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Bird crime and the assessment of risk areas in Slovakia

Vtáčia kriminalita a hodnotenie rizikovosti území na Slovensku

Tomáš VESELOVSKÝ, Boris MADERIČ, Jozef CHAVKO & Ján SVETLÍK

Abstract: Bird crime is a serious problem in many countries around the world. This study focuses on the situation in Slovakia, summarising data on bird crime in the country between 2016 and 2022. Over the course of that period, 92 cases were recorded in 27 districts involving 33 animal species. At least 249 protected birds and 78 mammals fell victim to illegal activities, and 61 poisoned baits were discovered. Social value is the monetary value which state institutions use to quantify the damage incurred to wildlife. Slovak law determines whether an illegal act is an offence or a criminal act based on the value of the incurred damage. The total social value of all of the protected animals as a result of illegal activities was estimated at € 696,250. Intentional poisoning, typically using carbofuran, was the most common of illegal act identified in the recorded cases, followed by shooting and trapping. An analysis of the recorded cases of bird crime was also used to assess the risk in each of Slovakia's districts in relation to landscape structure variables. The percentage share of arable land was found to be a reliable predictor of bird crime, regardless of whether the birds had been poisoned or shot. These findings can help to develop better preventive inspections to detect bird crime incidents. We also recommended several management measures to help tackle bird crime more quickly and effectively.

Abstrakt: Vtáčia kriminalita je vážnym problémom v mnohých krajinách na celom svete. V našom výskume sme zosumarizovali údaje o vtáčej kriminalite na Slovensku v rokoch 2016 až 2022. V uvedenom období sme zaznamenali 92 prípadov v 27 okresoch, ktoré sa týkali 33 druhov živočíchov. Najmenej 249 jedincov chránených druhov vtákov a 78 jedincov cicavcov sa stalo obeťami nelegálnych aktivít. Našli sme tiež 61 otrávených návnad. Spoločenská hodnota je peňažná hodnota, ktorú štátne inštitúcie používajú pri vyčíslení vzniknutej škody. Podľa výšky škody zákon určuje, či je nelegálny čin priestupkom alebo trestným činom. Celková spoločenská hodnota všetkých chránených druhov živočíchov bola stanovená na 696 250 €. Najčastejším typom zaznamenaných prípadov boli úmyselné otravy, nasledovali zástrely a odchyt do pascí. Páchatelia pri výrobe otrávených návnad najčastejšie používali prípravky s obsahom karbofuránu. Následne sme hodnotili rizikovosť území analýzou zaznamenaných prípadov vtáčej kriminality vo vzťahu k premenným o krajinnej štruktúre v jednotlivých okresoch na Slovensku. Najmä percentuálny podiel ornej pôdy sa ukázal ako spoľahlivý prediktor vtáčej kriminality bez ohľadu na to, či išlo o otravy alebo zástrely. Na základe týchto zistení bude možné lepšie zacieliť preventívne kontroly na odhaľovanie prípadov vtáčej kriminality. Za účelom rýchlejšieho a efektívnejšieho riešenia problematiky vtáčej kriminality sme odporučili niekoľko manažmentových opatrení.

Key words: wildlife crime, poisoning, carbofuran, land structure, arable land

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Introduction

Bird crime is defined as any illegal act in which the victim is a protected bird species. Illegal activities are specified in the Bern Convention (1982) and primarily consist of the deliberate killing of birds, their capture and the carrying out of illicit trade in birds and their derivatives, and disturbance during their breeding and wintering activities.

The types of illegal activity involved and the individual species which are affected can vary depending on the motives of the perpetrators. Prohibited killing and trapping of migratory birds is widespread around the Mediterranean Sea (Brochet et al. 2016), while vultures have been poisoned in protected reserves on the African continent by poachers attempting to hide poached elephant carcasses from detection by national park rangers (Roxburgh & McDougall 2012, Groom et al. 2013). In Europe, predatory birds have been poisoned to protect the breeding of homing pigeons (Vogler et al. 2015, Inderwildi et al. 2018) or to prevent the predation of small game species (Hernández & Margalida 2009). Protected bird species are not necessarily the primary target of intentional poisoning. Reljić et al. (2012) mention the case of a brown bear poisoned by bait which was likely set out for other carnivores such as jackals or foxes. But the use of toxic baits in this manner also threatens scavenger birds (Parvanov et al. 2018). Birds can also be unintentional victims of poisoning in disputes between herders, hunters and landowners in which poisoned baits are set to poison herding or hunting dogs (Ntemiri et al. 2018).

Perpetrators use various foods and toxic substances to make poisoned baits (Giorgi & Mengozzi 2011, Ibáñez-Pernía et al. 2022). Agricultural pesticides are also often misused for this purpose (DeRoma et al. 2018). Deák et al. (2020) have reported the frequently intentional poisoning of birds with carbofuran, a toxic carbamate insecticide which acts as an acetylcholinesterase inhibitor (Lewis et al. 2016). The lethal dose for most wildlife species is very low; for example, the LD_{50} value for the American kestrel (*Falco sparverius*) is just 0.6 milligrams per kilogram of body weight (Wiemeyer & Sparling 1991). In birds, carbofuran poisoning induces symptoms such as salivation, agitation, the ruffling of neck feathers, frequent defecation, tremors, ataxia, poor body coordination, convulsions, head jerking and tics, opisthotonus, hyperpnoea and shortness of breath (Lehel et al. 2010). Based on experience from field inspections, poisoned raptors have been found with their claws spasmodically clenched, often grasping leaves, twigs, dirt or other substrates, or lying with their wings partially outstretched and their heads rotated. Because the toxin acts rapidly, food residues are often still present in the beaks, and birds have been found directly beside the bait that killed them. Since 2008, Commission Decision (2007) no. 2007/416/EC has prohibited the use, sale or distribution of products containing carbofuran throughout the European Union. Secondary poisoning caused by rodenticides and insecticides is also common (Elliott et al. 1997; Sánchez-Barbudo et al. 2012), but this is considered to be an unintentional crime against birds. Slovakia formally committed itself to bird conservation with its ratification of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1975), the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1982) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention 1983). The conservation of selected bird species is enshrined in various items of Slovak legislation, specifically Act 543/2002 on Nature and Landscape Protection, as amended (The Collection of Laws of the Slovak Republic 2002) and Act 274/2009 on Hunting and the amendment of certain acts, as amended (The Collection of Laws of the Slovak Republic 2009). The social value of protected animal species, including birds, is laid out in Annex 6 of Ministry of Environment Decree 24/2003 and updated in Annex 5 of Ministry of Environment Decree170/2021, implementing Act 543/2002 on Nature and Landscape Protection, as amended and in Annex to the Ministry of Agriculture and Rural Development Decree 421/2013, determining the social value of game species (The Collection of Laws of the Slovak Republic 2003, 2013, 2021). Social value is the monetary value which state institutions assign to wildlife species in order to quantify the damage incurred, and the law determines whether an illegal act is an offence or a criminal act based on the value of this damage. As an example of this, the law defines the minimum amount of damage incurred at € 2,660 for the illegal

activity to qualify as the criminal act of the "Violation of the protection of plants and animals" (The Collection of Laws of the Slovak Republic 2005); if the damage is less than this value, the act is only considered to be an offence. The social value of individual protected species varies considerably. The lowest social value is € 200 for the common chiffchaff (*Phylloscopus collybita*), and the highest is € 50,000 for the saker falcon (*Falco cherrug*) (The Collection of Laws of the Slovak Republic 2021).

Since 2000, the non-governmental organisation Raptor Protection of Slovakia (RPS) has maintained a semi-public Bird Crime Database (Bird crime 2000) which records confirmed crimes and reasonably suspected illegal incidents of physical injuries and human-caused mortalities of individual protected bird species, as well as finds of poisoned baits and other poisoned mammals, the improper application of rodenticides that may have caused direct or secondary bird mortality, illegal trapping, and cases of destroyed or robbed nests. The database has no link to the databases managed by the Slovak Police Force or the Slovak Environmental Inspectorate, none of which are accessible to the public.

The main aims of this paper are: i) to evaluate data on bird crime in Slovakia, ii) to conduct a risk assessment of different areas based on the relationship between landscape structure and the incidence of bird crime, and iii) to recommend management actions to the relevant decision-makers to ensure a more rapid and more effective solution to the issue of bird crime.

Methods

Obtaining data on bird crime

The Bird Crime Database was updated with information on cases documented over a seven year period between 2016 and 2022. Data about bird crimes was obtained from members of RPS and of the Slovak Ornithological Society/ BirdLife Slovakia (SOS/BirdLife Slovakia), trained volunteers and staff at the State Nature Conservancy (SNC) and its injured animal rescue and rehabilitation stations. Information on animal deaths was also obtained through reports from the public and other stakeholders. Alleged crimes against birds were verified directly in the field with the assistance of a police dog unit. In some cases, dead animals were detected and located thanks to different brands and types of GPS/GSM transmitters (Ecotone Saker-H, Anitra BirdieOne).

Only confirmed crimes or cases with a reasonable suspicion of illegal activity which were committed outside urban areas are included in this analysis. Cases are considered to be confirmed as criminal acts by national authorities through the use of laboratory analyses (such as accredited LC-MS/MS or HPLC-MS TOF methods in suspected poisonings), veterinary examinations, autopsies and on the basis of recovered evidences. State-accredited laboratories analysed samples for up to seven chemical substances according to the police and state institutions' requirements. All samples sent to the laboratories were analysed for carbofuran and also, if suspected, the anticoagulant rodenticides warfarin, bromadiolone, brodifacoum, difenacoum, difethialone and flocoumafen.

The cases considered reasonably suspicious were not confirmed as criminal acts because it was not possible to carry out laboratory analyses on the carcasses due to the longer period of time since death or the lack of access to suitable testing, but the external signs of poisoning (e.g., spasmodically clenched claws, vomit around the beak, dead insects around the carcass) and other evidence clearly indicated that death or injury have been caused by illegal human activity (Fig. 1). The data taken from the Bird Crime Database was divided into six categories, grouped according to the nature of the illegal activity: i) intentional poisoning (as a result of intentional human activity, mainly carbofuran poisoning); ii) unintentional poisoning (as a result of the improper application of rodenticides, the use of unauthorised rodenticides or lead poisoning); iii) illegal possession of a protected bird species; iv) shooting; v) trapping (with, for example, folding traps or snap traps); and vi) suspicious deaths or injuries.

Recorded cases were evaluated based on the type of unlawful conduct involved, the animal species affected, and the time and landscape characteristics of the districts. If multiple bird crime-related incidents were identified in the same area over a period of several days, they were combined into a single case.

Landscape structure

Slovakia covers an area of 49,035 km^2 and is divided into 79 districts (Government Office of the Slovak Republic 2023). Landscape structure data for each district was obtained from the statistical yearbooks issued by the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (2023). In each of the 79 districts, the seven-year mean percentages of the following land variables were then calculated for i) arable land, ii) hop fields, iii) vineyards; iv) gardens, v) orchards, vi) permanent grasslands, vii) forests, viii) bodies of water, ix) built-up areas, and x) other areas.

Fig. 1. External signs of poisoning: a) one or more dead individuals in the locality b) bait found in the vicinity of the cadaver c) body position – the bird is lying with its wings partially outstretched and its head rotated d) vomit and food debris around the beak e) dead insects around the carcass f) spasmodically clenched claws. Photos: Archive of Raptor Protection of Slovakia.
Obr. 1. Vonkajšie znaky otravy a) jeden alebo viac uhynutých jedincov na lokalite b) návnada v blízkosti kadáveru c) poloha tela – vták leží s poloroztiahnutými krídlami a otočenou hlavou d) zvratky a zvyšky potravy okolo zobáka e) uhynutý hmyz okolo kadáveru f) kŕčovito zovreté pazúry. Fotografie: archív Ochrany dravcov na Slovensku.

Statistical analysis

The study aimed to investigate the relationship between occurrences of bird crime incidents and landscape structure across all of Slovakia's districts. The response binary variable represented the presence (coded as 1) or absence (coded as 0) of bird crime cases.

A series of landscape variables that could potentially be associated with bird crime was used to assess the data. In addition, we accounted for the 'district's total area as a covariate. Strong multicollinearity among the explanatory variables was examined using LASSO regression (Tay et al. 2023) which facilitated the selection of the most relevant predictors for bird crime type: i) poisoning (either intentional or unintentional), ii) shooting, and iii) total (incorporating all six bird crime categories).

A separate weighted logistic regression model with selected landscape variables serving as predictors was fitted for each type of bird crime. The response variable was modelled as a binary outcome, whereas the number of incidents (up to 11) was used as a weight. In order to assess the goodness of fit and the proportion of variability explained by the models, the pseudo-R2 value was calculated using null and residual deviances.

Due to the significance of the percentage of arable land in predicting bird crime across all types, a binary variable to classify districts with high and low proportions of arable land was also created. Districts with areas featuring more than 50% arable land were classified as 1, while those with 50% or less were coded as 0. The logistic regression models were subsequently re-fitted using the binary arable land variable as a predictor to quantify the impact of a high proportion of arable land on the incidence of bird crime.

The strength and nature of the relationship between the binary arable land variable and bird crime were examined by calculating the odds ratio (OR) and its 95% confidence interval (CI). All statistical analyses were performed using R statistical software, version 4.1.2 (R Core Team 2023), while the 'glmnet' (Tay et al. 2023) and 'dplyr' packages, version 1.1.0 (Wickham et al. 2023) were used for LASSO regression and data manipulation, respectively.

Results

Overview of bird crime cases

Between 2016 and 2022, 92 cases of bird crime involving 33 animal species were registered in 27 of Slovakia's districts (comprising 34.2% of all districts) (Fig. 2), with at least 249 protected bird and 78 mammal

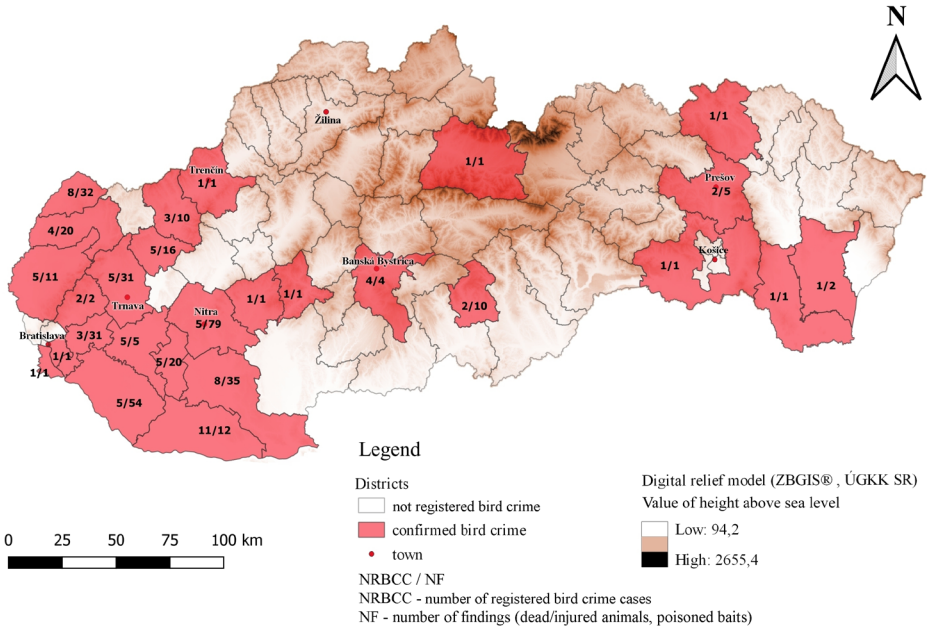

Fig. 2. Districts in Slovakia in which bird crime cases were registered in 2016–2022.
Obr. 2. Okresy na Slovensku so zaznamenanými prípadmi vtáčej criminality v období 2016–2022.

species falling victim to illegal activities over the course of the period. The most common bird crimes (64.1%) involved poisoning (41 confirmed and 18 reasonably suspected cases), with a total of 61 poisoned baits being documented (Tab. 1). The next most frequent forms of illegal activity were shooting (25.0%) from rifles or smoothbore weapons (22 confirmed and one reasonably suspected case), trapping (7.6%) by jaw or folding live traps (7 cases), and one case of the unlawful possession of a protected bird species. From the total number of 92 cases, eight dead raptors were detected and located thanks to the GPS/GSM transmitters which had been fitted to them.

If a case of wildlife crime goes undetected, similar cases may occur repeatedly over the following weeks, months or years; as a result, poisoned animals can be found in various stages of decomposition when the crime is finally documented. We recorded one case in which raptors were found at different stages of decomposition; some without soft tissues, others with soft tissues and some birds in the early stages of decomposition. The poisoned baits which were found included the skins of wild boars (*Sus scrofa*), European hares (*Lepus europaeus*), roe deer (*Capreolus capreolus*), chickens and a poisoned common buzzard (*Buteo buteo*) to which the perpetrator had applied carbofuran (Fig. 3).

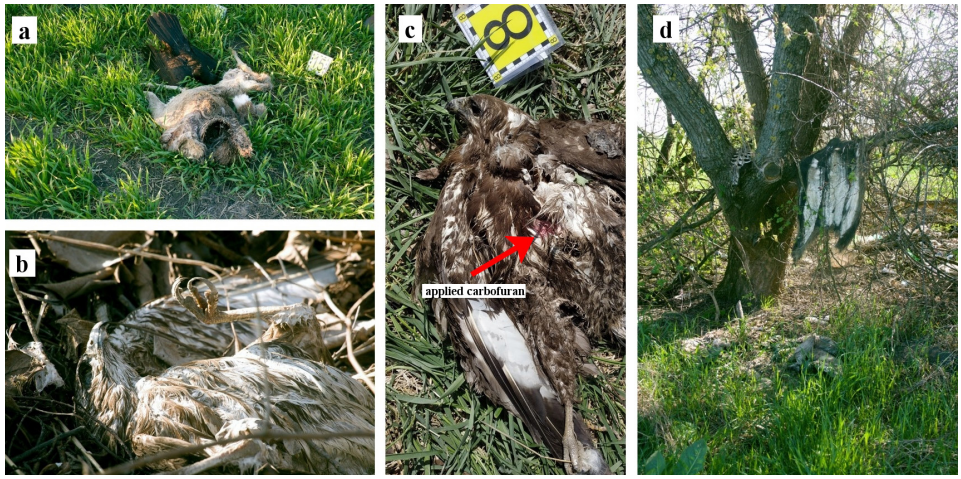

Fig. 3. Different levels of decomposition of carcasses at the crime scene: a) bird in the early stage of decomposition, b) carcass without soft tissues, c) poisoned common buzzard which a perpetrator has used as bait, d) baits in different decomposition levels.
Obr. 3. Rozdielny stav rozkladu kadáverov na mieste činu. a) vták v počiatočnom štádiu rozkladu b) kadáver bez mäkkých tkanív, c) otravený myšiak hôrny, ktorého páchateľ použil ako návnadu d) otrávené návnady v rôznom stupni rozkladu.

A total of 38 of the confirmed cases of poisoning were categorised as intentional poisonings (166 protected birds and 17 mammals), while three were deemed unintentional due to the improper application of rodenticides (18 protected birds and 60 mammals). Carbofuran had been used in 27 confirmed cases of intentional poisoning. Most of the bird crime cases were documented in spring and autumn (Fig. 4), with the largest number (n = 71) registered between January and May and peaking in March (n = 31). Over the seven-year period that ended in 2022, the highest number of cases (n = 21) was documented in 2018, followed by 17 cases in 2021.

Birds of prey were the most frequent victims of bird crime, with 198 birds of 13 different species falling victim to illegal activities. The most affected species were the common buzzard (n = 120), followed by the white-tailed eagle (*Haliaeetus albicilla*; n = 18) and the western marsh harrier (*Circus aeruginosus*; n = 17). Apart from birds of prey, birds of the *Corvidae* family were the next most frequent victims of bird crime, mainly through primary and secondary poisoning. The most commonly identified species in this group were the common raven (*Corvus corax*; n = 15) and the rook (*Corvus frugilegus*; n = 12). In terms of mammals, the most frequently reported deaths due to unintentional and intentional poisoning involved the European hare ((*Lepus europaeus*); n = 55) and the red fox (*Vulpes vulpes*; n = 16).

Based on currently relevant legislation, the total sum of the social values of all of the protected animals found dead was € 693,770 (Table. 1). The social values of the protected animals used by offenders to make poisoned baits came to a total of € 2480 (Table. 1).

Relationship between occurrences of bird crime and landscape structure

The analysis of land variables and their association with bird crime across all the districts in Slovakia yielded a number of significant findings. Most notably, the percentage of arable land was found to be a robust predictor of the incidence of bird crime irrespective of whether the birds were poisoned (incorporating all types of intentional and unintentional poisoning) or shot (GLM: $\chi^2 = 83.777$, df = 1, $p < 0.001$ (Fig. 5, Tab. 2).

Districts with an area consisting of more than 50% arable land had a 31-fold increase in the probability of bird crime compared to districts whose proportion of arable land was lower (OR: 95% CI: 11–135). In the context of poisonings, such incidents had a likelihood which was 15 times greater in districts with a high proportion of arable land (> 50%) (OR: 95% CI: 6–47). A similar finding was identified for shootings, where there was an approximately 12 times greater probability of such incidents in areas with high coverage of arable land (OR: 95% CI: 5–35).

Discussion

The European Union is making considerable efforts to protect endangered bird species through various international projects (e.g., PannonEagle LIFE 2016, LIFE EUROKITE 2019), but these efforts are thwarted by illegal human activities and bird crime in its various forms remains a serious problem in many countries (Brochet et al. 2016, 2019).

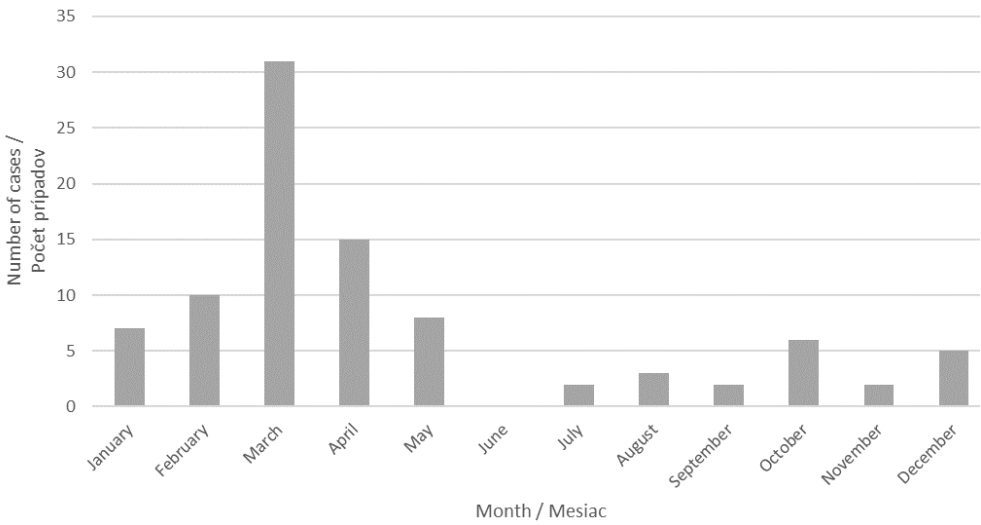

Fig. 4. Total number of bird crime cases recorded each month in 2016–2022.
Obr. 4. Celkový počet prípadov vtáčej kriminality zaznamenaných v jednotlivých mesiacoch v období 2016–2022.

Tab. 1. Number of individuals affected by bird crime. IP – intentional poisoning, UIP – unintentional poisoning, IPS – illegal possession, S – shooting, T – trapping, SDI – suspicious death or injury (SP – suspected poisoning, SS – suspected shooting, UC – unclear), TSSV – the total sum of social values according to current relevant legislation (in €).
Tab 1. Počet jedincov zasiahnutých vtáčou kriminalitou. IP - úmyselná otrava, UIP - neúmyselná otrava, IPS - nelegálna držba, S - streľba, T - pasca, SDI - podozrivý úhyn alebo zranenie (SP - podozrenie na otravu, SS - podozrenie na streľbu, UC - nejasné), TSSV – celkový súčet spoločenských hodnôt podľa zákona (v €).

Categories of bird crime						**SDI**			
Species	**IP**	**UIP**	**IPS**	**S**	**T**	**SP**	**SS**	**UC**	**TSSV**
Birds									
Buteo buteo	99	1		2	4	10		4	111 760
Haliaeetus albicilla	12			1		5			107 730
Circus aeroginosus	11			2		3	1		31 760
Corvus corax	14			1					5 940
Milvus milvus	13					2			272 270
Corvus frugilegus		12							2 760
Aquila heliaca	4			2		2			47 920
Accipiter gentilis	3		1		2			1	23 320
Pica pica	5	2							1 300
Falco peregrinus	1					3			22 120
Accipiter nisus				3					5 520
Corvus cornix	3								540
Aquila chrysaetos				1		1			9 220
Asio otus	1				1				1 840
Bubo bubo				2					4 000
Corvus monedula		2							1 840
Ciconia ciconia				1					2 300
Circaetus gallicus				1					10 000
Clanga pomarina				1					3 220
Columba oenas				1					1 380
Cygnus olor				1					500
Falco cherrug				1					5 530
Falco tinnunculus					1				920
Phalacrocorax carbo				1					500
Phasianus colchicus		1							50
Strix uralensis					1				2 300
Sturnus vulgaris					1				90
Tyto alba				1					1840
Mammals									
Lepus europaeus		55							11 000
Vulpes vulpes	14	1							1 600
Capreolus capreolus		4							2 400
Martes sp.	2								200
Martes foina	1					1			100
Baits	61								
Gallus gallus domesticus - egg	42								
Columba livia f. *domestica*	5								
Fish	4								
Sus scrofa	3								300
Columba palumbus	2								1 380
Gallus gallus domesticus	2								
Capreolus capreolus	1								600
Felis catus	1								
Lepus europaeus	1								200

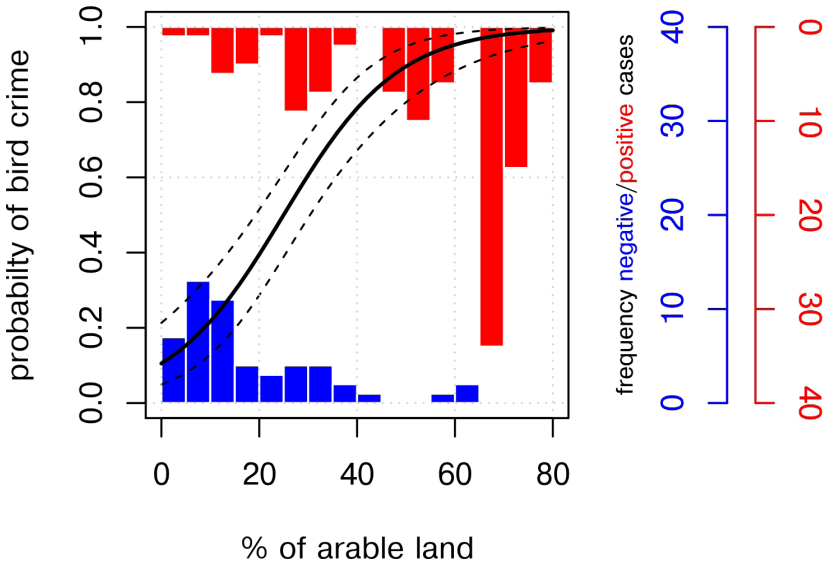

Fig. 5. Graphic representation of the GLM model depicting the probability of total bird crime cases (incorporating all six bird crime categories) from the percentage of arable land in evaluated districts. The sigmoid curve displays the mean estimation of probability, while the dashed lines indicate the 95% confidence interval of the estimate. Histograms reflect the number of cases associated with increasing percentages of arable land (in red) and the number of districts with no recorded bird crime cases (in blue).
Obr. 5. Grafické znázornenie GLM modelu zachytávajúceho pravdepodobnosť výskytu (celkového počtu) prípadov vtáčej kriminality (zahŕňa všetkých šesť kategórií vtáčej krinimality) na základe percentuálneho podielu ornej pôdy v hodnotených okresoch. Sigmoidná krivka zobrazuje priemerný odhad pravdepodobnosti, zatiaľ čo prerušované čiary označujú 95 % interval spoľahlivosti odhadu. Histogramy vyjadrujú celkový počet prípadov spojených so zvyšujúcim sa percentom ornej pôdy (červenou farbou) a počet okresov bez prípadov vtáčej kriminality (modrou farbou).

Our research has shown that higher proportions of arable land are an essential predictor of the likelihood of bird crime. In Slovakia, the districts with the highest proportion of arable land are situated in the lowlands of the southwest and eastern regions of the country, with these areas posing risks to wildlife from several perspectives.

The application of pesticides, especially rodenticides, on arable land is an intrinsic element of intensive agriculture. In Slovakia, only zinc phosphate-based products are authorised for such use (Central Control and Testing Institute in Agriculture 2023); these substances are applied directly into animal burrows using an applicator, but there have been documented cases of farmers using second-generation anticoagulant rodenticides (SGARs), mainly bromadiolone and brodifacoum, which are not approved for use in the wild. Data from the Bird Crime Database shows three recorded cases of the unauthorised use of SGAR products which resulted in widespread and massive mortalities of dozens of wildlife species, mainly brown hares, roe deer and birds. The field survey of these incidents took several days because of the extreme difficulty in locating all of the poisoned animals, and this may have caused the

Tab. 1. Number of individuals affected by bird crime. IP – intentional poisoning, UIP – unintentional poisoning, IPS – illegal possession, S – shooting, T – trapping, SDI – suspicious death or injury (SP – suspected poisoning, SS – suspected shooting, UC – unclear), TSSV – the total sum of social values according to current relevant legislation (in €).
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GLM (binomial)	Df	Null Dev.	Deviance	Resid. Dev.	p	pseudo-R2
total* ~ arable land (%)	1	201.79	83.777	118.01	<0.001	~ 46%
poisoning** ~ arable land (%)	1	161.78	57.99	103.79	<0.001	~ 36%
shooting ~ arable land (%)	1	129.033	36.151	92.882	<0.001	~ 28%

mortality to be underestimated, particularly that of the hares. When accumulated in the body of animals, SGARs can cause secondary poisoning of non-target organisms such as birds of prey (Berny et al. 1998, Eason et al. 2002, Sell et al. 2022). Agricultural poisoning is a specific type of unintentional crime which can have a potentially significant impact on local populations of small game species. The inappropriate use either of pesticides, either permitted or otherwise, is also a violation of the rules on conditionality (Regulation of the European Parliament and the Council 2021). National authorities in member states of the European Union (the Agricultural Payments Agency in Slovakia) may reduce payments of agricultural subsidies to the farmer because of transgressions of this nature. In practice, however, we have encountered a reluctance on the part of the public to report cases of unintentional field poisoning to the state authorities. This reluctance stemmed from a variety of concerns; for example, some hunting associations are unwilling to report their suspicions because of concerns was that the manager of the agricultural land would terminate their lease on land belonging to the hunting area.

The territory of Slovakia is divided into three types of hunting areas suitable for: i) red deer (*Cervus elaphus*), ii) roe deer, iii) small game species such as the European hare, common pheasant (*Phasianus colchicus*) or grey partridge (*Perdix perdix*) (The Ministry of Agriculture and Rural Development of the Slovak Republic 2023). Red deer and roe deer hunting areas tend to be located in the foothills or in mountainous areas, while small game species hunting areas typically overlap with lowland areas with a high proportion of arable land. In hunting areas, priority is given to the game species for which the area is intended. The diets of birds of prey, such as the common buzzard, may include small game species to varying proportions (Panek 2023), and this predation can be perceived negatively by potential offenders and lead to efforts to prevent it by illegal means. Consequently, the protection of small game species can be considered as a possible motive for deliberate forms of bird crime, particularly intentional poisoning and shooting. In Andalusia, Spain, a higher incidence of poisoning has been correlated with areas of high predator abundance and high yields of wild rabbit hunting (Márquez et al. 2013).

Most cases of bird crimes were recorded during the spring months, with these crimes being more serious because several species are already nesting in this period. When one or both parents are killed, eggs are abandoned in the nest or chicks can die. One example of this was the discovery in March 2018 of a common raven and six white-tailed eagles, two of them chicks, which had been deliberately poisoned at a single location (Veselovský et al. 2019); for context, there were only 17 known breeding pairs of white-tailed eagles in Slovakia in this period (Chavko 2019).

Powerful poisons were used to perpetrate the documented bird crimes, with carbofuran being the most frequently used poison (n = 27). The misuse of carbamate products, including carbofuran, in wildlife crimes have been reported in many countries (Guitart et al. 2010, Deák et al. 2020, Poledníková et al. 2010). The recorded cases probably reflect only a fraction of actual mortality, as bird crime is difficult to detect. Dogs which have been specially trained to detect poisoned baits and the animals killed by them have proved their worth in practice (Fajardo et al. 2012, Kret et al. 2015, Deák et al. 2020), and the PannonEagle LIFE project, in which RPS also participated, has played a major role in promoting the use of dogs in detecting bird crimes from Hungary to the Czech Republic, Slovakia and Austria (BirdLife Hungary 2023). In Slovakia, a police dog detection unit operated by the Waterways Department of the Slovak Police Force regularly patrols high-risk areas in which cases of bird crime have been documented. By actively searching for poisoned baits and dead birds, the unit seeks evidence of bird crimes and plays an important preventive role. Sniffer dogs have managed to find dead birds which have been partially buried or hidden under branches to cover up their illicit killing. In the future, specially trained dogs may be used more extensively in forest areas where there is evidence of bird crime or poisoning of other protected animals, such as mammal predators.

In addition to the negative impact on protected animal species, poisoning also threatens domestic animals. Pivariu et al. (2020) mention cases of dogs being poisoned from eating bait laced with carbofuran. Carbofuran can be ingested, inhaled or otherwise absorbed into the body through contact with the skin and mucous membranes (Lewis et al. 2016). Contact with and ingestion of this carbamate pesticide also poses a risk to humans (Zeljezic et al. 2008).

Given these facts, the use of poisoned carbofuran bait is a grave crime that threatens not only wildlife but also human society. The mere possession of carbofuran is now interpreted in Slovakia as a criminally negligent act, as was confirmed in a 2021 ruling by a regional court (Judgment of the Regional Court in Nitra 2021).

Based on the data mentioned above, we consider bird crime in Slovakia to be a serious human activity that

negatively affects animal populations, especially those of protected and threatened raptor species, and also, in the case of poisoned animals, poses a genuine threat to humans due to the risk of possible intoxication with poisonous substances. The social significance of the issue has also led to the enhancement of the Slovak Police Force's organisational and professional capacities, such the establishment in February 2022 of separate regional environmental crime departments, the introduction of professional training, and the procurement of specialised technical equipment.

In addition to government institutions, the public should also become more involved in looking out for suspicious cases and reporting their findings. By identifying the main predictors of bird crime on the basis of landscape structure, it will be possible to determine the districts which are most at risk of illegal activities. Residents of these areas can be targeted with media campaigns and educational activities highlighting the issue of bird crime, thereby allowing the specialised dog police unit to be deployed more effectively on pre-selected high-risk localities.

Management recommendations

In order to tackle the problem of bird crime more rapidly and effectively, we also recommend several measures that should be implemented by the state authorities. Based on our experience, we suggest that the Ministry of the Environment should work to increase the social values of those protected species of birds of prey and owls whose social value falls below the threshold of constituting a criminal offence. The Ministry of Agriculture and Regional Development, should also employ the Central Control and Testing Institute in Agriculture to monitor the correct use of rodenticides more actively and to inform the Agricultural Payments Agency about any possible violations of the rules of conditionality. In the future, we recommend the establishment of a police dog unit under the auspices of the State Nature Conservancy or a non-governmental organisation focusing on nature conservation which would provide greater flexibility in field deployment and possess a greater knowledge of the local terrain. During the assessment period, several carcasses were located which showed signs of poisoning, but the subsequent laboratory analysis showed no evidence of the selected chemicals. New methods of sample analysis are therefore also needed to investigate bird crime, particularly cases of poisoning, by analysing a wider range of chemicals. Furthermore, investigators should also take into consideration the types of poisons used by offenders in other countries.

The cooperation of stakeholders, especially the Slovak Hunters' Chamber and the Slovak Hunting Union, can also help to reduce bird crime by putting pressure on local hunting associations to record suspicious finds and report them to the authorities. They must also stress that bird crime will not be tolerated and that such behaviour will be condemned.

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