Breeding birds on organic and conventional arable farms

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Summary

As a result of agricultural intensification, populations of farmland birds have been in steep decline since the 1960s. Once common species such as grey partridge (*Perdix perdix*), skylark (*Alauda arvensis*) and corn bunting (*Emberiza calandra*) have shown declines of over 90%. Many species are present on Red Lists in most western European countries. Several studies showed that densities of breeding birds are higher on organically managed farms. This is often addressed to be caused by higher crop diversity, more non-crop habitats (e.g. grassy field margins) and the no-use of pesticides and artificial fertilizers on these farms. However, the causal mechanisms behind higher bird densities on organic farms are still not well understood. Besides that, no good data are available on the breeding success of birds on organic and conventional farms. This study focussed on comparing and explaining differences in breeding bird densities and breeding success between organic and conventional arable farms in the Netherlands. Additionally, effects of volunteer nest protection on nest success were analysed on both farm types. Finally, differences in invertebrate prey abundance were investigated between the two farm systems. This was done from a perspective of three different bird species, all with different feeding habits. These species were lapwing (*Vanellus vanellus*), feeding mainly on earthworms; skylark, feeding mainly on surface active invertebrates and barn swallow (*Hirundo rustica*) feeding on aerial invertebrates.

The study was carried out on 20 organic and 20 conventional arable farms in Oostelijk Flevoland and Noordoostpolder in the Netherlands. Both areas are characterised by open landscapes dominated with arable land use. Dominating crops are cereals (mainly winter wheat), potatoes, sugar beet and onions. A pairwise approach for farm selection was adopted in which surrounding landscape factors were kept equal for both farms. All organic farms

have been managed organically for at least 5 years and were all certified with the SKAL certificate.

Breeding bird densities

Territory densities of field-breeding species were compared during two years. In both years, densities of most species did not differ between organic and conventional farms. Only skylark and lapwing were more abundant on organic farms, but only skylarks showed a consistent pattern over both years. Differences in territory densities between the two farm types were explained examining the effects of three factors on territory densities: (1) non-crop habitats, (2) crop types and (3) within-crop factors. Organic farms had a more diverse cropping pattern, but there was no difference in the presence of non-crop habitats. Larger areas of spring cereals grown on conventional farms were the only explaining factor for differences in densities of skylark. For lapwing, the difference was only partly due to differences in crop type (more winter cereals on conventional farms), but differences in within-crop factors (probably as a result of crop management) were likely to have had an effect as well. Abundance of non-crop habitats did not differ between the two farming systems and could therefore not be responsible for found differences in breeding bird densities.

Besides comparing densities of field-breeding species, also the abundance of breeding barn swallows, a species of farmyards, was compared. This study also compared farmers' attitude towards presence of barn swallows. Abundance of breeding barn swallows did not differ between organic and conventional arable farms. Both organic and conventional farmers were positive towards the presence of barn swallows on their farms. This study showed that organic farming does not attract more barn swallows.

Breeding success

Although organically managed have higher densities of lapwings and skylarks than conventionally managed holdings, differences in crop management may lead to lower levels of 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. Therefore, nest success of lapwings was compared between organic and conventional arable farms during two years. Besides that, skylark breeding success was studied in one year (2006). Differences in breeding success were explained by analysing nest failure rates due to agricultural operations, predation and nest desertion.

For lapwing, nest success was lower on organic compared to conventional farms in one year. 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 do face specific threats on organic farms. To sustain or enhance lapwing populations on these farms, additional conservation measures should be implemented.

Skylark nest density was seven times higher on organic farms than on conventional farms. Skylarks showed a strong preference for spring cereals, lucerne and grass leys, all of which were mainly or exclusively grown on organic farms. On organic farms nests were initiated during the entire breeding season, but on conventional farms no nesting activity was found during the peak of the season (early May to early June). On organic farms 27% of all nests were successful. During the peak of the breeding season availability of suitable breeding habitat was limited on conventionally managed farms. Increasing the availability of suitable breeding habitat during the peak of the breeding season on conventional farms might provide one means of enhancing breeding skylark populations. On organic farms, crop management should focus on reducing nest loss due to farming operations.

Clutches of ground-nesting farmland birds are often destroyed by farming operations, especially on organic farms. This results in insufficient reproductive success and subsequently declining populations. Volunteer nest protection might enhance nest success of ground-nesting birds. Nest success of protected and unprotected Lapwing nests were therefore compared over two years. Although nest protection significantly reduced nest loss due to farming operations, there were no significant differences in total clutch survival of protected and unprotected nests. However, sample sizes of unprotected nests, and protected nests on organic farms, were relatively small, which may have reduced statistical power. There were indications that protected nests were predated or deserted more often. It should be recommend exploring different ways to improve the effectiveness of volunteer nest protection through a further reduction of nest loss due to farming operations and predation.

Food abundance

Reduction of food abundance has been mentioned to be one factor behind the declines of farmland bird populations. Extensive farm management, such as organic, is expected to provide more food for birds. In this study, we compared invertebrate prey abundance for birds between organic and conventional arable farms during the breeding season. Comparisons were made for three different groups of birds: (1) birds feeding on soil living invertebrates (earthworms), (2) birds feeding on ground-dwelling invertebrates and (3) birds feeding on aerial invertebrates. Invertebrate abundance was compared between organic and conventional farms and between crops and non-crop habitats. On organic farms earthworm abundance was 2-4 times higher compared to conventional sites, but no differences were found between crop types. Total abundance of ground-dwelling invertebrates did not differ significantly between organic and conventional farms, but positive effects were found for several individual taxonomic groups, such as carabid beetles and spiders. On organic farms invertebrate abundance was higher in carrots, cereals and onions compared to other crops. On conventional farms this was true for onions. Compared with most crops, ground dwelling invertebrate abundance was low in uncropped field margins and on ditch banks. On organic farms aerial invertebrate abundance was approximately 70% higher compared to conventional farms. Especially on cereal fields aerial invertebrates were abundant.

This study showed that organic farming will probably not enhance breeding bird populations of most species of farmland birds. However, differences in population trends of farmland birds between organically and conventionally managed farms are still unknown. Therefore, other options should be explored. These options should focus on enhancing availability of suitable breeding habitat, food availability during the breeding season and at improving the winter situation. Development of effective agri-environment schemes and reintroduction of set-aside should therefore be stimulated by policy makers. Currently, financial possibilities are too limited to ensure effective management of farmland bird populations. The future European Common Agricultural Policy (CAP) should therefore be reformed and focusing more on delivering social values, such as biodiversity and environmental quality.

Chapter 1

General introduction

ABC-book from the 1950s indicating that the skylark was a common bird in those days

Intensification of arable farming and the decline of farmland birds

During the past decades agricultural yields have increased enormously in north-western Europe (e.g. Chamberlain *et al.*, 2000). In order to reach these high yields European agriculture has intensified drastically. The process of agricultural intensification is characterized farm specialization, increased field size, removal of semi-natural habitats and increased inputs of agrochemicals (artificial fertilizers and pesticides). Mixed farms have been replaced by farms which focus on only one type of agriculture, such as arable or dairy. Moreover, arable farmers grow less different crop types and less varieties of certain crop types, and together with removal of semi-natural habitats this has resulted in larger monocultures (e.g. Stoate *et al.*, 2001; Robinson and Sutherland, 2002). The use of agro-chemicals has been expanded from the 1970s onwards. Larger areas are sprayed with pesticides and per area unit more fertilizers are applied (Chamberlain *et al.*, 2000; Stoate *et al.*, 2001).

As a consequence of processes linked to agricultural intensification, landscape quality, in terms of landscape diversity and areas of semi-natural habitats of modern farmland, has declined (Stoate *et al.*, 2001; Robinson and Sutherland, 2002). In the Netherlands currently, farm area covered with semi-natural habitats is only about 2-3% (Manhoudt and de Snoo, 2003). Semi-natural habitats like field margins and hedgerows are of large importance for plants, invertebrates, birds and mammals in agricultural habitats. As a result of this development agricultural landscapes offer less suitable habitat for many species.

Besides negative effects on landscape quality, agricultural intensification has also resulted in reductions of populations of a wide range of taxonomic groups. Herbicide use, increased inputs of fertilizers and increased tillage frequency have had negative effects on wild plants (Robinson and Sutherland, 2002; Baessler and Klotz, 2006). Increased usage of insecticides is one of the main causes behind declines of invertebrate populations (Benton *et al.*, 2002; Robinson and Sutherland, 2002; Schweiger *et al.*, 2005). Reduction of available plant material and invertebrates has resulted in the fact that species higher in the food chain, such as birds, have become more and more under pressure as well (Siriwardena *et al.*, 1998; Donald *et al.*, 2001; Wretenberg *et al.*, 2006).

Population declines of farmland birds have strongly raised the attention of conservationists and ecologist. Consequently, relations between agricultural intensification and farmland birds have been studied intensively (e.g. Chamberlain *et al.*, 2000; Donald *et al.*, 2001, 2006, Wretenberg *et al.*, 2006). Populations of several species show severe declines and currently species like skylark *Alauda arvensis*, linnet *Carduelis cannabina* and grey partridge *Perdix perdix* have been placed on Red Lists in several countries (Gregrory *et al.*, 2002; van Beusekom *et al.*, 2004; Gärdenfors, 2005). As an illustration table 1 shows the trends of characteristic bird species of arable land in the Netherlands, UK and Sweden, as well as their conservation status.

Several changes in current agricultural practice have initiated these population declines. During the breeding season, availability of suitable nest sites and food are limited in modern agricultural landscapes. First of all, the reduction of crop diversity has limited multi-brooded ground-breeding species (e.g. skylark, yellow wagtail *Motacilla flava*) to produce multiple broods. These species probably need more than one successful brood per breeding season in order to self sustain the breeding population (Wilson *et al.*, 1997). Secondly, the shift from spring sown cereals to autumn sown cereals which took place especially in the UK (e.g Chamberlain *et al.*, 2000) has reduced the availability of suitable breeding habitat for species like skylark (Wilson *et al.*, 1997; Chamberlain *et al.*, 1999a). Thirdly, removal of semi-natural habitats like hedgerows has reduced the availability of suitable breeding sites for species like linnet and yellowhammer *Emberiza citrinella.* Fourthly, evidence has been found that increased usage of insecticides has resulted in reduced food (invertebrate) availability and consequently a reduction in reproductive success (Potts, 1986; Hart *et al.*, 2006).

Besides problems during the breeding season, also winter habitat has been degraded. The switch from spring sown cereals to autumn sown cereals have reduced the availability of stubble fields, which are important foraging habitats for wintering granivorous farmland passerines (e.g Hancock and Wilson, 2003; Gillings *et al.*, 2005; Orlowski, 2006; Perkins *et al.*, 2008). The use of more efficient harvesting methods has reduced the amount of cereal grains left on the fields during winter. Furthermore, increased usage of herbicides has limited weed seed production. These factors have probably contributed to reduced winter survival rates of farmland birds and consequently population declines (Peach *et al.*, 1999; Siriwardena *et al.*, 2008).

In order to reverse the declines of farmland bird populations, roughly two approaches could be adopted: (1) agri-environment schemes and (2) organic farming. Agri-environment schemes are based on the principle that some area of the agricultural land is managed less intensively in order to provide suitable habitat for certain species or taxonomic groups. The remaining area can still be managed very intensively. Examples of agri-environment schemes are uncropped field margins and set-aside land. In contrast with agri-environment schemes, organic farming aims at sustaining healthy ecosystems. IFOAM, the worldwide organization for organic farming, uses the following definition for organic farming:

"Organic farming is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the

shared environment and promote fair relationships and a good quality of life for all involved."

As a result of this system-broad conversion it a wide spectrum of species and taxonomic groups benefits from this (Hole *et al.*, 2005).

Table 1 Population trends and presence on Red Lists of bird species characteristic to arable farmland. Population trends are expressed as % of population change, NDA = no data available. NL = the Netherlands, UK – United Kingdom, SW = Sweden. Sources: Gregrory *et al.*, 2002; van Beusekom *et al.*, 2004; Gärdenfors, 2005.

	Population trend			Present on Red List		
Species	NL (1973-2000)	UK (1970-2001)	SW (1976-2001)	NL	UK	SW
Grey Partridge	-73	-86	NDA	X	X	X
Skylark	-90	-54	-55	X	X	X
Tree Sparrow	-84	-94	-25	X	X	
Linnet	-53	-51	-53	X	X	X
Yellowhammer	0	-52	-40		X	
Corn Bunting	-94	-89	NDA	X	X	X
Reed Bunting	+55	-48	-1.8[1]		X	
Yellow Wagtail	-18	-59	-3.9[1]	X		
Meadow Pipit	-25	-31	-1.4[1]	X		
Lapwing	+5	-41	-32			
Turtle Dove	-74	-77	Not breeding	X	X	NA
Barn Swallow	0	+11	-3	X		

[1] = Mean population change per year

Managing birds on arable farmland

Agri-environment schemes

In arable areas, one of the most common initiatives is the installation of uncropped field margins. In general, these margins are approximately 3-10 m wide, with a grass or herbaceous vegetation. Aim of these margins is often to safeguard habitats for plants, invertebrates and birds. Some evidence has been found that uncropped field margins can be an effective measure for flora protection in agricultural habitats (Kiss *et al.*, 1997). In addition to this, several studies have pointed out the importance of uncropped field margins for different invertebrate groups (e.g. Dennis and Fry, 1992; Kromp and Steinberger, 1992). Also for birds positive effects of field margins have been recorded. Field margins can have different functions for birds, such as foraging sites (Perkins *et al.*, 2002) and breeding sites.

A second widespread agri-environment scheme is set-aside. Originally, the EU installed the set-aside regulation in the early 1990s in order to counteract overproduction of cereals. As a result of this regulation farmers were obliged to take some of their land out of production in order to counteract the overproduction. Side-effect of this regulation was a positive effect on farmland bird numbers. Soon it was clear that set-aside fields attracted high numbers of bird during the breeding season and during winter (Berg and Pärt, 1994; Buckingham *et al.*, 1999; Henderson *et al.*, 2000). In the Netherlands Montagu's harrier *Circus pygargus* numbers increased as a result of the introduction of set-aside fields which resulted in high numbers of voles (Koks *et al.*, 2007).

Although some studies have proven that agri-environment schemes can enhance farmland bird populations (e.g. Peach *et al.*, 2001), the effectiveness of agri-environment schemes has been under debate (e.g. Kleijn *et al.*, 2001; Kleijn and Sutherland, 2003; Kleijn and van Zuylen, 2004). Besides this, agri-environment schemes are financed with government money and thus vulnerable for changes in the political field. This means that there is no guarantee for subsidies and thus for sustainable management of farmland birds.

Organic farming for farmland birds

Organic arable farms and 'landscape lay-out': crop rotation and semi-natural habitats

Organic arable farmers generally grow more different crop types than conventional farmers (McCann *et al.*, 1997; Levin, 2007). This is mainly done to reduce the risk of outbreaks of crop damaging fungi and soil active invertebrates (e.g. Nematoda). More different crop types provide more different habitats and that might result in higher avian diversity. Besides that, higher crop diversity on organic farms might provide multi-brooded species with more suitable nesting sites throughout the entire breeding season. Besides more different crop types, organic farmers grow often spring sown cereals in stead of autumn sown cereals (Bengtsson *et al.*, 2005; Hole *et al.*, 2005). Growing mainly spring sown crop probably enhances food accessibility for ground feeding birds as swards are less dense during the breeding season. Furthermore, it is probably more suitable as nesting site for ground-breeding species, such as lapwing and skylark.

Several studies showed that organic farms have more semi-natural habitat (i.e. habitats not used for production purposes) compared to conventional counterparts (van Mansvelt *et al.*, 1998; Fuller *et al.*, 2005; Gibson *et al.*, 2007; Levin, 2007). Additionally, semi-natural habitats on organic farms are found to have larger dimensions as well (Chamberlain *et al.*, 1999b; Fuller *et al.*, 2005; Gibson *et al.*, 2007). As semi-natural habitats probably need a certain minimum size in order to attract birds (Sparks *et al.*, 1996; Marshall *et al.*, 2006) the effects on bird densities might be stronger when they are larger, wider or taller.

Organic arable farms and crop management: pesticides and fertilizers

In organic agriculture the use of artificial pesticides is prohibited (SKAL, 2008). In stead, organic farmers apply “natural” methods to control insect pests and weeds. Among other ways, insect pests are controlled by enhancing populations of natural enemies (e.g. Staphylinidae, Parasitica). Weeds are mainly controlled mechanically, by harrowing and hoeing. Although the prohibition of artificial agrochemicals is likely to result in higher food abundance (invertebrates and plant material) for birds, mechanical weeding might be a potential threat to especially ground-breeding birds (e.g. skylark, yellow wagtail, lapwing).

Instead of artificial fertilizers, organic farmers apply organic manure and sow nitrogen binding crops after harvesting. As a result, soil organic matter probably increases, stimulating soil life. Consequently, a richer soil life probably also stimulate above ground invertebrates (Smeding and de Snoo, 2003), which form an important part of the diet of many farmland birds (Holland *et al.*, 2006).

Objectives

There are several previous studies that compared breeding bird densities between organic and conventional farms (Christensen *et al.*, 1996; Wilson *et al.*, 1997; Chamberlain *et al.*, 1999b; Freemark and Kirk, 2001; Beecher *et al.*, 2002; Lubbe and de Snoo, 2007). Most of these studies concluded positive effects of organic farming on breeding bird densities, but the reasons behind these differences are not clear yet.

However, territory establishment is only one part of the story. Differences in crop management and crop partition are likely to affect breeding success. This information is of crucial importance in order to conclude whether organic farming does not only hold higher densities of bird, but also enhances farmland bird populations. The objective of this dissertation is to compare organic and conventional arable farms as breeding habitat for farmland birds. Therefore, territory densities, breeding success and food abundance will be compared between organic and conventional arable farms. Differences will be explained by investigating the effects differences in farm lay-out (crops and non-crop habitats), crop management and food abundance (for territory densities and breeding success).

In pursuit of this goal, a series of studies was carried out with the following objectives: (1) assessing and explaining differences in breeding bird densities between organic and conventional arable farms, (2) assessing and explaining differences in breeding success of birds between organic and conventional farms, (3) assessing the effectiveness of volunteer nest protection on reproductive success on both farm types, (4) assessing chick food availability on organic and conventional arable farms. Differences in breeding bird densities were explained by looking at three different factors: (1) abundance of non-cropped habitats, (2) crop partition, and (3) within-crop factors. The latter includes sward structure and food abundance. Concerning reproductive success, direct effects of farm management on nest survival were investigated. Additionally, the possibility of indirect effects of differences in food resources on breeding success was assessed as well.

Thesis structure

Differences in breeding bird densities

Chapter 2: In this chapter territory densities of ground-breeding birds were compared between organic and conventional arable farms for a selection of farmland bird species. Additionally, it was analysed why the abundance of certain species differed between the two farming systems and why this was not the case for other species.

Chapter 3: This chapter describes differences in abundance of breeding barn swallows (*Hirundo rustica*) on organic and conventional arable farms. Besides this, farmers' attitude towards presence of Barn Swallows was compared as well.

Differences in breeding success

Chapter 4: This chapter focuses on the nest success of lapwings (*Vanellus vanelus*) on organic and conventional farms. Differences in nest success between the two farming systems were analysed and explained by investigating three causes of nest failure: (1) farming operations, (2) predation, and (3) nest desertion.

Chapter 5: This chapter focuses on the breeding activity and breeding success of skylarks (*Alauda arvensis*) on organic and conventional arable farms. The effects of crop partition on breeding activity and crop management on breeding success are evaluated.

Chapter 6: In this chapter it was analysed whether volunteer nest protection of lapwings could be a possibility to enhance populations of ground-breeding farmland bird. Therefore, a case study was carried out comparing the nest success of lapwings on organic and conventional arable farms with and without nest protection.

Differences in food abundance

Chapter 7: In this chapter bird chick food availability is compared between organic and conventional farms.

Chapter 8: General discussion

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Chapter 2

Field-breeding birds on organic and conventional arable farms in the Netherlands

Steven Kragten & Geert R. de Snoo

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The author carrying out a breeding bird survey

Abstract

In this study territory densities of field-breeding farmland birds were compared on pairwise-selected organic and conventional arable farms for two years. Differences in territory densities between the two farm types were explained examining the effects of three factors on territory densities: (1) non-crop habitats, (2) crop types and (3) within-crop factors. In both years, densities of most species did not differ between organic and conventional farms. Only skylark and lapwing were more abundant on organic farms, but only skylarks showed a consistent pattern over both years. Differences in crop types grown between the two systems were the only explaining factor for differences in densities of skylark. For lapwing, the difference was only partly due to differences in crop type, but differences in within-crop factors (probably as a result of crop management) were likely to have had an effect as well. There were no significant differences in abundance of non-crop habitats between the two farming systems, so this could not explain differences in territory densities.

Key words: Organic farming; Farmland birds; Habitat preference; Non-crop habitats; Crops; Landscape composition

Introduction

Populations of characteristic farmland birds are under severe pressure in north-west Europe (BirdLife International, 2004), with agricultural intensification cited as the main force behind this decline, i.e. increased usage of agrochemicals (pesticides, artificial fertilizers), removal of non-crop habitats and farm specialisation (Chamberlain *et al.*, 2000; Donald *et al.*, 2001, 2006). Organic farming is mentioned as one possible way of enhancing farmland bird populations (Christensen *et al.*, 1996; Lokemoen and Beiser, 1997; Chamberlain *et al.*, 1999; Freemark and Kirk, 2001; Beecher *et al.*, 2002; Belfrage *et al.*, 2005).

Organic farming systems differ from conventional systems in several aspects. In the first place, no artificial pesticides or fertilizers are used on organic farms, leading to greater food availability in terms of both invertebrates and plant matter (reviewed by Bengtsson *et al.*, 2005; Hole *et al.*, 2005). Secondly, organic arable farms generally have a wider crop rotation scheme, resulting in greater crop diversity (McCann *et al.*, 1997; Levin, 2007). A more diverse cropping pattern may provide multi-brooded ground-breeding birds with more suitable nesting sites throughout the breeding season (Wilson *et al.*, 1997). Finally, organic farms generally have larger areas of non-crop habitats (Gibson *et al.*, 2007; Levin, 2007). As non-crop habitats are used as foraging and nesting sites by many bird species (Sparks *et al.*, 1996; Vickery and Fuller, 1998), this is likely to have beneficial effects on bird densities as well.

Although several studies compared bird territory densities on organic and conventional farms, deeper analyses of the causal mechanisms behind observed differences are scarce (e.g. Chamberlain *et al.*, 1999; Freemark and Kirk, 2001). To explore opportunities for enhancing farmland bird populations, it is not enough just to know *whether* organic farming benefits farmland birds, but also *how* it does so. As birds use species-specific cues to select territories, differences between organic and conventional arable farms may give rise to species-specific differences in territory densities (Cody, 1985). Therefore, more detailed analyses at species level should be carried out. The present study aims to compare bird territory densities on organic and conventional arable farms. Furthermore, it aims at species-specific explanations for observed differences. These explanations are related to three different factors: (1) differences in non-crop habitats, (2) differences in crop type and (3) differences in within-crop factors.

Materials and methods

Study area

This study was carried out in two neighbouring large-scale arable farming areas of the Netherlands: Oostelijk Flevoland and Noordoostpolder. Both are young polders (reclaimed during the 1950s and 1930s, respectively) with a clay soil of marine origin. Both polders have a similar homogenous landscape which is characterised by rectangular parcels of approximately 22 (Noordoostpolder) and 30 (Oostelijk Flevoland) ha. Most parcels are bordered by ditches and larger waterways. The only tree lines are along roads. At several locations there are operational wind turbines. The dominant crops are potatoes, winter cereals, sugar beet and onions. Set-aside fields are very rare in the area and in most cases they do not have grassy or regenerated vegetation, but are tilled frequently, in order to minimize weed populations. Fields are generally ploughed in autumn, with no stubble being left in winter. Pesticide use by farmers is comparable to other Dutch arable regions (de Snoo and de Jong, 1999).

In the study a total of 40 arable farms were selected in a pairwise set-up, each pair consisting of one organic and one conventional farm. Farms were paired with respect to surrounding landscape elements such as woodlots, tree lines, roads, power lines and wind turbines, with soil type and groundwater levels the same on both. On average, the conventional farms were slightly larger than the organic, but this difference was not significant (organic: 36 ha.; conventional: 40 ha.; Paired-Samples T-test, $t = 1.062$, df 19, NS). There was only little variation in surrounding landscape between farm pairs. On-farm habitat factors such as crops and non-crop habitats were not included in the pairing protocol, these constituting essential differences between the two farming systems and are a result of farm management. All organic farms were managed organically for at least five years and are certified by SKAL, the certification body for organic food production in the Netherlands (www.skal.nl). According to the SKAL guidelines, use of non-biological agrochemicals and artificial fertilizers is prohibited.

Data collection

The study was carried out in 2004 and 2005. In 2004 20 farms (10 organic and 10 conventional) were included, while in 2005 the study was extended to 40 farms (20 organic and 20 conventional). All farms involved in 2004 participated in 2005 as well. During field visits, crops and non-crop habitats were mapped and acreages of each determined by measuring the dimensions (length and width). In the case of woody elements the tree crown projection was defined as the area. On each visit, crop height (cm) and ground cover (visual estimate) were determined at three fixed points in the fields.

To assess bird territory densities, the standard method of the Dutch Breeding Bird Monitoring Project was employed (van Dijk, 2004). Farms were visited five times between April and July. Visits were carried out from 30 min. before sunrise till three h. after sunrise. Both of the farms in each pair were investigated on the same morning, but the order in which they were visited was alternated during the field period. Birds were mapped while walking transects along the field edges. Only the territories of field-breeding species were surveyed, thus excluding farmyard and hedgerow species. Species that breed almost exclusively in reed-beds were also not included in this study, as reed-beds were managed by the water board, although owned by the farmers.

Data analysis

Non-crop habitats were assigned to one of four categories: (1) grassy (including field margins and ditch banks), (2) ditches, (3) reed and (4) woody and the percentage area in each category calculated for each farm. Rotational leys, present on just two organic farms, were not included in grassy non-crop habitats but were considered as crops. Ditches were dry during the majority of the breeding season. Reed was mainly present alongside larger waterways owned by the water board and was cut every two years. Hedgerows, shrubs and trees were considered as woody habitat elements. The relative abundance of crops on each farm was likewise calculated as a percentage of farm area. In addition, crop diversity was calculated and expressed as the Shannon-Wiener index *H'*. Differences in abundance of non-crop habitats, crops and crop diversity between the two farm types were tested using Wilcoxon matched pair tests.

To analyse differences in territory densities between both farming types General Linear Mixed Models (GLMM) with Poisson error and logarithm link function were used. Therefore, territory densities per farm were log(x+1) transformed. Farm type (organic/conventional) and interaction between farm type and polder (Oostelijk Flevoland/Noordoostpolder) were included as fixed terms. Farm pair was included as random factor. The analyses were carried out in Genstat 10.1. Because effects of organic farming on territory densities are probably independent between species, a correction method for multiple testing (e.g. Bonferroni) was not required (Sokal and Rohlf, 2000).

To investigate crop preference, bird territory densities were compared between the six main crops: potatoes, sugar beet, onions, spring cereals, winter cereals and carrots. Analyses were carried out using the Kruskall-Wallis test (SPSS 12.0), followed by a testing procedure analogous to the Bonferroni pairwise comparison procedure as described in Neter *et al.* (1996).

Territory densities on organically and conventionally managed crops were compared in order to assess the effects of factors at crop level. Because in most cases the analysed crop was not grown on both farms of a pair a paired test could not be applied and Mann-Whitney U-test was used instead. In this case, test results per species are probably not independent between different crops, so the Dunn-Šidak method (Sokal and Rohlf, 2000) was applied to correct for this. In order to see whether differences in crop height or ground cover appeared between organic and conventional crop types these variables were compared at five moments during the breeding season using a Mann-Whitney U-test.

Results

On average, about 3-4% of the farm area consisted of non-crop habitats. Grassy, semi-natural elements were far more dominant than ditches, reed or woody elements. Grassy elements comprised grassy field margins and ditch banks. Woody elements consisted mainly of solitary trees and scrub, though some farms had a small hedgerow. Organic farms had slightly more non-crop habitat than conventional farms (2004: 3.7 % vs. 3.1%; 2005: 4.4% vs. 3.6%), although in both years differences were not significant (2004: Wilcoxon, $Z = 1.682$, NS, 2005: Wilcoxon, $Z = 1.717$, NS). When differences were analysed per habitat type only in 2005 more woody habitat elements were found on organic farms (Wilcoxon, $Z = 2.666$, $P < 0.01$), although the absolute difference was small.

The dominant crops were potatoes, spring cereals, onions, sugar beet and winter cereals, though most farms had some vegetable crops, too. There were several major differences in crop type between the two farming systems (Table 2). On conventional farms relatively more potatoes, sugar beet and winter cereals were grown. On organic farms more spring cereals were grown. Furthermore, crop diversity was generally higher on the organic farms.

Table 2 Differences in crop type between organic and conventional arable farms, showing mean relative farm area (± SD) with each crop and percentage of farmers growing the crop. Crop diversity is expressed as the Shannon-Wiener index. N = number of farms. *** = $P < 0.001$, ** = $P < 0.005$, * = $P < 0.05$, NS = $P > 0.05$.

Year	**2004**					**2005**				
Farm type	***Organic (N=10)***		***Conventional (N=10)***			***Organic (N=20)***		***Conventional (N=20)***		
	Area (%)	Farms (%)	Area (%)	Farms (%)	Sig	Area (%)	Farms (%)	Area (%)	Farms (%)	Sig
Potatoes	19 ± 4	100	28 ± 6	100	*	16 ± 9	85	27 ± 8	95	**
Spring cereals	28 ± 8	100	4 ± 6	30	**	27 ± 11	100	5 ± 9	30	***
Onions	11 ± 7	70	11 ± 9	70	NS	11 ± 7	75	11 ± 10	65	NS
Sugar beet	5 ± 11	20	16 ± 9	80	*	2 ± 5	15	15 ± 10	80	***
Winter cereals	0 ± 0	0	15 ± 11	70	*	0	0	12 ± 14	50	*
Carrots	7 ± 8	50	4 ± 5	40	NS	7 ± 8	55	4 ± 6	35	NS
Belgian endive	1 ± 3	10	6 ± 8	40	NS	3 ± 6	25	8 ± 11	45	NS
Beans	5 ± 7	40	3 ± 11	10	NS	5 ± 6	50	3 ± 8	15	NS
Peas	3 ± 8	20	0 ± 0	0	NS	6 ± 8	40	1 ± 4	15	*
Other crops	21 ± 17	90	12 ± 16	60	*	23 ± 15	85	14 ± 17	45	NS
Crop diversity	2.5 ± 0.3		2.3 ± 0.3		NS	2.6 ± 0.5		2.2 ± 0.4		*

Table 3 shows mean bird territory densities per 100 ha. on organic and conventional farms. There were no significant differences in total territory density of field-breeding species between the two types of farm. At the species level, only skylark (in 2004 and 2005) and lapwing (only 2004) were significantly more abundant on organic farms. Although territory densities of other species did not differ significantly between farm type, each species had a consistent pattern of farm preference in both years. For example, territory densities of common quail (*Coturnix coturnix*) were higher on organic farms in both years. Of the investigated species, four were more abundant on organic farms in both years, while for three species the opposite was true.

As an extra check to see whether results were repeatable between years bird territory densities of 2005 were analysed using the subset of farm that took part in the study in 2004 as well. As in 2004, skylark reached higher densities on organic farms (GLMM, $F = 6.84$, $P < 0.05$). Lapwing reached again higher densities as well, although the difference approached significance (GLMM, $F = 4.29$, $P = 0.053$). Territory densities of all other species did not differ.

As there were no differences in the abundance of non-crop habitats between organic and conventional farms this could not have caused differences in bird territory densities. Therefore, possible effects of non-crop habitats on bird abundance were not further analysed.

Skylarks showed a consistent crop preference in both years (Figure 1). Skylark densities were relatively high in spring cereals compared with other crops. So, the larger areas of spring cereals on organic farms are probably enhancing skylark territory densities here. For lapwings, crop preferences were less clear, although in both years winter cereals were completely avoided. In 2005 lapwing territory densities were highest in onions, but in 2004 no crop type was clearly preferred. Winter cereals were exclusively grown by conventional farmers, but there were no differences in relative areas of onions between the two management types. The larger areas of winter cereals grown on conventional farms seem to have a negative effect on breeding lapwing densities. Of the species that did not differ between the two farm types yellow wagtail, common quail and meadow pipit showed a crop preference. These species preferred spring and winter cereals, potatoes (only yellow wagtail) and carrots (only meadow pipit). However, the total area of these crops did not differ between farm types.

Table 3 Mean bird territory densities (per 100 ha. ± SD) on organic and conventional arable farms. Total bird territory density and bird diversity are also shown. ** = *P* < 0.01, * = *P* < 0.05, NS = *P* > 0.05.

Year	**2004 (10 farm pairs)**			**2005 (20 farm pairs)**		
Farm type	***Organic***	***Conventional***	***P***	***Organic***	***Convention al***	***P***
Common Quail *Coturnix coturnix*	1.4 ± 1.6	1.0 ± 1.9	NS	1.2 ± 1.6	1.0 ± 2.1	NS
Oystercatcher *Haematopus ostralegus*	1.2 ± 2.0	1.5 ± 3.1	NS	1.3 ± 1.8	1.6 ± 2.6	NS
Lapwing *Vanellus vanellus*	13.1 ± 7.3	5.7 ± 6.7	*	12.6 ± 9.8	8.0 ± 6.6	NS
Skylark *Alauda arvensis*	8.8 ± 4.3	2.3 ± 2.8	*	7.7 ± 4.6	3.3 ± 3.1	*
Meadow Pipit *Anthus pratensis*	6.0 ± 4.3	8.1 ± 5.7	NS	9.5 ± 10.7	9.6 ± 6.7	NS
Yellow Wagtail *Motacilla flava flava*	17.5 ± 10.4	20.1 ± 11.4	NS	9.7 ± 8.3	14.1 ± 12.6	NS
Ringed Plover *Charadrius hiaticula*	0.3 ± 1.0	0.0 ± 0.0	NS	0.7 ± 2.9	0.1 ± 0.5	NS
Redshank *Tringa totanus*	--	--	NA	0.0 ± 0.0	0.2 ± 0.8	NS
Black-tailed Godwit *Limosa limosa*	--	--	NA	0.0 ± 0.0	0.5 ± 2.1	NS
Total density	48.1 ± 20.3	38.7 ± 18.3	NS	42.6 ± 28.4	38.4 ± 27.1	NS

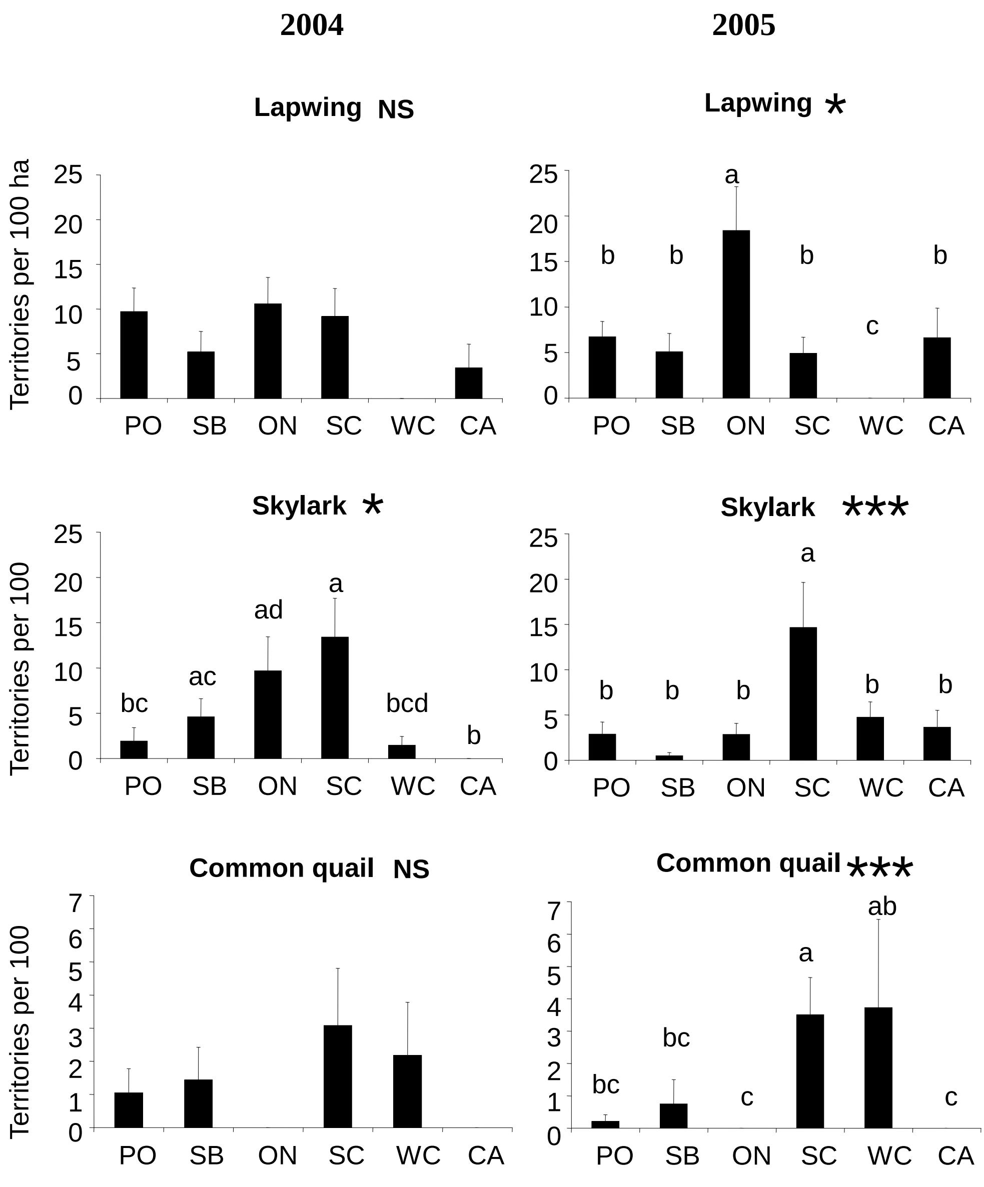

Figure 1 Territory densities (mean/100 ha. ± SE, vertical axis) of lapwing and skylark in six main crops in 2004 and 2005. PO = potatoes, SB = sugar beet, ON = onions, SC = spring cereals, WC = winter cereals, CA = carrots. Kruskal-Wallis test: * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$, NS = $P > 0.05$. Letters above bars indicate inter-crop differences.

2004 2005

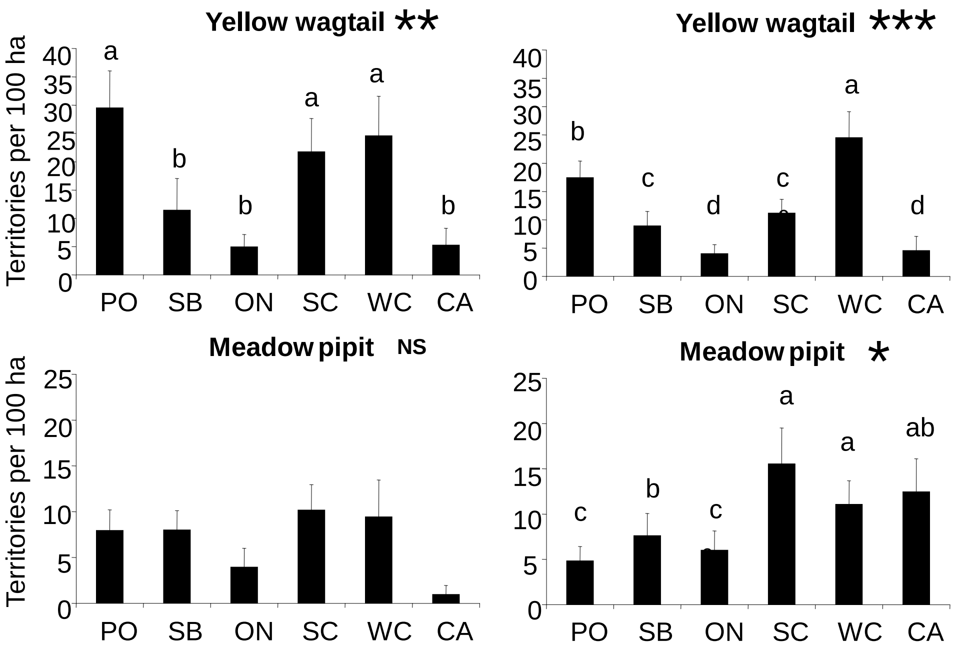

Figure 1 Continued.

To investigate whether differences in bird territory densities were caused by within-crop factors, comparisons were carried out within crops grown by at least six organic and six conventional farmers: potatoes (2004 and 2005), onions (2004 and 2005), spring cereals (2005) and carrots (2005). In both years lapwing densities were higher on organically managed onion fields compared to conventionally managed fields, but only in 2004 the difference was significant. Densities of other species did not differ between organic and conventional crop types. There was no difference in the growth rate of organic and conventional onions (all Mann-Whitney *U*-tests, $P > 0.05$). Therefore, the difference in lapwing densities was likely to be due to other within-crop factors.

Discussion

This study showed that the effects of organic arable farming on field-breeding birds are limited. Total densities did not differ between the two farming types and at the species level only skylark and lapwing reached higher territory densities on organic farms. This latter is in line with findings of previous studies (Christensen *et al.*, 1996; Wilson *et al.*, 1997; Chamberlain *et al.*, 1999). However, higher densities of lapwings were only found in 2004 when only ten pairs of farms were included in the study. Larger areas of spring cereals on organic farms seemed to be the only cause for higher skylark densities. For lapwings, larger areas of winter cereals on conventional farms and organic crop management (onions) are likely to have resulted in higher densities on organic farms. Territory densities of other species did not differ between the two farm types. This is probably a result of the fact that these species do not have a preference for a crop type which is grown in larger areas on one of the farm types.

In general, abundance of non-crop habitats did not differ significantly between organic and conventional farms, which is in contrast with other studies (Gibson *et al.*, 2007; Levin, 2007). Only in 2005 woody elements were more abundant on organic farms. The birds investigated in this study all prefer open landscapes and presence of trees had a negative effect on densities of these species (e.g. Wilson *et al.*, 1997). Despite higher abundance of trees, skylark density was higher on organic farms in 2005. This indicated that the difference in farm area with woody elements between the two farming types was probably too small.

Cropping regime differed in many aspects between the two farming types. The proportion of farm area occupied by spring cereals was higher on organic farms. The opposite was true for winter cereals, potatoes and sugar beet. Furthermore, crop diversity was higher on organic farms. Several studies showed that spring cereals were more attractive to skylarks compared to most other crop types (e.g. Schläpfer, 1988; Wilson *et al.*, 1997; Kragten *et al.*, 2008). The avoidance of winter cereals by lapwing probably contributed to the lower lapwing densities on conventional farms.

Only for lapwing indications were found that actual organic management resulted in higher densities. In most cases however, territory densities did not differ between fields with the same crop type but different management (organic/conventional). This indicated that most species did not use cues related to crop management for territory selection. When the preferred crops are grown in equal proportions on both farm types, differences in territory densities between the two farm types are less likely to occur.

In order to get a complete picture of the effects of organic farming on breeding birds, reproductive output should be compared in order to conclude whether organic farming really enhances farmland bird populations. On organic farms, clutch survival of ground-nesting birds can be reduced because of usage of mechanical weeding methods instead of herbicides (Kragten and de Snoo, 2007). At the same time, though, breeding success might be enhanced by higher food availability (invertebrates, seeds) on such farms.

Further promotion of organic farming might further increase the area of organically managed farmland. Because arable farmers will change their crop rotation scheme when converting to organic farm management, the area of winter cereals will be reduced and the area of spring cereals will possibly grow. This can have positive effects on both skylark and lapwing. On the other hand, almost no differences were found in territory densities between organically and conventionally managed fields with the same crop type. This indicates that increasing the areas of preferred crop on conventional farms might help farmland bird populations as well.

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Chapter 3

Breeding barn swallows *Hirundo rustica* on organic and conventional arable farms in the Netherlands

Steven Kragten, Erwin Reinstra & Erik Gertenaar

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Abstract

Populations of farmland birds are under pressure as a result of agricultural intensification. Less intensive farming methods, such as organic are believed to be a possibility to halt these population declines. Besides that, organic farmers have possibly a more positive attitude towards nature and environment which can have positive effects on breeding birds as well. This study compared farmers' attitude towards presence of barn swallows *Hirundo rustica* and abundance of breeding barn swallows between organic and conventional arable farms in the Netherlands. Abundance of breeding barn swallows did not differ between organic and conventional arable farms. Both organic and conventional farmers were positive towards the presence of barn swallows on their farms. This study showed that organic farming does not attract more barn swallows. However, agricultural intensification could have resulted in lower breeding success and consequently population declines, although other factors are possibly playing a role as well.

Keywords: Barn swallow; Organic farming; Arable farming; Agricultural intensification; Farmers' attitude

Introduction

Populations of farmland birds have been in steep decline since a few decades now (e.g. Siriwardena *et al.*, 1998; Donald *et al.*, 2006). As a result of these declines species like skylark *Alauda arvensis*, corn bunting *Miliaria calandra* and grey partridge *Perdix perdix* have been put on Red Lists in several European countries (e.g. van Beusekom *et al.*, 2004; Gärdenfors, 2005). New developments on the world market, such as increased demands for cereals and biofuels, are likely to further intensify agriculture and possibly further decrease farmland bird populations.

Barn swallows *Hirundo rustica* are characteristic birds of agricultural areas, including grassland areas and arable areas. Just like other farmland birds, barn swallow populations declined during the last decades in large parts of Europe (BirdLife International, 2004). Causes of barn swallow population declines are related to conditions in breeding grounds, migration and conditions at wintering quarters. Agricultural intensification has contributed to reduced populations in several ways. First, increased pesticide use and reduced grazing livestock is associated with a reduction of invertebrates (e.g. Vickery *et al.*, 2001; Benton *et al.*, 2002). Reduction of food availability during the breeding season can reduce the breeding success (e.g. Hart *et al.*, 2006). Secondly, especially in arable areas, farm specialisation might have resulted in barn swallow population declines (Evans and Robinson, 2004). In wintering habitats and during migration environmental conditions are shown to have great impact on barn swallow populations (Baillie and Peach, 1992).

As agricultural intensification is mentioned to be one factor causing barn swallow population declines, less intensive farming such as organic should be beneficial for barn swallows. In order to see whether this could be true, the abundance of breeding barn swallows was compared between organic and conventional arable farms. Besides this, farmers' attitude towards presence of barn swallows was assessed as well. As respect for and conservation of the environment, nature and landscape have a central place in the philosophy of organic farming (IFOAM, 2005) it is hypothesized that organic farmers are more positive towards the presence of barn swallows. As a result, this could result in better habitat conditions for barn swallows on organic farms and consequently in higher numbers of breeding barn swallows.

Materials and methods

The study was carried out on 40 arable farms in the province of Flevoland in the Netherlands (approximate location 52°32'N, 05°46'E) in the spring of 2005. Conventional farms were somewhat larger than organic farms, but the difference was not significant (Conventional: 40 ha; Organic: 36 ha; Paired-samples *t*-test, t = 1.062, df 19, NS). Farms of one pair were at least 600 meters apart from each other. Conventional farms were never adjacent to an organically managed farm, including organic farms that were not included in this study. Dominant crops grown in the area are winter cereals, potatoes, sugar beet and onions. Farms were selected according to a pairwise set-up, each pair consisting of one organic and one conventional farm. All organic farms have been managed organically for at least 5 years. Conventional farms applied pesticides and artificial fertilizers. On organic farms weeds were removed mechanically and occasionally biological pesticides or natural enemies were used to fight insect pests. Instead of artificial fertilizers, only manure was used on organically managed farms. The pairing procedure was based on surrounding landscape, which was similar for both farms in a pair. On farm differences, such as crop rotation scheme and abundance of non-crop habitats (e.g. field margins, hedgerows), were not included in the pairing procedure as these are direct effects of differences in farm management. Organic farms grew more spring cereals compared to conventional farms and grew more crop types. On conventional farms, more potatoes, sugar beet and winter cereals were grown (see also Kragten and de Snoo, 2008). Organic farms had somewhat more non-crop habitat compared to conventional farms (4.4% of farm area vs. 3.6%), but this difference was not significant (Wilcoxon, $Z = 1.717$, NS). Woody elements (e.g. trees, hedgerows), which are of importance for foraging barn swallows during bad weather circumstances were on all farms present as tree lines around the farmyards. Some organic farms had some small solitary trees between fields.

In June 2005 each farm was visited once to count "occupied" nests. This was done by checking all buildings on the inside and on the outside. Both farms of a pair were visited during the same day. Difference in the number of occupied nests between organic and conventional farms was analysed using Wilcoxon matched pair test. In order to get a picture of farmers' attitude towards barn swallows a small questionnaire was carried out. Farmers were asked to react on the following statements:

1) Barn swallows are part of my farmyard
2) Presence of nesting barn swallows is a risk for food hygiene
3) Presence of barn swallows is hindering due to their droppings on windows, terrace, cars etc…
4) I always notice when barn swallows have returned

For each statement a score of 1 to 5 could be given, with 5 being the most positive for the swallows. Difference in farmers' attitude between organic and conventional farmers was analysed using Mann-Whitney test.

Results

On 60% of the farms at least one barn swallow nest was found. Of the organic farm 65% had swallow nests, while on 55% of conventional farms swallow nests were found. Occupancy rates of farm did not differ (logisitic regression, χ^2 = 0.328, df 1, NS) In total 99 nests were found, with the highest number found on one farm being 17. Mean number of nests (± SD) found did not differ significantly between organic and conventional farms (Organic: 2.40 ± 3.38, Conventional: 2.55 ± 4.50, Wilcoxon, Z = -0.380, NS).

The answers of 38 questionnaires were received and analysed. One organic and one conventional farmer did not fill out the questionnaire. Attitude towards presence of barn swallows did not differ between organic and conventional farmers (Table 4). Both organic and conventional farmers are generally positive towards the presence of barn swallows. Presence of barn swallows was not viewed as a risk for food hygiene.

Table 4 Attitude (mean ± SD) of organic and conventional farmers towards presence of barn swallows Answers could be given on a scale from 1-5, with 5 being the most positive towards barn swallows.

Statement	Organic	Conventional	*P*
Barn swallows are part of my farmyard	4.6 ± 0.5	4.5 ± 0.8	NS
Presence of nesting barn swallows is a risk for food hygiene	4.5 ± 0.7	4.0 ± 1.4	NS
Presence of barn swallows is hindering due to their droppings on windows, terrace, cars etc…	3.7 ± 1.2	3.7 ± 1.2	NS
I always notice when barn swallows have returned	4.9 ± 0.2	4.9 ± 0.5	NS

Discussion

This study indicates that organic and conventional arable farms are both equally qualified as nesting sites for barn swallows. Mean number of barn swallow nests per farm did not differ between the two farm types and also occupancy rates of farms did not differ significantly. Also farmers' "swallow-friendliness" is equal for organic and conventional farmers.

Similar results were found in a study comparing breeding barn swallow abundance between organic and conventional dairy farms in the Netherlands (Lubbe and de Snoo, 2007). However, Christensen *et al.* (1996) found higher numbers of barn swallow above organically managed fields compared to conventionally managed fields. Barn swallows feed on aerial invertebrates and several studies found that invertebrate abundance is generally higher on organically managed fields (Hole *et al.*, 2005). In 2004, on the same farms as where this barn swallow study was carried out aerial invertebrate abundance was found to be higher on organic farms (Kragten *et al.*, in prep.). Barn swallows forage above fields with highest food abundance (Evans *et al.*, 2007). It could be possible that lower food abundance on conventional farms will result in lower breeding success and chick body condition. So, in this way intensification of arable farming (e.g. use of pesticides and artificial fertilizers) could have resulted in barn swallow population declines. Future studies should therefore focus on the effects of arable farming intensification on barn swallow reproduction.

As a result of higher food abundance, it could be possible that barn swallow pairs breeding on organic farms are in better condition compared to birds breeding on conventional farms. This might lead to earlier starting dates of nests on these farms. As a consequence, some of these nests could have been missed during the counts in June. This could especially be the case on farms that were investigated at the end of the field period. This might have led to some bias, although this is probably limited because second nests are likely to have been initiated as well.

The number of breeding swallows on a farm might be positively influenced when the farm is located next to a food rich habitat, such as an organic farm. Barn swallows generally forage within 400 metres of their nest site (Ambrosini *et al.*, 2002). As paired farms in this study were at least 600 meters apart from each it is unlikely that breeding barn swallow abundance on conventional farms was influenced by possibly better foraging sites on organic farms.

The Pan-European Common Birds Monitoring program shows that barn swallow numbers have been in decline during the 1980s (-9%) and 1990s (-7%) (EBCC 2008). However, these declines are much smaller compared to other typical farmland birds such as skylark (1980s: -49%; 1990s: -28%) corn bunting (1980s: -64%; 1990s: -14%) and grey partridge (1980s: -79%; 1990s: -56%). A British study showed that barn swallow population levels were not correlated with agricultural intensification, but with climatic conditions during migration instead (Robinson *et al.*, 2003). Therefore, in the future more focus should be on wintering grounds and migration. At the breeding grounds, more effort is needed to study breeding success of barn swallows in extensively and intensively managed farmland and preferred foraging habitats. These studies can provide tools to design effective conservation plans for barn swallows.

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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

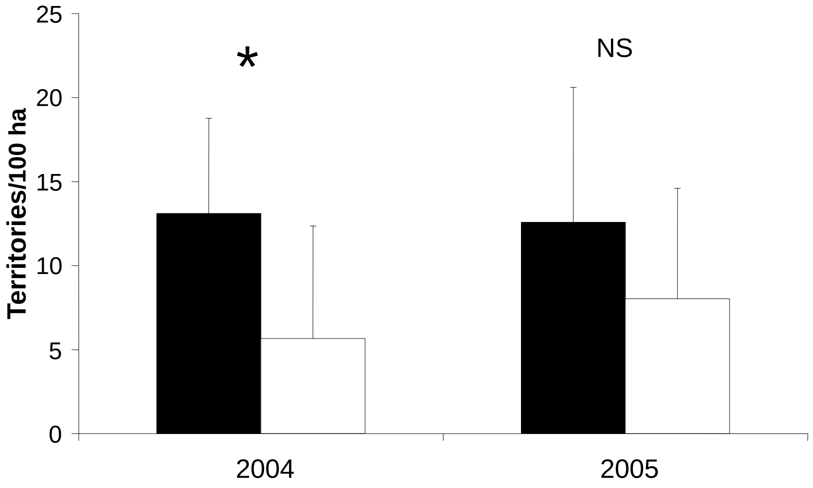

Figure 2 Lapwing territory densities (mean ± sd) on organic (filled bars) and conventional (open bars) arable farms in 2004 and 2005. * = $P < 0.05$, ns = $P > 0.05$.

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.

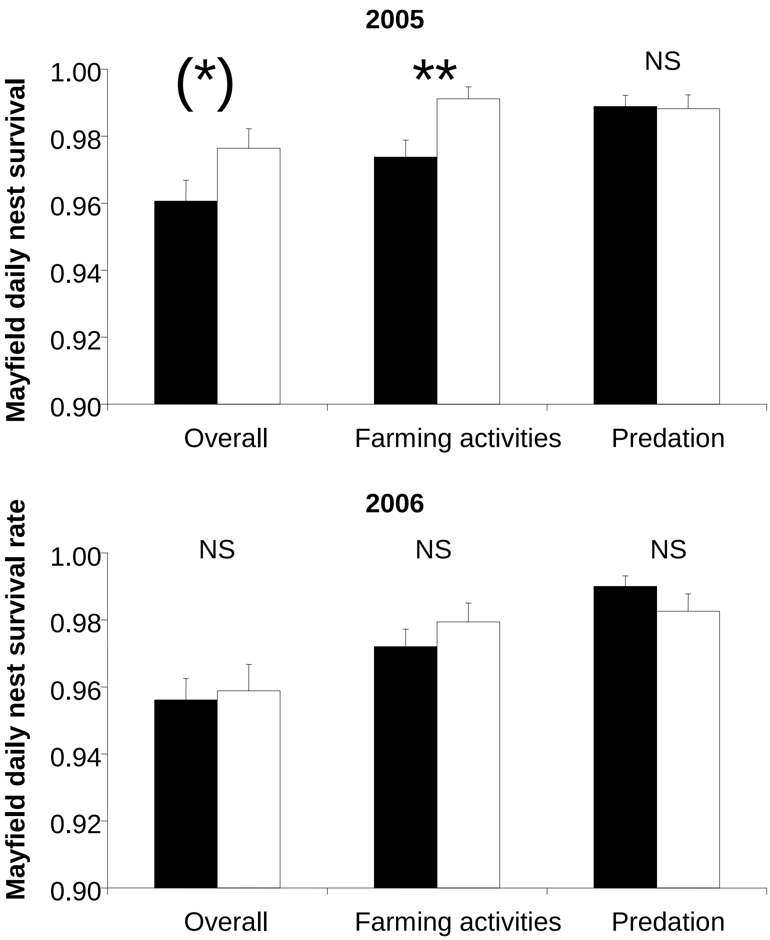

Figure 3 Mayfield estimates (± se) of total daily survival rates, daily survival rates when only farming activities are included as a cause of nest failure, and daily survival rates when only predation is included as a cause of nest failure. Filled bars represent organic farms, open bars conventional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

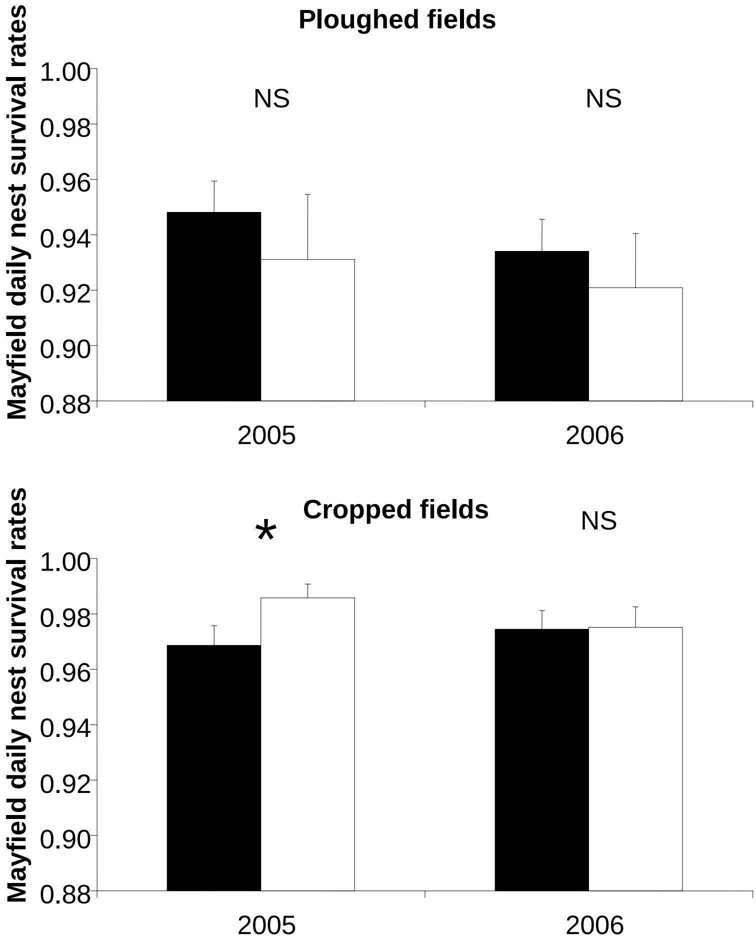

Figure 4 Mayfield estimates (± se) of total daily survival rates on ploughed fields and cropped fields on organic farms (filled bars) and conventional farms (open bars). * = $P < 0.05$, NS = $P > 0.05$.

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.

Acknowledgements

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Chapter 5

Breeding skylarks (*Alauda arvensis*) on organic and conventional arable farms in the Netherlands

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A rare thing: skylark nest in a conventional winter wheat crop

Abstract

The aim of this study was to analyse the effects of differences in cropping pattern between organic and conventional arable farms on the breeding activity of skylarks and to assess the effects of arable crop management on skylark nest survival. Skylark nest density was seven times higher on organic farms than on conventional farms (0.63 vs. 0.09 nest per 10 ha.). Skylarks showed a strong preference for spring cereals, lucerne and grass leys, all of which were mainly or exclusively grown on organic farms. On organic farms nests were initiated during the entire breeding season, but on conventional farms no nesting activity was found during the peak of the season (early May to early June). On organic farms 27% of all nests was successful. Increasing the availability of suitable breeding habitat during the peak of the breeding season on conventional farms might provide one means of enhancing breeding skylark populations. On organic farms, crop management should focus on reducing nest loss due to farming operations.

Keywords: Organic farming; *Alauda arvensis*; Habitat preference; Arable crops; Reproductive success; Mechanical weeding

Introduction

Once a very common bird in European agricultural landscapes, skylark *Alauda arvensis* populations in most western European countries are now under great pressure. Since the 1970s, declines of over 50% have been reported in several countries, such as the UK, the Netherlands, France and Sweden (Boutin *et al.*, 2003; Gregory *et al.*, 2004; Hustings *et al.*, 2004; Wretenberg *et al.*, 2006). As a result of these declines the skylark has been put on Red Lists in several countries (e.g. van Beusekom *et al.*, 2004; Gärdenfors, 2005).

As with other farmland bird species, skylark population declines have been associated with agricultural intensification. In particular, changes in cropping patterns are said to have affected skylark populations (Chamberlain *et al.*, 1999a). First of all, there has been a change from spring-sown to autumn-sown cereals (Chamberlain *et al.*, 2000). Even early in the breeding season, autumn-sown cereals are already unsuitable as a breeding habitat for skylarks, becoming too tall and dense (e.g. Chamberlain *et al.*, 1999a). Secondly, lower crop diversity is associated with lower skylark densities (Chamberlain *et al.*, 1999a; Browne *et al.*, 2000), possibly because this reduces opportunities for producing multiple nests (Wilson *et al.*, 1997).

On organic farms, crop diversity and the area of spring-sown cereals are generally larger than on conventional farms (e.g. Hole *et al.*, 2005; Levin, 2007) and several studies found higher skylark densities on organically managed farms (e.g. Wilson *et al.*, 1997; Chamberlain *et al.*, 1999b). Additionally, the absence of pesticide use on organic farms may have an indirect positive effect on skylark breeding success through higher food availability (Odderskær *et al.*, 1997; Boatman *et al.*, 2004), although the evidence is equivocal (Donald, 2004). On the other hand, organic farmers use mechanical methods of weed control, which might result in direct nest failure of ground-breeding birds (e.g. Kragten and de Snoo, 2007).

This study aimed at analysing breeding activity and breeding success of skylarks on organic and conventional arable farms. First of all, the effects of differences in cropping patterns on breeding activity were assessed. Secondly, the effect of crop management on skylark nest survival was investigated.

Materials and methods

Study area

The study was carried out from April to July 2006 in two arable areas in the centre of the Netherlands: Oostelijk Flevoland (approximate location 52°32’N, 05°43’E) and Noordoostpolder (approximate location 52°44’N, 05°46’E). Both areas are polders, reclaimed during the 1950s and 1930s, respectively, and are adjacent to each other. Both polders have a similar landscape: very open with few vertical landscape structures such as tree lines, wind turbines and power lines. In both areas the predominant crops are winter cereals, potatoes, sugar beet and onions.

A total of 36 arable farms (18 organic and 18 conventional), comprising 663 ha. organically managed and 764 ha. conventionally managed farmland, were selected in a pairwise set-up. All farms had one or more parcels of approximately 25 ha. These parcels were divided into several fields, but fields were not separated from each other by boundary structures. Vertical landscape elements are, if present, only at the edges of these parcels. To limit the bias caused by surrounding landscape elements, the pairing procedure was based on keeping these surrounding landscape elements (e.g. roads, forests, power lines, wind turbines) as similar as possible for both farms of a pair. All organic farms had been managed organically for at least seven years. The relative on-farm abundance of non-cropped habitats (e.g. field margins, hedgerows) was slightly higher on organic than on conventional farms (4.3 vs. 3.7% of total farm area), but no effect on skylark abundance was found (Kragten and de Snoo, 2008).

Data collection

Information about cropping pattern and crop management (type and timing of farming operations) was gathered by interviewing the farmers. All farms were visited at least once a week in order to observe skylark territory display or breeding activity, such as nest-building and chick-feeding. When a nest was found, its location was saved using a GPS device (Garmin Geko 201). In a few cases, nests were inconspicuously marked with a small piece of red tape approximately 15 m. from the nest. For all nests the type of crop, clutch size and number of hatchlings were recorded. All nests were visited every four days and on each visit the status of the nest was recorded (incubated, chicks present, failed, successful). Nests were defined as successful when at least one chick fledged. Skylark chicks normally leave the nest when they are eight days old (Donald, 2004). To be able to conclude whether a nest was successful, chick age needed to be known. Therefore, chick age was determined based on dates for the first egg-laying or hatching. If this was not possible, chick age was estimated by comparing feather development with that of chicks of known age. For all failed nests the cause of nest failure was determined. If a nest was found empty before the chicks had reached nest-leaving age, the nest was considered as failed due to predation. If there were signs of recent farming operations and the nest was damaged but still contained egg remnants, the nest was recorded as failed due to farming operations. In order to make sure that these nests had not been predated eggshells were checked for traces of predators (e.g. bitemarks). Nests with dead chicks in the near vicinity were defined as failed due to starvation. Also the dead chick bodies were checked on bitemarks in order to rule out predation as a cause of failure.

Data analysis

Skylark nest density (seasonal total) on conventional and organic farms was compared using a Wilcoxon Signed Ranks Test (SPSS 12.0). Most crops used by skylarks as breeding habitat were only available on some of the farms. Therefore, we considered all farms with a certain management (organic or conventional) as one study area in which the birds could select their breeding habitat. Then, a Chi-square test with the observed number of skylark nests per crop being compared with the expected value based on a uniform distribution of nests over different crops was used to analyse breeding habitat preference on both farm types. Based on first egg-laying dates, we analysed whether there was a shift in crops used as breeding habitat by skylarks as the season progressed. First egg-laying dates were calculated back from chick age, or from the number of eggs when nests were found during the egg-laying stage, assuming production of one egg per day (Donald, 2004).

In order to investigate the effects of differences in cropping patterns between organic and conventional farms on skylark breeding activity, two approaches were used. First, the relative abundance of crops used by skylarks as breeding habitat (based on nests) was compared between the two farming systems, using a Wilcoxon Signed Rank Test. Secondly, the availability of suitable breeding habitat was monitored throughout the breeding season. Suitable skylark breeding habitat was defined as a crop with a height of 20-50 cm. (e.g. Wilson *et al.*, 1997). In 2005, crop height and ground cover were measured for all crops on all farms on five occasions between mid April and mid-July. Each crop was measured at three randomly placed fixed points. Crop height was measured using a measuring stick, while ground cover was determined by visual estimation. Based on these data, polynomial crop growth curves were modelled and used to estimate the period in which the crop had a height of 20-50 cm. To correct for variation in sowing dates, growth curves were calculated for fields that were sowed within half-monthly intervals. The availability of suitable breeding habitat on organic versus conventional farms was compared per day, using Wilcoxon Signed Rank Tests. To gain more insight into the effects of crop density on breeding skylarks we estimated the crop density at the moment of nest initiation. For this purpose, polynomial growth curves were applied based on ground cover data collected in 2005 as well.

As ample size (n =7) was too small on conventional farms, skylark nest survival was only calculated for organic farms according to Mayfield (1975). A total nest period of 23 days was applied (including egg laying). Relative nest loss due to farming operations, predation and starvation was calculated using a technique similar to a baseline hazard approach (Kleinbaum, 1996). In this approach, only nests that failed due to a specific cause are considered as failed. Differences between nest failure rates due to different causes were then analysed using a likelihood-ratio test, as described by Aebischer (1999).

Results

A total of 49 nests were found, 42 of them on organic farms and seven on conventional farms. Nests were found on 11 organic and five conventional farms. Nest density was significantly higher on organic farms (0.63 vs. 0.09 nest per 10 ha.; Wilcoxon Signed Ranks Test, Z = 2.668, P = 0.008). On conventional farms the nests were found in winter cereals, spring cereals and peas (Table 8). On organic farms the nests were found in spring cereals, lucerne, grass leys, carrots, peas, oregano, potatoes, winter cereals and onions. Table 8 shows the percentage of nests found in a specific crop type compared to the expected percentage of nests in case of a uniform distribution of nest over crop types. On conventional farms, winter cereals in particular were preferred as a breeding habitat On organic farms especially in spring cereals, lucerne and grass leys more nests were found than expected. Areas of most crops preferred by skylarks (spring cereals, lucerne and grass leys) were larger on organic farms (Table 9).

For 37 nests the initiation date could be determined. There was a clear shift in crop preference as the breeding season progressed. In Table 1 nest initiation dates of the first and last nest built in a crop type are shown. Early in the breeding season most nests were found in winter cereals (mainly on conventional farms), regenerated lucerne and grass leys (on organic farms). During the peak of the breeding season (May – early June) the majority of the nests found were in spring cereals (mainly on organic farms). With one exception, nests were not initiated in spring cereals after the first half of June, but other crops like lucerne, carrots and potatoes were used instead.

Of all nests, 88% were initiated (first egg) when the crop was 20-50 cm. high. However, the crop density (percentage ground-cover) at the moment of initiation showed major variation between crops: spring cereals (65-100% ground cover), winter cereals (80-95%), lucerne (90-100%), grass leys (90-100%), peas (15-55%), carrots (30-50%) and potatoes (40-45%).

In five of the seven nests found on conventional farms, the first egg-laying date was between April 12 and May 8. This was followed by a period of approximately one month without any nesting on conventional farms. The two other nests were initiated on June 4 and June 9, respectively. On organic farms, breeding activity was observed throughout the whole breeding season (first nest April 6, last nest July 13), with no periods without breeding activity (Figure 5).

Table 8 Number of skylark nests (N) found per crop type on organic and conventional farms. “Observed nests” (Obs.) is expressed as percentage of the number of nest found per farm type. “Expected nests” (Exp.) is the percentage of nests that should be expected based on a uniform distribution of nest over all crop types. Nest initiation dates are given for the first and last nest initiated.

	Organic			Conventional			Nest initiation dates	
Crop type	N	Obs.	Exp.	N	Obs.	Exp.	First nest	Last nest
Spring cereals	18	42.9	22.3	1	14.3	7.2	May 7	June 27
Lucerne	7	16.7	4.4	--	--	--	April 6	July 3
Grass leys	4	9.5	2.7	--	--	--	May 6	May 14
Carrots	4	9.5	8.4	0	0	5.8	June 21	July 13
Peas	3	7.1	6.7	1	14.3		May 24	June 4
Oregano	2	4.8	0.3	--	--	--	April 26	May 28
Potatoes	2	4.8	16.5	0	0	24.3	June 10	June 10
Winter cereals	1	2.4	1.0	5	71.4	14.3	April 12	May 8
Onions	1	2.4	10.6	0	0	12.3		

Table 9 Mean percentage of farm area (±SD) with crops in which skylark nests were found. N = number of farms on which the crop was grown. *P* represents the level of significance between organic and conventional farms where ** < 0.01, * < 0.05, NS > 0.05.

	Organic	N	Conventional	N	*P*
Potatoes	16 ± 10	15	26 ± 10	17	*
Spring cereals	22 ± 11	17	5 ± 11	4	**
Onions	11 ± 8	13	11 ± 8	13	NS
Winter cereals	1 ± 5	2	15 ± 13	11	**
Carrots	10 ± 9	12	6 ± 10	8	NS
Peas	6 ± 12	5	1 ± 4	2	NS
Lucerne	6 ± 10	6	0	0	*
Grass leys	3 ± 8	2	0	0	NS
Oregano	0.3 ± 1	1	0	0	NS

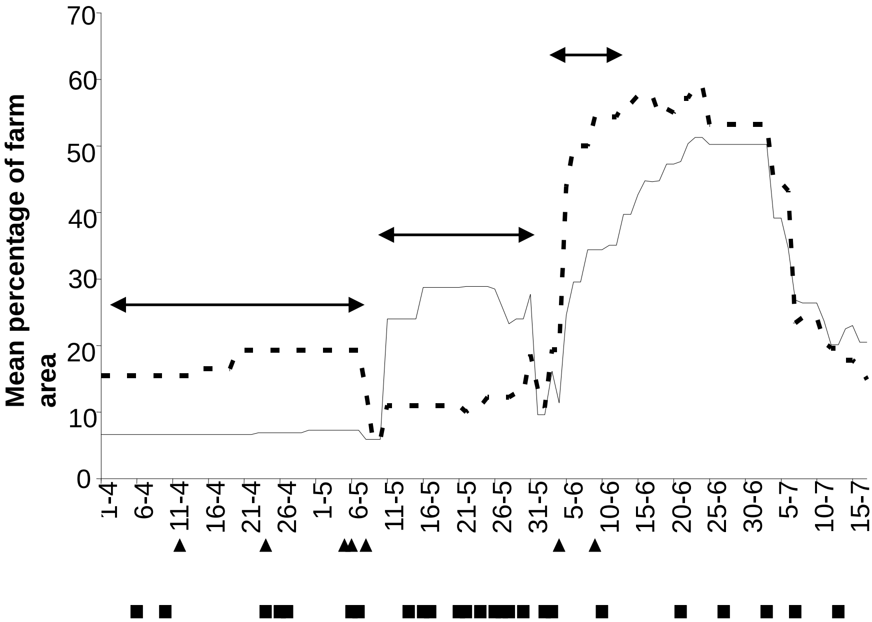

Figure 5 Mean percentage of farm area with suitable breeding habitat for skylarks in relation to skylark nest initiation. The solid line represents organic farms, the dashed line conventional farms. Arrows represent periods with a significant difference in the availability of suitable breeding habitat (Wilcoxon Signed Rank Test, $P < 0.05$) between organic and conventional farms. ▲ = nest initiated on conventional farm, ■ = nest initiated on organic farm.

On both farm types, the relative area with suitable breeding habitat for skylarks changed as the breeding season progressed (Figure 5). Based on these changes, the breeding season was divided into three periods. During the first period (until May 9) conventional farms had relatively more suitable habitat compared with organic farms (Wilcoxon Signed Ranks Test, $P < 0.05$), due mainly to the presence of winter cereals on the former, which were more suitable compared to spring-sown crops. The second period (May 10 - June 1) was characterised by higher breeding habitat availability on organic farms (Wilcoxon Signed Ranks Test, $P < 0.05$), owing to the presence of spring cereals. By then, winter cereals have become too tall (> 50 cm.), while especially spring cereals have reached a suitable height. During the third period (from June 2 onwards), finally, the availability of breeding habitat increased markedly on both types of farm. By this time, spring cereals have become too tall (> 50 cm.), but several vegetable crops (e.g. carrots, potatoes) are sufficiently high. There is consequently a substantial increase in the amount of suitable breeding habitat available on both farm types, with conventional farms having relatively more suitable habitat during the first days of this period (Wilcoxon Signed Ranks Test, $P < 0.05$).

The period without breeding activity on conventional farms (May 9 - June 3) corresponded well with the period (10 May - 1 June) in which suitable breeding habitat was limited on these farms (Figure 5). In contrast, on organic farms 19 nests (45% of the total) were initiated during this period and there was no shortage of suitable breeding habitat. During the peak of the breeding season there is thus a gap in the availability of breeding habitat on conventional farms, which is likely to limit breeding activity of skylarks.

Mayfield calculations for organic farms were based on 36 nests. Of these nests 21 were successful, ten failed due to farming operations, four were predated and the result of one nest was unknown. Daily skylark nest survival rate (± SE) on organic farms was 0.944 ± 0.015, which equals 27% of all nests being successful. On organic farms nest failure as a result of farming operations seemed to be higher than nest predation rates, but the difference was not significant (Likelihood ratio test, df 1, $D = 2.731$, NS). Of the nests failed due to farming operations, four failed due to mechanical weeding (spring cereals and onions), three due to cutting (grass), three due to ploughing (lucerne) and one due to ridging-up (carrots).

Discussion

In our study skylarks nest densities on organic farms were almost seven times higher than on conventional farms, which is in line with previous findings (e.g. Wilson *et al.*, 1997; Chamberlain *et al.*, 1999b). The strong preference for crops like spring cereals and lucerne (also found by Wilson *et al.*, 1997; Eraud and Boutin, 2002), plus the fact that these crops were grown over larger areas on organic farms, is probably an important factor behind the difference in nest density.

Besides larger areas of preferred breeding habitat, organic farms especially provide more suitable breeding habitat during the peak of the breeding season. This is likely to facilitate skylarks to produce multiple clutches on these farms. On conventional farms however, there seems to be a gap in the availability of suitable breeding habitat during the peak of the breeding season.

In this study suitable breeding habitat was defined as a crop with a height of 20-50 cm. The estimated nest initiation dates and data on crop development show that indeed most nests were initiated when the crop has reached this height, but ground-cover showed a large variation between crop types. Besides crop height, other factors that might have influenced breeding activity is the patchiness of a field (Daunicht, 1998) and food availability.

Breeding success on organic farms was at approximately the same level found earlier in the UK (Wilson *et al.*, 1997). However, in 2006 the total amount of precipitation was very high during the second half of May and mechanical weeding was consequently often impossible. In spring cereals, a crop strongly preferred by skylarks as breeding habitat during this period, far fewer farming operations were carried out compared with years with more average weather circumstances.

On conventional farms, the limited availability of suitable breeding habitat during the peak of the breeding season is probably one of the main reasons that skylark breeding activity was low and limits the possibility of production of multiple clutches. By increasing the areas of crops that are suitable as breeding habitat during the peak of the breeding season (e.g. spring-sown cereals and peas), skylarks will possibly be able to produce multiple clutches on these farms.

On organic farms, during the peak of the breeding season the availability of suitable breeding habitat is higher and nests were found during the entire season. However, organic crop management may have a markedly negative effect on breeding success. A reduction of farming operations in spring cereals, especially, for a certain period could enhance skylark breeding success.

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Chapter 6

The effectiveness of volunteer nest protection on the nest success of northern lapwings *Vanellus vanellus* on Dutch arable farms

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Lapwing egg destroyed by an agricultural operation

Abstract

Clutches of ground-nesting farmland birds are often destroyed by farming operations, resulting in insufficient reproductive success and subsequently declining populations. The aim of this study was to investigate whether volunteer nest protection can enhance nest success of ground-nesting birds. The study compared nest success of protected and unprotected northern lapwing *Vanellus vanellus* nests over two years on arable farms in the Netherlands. Because of different crop management, nest success of ground-breeding birds might differ between organic and conventional arable farms. The effectiveness of volunteer nest protection was therefore investigated on both farm types. Although nest protection significantly reduced nest loss due to farming operations, there were no significant differences in total clutch survival of protected and unprotected nests. However, sample sizes of unprotected nests, and protected nests on organic farms, were relatively small, which may have reduced statistical power. There were indications that protected nests were predated or deserted more often. We recommend exploring different ways to improve the effectiveness of volunteer nest protection through a further reduction of nest loss due to farming operations and predation.

Keywords: Agriculture; Organic farming; Arable; Predation; Desertion

Introduction

Over recent decades, changes in agricultural practice have led to a decline in the populations of several bird species characteristic of agricultural landscapes in Western Europe (Chamberlain *et al.*, 2000; Donald *et al.*, 2001, 2006; Robinson and Sutherland, 2002; Wretenberg *et* al., 2006). One species that has suffered from these changes is the northern lapwing *Vanellus vanellus*. Declines in lapwing populations have been reported in several countries, including the Netherlands, the UK, and Sweden (BirdLife International, 2004; Wretenberg *et* al., 2006), with low reproductive success cited as the most likely mechanism (Peach *et al.*, 1994). One factor responsible for reducing reproductive success is intensified farming operations which can result in high nest losses (Baines, 1990; Shrubb, 1990; Berg *et al.*, 1992).

Previous studies have shown that lapwings reach higher densities on organically managed than on conventionally managed arable farms (Christensen *et al.*, 1996; Kragten and de Snoo, 2007). However, the use of agrochemicals is prohibited on organic farms and therefore these farmers are restricted to using non-chemical methods of weed control. These methods include harrowing and hoeing which can lead to even higher nest losses compared to conventional crop management (Kragten and de Snoo, 2007).

In an effort to improve the nest success of lapwings and other ground-nesting farmland birds, Landschapsbeheer Nederland started a Volunteer Meadow Bird Protection programme, which has been in place on large tracts of farmland in the Netherlands for over a decade now. The aim of this study is to investigate the effectiveness of volunteer nest protection for lapwings on organic and conventional arable fields. To this end, we compared the nest success of protected and unprotected nests on both farm types. Protected and unprotected nests differ in a number of ways. First of all, the location of protected nests is communicated to the farmer which should reduce the risk of the nest being destroyed by farming operations. Additionally, the nests are marked in the field with two large bamboo canes (approximately 1 metre high) relatively close to the nest (approximately 3-5 metres). Marking of the nests is intended to reduce nest destruction by farming operations, but might also attract predators or increase nest desertion (Götmark, 1992). We therefore measured failure rates due to farming operations, predation and nest abandonment for both protected and unprotected nests.

Materials and methods

Study area

This study comprises data on lapwing nests collected in 2005 and 2006 in two large-scale agricultural areas in the Netherlands: Noordoostpolder and Oostelijk Flevoland (approximate location 52°36’29.65” N, 5°38’52.08” E). These are two relatively young, neighbouring polders of marine origin, reclaimed during the 1930s and 1950s, respectively. Their landscapes are similar: very open with a few vertical landscape elements (tree lines, wind turbines, power lines). Land use is mainly arable, but there is also some dairy farming. In both polders, the predominant crops are potatoes, cereals (both winter and spring), sugar beet, onions and vegetables. Because the majority of crops are spring-sown, most farming operations coincide with the lapwing breeding season. In the study area, lapwings reach densities of approximately 5-8 territories per 100 hectares on conventionally managed arable farms, and around 13 breeding pairs per 100 hectares on organic farms (Kragten and de Snoo, 2007).

As the landscape within both polders is uniform, farms with nest protection and farms without nest protection were similar in terms of surrounding landscape. All farms consist of one or more parcels of approximately 25 hectares, bordered by ditches. Vertical landscape structures, such as tree lines are only present around farms and along some main roads and larger waterways. Organic farmers in general had a more diverse crop rotation and grew more spring cereals than conventional farms, while conventional farms grew winter cereals and relatively more potatoes. Conventional farmers used pesticides and artificial fertiliser, while organic farmers used organic manure and applied non-chemical methods such as mechanical weeding to reduce weed burdens, and the use of natural enemies to control insect pests. Mechanical weeding is generally carried out using big machinery for harrowing and hoeing. Weeds may also be removed by hand.

Data collection

As protected nests, we used those found by the Volunteer Meadow Bird Protection programme. In the study area, 171 and 155 volunteers were active on 8314 and 8658 hectares of arable land in 2005 and 2006 respectively. In 2005, 121 arable farms participated in the volunteer nest protection programme, and in 2006 113 farms. Since nearly all of these farmers managed their land conventionally, the majority of protected nests were found on conventionally managed land (Table 10).

Table 10 Number of protected and unprotected nests used in this study. NOP = Noordoostpolder, OF = Oostelijk Flevoland, Org = organic farms, Conv = conventional farms.

	2005						2006					
	NOP		OF		Total		NOP		OF		Total	
	Org	Conv	Org	Conv	Org	Conv	Org	Conv	Org	Conv	Org	Conv
Protected	20	523	28	282	48	805	35	443	17	296	52	739
Unprotected	39	12	41	29	80	41	31	17	35	25	66	42

In 2005 and 2006, volunteers found respectively 853 and 791 lapwing nests which could be included in the analyses. Once found, these protected nests were marked with two bamboo poles (approximately one metre high) placed 3-5 metres away from the nest and farmers were informed of their location by pointing out the nests on a map of the farm. In this way, nests could be spared by farming operations. In 2005, protected nests were found and marked between 11 March and 17 June. In 2006, the first nest was marked on 25 March and the last on 17 June.

Unprotected nests were those found for a study comparing the nest success of lapwings on organic and conventional arable farms (Kragten and de Snoo, 2007). These nests were found on 20 organic and 20 conventional farms, comprising 720 hectares of organically managed and 809 hectares of conventionally managed land. These areas did not overlap with areas covered by volunteers. In 2005, 121 nests were found which could be included in the analyses and in 2006, 108 nests were found. Because half of the farms in this study were organic, the number of nests was more equal across the two farm types than was the case for the sample of protected nests (Table 1). The unprotected nests were not marked, and nor were farmers informed of their presence. In order to be able to relocate these nests, their location was recorded using a GPS device. In 2005, unprotected nests were found between 31 March 31 and 2 June. In 2006, the first unprotected nest was found on 5 April, and the last on 20 June.

In order to determine nest success, all nests were visited. Because volunteers did not always register all their visits, the visit frequency could not be determined for protected nests. However, for all nests included in the analyses, the finding (and marking) date and the day of the last visit were noted, so the number of nest days could be calculated and thus nest success could be calculated. Unprotected nests were checked by visiting them at one-week intervals. All volunteers and professional researchers were instructed in order to be able to determine the fate of a nest. Nests were recorded as successful when at least one egg hatched. Eggs were assumed to have hatched when small remnants of eggshell were present in the nest. Nests were assumed to have failed when no eggs hatched. If a nest was found empty, without small remnants of eggshells, or with larger pieces of eggshell nearby, the nest was recorded as predated. Nest predation was defined as the predation of a whole clutch. If there were signs of recent farming operations, and remnants of the nest were found, the nest was recorded as failed due farming activities. When a nest was found containing cold eggs, the nest was recorded as deserted. To verify this, one egg was arranged in the nest with its pointed end facing outwards and if the position of the egg remained the same at the next visit then nest desertion was confirmed.

Data analysis

The nest success of protected and unprotected nests was compared on organically and conventionally managed farms. Nest success was estimated using the Mayfield method (Mayfield, 1961, 1975). Differences in nest success of protected and unprotected nests were analysed at different levels. First, an overall test was carried out using a Generalised Linear Model with binomial error and logistic link (Aebischer, 1999), including all data. Additionally, likelihood-ratio tests were used to analyse the effects of year, farm type and polder (Aebischer, 1999). For example, in order to test for the effects of nest protection on organic farms in 2005 only nests found in this year and on this farm type were involved. Relative nest loss due to farming operations, predation and desertion was analysed and compared between protected and unprotected nests using a technique similar to a baseline hazard approach (Kleinbaum, 1996). In this approach, only nests that failed due to a specific cause are considered as failed. For example, the nest failure rate as a result of farming operations was calculated by defining failed nests as only those nests that failed due to farming operations. Nest failed due to other causes were considered as not failed and were included only until they were either lost from other causes or hatched.

Results

Effectiveness of nest protection

Table 11 gives an overview of the number of nests failed due to a specific cause. The overall test in which data of both years, study sites (polders) and farm type were combined showed no effect of volunteer nest protection on the nest success of Lapwings (GLM, $F_{1, 1886} = 1.22$, $P = 0.269$). When we analysed the data per year and per farm type, in all cases the daily nest survival rate (DSR) of protected nests seemed to be a little higher than that of unprotected nests, but differences were not significant (Organic: 2005 $D = 1.459$, df 1, $P = 0.0227$; 2006 $D = 0.085$, df 1, $P = 0.770$; Conventional: 2005 $D = 0.963$, df 1, $P = 0.326$; 2006 $D = 2.645$, df 1, $P = 0.104$) (Figure 6A). When we analysed the data per polder, it was only on organic farms in Noordoostpolder in 2005 that the DSR of protected nests proved higher than that of unprotected nests ($D = 8.952$, df 1, $P = 0.003$).

Lapwing nests mainly failed as a result of farming operations, predation or desertion (Table 11). Daily nest loss rates due to farming operations were significantly higher for unprotected nests on both organic and conventional farms and in both years (Organic: 2005 $D = 22.910$, df 1, $P < 0.001$; 2006 $D = 35.140$, df 1, $P < 0.001$; Conventional: 2005 $D = 6.744$, df 1, $P = 0.009$; 2006 $D = 11.880$, df 1, $P < 0.001$) (Figure 6B). This means that protected nests failed less often due to farming activities. On organic farms with nest protection, no nests failed owing to farming operations.

Table 11 Number (%) of successful nests and nests failed due to different causes.

	Protected nests				Unprotected nests			
	Organic		Conventional		Organic		Conventional	
	2005	2006	2005	2006	2005	2006	2005	2006
Total number of nests	48	52	805	739	80	66	41	42
Successful	33 (69%)	19 (37%)	584 (73%)	461 (62%)	41 (51%)	25 (38%)	27 (66%)	19 (45%)
Failed								
Farming operations	0 (0%)	0 (0%)	30 (4%)	69 (9%)	26 (33%)	28 (42%)	6(15%)	13 (31%)
Predation	5 (10%)	16 (31%)	99 (12%)	106 (14%)	11 (14%)	7 (11%)	7 (17%)	8 (19%)
Desertion	8 (17%)	3 (6%)	51 (6%)	67 (9%)	2 (3%)	2 (3%)	1 (2%)	2 (5%)
Other causes	0 (0%)	0 (0%)	2 (0%)	1 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Unknown	2 (4%)	14 (27%)	39 (5%)	35 (5%)	0 (0%)	4 (6%)	0 (0%)	0 (0%)

On organic farms in 2006 daily nest predation rates were higher for protected nests compared to unprotected nests.(D = 5.167, df 1, P = 0.023) (Figure 6C). However, in the other cases the tendency was opposite, though not significant (Organic: 2005 D = 0.122, df 1, P = 0.727; Conventional: 2005 D = 0.581, df 1, P = 0.446; 2006 D = 0.521, df 1, P = 0.471). Possible difference in predator abundance between the two polders could have an effect on the effectiveness of nest protection. Therefore, we analysed whether there was a difference in nest predation rates between the two polders. In 2006 nest predation rates were higher in Oostelijk Flevoland compared to Noordoostpolder for both protected and unprotected nests (Protected: D = 21.362, df 1, $P < 0.001$; Unprotected: D = 8.104, df 1, P = 0.004). As this polder effect was similar for both protected and unprotected nests, it is not likely that this has influenced the effectiveness of nest protection.

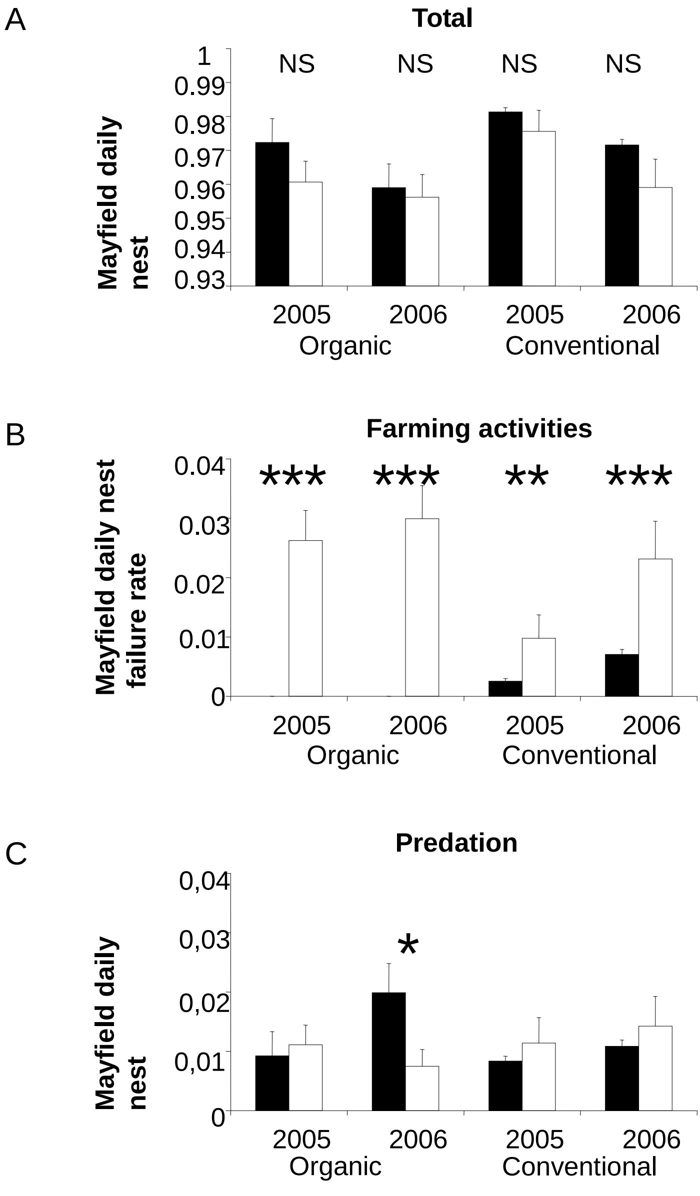


Figure 6 Total daily nest survival rates (A) and daily nest failure rates due to different causes of nest failure (B, C, D) (± SE) of protected (filled bars) and unprotected (open bars) lapwing nests on organic and conventional farms. Sample sizes are given in Table 10. Figures 6B, 6C and 6D show nest failure rates as a result of farming activities, predation and desertion respectively. * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.005$.

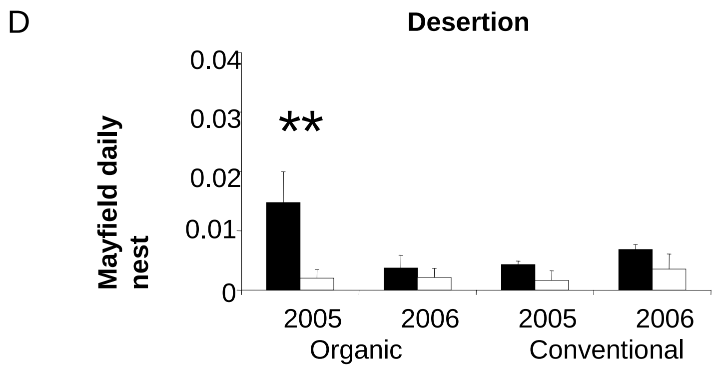
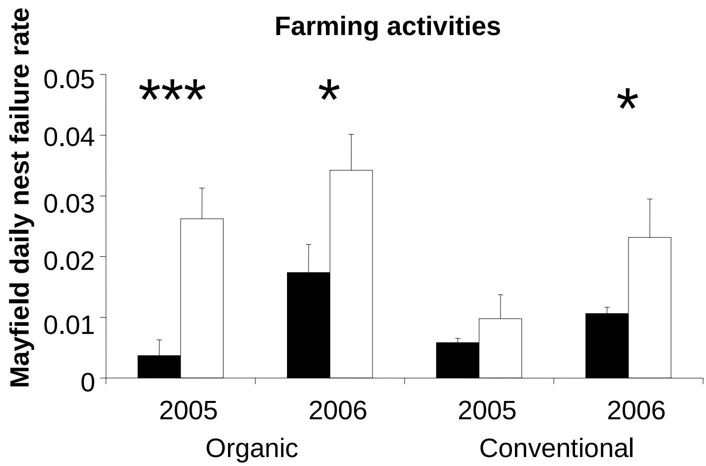


Figure 6 Continued

Additionally, on organic farms in 2005 nest desertion occurred more when nests were protected (*D* = 8.430, df 1, *P* = 0.004), but again in all other cases no significant differences were observed although here the tendencies were all in the same direction (Organic: 2006 *D* = 0.381, df 1, *P* = 0.537; Conventional: 2005 *D* = 1.297, df 1, *P* = 0.255; 2006 *D* = 1.035, df 1, *P* = 0.309) (Figure 6D). Hypothetically, if nest marking triggers nest desertion, nest desertion will happen immediately after nests are marked. Therefore, we compared the average nest days of deserted nests with nest lost due to other causes. The average number of nest days of deserted nests was not lower compared to other nests (Deserted: 11.5 days; Other causes: 10.0 days), so it was unlikely that nest marking resulted in immediate nest desertion.

Although for most nests the cause of nest failure could be determined, there were also nests for which this was not possible. Of the protected nests, the cause of failure could not be determined for 25% (2005) and 22% (2006) of the failed nests. Of the unprotected nests, these percentages were only 2% and 6%, respectively. Because of this, we analysed two scenarios to test the robustness of our findings presented in figure 6: (1) all nests with an unknown cause of nest failure failed because of farming activities, and (2) all nests with an unknown cause of nest failure were predated. We did not carry this analysis out for nest desertion, as nest desertion is easy to determine in the field, and therefore not likely to be missed. In the first scenario, the nest loss rate of protected nests remained significantly lower in most cases (Organic: 2005 $D = 12.616$, df 1, $P < 0.001$; Organic: 2006 $D = 4.916$, df 1, $P = 0.027$; Conventional: 2005 $D = 1.290$, df 1, $P = 0.256$; 2006 $D = 5.814$, df 1, $P = 0.016$) (Figure 7A). This reinforces the conclusion that nest protection reduces nest loss due to agricultural practices. When we applied the second scenario, differences in nest predation rates between protected and unprotected nests were still only significant on organic farms in 2006 (Organic: 2005 $D = 0.098$, df 1, $P = 0.754$; Organic: 2006 $D = 12.525$, df 1, $P < 0.001$; Conventional: 2005 $D = 0.003$, df 1, $P = 0.955$; 2006 $D = 0.001$, df 1, $P = 0.973$) (Figure 7B). This indicates that the effects of nest protection on predation might be limited.

A



B

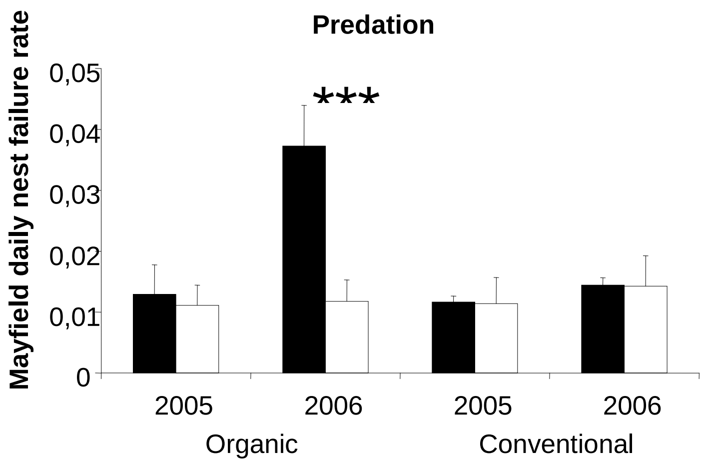


Figure 7 Daily nest failure rates (± SE) of protected (filled bars) and unprotected (open bars) lapwing nests on organic and conventional farms when failed nests with an unknown cause of nest failure are assigned to farming activities (A) or predation (B). Sample sizes are given in Table 10. * = $P < 0.05$, *** = $P < 0.005$.

Discussion

Even though protected nests failed significantly less often as a result of farming activities, total nest success of lapwing nests was not significantly enhanced by volunteer nest protection. However, sample size of unprotected nests, and protected nests on organic farms, were relatively small and this may have reduced statistical power (Hensler and Nichols, 1981). If we could have obtained similar-sized samples for these groups it is likely that that nest protection would be shown to have a small beneficial effect on nest success of lapwings. Despite these small sample sizes, limited evidence was found for higher predation and desertion rates of protected nests. In 2005, desertion rates of protected nests were higher on organic farms and in 2006 more protected nests on organic farms were predated. Furthermore, protected nests failed more often due to unknown circumstances. When all nests that failed through unknown causes were assigned to farming operations as a cause of failure, protected nests still failed less often through farming activities in three of the four cases. This reinforces the finding that volunteer nest protection indeed reduces nest loss due to farming activities.

Marking and visiting nests

Limited evidence was found that protected nests suffer from higher predation and desertion rates. Marking and visiting of nests and their effects on nest survival have always been topic of discussion (e.g. Götmark, 1992). Several studies have investigated the effects of nest marking or visiting on the outcome of lapwing nests. No effects of nest visiting on clutch survival have been found in these studies (Galbraith, 1987; Fletcher *et al.*, 2005). In our study volunteers often checked whether the nest was still present by observing it from a distance, without actually approaching the nest. On the other hand, unprotected nests were approached at weekly intervals. It is therefore likely that, on average, protected nests were visited less frequently than unprotected nests. So it is improbable that the higher nest predation and desertion rates of protected nests were a result of nest visiting. With respect to nest marking, Galbraith (1987) found no differences between the number of successful marked and unmarked nests. However, in Galbraith's study nests were marked inconspicuously compared to the protected nests in our study. It is possible that the conspicuous markings used in the Volunteer Meadow Bird Protection programme enhanced nest predation in some circumstances.

This study only found indications that marking of lapwing nests might increase nest predation or desertion rates. To examine formally whether nest marking does increase nest predation or desertion, an experimental study design should be used. In this design, nests should be left unmarked for a certain amount of time and then be marked. Nest survival rates over marked and unmarked periods can then be compared with control nests that remain unmarked throughout (Berg *et al.*, 1994).

How to improve nest protection programmes?

The effectiveness of volunteer nest protection could be enhanced in two ways. First, especially on conventional farms, marked nests were still destroyed by farming operations. Nest loss due to farming operations could be reduced by paying farmers for successful clutches on their land. This has been proven to be effective for breeding waders on dairy farms in the Netherlands (Musters *et al.*, 2001), as farmers spare the nests during their work. The second possibility would be to experiment with different nest marking methods, which might reduce nest predation. Currently, volunteer nest protection takes place by placing large poles relatively close to the nest and this study found limited evidence that this might increase nest predation rates. Galbraith (1987) found that lapwing nests which are inconspicuously marked at a larger distance did not suffer from higher predation rates compared to unmarked nests. However, marking of the nests should happen in such a way farmers still notice the nests, so nests should not be marked too inconspicuously. Field-experiments should point out the best method. As well as the type of marking, the timing of nest marking could be changed to reduce nest loss due to predation. Currently, nests are marked immediately after they have been found. As marking could increase clutch predation, the period a nest is marked should be reduced as much as possible. In other words, nests should ideally be marked just before farming operations will be carried out. It is questionable whether this will be practicable as this requires volunteers to be available at short notice during the breeding season.

In general, nest protection programmes generally aim at larger species, such as northern lapwing, black-tailed godwit *Limosa limosa,* Montagu's harrier *Circus pygargus* and stone curlew (e.g. Musters *et al.,* 2001; Koks and Visser, 2002). However, ground-nesting songbirds such as skylark *Alauda arvensis* and whinchat *Saxicola rubetra* still suffer from high nest loss rates due to farming operations (Vickery *et al.*, 2001; Müller *et al.*, 2005). Therefore, in the future nest protection programmes could aim more at these species as well, although the nests of these species are in general more difficult to find.

Volunteer conservation programmes could be a useful instrument in farmland bird conservation, as they can involve many people and consequently raise awareness of population declines of farmland birds. It is therefore of high importance that such programmes, which potentially have a large social impact, are designed in such a way that they really work.

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Chapter 7

Abundance of invertebrate prey for birds on organic and conventional arable farms in the Netherlands

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One of the nearly 1.000 pitfall traps used for invertebrate sampling

Abstract

As a result of agricultural intensification populations of farmland birds have been in steep decline for several decades now. Reduction of food abundance has been mentioned to be one factor behind these declines. Extensive farm management, such as organic, is expected to provide more food for birds. In this study, we compared invertebrate prey abundance for birds between organic and conventional arable farms during the breeding season. We made comparisons for three different groups of birds: (1) birds feeding on soil living invertebrates (earthworms), (2) birds feeding on ground-dwelling invertebrates and (3) birds feeding on aerial invertebrates. Invertebrate abundance was compared between organic and conventional farms, crops and non-crop habitats, and between crops and non-crop habitats under the same farm management. On organic sites earthworm abundance was 2-4 times higher compared to conventional sites, but no differences were found between crop types. Total abundance of ground-dwelling invertebrates did not differ between organic and conventional sites, but positive effects were found for several individual taxonomic groups, such as carabid beetles and spiders. On organic farms invertebrate abundance was higher in carrots, cereals and onions compared to other crops. On conventional farms this was true for onions. Compared with most crops, ground dwelling invertebrate abundance was low in uncropped field margins and on ditch banks. On organic farms aerial invertebrate abundance was approximately 70% higher compared to conventional farms. On cereal fields aerial invertebrates were especially abundant.

Keywords: Skylark; Lapwing; Barn Swallow; Food abundance; Earthworms

Introduction

The past few decades have seen a dramatic intensification of arable farming, characterised by increased pesticide usage, high inputs of artificial fertilizers, removal of non-crop habitats (such as hedgerows and ditches), larger fields and reduced crop diversity (Medley *et al.* 1995, Chamberlain *et al.* 2000, Stoate *et al.* 2001, Robinson and Sutherland 2002). At the same time, populations of bird species associated with arable landscapes have shown a marked decline (e.g. Krebs *et al.* 1999, Donald *et al.* 2001, 2006, Wretenberg *et al.* 2006).

One of the mechanisms believed to contribute to the decline of farmland bird populations is a reduction in the availability of invertebrate prey, one of the most important food sources for adults, and especially chicks, of most farmland bird species (Wilson *et al.* 1999, Benton *et al.* 2002, Holland *et al.* 2006). In agricultural areas invertebrate populations have declined as a result of several changes in farming practice (cf. Robinson and Sutherland 2002), viz.: (1) increased pesticide use, (2) a switch from organic manure to artificial fertilizers and (3) loss of semi-natural habitats.

An array of studies have shown that breeding bird densities are higher on organically managed farms (e.g. Christensen *et al.* 1996, Chamberlain *et al.* 1999, Beecher *et al.* 2002, Kragten and de Snoo 2008). One of the factors suggested as being responsible is the greater availability of food on organic farms (e.g. Christensen *et al.* 1996). Several studies have focussed on differences in invertebrate abundance between organically and conventionally managed farms e.g. (Hole *et al.* 2005). However, most studies focussed on only one taxonomic group of invertebrates and in most cases only one crop type was investigated. Farmland birds have different diets and diets often have a diverse prey composition (Holland *et al.* 2006). In order to assess the food abundance for farmland birds on farms it is therefore necessary to focus on a wide range of taxonomic groups of invertebrates. Besides this, crop type is likely to influence food availability as a result of crop management and sward structure (e.g. Atkinson *et al.* 2005, Hole *et al.* 2005). However, so far it is unknown which crop types provide most food for farmland birds under organic or conventional management.

The present paper seeks to analyse whether organic arable farms provide insectivorous farmland birds with more prey items during the breeding season compared to conventionally managed farms. To this end three studies were designed, each focusing on a different group of invertebrates: soil-dwelling invertebrates (earthworms), ground-dwelling invertebrates (carabids, spiders, etc.) and aerial invertebrates. These groups represent the main prey items of different avian feeding guilds: (1) birds feeding mainly on earthworms (e.g. lapwing, *Vanellus vanellus*), (2) birds feeding mainly on invertebrates active on the ground surface (e.g. skylark, *Alauda arvensis*) and (3) birds feeding mainly on aerial invertebrates (e.g. barn swallow, *Hirundo rustica*). The abundance of each invertebrate group on organic and conventional farms was compared at both farm level and crop level. A comparison was also made of invertebrate abundance on different crop types under the same type of farm management. In this way not only was an overall picture obtained of the effects of organic farming on bird food abundance, but insights were also obtained into which types of crop potentially provide the greatest availability of food items. On the same farms included in this study, breeding bird surveys have been carried out as well (Kragten and de Snoo 2008, Kragten *et al.* 2009). Consequently, this study could give some more insight in the effects of differences in food abundance between organic and conventional arable farms on breeding bird densities.

Methods

Study site and data collection

The different studies were all carried out on organic and conventional arable farms in the province of Flevoland (52° 34' N, 5° 39' E), the Netherlands, in spring 2004 and 2005. Farms were selected in two sub-areas: Oostelijk Flevoland and Noordoostpolder, both polders, reclaimed during the 1950s and 1930s respectively. The soil type is therefore of marine clay origin. The main form of land use in the study area is agricultural (64% of total area). Of the farmland 75% is used for arable farming, 13% for grassland and 12% for other types of agriculture. Approximately 8% of the farmland is managed organically (Bakker 2007). The landscape is very homogeneous and open Natural habitats consist mainly of woodland patches, grass margins and artificial watercourses. Main differences between the two sub-areas are: (1) somewhat smaller parcels in Noordoostpolder and (2) trees are generally older in Noordoostpolder.

In both sub-areas 10 conventional and 10 organic farms were selected. A pairwise was used for farm selection with each pair consisting of one organic and one conventional farm. Both farms within a pair were surrounded by similar landscape elements, such as woodlots, tree lines, roads, power lines and wind turbines. Distance between farms was at least 600 m. Because of the homogeneous landscape between-pair variation of surrounding landscape was very limited. On-farm habitat factors, such as crops and non-crop habitats were not included in the paring protocol as they constitute essential differences between the two farming systems and are a direct result of farm management. Consequently, there were large differences in crop composition between the two farm types (Table 12). On average, about 3–4% of the farm area consisted of non-crop habitats. Grassy, semi-natural elements were far more dominant than ditches, reed or woody elements. Grassy elements comprised grassy field margins and ditch banks. Woody elements consisted mainly of solitary trees and scrub, though some farms had a small hedgerow. Organic farms had slightly more non-crop habitat than conventional farms (2004: 3.7% vs. 3.1%; 2005: 4.4% vs. 3.6%), although in both years differences were not significant (2004: Wilcoxon, $Z = 1.682$, NS, 2005: Wilcoxon, $Z = 1.717$, NS). When differences were analysed per habitat type only in 2005 more woody habitat elements were found on organic farms (Wilcoxon, $Z = 2.666$, $P < 0.01$), although the absolute difference was small. All the organic farms selected had been managed according to European Union Regulation 2092/91/EEC for at least 5 years. On these farms, farmyard manure was used and weeds were controlled mechanically. All the conventional farmers used artificial fertilizers (in some cases manure as well), herbicides, pesticides and fungicides. The farm layout (crop partitioning and abundance of non-crop habitats) has been described previously by Kragten and de Snoo (2008).

In spring 2005 the study on earthworms was carried out. On ten organic and ten conventional arable farms, which were all in the same sub-area, earthworms were sampled in two sampling rounds: the first from 30 March to 1 April and the second from 28 April to 3 May. These periods coincide with the breeding season of lapwings, which feed largely on earthworms (Sheldon, 2002). On each farm a maximum of 4 fields were sampled by taking 4 30×30×30 cm soil cores on each field. Only fields with potatoes, onions, sugar beet, organic spring cereals or bare ploughed fields were sampled, as these were the dominant crop types. During the first sampling round 61 fields were sampled (33 on organic and 28 on conventional farms) and during the second round 55 fields (29 on organic and 26 on conventional farms).

Table 12 Differences in crop type between organic and conventional arable farms, showing mean relative farm area (± SD) with each crop and percentage of farmers growing the crop. Crop diversity is expressed as the Shannon-Wiener index. N = number of farms. PO = potatoes, SC = spring creals, ON = onions, SB = sugar beet, WC = winter cereals, CA = carrots, BE = Belgian endive, BEA = beans, PE = peas, OC = other crops, CD = crop diversity. *** = $P < 0.001$, ** = $P < 0.005$, * = $P < 0.05$, NS = $P > 0.05$.

Year	**2004**					**2005**				
	Organic (N=10)		***Conventional (N=10)***			***Organic (N=20)***		***Conventional (N=20)***		
	Area (%)	Farms (%)	Area (%)	Farms (%)	Sig.	Area (%)	Farms (%)	Area (%)	Farms (%)	Sig.
PO	19 ± 4	100	28 ± 6	100	*	16 ± 9	85	27 ± 8	95	**
SC	28 ± 8	100	4 ± 6	30	**	27 ± 11	100	5 ± 9	30	***
ON	11 ± 7	70	11 ± 9	70	NS	11 ± 7	75	11 ± 10	65	NS
SB	5 ± 11	20	16 ± 9	80	*	2 ± 5	15	15 ± 10	80	***
WC	0 ± 0	0	15 ± 11	70	*	0	0	12 ± 14	50	*
CA	7 ± 8	50	4 ± 5	40	NS	7 ± 8	55	4 ± 6	35	NS
BE	1 ± 3	10	6 ± 8	40	NS	3 ± 6	25	8 ± 11	45	NS
BEA	5 ± 7	40	3 ± 11	10	NS	5 ± 6	50	3 ± 8	15	NS
PE	3 ± 8	20	0 ± 0	0	NS	6 ± 8	40	1 ± 4	15	*
OC	21 ± 17	90	12 ± 16	60	*	23 ± 15	85	14 ± 17	45	NS
CD	2.5 ± 0.3		2.3 ± 0.3		NS	2.6 ± 0.5		2.2 ± 0.4		*

The study on ground-dwelling invertebrates took place on twenty organic and twenty conventional farms. These invertebrates were sampled for one week (June 1-8) in 2004. During this period many farmland passerines have chicks (e.g. Wilson *et al.* 1997, Kragten *et al.* 2008). Ground-dwelling invertebrates were sampled using pitfall traps (diameter 11.6 cm, depth 7 cm) filled with ethylene glycol diluted with water (1:1). Pitfalls were placed in the dominant crop types of each farm (maximum of 6 crop types per farm) and, if these were present, in one grassy field margin and on one ditch bank. In all, 25 different crop types were sampled. In each plot four pitfalls were placed, separated by a distance of 15 m. Within the crops the pitfalls were placed at 15, 30, 45 and 60 m from the field edge.

Aerial invertebrates were sampled during the same period and on the same farms as ground-dwelling invertebrates were sampled. The sampling periods coincided with the peak of the barn swallow breeding season (Evans *et al.* 2007). On each farm aerial invertebrates were sampled in the dominant crop types (maximum 6 crop types per farm) and, if present, on one ditch bank and in one field margin using two Sticky Traps (*Phero*bank®). Sticky Traps are plastic plates (25 x 10 cm) covered on both sides with non-drying and non-drip 'insect-glue'. These traps were attached to 1 m high bamboo poles, thus protruding above the vegetation, and placed at 30 and 60 m from the field edge, where they were left for a period of 7 days. The invertebrates trapped were then counted.

Data analysis

For all three invertebrate groups (soil-dwelling, ground-dwelling and aerial) a three-part analysis of the results was carried out. First, invertebrate abundance on organic and conventional farms was compared. Second, their abundance on organic and conventional crops was compared (for example, organically versus conventionally managed cereal fields). Similar analyses were performed for non-cropped field margins and ditch banks. Third, invertebrate abundance on different crop types was compared with that found in non-crop habitats under the same type of farm management.

Mean invertebrate abundance was calculated per sampled field after log10(x+1) transformation and used for statistical analysis. For the farm-level comparisons the mean value per crop per farm was multiplied by the relative area occupied by that crop on the farm concerned. In this way a correction was made for inter-farm differences in crop composition. Comparisons were only made when the number of sampled fields was at least five per farm type (Table 13). As aerial invertebrates were sampled in field margins on only four conventional farms, the data on field margins and ditch banks were pooled. In this was aerial invertebrate abundance in non-crop habitats could be compared with abundance in crops. To analyse differences in invertebrate abundance between organic and conventional farms or crop types, General Linear Mixed Models (GLMM) with Poisson error and logarithm link function were used with farm management (organic/conventional) set as the fixed effect and farm pair as random effect.

The farms on which ground-dwelling and aerial invertebrates were sampled were located in two different regions of the study area and therefore, 'region' was included as a random effect in the analyses for these two groups. Because on some farms earthworms were sampled on more than one bare ploughed field, 'farm' was included as a random effect as well. To assess whether the sampling position in the field was of influence on invertebrate abundance, differences in invertebrate number per position were analysed by means of a Kruskal-Wallis test. No systematic effects were found and therefore sampling position was not included in the analyses. Differences in invertebrate abundance between different crop types under the same farm management were analysed using a Kruskal-Wallis test followed by a Bonferroni-like procedure as described by Neter *et al.* (1996). Analyses were carried out using Genstat 10.0 (GLMM) and SPSS 12.0 (Kruskal-Wallis).

Table 13 Number of fields sampled per crop type and per invertebrate group. -- = no fields available for sampling. Other crops are mainly vegetable crops.

	Earthworms				Aerial invertebrates		Ground surface invertebrates	
	Period 1		Period 2					
Crop type	O	C	O	C	O	C	O	C
Bare ploughed	30	23	3	6	--	--	--	--
Potatoes	--	--	6	5	15	16	18	19
Onions	1	3	8	8	8	12	14	14
Spring cereals	4	--	10	--	19	4	20	3
Sugar beet	--	3	2	8	4	12	5	17
Carrots	--	--	--	--	7	4	7	5
Winter cereals	--	--	--	--	--	9	--	11
Other crops	--	--	--	--	18	11	21	20
Field margins	--	--	--	--	10	4	13	5
Ditch banks	--	--	--	--	12	16	20	19

Results

Earthworms

Earthworm abundance was generally 2 to 4 times higher on organic farms and fields. At the farm level this difference was significant during the first sampling period only (Table 14). At the crop level, too, earthworm abundance on organic farms was generally higher than on conventional farms. During the first sampling period the difference was significant for bare ploughed fields and during the second period for all cropped fields combined (Table 14). Earthworm abundance did not differ significantly among the various crop types.

Table 14 Mean numbers (± SE) of earthworms caught on organic and conventional farms and fields. Significant results are indicated by * (*P* < 0.05) and ** (*P* < 0.01). -- = no fields available for sampling. No significant differences between crop types were found.

		Organic	Conventional	F
Period 1 (March 30-April 1)	Farm level	4.3 ± 1.9	1.1 ± 0.3	5.54 *
	Bare ploughed	4.5 ± 1.0	1.0 ± 0.3	11.67 **
	All crops	5.4 ± 5.0	1.4 ± 0.4	2.30
Period 2 (April 28-May 3)	Farm level	4.4 ± 1.0	2.3 ± 0.8	2.82
	Bare ploughed	--	4.6 ± 3.5	--
	All crops	4.5 ± 0.7	1.6 ± 0.4	10.98 **
	Onions	4.3 ± 0.9	2.0 ± 0.8	2.80
	Potatoes	5.2 ± 2.4	1.0 ± 0.7	3.97
	Spring cereals	4.8 ± 1.1	--	--

Ground-dwelling invertebrates

No evidence was found for greater total abundance of ground-dwelling invertebrates on organic farms (Table 15). In total, 18 taxonomic groups of invertebrates were distinguished, with Carabidae, Diptera and Collembola predominating. At the farm level the abundance of 13 groups was greater on organic farms and for Carabidae Araneae, Aphididae, Hymenoptera and Cicadellidae these differences were significant. The abundance of ‘other Coleoptera’ was greater on conventional farms. For all the other groups analysed no significant effects of farm type were found.

At the crop level there was no evidence that organic management led to a greater total invertebrate abundance. However, certain individual taxonomic groups were found to more abundant in organic crops, viz.: Carabidae (cereals and potatoes), Araneae (cereals), Staphylinidae (potatoes), Formicidae (carrots) and 'other invertebrates' (carrots). In cereals, Staphylinidae and Collembola showed the opposite trend. With respect to non-crop habitats, Isopoda were found in greater numbers in organically managed field margins. In contrast, Carabidae and ‘other Coleoptera’ were found to be more abundant on conventionally managed ditch banks compared to organically managed ditch banks.

Within a given farm type, total ground-dwelling invertebrate abundance differed significantly between crop types (organic: Kruskal-Wallis, df 6, $x^2 = 16.90$, $P = 0.010$; conventional: Kruskal-Wallis, df 6, $x^2 = 14.74$, $P = 0.022$). On organic farms total invertebrate abundance was greatest in carrots, onions and cereals and least on ditch banks. On conventional farms total invertebrate abundance in onions exceeded that on any other crop.

Aerial invertebrates

At the farm level aerial invertebrate abundance was significantly greater on organic farms (Table 16). At the crop level all comparisons showed greater aerial invertebrate abundance on organic fields as well, but only in the case of potatoes was the difference significant. In non-crop habitats aerial invertebrates were more abundant on organic farms, but this difference was not significant (Table 16). On both organic and conventional farms the numbers of aerial invertebrates caught differed from crop to crop (organic: Kruskal-Wallis, df 4, _2 = 19.22, P = 0.001; conventional: Kruskal-Wallis, df 4, _2 = 13.70, P = 0.008). On both types of farm aerial invertebrate abundance was greatest over cereal fields. On organic farms aerial invertebrates were least abundant over carrots and onions and on conventional farms over potatoes and sugar beet.

Table 15 Mean number of ground-dwelling invertebrates on organic and conventional farms and crops. *P* indicates level of significance for difference in abundance between organic and conventional plots. *** < 0.001, ** < 0.01, * < 0.05, NS not significant. Ca = Carabidae, Di = Diptera, Co = Collembola, Ot =other Coleoptera, St = Staphylinidae, Ar = Arachnida, Ap = Aphididae, Ch = Chilopoda, Hy = Hymenoptera, Fo = Formicidae, Ac = Acari, Ga = Gastropoda, Ci = Cicadellidae, Is = Isopoda, Lu = Lumbricina, Ph = Phalangida, In = other invertebrates, He = Heteroptera.

	Farm-level			Carrots			Cereals			Onions		
	O	C	*F*	O	C	*F*	O	C	*F*	O	C	*F*
Total	140.9	116.5	NS	150.0	85.2	NS	158.7	100.1	NS	133.2	187.5	NS
Ca	61.9	34.2	*	44.9	14.0	NS	79.9	17.9	*	37.7	69.5	NS
Di	23.8	29.4	NS	19.5	26.9	NS	7.4	6.0	NS	33.8	37.1	NS
Co	15.9	25.1	NS	46.0	15.5	NS	4.4	23.1	**	33.2	50.2	NS
Ot	7.8	10.0	*	10.9	12.7	NS	3.9	4.4	NS	9.3	15.0	NS
St	9.8	6.7	NS	6.8	4.3	NS	10.4	22.2	*	8.6	6.0	NS
Ar	8.1	3.9	**	4.0	2.6	NS	12.8	5.7	*	3.1	3.1	NS
Ap	6.5	1.5	***	11.3	1.9	NS	13.2	4.3	NS	1.8	1.7	NS
Ch	2.3	2.2	NS	1.5	5.2	NS	2.8	4.6	NS	1.8	2.0	NS
Hy	1.7	0.9	*	2.3	1.0	NS	1.2	1.2	NS	1.8	0.9	NS
Fo	1.2	0.9	NS	1.5	0.4	*	0.9	1.1	NS	1.2.	1.0	NS
Ac	0.6	0.8	NS	0.5	0.1	NS	0.4	1.7	NS	0.3	0.2	NS
Ga	0.3	0.3	NS	0.0	0.0	NS	0.0	0.1	NS	0.0	0.0	NS
Ci	0.3	0.1	***	0.2	0.4	NS	0.1	0.1	NS	0.1	0.1	NS
Is	0.2	0.2	NS	0.2	0.0	NS	0.0	0.1	NS	0.0	0.1	NS
Lu	0.2	0.2	NS	0.0	0.1	NS	0.2	0.1	NS	0.2	0.5	NS
Ph	0.1	0.1	NS	0.2	0.0	NS	0.1	0.4	NS	0.0	0.0	NS
In	0.1	0.1	NS	0.2	0.0	*	0.0	0.1	NS	0.3	0.1	NS
He	0.0	0.0	NS	0.0	0.0	NS	0.0	0.0	NS	0.0	0.0	NS
O>C		13			11			7			8	
C>O		5			5			10			10	

	Potatoes			Sugar beet			Field margins			Ditch banks				
	O	C	*F*	O	C	*F*	O	C	*F*	O	C	*F*	O>C	C>O
Total	122.6	104.6	NS	100.6	113.8	NS	110.8	82.9	NS	71.3	83.1	NS	4	3
Ca	55.5	21.7	*	36.7	46.1	NS	20.0	21.5	NS	4.4	9.4	*	3	4
Di	33.9	45.9	NS	22.1	22.3	NS	13.2	8.0	NS	6.3	6.5	NS	2	5
Co	14.2	20.6	NS	15.3	13.4	NS	3.2	6.5	NS	4.1	6.5	NS	2	5
Ot	5.6	6.5	NS	10.7	17.6	NS	7.4	8.8	NS	3.2	5.3	**	0	7
St	5.1	2.9	*	4.0	3.4	NS	8.6	4.6	NS	4.2	4.9	NS	5	2
Ar	2.3	1.5	NS	2.3	4.6	NS	21.3	13.5	NS	12.6	10.9	NS	6	1
Ap	1.4	1.0	NS	1.7	0.9	NS	3.2	3.1	NS	2.0	1.2	NS	7	0
Ch	1.8	2.0	NS	4.5	3.3	NS	1.2	1.9	NS	1.4	2.9	NS	1	6
Hy	1.4	0.8	NS	0.9	0.7	NS	4.0	2.4	NS	3.1	2.5	NS	7	0
Fo	0.6	0.5	NS	1.4	0.8	NS	7.7	3.9	NS	7.5	8.7	NS	5	2
Ac	0.4	0.8	NS	0.5	0.3	NS	3.4	2.2	NS	3.4	4.7	NS	4	3
Ga	0.0	0.0	NS	0.0	0.0	NS	4.6	3.6	NS	7.5	10.1	NS	2	3
Ci	0.0	0.0	NS	0.0	0.0	NS	3.9	1.1	NS	3.6	3.8	NS	2	5
Is	0.0	0.0	NS	0.2	0.0	NS	1.2	0.2	**	4.8	5.9	NS	4	3
Lu	0.1	0.1	NS	0.1	0.2	NS	0.4	0.5	NS	0.7	0.7	NS	2	5
Ph	0.1	0.0	NS	0.0	0.1	NS	0.5	0.2	NS	0.4	0.3	NS	5	2
In	0.0	0.1	NS	0.0	0.0	NS	0.8	0.9	NS	0.7	0.5	NS	3	4
He	0.1	0.0	NS	0.0	0.0	NS	0.2	0.1	NS	0.2	0.2	NS	2	2
O>C		12			8			12			5			
C>O		6			8			6			13			

Table 16 Mean numbers (± SE) of aerial invertebrates caught on organic and conventional farms and over crops and non-crop habitats. Significant results are indicated by * (*P* < 0.05), ** (*P* < 0.01) and *** (*P* < 0.001). Letters indicate significant differences between crop types within the same type of farm management. Same letters indicate no difference.

	Organic	Conventional	F
Farm level	169.3 ± 19.2	100.1 ± 7.9	15.14 ***
Non-crop habitat	149.3 ± 21.4[b]	121.3 ± 8.9[ab]	2.62
Onions	106.4 ± 17.7[c]	106.1 ± 12.1[bc]	0.32
Potatoes	153.8 ± 28.4[b]	92.9 ± 10.1[cd]	4.87 *
Cereals	228.9 ± 26.3[a]	140.7 ± 18.0[a]	12.27 **
Carrots	99.4 ± 9.4[c]	--	--
Sugar beet	--	82.5 ± 15.7[d]	--

Discussion

This study found positive effects of organic farming on the abundance of earthworms and aerial and ground-dwelling invertebrates. Earthworm abundance was 2-4 times higher on organic farms and fields. For a given type of farm management no differences in earthworm abundance between crop types were found. The total abundance of ground dwelling invertebrates did not differ significantly between farm types, although Carabidae, Araneae, Aphididae, Hymenoptera and Cicadellidae were all more abundant on organic farms. The opposite was true for the group of 'other invertebrates'. In carrot, cereal and potato fields certain groups were found to be more abundant on organically managed farms. On organic farms ground-dwelling invertebrates were most abundant in carrots, cereals and onions. On conventional farms this held true for onion fields. Compared with most crops, ground-dwelling invertebrate abundance was low in uncropped field margins and on ditch banks. Aerial invertebrates were more abundant on organic farms. At the crop level significantly higher abundances were found in organically managed cereal and potato fields. Compared with other crop types, aerial invertebrate abundance was greatest in cereal fields. Some caution should be applied when interpreting the results of this study as ground-dwelling and aerial invertebrates were sampled during a period of one week only.

The greater abundance of earthworms on organic farms may be due to the use of farmyard manure rather than artificial fertilizers, manure constituting an important food resource for earthworms (Pfiffner and Mäder 1997). The absence of pesticide use may also be beneficial, especially for earthworms close to the soil surface (Pfiffner and Mäder, 1997). Many taxonomic groups of ground-dwelling invertebrates were found in greater abundance on organically managed compared with conventionally managed sites. Possible causes of these differences are absence of pesticide use, richer understory vegetation and increased food supply (Hole *et al.* 2005), but these parameters were not measured during the present study. The effects of organic farming on ground-dwelling invertebrates were somewhat inconsistent among crop types. This may be due to differences in farming practice among the various crops, including differences in tillage and pesticide application (Hole *et al.* 2005).

The greater abundance of aerial invertebrates on organic farms was probably caused by the absence of pesticide use and by higher inputs of organic fertilizers. Pesticides inputs are known to have damaging effects on invertebrate populations (e.g. Aebischer 1990, Anderson and Lydy 2002). Higher inputs of organic material are known to have positive effects on the numbers of decomposers like many Diptera species (Smeding and de Snoo 2003).

Landscape composition is known to affect differences in invertebrate abundance and diversity between organic and conventional farming systems (Purtauf *et al.* 2005, Schmidt *et al.* 2005, Holzschuh *et al.* 2007). In this study, the surrounding landscape composition was part of the farm pairing protocol. Besides this, landscape composition of the entire study area was relatively homogeneous. Therefore, it is unlikely that this has been of influence on the results. On-farm landscape composition differed largely as a result of different crop rotation systems (Table 12), but this is a direct effect of different farm management strategies.

Several studies have shown the importance of grassy or herbaceous field margins as foraging sites for birds (e.g. Marshall and Moonen 2002). In our study the abundance of ground-dwelling invertebrates in field margins was much lower than in crops. This could be a bias resulting from the sampling method adopted. With pitfalls, insect activity density is measured (e.g. Winder *et al.* 2005). Invertebrate activity depends on food availability, vegetation structure and micro-climatic conditions, and therefore comparing invertebrate abundance between different habitats using pitfalls could be biased. Also comparisons between crops could suffer to some extent from this bias, so some caution in interpreting these results should be taken.

Although overall abundance of ground-dwelling invertebrates was generally lower in uncropped habitats, certain taxonomic groups were more abundant here than in crops (Table 15). Groups characteristic of stable habitats, in particular, were more abundant in field margins and on ditch banks. In addition, most of these groups are detrivorous, hydrophylous or associated with dense vegetation structures.

Implications for birds

In 2004 and 2005 breeding bird surveys for field-breeding species were carried out on the same farms as where the invertebrates surveys took place. Besides that, barn swallow nests were counted on all these farms during spring 2005. Skylark and lapwing were both breeding in higher densities on organic farms (Kragten and de Snoo 2008), but there was no difference in the number of breeding barn swallows between the two farming types (Kragten *et al.* 2009). In contrast to skylarks, breeding densities of other species feeding mainly on ground-dwelling invertebrates, such as yellow wagtail *Motacilla flava* and meadow pipit *Anthus pratensis*, did not differ between the two farm systems. For lapwing indications were found that differences in food abundance could play a role in this. Lapwing densities were higher on organic onion fields compared to conventional onion fields, probably an effect of differences in crop management and consequently food abundance. However, for skylarks no such indications were found. Differences in skylark densities were mainly caused by differences in crop rotation schemes between the two farming systems.

The present study shows that lapwing food (earthworms) is indeed more abundant on organically managed farms. In addition to this, Baines (1990) found correlations between lapwing densities and food abundance. This reinforces the hypothesis that higher lapwing densities on organic farms are due to greater earthworm abundance. Besides lapwing, other species feeding on earthworms (e.g. blackbird, *Turdus merula*, song thrush, *Turdus philomelos*) are also likely to benefit from organic farm management.

Carabidae, Araneae and Aphididae are all relatively abundant in the diets of farmland birds (Wilson *et al.* 1999, Holland *et al.* 2006). These groups were found in greater abundance on organic farms. However, no indications were found that these differences have caused differences in densities of birds feeding on these prey items (Kragten and de Snoo 2008). It is likely, though, that skylarks and other insectivorous passerines will benefit from the greater food abundance in terms of improved breeding success (e.g. Boatman *et al.* 2004, Hart *et al.* 2006).

Christensen *et al.* (1996) found greater numbers of barn swallows flying over organically managed fields than conventionally managed fields. In the Netherlands however, no difference was found in the number of breeding barn swallows (Lubbe and de Snoo 2007, Kragten *et al.* 2009). The number of breeding barn swallows is probably correlated with the availability of suitable breeding sites. This is likely to be the same on organic and conventional farms, as the types of building on both are more or less equivalent (Lubbe and de Snoo

2007). However, the number of foraging swallows shows a positive relationship with prey abundance (Evans *et al.* 2007). Greater food abundance may therefore result in improved barn swallow breeding success, but is not likely to result in higher breeding densities.

Especially for birds feeding on ground-dwelling invertebrates, greater food abundance does not necessarily mean greater food availability as well, for differences in sward structure can lead to differences in availability even if food is equally abundant. Dense, high swards generally limit accessibility (Atkinson *et al.* 2005) and many birds prefer to forage in short swards (Devereux *et al.* 2004). As organic farms grow more spring-sown crops compared with conventional farms (e.g. Hole *et al.* 2005, Kragten and de Snoo 2008), swards are generally lower and food accessibility therefore probably higher.

The present study shows that food abundance for insectivorous breeding farmland birds is higher on organically managed arable farms. It is likely that this will result in higher adult survival rates, breeding success and better fledgling body condition of breeding birds on organic farms. Therefore, organic farming systems could potentially be beneficial for farmland bird populations. However, data on these topics are scarce and therefore future studies should focus on this.

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Chapter 8

Conclusions and discussion

The main objective of this study was to compare organic and conventional arable farms as breeding habitat for farmland birds. Therefore, a series of studies was carried out in a uniform, highly productive arable landscape in the Netherlands with the following objectives: (1) assessing and explaining differences in breeding bird densities between organic and conventional arable farms, (2) assessing and explaining differences in breeding success of birds between organic and conventional farms, (3) assessing the effectiveness of volunteer nest protection on reproductive success on both farm types, and (4) assessing chick food availability on organic and conventional arable farms. Differences in breeding bird densities were explained by looking at three different factors: (1) abundance of non-cropped habitats, (2) crop partition, and (3) within-crop factors. The latter includes sward structure and food abundance. Concerning reproductive success, direct effects of farm management on nest survival were investigated. Additionally, the possibility of indirect effects of differences in food resources on breeding success was assessed as well.

In this chapter first the overall conclusions related to breeding bird densities, breeding success and food abundance will be summarized briefly. Following, the implications for management will be discussed:

1) Can organic farming enhance farmland bird populations?
2) Are there other options to counteract the decrease of arable birds?
3) How should arable bird conservation be facilitated?

Conclusions

Differences in breeding bird densities

Total territory density of field-breeding species did not differ between organic and conventional arable farms. However, the species composition was different.

At the species level, skylark and lapwing were significant more abundant on organic farms. Skylark reached 3-4 times higher densities and lapwing densities were about twice as high on these farms. For both species differences in cropping pattern were the most explaining factor for the higher densities. Organic farms had a more diverse cropping pattern. Besides this, organic farms grow relatively large areas of spring cereals. Conventional farms grow relatively large areas of winter cereals, sugar beet and potatoes. Larger areas of spring cereals on organic farms contributed to higher densities of breeding skylarks. It was shown that on conventional farms suitable breeding habitat for skylarks is limited during the peak of the breeding season: at this time winter cereals are too dense and too high and no alternative habitat is available. On organic farms however, suitable breeding habitat was available during the entire breeding season. The larger areas of winter cereals on conventional farms limited lapwing densities these farms. Non-crop habitats did not result in differences in breeding bird densities between organic and conventional arable farms. Both organic and conventional farms had similar amounts of non-crop habitats (field margins, ditch banks, reed beds). Woody landscape elements, like solitary trees and hedgerows were only present around organic fields, but acreages were very small. Finally, indications were found that higher food abundance on organic farms contributed to higher lapwing densities.

Comparing the breeding densities of the farmyard bird species barn swallow no difference was found between the organic and conventional farms. Farmers' attitude towards these birds did not differ either; both were very positive.

Differences in breeding success

Breeding success was studied for two field-breeding species: lapwing and skylark. Indications were found that on organic farms nest success of lapwings is lower compared to conventional farms. This was caused by higher nest failure rates due to agricultural operations, especially mechanical weeding. Nest predation rates did not differ between the two farm types. Nest protection significantly reduces nest loss due to agricultural operations, but indications were found that nest protection might lead to higher nest predation and desertion rates. Overall the effectiveness of nest protection on total nest success was limited. For skylarks a comparison of breeding success of could not be made between the two farm types, however, indications were found that agricultural operations were te most common cause of nest failure.

Differences in food abundance

Food abundance was compared between organic and convention al arable farms for three groups of birds: (1) soil invertebrate (earthworm) feeders, (2) ground-dwelling invertebrate feeders and (3) aerial invertebrate feeders. Earthworms and aerial invertebrates were generally more abundant on organic farms. Total ground-dwelling invertebrate abundance did not differ between the two farming types, but some groups (e.g. carabid beetles and spiders) were more abundant on organic farms. Earthworm abundance did not differ between crop types, but ground-dwelling and aerial invertebrates did. Ground-dwelling invertebrates were most abundant in onions, carrots and cereals on organic farms and in onions on conventional farms. Aerial invertebrates were more abundant above cereal fields on both farm types.

General discussion

Can organic farming enhance farmland bird populations?

Organic farms are often mentioned to provide better habitat for birds as a result of a more diverse cropping pattern, higher food availability, and better quality of non-crop habitats (Christensen *et al.*, 1996; Wilson *et al.*, 1997; Chamberlain *et al.*, 1999). However, based on the results of this study it is doubtful whether organic farming is able to enhance farmland bird populations. In this study only skylark and lapwing were found to breed in higher densities on organic farms. Other studies however generally found positive effects on more species (e.g. Christensen *et al.*, 1996; Beecher *et al.*, 2002). However, studies comparing bird numbers between organic and conventional farms have so far been always a comparison at a given moment. In order to conclude whether organic farming can enhance farmland bird populations, future studies should focus on the difference in population trends between organic and conventional farms. Besides that some of these studies had some methodological differences, they also focussed on more than only field-breeding species. These other species might benefit from differences in non-crop habitats between both farm types (Chamberlain *et al.*, 1999), although most studies did not analyse this possibility. As mentioned earlier, quantitative differences in non-crop habitats between both farm types were very limited in this study. This was caused by the fact that the study area of this study was very homogenous in terms of presence of non-crop habitats, also including land not owned by farmers. Therefore, it is unlikely that birds dependent on these habitats will differ in abundance on the studied farms. The fact that the number of breeding barn swallows did not differ between organic and conventional farms indicates that the quality of farmyards of both farm types is more or less equal.

Certain factors should get more attention before a final conclusion can be drawn. These factors include: (1) ecological quality of non-crop habitats, (2) landscape composition (3) non-use of pesticides and mechanical weeding, (4) improving nest protection schemes and (5) winter situation. Additionally, population dynamic models should be designed for a more complete assessment of the effects of organic farming on farmland birds.

In this study no difference in the amount of non-crop habitats was found, but the quality of these habitats was only partly studied by focussing on invertebrate abundance. Suitability of a certain habitat is also determined by vegetation structure and composition and by management (e.g. Devereux *et al*, 2004). Vegetation density determines whether the habitat is suitable for nesting or foraging. These qualitative factors should be better investigated in future studies.

Landscape composition of an area might be of influence on the difference in bird densities between organic and conventional farms. Christensen *et al.* (1996) conducted their study in a more mixed agricultural landscape and found most species in higher numbers on organic farms. In many agricultural areas organic farms are characterised as mixed farms. However, the organic farms in this study were in most cases specialised arable farms. Although some farmers had livestock, their pastures were often outside the study area. This might have resulted in the somewhat limited effects of organic farming on breeding birds compared to other studies. Besides this, the heterogeneity of the landscape can have an effect as well. This study was carried out in a homogenous open area. In a landscape with small scale agriculture and more non-crop habitats, different bird species will occur and possibly different effects of organic farming might be found. So, further studies should be conducted in mixed areas and in areas with small scale agriculture.

The non-use of pesticides on organic farms is often mentioned to have positive effects invertebrates and consequently breeding numbers and breeding success of farmland birds (Smeding and de Snoo, 2003; Boatman *et al.*, 2004;

Hart *et al.*, 2006). In this study some indications were found that higher food abundance on organic farms might lead to higher lapwing densities. However, intensive and frequently carried out agricultural operations (e.g. mechanical weeding) are an important cause nest failure for field-breeding birds on organic farms. This was shown for lapwing and skylark, both the species which were more abundant on organic farms. Therefore, a detailed study should be carried out it focussing on this dilemma. Population dynamic models should be developed to analyse whether the reproductive success on organic farms is sufficient to enhance farmland bird populations.

Especially on organic arable farms nest protection programmes might be an effective conservation measure. However, these programmes can be better designed. Currently nests are often protected by volunteers by marking them with poles. However, this often happens during periods where no agricultural activities take place. Marking nests might attract predators or result in nest desertion. By marking the nests only shortly before agricultural operations will take place, chance of predation will be limited and effectiveness of nest protection might be further improved (Berg *et al.*, 1994). For small passerine birds (e.g. skylark, yellow wagtail) nest protection will be practically impossible, as nests of these species are well hidden en thus difficult to find. For these species nest protection is not an option and solutions should be found in field-scale management. These could include postponed cutting and weeding dates for certain crops.

This study focussed completely on the breeding season situation. Several previous studies indicated that the winter situation is an important explaining factor for declining farmland bird populations as well (Peach *et al.*, 1999; Siriwardena *et al.* 2008). Low food availability is often mentioned to be the most important factor. So far, no studies have compared food availability between organic and conventional arable farms during winter. During winter, most species feed on plant material such as cereal grains and seeds. Stubble fields and unharvested seed-bearing crops are important foraging habitats during winter (e.g. Henderson *et al.,* 2004; Bradbury *et al.,* 2008). Because of agronomic reasons it is not likely that the availability of these habitats differs between both farming types. However, the lack of herbicide use on organic farms might lead to higher seed availability on organic fields (Bradbury *et al.*, 2008). This might be a cause for higher numbers of wintering birds on organically managed farms (Chamberlain *et al.*, 1999, 2009; Fuller *et al.*, 2005). The winter situation on organic and conventional arable farms for farmland birds is still unclear in the Netherlands and should therefore be investigated in the future.

Are there other options to counteract the decrease of arable birds?

Besides organic farming, other ways for farmland bird conservation should be explored. One of the most widespread alternatives are agri-environment schemes, which have been implemented in many European countries (Kleijn and Sutherland, 2003). Although there has been a serious discussion about the effectiveness of agri-environment schemes (e.g. Kleijn *et al.,* 2001; Kleijn and Sutherland, 2003; Kleijn and van Zuijlen, 2004) there are several examples of effective agri-environment schemes for birds of arable farmland. Thus, establishments of field margins and cereal stubble fields have had positive effects on cirl bunting *Emberiza cirlus* numbers (Peach *et al.*, 2001; Bradbury *et al.*, 2008). Wintering granivorous passerines and skylarks benefit from stubble fields and wild bird cover crops (Bradbury *et al.*, 2003). Also positive effects of agri-environment schemes on breeding lapwings and populations of grey partridges were found (Bradbury and Allen, 2003; Bradbury *et al.,* 2003). The discussion about effectiveness of agri-environment schemes was mainly based on disappointing results of such schemes in grassland areas. Meadow birds (e.g. black-tailed godwit *Limosa limosa*, common redshank *Tringa totanus*) use meadows for all stages during the breeding period: nesting, feeding and chick rearing. In common agricultural practice all fields are cut during the breeding season, making these fields unsuitable for nesting and chick rearing (Kruk, 1994). So, there is a large conflict between common agricultural practice in grasslands and arable birds. However, for birds breeding on conventionally managed arable land the conflict is likely to be smaller, as not many nest threatening farming operations are carried out. Agri-environment schemes for arable birds can focus on three different factors: (1) providing breeding habitat (2) providing foraging habitat during the breeding season and (3) providing foraging habitat during winter.

In the UK, so-called 'Skylark-plots' have been introduced as a measure to increase breeding habitat for especially skylarks (Morris *et al.*, 2004). However, these plots seem to be not effective in the Netherlands (Willems *et al.*, 2008). Another option to increase availability of breeding habitat for ground breeding birds is the reintroduction of set-aside. Set-aside was originally introduced to counteract the overproduction of cereals in the EU. Farmers were obliged to leave a certain area of their land out of production. These areas proved to attract high numbers of breeding and wintering birds (e.g. Buckingham *et al.*, 1999; Henderson *et al.*, 2000). Furthermore, a species like skylark produced more chicks on set-aside fields compared to conventional arable crops (Poulsen *et al.*, 1998). However, cereal stocks have diminished and worldwide cereal demands are increasing. Because of this, the EU has abolished the set-aside regulation and because of increasing cereal prices it is unlikely that farmers will maintain set-aside. As a consequence, it is likely that farmland bird populations will become more under pressure (Kragten, 2008). Therefore, set-aside could be adopted as an agri-environment scheme.

This study found lower invertebrate abundance in field margins compared to crops. However, this could be a bias effect of the sampling protocol. In contrast with these results, several other studies showed that foraging habitat can be offered by grassy field margins or by cereal margins (e.g. Vickery *et al.*, 2002). Also unsprayed field margins might be useful as foraging habitats for species like yellow wagtail (de Snoo, 1999). In order to be effective though, field margins should have certain robustness (e.g. Koks *et al.*, 2007). Currently new agri-environment schemes are being discussed in the Netherlands, for example a minimum width of 9 meters for field margins, but this might be a result of biased sampling.

In winter, food availability can be improved by leaving seed bearing crops (e.g. cereals, quinoa, linseed, kale) unharvested or by leaving (cereal) stubble fields (e.g. Henderson *et al.*, 2004; Bradbury *et al.*, 2008). From 2010, only two agri-environment schemes aiming at arable farmland birds will be available in the Netherlands. One of these schemes mainly aims at providing foraging habitat during the breeding season, the other one at providing foraging habitat during winter. So, there will be no schemes available aiming at providing more breeding habitat. As this thesis shows that skylark populations probably suffer from limited availability of breeding habitat on conventional arable farms, development of such schemes should have priority.

How should arable bird conservation be facilitated?

Farmland bird conservation can only be achieved when at least some of the agricultural land will be managed less intensively and in a lot of cases will not be primarily used for food production. This means that farmers are likely to lose income when they apply conservation measures for farmland birds. Therefore, farmers need be financially compensated in order to carry out conservation measures, which are often organised under agri-environment schemes.

Budgets available for agri-environment schemes are mainly determined by the European Common Agriculture Policy (CAP), although member states have some flexibility. The CAP was originally installed to safeguard food production and farmers income. The CAP consists of two financial pillars. Pillar I is the traditional market- and price policy, mainly aimed at protecting farmers against fluctuations in the world market. Pillar II is aimed at sustainable rural development. One of the goals of this pillar is improving the quality of the environment, nature and landscape in rural areas. Agri-environment schemes are financed through this pillar. Currently, the budget available for Pillar I is approximately 5-10 times higher than the available budget for Pillar II in most European countries (Farmer *et al.*, 2008). For the period 2007-2013, the Netherlands had a total CAP budget of € 6.4 billion, of which 5.9 billion was labelled to Pillar I and the remaining 0.5 to Pillar II.

From 2013 a new CAP will be introduced and there is a strong call to focus the future CAP more on social values, such as biodiversity and environmental quality (e.g. SER, 2008). In other words, future agriculture should contribute to social welfare: production of sufficient food and delivering green services. One way to do this could be by only providing farmers income support when they deliver green services, such as field margins or winter food measures. Switzerland is already working with a system like this.

The coming decades, conservation of farmland biodiversity will be the biggest challenge for conservationists and policy makers. The skylark was once one of the most common bird species in the Netherlands. The severe decline of this species indicates a dramatic downfall of ecosystem health in agricultural areas. Typical farmland birds like corn bunting and ortolan bunting are already extinct from the Netherlands and at the current rate of population declines black-tailed godwits, skylarks and grey partridges will soon follow. Arable farmland birds are slowly getting more and more attention in the Netherlands. Although the Netherlands have no international responsibility for the conservation of these species, they contribute to the quality of life in a large part of the Dutch agricultural landscape. It is therefore important to protect these species and take immediate action.

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Samenvatting

Intensivering van de landbouw heeft ertoe geleid dat populaties van boerenlandvogels sterk zijn afgenomen sinds de jaren 60. Ooit veelvoorkomende soorten als patrijs (*Perdix perdix*) veldleeuwerik (*Alauda arvensis*) en grauwe gors (*Miliaria calandra*) zijn met meer dan 90% afgenomen. Veel soorten staan inmiddels vermeld op de Rode Lijst in verschillende West-Europese landen. Biologische landbouw wordt vaak genoemd als mogelijkheid om populaties van boerenlandvogels te herstellen. Dit is gebaseerd op de grotere variatie aan gewassen, meer semi-natuurlijke landschapselementen (bijv. akkerranden) en het achterwege blijven van het gebruik van chemische gewasbeschermingsmiddelen. Echter, hoe biologische landbouw daadwerkelijk leidt tot hogere aantallen vogels is nog steeds niet goed begrepen. Daarnaast zijn er nog onvoldoende gegevens die het broedsucces van vogels tussen biologische en gangbare boerenbedrijven vergelijken. Deze studie richt zich daarom op het vergelijken van broedvogelpopulaties op biologische en gangbare akkerbouwbedrijven en het verklaren van eventueel gevonden verschillen in dichtheden en broedsucces. Verschillen in dichtheden zijn verklaard door de effecten van 3 factoren te bepalen: (1) semi-natuurlijke landschapselementen, (2) gewassen en (3) gewasmanagement. Verschillen in broedsucces werden verklaard aan de hand van agrarische activiteiten, predatie en nestverlating. Aanvullend hierop werd het voedselaanbod tijdens het broedseizoen vergeleken tussen beide bedrijfstypen. Dit werd gedaan voor soorten die zich voeden met bodemdieren (ongewervelden), oppervlakteactieve ongewervelden en vliegende insecten. Tot slot werd het effect van vrijwillige nestbescherming op de nestoverleving onderzocht.

Deze studie werd uitgevoerd op 20 biologische en 20 gangbare akkerbouwbedrijven in Oostelijk Flevoland en de Noordoostpolder. Beide gebieden hebben een karakteristiek open landschap dat gedomineerd wordt door akkerbouw. Meest verbouwde gewassen zijn granen (vooral wintertarwe), aardappels, suikerbieten en uien. Bij het selecteren van de bedrijven voor deze studie werd gebruik gemaakt van een paarsgewijze opzet. Dit hield in dat verschillende omgevingsfactoren voor ieder bedrijf binnen een paar gelijk moesten zijn. Daarnaast waren alle biologische bedrijven al minimaal 5 jaar volledig omgeschakeld en in et bezit van het SKAL-certificaat.

Territoriumdichtheden van grondbroedende vogels werden gedurende 2 jaar vergeleken. In beide jaren verschilden de dichtheden van de meeste soorten niet tussen gangbare en biologische bedrijven. Alleen veldleeuwerik en kievit (*Vanellus vanellus*) kwamen in hogere dichteden voor op biologische bedrijven, zijn het dat alleen veldleeuwerik een consistent patroon liet zien over beide jaren. Verschillen in bouwplan tussen de beide bedrijfstypen waren de enige verklarende factor voor de hogere dichtheden op biologische akkerbouwbedrijven. Voor de kievit was dit ook een verklarende factor, maar ook gewasmanagement leek hier een rol te spelen. Er werden geen verschillen gevonden in de hoeveelheid semi-natuurlijke landschapselementen tussen beide bedrijfstypen, dus dit kon geen effect hebben op de verschillen in dichtheden broedvogels.

Gedurende 1 jaar werden de aantallen broedende boerenzwaluwen (*Hirundo rustica*) vergeleken tussen beide bedrijfstypen. Deze soort broedt op boerenerven. Ook werd gekeken of de houding van agrariërs tegenover deze vogel verschilde. Er werd geen verschil gevonden tussen het aantal broedende zwaluwen op beide typen bedrijven. Zowel biologische als gangbare akkerbouwers stonden positief tegenover de aanwezigheid van de vogel.

Hoewel er op biologische bedrijven hogere dichtheden van veldleeuwerik en kievit voorkwamen, hoeft dit niet perse te betekenen dat het broedsucces hier ook hoger is. Het achterwege blijven van chemische gewasbeschermingsmiddelen kan resulteren in een hoger voedselaanbod en indirect in een hoger broedsucces. Echter, mechanische onkruidbestrijding is een potentieel gevaar voor de nesten van grondbroedende soorten. Daarom werd de nestoverleving van kieviten vergeleken tussen biologische en gangbare akkerbouwbedrijven. In 1 jaar werd er een sterke aanwijzing gevonden dat de nestoverleving van kieviten lager is op biologische bedrijven. Dit werd veroorzaakt door landbouwkundige activiteiten, zoals mechanische onkruidbestrijding. Er werd geen verschil gevonden in predatiekans. Om kievitpopulaties beter te beschermen op biologische bedrijven zouden extra maatregelen genomen dienen te worden.

De dichtheid van veldleeuweriknesten was 7 maal hoger op biologische akkerbouwbedrijven in vergelijking met gangbare akkerbouwbedrijven (0.63 en 0.09 nest per 10 ha.). Veldleeuweriken hadden een sterke voorkeur voor zomergranen, luzerne en grasland, allemaal gewassen die voornamelijk of uitsluitend op biologische bedrijven werden verbouwd. Op biologische bedrijven werd gedurende het gehele seizoen gebroed, terwijl op gangbare bedrijven niet werd gebroed gedurende de piek van het broedseizoen (begin mei – begin juni). Op de biologische bedrijven was 27% van de nesten succesvol. Een toename van de beschikbaarheid van geschikt broedhabitat gedurende de piek van het broedseizoen op gangbare bedrijven zou een mogelijkheid kunnen zijn om de populatie veldleeuweriken te doen toenemen. Op biologische bedrijven zou de methode van gewasbescherming meer moeten worden afgestemd op broedende veldleeuweriken.

Nesten van grondbroedende vogels gaan vaak verloren door landbouwkundige activiteiten. Dit is vooral het geval op biologische akkerbouwbedrijven. Dit kan resulteren in een te lage reproductie om de populatie in stand te houden. Vrijwillige nestbescherming zou de nestoverleving van grondbroedende vogels kunnen verhogen. De nestoverleving van beschermde en onbeschermde nesten werd daarom gedurende twee jaar vergeleken op biologische en gangbare bedrijven. Alhoewel er minder nesten verloren gingen door landbouwkundige activiteiten, waren er geen significante verschillen tussen de overleving van beschermde en onbeschermde nesten. Echter, de steekproef voor biologische bedrijven was relatief klein. Er werden aanwijzingen gevonden dat beschermde nesten vaker werden gepredeerd en verlaten. Het verdient daarom aanbeveling om te onderzoeken hoe vrijwillige nestbescherming verder geoptimaliseerd kan worden.

Afname van voedselaanbod wordt vaak genoemd als een oorzaak voor de afname van populaties boerenlandvogels. Extensieve agrarische bedrijfsvoering, zoals biologische bedrijfsvoering, zal waarschijnlijk meer voedsel voor vogels bieden. Om dit te onderzoeken werd de aanwezigheid ongewervelden tijdens het broedseizoen vergeleken tussen biologische en gangbare akkerbouwbedrijven. Dit werd gedaan vanuit het oogpunt van 3 groepen vogels: (1) soorten die leven van bodemdieren (met name wormen), (2) soorten die voornamelijk leven van oppervlakte actieve ongewervelden en (3) soorten die leven van vliegende insecten. De voedselbeschikbaarheid werd vergeleken tussen biologische en gangbare *bedrijven, gewassen en semi-natuurlijke landschapselementen*. Daarnaast werd per bedrijfstype gekeken of er verschillen waren tussen verschillende gewassen en semi-natuurlijke habitats. Op biologische bedrijven werden 2 tot 4 maal zoveel wormen aangetroffen. Echter, er werden geen verschillen tussen gewassen gevonden. De totale hoeveelheid aan oppervlakteactieve ongewervelden verschilde niet tussen beide bedrijfstypen. Voor afzonderlijke taxonomische groepen, waaronder loopkevers en spinnen, werden echter wel positieve effecten van biologische landbouw gevonden. Op biologische bedrijven werden de meeste oppervlakteactieve ongewervelden aangetroffen in peen, granen en uien. Op gangbare bedrijven was dit het geval voor uien. Vergeleken met gewassen kwamen er relatief weinig ongewervelden voor in de semi-natuurlijke landschapselementen. Tot slot kwamen op biologische bedrijven ongeveer 70% meer vliegende insecten voor in vergelijking met gangbare bedrijven. Vooral boven graanpercelen waren vliegende insecten talrijk.

Deze studie toont aan dat biologische landbouw waarschijnlijk niet zal leiden tot een toename van de meeste boerenlandvogels. Hierbij dient echter wel de opmerking te worden gemaakt dat er tot op heden nog geen studies gedaan zijn die populatietrends van vogels tussen biologische en gangbare bedrijven vergelijken. Er zou daarom ook naar andere oplossingen gezocht moeten worden, gericht op het verbeteren van broedhabitat , voedselvoorziening en wintersituatie. De ontwikkeling van effectieve vormen van agrarisch natuurbeheer en de herintroductie van de braaklegregeling zouden door beleidsmakers gestimuleerd moeten worden. Financiële middelen zijn momenteel echter te beperkt om op grote schaal effectief agrarisch natuurbeheer uit te voeren. Het toekomstige Europees landbouwbeleid zou daarom hervormd dienen te worden, waarbij meer aandacht moet worden besteed aan het leveren van maatschappelijke waarden, zoals biodiversiteit en milieukwaliteit.

Curriculum vitae

Steven Kragten werd geboren op 2 april 1977 te Utrecht. Na het doorlopen van HAVO en VWO op het Cobbenhage College te Tilburg, begon hij in 1996 met de studie biologie aan de Universiteit van Leiden. Na het behalen van zijn propedeuse specialiseerde hij zich in de richting milieukunde.

Tijdens zijn doctoraalfase heeft hij twee stages uitgevoerd. De eerste stage werd bij het Centrum voor Milieuwetenschappen Leiden (CML) uitgevoerd onder leiding van Prof. Dr. Geert de Snoo. Doel van deze stage was het onderzoeken van de relatie tussen kleine landschapselementen en het voorkomen van bladluizen in wintertarwe. Voor zijn tweede stage ging hij naar Kameroen waar hij het habitatgebruik van de westelijk kob antiloop (*Kobus kob kob*) onderzocht. Deze stage werd begeleid door Dr. Paul Loth (CML) en Dr. Arend Brunsting (Wageningen Universiteit). Naast deze twee stages deed hij nog een literatuuronderzoek naar de ruimtelijke kwaliteit van habitatnetwerken op agrarische bedrijven en een evaluatie studie van agrarisch natuurbeheer in Nederland. In 2002 werd de studie succesvol afgerond.

Vanaf maart 2002 tot en met mei 2003 was hij als junior onderzoeker verbonden aan het Centrum voor Milieuwetenschappen te Leiden. Hier hield hij zich bezig met een benchmark-project voor agrarische bedrijven en werkte hij mee aan het opzetten voor een monitoringsnetwerk voor stadsnatuur in Leiden. In juli 2003 begon hij met zijn promotieonderzoek. In 2009 heeft hij dit in de vorm van dit proefschrift afgerond. Vanaf juli 2007 heeft hij 7 maanden bij b&d Natuuradvies te Amsterdam gewerkt. Hier hield hij zich onder andere bezig met ecologische monitoring, ecologische kwaliteitsbepalingen van oppervlaktewater en onderzoeken in et kader van de Flora- en Faunawet. Sinds maart 2008 werkt hij als senior beleidsmedewerker Landelijk Gebied bij Vogelbescherming Nederland te Zeist. Hier houdt hij zich met name bezig met akkervogels.

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