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Breeding bird communities in three cemeteries in the City of Bratislava (Slovakia)

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A b s t r a c t . The bird communities in three cemeteries of Bratislava (the Ondrejský cemetery, the Ružinov cemetery and the Slávičie údolie cemetery) were investigated within the period 1992-1995 with the aim to characterise breeding bird communities in this urban type of habitat. A total of 33 breeding bird species was found in the localities, with nine species constantly breeding in each of them. The mean density varied from 3.30 to 14.72 breeding pairs (BP)/ha. Altogether, five species were classified as dominant: *Turdus merula*, *Carduelis chloris*, *Sylvia atricapilla*, *Serinus serinus*, *Streptopelia decaocto*. The breeding bird communities follow the geometric model of abundance distribution, indicating harsh environment. The occurrence of breeding birds depended on the location of the cemetery in the town, and on the age, structure and composition of its vegetation. *Passer montanus*, *Passer domesticus* and *Sturnus vulgaris* occupied habitats with old lime trees characterised with high basal area. *Fringilla coelebs* was associated with high ash trees and *Luscinia megarhynchos* with dense young trees. Birds most connected with dense conifers included *Turdus merula* and *Carduelis chloris*. Areas with medium tree and shrub cover were prefered by *Serinus serinus*, *Sylvia atricapilla*, *Parus major*. Information generated by this study have important implications for management of vegetation in cemeteries.

Key words: bird-vegetation relationship, habitat selection, urban green area

Introduction

Cemeteries represent in many cases the last remnants of greenery in large cities. These habitats provide food and suitable nesting places for some bird species adapted to urban conditions.

In the City of Bratislava, the breeding birds in cemeteries have not been studied before, though numerous studies have been devoted to urban avifauna (F e r i a n c o v á - M a s á r o v á 1994, F e r i a n c o v á - M a s á r o v á & F e r i a n c 1982, 1985, 1987, O r s z á g h o v á 1992, M ü l l e r o v á - F r a n e k o v á & K o c i a n 1995, O r s z á g h o v á & Š u s t e k 1999, P o l i e v k o v á - L i č k o v á & K o c i a n 2000). In other Slovakian towns the situation is similar. In the Czech Republic, T i c h ý (1992) examined breeding communities in cemeteries in Louny town, Š r á m e k - H u š e k & D u b e n (1946) in a cemetery near Čáslav town. Several studies on breeding bird communities of urban habitats, including cemeteries, have been done in Poland (B r o z e k 1978, L u n i a k 1981, 1996, Z a l e w s k i & P r z y s t a l s k i 1993, B i a d u ń 1994). In Finland, S u h o n e n & J o k i m ä k i (1988) examined the structure of breeding bird assemblages of cemeteries and urban parks in different geographical regions.

The aim of our study was to characterise the structure of breeding bird communities in three cemeteries of Bratislava, as well as to determine the influence of the vegetation structure and composition on presence or absence of particular bird species.

Study Area

The research was conducted in three cemeteries in the city of Bratislava, south-western Slovakia. The localities under investigation were the Slávičie údolie cemetery (CSU), the Ružinov cemetery (CR) and the Ondrejský cemetery (OC). These cemeteries are located in the city of Bratislava, and differ from each other in their area, location as well as in the composition, structure and age of their vegetation.

The Slávičie údolie cemetery (18.15 ha) is situated on the western periphery of the town in the vicinity of former gardens and university campuses. Since its establishment in 1912 it has been extended many times. The dominant tree species include *Acer platanoides*, *A. pseudoplatanus*, *Fraxinus excelsior*, *Populus nigra*, *Tilia cordata*, *Betula verucosa*. *Thuja occidentalis*, *T. orientalis*, *Taxus baccata* are dominant in the shrub layer.

The Ružinov cemetery (16.46 ha) is located in the eastern part of the town periphery. It is the youngest one among the cemeteries studied, established in 1970s. The vegetation of this locality is dominated by *Acer platanoides*, *Tilia cordata*, *Picea pungens*, *Pinus nigra*, *P. sylvestris*. The main shrubs in this area are *Sambucus nigra*, *Thuja occidentalis*, *T. orientalis*.

The Ondrejský cemetery (6.32 ha) is situated in the centre of the town. It was founded in 1784, and so it is the oldest cemetery among the three localities studied. The dominant tree species are *Tilia cordata*, *Fraxinus excelsior*, *Robinia pseudoacacia*, *Picea pungens*. The dominant shrub species include *Syringa vulgaris*, *Hedera helix*, *Taxus baccata*, *Thuja orientalis*.

Material and Methods

Bird censuses

The bird censuses were based on the combined version of the mapping method (Tomiałojć 1980) and included all passerine species except Corvidae. The abundances of cavity nesters (*Parus major*, *P. caeruleus*, *Passer montanus*, *P. domesticus*, *Sturnus vulgaris*, *Dendrocopos major*, *D. syriacus*) as well as Corvidae (*Pica pica*, *Corvus corone cornix*) and *Columba palumbus*, *Streptopelia turtur*, *Falco tinnunculus* were determined on the basis of nests found. Field observations were carried out from late March to early July (breeding season for all birds) 1992 and 1993 in OC, 1993 and 1994 in CR, 1994 and 1995 in CSU. In each locality, 11–14 census surveys per breeding season were carried out (9–12 during the early morning hours and two visits during evening). Bird censuses were performed under favourable weather conditions only. Individual registrations were transferred onto the species maps. If at least three registrations were recorded or if the nest was found, the bird was considered to have established its breeding territory. All territories within the locality were regarded as breeding pairs (BP). Some territories situated at marginal parts of the locality had only a half of their area inside the locality; these were considered as 0.5 BP.

Calculation of community parameters

The following parameters were used to describe the bird communities: number of bird species on a locality (species richness - SR), number of breeding pairs (BP), number of breeding pairs per hectare (density - De), Shannon's index of diversity (H'), which was performed using the natural logarithm. The Sorensen coefficient (SQ) and Renkonen coefficient (Re) were used to compare the breeding bird communities (Janda & Řepa 1986). Density and dominance (relative abundance) of individual species were not evaluated separately for each year, but means were calculated. These values were used to determine the average communities. The overall mean density of each species was expressed as weighted average of its particular density in all three cemeteries, with the weights being equal to the areas of the cemeteries. Similarly, the overall mean dominance was obtained. Species that reached more than 5 % of the overall density were classified as dominant. Species abundance models were tested for each locality to obtain the most complete mathematical description of the breeding bird communities (Magurran 1988).

Habitat sampling

Habitat measurements were collected in a total of 150 samples (43 samples on OC, 44 samples on CR, 63 samples on CSU). A sample unit covered 0.04 ha, using a circle with 11.3 m radius. Sample units were taken at randomly selected locations and at places of bird territories. Habitat surveys were carried out in late July and August after the bird censuses were completed.

Vegetation variables were separated into two categories: structural characteristics of the habitat and floristic composition. The basic structural variables were measured as proposed by James & Shugart (1970) and Noon (1981). The structural characteristics included: tree height (m), shrub height (cm), herb height (cm), average trunk diameter at breast height (cm), number of trunks of trees, basal area (cm^2), vegetation volume (%) in different layers (0–0.3 m, 0.3–1 m, 1–3 m, 3–7 m, 7–9 m, above 9 m), total vegetation volume (sum of the values from six layers), proportion of grass in ground cover (%), proportion of dicotyledons in ground cover (%), proportion of woody vegetation less than 1 m tall in ground cover (%), proportion of bare ground in ground cover (%), proportion of graves and concrete paths in ground cover (%).

The floristic variables included the percent cover of dominant tree and shrub species and genera, respectively. The diameter of trunk at breast height was measured to distinguish between trees (> 3 cm) and shrubs (< 3 cm). The list of trees considered is: *Acer* spp., *Betula* spp., *Fraxinus excelsior*, *Syringa vulgaris*, *Tilia* spp., *Taxus baccata*, *Thuja* spp., *Pinus* spp., *Picea pungens*. The following shrubs were included: *Rosa* spp., *Hedera helix*, *Buxus sempervirens*, *Taxus baccata*, *Sambucus nigra*, *Thuja* spp. Total tree cover (%), total shrub cover (%) and number of tree genera were also recorded. Some additional variables that could be important for occurrence of some bird species were also measured. Tombstones were considered as possible nesting sites for *Phoenicurus ochruros*, *Muscicapa striata*, *Passer domesticus*. So number of graves with a tombstone was included in habitat measurements.

Bird-habitat relationships

Canonical correspondence analysis (CCA) was performed to assess the relationships between bird distribution and environmental variables using the program CANOCO (ter Braak &

Šmilauer 1998). In the analysis, only those species that reached at least 2 % of the total density were considered. The species by site matrix included 14 bird species and 150 sample units. Presence or absence of species on the sites was evaluated as follows: the particular species was considered to be present on the site if its breeding territory attained the sample unit at least in one of the breeding seasons investigated. The environmental variables by site matrix contained values of 41 environmental variables measured on 150 sample units. The forward-selection method was used to determine the minimal set of environmental variables that could explain the largest amount of variation in the bird data. At each step, the statistical significance of the environmental variable added in the course of the forward selection was tested by means of a Monte Carlo permutation test. Variables were taken to be significant if the permutation test derived $P \leq 0.05$.

Results

Characteristics of bird communities

A total of 33 breeding bird species were found in three cemeteries of Bratislava and 9 species constantly bred in each of them. The number of breeding species according to localities varied from 17 to 22 and the density from 3.30 to 14.72 BP/ha (Table 1). Species richness and total density were found to be highest in OC (22 breeding species, 14.72 BP/ha). CSU showed the lowest species richness and the lowest diversity (17 breeding species, H'= 2.45). Diversity was highest in CR (H'= 2.73). Significance tests of the Shannon's diversity between pairs of localities showed significant difference only between CSU and CR ($t = 2.422$; $df = 113$; $P < 0.05$), the other two pairs of values (CSU - OC and OC - CR) were not significantly different.

Table 1. Basic characteristic of breeding bird communities (SR - species richness, BP - number of breeding pairs, De - density of breeding pairs (BP/ha), H' - Shannon index of diversity).

Locality	Year	SR	BP	De	H'
Slávičie údolie cemetery	1994	12	60	3.31	2.31
(CSU)	1995	17	60	3.31	2.49
	1994 and 1995	**17**	**60**	**3.31**	**2.45**
Ružinov cemetery	1993	20	57.5	3.49	2.68
(CR)	1994	17	51	3.10	2.63
	1993 and 1994	**21**	**54.25**	**3.30**	**2.73**
Ondrejský cemetery	1992	18	87	13.77	2.49
(OC)	1993	20	99	15.66	2.51
	1992 and 1993	**22**	**93**	**14.72**	**2.53**

Altogether, five species were classified as dominant species: *Turdus merula*, *Carduelis chloris*, *Sylvia atricapilla*, *Serinus serinus*, *Streptopelia decaocto* (Table 2). *Streptopelia decaocto* did not belong to the dominant species of CSU and CR, but the other four species were typical for each locality. In CSU also *Pica pica*, *Phoenicurus ochruros*, *Parus major*, *Fringilla coelebs* and *Oriolus oriolus* were found to be dominant. *Pica pica* and *Oriolus oriolus* were dominant also in CR, but *Luscinia megarhynchos* reached the highest value of dominance (it was present only in this locality). *Passer montanus* and *Sturnus vulgaris* belonged to dominant species of OC as well.

Table 2. The mean density (breeding pairs per ha) and dominance (relative abundance) of breeding bird species in three cemeteries of Bratislava.

Species	Slávičie údolie cemetery (CSU)		Ružinov cemetery (CR)		Ondrejský cemetery (OC)			
density dominance	mean density	mean dominance	mean density	mean dominance	mean density	mean dominance	overall mean	overall mean
	BP/ha	%	BP/ha	%	BP/ha	%	BP/ha	%
Turdus merula	0.59	17.92	0.47	14.29	4.03	27.42	1.08	21.23
Carduelis chloris	0.34	10.42	0.27	8.29	1.58	10.75	0.51	10.01
Sylvia atricapilla	0.47	14.17	0.23	6.91	0.79	5.38	0.42	8.32
Serinus serinus	0.36	10.83	0.24	7.37	0.95	6.45	0.40	7.96
Streptopelia decaocto	0.14	4.17	0.11	3.23	1.19	8.06	0.29	5.67
Pica pica	0.30	9.17	0.27	8.29	-	-	0.24	4.83
Parus major	0.23	7.08	0.15	4.61	0.47	3.23	0.24	4.70
Passer montanus	-	-	0.09	2.76	1.27	8.60	0.23	4.58
Luscinia megarhynchos	-	-	0.52	15.67	-	-	0.21	4.10
Phoenicurus ochruros	0.29	8.75	0.12	3.69	0.08	0.54	0.19	3.74
Fringilla coelebs	0.17	5.00	-	-	0.55	3.76	0.16	3.14
Sturnus vulgaris	0.03	0.83	-	-	0.87	5.91	0.15	2.90
Oriolus oriolus	0.17	5.00	0.18	5.53	-	-	0.15	2.90
Passer domesticus	-	-	0.03	0.92	0.63	4.30	0.11	2.17
Muscicapa striata	-	-	-	-	0.63	4.30	0.10	1.93
Hippolais icterina	0.06	1.67	0.03	0.92	0.32	2.15	0.09	1.69
Dendrocopos major	0.06	1.67	0.06	1.84	0.08	0.54	0.06	1.21
Streptopelia turtur	-	-	0.15	4.61	-	-	0.06	1.21
Parus caeruleus	-	-	-	-	0.32	2.15	0.05	0.97
Sylvia curruca	0.03	0.83	-	-	0.24	1.61	0.05	0.97
Corvus corone cornix	-	-	0.06	1.84	0.16	1.08	0.05	0.97
Columba palumbus	-	-	0.09	2.76	-	-	0.04	0.72
Phylloscopus collybita	-	-	0.09	2.76	-	-	0.04	0.72
Carduelis carduelis	-	-	-	-	0.16	1.08	0.02	0.48
Erithacus rubecula	-	-	-	-	0.16	1.08	0.02	0.48
Dendrocopos syriacus	-	-	0.06	1.84	-	-	0.02	0.48
Remiz pendulinus	0.03	0.83	0.03	0.92	-	-	0.02	0.48
Coccothraustes coccothraustes	-	-	-	-	0.08	0.54	0.01	0.24
Phylloscopus sibilatrix	-	-	-	-	0.08	0.54	0.01	0.24
Turdus philomelos	-	-	-	-	0.08	0.54	0.01	0.24
Sylvia communis	-	-	0.03	0.92	-	-	0.01	0.24
Falco tinnunculus	0.03	0.83	-	-	-	-	0.01	0.24
Sitta europaea	0.03	0.83	-	-	-	-	0.01	0.24
Total	3.31	100	3.30	100	14.72	100	5.06	100

The comparison of the breeding bird communities among localities revealed that CR and CSU were the most similar, CR and OC were less similar according to both qualitative and dominance similarity index. The qualitative similarity as measured by the QS index was 56 % when OC and CR were compared, 62 % (OC, CSU) and 63 % (CR, CSU). The dominance similarity index (Re) was 48–65 % in all three combinations and showed the same trend.

As Fig. 1 illustrates, there were a few species dominant and the remaining species fairly uncommon in every locality. The relative abundance curves for species in rank order appear as straight lines with a steep gradient. On the basis of testing mathematical fit to a geometric model (CSU: $\chi^2 = 1.9008$, df = 16, NS; CR: $\chi^2 = 1.0859$, df = 20, NS; OC: $\chi^2 = 11.5511$, df = 21, NS) we conclude that the breeding bird communities follow the geometric series.

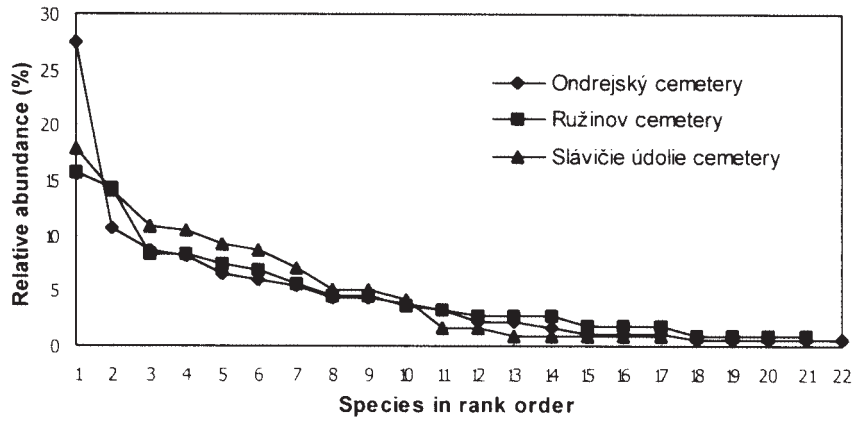

Fig. 1. Relative abundance curves for species in rank order in the breeding bird communities in three cemeteries of Bratislava.

Relationships between birds and habitat variables

Forward selection and Monte Carlo permutation tests indicated that seven of the 41 environmental variables contributed statistically to explain the variance in the species data. Eigenvalues of the first two canonical axes, that are constrained to be linear combinations of selected environmental variables, were $\lambda_1 = 0.203$ and $\lambda_2 = 0.123$. The first two canonical axes accounted for 9.3 % of the total variance of the species data and 70.4 % of the species-environment relation. The species-environment correlation was high, indicating a strong relationship between seven of the environmental variables and the 14 bird species. The first axis was positively correlated with the basal area (r = 0.82), the canopy height (r = 0.78) and the percent cover of three tree taxa (*Tilia* spp.; r = 0.75; *Taxus baccata*; r = 0.45; *Fraxinus excelsior*; r = 0.32). In addition, this axis was negatively correlated with the number of trunks of trees, although the correlation was weak (r = -0.16). The first canonical axis is therefore associated with increasing basal area and tree height and decreasing number of trunks of trees. The second axis showed a positive correlation with several tree variables and a negative correlation with the foliage volume (r = -0.67). Consequently, the second canonical axis is associated with decreasing vegetation volume.

Fig. 2 shows the CCA ordination of the bird data constrained to the environmental variables. The distribution of sample units in ordination space is shown in Fig. 3. The first canonical axis separated sample units of OC from the other localities, the second axis separated the sample plots of CR from those of CSU. The sample units of OC are most dispersed in the ordination space, this is because the vegetation structure of OC was very heterogenous. On the other side, the sample units of the youngest cemetery (CR) are less dispered, indicating rather homogenous vegetation. Fig. 2 shows strong positive relationship of *Passer montanus*, *P. domesticus*, *Sturnus vulgaris* with the first canonical axis and so with the basal area and cover of *Tilia* spp. This reflects the association of these bird species with OC, where old lime trees were dominant. These trees provided many tree hollows and therefore good nesting conditions for hole nesting birds. Although *Passer domesticus* bred not only in tree hollows but also on the buildings in the area of OC, its position in the diagram is near the other hole-nesting birds. *Passer domesticus* was abundant in OC,

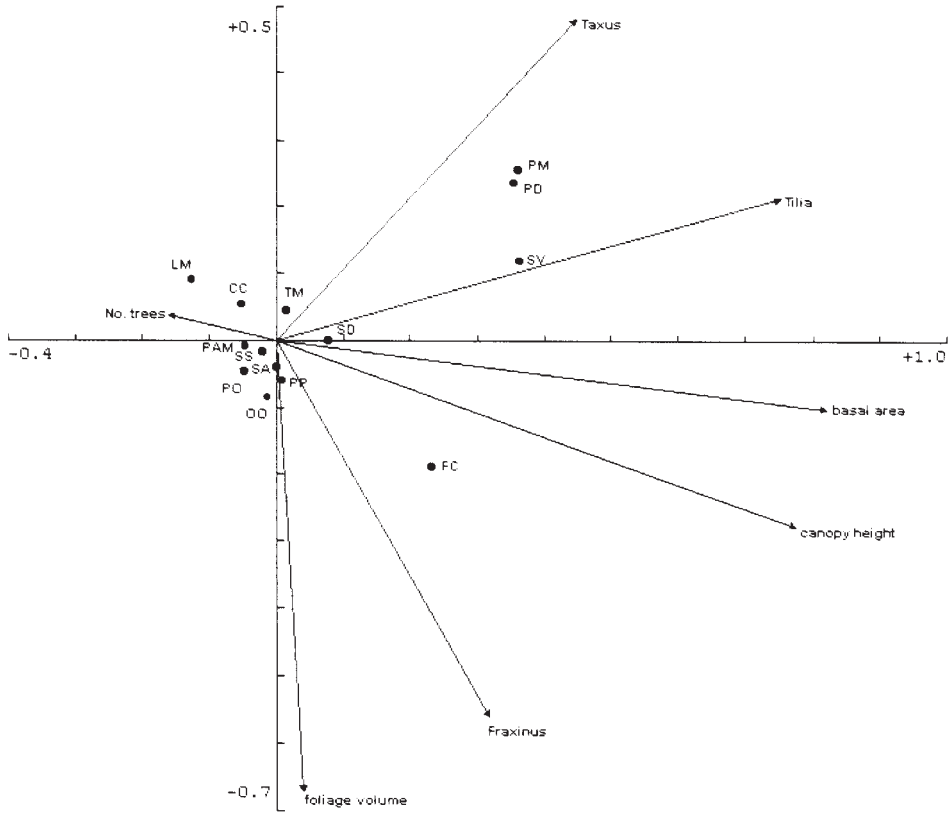

Fig. 2. First two axes of canonical correspondence analysis (CCA) as a biplot of bird species and environmental variables. Bird species coded: CC - *Carduelis chloris*, FC - *Fringilla coelebs*, LM - *Luscinia megarhynchos*, OO - *Oriolus oriolus*, PAM - *Parus major*, PD - *Passer domesticus*, PM - *Passer montanus*, PO - *Phoenicurus ochruros*, PP - *Pica pica*, SA - *Sylvia atricapilla*, SD - *Streptopelia decaocto*, SS - *Serinus serinus*, SV - *Sturnus vulgaris*, TM - *Turdus merula*.

characterised with old lime trees, therefore the association of this species with the lime trees. *Parus major* seemed to select other habitats in which sparrows do not nest. *Fringilla coelebs* occurred in CSU as well as in OC. The breeding habitat of this species is characterised by high trees and high cover of *Fraxinus excelsior*. *Pica pica* and *Oriolus oriolus* nested only on the periphery of the town (CR, CSU), in areas with less shrubs and high trees, mainly *Fraxinus excelsior*. *Luscinia megarhynchos* was associated with dense young trees in CR, which is why its position is in the left part of the diagram. *Carduelis chloris* and *Turdus merula* are located near the centre of the diagram, but shifted towards the variable *Taxus*, so the breeding habitat of these species is represented by conifers. Indeed, most nests of *Turdus merula* were found in dense trees and shrubs of *Taxus baccata*, *Thuja* spp. and *Hedera helix*, two nests in nooks of tombstones. The nest places of *Carduelis chloris* occurred mainly in *Taxus* and *Thuja* shrubs. Birds most associated with medium tree and shrub cover included *Serinus serinus*, *Sylvia atricapilla* and *Parus major*. These most common species were located in the centre of the ordination space. Therefore distinct habitat factors related to occurrence of these species could not be determined.

Discussion

Breeding bird communities in cemeteries

During our study in three cemeteries of Bratislava we observed 17 - 22 breeding species with the density of 3.30 - 14.72 BP/ha. Similar results have been obtained in cemeteries in other central European towns. Tichý (1992) recorded 4 - 17 breeding species in three cemeteries of Louny and the density of 10.71 - 27.78 BP/ha. Luniak (1981) examined breeding communities in Warsaw cemeteries. The number of species nesting there varied from 4 to 28, with a density of 1.3 to 10.4 BP/ha. On the basis of long-term investigations of birds in Warsaw, Luniak (1996) concluded that the cemeteries and parks are the main habitat for 24 breeding species with a density of 5 to 10 BP/ha. Biaduń (1994) investigated five cemeteries in Lublin. The number of breeding species found there was 19 - 27. Density recorded by Biaduń (1994) varied from 4.65 BP/ha to 22.28 BP/ha. Zalewski & Przystalski (1993) found 13 - 22 breeding species with the density of 6.4 to 19.6 BP/ha in five cemeteries in Toruń. Brozek (1978) studied the bird community in one cemetery in Krakow, where he recorded 30 breeding species with a density of 5.79 BP/ha.

The number of species generally increases with habitat area in cemeteries (Tichý 1992, Luniak 1981, Zalewski & Przystalski 1993, Biaduń 1994, Suhonen & Jokimäki 1988). The results of our study do not seem to corroborate this conclusion, because the highest number of breeding species was found in the smallest and most isolated cemetery (OC). This is not surprising, as the vegetation structure was the most heterogenous in OC (CCA, Fig. 3). We suppose that the age of the vegetation and vegetation heterogeneity are the most important factors influencing the number of breeding species in our case.

On the basis of our results we notice that the density of breeding birds is lower in larger areas (CSU, CR) than in the smaller one (OC). This is also confirmed in the cemeteries of Louny (Tichý 1992), partly in the cemeteries of Lublin (Biaduń 1994). Suhonen & Jokimäki (1988) found a negative correlation between the bird density and park area in 20 cemeteries and urban parks in Finland.

The breeding bird communities of all three cemeteries follow the geometric series. This model is found in species-poor environments or in the early stages of a succession (Magurran 1988).

In the three cemeteries, tree species of passerines dominated. This is characteristic also for bird communities in other central and east European towns (Luniak 1990). We do not assume that there is a special bird community typical for cemeteries. We did not observe the preference of tombstones for nesting by particular bird species. During our study, only two nests of *Turdus merula* and two of *Muscicapa striata* were found in tombstones (both in OC). Several studies from central Europe recorded nesting of species *Upupa epops*, *Motacilla alba*, *Turdus merula*, *Phoenicurus phoenicurus*, *Muscicapa striata*, *Passer domesticus* in tombstones (Matoušek 1956, Šrámek-Hušek 1944, Šrámek-Hušek & Duben 1946, Brozek 1978, Luniak 1981).

Habitat requirements of the bird species in cemeteries

The differences in bird species composition among particular urban green areas are caused by the localisation of the plot in the city and by the presence of some special habitat features.

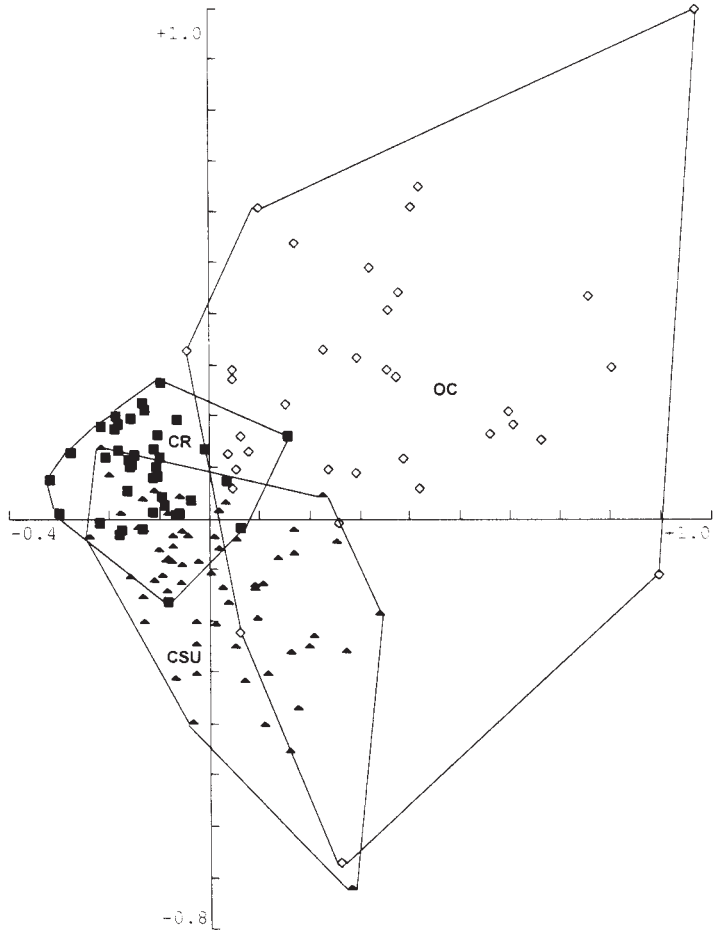

Fig. 3. Distribution of sample units in ordination space. Sample units from different localities are coded as follows: empty diamonds - OC (Ondrejský cemetery), full squares - CR (Ružinov cemetery), full triangles - CSU (Slávičie údolie cemetery).

In the bird communities studied, both *Passer montanus* and *P. domesticus* were found nesting in tree holes (*Tilia* spp. were the trees most connected with *Passer* spp.; Fig. 2), *Passer domesticus* nested also on buildings in the area. A similar conclusion was mentioned by Šrámek-Hušek (1944), Šrámek-Hušek & Duben (1946) who reported on nesting of *Passer domesticus* on buildings and also in old lime trees. Nesting of this species in buildings were observed by Brozek (1978) in a cemetery in Krakow. Luniak (1981) recorded *Passer domesticus* in the vicinity of buildings, *P. montanus* occurred in larger cemeteries in Warsaw. These species used as nesting places both natural tree holes and nest boxes, recesses, nooks in buildings, and often holes in lamp posts and lamp-shades (Luniak 1981). Breeding of hole-nesting birds in the nooks and crevices of buildings was observed also in Lublin (Biaduń 1994).

Parus major, another hole nesting bird, was found in all three localities. Its density was lower in OC because of the competition with both the *Passer* species. In other localities it

seemed to select habitats that sparrows do not breed in (look at the position of *Parus major* in ordination diagram, Fig. 2). The same phenomenon was observed by L u n i a k (1981) in cemeteries and parks of Warsaw. His conclusion was that *Parus major* as well as *Parus caeruleus* were able to nest on sites where the competition from sparrows was strong, and even in areas where sparrows found no possibilities for nesting.

T i c h ý (1992) considered *Fringilla coelebs* as one of the most frequent bird species in cemeteries. We did not record this species in the youngest cemetery (CR), probably because of less developed vegetation structure in this locality. Our results showed that the breeding habitat of *Fringilla coelebs* was associated with high trees and high cover of *Fraxinus excelsior*. Š r á m e k - H u š e k & D u b e n (1946) observed nesting of *Fringilla coelebs* in *Tilia*, *Acer*, *Salix* and *Pinus* spp. Unfortunately, in their study the age and structure of the vegetation is not mentioned.

Turdus merula selected nesting places in dense trees and shrubs mainly of *Taxus baccata*, *Thuja* spp. and *Hedera helix*, and two nests were found in nooks of tombstones. T i c h ý (1992) considered *Turdus merula* as a common bird in cemeteries, nesting in *Thuja* spp. and on tombstones covered with *Hedera helix*. Š r á m e k - H u š e k (1944), Š r á m e k - H u š e k & D u b e n (1946) observed *Turdus merula* in maple and elm trees, in hedgerows and also on tombstones.

The nesting places of *Carduelis chloris* occurred mainly in *Taxus* and *Thuja* shrubs. The breeding habitat of this species was similar to that of *Turdus merula* (Fig. 2). Š r á m e k - H u š e k (1944), Š r á m e k - H u š e k & D u b e n (1946) recorded nests of *Carduelis chloris* in *Pinus*, *Acer*, *Taxus* and *Juniperus* spp. T i c h ý (1992) observed nests of *Carduelis chloris* always in *Hedera helix* which grew on birch trees. The results of these studies, as well as our conclusions, indicated that *Carduelis chloris* selected dense vegetation for its nesting places.

Serinus serinus and *Sylvia atricapilla* were associated with medium tree and shrub cover (Fig. 2). Š r á m e k - H u š e k (1944), Š r á m e k - H u š e k & D u b e n (1946) found most of the *Serinus serinus* nests in *Thuja* spp., fewer in *Buxus*, *Juniperus* and *Acer* spp. A nest of *Sylvia atricapilla* was found in *Syringa vulgaris* near a tombstone (T i c h ý 1992). L u n i a k (1981) concluded, that rich undergrowth (shrubs) increase the density of *Sylvia atricapilla.*

C e m e t e r i e s - t h e i m p o r t a n t u r b a n t y p e o f h a b i t a t f o r b r e e d i n g b i r d s

The number of breeding species and their density in cemeteries studied is similar to the parks in Bratislava. M ü l l e r o v á - F r a n e k o v á & K o c i a n (1995) found 11–28 breeding species in three parks of Bratislava, with a density of 5.9 to 14.4 BP/ha. In eight small (with an area of 0.6–1.84 ha) urban parks of Bratislava 9 breeding species were recorded (P o l i e v k o v á - L i č k o v á & K o c i a n 2000). The breeding communities in housing estates of Bratislava consisted of 8–19 species (O r s z á g h o v á 1992). The number of species increases and density decreases with park area, as it was the case in cemeteries (M ü l l e r o v á - F r a n e k o v á & K o c i a n 1995, P o l i e v k o v á - L i č k o v á & K o c i a n 2000, B i a d u ń 1994, S u h o n e n & J o k i m ä k i 1988).

The bird species composition of cemeteries is comparable to the other types of urban greenery in Bratislava (M ü l l e r o v á - F r a n e k o v á & K o c i a n 1995, P o l i e v k o v á - L i č k o v á & K o c i a n 2000). The similarity of these habitats in

bird species composition is obvious also from other central European towns (Luniak 1981, Zalewski & Przystalski 1993, Biaduń 1994).

In the locality CR, which is situated in the periphery of the town, we observed nesting of *Columba palumbus* and *Streptopelia turtur*, but not in the centre of the town (OC). Tichý (1992) recorded nesting of *Columba palumbus* only in the outskirts of the town. *Streptopelia turtur* was recorded in the centre of Bratislava as a nesting bird only once (Rác 1975). *Pica pica* and *Oriolus oriolus* also nested just on the periphery of the town (CSU, CR). *Pica pica* was observed in the center of Bratislava only sporadically. *Oriolus oriolus* has never been recorded in the center of Bratislava. Nesting of *Remiz pendulinus* in outskirts of Bratislava (CSU, CR) is a new phenomenon and the older studies (Feriancová-Masárová & Ferianc 1982, 1987, Feriancová-Masárová 1994, Országhová 1992) do not mention this species in the town. *Remiz pendulinus* bred neither in other Slovak towns (Feriancová-Masárová & Ferianc 1985, Kaňuščák 1985), nor in central and east European cities (Luniak 1990). Nesting of *Remiz pendulinus* in the surroundings of Košice depended on the presence of water (Mošanský 1990).

Our study showed several important cases on breeding of some bird species in cemeteries. Our results emphasize the importance of this urban type of habitat for birds. To increase the number of species in such localities, habitat requirements of particular bird species have to be known. Different species benefit from different vegetation attributes, so in order to maximize species diversity, a mixture of habitats should be created. The way of increasing vegetation heterogeneity is by preserving old trees suitable for hole nesting birds as well as by laying out shrubs and trees.

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