in fishponds, compared to only 0.20 in field interiors (observation time was 46 and 18 hours for fishponds and fields, respectively; unpubl. data).

On the basis of our data, it is not fully clear which habitat is more attractive to plovers. The phenotypic parameters of adults, as well as other characteristics correlated with habitat attractiveness in birds, including timing of breeding, did not differ between the two habitats, suggesting that plovers may not actually discriminate between them. However, one parameter – breeding density – was higher in fishponds than in fields. Fishponds may offer more food resources for breeding birds and/or their chicks. It is hence possible that the low hatching success in fishponds is outweighed by higher survival rate of the young, which may benefit from the better availability of small invertebrates. However, data on hatchling survival would be needed to test this hypothesis. The observed lower frequency of changeovers at the nests in fields might give some support to this assumption, suggesting that the adults have to leave the breeding site to find food and thus spend more time foraging. After the young hatch, plover families could move from fields to a more convenient habitat, e.g. to the nearest fishpond, a phenomenon known in other charadriid species (Blomqvist & Johansson 1995). In fact, the consequences for brood survival of staying in fields remain unclear. Considering the overall predation intensity we can only speculate that predation pressure on chicks would again be lower in fields than in fishponds.

An alternative explanation is that, at the time of settlement, Little Ringed Plovers may be unable to make a proper assessment of the predation risk (Székely 1992, Bollmann *et al.* 1997). They may concentrate less on potential predation than on certain key characteristics of the habitat, such as low and scarce vegetation enabling a good view (but there is lower cover within 1 m around nests in fields than in fishponds) and the availability of food. This combination of cues may lead plovers to prefer fishponds over fields despite higher predation pressure in fishponds.

Without knowing about survival of young and productivity in field and fishpond habitats, we cannot definitely identify the consequences of field and fishpond breeding on populations of Little Ringed Plovers. Nevertheless, our results indicate that some ground-nesting birds could benefit from breeding in fields at least because of low predation pressure and high nest survival in this habitat. On the other hand, fishpond margins currently seem to be an unsafe habitat for plovers due to a combination of high risk of nest predation and changing water levels, leading to flooding of the clutch and nest desertion by the adults.

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