Ornis Fennica 79:164–172. 2002

Habitat use of Yellowhammers *Emberiza citrinella*, Ortolan Buntings *E. hortulana*, and Corn Buntings *Miliaria calandra* in farmland of east-central Poland

Artur Goławski & Andrzej Dombrowski

Goławski, A., Department of Zoology, University of Podlasie, Prusa 12, 08-110 Siedlce, Poland. E-mail: artgo@ap.siedlce.pl
Dombrowski, A., Świerkowa 18, 08-110 Siedlce, Poland

Received 3 April 2002, accepted 30 May 2002

We studied the habitat use of the Yellowhammer, Ortolan Bunting, and Corn Bunting during 1995–2000 in an agricultural landscape in east-central Poland (total area of 46.5 km^2). Using the Jacobs D preference index, we found that Yellowhammer preferred woods and avoided areas with settlements. Ortolan Bunting preferred woods and avoided areas with settlements. Corn Bunting preferred grassland and wastelands, but avoided woods and areas with settlements. A comparison of the proportions of different habitat types in breeding territories of birds showed the most similarity between Yellowhammer and Ortolan Bunting, less similarity between the Yellowhammer and Corn Bunting, and the largest differences between Ortolan Bunting and Corn Bunting. We found positive correlation between the number of wooded patches and both the numbers of the Yellowhammer and Ortolan Bunting. Yet the length of wood margins had a positive effect only on the Yellowhammer. The Yellowhammer avoided wood-field ecotones as compared with wood-grassland ecotones, whereas the Ortolan Bunting showed an opposite tendency. Habitat preferences of bunting species seem to differ in different parts of a species range. In general these three species occupied diversified farmland in Poland. Their survival will thus depend on the maintenance of habitat diversity. The planned afforestation of poor soils can reduce numbers of Corn Bunting but enhance numbers of Yellowhammer and Ortolan Bunting. Rotational fallowing of arable land will promote Corn Bunting.

1. Introduction

The Bunting populations are declining throughout Europe, but most especially in western and central parts. The declining trend is most pronounced in the Corn Bunting (*Miliaria calandra*) and Ortolan Bunting (*Emberiza hortulana*) (BirdLife International/European Bird Census Council 2000). Numbers of Corn Bunting declined in most European countries. At the same time the distribution of this species is shrinking (Tucker & Heath 1994). There has been a dramatic decline in the numbers of Ortolan Bunting in western Europe, and, in some countries, the range is shrinking. Tucker and Heath (1994) do not mention any country with increasing population of this species. The Yellowhammer (*Emberiza citrinella*) population is relatively stable. Although declines have recently been noted in

some countries, they may account for only about 5% of the European population (Tucker & Heath 1994, Kyrkos *et al.* 1998).

In Poland, the Ortolan Bunting population is considered to be stable (Kuźniak *et al.* 1997), but no data are available to estimate population trends in the Corn Bunting and Yellowhammer populations (Tryjanowski *et al.* 1995). Data obtained from central-eastern Poland suggest that Yellowhammer and Corn Bunting populations have been stable over the last 20 years (Dombrowski *et al.* 2001, Goławski *et al.* 2001). The highest densities of birds include up to 9.9 pairs/km^2 for the Yellowhammer, 5.5 pairs/km^2 for the Corn Bunting, and 2.2 pairs/km^2 for the Ortolan Bunting (Kuźniak *et al.* 1997, Dombrowski *et al.* 2001, Goławski *et al.* 2001).

The main threats to the populations of all bunting species are changes in agriculture such as the reduction in crop diversity, the change from spring-sown cereals to winter-sown cereals, earlier dates of hay-making and the conversion of hay meadows into intensively cultivated silage, the increased use of pesticides, the removal of trees from roads crossing arable land, and the expansion of settlements (Tucker & Heath 1994, Hagemeijer & Blair 1997, Sirivardena *et al.* 2000). These practices may be especially threatening to granivorous lowland birds, including buntings. Consequently, the study of habitat use by these birds is of great importance. The results of the analyses performed by Sirivarden *et al.* (2000) "suggested that farming which is mixed at a small scale is widely beneficial". Such a situation is likely to exist in our study area in central-eastern Poland.

The habitat preference by buntings in Poland has not yet been studied. Such analyses are urgently needed, especially in view of the fact that Poland will become a member of the European Union, and this is likely to be associated with deep changes in Polish agriculture.

2. Material and methods

2.1. Study area

The study was conducted in the Siedleckie province (central-eastern Poland; 21°18′–22°42′E and 51°40′–52°28′N), a typical agricultural region, where arable land covers 47.9% of the total area (8500 km^2), while forests cover 22.3% of the total area. Permanent pastures and hay meadows cover 17.2% of the total area, whereas wasteland covers 5.2% of the total area. Individual farms are small, as 71% of the farms do not exceed 7 ha, and mean farm size is 7.7 ha (Powszechny Spis Rolny 1997). Settlements are small villages — up to 250 inhabitants — or single farms settled over farmland.

We collected data on the proportion of different habitats in bunting's breeding territories from four study plots during the years 1995–2000. The distance between Ogrodniki and Paprotnia plots was 2 km. These two plots were located about 85 km from Dziecinów and Sobienie study plots. The distance between Dziecinów and Sobienie plots was 0.5 km. All the plots were dominated by arable land, but they differed in the proportion of non-farmed habitats (Table 1). Arable land cut with

Table 1. The structure of land use (in percentage), length of forest margin (km), and number of wood patches in the agricultural landscape of central-eastern Poland.

Plot	Dziecinów (7.5 km^2)	Sobienie (10 km^2)	Paprotnia (18 km^2)	Ogrodniki (11 km^2)	Total (46.5 km^2)
Woods	1.5	2.2	15.8	17.3	11.0
Orchards	5.0	10.8	0.1	8.9	5.3
Arable fields	75.7	71.3	78.7	57.8	71.6
Wasteland	10.5	7.2	0.2	0.3	3.4
Grasslands	7.0	4.8	2.0	12.8	6.0
Settlements	0.3	3.7	3.2	2.9	2.7
Length of forest margin (km)	3.8	8.6	20.0	27.0	14.8
Number of wood patches	7	10	18	38	18.2

bulks into strips not much more than 20-m wide was sown with cereals (mostly rye and oats, less often barley and wheat) and potatoes. The largest woods are 60 ha, but most patches do not exceed 10 ha. About 90% of woods are represented by pine stands with sparse undergrowth but rather well developed herb layer. The remaining woods form several-ha patches of deciduous stands (oaks, birches and alders). As a patch we define woods, which were separated from another by a distance of at least 50 m. The size of wood patches was measured by using a planimeter. We distinguish between two types of ecotones. Woods bordered on cereals or potatoes characterize the wood-field ecotone, and woods bordered on hay meadows or pastures characterize the wood-grassland ecotones.

2.2. Data analysis

The paper describes habitat use by three species of buntings, based on the comparison of the proportion of different habitat types in their hypothetical territories with the proportion of these habitats at the landscape scale. Comparisons between used and available habitats are more appropriate than comparisons between used and unused habitats (according to Jones 2001).

We obtained data on the distribution and abundance of buntings using the mapping method (Tomiałojć 1980). The number of censuses on each plot varied from six (characterized by the proportion of forests as lower than 10% of the total area) to ten (characterized by the proportion of forests as higher than 10% of the total area). We approximated hypothetical territories by drawing circles centred upon the sites of most frequent records of singing males. Single encounters of males singing at large distances from the sites of most frequent records were discarded when estimating the centres of hypothetical territories. This method of delimiting hypothetical territories cannot guarantee that the habitats unused by birds will be excluded, but it shows interspecific differences, as well as differences among plots in landscape use by the three bunting species. The radius of these circles corresponds to the mean territory size of each species, the Yellowhammer territories were estimated at 50 m (0.78 ha) while the Ortolan and Corn Buntings were estimated at 100 m (3.14 ha) (Cramp & Perrins 1994). We used data from individual plots to calculate the availability of various habitats in bird territories, the correlation between the character of wooded patches and bird densities, and the Jacobs preference index, D (Jacobs 1974):

$$D = (r - p)/(r + p - 2rp)$$

where r is the proportion of a habitat in bird territory and p is the proportion of the same habitat on the plot. The index ranges from −1 (complete avoidance) to +1 (exclusive use). The value of 0 indicates that the habitat was used in proportion to its availability.

To estimate the preference of the Yellowhammer and Ortolan Bunting for the wood-field and wood-grassland ecotones, we used data from only two plots (Ogrodniki and Paprotnia) because the length of these two ecotone types was similar only on these plots (wood-field ecotone: Ogrodniki — 16 km, Paprotnia 13 km; wood-grassland ecotone: Ogrodniki — 11 km, Paprotnia — 7 km). We considered only breeding territories that could uniquely be assigned to a particular ecotone type. The number of hypothetical territories was calculated along 1-km sections. Other ecotone types exhibiting sparse occupation of buntings were not analysed. All statistical tests are two-tailed.

3. Results

3.1. Territory characteristics

Almost all (93%) territories of the Yellowhammer and Ortolan Bunting included woodlands, while only 5.1% of the territories of the Corn Bunting included woodlands. All territories of the Corn and Ortolan Buntings included arable land, while only 65% of the Yellowhammer territories included arable land. Orchards and settlements were present in smaller number of territories of all these species (Table 2).

The proportion of these habitat types within bird territories paralleled the frequency of their occurrence in territories of different species. The largest differences in the percentage cover of territories with different habitats were obtained between the Corn and Ortolan Bunting territories ($G_5 = 120.0$, $P < 0.001$), then between the Yel-

Table 2. Frequency of different habitat types in breeding territories of three bunting species in the agricultural landscape of central-eastern Poland.

Species	Woods	Orchards	Arable fields	Wasteland	Grasslands	Settlements	No territories	Plot
Emberiza citrinella	100.0	0.0	72.7	0.0	48.5	0.0	66	Paprotnia
	91.5	20.3	55.9	0.8	57.6	14.4	115	Ogrodniki
	100.0	0.0	80.0	60.0	0.0	0.0	10	Dziecinów
	66.7	33.3	93.3	40.0	6.7	6.7	15	Sobienie
Emberiza hortulana	100.0	0.0	100.0	0.0	22.2	0.0	9	Paprotnia
	100.0	27.3	100.0	13.6	18.2	9.1	22	Ogrodniki
	80.0	20.0	100.0	40.0	40.0	0.0	5	Dziecinów
	60.0	80.0	100.0	40.0	0.0	20.0	5	Sobienie
Miliaria calandra	0.0	15.6	100.0	3.1	40.6	9.4	32	Paprotnia
	7.3	17.1	100.0	53.7	29.3	0.0	41	Dziecinów
	7.7	23.1	100.0	42.3	57.7	26.9	26	Sobienie
Emberiza citrinella	92.8	13.9	65.1	6.2	48.3	8.6	206	weighed means
Emberiza hortulana	92.7	26.8	100.0	17.1	19.5	7.3	41	weighed means
Miliaria calandra	5.1	18.2	100.0	34.3	38.4	10.1	99	weighed means

Table 3. Preference index (Jacobs) of buntings for landscape features within breeding territories in the agricultural landscape of central-eastern Poland.

Species	Woods	Orchards	Arable fields	Wasteland	Grasslands	Settlements	Plot
Emberiza citrinella	+0.36	–0.22	–0.59	0.00	+0.37	+0.12	Ogrodniki
	+0.60	–1	–0.76	–1	+0.87	–1	Paprotnia
	+0.87	–0.20	–0.43	+0.41	–0.59	–0.95	Sobienie
	+0.94	–1	–0.61	+0.41	–1	–1	Dziecinów
Emberiza hortulana	+0.30	–0.51	+0.06	+0.73	–0.42	–0.71	Ogrodniki
	+0.23	–1	–0.03	–1	+0.05	–1	Paprotnia
	+0.70	+0.30	–0.17	–0.30	–1	–0.11	Sobienie
	+0.91	+0.06	–0.42	–0.19	–0.12	–1	Dziecinów
Miliaria calandra	–1	+0.52	+0.34	+0.61	+0.68	–0.68	Paprotnia
	–0.52	–0.27	–0.14	+0.04	+0.65	–0.65	Sobienie
	–0.31	–0.20	–0.14	+0.15	+0.29	–1	Dziecinów
Emberiza citrinella	+0.62	–0.16	–0.68	–0.20	+0.68	–0.13	weighed means
Emberiza hortulana	+0.45	–0.07	–0.18	–0.18	–0.19	–0.64	weighed means
Miliaria calandra	–0.90	–0.09	–0.04	+0.31	+0.58	–0.75	weighed means

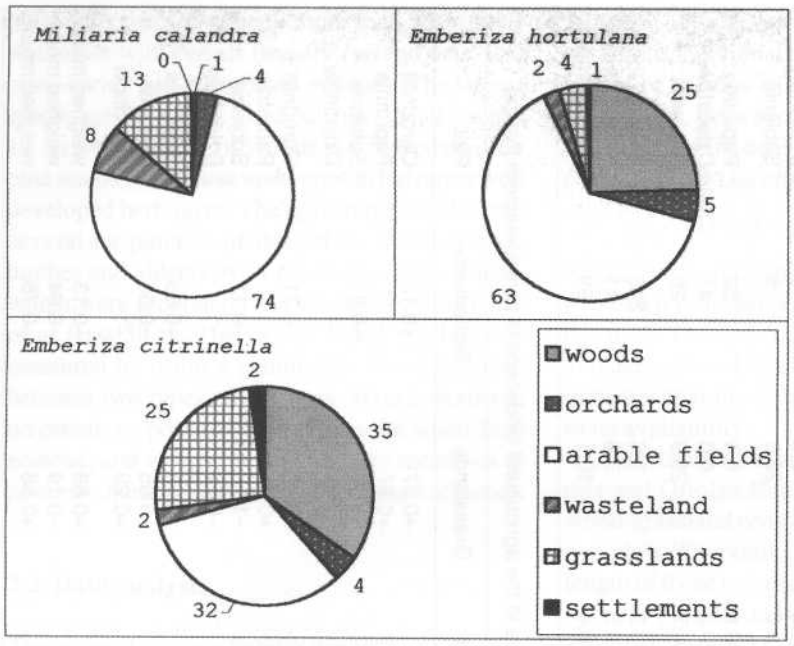

Fig. 1. Habitat composition (%) of breeding territories of the buntings in the agricultural landscape of central-eastern Poland.

lowhammer and Corn Bunting territories ($G_5 = 104.7$, $P < 0.001$), and finally between the Yellowhammer and Ortolan Bunting territories ($G_5 = 39.5$, $P < 0.001$). These differences were most evident in the proportion of woods and arable lands. Yellowhammer territories contained the highest proportion of woods, 35% on the average, whereas Corn Bunting territories only 1% (Fig. 1). An opposite situation was in the proportion of arable fields. They amounted to 74% in the Corn Bunting territories and to only 32% in the Yellowhammer territories. Grasslands formed 4% of the Ortolan Bunting territories and 25% of the Yellowhammer territories (Fig. 1).

Using the Jacobs D preference index for all the plots combined, we found that woods were most preferred by the Yellowhammers and Ortolan Buntings (+0.62 and +0.45, respectively) and strongly avoided by Corn Buntings (–0.90) (Table 3). Orchards were of minor importance to the Ortolan and Corn Buntings, while they were avoided by the Yellowhammers. Furthermore, the Yellowhammers also most strongly avoided arable lands (–0.68). Wasteland was most important for Corn Buntings (+0.31), and was avoided by Ortolan Buntings and Yellowhammers. Grasslands were preferred by Yellowhammers and Corn Buntings, while Ortolan Bunting avoided them. All the three species avoided human settlements (Table 3). However, the results were not consistent between all the study areas.

3.2. The effect of wood characteristics on the distribution of buntings

We found positive correlation between the number of wooded patches in the study plots and both the numbers of the Yellowhammers and Ortolan Buntings ($r = 0.97$, $P = 0.023$, and $r = 0.99$, $P = 0.008$, respectively). There was no such relationship for Corn Bunting ($r = -0.93$, $P = 0.073$, $n = 4$ plots). The length of the wood ecotone positively correlated only with the number of Yellowhammers ($r = 0.98$, $P = 0.020$, $n = 4$ plots). No relationship was found between numbers of these three species and wood size ($P = 0.242$ for Yellowhammer, $P = 0.470$ for Ortolan Bunting and $P = 0.654$ for Corn Bunting, $n = 4$ plots).

3.3. The effect of ecotone type on the density of buntings

On average, Yellowhammers occupied 3.83 territories along 1 km length of the wood-grassland

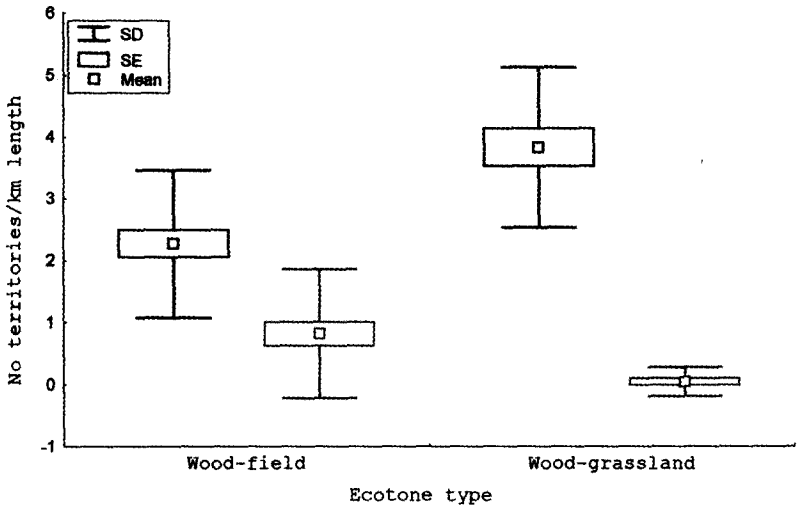

Fig. 2. Comparison of the densities (No. territories/ km length) of the Yellowhammer (n = 135, black bar) and Ortolan Bunting (n = 25, grey bar) on ecotones of two types in the agricultural landscape of central-eastern Poland.

ecotone and 2.27/km territories along the wood-field ecotone (n = 135 territories, Fig. 2). Thus, the Yellowhammer avoided the wood-field ecotone as compared with the wood-grassland ecotone (independent t-test, $t_{45} = -4.21$, $P < 0.001$), whereas the Ortolan Bunting preferred the wood-field ecotone to the wood-grassland ecotone (independent t-test, $t_{45} = 3.09$, $P = 0.003$). On the average, Ortolan Buntings held 0.83 territories along 1 km of the wood-field ecotone, and merely 0.06/km territories along the wood-grassland ecotone (n = 25 territories, Fig. 2).

4. Discussion

The present analysis shows that in the agricultural landscape of central-eastern Poland, habitat composition of breeding territories of the bunting species was mainly determined by small woods scattered in fields and grasslands, which together with rural settlements, constitute a characteristic component of farmland in this part of Poland. We found differences in the use of different habitats between the study plots, as best indicated by the Jacobs index of habitat preference. These differences mainly issued from differential spatial structure of open habitats adjacent to the woods strongly preferred by Yellowhammers and Ortolan Buntings. The analysis of the percentage contribution of the habitats does not reflect their distribution. For example, grasslands on Sobienie and Dziecinów were distant from woods, and they were absent from the hypothetical territories of these two buntings. In part, this could also be a result of the marginal proportion of a given habitat at the scale of the total study and then even one pair nesting in this habitat accounted for a high value of the preference index. For example, this was the case of the preference for orchards in Corn Bunting on plot Paprotnia and for wasteland in Ortolan Bunting on plot Ogrodniki.

The Yellowhammer showed a higher preference for woods than did the Ortolan bunting, as the latter occasionally occupied territories with single trees among crop fields. Both these species used trees at wood margins as song posts, and the Yellowhammer built nests in shrubs growing along wood margins (nests on the ground accounted for only one-third of all the nests, n = 20). The Corn Bunting showed a preference for open habitats, similar to, in Denmark, where the density of the breeding population was positively correlated with the distance to the nearest woods, and also with the distance to the nearest urbanized areas (Petersen 1998). Similarly, in western Poland the abundance of Corn Bunting was positively correlated with the proportion of grasslands in the farmland (Kosiński & Tryjanowski 2000), owing to the great abundance of weed seed and insects for nestlings and adult birds. Also according to Stoate and Szczur (1997) and Fischer and Schneider (1996), set-asides are a rich source of invertebrates. In addition, the importance of un-

cultivated crop fields for Corn Buntings is supported by an increase in their numbers with increasing area of wasteland, combined with persistence of stable or slightly decreasing populations where the proportion of wasteland does not vary (Flade & Schwarz 1999, Goławski *et al.* 2001). In Britain, however, Corn Buntings preferred intensively cultivated areas, rather than meadows (Sparks *et al.* 1996, Gregory 1999, Robinson *et al.* 2001). In some places they even avoided pastures and did not show preference for wasteland (Mason & Macdonald 2000a). Evans (1997) and Brickle and Harper (2000) have shown that grasslands and also cornfields are important. According to Mason and Macdonald (2000a) these differences imply that Corn Bunting is adapted to different open habitats.

In central-eastern Poland, the Ortolan Bunting preferred fields to grasslands. In some countries, the Ortolan Bunting can occupy quite different habitats. For example, in Norway most breeding territories were established on forest-fire sites and on peat bogs, but the birds foraged mainly on the adjacent farmland (on oat fields — Dale & Hagen 1997, Dale 2000), and in the Netherlands on heather land (van Noorden 1991).

Based on the frequency of habitats in breeding territories and on the Jacobs D preference index, it can be concluded that all buntings avoided human settlements, however, the Yellowhammer appears to be the most tolerant species. Surprising was lack of preference for orchards (seemingly substitutes for wood patches) in the Ortolan Bunting and the Yellowhammer. The avoidance of orchards by Yellowhammers was also observed in Britain but, at the same time, they avoided woodlands and strongly preferred hedgerows (Mason & Macdonald 2000b). But at the scale of the British Isles, woods (also fallows and old grasslands) had a positive effect on the occurrence of the Yellowhammer (Sirivardena *et al.* 2000). Also in Danish farmland the effect of woods was positive, though hedgerows were strongly preferred (Petersen 1998).

The strong preference for grasslands and equally strong avoidance of arable land by Yellowhammers may also be startling. It is confirmed by the analysis of the occurrence of this species in two types of ecotones. The wood-grassland ecotone was more preferred than the wood-field ecotone. A similar situation was observed in Switzerland (Biber 1993). Presumably, grasslands, which were covered with relatively short vegetation and mown twice (in the breeding season of the Yellowhammer), provided better foraging grounds for this species, compared with arable land under crops dominated by tall, winter-sown cereals. In eastern England, Yellowhammers preferred most of all grass and set-asides, also peas (though the relationships were weak: Jacobs D index varied from +0.23 to +0.27), probably because at the beginning of the breeding season food was most readily available in set-aside and broad-leaved crops (Mason & Macdonald 2000b cited in Stoate *et al.* 1998). In Britain, Yellowhammers preferred ecotones with fallows (Bradbury *et al.* 2000) and also with crop fields (Fuller *et al.* 1997, Kyrkos *et al.* 1998, Morris *et al.* 2001), possibly as a consequence of a different character and intensity of grassland management in this country. In central-eastern Poland, meadows and pastures are used extensively, and they were not converted into grassy monocultures.

It seems that at present, habitat conditions are suitable for the buntings in this part of Poland, as evidenced by high densities of these three species. The highest densities of the Yellowhammer and Ortolan Bunting were observed on plot Ogrodniki, supporting the most mosaic plant cover, with a long forest-margin line (9.9 and 2.0 pairs/km^2, respectively). The Corn Bunting reached a highest density of 5.5 pairs/km^2 on plot Dziecinów, where the proportion of wasteland was the highest of all the four plots considered here (Kuźniak *et al.* 1997, Dombrowski *et al.* 2001, Goławski *et al.* 2001).

In addition to the beneficial habitat conditions for buntings also others factors might affect their abundance. No significant changes were observed in the landscape between 1970s/1980s and recent years, except that the area of wasteland increased, this being rather beneficial to birds. The use of pesticides even slightly declined between 1980 and 1994: from 0.9 kg/ha to 0.7 kg/ha (the use of insecticides dropped to ninth over this period — WUS 1995). The application of mineral fertilisers dropped from 124.4 kg/ha in the season 1979/1980 to 59.1 kg/ha in the season 1993/1994. The number of corvids that can destroy buntings' nests (Crows and Magpies) did not increase from the 1970s/

1980s. The abundance of the Jay increased in the same period (Dombrowski & Goławski 2002).

Habitat preferences of buntings in central-eastern Poland show an important role of wasteland and grasslands. After joining the European Union, small-scale mixed farming in Poland will probably be replaced by large-scale monocultures with no woods and single trees. Light soils will be afforested, and small patches of pastures and hay meadows among arable land will disappear. The highly diversified landscape will be simplified, and in combination with the planned intensification of the use of chemicals for plant protection, this will contribute to changes in bunting numbers. These changes, combined with afforestation of the poorest soils, are likely to affect Corn Buntings to the highest degree, although initially this species will take advantage of the field's set-aside. The abundance of Yellowhammers and Ortolan Buntings should increase with afforestation, but inevitable changes in agriculture (increasing areas of farms and fields, increasing use of pesticides and fertilizers, simplification of landscape structure) can also affect these species in a more distant future.

Acknowledgements: We wish to thank Dr C. Mitrus and Dr P. Tryjanowski for their critical comments on the first draft and L. Siefferman for improved English. We thank G. M. Siriwardena and anonymous person who reviewed paper. We express our gratitude to J. Jokimäki for constructive help on previous drafts of the manuscript.

Selostus: **Keltasirkun, peltosirkun ja harmaasirkun elinympäristön käyttö Puolan maatalousalueilla**

Monet sirkkulajit ovat vähentyneet maataloudessa tapahtuneiden muutosten johdosta etenkin Länsi- ja Keski-Euroopassa. Muutoksia on odotettavissa myös Puolassa, maan liittyessä Euroopan unioniin. Kirjoittajat tutkivat keltasirkun, peltosirkun ja harmaasirkun elinympäristön käyttöä Siedleckien maakunnassa sijainneella neljällä tutkimusalueella vuosina 1995–2000. Noin puolet maakunnan pinta-alasta oli maatalousvaltaista aluetta. Yksittäiset maatilat olivat pinta-alaltaan pieniä, noin kahdeksan hehtaarin kokoisia. Sirkkujen reviireiltä määritettiin erilaisten elinympäristöjen pinta-alaosuudet. Lisäksi arvioitiin metsälaikkujen koko ja määrä. Tutkijat mittasivat myös erityyppisten reunojen pituuden. Sirkkujen esiintyminen ja runsaus arvioitiin kartoitusmenetelmällä. Tutkimusalueilla tehtiin lintulaskentoja 6–10 kertaa vuodessa. Sirkkujen reviireillä esiintyneiden elinympäristöjen pinta-alaosuuksia vertailtiin samojen elinympäristötyyppien pinta-alaosuuksiin tutkimusalueilla. Käytetyn Jacobs D-indeksin mukaan keltasirkku ja peltosirkku suosivat metsiä ja välttivät asuttuja alueita. Harmaasirkku suosi puolestaan heinäpeltoja ja joutomaita sekä vältti metsiä ja asuttuja alueita. Keltasirkun ja peltosirkun reviirit eivät poikenneet toistaan elinympäristötyyppien jakaumien suhteen. Peltosirkun ja harmaasirkun reviirit poikkesivat toisistaan eniten. Keltasirkun ja peltosirkun runsaus kasvoi metsälaikkujen määrän kasvaessa. Metsän reunan pituuden kasvu vaikutti positiivisesti keltasirkkujen lukumäärään. Keltasirkkua tavattiin runsaampana metsän ja nurmialueiden välisillä reunoilla kuin metsän ja peltojen välisillä reunoilla. Vastaavasti peltosirkku oli runsaampi metsien ja peltojen välisillä reunoilla kuin metsien ja nurmialueiden välisillä reunoilla. Kirjoittajien mukaan eri sirkkulajien suosimat elinympäristöt näyttävät poikkeavan toisistaan lajien esiintymisalueilla. Puolassa tutkitut lajit esiintyivät monimuotoisilla viljelysalueilla. Lajien esiintymisen turvaamiseksi kirjoittajien mielestä olisikin pyrittävä ylläpitämään elinympäristöjen monimuotoisuutta. Suunnitellut metsitysprojektit vähentänevät toteutuessaan harmaasirkkujen ja lisännevät peltosirkkujen sekä keltasirkkujen määrää Puolassa. Kesannoinnin liittäminen viljelykiertoon voisi puolestaan olla edullista harmaasirkuille.

References

Biber, O. 1993: Availability and use hedges and shrubs as nest sites by Yellowhammers Emberiza citrinella in an area of intensive agriculture in Switzerland. — Orn. Beob. 90: 115–132. (In German with English summary.)

BirdLife Intrenational/European Bird Census Council. 2000: European bird populations: estimates and trends. — Cambridge, UK: BirdLife International (BirdLife Conservation Series No. 10).

Bradbury, R. B., Kyrkos, A., Morris, A. J., Clark, S. C.,

Perkins, A. J. & Wilson, J. D. 2000: Habitat associations and breeding success of Yellowhammers on lowland farmland. — J. Appl. Ecol. 37: 789–805.

Brickle, N. W. & Harper, D. G. C. 2000: Habitat use by Corn Buntings Miliaria calandra in winter and summer. — In: Aebischer, N. J., Evans, A. D., Grice, P. V. & Vickery J. A. (eds), Ecology and Conservation of Lowland Farmland Birds: 43–54. Tring: British Ornithologists' Union, Hertfordshire.

Cramp S., Perrins, C. M. (eds). 1994: The Birds of the Western Palearctic [Emberiza]. 9. — Oxford University Press, Oxford.

Dale, S. 2000: The importance of farmland for Ortolan Buntings nesting on raised peat bogs. — Ornis Fenn. 77: 17–25.

Dale, S. & Hagen, Ø. 1997: Population size, distribution and habitat selection of the Ortolan Bunting Emberiza hortulana in Norway. — Fauna norv. Ser. C, Cinclus 20: 93–103.

Dombrowski, A. & Goławski, A. 2002: Changes in numbers of breeding birds in an agricultural landscape of east-central Poland. — Vogelwelt 123: 79–87.

Dombrowski, A., Goławski, A., Kot, H., Adamczyk, Z. & Szymkiewicz, M. 2001: Densities and changes in numbers of the Yellowhammer (Emberiza citrinella) in the agricultural landscape of central-eastern Poland. — In: Tryjanowski, P., Osiejuk, T. S. & Kupczyk, M. (eds), Bunting studies in Europe: 63–70. Bogucki Wyd. Nauk., Poznań.

Evans, A. 1997: The importance of mixed farming for seed-eating birds in the UK. — In: Pain, D. J. & Pienkowski, M. W. (eds), Farming and birds in Europe: The Common Agricultural Policy and its Implications for Bird Conservation: 331–357. London: Academic Press.

Fischer, S. & Schneider, R. 1996: The Corn Bunting Emberiza calandra as an indicator species of farmland. — Vogelwelt 117: 225–234. (In German with English summary.)

Flade, M. & Schwarz, J. 1999: Current status and new results from the German Common Birds Census (DDA Monitoring Program). — Vogelwelt 120, Suppl.: 47–51.

Fuller, R. J., Trevelyan, R. J. & Hudson, R. W. 1997: Landscape composition models for breeding bird populations in lowland English farmland over a 20 year period. — Ecography 20: 295–307.

Goławski, A., Dombrowski, A. & Szymkiewicz, M. 2001: Changes in numbers of the Corn Bunting (Miliaria calandra) in the agricultural landscape of central-eastern Poland. — In: Tryjanowski, P., Osiejuk, T. S. & Kupczyk, M. (eds), Bunting studies in Europe: 123–127. Bogucki Wyd. Nauk., Poznań.

Gregory, R. D. 1999: Broad-scale habitat use of sparrows, finches and buntings in Britain. — Vogelwelt 120, Suppl.: 163–173.

Hagemeijer, W. J. M. & Blair, M. J. 1997. The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. — T & A D Poyser, London.

Jacobs, J. 1974: Quantitative measurement of food selection. — Oecologia 14: 413–417.

Jones, J. 2001: Habitat selection studies in avian ecology: a critical review. — Auk 118: 557–562.

Kosiński, Z. & Tryjanowski, P. 2000: Habitat selection of breeding seed-eating passerines on farmland in Western Poland. — Ekológia (Bratislava) 19: 307–316.

Kuźniak, S., Dombrowski, A., Goławski, A. & Tryjanowski, P. 1997: Present condition and threats to the Polish population of the Ortolan Bunting Emberiza hortulana against the species situation in Europe. — Not. Orn. 38: 141–150. (In Polish with English summary.)

Kyrkos, A., Wilson, J. D. & Fuller, R. J. 1998: Farmland habitat change and abundance of Yellowhammers Emberiza citrinella: an analysis of Common Birds Census data. — Bird Study 45: 232–246.

Mason, C. F. & Macdonald, S. M. 2000a: Corn Bunting Miliaria calandra populations, landscape and land-use in arable district of eastern England. — Bird Conservation International 10: 169–186.

Mason, C. F. & Macdonald, S. M. 2000b: Influence of landscape and land-use on the distribution of breeding birds in farmland in eastern England. — J. Zool. Lond. 251: 339–348.

Morris, A. J., Whittingham, M. J., Bradbury, R. B., Wilson, J. D., Kyrkos, A., Buckingham, D. L. & Evans, A. D. 2001: Foraging habitat selection by Yellowhammers (Emberiza citrinella) nesting in agriculturally contrasting regions in lowland England. — Biol. Conserv. 101: 197–210.

van Noorden, B. 1991: A glimpse of hope for the Ortolan Bunting Emberiza hortulana? — Limosa 64: 69–71. (In Dutch with English summary.)

Petersen, B. S. 1998: The distribution of Danish farmland birds in relation to habitat characteristics. — Ornis Fenn. 75: 105–118.

Powszechny Spis Rolny 1996: 1997. — Wojewódzki Urząd Statystyczny, Siedlce.

Robinson, R. A., Wilson, J. D. & Crick H. Q. P. 2001: The importance of arable habitat for farmland birds in grassland landscapes. — J. Appl. Ecol. 38: 1059–1069.

Siriwardena, G. M., Crick, H. Q. P., Baillie, S. R. & Wilson, J. D. 2000: Agricultural land-use and the spatial distribution of granivorous lowland farmland birds. — Ecography 23: 702–719.

Sparks, T. H., Parish, T. & Hinsley, S. A. 1996: Breeding birds in field boundaries in an agricultural landscape. — Agric. Ecosyst. Environ. 60: 1–8.

Stoate, C. & Szczur, J. 1997: Seasonal changes in habitat use by Yellowhammers (Emberiza citrinella). — Brighton Crop Protection Conference — Weeds, Conference Proceedings Vols. 1–3: 1167–1172.

Tomiałojć, L. 1980: The combined version of the mapping method. — Not. Orn. 21: 33–54. (In Polish with English summary.)

Tryjanowski, P. 1997: Changes in population size of the Yellowhammer (Emberiza citrinella) in farmland of western Poland. — Ring 19: 127–133.

Tryjanowski, P., Kuźniak, S., Kujawa, K. & Dombrowski, A. 1995: The condition and threats to the polish population of the Corn Bunting (Miliaria calandra). — Not. Orn. 36: 331–341. (In Polish with English summary.)

WUS (Wojewódzki Urząd Statystyczny) 1995: The environment protection in Voivodeship of Siedlce. — Siedlce. (In Polish.)