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*Original Research*

# Bird Community Breeding in Apple Orchards of Central Poland in Relation to Some Habitat and Management Features

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**Abstract**

The purpose of this study was to characterize avian community structure and to determine responses of the birds to the management regime of an orchard system in central Poland. The avian assemblages in the apple orchards were shaped by the diversity of the surrounding habitats and the age of trees. The results document the decrease in bird numbers during the breeding season in relation to pesticide use.

**Keywords:** farmland habitat, agricultural practices, pesticides, orchards

## Introduction

Agriculture intensification over the last several years is considered to be a primary cause of the severe population decline in farmland birds [1, 2]. Intensification encompasses a wide range of components, including increased mechanization, increased use of fertilizers and pesticides, changes in crop types, the simplification of landscape structure and the loss of small, non-farmed habitats suitable for birds [3-5]. Understanding the link between increasing agriculture intensity and decreasing farmland biodiversity is of considerable importance [6]. Production intensification and modified land use are expected to affect farmland biodiversity adversely, especially due to Poland joining the EU. Poland's accession to the EU at the subsequent introduction of intensive farming methods carries the threat of irreversible changes in landscape structure [7].

Apple orchards provide semi-natural habitat for animals within a fragmented agricultural landscape. However, conventional modern apple production depends on frequent use of pesticides. Birds nesting during the most intensive period of application may be exposed to a wide variety of chemical compounds [8-13]. Interest in biological control of pests in apple orchards is increasing but the potential contribution of vertebrate predators such as birds to this control is mostly overlooked, because sufficient quantitative data on their performance in this kind of habitat is lacking [14].

Our objective was to characterize avian community structure within orchards during the breeding season and to examine the influences of different habitat characteristics on bird communities. We also wished to test the hypothesis that the abundance and species diversity of birds would be positively correlated to the age of trees in the study orchards. We expected that older trees create more diverse habitat for more species of birds. We looked at the temporal coincidence of bird use of orchards and pesticide applications to evaluate the risk to the birds from pesticides. Finally we tried to identify the effects of management regimes on the species assemblages, comparing the number of birds recorded in orchards over three consecutive counts during the breeding season.

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## Materials and Methods

We recorded bird species on transects in 12 orchards distributed across two study areas in the Middle Wisła River valley in central Poland (Fig. 1). The first group of transects was located near Józefów and the second near Sandomierz (specific sites are listed in Table 1). The overall landscape is characterized by agriculture plains, scattered forest islets and human settlements. Around the Józefów area arable fields accounts for approximately 34% of the land cover, orchards for 25%, forests for 23%, meadows for 5% and other habitats 13%. The area around Sandomierz consists of 51% arable fields, 20% orchards, 10% meadows, 8% forests and 11% built-up areas and other. The Sandomierz area is a plateau, higher in elevation than the Józefów area. The age of the apple plantations ranged from 21-40 years old, with only occasional small fragments containing older or younger trees. Characteristics of study transects are presented in Table 1.

We obtained information on pesticide use in the orchards from interviews with farmers. Orchards were sprayed with various pesticides up to 15 times per season (March-October). Pesticides used included insecticides (e.g. "Owadofos"), fungicides ("Miedzian", "Unix 75 WG", "Kaptan 50 WP", "Systemik 125 SL", "Alert 375 SC", "Penncozeb 80 WP") and herbicides.

Censuses were carried out during the 2005 breeding season in the first hours after dawn on days without heavy rainfall or strong winds. Each transect was censused three times, each morning between 20-22 April, 4-6 May and 14-24 June. The June census was a control, made after the breeding season had ended. Line transects were ideal for this habitat, because the study orchards were long and narrow. Transect lines were located with a hand-held Global Positioning System (GPS). They were always 60 m wide (30 m on each side of the transect). The observer walked at a slow pace (ca. 1 km $h^{-1}$ with occasional pauses) along transects. During each field-visit all individuals detected (seen or heard) were noted. Birds flying high over transects were not recorded because their association with orchards could not be established with certainty. We considered the total number of individuals detected on all of the censuses conducted at each transect when calculating the abundance of each species in the avian community. Bird guilds were distinguished according to Wuczyński [15] and Tomiałojć et al. [16]. Transects were classified according to the age of the trees: old orchards (31-40 years old) and young orchards (21-30 years old). Data were tested for statistical normality using a Kolmogorov-Smirnov test, and then analyzed with parametric tests (ANOVA, STATISTICA 6.0 pack), [17]. All tests were two-tailed. Data are presented as mean ± SD.

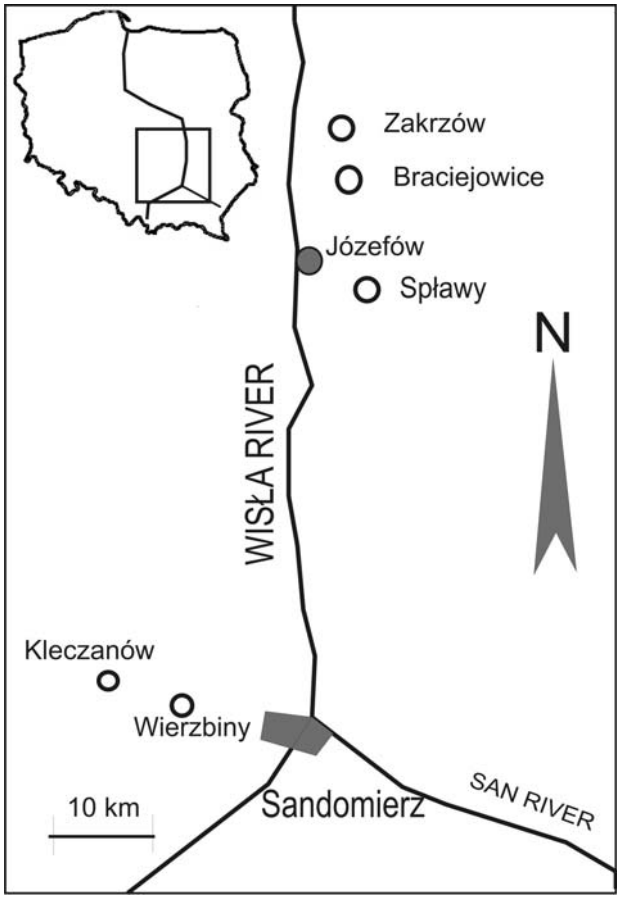


Fig. 1. A map of the study area.

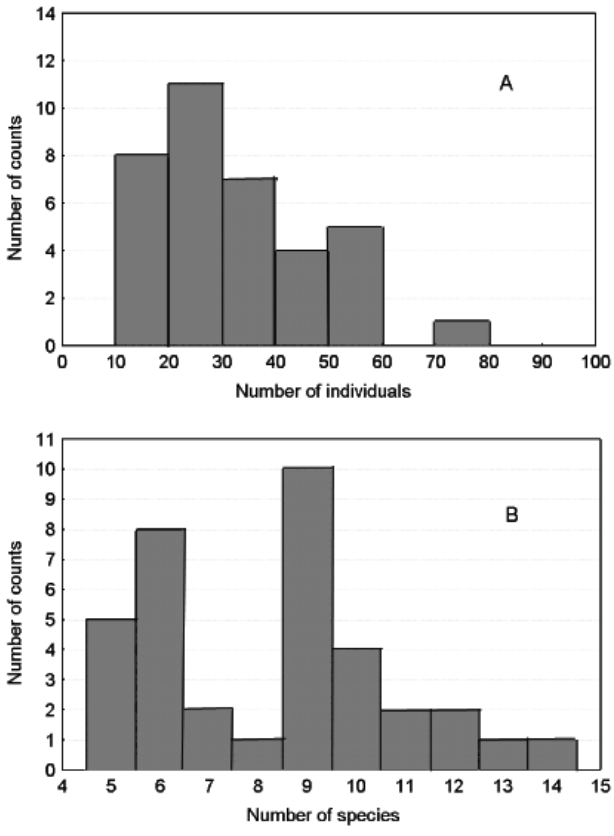


Fig. 2. Distribution of the number of individuals (A) and species (B) per count.

Table 1. The characteristics of the studied orchards.

| Transect code | Coordinates | Length (m) | Age of trees (years old) | Elevation ( m a. s. l.) |
|---|---|---|---|---|
| Kleczanów 1 | 50º43´1.3”N 21º34´43.7”E | 547 | 31-40 | 232 |
| Kleczanów 2 | 50º42´38.5”N 21º34´29.4”E | 735 | 21-30 | 246 |
| Kleczanów 3 | 50º42´59.8”N 21º34´52”E | 648 | 21-30 | 251 |
| Kleczanów 4 | 50º42´54.6”N 21º35´13.1”E | 523 | 21-30 | 250 |
| Wierzbiny 1 | 50º42´10.4”N 21º39´16.6”E | 490 | 21-30 | 219 |
| Wierzbiny 2 | 50º41´45.2”N 21º38´59.3”E | 872 | 31-40 | 203 |
| Braciejowice | 51º10´38.7”N 21º49´16.8”E | 1080 | 31-40 | 121 |
| Spławy 1 | 51º02´44.6”N 21º54´45.1”E | 1060 | 31-40 | 212 |
| Spławy 2 | 51º01´51.7”N 21º53´59.8”E | 880 | 31-40 | 183 |
| Spławy 3 | 51º12´14.6”N 21º48´57.0”E | 708 | 31-40 | 127 |
| Zakrzów 1 | 51º12´14.6”N 21º48´48.7”E | 677 | 31-40 | 123 |
| Zakrzów 2 | 51º12´14.6”N 21º48´57.0”E | 708 | 31-40 | 127 |

## Results

A total of 1200 individuals from 30 species of birds was detected in this study (Table 2). Nine species were recorded in more than 50% of the censuses. The most abundant species on all transects was *Fringilla coelbes*. Species noted in a single census ranges from 5 to 14 (mean=8.3, SD=2.5, N=36, Fig. 2B). The average number of individuals on a particular count was 33.7, SD=15.1, range 13–75, N=36 (Fig. 2A). The number of species present on a single transect over all censuses ranged from 9 to 21 (mean=12.9, SD=4.2, N=12). The mean number of individuals on a transect was 100.0, SD=35.9 (range 46-168, N=12).

Five species each represented more than 5% of all individuals recorded: *Fringilla coelebs, Turdus pilaris, Carduelis cannabina, Serinus serinus, Alauda arvensis* together they constituted 78% of the community (Table 2). Birds nesting in trees represented 85% of the birds recorded, ground nesting species 10% and hole nesters 5%. During the study we observed 5 hole-nesting species: *Sturnus vulgaris, Jynx torquilla, Cyanistes caeruleus, Parus major, Passer montanus*. Birds feeding on invertebrates were the most numerous in the area (33% species with pure insectivorous diet and 31% species with mixed granivorous-insectivorous diet) followed by plant-eating species (36%), and predatory species (i.e. *Buteo buteo*). Birds of the peripheral forest zone (up to 500 m deep into the forest [16]) dominated (50%) the avifauna in the study orchards, followed by species of human settlements (32%), forest edge (8%), open habitat (6%) and the forest interior (4%).

No correlations were found between transect length and the overall number of individual birds (Spearman correlation, $r_S$=0.23; P=0.48; N=12), or the number of species

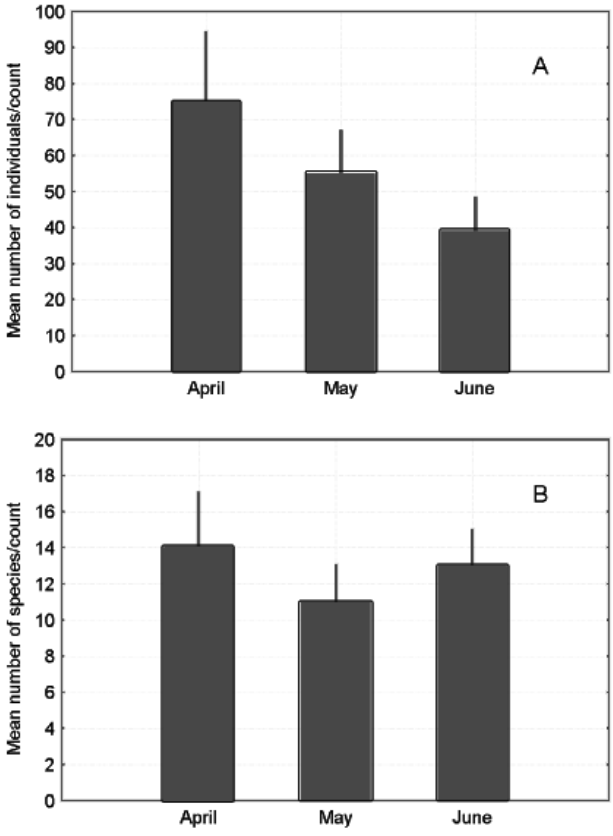


Fig. 3. Average number (± standard deviation) of individuals (A) and species (B) per count during the first (20-22 April 2005), second (4-6 May 2005) and third (14-24 June 2005) control.

Table 2. Bird community of apple orchards during the breeding season in central Poland.

| Species | Number of individuals | Share in community (%) | Frequency of occurrence in all 36 counts (%) |
|---|---|---|---|
| *Fringilla coelebs* | 279 | 23.3 | 97.2 |
| *Turdus pilaris* | 230 | 19.2 | 88.9 |
| *Carduelis cannabina* | 192 | 16.0 | 86.1 |
| *Serinus serinus* | 179 | 14.9 | 80.6 |
| *Alauda arvensis* | 60 | 5.0 | 58.3 |
| *Turdus merula* | 48 | 4.0 | 61.1 |
| *Emberiza citrinella* | 35 | 2.9 | 50.0 |
| *Sturnus vulgaris* | 35 | 2.9 | 30.6 |
| *Turdus philomelos* | 30 | 2.5 | 55.6 |
| *Carduelis carduelis* | 21 | 1.8 | 22.2 |
| *Carduelis chloris* | 19 | 1.6 | 33.3 |
| *Sylvia communis* | 9 | 0.8 | 8.3 |
| *Jynx torquilla* | 7 | 0.6 | 19.4 |
| *Columba palumbus* | 6 | 0.5 | 13.9 |
| *Cyanistes caeruleus* | 6 | 0.5 | 8.3 |
| *Acrocephalus palustris* | 5 | 0.4 | 11.1 |
| *Phylloscopus trochilus* | 5 | 0.4 | 11.1 |
| *Parus major* | 5 | 0.4 | 11.1 |
| *Hirundo rustica* | 4 | 0.3 | 5.6 |
| *Motacilla alba* | 4 | 0.3 | 11.1 |
| *Passer montanus* | 4 | 0.3 | 5.6 |
| *Buteo buteo* | 3 | 0.3 | 8.3 |
| *Phoenicurus ochruros* | 3 | 0.3 | 5.6 |
| *Coccothraustes coccothraustes* | 3 | 0.3 | 2.8 |
| *Lullula arborea* | 2 | 0.2 | 5.6 |
| *Sylvia atricapilla* | 2 | 0.2 | 5.6 |
| *Saxicola rubetra* | 1 | 0.1 | 2.8 |
| *Garrulus glandarius* | 1 | 0.1 | 2.8 |
| *Pica pica* | 1 | 0.1 | 2.8 |
| *Oenanthe oenanthe* | 1 | 0.1 | 2.8 |
| TOTAL | 1200 | 100.0 | - |

($r_S$=0.35; P=0.26; N=12) recorded along it. However, both the number of individuals ($r_S$=- 0.69; P < 0.02; N=12, Fig. 4A) and the number of species ($r_S$=- 0.68; P < 0.02; N=12, Fig. 4B) along a transect were negatively correlated with elevation. More species (median=14 species, N=8) occurred in older orchards than in younger ones (median=9 species, N=4) and the difference was statistically significant (Mann-Whitney test, U=0.5; Z=- 2.63; P < 0.01). The overall number of individuals in older orchards was higher (median=120.0 individuals, N=8 transects) than in younger orchards (median=70.5 individuals, N=4 transects), however this difference was not significant (Mann-Whitney test, U=6.0; Z=- 1.70; P=0.09). The number of individuals in a single count decreased as the season progressed (ANOVA, $F_{2, 33}$=3.31; P < 0.05, Fig. 3A). Further *post-hoc* analysis indicated the significant difference between April and June counts (Tuckey test, P < 0.05). Despite this, we noted the stable number of species during the whole study period (ANOVA, $F_{2, 33}$=0.96; P=0.39, Fig. 3B).

## Discussion

Thirty species were observed in all orchards in the study area. A similar number of species (26) was recorded in orchards in Italy [18]. None of the species that we recorded is considered to be a high-priority species for conservation

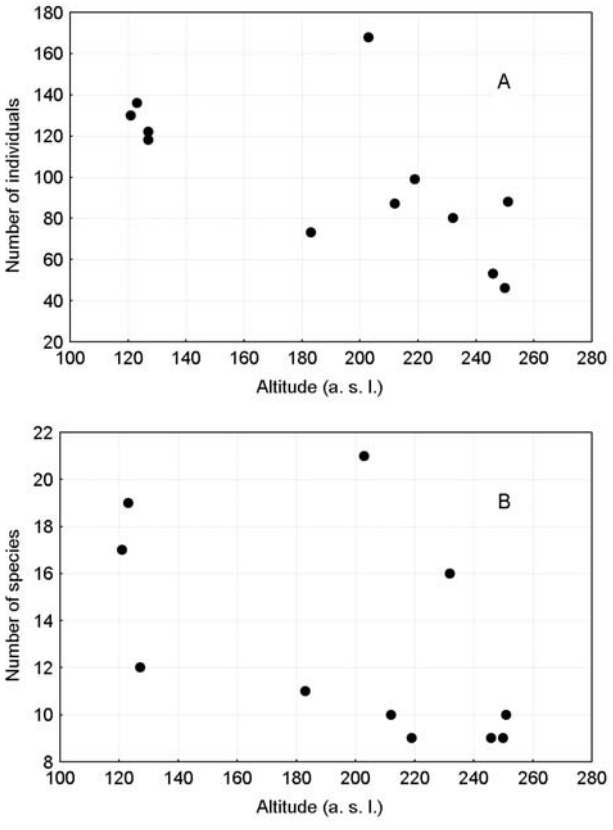


Fig. 4. Relationship between elevation and number of individuals (A) and species (B) per transect.

action [19] and only one species – *Lullula arborea* is listed in Annex I of Directive 79/409 of the European Union for Bird Conservation. The point of management, however, should be to prevent species from reaching threatened or endangered status rather than to rescue them once they have arrived [20]. Compared to other farmland habitats, the orchards we studied have a low species richness and conservation value. For example, a total of 50 species were found in two archipelagos of forest islands located in the agricultural landscape of eastern Poland [21] and 38 species were recorded in farmland woodlands of western Poland [22]. In this study the dominant bird species was *Fringilla coelebs* (23% of all birds recorded). This species is a generalist that also occurs in a wide spectrum of woodland habitat types. Nevertheless, orchards provide important breeding habitat for some bird species, particularly *Turdus pilaris, Carduelis cannabina* and *Serinus serinus*. The contribution of these species to the bird community in our study area was high compared assemblages in other habitats in Poland [23].

Tree nesters constituted the most numerous nesting guild, whereas hole-nesters avoided nesting in orchards, probably because of a shortage of holes. Hole nesting species can be largely absent from early stages of growth in managed forests and wood plantations [24, 25]. The absence or infrequent presence of hole-nesters in orchards agrees with findings of studies carried out in Italy, Switzerland and England [18]. In contrast to Italy [18] and Switzerland [25], where granivorous birds were the most common and abundant in orchards, in this study insectivorous species were the most numerous. The bird assemblages in the orchards we studied were characterized by a considerable percentage of species associated with forest edge habitats. Species inhabiting open fields (e.g. *Alauda arvensis*) were also fairly numerous.

Most studies indicate that numbers of species and individuals increase with plot size [21, 26]. The lack of a relationship between orchard size and the number of birds recorded in our study area suggests that abundance may depend more on habitat conditions within particular orchards than on plot size. In our study bird abundance was affected negatively by elevation, probably because of the reduced diversity of the surrounding habitats. The upper elevation areas near Sandomierz are relatively homogeneous compared with the more mosaic-like agricultural landscape along the Wisła Valley near Józefów that includes meadows, old river beds and farmland woodlands. Many studies have highlighted the idea that heterogenity within broad agricultural landscapes is associated with higher species richness [27].

Species richness was correleted with the age of apple trees in our study. The number of bird species breeding in young orchards was markedly lower than that in old orchards. These results were expected because the structure of vegetation in young orchards is innapropriate for species that build their nests high in tree-crowns [13, 22]. Bird abundance (number of individuals) also decreased systematically and significantly through time as the breeding season progressed, although the vegetation was increasingly developed and late migrants continued to arrive. It is likely that the bird communities in the orchards surveyed are most influenced by the supply of insects. Inscticides sprayed in the apple plantations may deplete or eliminate the arthropod food which is exploited by adults and their dependent young during the breeding season [9]. While most herbicides are not acutely toxic to birds, several indirect impacts have been demonstrated [3]. By decreasing plant diversity, herbicides can reduce arthropode populations for birds. Herbicides also eliminate plants whose seeds comprise an important food for *Fringilidae* and reduce cover in an already depauperate agricultural landscape. The heavy human impacts on agricultural landscapes and more generally all types of disturbance due to intensive agricultural mangement are likely to lead to decreased levels of biodiversity.

## Conclusions

Even within more intensively managed areas of farmland such as orchards, agricultural management could be adapted to meet conservation objectives, either by restoring traditional extensive management, or by introducing novel management practices that are designed specifically to meet the ecological requirements of birds breeding in orchards. The main factors in limiting the number of birds in orchards were pesticides and herbicides, age of the apple trees, and the variability of the surrounding landscape (habitats available for birds).

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