Breeding birds on organic and conventional arable farms

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Chapter 4

Nest success of lapwings *Vanellus vanellus* on organic and conventional arable farms in the Netherlands

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Lapwing nest found on a conventional field in 2005.

Abstract

Increasing agricultural intensification has put farmland bird populations under great stress. Although organically managed farms tend to have higher densities of farmland birds than conventionally managed holdings, differences in crop management may also lead to differences in breeding success. With the use of agrochemicals prohibited on organic farms, weeds are controlled using mechanical methods that may pose a threat to ground-nesting birds. This study compares the territory densities and nesting success of the lapwing *Vanellus vanellus* on organic and conventional arable farms in the Netherlands. Territory densities were generally higher on organic farms, although in one year nesting success was lower on organic compared to conventional farms. This was caused by higher nest loss resulting from farming activities on organic farms. There were no differences in predation rates. The results of this study show that breeding lapwings may face potential threats on organic farms. To sustain or enhance lapwing populations on these farms, additional conservation measures should be implemented.

Keywords: Arable farming; Nest survival; Farming operations; Nest predation; Breeding success

Introduction

European populations of farmland birds have been in decline for several decades (BirdLife International, 2004a), with agricultural intensification identified as a key contributing factor (Chamberlain *et al.,* 2000; Donald *et al.*, 2001, 2006; Stoate *et al.*, 2001; Robinson and Sutherland, 2002; Newton, 2004). Species that were common 25 years ago are now on the Red List in several countries (Gregory *et al.*, 2002; BirdLife International, 2004b; van Beusekom *et al.*, 2004). Previous studies have shown that organic farming may have the potential to reverse the decline of farmland bird populations. Organic farms have greater abundances of at least some species during the breeding season (Christensen *et al.*, 1996; Lokemoen and Beiser, 1997; Wilson *et al.*, 1997; Chamberlain *et al.*, 1999b; Freemark and Kirk 2001; Beecher *et al.*, 2002) and in winter (Chamberlain *et al.,* 1999b; Fuller *et al.*, 2005).

To establish whether farmland bird populations indeed benefit from organic farming, data on reproductive success are required. Given the differences in crop management between conventionally and organically managed farms, there may well also be differences in breeding success. For example, the insecticides used on conventional farms are likely to depress the breeding performance of farmland birds by reducing the availability of food for chicks (Boatman *et al.*, 2004; Hart *et al.*, 2006). In contrast to conventional farmers, organic farmers use no synthetic herbicides or pesticides, applying mechanical and other non-chemical methods for weed control. These include inter-row cultivation in root crops and sometimes cereals, post-emergence harrowing in denser crops like cereals and peas, and burning of weeds (Bond and Grundy, 2001), all of which qualify as potential threats to ground-nesting birds. Besides mechanical weeding methods, other farming activities may also potentially destroy the nests of ground-breeding birds. These activities, also carried out on conventional farms, include ploughing, planting, ridging up (to provide plants with more soil) and rolling. There are several studies showing that farming activities are an important cause of nest failure for ground-nesting birds (e.g. Berg *et al.*, 1992, 2002; Lokemoen and Beiser, 1997).

To date, only a few studies have compared the reproductive success of birds on organic and conventional farms. In the United Kingdom no difference was found in the breeding success of skylark *Alauda arvensis* or yellowhammer *Emberiza citrinella* between organically and conventionally managed sites (Wilson *et al.*, 1997; Bradbury *et al.*, 2000). As yellowhammers do not nest within the actual crop, however, their breeding success is unlikely to be directly affected by crop management. The skylark study comprised nests found mainly in cereals, silage and set-aside. In silage and set-aside no mechanical weeding is applied. In the United States, too, no differences were found in the hatching success of passerines and waders between organic and conventional farms, although hatching success was higher on minimum-tillage fields compared with organic fields (Lokemoen and Beiser, 1997).

This study tries to assess the effects of organic arable farming on lapwings *Vanellus vanellus*. The lapwing is a common breeding bird in most of north-west Europe (BirdLife International, 2004a). It prefers open habitats with short or sparse vegetation, including arable land and pastures (Galbraith *et al.*, 1984; Beintema *et al.*, 1995; Berg *et al.*, 2002; Henderson *et al.*, 2002; Sheldon, 2002; Sheldon *et al.*, 2004). Lapwings build open nests, usually with four eggs. The main breeding period is from early April to early May.

In most European countries breeding populations of lapwings have declined (BirdLife International, 2004a). These declines seem to be due to low reproductive success (Peach *et al.*, 1994). As the breeding period of lapwings coincides with numerous sowing and weeding activities, the latter mainly on organic farms, the hatching success of their brood may be severely affected by these activities. With such activities more frequent and varied on organic farms, the impact on reproductive performance is also likely to be greater. As a result, overall hatching success might therefore be lower on organic farms.

The study presented here compares territory densities, nest densities and nest success of lapwings on organic and conventional arable farms in the Netherlands by investigating the relative importance of farming activities and predation as causes of nest failure. The results of this study yield new insight into the actual effects of organic agriculture on ground-nesting farmland birds. This information can be used to develop more efficient conservation measures aimed at enhancing breeding success of these birds.

Materials and methods

Study area

The study was carried out in two large-scale, open and very homogenous, mainly arable areas in the Netherlands (Oostelijk Flevoland and Noordoostpolder) from 2004 to 2006. Both areas are relatively young polders on a marine clay soil. The predominant crops are potatoes, cereals, sugar beet and onions. A total of 40 farms were selected in a pair-wise set-up. Each pair consisted of an organic and a conventional farm, with the numbers of pairs divided equally over the two areas. The two farms in each pair were selected in such a way that the surrounding landscape features and soil type were similar for both, thus minimizing influences other than farm management. All the organic farms were certified by SKAL, the Dutch inspection body for organic produce, and had been managed organically for at least five years. When an organic farmer volunteered to take part in the study, a nearby conventional farm was sought by contacting conventional farmers in the vicinity. When one of the latter volunteered, their farm was visited to check whether it was sufficiently matched with the organic farm.

Data collection

In 2004 and 2005 lapwing territories were mapped on 10 and 20 pairs of farms respectively, using the standard method applied for the Breeding Bird Monitoring Project in the Netherlands (van Dijk, 2004). All 10 pairs taking part in the study in 2004 also participated in 2005. The two farms in each pair were visited on the same morning, but the order in which they were covered was alternated throughout the inventory period.

In 2005 and 2006 surveys of lapwing nests were carried out on all 40 farms. All the farms took part in the study in both years. As in the breeding bird surveys, both farms in each pair were visited on the same day, with all farms being visited once a week. Nests were located by looking for nest-indicating bird activity, such as incubating females, guarding males or anti-predator behaviour. When a nest was found, it was marked using GPS and this was used to relocate the nest on following visits. To avoid farmers adapting their farming activities, nests were not marked and farmers were not informed of their presence. Every nest was visited once a week to check whether it was still present and, if so, whether it had hatched or failed. Nests were assumed to have hatched successfully when there were small remnants of egg shell left on the bottom of the nest or when newly hatched chicks were present in the nest. Occasionally, no traces of a nest could be found at the original location as a result of farming activities. These nests were assumed to have hatched when parent birds exhibiting alarm behaviour were present close to the original location. For all failed nests, the cause of failure was determined. Empty nests lacking small pieces of egg shell on the bottom or egg shells close to the nest were assumed to have been predated. Farming activities were identified as the cause of nest failure when remnants of the nest or eggs were found and there were clear signs of recent agricultural activities. A nest with cold eggs was assumed to have been abandoned. This was verified on a later visit.

Data analysis

Territory densities were calculated using seasonal maximum densities. Territory and nest densities were expressed per 100 ha. Differences in densities were tested with a Wilcoxon matched-pair test using SPSS 12.0.

Daily nest survival rates were calculated for organic and conventional farms using the Mayfield method (Mayfield, 1961, 1975). A nesting period of 32 days was assumed: 5 days of nest-building and egg-laying and 27 days of incubation. Nest success was compared between the two farming systems, and for uncropped and cropped fields separately. Differences in nest success were tested using a likelihood-ratio test, for which the statistic D is calculated as the difference in deviance of nest success between the two groups (Aebischer, 1999). The statistic D is distributed approximately as χ^2 where df = 1 for a two-sample comparison.

To analyse whether farming activities or predation were responsible for differences in mortality rates, we considered farming activities and predation to be two separate factors causing nest failure. Nest mortality due to each factor was calculated using a baseline hazard approach (Kleinbaum, 1996). Nest mortality due to farming activities was calculated as a percentage of all other nests, whether successful or lost through another cause. Nests failing due to causes other than farming activities were included in the analyses as not failed. Nest predation rates were calculated using the same methodology. For one failed nest, the cause of nest failure could not be determined and was therefore omitted from this analysis.

Results

Farm lay-out and weather

The organic farms were slightly smaller than the conventional farms on average, but this difference was not significant (organic 36 ha, conventional 40 ha; paired-sample T-test, t_{19} = 1.062, NS). There were several major differences in crop rotation schemes between organic and conventional farms (Table 5). Organic farms grew more crops than conventional farms. In addition, spring cereals were the principal crop grown on organic farms, while conventional farms had relatively more potatoes, sugar beet and winter cereals. The areas devoted to grass leys and set-aside were very small. There was no regeneration of vegetation on the set-aside, as it was tilled frequently to control weed growth. All the organic farmers applied non-chemical weeding methods such as harrowing and hoeing. All the conventional farms were managed using artificial pesticides and fertilizers.

In the three years of the study, spring weather conditions varied (Table 6). Spring 2004 was the driest and 2006 the wettest. With respect to temperature, 2004 and 2005 did not differ greatly. However, March and April 2006 were relatively cold compared with the other two years, while May 2006 was relatively warm.

Territory and nest densities

In 2004 and 2005 lapwing territory densities were compared on organic and conventional farms. In 2004 significantly higher territory densities were found on the former (Wilcoxon matched-pair test, Z = 2.090, P = 0.037). In 2005 the mean territory density on organic farms was again higher, but tested non-significant (Z = 1.568, P = 0.117; Figure 2).

Table 5 Relative areas of crops (expressed as percentage of total area) grown on organic (O) and conventional (C) farms. 'Other spring-sown crops' comprises crops grown on less than 5% of the total area in all cases.

	2004		2005		2006	
	O	C	O	C	O	C
Potatoes	19%	26%	15%	25%	16%	24%
Spring cereals	22%	3%	27%	4%	21%	7%
Onions	10%	13%	12%	12%	10%	12%
Sugar beet	7%	18%	3%	16%	2%	13%
Winter cereals	0%	18%	0%	15%	1%	14%
Carrots	6%	4%	7%	4%	8%	6%
Peas	4%	0%	7%	2%	7%	2%
Beans	4%	2%	6%	2%	2%	2%
Belgian endive	1%	4%	3%	5%	4%	6%
Cabbage	5%	1%	2%	0%	7%	1%
Other spring-sown crops	19%	11%	12%	14%	17%	13%
Grass leys	3%	0%	3%	0%	3%	0%
Set-aside	0%	0%	3%	1%	2%	0%
Number of crops	24	15	27	19	26	19

Table 6 Amount of rainfall and mean temperature during the research period. (Source: Royal Netherlands Meteorological Institute, www.knmi.nl).

	Month	Normal	2004	2005	2006
Rain (mm)	March	65	42	50	104
	April	44	33	63	40
	May	62	31	54	90
Temperature (°C)	March	5.8	5.9	6.5	3.9
	April	8.3	10.4	10.4	9.0
	May	12.7	12.3	12.6	14.5

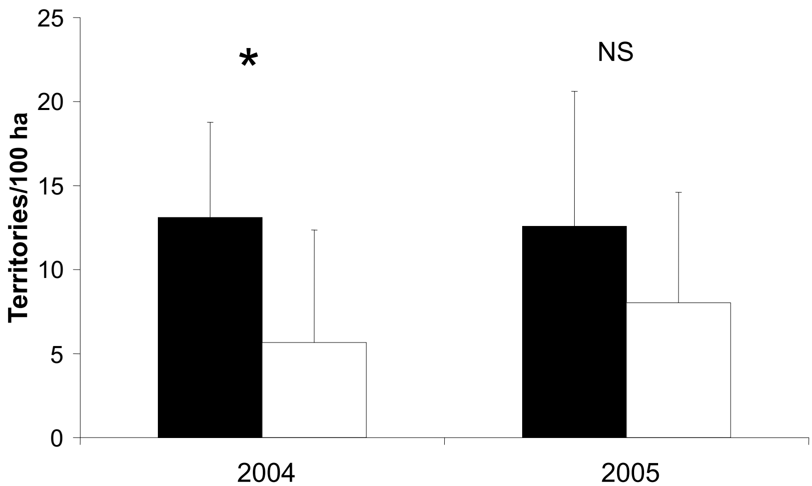

Figure 2 Lapwing territory densities (mean ± sd) on organic (filled bars) and conventional (open bars) arable farms in 2004 and 2005. * = $P < 0.05$, ns = $P > 0.05$.

A total of 256 lapwing nests were found: 135 in 2005 (87 on organic farms, 48 on conventional) and 121 in 2006 (74 on organic farms, 47 on conventional). Although nest densities (per 100 ha ± sd) were almost twice as high on organic farms in both years (2005 organic 11.9 ± 16.1, conventional 6.0 ± 7.6; 2006 organic 11.0 ± 14.8, conventional 6.3 ± 8.3), the differences were not significant (2005 $Z = 1.489$, $P = 0.136$; 2006 $Z = 1.189$, $P = 0.234$).

Nest success

Overall daily nest survival rates for 2005 were based on 125 nests (80 on organic farms, 45 on conventional) and for 2006 on 117 nests (71 organic, 46 conventional). In 2005, there was a trend towards a lower daily nest survival rate on organic farms ($D_1 = 3.253$, $P = 0.071$; Figure 3). In 2006, however, daily survival rates were more or less the same on both farm types ($D_1 = 0.073$, $P = 0.787$). This was mainly because nest success on conventional farms was much lower in 2006 compared with 2005 and this difference was almost significant

(D_1 = 3.254, P = 0.071). On organic farms, daily survival rates did not differ between the two years (D_1 = 0.260, P = 0.610). Based on nest densities and daily nest survival rates, the productivity in terms of number of successful nests per 100 ha was calculated. In 2005 the productivity (± se) on organic and conventional farms was 3.3 ± 1.0 and 2.8 ± 0.8 successful nests per 100 ha respectively. In 2006, this was 2.6 ± 0.8 and 1.7 ± 0.5 nests per 100 ha. Only in 2005 could the number of successful nests per breeding pair be calculated by comparing the density of successful nests and the density of breeding pairs. On organic farms there were 0.26 (95% confidence interval 0.098 to 0.500) successful nests per breeding pair and on conventional farms 0.35 (95% confidence interval 0.141 to 0.673) successful nests per breeding pair.

During this study, a total of 125 nests failed (55 in 2005, 70 in 2006). There were three causes of nest failure: farming activities, predation and desertion. On organic farms relatively more nests failed owing to farming activities compared with predation, while on conventional farms the differences in relative nest loss due to these specific causes were less obvious (Table 7). When only farming activities were included as a cause of nest failure, daily nest survival rates were lower on organic than on conventional farms in 2005 (D_1 = 7.144, P = 0.008; Figure 3). In 2006, however, no significant difference was found (D_1 = 1.339, P = 0.247). In neither year did lapwing nest predation rates differ between organic and conventional farms (2005 D_1 = 0.018, P = 0.894; 2006 D_1 = 1.636, P = 0.201). Therefore, the lower nest success on organic compared to conventional farms in 2005 was a result of higher nest failure rates due to farming activities.

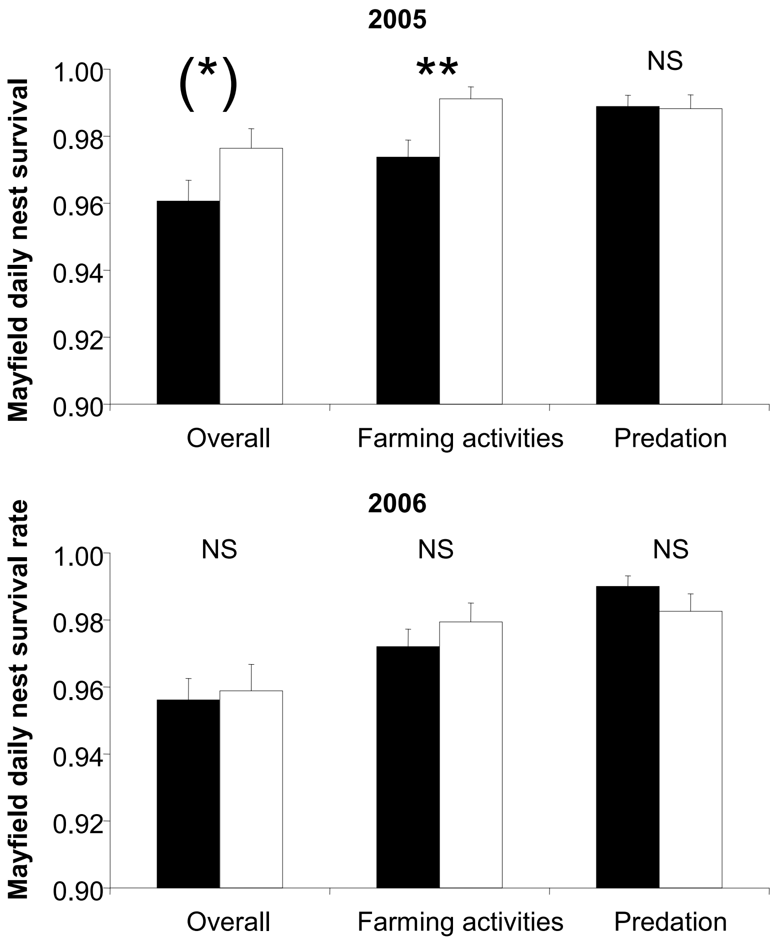

Figure 3 Mayfield estimates (± se) of total daily survival rates, daily survival rates when only farming activities are included as a cause of nest failure, and daily survival rates when only predation is included as a cause of nest failure. Filled bars represent organic farms, open bars conventional farms. ** = $P < 0.01$, (*) = $P < 0.10$, ns = $P > 0.10$.

Table 7 Total numbers of nests failed and relative nest failure as a result of farming activities, predation and desertion on organic and conventional arable farms in both years.

	Organic		Conventional	
	2005	2006	2005	2006
Number of nests found	87	74	48	47
Total nest loss	40	45	16	26
Farming activities	65%	62%	38%	50%
Predation	30%	24%	50%	42%
Desertion	5%	4%	6%	8%
Unknown	0%	9%	6%	0%

On conventional farms, nest loss as a result of farming activities was higher in 2006 than in 2005, a difference that approached significance (D_1 = 3.196, P = 0.074). On organic farms, nest failure due to farming activities did not differ between the two years (D_1 = 0.055, P = 0.814). There was no difference in nest predation rates between the two years (2005 D_1 = 0.060, P = 0.807; 2006 D_1 = 0.718, P = 0.397).

Lapwing nests were found on both ploughed (i.e. uncropped) and cropped fields. On organic farms, 37 nests were found on ploughed fields in 2005 and 43 on cropped fields. In 2006 these numbers were respectively 40 and 31. On conventional farms 11 nests were found on ploughed fields in 2005 and 34 on cropped fields. In 2006, these numbers were respectively 20 and 26.

In 2005, daily nest survival rates were higher in conventionally managed than in organically managed crops (D_1 = 3.902, P = 0.048; Figure 4). This difference was caused by higher nest failure rates due to farming activities (D_1 = 9.085, P = 0.003). In 2006 there was no difference (D_1 = 0.005, P = 0.943). Daily nest survival rates on ploughed fields did not differ between organic and conventional farms in either year (2005 D_1 = 0.467, P = 0.494; 2006 D_1 = 0.348, P = 0.555). There were no differences in nest predation rates on either type of field, nor did daily nest survival rates differ between the two years.

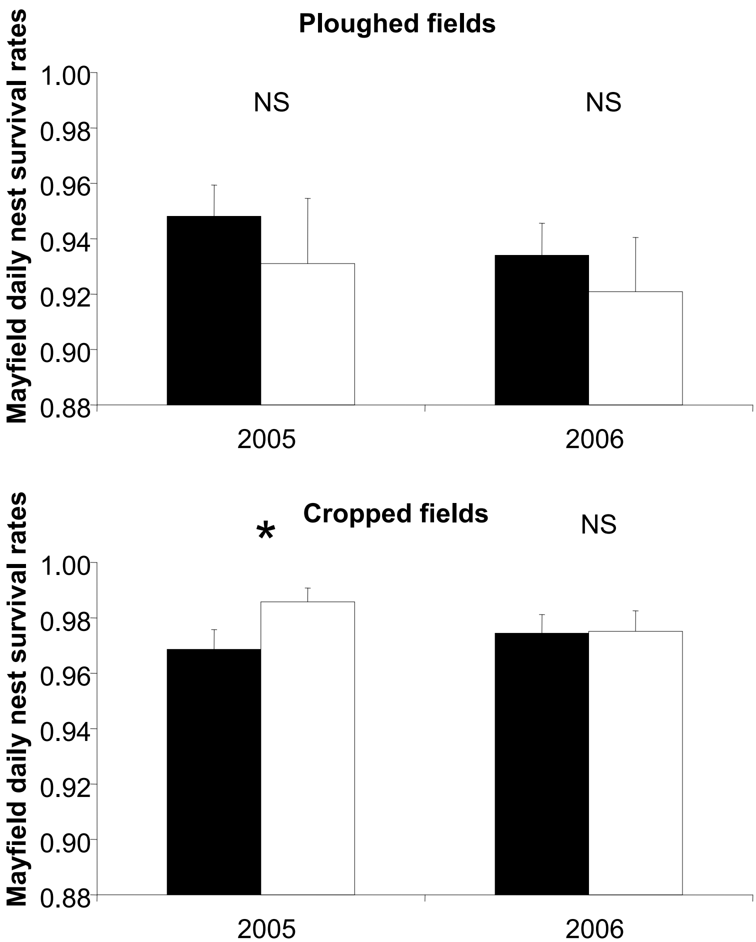

Figure 4 Mayfield estimates (± se) of total daily survival rates on ploughed fields and cropped fields on organic farms (filled bars) and conventional farms (open bars). * = $P < 0.05$, NS = $P > 0.05$.

Discussion

Territory and nest densities

In 2004 lapwing territory densities were significantly higher on organically managed farms, which is in line with previous findings in Denmark

(Christensen *et al.*, 1996). In 2005 the difference was still quite large, but not significant. Compared with studies carried out in arable areas in other countries, territory densities were much higher (Berg *et al.*, 2002; Milsom, 2005). These higher territory densities are probably a result of the open landscape of our study site. Differences in nest densities were similar to differences in territory densities.

Previous studies have pointed to the importance of meadows and arable areas for chick-rearing by lapwings (Galbraith, 1988; Johansson and Blomqvist, 1996). Although organic farms are often characterised by their mixture of arable land and grassland, in our study just three organic farms had rotational grass leys and one of these farms had no lapwing territories. It is therefore unlikely that this was an important factor causing the higher territory densities, so other factors might be potentially important. In the first place, the presence of winter cereals on conventional farms reduces the area of suitable breeding habitat. Even in the early breeding season, winter cereals are already too high for lapwings to find a suitable nesting site because the high vegetation limits their view of predators (Shrubb and Lack 1991; Wilson *et al.*, 2001). Secondly, differences in food abundance between organic and conventional sites might play a role. It is known that the presence of foraging habitats is important during territory selection by lapwings (Berg, 1993) and lapwing densities are related to food abundance (Galbraith, 1989; Baines, 1990). Lapwings feed mainly on earthworms and surface-active invertebrates (Baines, 1990) and several studies have shown that these prey items are more abundant on organic farmland (Bengtsson *et al.*, 2005; Hole *et al.*, 2005).

Nest success

In 2005 the nest success of lapwings was lower on organic farms. In 2006 no significant difference in nest success was observed. Lokemoen and Beiser (1997) found no difference in hatching success of ground nesting birds between organic and conventional fields. On minimum-tillage fields, however, they did find lower nest failure rate compared to organic fields as a result of tillage. In our study, nest failure due to farming activities was lower on conventional farms in one year. Both of these results indicate that a higher frequency of soil-disturbing farming activities results in greater nest failure rates of ground-nesting birds.

Nest success on conventional farms was lower in 2006 than 2005. This was due mainly to more nest losses as a result of farming activities on conventional farms in 2006. In 2006, slightly more nests failed in conventional crops owing to farming activities (e.g. rolling, ridging-up). These activities were probably carried out because of the cold and wet early spring, which limited crop development. Besides these climatic differences between the years, the distribution of nests over ploughed (i.e. uncropped) and cropped fields may also have had an influence. In 2006 relatively more nests were found on ploughed fields, where nest success was lower. Climatic conditions were more typical in 2005 compared with 2006. Because the breeding activity of lapwings (Both *et al.*, 2005) and farmers' activities both depend on weather conditions, the results for 2005 are likely to be closer to those of an average year.

With this in mind, the question is whether organic farms act as ecological traps for lapwings. Our study was limited to just part of the lapwing's life cycle. It may be the case that higher nest loss rates are compensated by higher chick survival rates resulting from higher food availability on organic farms (e.g. Hole *et al.*, 2005). On the other hand, the higher mechanisation rates (e.g. mechanical weeding) on organic farms may lead to higher chick mortality.

Therefore, to answer this question, we suggest that future studies focus on these aspects.

Organic arable farmers in other European countries employ the same mechanical methods of weed control (Bond and Grundy, 2001). However, it is unknown whether they use these methods with the same frequency as Dutch organic farmers. The frequency of mechanical weeding is dependent on crop type, soil type, weather and any other measures taken to combat weeds. It is therefore possible that the impact of organic farming on lapwing nest success differs from country to country.

Implications for conservation

This study provides strong indications that while organic farming attracts higher densities of lapwings compared with conventional farming, nest success may in fact be lower due to higher rates of mechanical disturbance. Since inadequate breeding success is likely to be the cause of declines in lapwing populations (Peach *et al.*, 1994), organic farming will possibly not in itself enhance these populations unless additional measures are taken. These measures should be focussed on enhancing breeding success. Lapwing nests are relatively easy to find and thus are easy to protect from farming activities. In the Netherlands large numbers of volunteers participate in nest protection projects geared to lapwings and other ground-breeding farmland birds (Landschapsbeheer Nederland, 2005). In grassland, these projects result in greater nest success and bird populations in areas with such projects show a more positive trend than those outside these areas (Teunissen and Willems, 2004). A further option would be for farmers to be paid to protect nests within the framework of agri-environment schemes.

Besides lapwings, other ground-breeding farmland birds such as skylark, yellow wagtail *Motacilla flava* and stone curlew *Burhinus oedicnemus* might also suffer from the increased mechanisation rates on organic farms. Such effects might differ from species to species, however, given the differences in nest site preference and breeding period. Future studies should focus on these issues in order to obtain a complete picture of the effects of organic farming on different species of ground-breeding birds.

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