

## Analysis of Hedgehog (*Erinaceinae*) Mortality due to Collisions with Cars

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### Abstract

The protection of animal life and the preservation of their natural habitats are a priority within several countries. The objective of this work is to analyze hedgehog (*Erinaceinae*) mortality due to collisions with cars based on data derived from two different cities: Komárno (Slovak Republic), and Prague (Czech Republic). A total of 75 hedgehog cadavers were documented on, or along roads from Komárno and Prague, respectively. Hedgehog cadavers were found on roads in the center of Komárno, near blocks of flats, near to houses, including the outskirts of the city. On the other hand, no hedgehog cadavers were found in the center of Prague, but similarly, they were found on roads near blocks of flats, near family houses, and on the periphery of the city. The results of the work are placed in the context of the requirements for life of hedgehogs and the architecture of different cities. There is a direct relationship between the organization of the city, particularly in relation to the location of green spaces, and the occurrence of, and therefore potential hazards for, hedgehogs. The creation of larger green spaces should be planned in the future in the context of hedgehog conservation.

**Keywords:** hedgehog, nature conservation, traffic accidents, veterinary forensic medicine, wildlife.

### 1. INTRODUCTION

The hedgehog (*Erinaceinae*) is one of the animals that are commonly found throughout the Slovak and the Czech Republic. Originally it was presented as one species, but, later, it was classified as two, separate, species, which differ in coloration, cranial features, and chromosome structure. The occurrence of the Eastern European (*Erinaceus roumanicus*) as well as the Western European (*Erinaceus europaeus*) species is well documented in the Czech Republic.

The Western European species dominates in numbers, but the contact zone of encounter passes through Central Europe with the widest part of the zone through the Czech Republic [5]. The occurrence of the western European species was not originally expected in Slovakia [10]. However, the boundaries of the encounter between the two species seem to have gradually

expanded, as the western European species has already been identified in Slovakia [12]. It is a protected animal that is easily recognizable by its characteristic appearance, and zoologists do not seem to have much difficulty in identifying individual species. There has been a long-term, gradual decline in hedgehog numbers throughout Europe [4]. However, this is not an acute problem, but rather a combination of several factors that are gradually contributing to this. The first historical, persistent, factor is the continual housing development or reshaping of natural resources, which is accompanied by a reduction in the natural area available for wildlife life. The second factor is the long-term intensification of agricultural production with the application of chemical products, that gradually reduced the natural occurring sources of food for hedgehogs, with a possible negative impact on their reproductive parameters. The third factor is the

enormous development of the automotive industry, including the construction of a more extensive road networks, which has encroached onto the habits of wild animals. Another factor is climate change: more frequent alternation of cold and warm spells during the winter, have entailed interruptions of hibernation entailing loss of stored fat and consequently increased pre-spring mortality. Limited regulation of natural predators of hedgehogs, such as foxes, may also play a role. The natural movement of hedgehogs in the wild, in areas with roads in towns and villages, results in collisions with cars which regularly prove fatal. We have not found an individual study analyzing the mortality of hedgehogs due to collisions with cars in the Slovak or the Czech Republic in the literature. Such a study could provide an indication of the status of hedgehogs in our territory, including expanding information on the causes of their mortality in specific locations. We hypothesize some differences between location and territory of hedgehogs between different cities, which can be applied also to other bigger cities, including other small cities in several countries. Therefore, the objective of our work is to analyze hedgehog

mortality after collisions with cars, including site data, interfering factors and to discuss preventive factors, which can be applied in cities to safe wild animals.

## 2. MATERIALS AND METHODS

Seventy-five (n=75) hedgehog cadavers were photographically documented after collisions with cars in this study. The first set of cases (n=47) was collected in the Komárno city, located in western Slovakia. The second set of cases (n=28) was collected in the capital of the Czech Republic, Prague. Each case was individually photographically documented with special attention to the locality including interfering factors. The locality includes the place where the cadaver was found (city center, residential zone, or the periphery of the city). The interfering factors included selected characteristics that were identified in the vicinity of the where the hedgehog cadavers were found (blocks of flats, houses, public bins or dumpsters, grassy or wooded area, and natural water body ((lake over 10 ha or river flowing through the city)). In doing so, four distance parameters were defined (<100 m, <500 m, >100 m, >500 m).

## 3. RESULTS AND DISCUSSION

The results are presented in Table 1 and Table 2.

**Table 1.** Characteristics of hedgehog cadavers found in Komárno.

I	Locality			Interfering factors				
	CC	RZ	CP	BF	H	PBD	GWA	NWB
1	x			<500 m	<500 m	<100 m	<100 m	>500 m
2		x		<100 m	<100 m	<100 m	<100 m	<500 m
3		x		>100 m	<100 m	<100 m	<100 m	>500 m
4	x			<100 m	>500 m	<100 m	<100 m	>500 m
5			x	>500 m	<100 m	>500 m	<100 m	>500 m
6			x	>500 m	<100 m	<100 m	<100 m	>500 m
7			x	>500 m	<100 m	<100 m	<100 m	>500 m
8		x		<100 m	<100 m	<100 m	<100 m	>500 m
9		x		<100 m	<100 m	<100 m	<100 m	>500 m
10	x			>100 m	>500 m	<100 m	<100 m	>500 m
11		x		<100 m	<100 m	<100 m	<100 m	>500 m
12		x		<100 m	<100 m	<100 m	<100 m	<500 m
13	x			<100 m	>500 m	<100 m	<100 m	<500 m
14		x		<100 m	<100 m	<100 m	<100 m	>500 m
15		x		<100 m	<100 m	<100 m	<100 m	<500 m
16			x	>500 m	<100 m	<100 m	<100 m	<100 m
17			x	<500 m	<500 m	<100 m	<100 m	<100 m
18		x		<100 m	<100 m	<100 m	<100 m	>500 m
19	x			<100 m	>500 m	<100 m	<100 m	>500 m
20			x	>500 m	<100 m	<100 m	<100 m	>500 m
21		x		<100 m	<100 m	<100 m	<100 m	>500 m
22		x		<100 m	<100 m	<100 m	<100 m	>500 m
23			x	>500 m	<100 m	<100 m	<100 m	<100 m
24			x	>500 m	>500 m	<100 m	<100 m	<100 m
25		x		>500 m	>500 m	<100 m	<100 m	>500 m

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26			x	>500 m	<100 m	<100 m	<100 m	<100 m
27			x	<100 m	>500 m	<100 m	<100 m	<100 m
28	x			<100 m	>500 m	<100 m	<100 m	>500 m
29		x		<500 m	>100 m	<500 m	>100 m	<500 m
30	x			>500 m	>100 m	<100 m	>100 m	<500 m
31	x			>100 m	<500 m	<100 m	>100 m	<500 m
32	x			>100 m	<500 m	>100 m	>100 m	<500 m
33		x		>100 m	>500 m	>100 m	<100 m	<500 m
34	x			>100 m	<500 m	<100 m	>100 m	<500 m
35		x		>100 m	<500 m	<100 m	<100 m	<500 m
36		x		>100 m	<500 m	<100 m	<100 m	<500 m
37	x			<500 m	>100 m	<100 m	<100 m	<500 m
38		x		>100 m	>100 m	<100 m	<100 m	<500 m
39		x		<100 m	>100 m	<100 m	<100 m	<500 m
40	x			>100 m	<500 m	<100 m	>100 m	<500 m
41	x			>100 m	<500 m	>100 m	>100 m	<500 m
42			x	<500 m	<100 m	<500 m	>100 m	<500 m
43	x			>100 m	<500 m	>100 m	>100 m	<500 m
44	x			>100 m	<500 m	<100 m	>100 m	<500 m
45			x	<500 m	<500 m	<500 m	>100 m	>500 m
46			x	<500 m	<500 m	<500 m	>100 m	>500 m
47			x	<500 m	<500 m	>100 m	>100 m	>100 m

Legend: I – Indicator; CC – City Center; RZ – Residential Zone; CP – City Periphery; BF – Blocks of Flats; H – Houses; PBD – Public Bins or Dumpsters; GWA – Grassy or Wooded area; NWB – Natural Water Body.

**Table 2.** Characteristics of hedgehog cadavers found in Prague.

I	Locality			Interfering factors				
	CC	RZ	CP	BF	H	PBD	GWA	NWB
1			x	>500 m	>100 m	>100 m	<100 m	>500 m
2		x		>500 m	<100 m	<100 m	<100 m	>500 m
3			x	>500 m	>100 m	>100 m	<100 m	>500 m
4			x	>500 m	>100 m	>100 m	<100 m	>500 m
5			x	>500 m	>500 m	>500 m	<100 m	>500 m
6			x	>500 m	>500 m	>500 m	<100 m	>500 m
7			x	>500 m	<100 m	>100 m	<100 m	>500 m
8			x	>500 m	<100 m	<100 m	<100 m	>500 m
9			x	>500 m	>500 m	>100 m	<100 m	>500 m
10		x		>500 m	<100 m	<100 m	<100 m	>500 m
11			x	>500 m	>500 m	>500 m	<100 m	>500 m
12		x		<500 m	>500 m	>100 m	<100 m	>500 m
13		x		<100 m	<100 m	<100 m	<100 m	>500 m
14		x		<100 m	<100 m	<100 m	<100 m	>500 m
15			x	>500 m	>500 m	>100 m	<100 m	>500 m
16		x		<100 m	<100 m	<100 m	<100 m	>500 m
17			x	>100 m	>500 m	>100 m	<100 m	>500 m
18			x	>500 m	>500 m	>500 m	<100 m	>500 m
19		x		<500 m	<100 m	<100 m	<100 m	>500 m
20		x		>500 m	<100 m	<100 m	<100 m	>500 m
21		x		<100 m	<100 m	<100 m	<100 m	>500 m
22			x	>500 m	>500 m	>100 m	<100 m	>500 m
23		x		<100 m	<500 m	<100 m	<100 m	>500 m
24			x	>500 m	<100 m	<100 m	<100 m	>500 m
25			x	>500 m	<100 m	>100 m	<100 m	>500 m
26			x	>500 m	<100 m	<100 m	<100 m	<500 m
27			x	>500 m	<100 m	>100 m	<100 m	>500 m
28			x	>500 m	<100 m	<100 m	<100 m	<500 m

Legend: I – Indicator; CC – City Center; RZ – Residential Zone; CP – City Periphery; BF – Blocks of Flats; H – Houses; PBD – Public Bins or Dumpsters; GWA – Grassy or Wooded area; NWB – Natural Water Body.

The current boom in the automotive industry has visibly manifest itself in increased traffic on our domestic roads. The concentration of cars and trucks has also increased several times over the decades. This was not foreseen when the roads were originally designed. Compared to the past, car accidents have increased dramatically [15]. Other countries are also struggling with similar problems, and therefore, several preventive measures have been proposed [3, 17]. Meanwhile, some of our roads are now so congested that several kilometers of slow-moving cars form queues on them almost every day (Fig. 4A). These are mainly access roads to major cities. These are usually surrounded by grassy or wooded areas where smaller or larger wildlife naturally move around. This fact is confirmed by the results of our work, in which we repeatedly found hedgehog cadavers on the roads on the outskirts of Komárno (Fig. 3K, 3L), as well as on the periphery of Prague (Fig. 4H, 4I, 4J, 4K, 4L). It can be assumed that hedgehogs cross roads when moving through the countryside, where collisions with cars subsequently occur. However, we are of the opinion that this is more likely to be a case of hedgehogs deliberately seeking out the road. In summer or early autumn, when temperatures are high during the day and night, insects, which are the hedgehog's favorite food, linger on the hot asphalt with the aid of night lighting. It is at this time of the year that we clearly found the majority of new hedgehog cadavers in the morning hours. In one study from Ireland, selected roads were monitored between April 2008 and November 2010 with the primary purpose of ascertaining the numbers of hedgehogs killed by cars [8]. The authors documented 135 hedgehog cadavers. In the Netherlands, to take another example where data is produced and available, relatively high numbers of hedgehogs killed in this way are reported, ranging from 113,000 to 340,000, with an annual reduction in the hedgehog population of 3 to 22% [11]. A study from Belgium documents 1,281 hedgehog cadavers over a two-year interval [9]. A study conducted in Poland found 78 hedgehog cadavers at over one year [16]. Mortality is likely influenced by vehicle concentration, because comparing the years prior to the COVID-19 pandemic (2018 and 2019) with the pandemic period (2020) documented a 50% lower rate of hedgehog kills, with tens of thousands of hedgehogs surviving in the Polish setting [13]. Very well documented and long-term numbers of hedgehogs killed by cars are available from the New Zealand setting, where

several authors have independently addressed this issue [6]. There, calculations of cadavers found, per 100 km, have been undertaken, and compared with each other in relation to the overall hedgehog population trends. The reader will have noticed the rather large differences in the numbers of hedgehog cadavers counted in different states. However, these differences are the result of the methodology of the individual working groups rather than differences in the actual numbers of hedgehogs killed. These include differences in the size of the area surveyed, differences in the locations of the countries surveyed, and differences in the length of time each study has been carried out. The numbers of hedgehog cadavers found in our work are much lower when compared with the above-mentioned studies. Rather, we present figures relating to two different cities or only certain parts of the cities mentioned, with clearly lower numbers of hedgehog cadavers compared to the national figures. However, it is possible to recalculate these by the number of towns for each state to give an average figure for the number of hedgehogs killed on our roads. Just for comparison, the work of Bartonička *et al.* [2] addressing animal mortality after collisions with automobiles on three Class II and Class III roads southwest of Brno documents 71 cadavers of smaller vertebrates. However, only three hedgehogs were identified from the total number of cadavers found. On the other hand, the primary aim of our work was not to provide precise numbers of car-killed hedgehogs on a national level. Primarily, we wanted to highlight the causes of hedgehogs killed after collisions with cars within individual cities. This information could ultimately contribute to the definition of preventive measures that would contribute to the reduction of car-animal collisions. For example, there were an estimated 30 million hedgehogs in England in 1950, with numbers dramatically reduced to 1.5 million by 1955 [14]. As noted in the introduction of our paper, it is evident that these facts, even in the English setting, correspond to a confluence of several factors. Thus, it is not just a matter of hedgehog numbers declining because of collisions with cars. On the other hand, although it has been suggested that hedgehogs may have two litters per year, the effects of increased vehicle concentration on wildlife numbers should not be entirely underestimated, with particular attention to the possible regulation of wildlife numbers in the breeding season [7]. Thus, this also applies to the hedgehog, and our work is a document of this. However, if we look at England as mentioned

above, one paper analyzed hedgehog mortality data due to collisions with cars from four independent studies conducted between 1952 and 2004 [20]. The authors estimated 167,000 to 335,000 individuals killed in this way, with a 30% decline in the hedgehog population. To prevent further declines in hedgehog populations, there has been the introduction of completely new road signs with the hedgehog symbol, drawing attention to the increased numbers of these animals in the area. Our results show that one of the most important factors involved in hedgehog movement is habitat. Wooded areas along roadsides are much more at risk in this respect compared to concreted areas in the center of towns. Slovak Komárno is smaller, in both size and population, than Prague, and we have recorded many more hedgehog cadavers there in the same time interval compared to the number of hedgehog cadavers in Prague. This is, not only, explained by differences in the concentration of cars, but also by differences in the layout of grassed or wooded areas versus concreted areas within each city. We also acknowledge that this may be due to differences in hedgehog abundance between towns. Although larger towns try to provide green spaces in the epicenters of individual districts, in some places it is just an isolated grassy area with more, or less, trees in which only birds find refuge. On the other hand, green spaces in large cities are characterized by a different architecture compared to green spaces in smaller towns. In general, however, the central parts of cities are exposed to car noise virtually all day and sometimes even at night, including human noise, which is a deterrent to animals. Unless there is sufficient green space, smaller wildlife cannot move around naturally and, above all, safely. On the other hand, litter and especially food are an attraction for several smaller vertebrates, including rodents, which are often overpopulated in both larger and smaller cities. Our results also document a relationship between the presence of public garbage bins (or dumpsters) and hedgehog cadavers on adjacent roads. Often, there were several overcrowded dumpsters placed on the periphery of roads with food scraps scattered around (Fig. 3F, 4D). Besides, larger cities are usually much better equipped with street cleaning services compared to smaller cities, where street cleaning is only carried out occasionally or not at all. Based on the assumption that Prague is counting on a steady income of funds from tourism, it also has to take care of the city's cleanliness, which is carried out on a daily basis. In Komárno, even though it blindly prides itself

on tourism, cleaning is, in fact, carried out only in selected parts of the city, in other parts only superficially or not at all. Perhaps that is why we found fewer car-killed hedgehogs in Prague compared to Komárno. While we commonly found hedgehog cadavers in the center of Komárno (Fig. 3A, 3B, 3C), we did not find them in the center of Prague during our study period.

As we have already indicated, these findings should be taken with a grain of salt, because different parts of Prague, several of which differ significantly in architecture and thus in area, layout, including significant differences in naturally or artificially grassed or wooded areas, may differ in the number of hedgehog cadavers. In addition, the requirements for the management of these areas, including mechanized mowing and thus the possible regulation of wild animals that do not find a safe environment to live in, should not be underestimated. Some data on the distribution of hedgehogs in Prague have already been outlined to the professional public in the past [1]. Prague covers an area of 49 605 ha, with 56.74% of the total area of the city being natural or artificial green space, with up to 220 m<sup>2</sup> of green space per inhabitant. Komárno covers an area of 10 317 ha, but data on the total area of green space, compared to the built-up area, are not officially available. Given the above figure for the area of green space in Prague, it is therefore clear that even large cities can be a reservoir of hedgehogs. Some of them could perhaps be arranged a little differently (Fig. 4B, 4C). It is different with residential zones and especially with the periphery of cities, which is normally in contact with wooded areas. There, we observed similar results at the level of Komárno and Prague with numerous hedgehog cadavers. According to Pokorná [18], hedgehogs are now much more common around human settlements compared with open nature. This is derived from the demands and requirements of hedgehog life. The hedgehog primarily seeks diverse landscapes with small thickets, scrub, smaller grasslands and therefore often migrates to the vicinity of human settlements. As these are usually only smaller garden areas that are often in contact with more or less busy roads, hedgehogs are commonly at risk of collisions with cars (Fig. 1, 2). Also, the results of our work document cadavers on roads around blocks of flats, and around houses both in Komárno (Fig. 3D, 3E, 3G, 3H, 3I, 3J) and in Prague (Fig. 4E, 4F, 4G). In our study, the relationship between water bodies, rivers and the presence of cadavers was not confirmed. One study analyzed the

movements of four female and four male hedgehogs in built-up areas of English cities [19].

The results showed that roads and road peripheries were the least sought after and, conversely, playgrounds and gardens were preferred. These facts should, in our view, be considered particularly when planning urban development or further expansion of smaller or larger cities. The real estate market has long been oriented towards the purchase of land on the periphery of cities or in the center of cities, where the construction of residential zones is planned and implemented. The spatial planning of these developments should involve the idea of preserving green space, even with limited human access to these areas, possibly with the construction of effective green barriers to prevent animals from crossing the roads so that smaller wild animals can live safely close to people. Beyond that, our young people's view of wild

animals, their needs, and their importance should be changed, at least in part, so that they are not just seen as insignificant or annoying animals but as a natural part of our planet that needs to be protected and as sentient creatures that possess capacities for motility and affect. This might be addressed by teaching some of the new biology in schools. The whole system at all levels of undergraduate education should concentrate much more on practical teaching as opposed to theoretical interpretation. Collisions between smaller or larger wild animals and cars will continue to occur in the future, and these collisions cannot possibly be avoided altogether. However, by respecting measures, some of which are very familiar to car drivers, it is possible to eliminate the number of these collisions. In addition, with further urban development, infrastructure planning can create safer living conditions for wildlife and therefore hedgehogs.



**Figure 1**

Several photographs (each column corresponds to one case with an approaching shot from top to bottom) showing hedgehogs in the vicinity of more or less frequented roads. In close proximity with the road peripherally captured on the left, a hedgehog passes in a grassy area at night (A, E, I). To the left is a peripherally captured road, with a fenced house to the right and a hedgehog

crossing a narrow space in the grassed area in the late-night hours (B, F, J). A tall brick fence of a house is visible on the left, a road on the right, and a hedgehog captured in the middle in an isolated grassy strip in the late-night hours (C, G, K). Two hedgehogs cross the isolated grassed area in contact with the crossroad in the late-night hours (D, H, L).



**Figure 2**

In the afternoon, a young individual is captured from the periphery of a busy road.



Figure 3

The photos show hedgehog cadavers in different parts of Komárno. Hedgehog cadavers are visible on the roads that run through the center of the city (A, B, C). In residential zones, on adjacent roads, there are also hedgehog cadavers (D, E). Please note several tightly packed dumpsters on the

periphery of the road and a hedgehog cadaver nearby (F). There are numerous houses and roads in built-up areas with hedgehog cadavers (G, H, I, J). In the peripheral parts of the town, there are roads with hedgehog cadavers (K, L).



Figure 4

The photographs show hedgehog cadavers in different parts of Prague. Near one of the entrances to the center of Prague in the morning hours, long queues of slowly following cars form, and a fresh hedgehog cadaver is visible among them (A). A 'trap' for both wild and domestic animals are the continuous strips of hedges that are localized between the footpath and the local road. One photograph captures the start of the hedge (B), and the following photograph captures the center of the same path, which remains in tandem with the hedge strip and hedgehog cadaver (C). Several tightly packed dumpsters on the periphery of the road, and a hedgehog cadaver is visible nearby (D). Hedgehog cadavers can commonly be seen on adjacent roads in zones where houses have been built (E, F, G). There are larger grassed or larger wooded areas and numerous hedgehog cadavers on access roads, and possibly on the roads that separate the different parts of the town (H, I, J, K, L).

#### 4. CONCLUSION

The paper is addressing the problem of hedgehog mortality due to collisions with cars on the

background of two cities: Komárno, in Slovakia, and Prague, the capital of the Czech Republic. From the analysis of the data on location and other interfering factors in relation to the cadavers, it can be concluded that there are some differences between smaller and larger cities.

These arise primarily from the architecture of the city, the number of green spaces or wooded areas, the layout of roads and the concentration of vehicles. An analysis of the factors under which such collisions occur would be helpful to urban planners who need some guidance in their construction of new cities and roads. This, especially, applies to the construction of new roads, and the increased concentration of cars on existing roads. Collisions with animals are increasing in frequency and are often fatal for hedgehogs. Therefore, in our paper, we recommend that the competent authorities consider more sensitively the conditions and needs of hedgehog life when dealing with developing the layout of the infrastructure in order to promote the safety of wildlife.

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