

The influence of weather on birds wintering in the farmlands of eastern Poland

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Counts of wintering birds were conducted in the extensively cultivated farmland of eastern Poland during three seasons. The number of wintering species of birds was negatively correlated with the depth of snow and positively related to the number of species recorded during the previous count. The total number of birds was negatively correlated with the depth of snow cover and positively correlated with the total number of birds recorded during the previous count. To a great extent it was the presence of snow cover that shaped the assemblages of birds wintering in farmland. During long-lasting snow, birds may leave this type of landscape. At wintering grounds influenced by conditions similar to those in eastern Poland the depth of snow may be of greater importance for birds than the presence of suitable feeding habitats because food is limited. As a consequence of the global climate change, changes in snow cover will occur and should increase the numbers and abundance of bird species wintering in eastern Poland.



1. Introduction

Winter-time weather conditions can be harsh for birds, especially in northern and central Europe, increasing the difficulty in finding food (Hake 1996, Newton 1998). During adverse weather conditions (e.g., low ambient temperature) birds must increase their feeding intensity (Swennen *et al.* 1989), spend more time foraging (Lima 1988) and save energy during periods between feeding (Meijer *et al.* 1996). Weather may negatively influence birds wintering in farmland. In northern and eastern European landscapes, most over-wintering birds feed mainly on seeds, mostly of weeds (Field *et al.* 2007). When the weather deteriorates and snow covers the fields, these seed-eaters have to choose between two strategies. The first is to

migrate to areas of milder winter conditions. The second is to undertake local movements to other types of habitats, such as settlements, where food is more readily available (Fedrigo *et al.* 1989, Hardi 1989). These kinds of movement impede the analysis of the influence of weather on wintering birds, because at least some species do not return to the study area after the weather improves.

The wintering of birds in areas of transitional climate is greatly influenced by variation in weather conditions. In these areas, weather factors in farmland exert a greater influence on the wintering birds than in many other areas of Europe (e.g., Galarza 2000). During winter the temperature frequently crosses the 0 °C threshold (Kožuchowski & Degirmendžić 2005). Sequences of thaws and then falling temperatures, often accompanied by

snowfall, are repeated many times. The changing weather conditions in eastern Poland allow effective studies of birds' reactions to these variations. Preliminary studies have shown high variation in the numbers of wintering birds (Goławski & Kasprzykowski 2008).

The present paper aims to identify the influence of certain weather components on the number of species and the abundance of birds wintering in the farmlands of eastern Poland. This problem is important in view of global climate change because weather influences the annual cycles of birds (Carey 2009). Inclement weather can lead to mortality among birds, and also affect their condition later, at the onset of the breeding season (Newton 1998). The condition in which birds find themselves after the winter is a factor that must be taken into account in any assessment of their breeding success (Robb *et al.* 2008). Species overwintering in farmland are primarily those that also breed in this habitat. In Europe there has been a sharp decline in the breeding populations of many such species (PECBMS 2009).

2. Material and methods

2.1. Study area and bird counts

The study was conducted during three winter seasons – 2003/2004, 2004/2005 and 2005/2006 – in the farmlands of eastern Poland. This region is characterized by fragmented fields separated by strips of uncultivated land and a dense network of dirt roads often overgrown by weeds. Fields are seldom more than 20 m wide. Two transects without woodlands and buildings (coordinates of the middle of the transect I are 52°01' N, 22°18' E, and those of the transect II are 52°06' N, 22°21' E), located in the vicinity of the town of Siedlce, were selected to study. Only scattered single trees and bushes, mainly pear trees *Pyrus communis*, birches *Betula* spp. and willows *Salix* spp. grew within the transects. Each transect was 11 km in the first season and 12 km in the subsequent seasons, the width of each transect being 200 m (see below). The route of each transect was constant in each season, apart from 1-km sections that were added in the second and third season. In the first season the counts covered an area of 220 ha along

each transect; in the two subsequent seasons they covered 240 ha. Ploughed fields (45.1%) and winter crops (41.8%) were the predominant habitats in the strips along the transects. Fallow land (5.1%), stubble fields (3.4%), gravel quarries (1.2%) and other crops (3.4%) covered smaller areas. The ratios of all types of crops were similar in the subsequent seasons.

The count method followed Mason and Macdonald (1999). Observers thus counted all the birds in a 200-m wide strip, 100 m on either side of the transect, with the aid of 10 × 42 binoculars while walking along the transect. Only those birds were included that were perched on the ground or in trees or were feeding within the transect, such as birds of prey hunting in flight.

The counts were conducted every 10 days between the beginning of December 2003 and the end of February in 2004 and between the beginning of November and the end of February in the two subsequent seasons. In accordance with Stapanian *et al.* (1999), the period between 1 November and 28 February was considered to be the wintering season for two reasons: food sources are not renewed during this period, and tropical migrants are rare or absent. This period enabled comparisons to be made with other studies carried out in Europe and North America (Mason & Macdonald 1999, Stapanian *et al.* 1999, Gillings & Baeven 2004). A total of 33 counts were done along each transect: 9 in the first season, and 12 in each of the two following seasons. Because no significant differences between the number of birds (species and individuals), seasons or transects (ANOVA, $P > 0.240$ in all cases) were found, the data were pooled to obtain larger samples. Counts were conducted between 08:30h and 14:00h on days free from precipitation or strong wind. For more details on the study area, count methods and bird assemblages, see Goławski and Kasprzykowski (2008).

2.2. Data analysis

The analysis of the influence of weather on wintering birds took two factors into consideration (the available numerical data): ambient temperature and snow depth. The impact of other meteorological factors, such as precipitation and strong wind, was eliminated by not performing counts during

Table 1. Numbers, dominance structure and frequency of a bird assemblage wintering in the farmlands of eastern Poland.

Species	No. observed	Dominance	Frequency
<i>Buteo buteo</i>	74	0.8	58
<i>Buteo lagopus</i>	18	0.2	20
<i>Perdix perdix</i>	350	3.9	53
<i>Alauda arvensis</i>	17	0.2	15
<i>Eremophila alpestris</i>	990	10.9	44
<i>Parus caeruleus</i>	25	0.3	15
<i>Lanius excubitor</i>	26	0.3	32
<i>Pica pica</i>	77	0.8	52
<i>Corvus monedula</i>	175	1.9	5
<i>Corvus frugilegus</i>	319	3.5	5
<i>Corvus corax</i>	350	3.9	82
<i>Passer montanus</i>	656	7.2	26
<i>Carduelis chloris</i>	793	8.7	35
<i>Carduelis carduelis</i>	40	0.4	11
<i>Carduelis cannabina</i>	474	5.2	24
<i>Carduelis flavirostris</i>	137	1.5	15
<i>Carduelis flammea</i>	276	3.0	26
<i>Plectrophenax nivalis</i>	206	2.3	15
<i>Emberiza citrinella</i>	4,019	44.2	71
<i>Emberiza calandra</i>	61	0.7	21
Total	9,083	100	–

such weather. The mean 24-hour ambient temperature on the day of the count was calculated from measurements taken every hour by an automatic meteorological station about 15 km from the study area. The depth of the snow was measured along the transects on the day of the count. Three measurements were randomly obtained in each of five habitat types: ploughed fields, winter crops, stubble, fallow land and dirt roads among the fields. The depth of snow was measured with a ruler in the corners of a 50 cm square frame, providing four measurements, following Wakeham-Dawson and Aebischer (1998).

An additional variable that defined the occurrence of birds during the previous count was also considered and treated as a stabilizing parameter. Time-series analysis showed that the lag correlation was one count behind both for numbers of species and numbers of individuals (Partial Autocorrelation Function; $R = 0.88, p = 0.050$ and $R = 0.79, p = 0.050$, respectively; $n = 26$ for both cases; data pooled across the two transects between 1 December and 28 February).

The whole assemblage of wintering birds, including all species of which more than 10 individuals were seen and the frequency of whose records exceeded 10% at the same time, was subjected to a statistical analysis. Also species occurring only incidentally and not associated with farmland, such as Mute Swan *Cygnus olor*, Great Spotted Woodpecker *Dendrocopos major* and Jay *Garrulus glandarius*, were excluded. Data from only 60 out of the total of 66 counts were analysed, as the first counts in each season were rejected. A subsequent multiple regression with backward stepwise selection of variables (numbers observed in preceding count, temperature, and snow depth) was applied. Snow depth data were log transformed to improve the shape of their distribution (Sokal & Rohlf 2001). Calculations were performed using Statistica 6.0 (StatSoft 2003).

3. Results

During the study 9083 individuals of 20 species were observed (Table 1). An average of 137.7 individuals (SD = 138.7, range 0–531, $n = 66$) of 6.2 species (SD = 2.3, range 0–11, $n = 66$) was noted during each count.

The number of species declined over the wintering period, but the numbers of individuals increased until mid-December, after which they decreased distinctly (Figs. 1–2). The 24-hour temperature varied greatly in the three seasons of our studies (Fig. 3). The highest temperature variation was recorded in the 2005/2006 season (variance = 34.9) and the lowest during the 2004/2005 season (variance = 21.6). The 0 °C threshold was crossed many times: 10 times in 2003/2004, 12 times in 2004–2005 and 8 times in 2005–2006 (Fig. 3). The depth of snow increased during the season, with a maximum of 23.6 cm (the mean value for all habitats; Fig. 4).

The number of wintering birds depended on the depth of snow and the number of species observed during a preceding count (ANOVA; $F_{2,57} = 12.99, R^2 = 0.29, p < 0.001$). The number of individuals thus decreased with increasing snow depth, the partial correlation for this variable being $-0.43 (p < 0.001)$. The partial correlation for the number of individuals during the preceding count was $+0.28 (p = 0.033)$. The influence of ambient

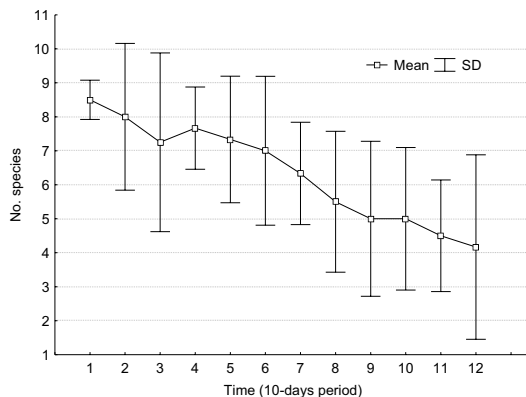


Fig. 1. Numbers of bird species during three winter seasons (November–February, 2003–2006) in the farmlands of eastern Poland.

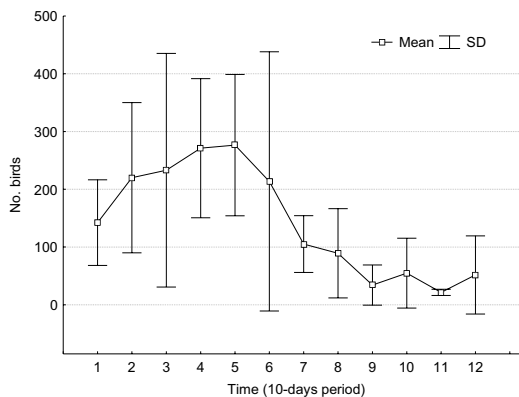


Fig. 2. Numbers of birds during three winter seasons (November–February, 2003–2006) in the farmlands of eastern Poland.

temperature was statistically non-significant ($p = 0.893$). Also the number of wintering species significantly depended on snow depth and numbers in the preceding count (ANOVA; $F_{2,57} = 14.97$, $R^2 = 0.32$, $p < 0.001$). Deeper snow led to a smaller number of species; the partial correlation for this variable was -0.43 ($p < 0.001$). The number of species was again positively correlated with the number of species observed in the preceding count, with the partial correlation for this variable being $+0.31$ ($p = 0.018$). The effect of ambient temperature was statistically non-significant ($p = 0.644$).

4. Discussion

The numbers of species and individuals wintering in the farmlands of eastern Poland were mostly affected by snow, both numbers decreasing with greater depth of snow. During one count when the snow was deepest, no wintering birds were observed at open fields along the two transects. The birds had abandoned these fields probably because of the limited availability or complete lack of food. The deepest snow was found on fallow land and on stubble, i.e., habitats where the greatest food resource for species eating seeds of weeds could be expected. The reason for high snow depth at these spots was due to abundant tall plants or their re-

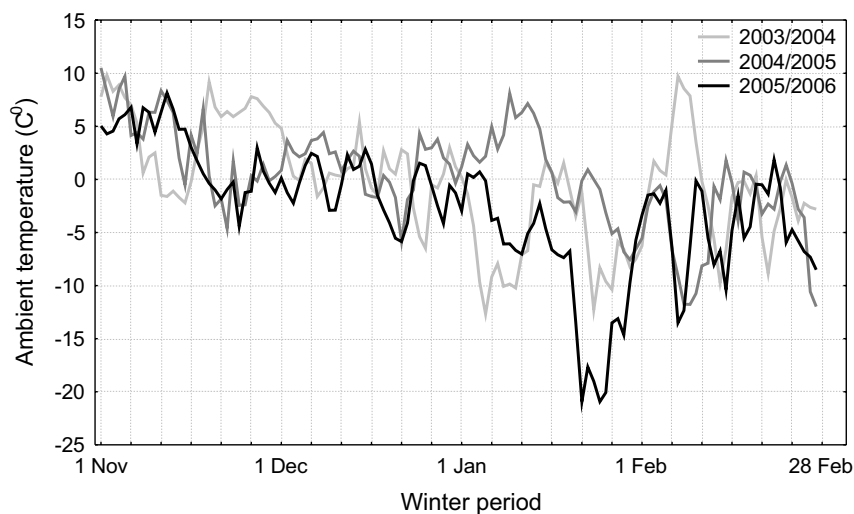


Fig. 3. Mean daily temperatures during three winter seasons (2003–2006) in eastern Poland.

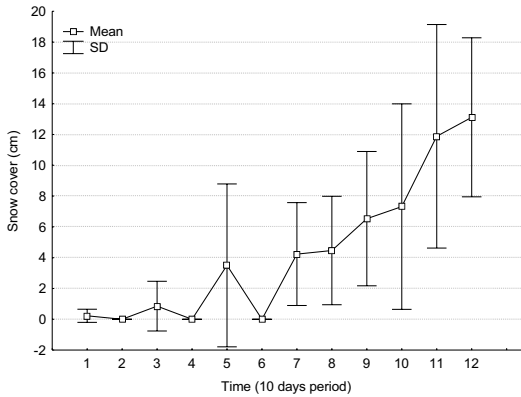


Fig. 4. The depth of snow cover during three winter seasons (November–February, 2003–2006) in the farmlands of eastern Poland.

mains that prevented the snow from being blown away, so any seeds lying on the ground had probably become unavailable to most birds. In eastern Poland these habitats are of less significance for wintering birds than comparable habitats in western Europe (Moorcroft *et al.* 2002).

In their search for food, some wintering species are forced to move to west or south, where the winter weather is more favourable (Orłowski & Gębski 2007). Other species may move to villages where they can find alternative sources of food. There is a negative correlation in the numbers of birds between farmlands and nearby villages (A. Goławski & A. Dombrowski, unpubl. data). In the rural settlements of eastern Poland, such food includes stored corn, manure and food for poultry. Yellowhammers *Emberiza citrinella* and Tree Sparrows *Passer montanus*, may benefit from these sources, and they form the core of the winter bird assemblage in these farmlands (Goławski & Kasprzykowski 2008, A. Goławski & A. Dombrowski, unpubl. data). In accordance with this scenario, larger numbers of Yellowhammers and Tree Sparrows have been reported in villages during heavy snow in western Poland (Wiatr 1975).

As shown with the present data, snow is of great importance for ground-feeding species (Newton 1998). Increasing snow cover reduces the numbers of birds in eastern Poland (Kasprzykowski & Goławski 2003, Dzierżanowski 2006), but bird numbers have been reported to increase after snowfall in western Poland (Wiatr 1975, Górski 1976). The different influence of the

snow cover on bird numbers in different regions of Poland probably results from farming practices that have changed over the past few decades. In eastern Poland, where cereals have not been stored in stacks, birds abandon fields as the depth of snow increases or they gather near heaps of manure (A. Goławski & Z. Kasprzykowski, unpubl. data). In western Poland in the 1970s, however, cereals were stored in stacks where birds gathered after snowfall (Wiatr 1975, Górski 1976).

Ambient temperature, another factor we considered here, did not significantly influence the number of bird species or the number of individuals wintering in eastern Poland. This is probably because the temperature has only an indirect effect on food availability through modifying the ground humidity (Stapanian *et al.* 1999). Changes in ambient temperature, especially around the 0 °C threshold, were often associated with snowfall. Consequently, the statistical analysis may have indicated only the influence of snow cover, and not that of temperature, on wintering birds. Moreover, no clear relationship between the ambient temperature and the number of wintering birds have been reported in farmlands in other European regions (Galarza 2000) or habitat types (Robbins 1981). However, exceptionally low ambient temperatures can kill birds (Lack 1986, Wood 1998).

We showed here that the number of individuals was positively associated with the number of birds observed in the previous count, but the effect was smaller than that of the snow cover. This finding suggests that some individuals, and probably certain species, had abandoned the study area due to high snow depth. In these conditions nomadic species, such as Shore Lark *Eremophila alpestris*, Snow Bunting *Plectrophenax nivalis* and Twite *Carduelis flavirostris*, might migrate towards the west or the south and/or select habitats other than farmland (Dierschke & Bairlein 2004, Orłowski & Gębski 2007). On the other hand, climate change may force many species (such as Shore Lark) to change their migration strategies and attempts to over-winter in new areas, especially during less severe winters (Tryjanowski *et al.* 2005).

In conclusion, the depth of snow largely determines the assemblage of birds wintering in the farmlands of eastern Poland. When snow is deep and long-lasting, birds may retreat from this type of habitat. For wintering grounds with climate

similar to eastern Poland, this factor may have a greater influence than has the presence of suitable feeding habitats. However, snow cover may change in the near future as a consequence of global climate change (Jylhä *et al.* 2008, Ballester *et al.* 2009) and result in a general increase in the number of bird species and individuals wintering in eastern Poland. Shortening the time of migration to the wintering grounds, as in the case of the Shore Lark, may allow an earlier return to breeding areas. Advantages of early nesting have been described for many species (e.g., Naef-Daenzer *et al.* 2001). Climate warming and better food availability should also positively affect sedentary species, such as Yellowhammer and Grey Partridge *Perdix perdix*, contributing to an increase in their over-winter survival (Brittingham & Temple 1998). The numbers of the Polish breeding populations of these two species exceeds 10% of the numbers of their total European population (Sikora *et al.* 2007), so to a considerable extent the fate of these two species in Europe, which have declined dramatically in recent years (PECBMS 2009), hangs on their fate in Poland. From a conservation perspective it is also important to note that probably not all species respond positively to climate change. This topic clearly deserves more in-depth research at farmland areas.

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Sään vaikutus Itä-Puolan maatalousalueilla talvehtiviin lintuihin

Talvilintuja laskettiin voimakkaasti viljellyllä alueella Itä-Puolassa kolmena kautena. Lintujen laji- ja yksilömäärät korreloivat negatiivisesti lumen syvyyden ja positiivisesti edellisen laskennan laji/yksilömäärän kanssa. Lumipeite muokkaa voimakkaasti talvehtivää viljelymaiden lintuyhteisöä. Linnut voivat siirtyä muualle alueilta, joilla on pitkään pysyvä lumipeite. Niillä talvehtimisalueilla, joilla on samankaltaiset olosuhteet kuin tutkitulla Itä-Puolassa sijaitsevalla alueella, lumen syvyys voi olla linnuille ruokailuympäristöjä tärkeämpi, koska ravinto rajoittaa niiden esiintymistä. Glo-baalien ilmastomuutoksen seurauksena tapahtu-

vat lumipeitteen muutokset voivat nostaa Itä-Puolassa talvehtivien lintujen laji- ja yksilömääriä.

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