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Original paper

Bird mortality near roads in the Sabinov district, Slovakia

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Abstract
This study presents findings from a pilot investigation regarding the presence of bird carcasses in close proximity to roadways in the district of Sabinov, located in eastern Slovakia. Over the period of 2016 to 2021, a total of 29 bird carcasses were identified through mapping. The highest frequency of carcasses was observed during April and May (exceeding 60% of the total). Based on zoological classification, the carcasses were categorized into 6 orders, 13 families, and 18 species. Carcasses of the following species were repeatedly found: *Emberiza citrinella* Linnaeus, 1758 (5 birds), *Turdus merula* Linnaeus, 1758 (4 birds), and *Turdus pilaris* Linnaeus, 1758 (4 birds). Based on our pilot study results, it appears that bird-car collisions are more likely to occur in areas with vertical barriers on both sides of the road and where landscape structures such as non-irrigated arable land and a discontinuous urban fabric are dominant.

Key words: Aves, Passeriformes, carcasses, landscape structure, vertical barrier

Introduction

Car traffic significantly eases people's lives. However, it also has negative effects on the environment (Demková et al. 2019). One negative effect is that it poses a significant threat to wildlife like birds in the surrounding areas (Kambourova-Ivanova et al. 2012; Ďula 2013; Loss et al. 2014; Garcês et al. 2020). Birds are the most common animals killed on roads (Kambourova-Ivanova et al. 2012). According to Loss et al. (2014), many factors affect the incidence of birds colliding with vehicles (see Figure 1).

Figure 1. The corpse of a male European Green Woodpecker (*Picus viridis* Linnaeus, 1758) found at site 22.

The main factors are the speed and volume of traffic (Case 1978) and the presence of young birds (e.g. Erritzoe et al. 2003; Gunson et al. 2010; Boves & Belthoff 2012). The highest number of victims on motorways are passerine birds, with the highest number of individuals killed in March and June (Kambourova-Ivanova et al. 2012).

The main objective of this work was to obtain the first information on bird carcasses near roads in eastern Slovakia in order to describe their biodiversity and to try to determine the landscape structure that influences the presence of these carcasses.

Material and methods

The cadastral surveys were carried out randomly during extensive cycling mapping activities in eastern Slovakia, Sabinov district, between 2016 and 2021. Only roads where cycling was possible were documented. Each carcass was documented (GPS position, date, time, landscape and systematic classification of the bird were recorded).

The location of the carcass was also used to determine the secondary landscape structure and its possible influence on the characteristics assessed. For research purposes, the flight distance of the birds was set at 150 m from the carcasses. Within this radius, the percentage of the following classes of land cover structure elements were determined according to the CORINE Land Cover (CLC) (2018): (2) discontinuous urban fabric, (3) industrial or commercial units, (12) non-irrigated arable land, (18) pastures, (20) complex cropping patterns, (21) land predominantly used for agriculture with significant areas of natural vegetation. The CLC (2018) is coordinated by the European Environment Agency (EEA) under the EU Copernicus programme and is implemented by national teams under EEA management and quality control. It consists of an inventory of land cover in 44 nomenclature classes, with a minimum mapping unit of 25 hectares and a minimum mapping width of 100 metres. Based on

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this vector data (see also Oboňa et al. 2022), we clipped a 150 m radius at each locality and, using the geographic information system QGIS, we counted the proportion of each class in the focus area. The 150 m radius was chosen in consultation with ornithologists.

The presence of vertical barriers was also assessed: (Ver 2) vertical barrier on both sides, (Ver 1) vertical barrier on one side, (Ver 0) vertical barrier not present. (Vertical barriers are obstacles close to the road with a height of at least 2 m and an area of at least 1 m^2).

Simple descriptive statistics were calculated and graphs were generated using LibreOffice software. PCA analysis was performed using PAST software (version 4.13; Hammer et al. 2001). The map was created in QGIS (version 3.22.4-Białowieża) using the standard OSM layer (OpenStreetMap; https://www.openstreetmap.org).

Two distant sites with specific species were not compatible with the others and were therefore used in the analyses of the effects of landscape structure and roadside vertical barriers.

Results and Discussion

A total of 29 carcass samples were documented between 2016 and 2021 (Figure 2; see also Supplement 1). According to the date, the bird carcasses were found from March to September. Of the total number, 34% of all the carcasses were found in April, 31% in May, 13% in June, 10% in July and 4% in March, August and September. The difference in seasonal timing also appears to be an important factor, as confirmed by other studies (e.g. Erritzoe et al. 2003).

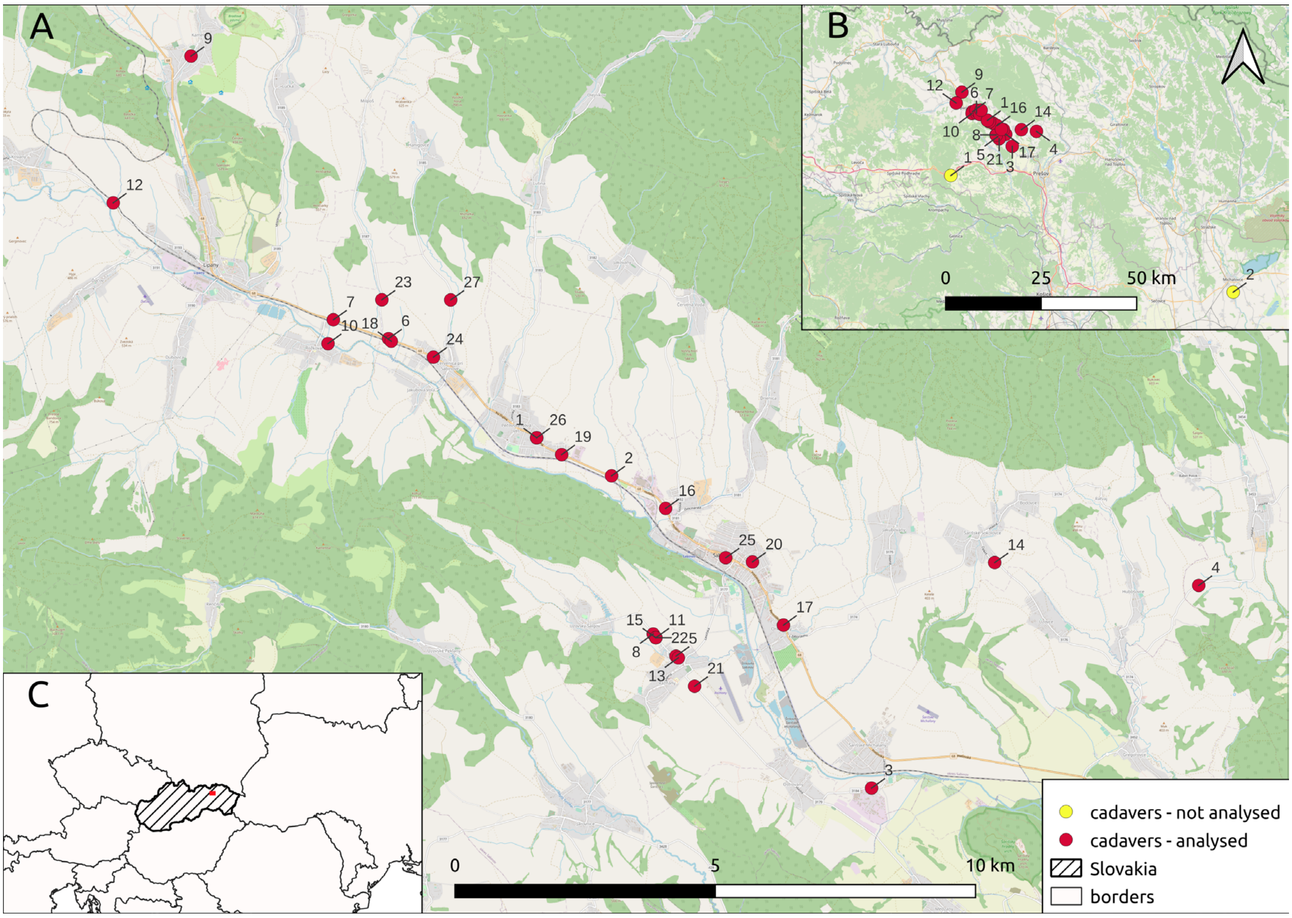

Figure 2. Map of the sites. A – sites included in the analyses. B – sites with both analysed and unanalysed sites. C – overview map.

According to the taxonomic classification, the bird carcasses belong to 6 orders. Most of the carcasses belonged to the family Passeriformes (79%), followed by Piciformes (7%), Accipitriformes, Anseriformes, Galliformes and Strigiformes (4% each). A total of 13 families and 18 species were recorded. The repeated occurrence of carcasses was recorded for the species *Emberiza citrinella* Linnaeus, 1758 (5 individuals), *Turdus merula* Linnaeus, 1758 and *Turdus pilaris* Linnaeus, 1758 (4 each).

When assessing the presence of vertical barriers near the road at the site of the carcass, we found that 65% of Passeriformes carcasses were found at sites with vertical barriers on both sides of the road (Ver 2). Much fewer carcasses were found at sites with vertical barriers on only one side of the road (Ver 1) or with no vertical barriers (Ver 0). In general, carcasses were also found at sites with vertical barriers on both sides (Figure 3).

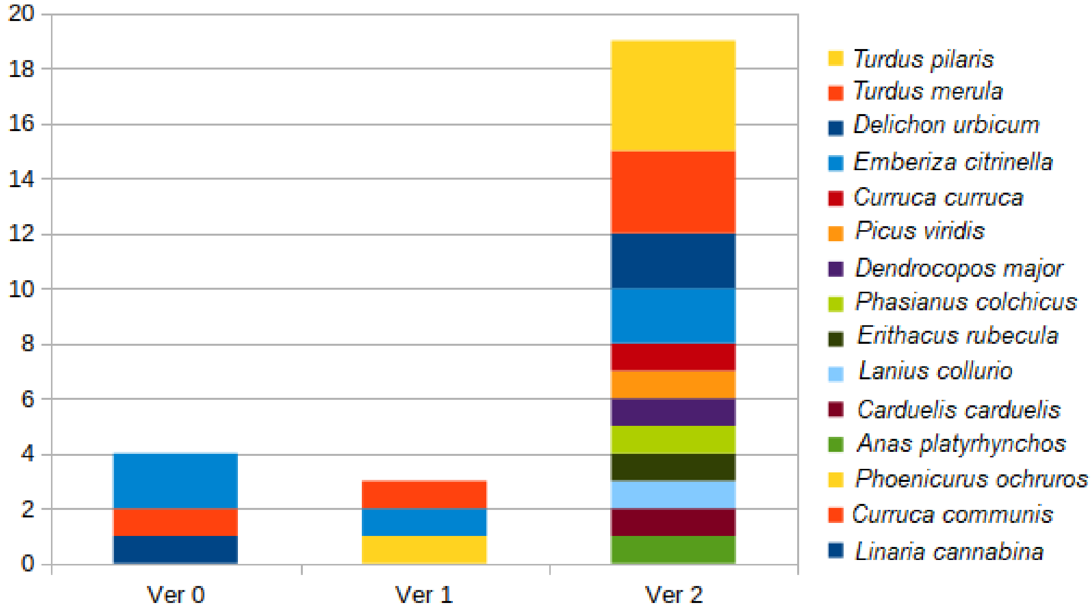

Figure 3. Carcass abundance of each species at sites with different presence of vertical barriers along the sides of the road. Ver 0 – no vertical barrier. Ver 1 – vertical barrier on one side. Ver 2 – vertical barriers on both sides.

When considering secondary landscape structures and their possible influence on the presence of Passeriformes carcasses, it seems that non-irrigated arable land (12) and discontinuous urban fabric (2) are the landscape structures with the strongest influence (Figure 4) and with the most frequent occurrence of these carcasses. We did not observe any significant pattern in the influence of landscape features at the species or family level. However, our results are probably largely influenced by the small number of samples and the presence/absence of landscape structures in this small study area. According to Ďula (2013), most collisions between cars and birds are related to adjacent vegetation and habitat type. Clevenger et al. (2003) stated that birds die more often in the open country than on roads crossing the forest or ecotone, which is consistent with our findings. Various vertical barriers around roads, e.g. bushes and trees, pose a risk especially for young birds, but they also allow birds to nest and are a source of food or a resting place for them (Havlín 1987; Seiler 2001; Erritzoe et al. 2003; Ďula 2013).

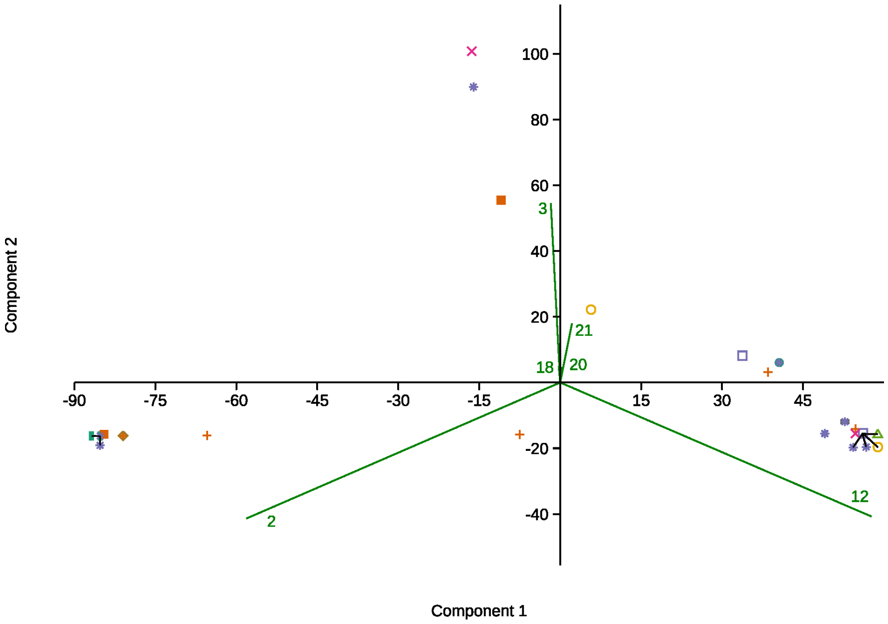

Figure 4. Presence of carcasses at sites with different landscape structures. PCA analysis (variance-covariance matrix, disregarding groups, PC1 explains 66.71% of the variance; symbols represent carcasses of particular species; numerical factor codes: 2 – discontinuous urban fabric, 3 – industrial or commercial units, 12 – non-irrigated arable land, 18 – pastures, 20 – complex cropping patterns, 21 – land mainly used for agriculture with significant areas of natural vegetation). Some symbols have been moved out of the clusters to make the image clearer and are connected to the original location by a black line.

At the species level, we observed differences in the presentation of carcasses. Three species, *E. citrinella*, *T. merula* and *T. pilaris*, collided repeatedly with cars in the study area. The collisions of *E. citrinella* are probably not related to the presence of a vertical barrier (Ver 1 – 1 carcasses, Ver 2 – 2, Ver 0 – 2; Figure 3). The collisions of *T. merula* are probably related to the presence of a vertical barrier on both sides (Ver 2 – 85%; Figure 2). It seems, that non-irrigated arable land (12) is the landscape structure with the most frequent occurrence of these carcasses and this structure seems to have the strongest impact on the traffic mortality of this species among the ones analyzed (Figure 4). The collisions of *T. pilaris* are probably also related to the presence of a vertical barrier on both sides (Ver 2 – 100%). However, the carcasses of this species occurred in different country structures. As with previous results, our findings are likely to be influenced by the small sample size and the presence/absence of landscape structures in this small study area. The validity of our findings is therefore limited and cannot be generalized without confirmation over a larger sample and area.

Despite the limitations imposed by the size of the area and the sample size, our data and results suggest that the vertical barriers on the sides of the road and landscape structures such as unirrigated arable land and discontinuous urban fabric could be significant factors in increasing the rate of bird-vehicle collisions.

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Supplement 1. A detailed overview of all recorded data.

	LCL (%)											Vertical barriers		
Site	**2**	**3**	**12**	**18**	**20**	**21**	**Date**	**GPS**		**Species**	**Ordo**	**Ver 2**	**Ver 1**	**Ver 0**
1	97		3				3.3.2017	49.116303214679	21.068378672179	*Emberiza citrinella* Linnaeus, 1758	Passeriformes	0	0	1
2			1			99	29.4.2016	49.139464369636	21.010485872802	*Curruca communis* Latham, 1787	Passeriformes	0	0	1
3	2		30		68		5.4.2020	49.163260149993	20.937422499236	*Erithacus rubecula* (Linnaeus, 1758)	Passeriformes	1	0	0
4	5		95				27.4.2020	49.101494961874	21.105407848127	*Turdus merula* Linnaeus, 1758	Passeriformes	1	0	0
5			100				13.5.2018	49.080090052813	21.090201124726	*Turdus pilaris* Linnaeus, 1758	Passeriformes	1	0	0
6	86		14				13.5.2018	49.06254650404	21.136699900207	*Emberiza citrinella* Linnaeus, 1758	Passeriformes	0	0	1
8			98			2	7.4.2019	49.097444758014	21.222680792389	*Emberiza citrinella* Linnaeus, 1758	Passeriformes	1	0	0
9			74			26	1.4.2019	49.085276021248	21.085308775482	*Emberiza citrinella* Linnaeus, 1758	Passeriformes	1	0	0
10			95			5	26.4.2019	49.088446437124	21.080018048064	*Phasianus colchicus* Linnaeus, 1758	Galliformes	1	0	0
10			95			5	26.4.2019	49.088446437124	21.080018048064	*Turdus merula* Linnaeus, 1758	Passeriformes	1	0	0
11	97		3				25.4.2019	49.101378584479	21.169058069764	*Passer montanus* (Linnaeus, 1758)	Passeriformes	0	1	0
12	99						19.5.2019	49.119954675787	21.055262670098	*Curruca curruca* (Linnaeus, 1758)	Passeriformes	1	0	0
13	45		55				19.5.2019	49.139906565896	21.009772405207	*Emberiza citrinella* Linnaeus, 1758	Passeriformes	0	1	0
14			67			33	19.5.2019	49.143163254902	20.995267018854	*Linaria cannabina* (Linnaeus, 1758)	Passeriformes	0	0	1
15		100					19.5.2019	49.188481997683	20.95786629635	*Delichon urbicum* (Linnaeus, 1758)	Passeriformes	1	0	0
16	100						19.5.2019	49.146588162442	21.008012876091	*Turdus pilaris* Linnaeus, 1758	Passeriformes	1	0	0
17	100						24.5.2019	49.110700859248	21.082580968915	*Dendrocopos major* (Linnaeus, 1758)	Piciformes	1	0	0
18		82		18			26.5.2019	49.13673156266	21.021563690676	*Turdus pilaris* Linnaeus, 1758	Passeriformes	1	0	0
19			100				1.6.2019	49.084968602583	21.085917636928	*Phoenicurus ochruros* (Gmelin, 1789)	Passeriformes	0	1	0
20	1		99				1.6.2019	49.139052000523	20.993864223537	*Delichon urbicum* (Linnaeus, 1758)	Passeriformes	1	0	0
21	100						5.6.2019	49.102203945993	21.098376497802	*Turdus pilaris* Linnaeus, 1758	Passeriformes	1	0	0
22	100						28.6.2020	49.090614868813	21.113559557118	*Picus viridis* Linnaeus, 1758	Piciformes	1	0	0
23			100				10.7.2020	48.994520810458	20.918518290101	*Accipiter nisus* (Linnaeus, 1758)	Accipitriformes	1	0	0
24		84	5			11	2.8.2020	48.721699885128	21.921578630984	*Otus scops* (Linnaeus, 1758)	Strigiformes	1	0	0
25		13	78			9	7.4.2021	49.122847565645	21.048701986849	*Anas platyrhynchos* Linnaeus, 1758	Anseriformes	1	0	0
25		13	78			9	7.4.2021	49.122847565645	21.048701986849	*Turdus merula* Linnaeus, 1758	Passeriformes	1	0	0
26			100				15.9.2021	49.146567108406	21.026107058107	*Turdus merula* Linnaeus, 1758	Passeriformes	0	1	0
10			95			5	12.7.2021	49.088446437124	21.080018048064	*Lanius collurio* Linnaeus, 1758	Passeriformes	1	0	0
27			100				13.7.2021	49.089091367657	21.07932208496	*Carduelis carduelis* (Linnaeus, 1758)	Passeriformes	1	0	0