



# Influence of seasonal activity of cloven-hoofed game on the number of collisions with cars in Košice region, Slovakia

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article

Karolová R, Takáčová D, Takáč L, Iglódyová A, Barbušinová E, Šmiga L, Lazár J. Influence of seasonal activity of cloven-hoofed game on the number of collisions with cars in Košice region, Slovakia. *Med Srod.* 2021; 24(1–4): 11–17. doi: 10.26444/ms/142429

## Abstract

The aim of the study was to evaluate the incidence of car accidents with cloven-hoofed game over a 5-year period in the Košice region. The highest number of accidents occurred on 1st class roads (11.18%), which are the shortest and most frequently occurring roads in Slovakia. There were a total of 4.1 animals/km found on such roads within the Košice region. Accidents occurred most frequently during April, October and November; with roe deer being the most commonly affected (62.12%). The roadkill numbers for red deer (21.59%) and wild boar (16.29%) were highest during October and November. These road traffic accidents were mostly related to the migration of game, especially during the rutting season. The time of the collision for each game species was also recorded. It was found that the majority of collisions involving roe deer occurred between 05.00–06.00 and 18.00–21.00, the collisions with red deer occurred most commonly between 21.00–22.00, and collisions involving wild boars occurred between 20–23.00. Over the 24-hour period studied (day, night, dusk and dawn), it was found that from the traffic collisions during the day, roe deer constituted the highest number of roadkill (28.35%). However, during the night, incidents involving wild boar were most frequent (84.88%). The number of car accidents involving cloven-hoofed game was the least frequent during dusk (6.25%), followed by dawn (11.37%) over the 24-hour period.

## Key words

cloven-hoofed game, seasonal movement, wildlife-vehicle collisions

## INTRODUCTION

In the past, the main pillar of hunting in Slovakia included small game, especially hare and partridges. Hoofed game, such as wild ruminants and wild boar, were few and far between on the territory of Slovakia during that time. From the point of view of game production, hoofed animals made up only 22.1% of animals, compared with 73.7% for hares between 1924–1929. However, the situation has now been reversed. The numbers of small game being produced are diminishing and without artificial breeding, pheasantry would be in an even worse situation. The pillar of hunting in Slovakia now is hoofed game. Hoofed game species should therefore be considered essential and increased attention should be paid to their management. It is necessary to preserve adequate numbers of animals, an optimal social structure, to ensure that the animals are of good quality and good health, and that there are no conflicts among the hunting, forestry and agricultural sectors. Although in recent years the number of the hoofed game has been increasing, a large number of the hoofed game is also currently hunted in Slovakia. However, the most serious damage, both to property and life, is caused by traffic collisions with the cloven-hoofed game (roe deer, wild boar and red deer). Accessibility of the motorway network can be solved by building either underpasses for game (however, cloven-hoofed animals usually do not like to enter them), or wide overpasses, so-called ‘green bridges’ with

a natural surface [1]. Currently, there are two bio-corridors on Slovak motorways. Individual bridge structures above highways and expressways serve as separate bio-corridors for game migration.

As traffic increases in volume, it not only brings many benefits to people but also increases the number of collisions occurring between vehicles and game [2]. One of the main causes of road collisions is the migration of game, especially during the night when game activity is at its highest. There are certain pathways that make it very difficult for migrating animals to cross safely. Another cause of collisions is the feed sources which are available for animals. Game from the forest sites must pass across roads to access agricultural crops when searching for feed [2].

## OBJECTIVE

The number of wildlife-vehicle collisions is clearly important in determining the direct effects of roads on wildlife, such as vehicle-related fatalities. The aim of the study was to evaluate the influence of the seasonal activity of cloven-hoofed game on the number of car collisions in the Košice region of Slovakia.

## MATERIALS AND METHOD

The number of car traffic collisions involving cloven-hoofed game was evaluated over a period of 5-years in the Košice region of Slovakia, the area of which is 1 541.33 km<sup>2</sup> (154 133 ha). The car accidents (recorded by the local Traffic Inspectorate) resulted in injuries and deaths of the cloven-hoofed game, damage to property, and sometimes injuries to the driver or passengers. The following species of cloven-hoofed game were included in the study: roe deer, red deer and wild boar. A 24-hour period was evaluated which divided into day, night, dusk and dawn. The frequency of car accidents with game was also evaluated over monthly periods to allow the differences between them to be studied. The issue of car collisions with cloven-hoofed animals was also dealt with according to the categories of roads on which these collisions occurred. Roads are divided into expressways and 1st, 2nd and 3rd road classes in the Košice region. Information regarding car accidents with animals was taken from the 'Record of Traffic Accidents' and 'Record of Verification of the Notice – Damage Event' provided by the District Directorate of the Police Force in Košice region and from the District Traffic Inspectorate. Information was obtained about the species of game, date, time and location (road category) of the car accident from the above-mentioned reports. StatSoft, Inc. (2007). STATISTICA (data analysis software system), version 8.0. www.statsoft.com was used to process the statistics.

## RESULTS

The study focused on car collisions involving cloven-hoofed game in the Košice region (Fig. 1 and 2) of Slovakia. There are currently 60 hunting management units (acreage 146,933 ha; average area 2,448 ha) in the region. The car collisions were evaluated according to the species of cloven-hoofed animals as ruminants (roe deer, red deer) and non-ruminants (wild boar) over a 5-year period. The total number of car collisions with game was 787 (Fig. 3) for the period under review, which were registered at the Košice region Traffic Inspectorate. A precisely defined species of the cloven-hoofed game was present in 528 of the cases (roe deer, red deer, wild boar); however, 259 of the cases were recorded as species not specified (most likely due to an accident when an injured animal escaped). Only the cases when different species of the cloven-hoofed game were identified were focused on. Figure 2 shows the total number of car traffic collisions with cloven-hoofed animals which has an increasing tendency



Figure 1. Map of Slovakia



Figure 2. Location of the county Košice – region in the map

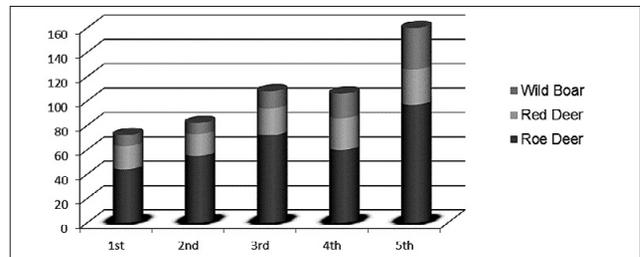


Figure 3. Number of car collisions with cloven-hoofed game in the county Košice – region during the the 5 – year period

from year to year. It was found that the highest number of car collisions recorded were with roe deer (62.12%), compared with red deer (21.59%) and wild boar (16.29%) (Tab. 1) in the Košice region for the observed period of 5 years.

Table 1. Overall evaluation of car collisions with cloven-hoofed game in the county Košice – region for a 5-years period

Years	Roe deer pcs	Red deer pcs	Wild boar pcs	Total pcs
1 <sup>st</sup>	44	19	9	72
2 <sup>nd</sup>	55	18	9	82
3 <sup>rd</sup>	72	22	14	108
4 <sup>th</sup>	60	26	20	106
5 <sup>th</sup>	97	29	34	160
Total:	328 62,12 %	114 21,59 %	86 16,29 %	528 100 %

Car collisions with cloven-hoofed animals were evaluated according to the categories of roads in the Košice region: the R4 expressway, and 1st, 2nd and 3rd class roads, with a total length of 576,976 km. The highway R4 is 14,268 km (2.5%) long in total and has been in operation since 2014. This road has all the safety features installed, including barriers, fencing, noise barriers, and overpasses. Natural migration routes are in place near water sources at the local streams for the game to Access, and therefore there were no collisions with the cloven-hoofed game in this area.

1st class roads are defined as roads that are particularly important for international and national transport. They ensure, without interruption, interconnections of counties and interconnections of border crossings. The length of the 1st class roads totals 64,523 km (11.18%) (Fig. 4). The number of car traffic collisions over the reporting period was 50.38% (Fig. 5), with an average number of collisions of 4.12 animals/km (Tab. 2). 1st class roads are highly frequented and connect the surrounding towns in Slovakia (Prešov, Trebišov, Rožňava, Spišská Nová Ves, Gelnica with the Republic of Hungary). These roads are predominantly

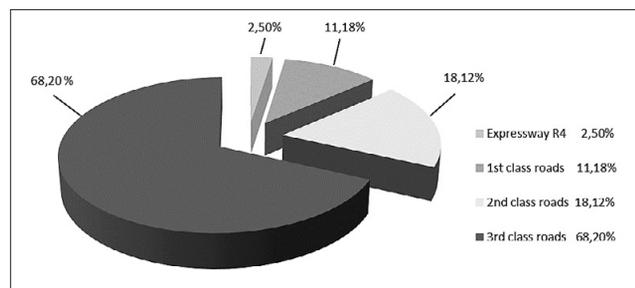


Figure 4. Road division by classes in Košice – region

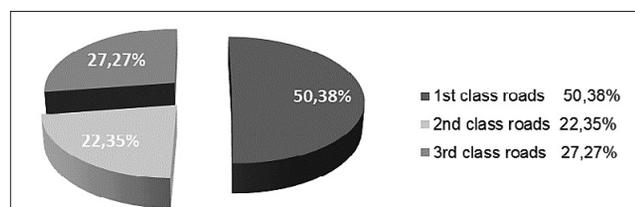


Figure 5. Car collisions with cloven-hoofed game on individual road classes in the county Košice – region for a period of 5 years

in the form of straight sections that pass through a strongly agrarian landscape with a high number of game residing in the surrounding areas.

2nd class roads are defined as roads that are particularly important for transport between regions and districts. They ensure the interconnection of towns and districts of importance. The total length of 2nd class roads is 104,652 km (18.12%) (Fig. 4). The number of car traffic collisions on this type of road was 22.35% (Fig. 4). The average number of game that passed over them was 1.13 pieces/km (Tab. 2).

3rd class roads are defined as roads that are of generally local importance. They connect municipalities with 1st or 2nd class roads if the municipalities lie outside them, and they supplement the road network with economically and transport-based road connections. The length of these roads equals 393,533 km (68.20%) (Fig. 4). On 3rd class roads, car crashes involving game totalled 27.27% (Fig. 4). The average number of collisions with game was 0.37 pieces/km (Tab. 2). 1st class roads (I/50 and I/68) are more frequent and cars drive faster when compared with 2nd class (II/547, II/548, II/550, II/552, and II/576) and 3rd class roads. On the 1st, 2nd and 3rd class roads a maximum speed of 90 km/h is allowed. 1st class roads represent only 11.18% of the total length of roads in the Košice region. When considering the average number of traffic collisions (4.12 pcs/km), this is significantly higher compared to both 2nd class roads (1.13 pcs/km) and 3rd class roads (0.37 pcs/km).

Table 2. Total number of car collisions with cloven-hoofed game divided by classes and length of roads in the county Košice – region over a period of 5 years

Road categories in the county Košice – region	Length		Car collision with game		Ø Number of car collision with game pcs/km
	km	%	pcs	%	
Expressway R4	14,268 km	2,50 %	0	0	0
1st class roads	64,523 km	11,18 %	266	50,38 %	4,12
2nd class roads	104,652 km	18,12 %	118	22,35 %	1,13
3rd class roads	393,533 km	68,20 %	144	27,27 %	0,37
Total	576,976 km	100 %	528	100 %	

Table 3. Evaluation of car collisions with cloven-hoofed game on individual classes of roads in the county Košice – region in 5-years period

Type of roads / % collisions	Game species	Involved years					Summary of 5 years	Total
		1st	2nd	3rd	4th	5th		
1st class 50,38 %	Roe Deer	23	18	28	28	46	143	53,76 %
	Red Deer	14	11	16	20	19	80	30,08 %
	Wild Boar	4	7	6	9	17	43	16,16 %
2nd class 22,35 %	Roe Deer	8	11	19	12	26	76	64,40 %
	Red Deer	3	2	4	4	8	21	17,80 %
	Wild Boar	3	0	3	7	8	21	17,80 %
3rd class 27,27 %	Roe Deer	13	26	25	20	25	109	75,69 %
	Red Deer	2	5	2	2	2	13	9,03 %
	Wild Boar	2	2	5	4	9	22	15,28 %
Total		72	82	108	106	160	528	528

Car traffic accidents with the above-mentioned species of cloven-hoofed animals on different categories of roads in Košice region were evaluated within a 5-year period. The highest number of car traffic collisions occurred with roe deer (53.76%) on 1st class roads, whereas on 2nd class roads it was recorded as 64.40% of car accidents, and on 3rd class roads there were 75.69% car accidents involving roe deer, compared to red deer and wild boar (Tab. 3). It was found that 30.08% of car accidents with red deer occurred on 1st class roads for the whole period under review, while on 2nd class roads it was recorded as 17.8%, and for 3rd class roads only 9.03% of car accidents involved red deer (Tab. 3).

Car accidents with wild boar occurred on 1st class roads at a rate of 16.16%; on 2nd class roads at 17.80%, and on 3rd class roads at 15.28%, compared to other monitored species of cloven-hoofed game. The chi-square statistic was calculated to be 27.803 and the p value at .000014. The result is significant at  $p < .05$ ,  $0.001^{**}$

One aim of the study was to determine whether the day and night periods have an impact on the frequency of car accidents with animals and was therefore hourly. The focus was mainly on the time of day and night – dawn and dusk. On the Internet (<https://calendar.zoznam.sk/sunset-sk.php>) it was found that the average time of dawn (the time when the sky begins to brighten and occurs before sunrise) and the average time of dusk (the transition time between day and night, after sunset the light gradually decreases until full night), and were recorded for each month (Tab. 4).

Roadkill numbers with the cloven-hoofed game were evaluated during a 24-hour period (Tab. 5) during which time it was found that the highest number of collisions occurred during the night (61.36%). According to the individual species of cloven-hoofed game, collisions with wild boar occurred at a rate of 84.88% during the night. When evaluating traffic collisions during the day, it was found that most of them involved roe deer (28.35%). During dusk and dawn, there were more roadkill numbers during dawn (roe deer – 12.28%, roe deer – 12.28%, and wild boar -10.46%). The highest number of car collisions involving wild boar was 84.88% (Tab. 5) which occurred during the night between 20.00–23.00 (Fig. 8), during dawn (10.46%), during dusk (2.33%), and during the day (2.33%) (Tab. 5). The rate of red deer collisions totalled 72.80% (Tab. 5), recorded between 21.00–22.00 (Fig. 7). The roadkill numbers were recorded during the day – 14.04%, during dawn – 12.28%, and dusk – 0.88% (Tab. 5) in red deer.

For roe deer a rate of 51.22% was recorded (Tab. 5) between

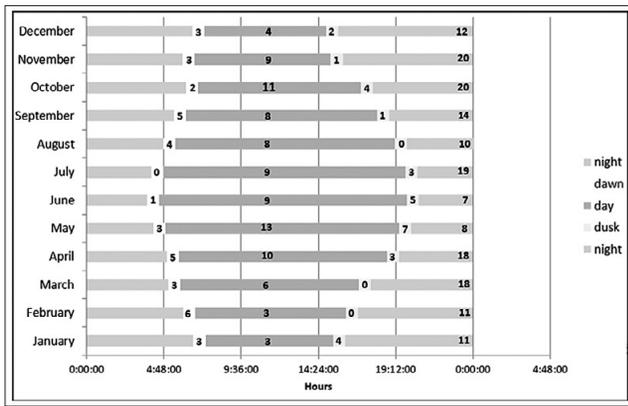


Figure 6. Car collisions with roe deer during day, night, dusk and dawn during 5-years period in the county Košice – region

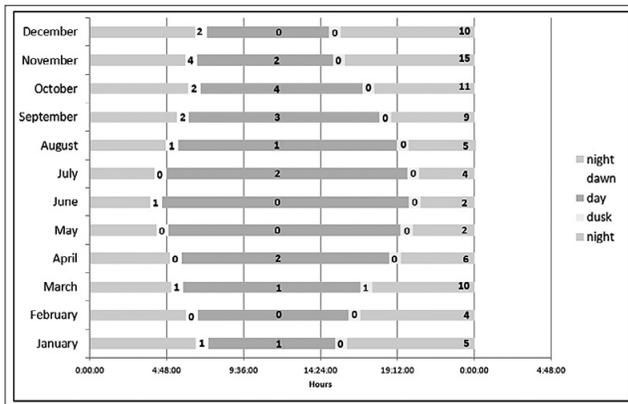


Figure 7. Car collisions with red deer during day, night, dusk and dawn during 5-years period in the county Košice – region

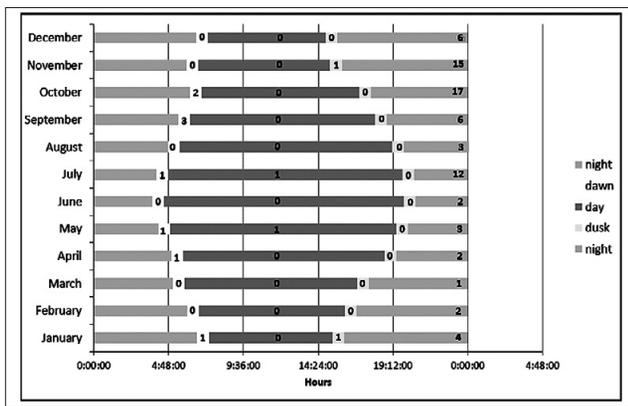


Figure 8. Car collisions with wild boars during day, night, dusk and dawn during 5-years period in the county Košice – region

05.00–06.00 am and 20.00–21.00 (Fig. 6), respectively, in the Košice region for the period under review. During the day, the rate was at 28.35%, during dawn – 11.28%, and dusk – 9.15% (Tab. 5).

Table 4. Hour average in dawn and dusk range evaluated by months over a 5-years period

	January – December											
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Dawn*	6.38-7.23	6.00-6.45	5.04-5.49	5.00-5.45	4.09-4.54	3.46-4.31	4.02-4.47	4.45 -5.27	5.25-6.10	6.09-6.54	5.57-6.42	6.35 -7.20
Dusk*	15.19-16.04	16.08-16.53	16.54-17.39	18.40-19.25	19.24-20.09	19.54-20.39	19.48-20.33	19.05-19.50	18.03-18.48	17.01-17.46	15.10-15.55	14.54-15.39

\*(from – till)

Table 5. Percentage average expression of car accidents with individual species of cloven-hoofed game within 24 hours during the 5-year period in county Košice – region

	Roe deer pcs / %	Red deer pcs / %	Wild boar pcs / %	Total pcs / %
Day	93 / 28,35 %	16 / 14,04 %	2 / 2,33 %	111 / 21,02 %
Night	168 / 51,22 %	83 / 72,80 %	73 / 84,88 %	324 / 61,36 %
Dusk	30 / 9,15 %	1 / 0,88 %	2 / 2,33 %	33 / 6,25 %
Dawn	37 / 11,28 %	14 / 12,28 %	9 / 10,46 %	60 / 11,37 %
Total	328 (100 %)	114 (100 %)	86 (100 %)	528 (100 %)

By evaluating the results using a unit of time (in hours), it can be stated that the average length of both dusk and dawn was only a very short 1.30 hours (0.45 hrs/dusk, 0.45 hrs/dawn) (Tab. 4), with the average length of the day during the year at 11.43 hrs, and the average length of night during the year – 11.01 hrs. Car collisions with cloven-hoofed game during dusk and dawn (1 piece/29.4 hours) after conversion in hours were twice higher than at night (1 piece/62 hours) and 6-times higher than during the day (1 piece/188 hours).

When comparing dusk and dawn, it was found that more collisions with cloven-hoofed game occurred during dawn, at the rate 11.37%, whereas during dusk it was almost half of this rate – 6.25%. Chi-square statistic – 52.954; p-value – <0.00001. The result is significant at p <.05.0,001\*\*\*.

We evaluated the seasonal dynamics of car crashes with cloven-hoofed game in the county Košice – region and we found that the highest roadkill numbers occurred between October and November during the monitored period. The highest number of car accidents with roe deer was recorded in April with 36 incidents, in October with 37 and in November with 33 (Figure 9). This was related to the territoriality, when there is increased movement of roe deer because of the rut during April and in October. There is the migration for feed when roe deer grow and young individuals become more independent.

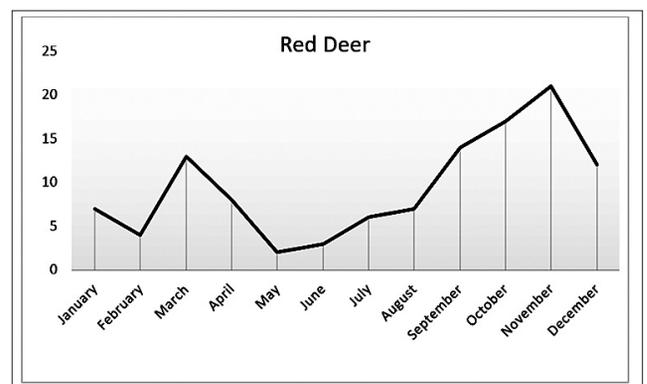
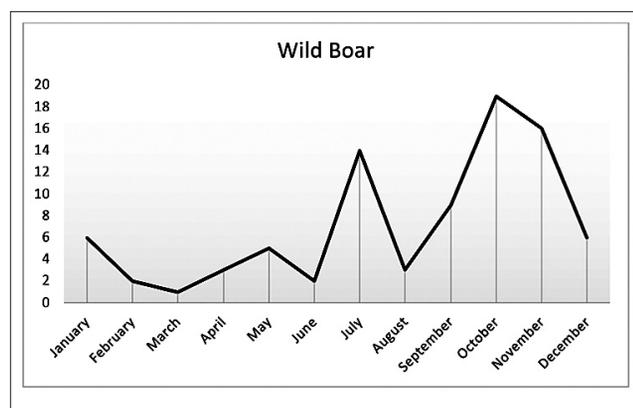
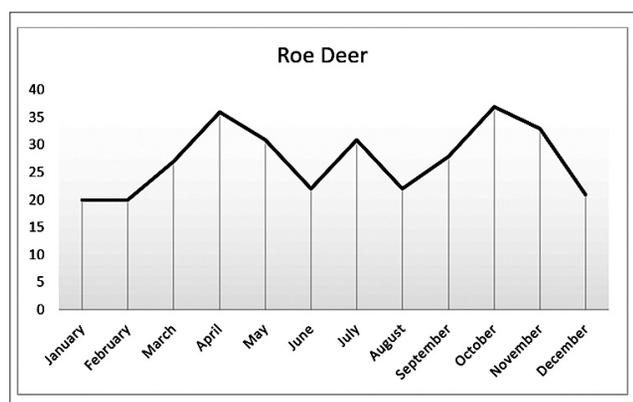


Figure 9. Number of car accidents with roe deer in Košice – region in 5-years period by months



**Figure 10.** Number of car accidents with red deer in Košice – region in 5-yers period by months



**Figure 11.** Number of car accidents with wild boar in Košice – region in 5-yers period by months

According to Fig. 10, the highest number of car collisions with red deer was recorded in March, when animals migrate from winter to summer outposts and in November the opposite occurs.

The highest number of car collisions with wild boar was in July, due to migration to agriculture for food. There is minimal migration in August because wild boars already have enough food. During October and November, the roadkill number increases, because it is rut season as well as the move to forest stands. The beginning of the common hunting season leads to an influx of hunters and their dogs which disturbs the natural behaviours of the wild boars. It is necessary for the wild boar to fight off hunters, which in turn affects their patterns of behaviour.

The highest incidence of car traffic collisions with red deer during the reporting period occurred during the months of November with 21 incidents, October with 17 and in September with a total of 14 incidents (Figure 10). The highest number of car accidents with wild boar was during October with 19 incidents total, whilst in November there were 16 accidents (Figure 11). The chi-square statistic is 16.8072. The p-value is .000224. The result is significant at  $p < .05$ ,  $0.001^{***}$ .

It was also determined whether the intensity of cars on the roads of the Košice region had an effect on the collision rate with animals over the 5-year period. Preliminary analysis revealed that the intensity of cars on the roads did not correlate with the collision rate for game in theregion, since the number of cars on each class of road was very high, reaching up to tens of millions in the 5-year period.

## DISCUSSION

In the Košice region there are 3 breeding units: J XXV Slanské mountain range, J XVI – Smolník and S XI – Prešovská, for which normalized stocks (NS) of roe deer have been established since 2010 by the District Office for Košice region – 3,441 pcs; 1,169 pieces of red deer were set by the NS, and 863 pieces for wild boar. A livestock unit is part of a hunting area or hunting site created by its division into smaller units with hunting grounds within the competence of one district forestry authority (Land and Forest Department) [15]. Normalized stock (NS) is the maximum number of animals of a certain density permitted without causing harm to the ecosystem [15]. It is the responsibility of the hunting district user to manage the hunting district to achieve and maintain a standard game stock, the prescribed age and gender structure of the game population and its good health [15].

In many countries, wildlife-related accidents, particularly deer-vehicle accidents, pose a serious problem for road safety and animal protection [3]. As shown by German statistics, 80% of all accidents are collisions with Cervidae species (red deer, roe deer, fallow deer, and elk) and merely 10% of accidents involve wild boars [4]. In the current study, it was found that during the monitored period, car accidents occurred mainly with roe deer (62.5%) during April and July.

In the Lublin Region of eastern Poland between 2011–2013, Tajchman [5] reported that more than half (66%) of the traffic accidents recorded were collisions with roe deer. In Sweden moose, roe deer, and wild boar were responsible for 97% of all vehicle accidents involving wildlife. In terms of landscape characteristics, forests positively and significantly contributed to the growth rate of moose and wild boar population proxies, whereas pasture had a significant and negative effect on the growth rate of wild boar populations [17].

Roe deer are grouped into large herds, especially in agricultural land. Roe deer activity is divided into 10–11 grazing periods, the highest being in the morning and the evening. They spend most of their time resting and chewing. Roe deer is a species with a more polyphasic daily activity, and belong to the largest group of cloven-hoofed species. Roe deer have several grazing cycles throughout the day and live in all-forest habitats, also found more abundantly in lower altitudes. It is also trophically linked to open habitats (forest meadows and cleans). The species' habitat is primarily determined by the availability of food and cover. Although roe deer eat a wide variety of plant species, the regional plant species they eat vary depending on the season and type of habitat. Because of this diversity, roe deer can easily adapt to a wide range of habitats [6].

The day and night phases were also monitored and evaluated and it was found that the highest number of car accidents with roe deer (51.22%) occurred between 05.00–07.00, and 17.00–22.00. Dawn and dusk, between 05.00–06.00 and between 17.00–22.00, respectively, and can be characterised as having an increased number of game-motor collisions. Neumann et al. [18] came to the conclusion that a high collision risk was caused not only by animal movements, but also by light and road surface conditions. Car traffic is also heavier at dusk and dawn, as individuals drive home from or towards their workplace. Morelle et al. [19] stated that the visual conditions at these hours are also not ideal (darkness, fog) and may contribute to the increased number of accidents. The number of accidents reduces in the middle of the night as

a result of less animal activity and reduced traffic. The game is more likely to go to pasture or return to the thicket, but the drivers also drive much faster during dawn and dusk due to the lower traffic levels [7]. Estimating the total number of animals killed on roads and the population implications is critical in and of itself, but collecting data on wildlife-vehicle accidents to understand other aspects of ecology is equally important [8].

Apart from the roe deer rut season (15 July – 15 August), there are collisions with traffic from early April to late May. This period is characterized by searching for food as well as for territories consisting of both male roe deer and, to a lesser extent, female roe deer. The number of deer-vehicle collisions is thought to have diurnal and seasonal patterns that reflect animal activity patterns [9].

According to Kitowski et al. [10], the daily distribution of roe deer-vehicle collisions in Lublin County in eastern Poland confirms that the risk of collisions is higher during the darker part of the day, especially shortly after sunset and early in the morning. Other authors who studied roe deer collisions obtained similar results. However, the risk for collision with roe deer varies over the year – the majority of crashes occur in April and May; nevertheless, the risk is high during summer and autumn as well. November was the most dangerous month for driving on Finnish roads, with 2,238 accidents. This is explained by the fact that it is the breeding season at the end of autumn, and many of these animals migrate in search of mating partners. Many incidents happened during the migrations in May and June, in addition to the autumn months. Animals prefer to move in the dark, when they pose the greatest danger for cars at dusk when there is usually a lot of traffic. The peak times in early morning and late evening, unfortunately for wild animals and the unwary motorist, frequently coincide with rush hour [20]. Tajchman [5] reported that road accidents with red deer represented 27% in the Lublin Region of eastern Poland during 2011–2013.

The rut in deer occurs between 10 October – 10 November. At this time, deer create a harem of female deer and fight for their favour. They resound a deep throat voice from evening to morning [7]. The deer, except for the oldest males and except during the rut, live in firmly organized herds. During the day, they hide in thickets, in tall grasses or in field crops, and only in the evening they go to a pasture. Moving more frequently increases mortality risk in the human-dominated-landscapes by increasingly more encounters with mortality sources like road traffic and hunters. As with other cervids, the autumn breeding season, or rut, is expected to increase vulnerability to mortality from a variety of sources, including the hunter harvest and deer-vehicle collisions [11].

In Slovakia, the highest incidence of car traffic collisions with red deer during the reported period was 17 in October and 21 accidents in November. Territoriality in male roe deer is a seasonal phenomenon, with territories established in the spring and maintained until the end of the rutting season [12].

Wild boar are the only representatives of non-ruminant cloven-hoofed game investigated at in the current study. As a species, they do not like open country. Peak activity is mostly at night, as confirmed in this study (84.88% of road accidents occurred at night). Wild boar seek food together and are omnivores feeding on a wide variety of food. They like to visit cornfields, but also eat clover and lucerne. Wild boar

need a lot of water and also like mud. They live in family herds and unite into larger groups with a firm social structure.

With the exception of adult boars, feral pigs live in family herds, consisting of sows, growers and pigs born within that year. Sometimes these family herds associate with larger families in a strong social structure [13]. They usually rest by hiding in thickets or tall field cultures during the day, and are active at night. They can walk several tens of kilometres at night [7]. Wild boar numbers continue to increase despite their intense hunting [14].

Game that are not caught in accordance with the hunting law [15] are considered to be ‘inedible’ for human consumption. This includes animals killed in car accidents. Drivers most often have broken windshields after a collision with game, cracks and bent bonnets, and minor or major injuries to the driver or passengers are also seen in the case of more serious collisions.

## CONCLUSION

Based on the results of the current study, the following measures are proposed to reduce car traffic collisions with game:

1. warning drivers of the risk of game collision;
2. preventing game from crossing roads.

The first includes warning signs and speed limits on curved sections of roads. Mirrors reflecting the light of approaching cars towards the surroundings of the road and are suitable for scaring away the game. The fencing of dangerous sections of the road through the use of mesh is the most effective strategy. There are different types of mesh from classical to newer styles, such as electrically-charged mesh. Depending on the type of game to be prevented from moving in the selected direction, the appropriate mesh type, as well as the appropriate fence height, should be used. The disadvantage of fencing is that it acts as a barrier to the game. Therefore, there may be an increase in the number of collisions at the end of the fencing. Degradation of the road environment that is suitable for game can be achieved by mulching, removing bushes and other sources of food and shelter for game. In hidden road sections with densely overgrown roadside edges, it is advisable to prune the edge trees and remove ground vegetation, providing both the game and drivers have a better view. The problem remains to involve the owners of the land in question. The enormous increase in wild boar, which not only threatens road users but also migrates to the edge of human dwellings, contributes significantly to accident statistics. Their reduction is therefore necessary for several reasons. By agricultural management, the growth of areas for maize cultivation also increases the presumption of a collision with wild boar (biogas stations) in these sections. Using new information and command tags, new brands are available that are highlighted by colour, reflective material and LEDs, for example. The result is at least a partial speed reduction and the associated reduced risk of collision.

Game detection is one of the most modern methods. These systems are based on the reception and measurement of the signal sent from the source and reflected from the animal or other technologies. Smell fences can be a good help, but they are only suitable as a temporary solution. On both sides of the road, at short distances, they are fastened to trees, shrubs or crash barriers using spray bombs of stinking foam. Such an

odour barrier is based on the smell of a predator or human, which should have a repellent effect on the game. In the opinion of experts, the fear of animals in front of them should be genetically fixed. The odour substance is generally effective for 3–4 weeks, after which it must be renewed.

Additionally, there should be the strategic sowing of the fields along the most critical sections, with species the game finds less attractive, and also off-level crossings built at regular intervals for their use. Introduction of a similar map web application as in the Czech Republic [16], which would identify migration routes of animals or sites where it would be necessary to preserve these routes in the form of eco-bridges.

Hunters should be encouraged to intensify hunting in areas with increased traffic. In practice, however, this is usually not observed due to a lack of hunting facilities (such as sitting or observation points) in the vicinity of roads.

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