

Mammals injured by road traffic in the Czech Republic: Trends, seasonal patterns, and outcomes in wildlife rehabilitation centres (2011–2020)

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Abstract

Wild animals are exposed to many negative effects associated with anthropogenic activity, while the impact of transport is one of the most important factors in urbanized and suburban areas. During the years 2011–2020, a total of 3,789 mammals injured by vehicles were admitted to 36 rehabilitation centres in the Czech Republic, and an increasing trend ($P < 0.05$) in the numbers of such disabled animals was identified over this ten-year period. The greatest proportion of animals admitted as a consequence of vehicle collision to rehabilitation centres was represented by the order of even-toed ungulates (27.87%), led by the roe deer (*Capreolus capreolus*), insectivores (24.81%) with the western European hedgehog (*Erinaceus europaeus*) being the most represented species, and carnivores (21.75%), among which red foxes (*Vulpes vulpes*) were admitted most frequently. Traffic-related injured mammals were most frequently admitted during the summer period. The length of stay in released mammals was similar ($P > 0.05$) between insectivores and carnivores (median 22 and 24 days, respectively) and the same ($P > 0.05$) in rodents and hares (median length of stay 8 days). From the total dataset of 3,789 admitted injured mammals, only 8.95% of individuals were successfully released back into the wild. From the obtained results, it is evident that the chance of release for mammals admitted to rehabilitation centres after collisions with vehicles is not very high. Given the low success rate of care, the study particularly highlights the importance of preventive measures in the landscape.

Animal rescue, transport infrastructure, treatment, release, mortality

The present period is characterized by a significant and global impact of human activity on the environment and on wildlife species (Daszak et al. 2001; Schenk and Souza 2014). One of the threats, particularly for the group of free-living mammals, is the expanding transport infrastructure, where due to its continuous development, road construction, and the increasing number of vehicles, the direct threat to the life and health of wild animals is increasing (Keken et al. 2024). With the rapid increase in the human population, there has also been a loss of natural habitats and the emergence of migration barriers (van der Ree et al. 2015), which forces animals to cross roads more frequently (Bíl and Bartonička 2022a). It has been demonstrated that the road network affects not only individuals but also entire populations of mammals (Barrientos et al. 2021), and this issue may be particularly significant for migrating large mammals. In cases of unsuccessful or impeded migrations, isolated populations may also arise, resulting in a reduction of genetic variability of the species and its resilience (Holderegger and Di Giulio 2010).

The key factor in preventing a collision with a vehicle is the animal's ability to perceive an approaching vehicle, assess its level of danger, and subsequently respond appropriately. However, animals react differently to approaching vehicles depending on the species, the availability of shelter, the phase of the period, and the type of vehicle (Brieger et al. 2022). It is not, however, a given that an animal will always evaluate a vehicle as a threat—

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especially in environments with higher traffic density, habituation may occur (Lima et al. 2015). The response to a vehicle may, for example, in cervids take the form of freezing or fleeing in the direction of the moving vehicle (Lima et al. 2015), which contributes to the risk of a subsequent collision. Small mammals that move slowly or respond to threats by freezing, such as hedgehogs, have higher mortality due to their body size and defensive strategies (Lima et al. 2015). For these reasons, it is important to choose an appropriate form of deterrence already at the stage when animals approach roads. Methods aimed at reducing collisions with wild animals vary in their effectiveness, cost, and efficiency. The implementation of mitigation measures in the landscape is primarily based on knowledge of the occurrence and spatial behaviour of animals and their relationship to traffic, and fencing and crossing structures appear to be the most effective (Gilhooly et al. 2019). Measures enabling safe passage simultaneously reduce the barrier effect, whereas measures preventing animal movement may increase it. The main purpose of fencing is to prevent animals from entering roads or to guide them towards crossing structures. Overpasses allow animals to cross above roads and are suitable for both small and large mammals. A disadvantage may be their frequent use by predators, which limits the passage of potential prey (Carvalho et al. 2017). Underpasses are similarly usable, depending on their design and size (Smith et al. 2015). Other options do not appear to be as effective, such as various types of reflectors or the use of olfactory repellents (D'Angelo and van der Ree 2015; Bíl and Bartonička 2022b).

Given the expected further expansion of transport infrastructure, collisions with animals will likely not decrease, and therefore preventive measures are a very important part of the protection of wild species. Assistance is also important for those animals that survive a collision with a vehicle but are unable to care for themselves due to injuries, for which wildlife rehabilitation centres are established. In the Czech Republic, they may be operated based on a permit issued by the Ministry of the Environment. In connection with traffic accidents involving mammals, a significant proportion of admitted individuals are patients with acute and severe injuries requiring rapid veterinary intervention and intensive care. In cases of severe injuries where there is no realistic chance of release back into the wild, timely assessment of the animal's condition regarding its welfare is crucial, including consideration of euthanasia (Willette et al. 2023). The prognosis of these patients is primarily limited by the type and extent of injuries typical of traffic trauma, such as fractures or organ ruptures, which substantially affects treatment success as well as the possibility of being released (Navas-Suárez et al. 2022).

Care for wild animals is specific due to their high sensitivity to stress, which may be triggered by the mere presence of humans or changes in the environment. It is known that even domesticated species are under increased stress in environments where other individuals are being handled (Kotianová et al. 2025), therefore this is an aspect of treatment that cannot be overlooked. For this reason, minimization of handling, stress, and length of hospitalization is crucial. In the care of animals admitted to rehabilitation centres, rapid clinical assessment of their condition and prognosis are essential, determining further management—intensive treatment, rehabilitation, or euthanasia. Acute treatment of trauma should be initiated without delay, including gentle handling and immobilization of the patient, especially in large mammals. The possibility of release back into the wild is always individual and depends on the extent of injury and the ability to recover. If an animal cannot be released but may be used for education or other purposes in nature and species conservation, the option of keeping such an individual in captivity should be considered. Although the keeping of non-domesticated animal species in the Czech Republic is relatively popular (Volfová et al. 2023), exact numbers of such permanently disabled animals are not known, and the impact on their welfare and contribution to nature and species conservation remains debatable.

The aim of this study was to evaluate the numbers of mammals admitted to wildlife rehabilitation centres in the Czech Republic following collisions with vehicles, to assess the most frequently admitted species and their taxonomic classification, the seasonality of admissions within these orders, the length of stay, and outcomes.

Materials and Methods

Data containing information on mammals admitted to wildlife rehabilitation centres following collisions with motor vehicles in the years 2011–2020 were provided by the Ministry of the Environment of the Czech Republic. The data were collected from 36 rehabilitation centres and, in addition to the identification of the mammal (taxonomic classification and species name), included information on the date of admission and outcomes and date of outcomes.

The studied dataset included representatives of six taxonomic orders: even-toed ungulates, insectivores, carnivores, lagomorphs, rodents, and bats. For each monitored order, two species were selected based on the highest numerical representation in rehabilitation centres. Due to the fact that within the dataset of mammals admitted because of traffic collisions ($n = 3,789$), 98.65% ($n = 3,738$) involved collisions with road vehicles, no separate statistical analysis was performed for rail transport (1.35%; $n = 51$); these cases were included in the overall evaluation as a single dataset. For the assessment of the number of admitted individuals according to season, the following categories were defined: spring (March–May), summer (June–August), autumn (September–November), and winter (December–February). Length of stay was defined as the difference between the date of outcomes and the date of admission of the individual to the rehabilitation centre. This duration was evaluated for mammals that were released into the wild after successful rehabilitation ($n = 339$), according to taxonomic orders, while bats were excluded from this analysis due to insufficient sample size. For mammals that were removed from the records on the day of admission, a length of stay value of 0.5 day was assigned regarding the time required for examination and care of the animal, including the decision on its outcome. For comparison of the number of mammals according to outcomes, individuals were divided into the following categories: unassisted death (natural death), euthanasia (euthanasia performed by a veterinarian), release, in care (treated at the time of record submission), transfer (transfer to another organisation or private person; e.g. hunting association), escape, unknown (reason for removal not stated).

The provided dataset was statistically evaluated using Unistat 6.5 software (Unistat Ltd., London, UK). For statistical comparisons of abundance by order, seasonality, and outcomes, contingency tables and Yates' correction were used. To assess the trend in the number of mammals injured in traffic collisions over the studied period of 2011 to 2020, Spearman's correlation test was applied. The length of stay of released mammals in relation to their order was evaluated using the non-parametric Kruskal-Wallis test (non-parametric one-way ANOVA). A level of $P < 0.05$ was considered statistically significant.

Results

During the monitored period of 2011–2020, a total of 3,789 mammals injured after collisions with vehicles were admitted to wildlife rehabilitation centres in the Czech Republic. Based on the data analysis, an increasing trend in admissions of such injured mammals was confirmed ($r_{Sp} = 0.9515$; $P < 0.05$; Fig. 1).

The most represented order among mammals admitted to wildlife rehabilitation centres after vehicle collisions was the order of even-toed ungulates, which accounted for 27.87% of the total number. This was followed by insectivores with a proportion of 24.81% and carnivores, representing 21.75% (Table 1).

Table 2 shows the numbers and percentage shares of the two most abundant species within each order. The most abundant even-toed ungulate was the roe deer, accounting for 24.47% of all mammals admitted after vehicle collisions. Among insectivores, the species was the western European hedgehog (18.47%), and among lagomorphs, the brown hare (15.52%).

In most taxonomic orders (even-toed ungulates, carnivores, lagomorphs, rodents, bats), the highest numbers of admissions were recorded in summer (Table 3). However, in insectivores the numbers of admissions in summer were comparable ($P > 0.05$) with autumn, and in brown hares there were non-significant ($P > 0.05$) differences between individual seasons, except for winter ($P < 0.05$).

The length of stay in rehabilitation centres after traffic collisions was highest in insectivores and carnivores (median 22 and 24 days, respectively; Fig. 2), between which no difference was found ($P > 0.05$). Rodents and lagomorphs spent a shorter time ($P < 0.05$) in rehabilitation centres before release (median length of stay 8 days for both). Even-toed ungulates spent a significantly shorter time until release in rehabilitation centres compared to the other orders ($P < 0.05$).

In the case of mammals injured by vehicles, death occurred most frequently (54.00%), while a smaller proportion ($P < 0.05$) were euthanized (21.35%). Only 8.95% of individuals were released back into the wild (Table 4).

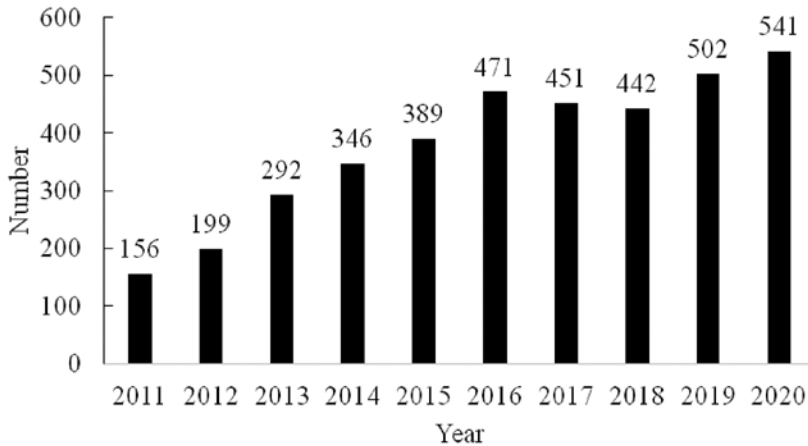


Fig. 1. Number of mammals admitted to wildlife rehabilitation centres in the Czech Republic after collisions with vehicles in the years 2011–2020 ($n = 3,789$)



Fig. 2. Length of stay of released mammals ($n = 339$) from wildlife rehabilitation centres in the Czech Republic after collisions with vehicles according to order during the years 2011–2020

^{a-c} Different superscripts indicate significant differences ($P < 0.05$) in the length of stay between orders (Kruskal-Wallis ANOVA)

Table 1. Taxonomic representation and percentage of mammals admitted to wildlife rehabilitation centres in the Czech Republic after collisions with vehicles in the years 2011–2020.

Order	Number (n = 3,789)	Percentage of n = 3,789
Even-toed ungulates	1,056	27.87 ^a
Insectivores	940	24.81 ^b
Carnivores	824	21.75 ^c
Lagomorphs	603	15.91 ^d
Rodents	342	9.03 ^e
Bats	24	0.63 ^f

^{a-f} Different superscripts within a column indicate significant differences ($P < 0.05$) in the numbers of admitted animals (χ^2 test)

Table 2. Representation of the two most abundant species from each order of mammals admitted to wildlife rehabilitation centres in the Czech Republic after collisions with vehicles in the years 2011–2020.

Order	Species	Number	Percentage of n = 3,789
Even-toed ungulates	Roe deer (<i>Capreolus capreolus</i>)	927	24.47
	Wild boar (<i>Sus scrofa</i>)	84	2.22
Insectivores	Western European hedgehog (<i>Erinaceus europaeus</i>)	700	18.47
	Northern white-breasted hedgehog (<i>Erinaceus roumanicus</i>)	233	6.15
Carnivores	Beech marten (<i>Martes foina</i>)	358	9.45
	Red fox (<i>Vulpes vulpes</i>)	250	6.60
Lagomorphs	Brown hare (<i>Lepus europaeus</i>)	588	15.52
	European rabbit (<i>Oryctolagus cuniculus</i>)	15	0.40
Rodents	Eurasian red squirrel (<i>Sciurus vulgaris</i>)	293	7.73
	Nutria (<i>Myocastor coypus</i>)	24	0.63
Bats	Common pipistrelle (<i>Pipistrellus pipistrellus</i>)	6	0.16
	Noctule (<i>Nyctalus noctula</i>)	5	0.13

Table 3. Number of mammals by order admitted to wildlife rehabilitation centres in the Czech Republic after collisions with vehicles in the years 2011–2020 according to season.

Season	Order											
	Even-toed ungulates		Insectivores		Carnivores		Lagomorphs		Rodents		Bats	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Spring	224	21.21 ^{b,c}	217	23.06 ^b	209	25.36 ^b	158	26.20 ^a	90	26.32 ^a	9	37.50 ^a
Summer	374	35.42 ^a	320	34.01 ^a	274	33.25 ^a	174	28.86 ^a	105	30.70 ^a	9	37.50 ^a
Autumn	260	24.62 ^b	353	37.51 ^a	195	23.67 ^c	153	25.37 ^a	102	29.82 ^a	6	25.00 ^a
Winter	198	18.75 ^c	50	5.42 ^c	146	17.72 ^d	118	19.57 ^b	45	13.16 ^b	0	0 ^b

^{a-d} Different superscripts within a column indicate significant differences ($P < 0.05$) in the numbers of admitted animals between seasons (χ^2 test)

Table 4. Outcomes of mammals admitted to wildlife rehabilitation centres in the Czech Republic after collisions with vehicles in the years 2011–2020.

Outcome	Number (n = 3,789)	Percentage of n = 3,789
Unassisted death	2,046	54.00 ^a
Euthanasia	809	21.35 ^b
Unknown	375	9.90 ^c
Release	339	8.95 ^c
In care	115	3.04 ^d
Transfer	101	2.67 ^d
Escape	4	0.11 ^e

^{a-e} Different superscripts within a column indicate significant differences ($P < 0.05$) in the number of admitted animals between outcomes (χ^2 test)

Discussion

In the Czech Republic, an increasing trend ($P < 0.05$) in the number of mammals admitted to wildlife rehabilitation centres after injuries caused by collisions with vehicles was confirmed. Although an increasing trend in the number of animals admitted to rehabilitation centres is generally described worldwide (Lazarova et al. 2024; Alencar-Silva et al. 2026), results related to collisions between wild animals and vehicles may differ depending on the locality (Molina-López et al. 2017; Kwok et al. 2021). The increasing numbers of admitted animals may be associated not only with more effective case recording and greater public awareness of the possibility of transferring disabled animals to rehabilitation centres, including a greater willingness to address the finding of an injured animal after a vehicle collision, but are also a consequence of the expansion of transport infrastructure and increasing traffic intensity, including habitat fragmentation. An important role may also be played by the continuing fragmentation of the landscape by other factors, which limits the natural permeability of the environment and leads mammals to cross roads more frequently in certain sections. The influence of increasing populations of some species must also not be overlooked (Massei et al. 2015), where higher numbers of admitted individuals are merely a consequence of higher numbers of animals in common populations within a given area. The importance of traffic collisions because of intensive transport was also confirmed during the period of epidemiological restrictions during the COVID-19 pandemic, when a reduction in traffic intensity also resulted in a decrease in the number of collisions with animals (Abraham and Mumma 2021; Raymond et al. 2023). However, this effect was only temporary, and mammals continue to be motivated by many circumstances to approach roads. Some mammal species may associate roads with food availability, for example as a result of grain spillage from freight trains or during road transport (Hill et al. 2021). Another attractant is the carcasses of road-killed animals, which attract scavenger species (Dean et al. 2019). Ungulates may also seek out roads during the winter period due to the application of road salt, which represents a source of minerals for them (Hill et al. 2021).

Admissions of mammals injured by vehicles may vary depending on the season and the mammalian group, as demonstrated by data from rehabilitation centres in the Czech Republic. Alencar-Silva et al. (2026) report an association between a higher number of collisions and the reproductive period of mammals, which occurs predominantly during the spring and summer months; the reproductive period may therefore be a direct cause of the increased frequency of road crossing during mate searching and may also be associated with reduced caution in animals. Rutting and parturition are also critical periods from the perspective of road mortality. Results from rehabilitation centres in Greece and Bulgaria show the highest frequency of animal admissions during June (Lazarova et al. 2024).

According to the obtained results, this month was also the most numerous for admissions of even-toed ungulates and carnivores to wildlife rehabilitation centres in the Czech Republic. Differences among individual studies may be related to the species composition of mammals, geographical location, and differing traffic intensity throughout the year. In even-toed ungulates, the highest number of individuals admitted after collisions with vehicles was recorded during the summer period ($P < 0.05$) compared to the other parts of the year, and therefore the higher number of admissions may be influenced by the biology of these species, especially roe deer. The higher number of collisions during this period may be associated with the increased mobility of young individuals, which become independent during the summer and search for new territories. These animals may be less experienced and less cautious when moving near roads. At the same time, the influence of the summer rut may also play a role, when males actively search for and pursue females (Kamieniarz et al. 2024) which may lead to reduced attention and an increased risk of collision with traffic. Insectivores, unlike the other orders, showed the highest number of admissions during the autumn period; however, the results were comparable ($P > 0.05$) with the summer period. The dominant representation of the western European hedgehog among insectivores in rehabilitation centres may, in turn, be closely associated with its preference for urbanized areas. Urban areas provide hedgehogs with food resources and shelter from predators; however, dangers resulting from anthropogenic influence also accompany this. In the Czech Republic, hedgehogs mate most frequently once, during March to April, and occasionally a second time during July to August (Fowler 1988). During the autumn period, hedgehogs exhibit increased activity to enhance their fat reserves and to find or build a winter shelter. For this reason, preparation for winter hibernation may be the period when hedgehogs show increased mobility while searching for food. Winter months represented the minimum in terms of the number of admitted mammals in all taxonomic orders. Lower admissions during the winter period in all orders are a consequence of true or false hibernation in some species together with lower mobility, when animals tend to concentrate around feeding sites and similar locations. Likewise, the lowest numbers in bats are the result not only of their aerial way of life, but also of their nocturnal activity, when traffic intensity is usually significantly lower than during daytime hours.

An interesting finding is the contrast between the frequency of even-toed ungulates, which was the highest within the total dataset of admitted mammals, and the duration of their recovery, i.e. the length of stay, which was the shortest in comparison with the other orders. This finding may be associated with the severity of trauma and treatment success. The most frequent clinical finding in mammals after collisions with vehicles are fractures, especially in even-toed ungulates, carnivores, and rodents, together with the occurrence of pelvic fractures, haemorrhages, and injuries to internal organs (Navas-Suárez et al. 2022). It may be assumed that less severe injuries predominated in released even-toed ungulates, which may have contributed to their relatively short stay in the rehabilitation centre and faster return to the wild (median = 2 days). However, the course of treatment in released mammals was not recorded in the dataset, and therefore factors influencing the length of stay cannot be unequivocally assessed. Kelly and delBarco-Trillo (2020) state that the length of stay depends on the health condition of the mammal already at the time of admission to the rehabilitation centre. Fractures may be treated surgically or stabilized using fixation devices; however, these procedures also prolong the duration of recovery and hospitalization as well as economic costs, especially in animals with a poor prognosis (Molina-López et al. 2017). A longer duration of hospitalization may also be associated with differences in the type of care provided among individual rehabilitation centres. Risks reducing the animal's ability to return to the wild after recovery include not only the manner of healing, infections, and other postoperative complications, but also habituation to handling by humans during prolonged stays.

While in the Czech Republic unassisted death occurred more frequently in cases of mortality, results in other studies may differ and animals are more often euthanized based on a poor prognosis (Molina-López et al. 2017). This difference may be caused by the environment from which the data originate. In the case of admission of animals to a veterinary clinic, the veterinarian has the possibility to immediately decide on its further fate. In contrast, when an animal is brought to a wildlife rehabilitation centre, there may be a delay between admission and examination by a veterinarian. It is therefore likely that, in cases of an unfavourable health condition, the animal dies before a final decision is made. In general, however, the mortality rate, both unassisted deaths and euthanasia, is quite high in vehicle collisions (Kwok et al. 2021), higher than with non-anthropogenic causes of admission to rehabilitation centres (Schenk and Souza 2014). The highest euthanasia rate was recorded in even-toed ungulates. Limitations in the care of even-toed ungulates may also include housing requirements for disabled animals according to national legislation.

Moreover, care for wild animals is specific due to their high sensitivity to stress, which may be induced by proximity to humans or due to environmental change. The high level of stress in some species is associated with further impairment of health status affecting the treatment process and survival (Dinesh et al. 2020). Wild animal care represents a specific discipline, with difficulties stemming primarily from the unknown anamnesis and health condition at the time of admission to a rehabilitation centre, but also from the above-mentioned effects of stress, to which, for example, even-toed ungulates are extremely susceptible. In addition, the interpretation of rehabilitation outcomes may be affected by incomplete information in the database. The “Unknown” category, which represented 9.90% of all reported outcomes, most likely includes cases for which the final rehabilitation outcome was not available, for example due to incomplete reporting or missing final records from individual rehabilitation centres. Cooperation with the public, professional training, and cooperation between state and private organizations are important in many areas of animal welfare (Pajtášová et al. 2025), including that of wild animals.

In conclusion, collisions with vehicles represent a major cause of death in mammals, which cannot be substantially influenced even by care provided in wildlife rehabilitation centres. Our results show that the numbers of mammals admitted to rehabilitation centres in the Czech Republic due to traffic collisions are relatively high and increasing over the years; the return of recovered individuals back into the wild is low, and most cases end in death or euthanasia. The identified differences in the seasonal dynamics of admissions and in the representation of individual taxonomic groups may contribute to a better understanding of risk periods. Given the high mortality of individuals injured as a result of traffic collisions, prevention appears to be the most important protective element in landscapes with extensive and continuously developing transport infrastructure.

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