

COLLISIONS OF ANIMALS WITH ROAD VEHICLES IN TRAFFIC IN THE CZECH REPUBLIC IN CONNECTION WITH TOURISM –

ANALYSES OF CAUSES AND PREVENTION

ANALÝZA PŘÍČIN A PREVENCE STŘETŮ ZVĚŘE S DOPRAVNÍMI PROSTŘEDKY V SILNIČNÍM PROVOZU V ČESKÉ REPUBLICE VE VZTAHU K CESTOVNÍMU RUCHU

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Abstract

The paper analyses the collisions of animals with means of transport in road traffic in the entire territory of the Czech Republic in connection with tourism. The collisions were evaluated for the period from 2007 to 2016 under the different conditions in which they occurred, for example, season, time of day, weather conditions, visibility and the like. The development of the number of accidents in individual periods and the scope of damage in relation to the collisions are analysed in such a manner as to allow for comparison of any financial resources spent on prevention with damage that has already occurred.

The result is that highest number of accidents was recorded in 2016, the lowest in 2009. After 2008, the rate of accidents involving collisions with animals had a declining trend, but rapidly increased again from 2010. Another finding is that highest damage to property occurred in 2016 in the amount of €13,974,886, while the least was in 2009 in the amount of €4,225,879. If we focus on the health and safety of people, which is the highest priority of the research, we ascertained that in the period in question a total of 923 people were injured, of whom 5 people unfortunately died of their injury and other research results are shown in the text.

Keywords: wild game, collisions, roads, means of transport, traffic safety, prevention, safety precautions, tourism, destination(s)

Abstract

Práce se zabývá analýzou střetů zvěře s dopravními prostředky v silničním provozu na území celé České republiky ve vztahu k cestovnímu ruchu. Kolize byly vyhodnocovány za období od roku 2007 do roku 2016 a to za různých podmínek, ve kterých k nim docházelo jako např. roční období, denní doba, povětrnostní podmínky, viditelnost apod. Vývoj počtu nehod v jednotlivých obdobích a rozsahu škody v souvislosti se srážkami jsou analyzovány takovým způsobem, aby bylo možné porovnat případné vynaložení finančních prostředků do prevence, s již vzniklou škodou.

Výsledkem je, že nejvyšší počet nehod byl zaznamenán v roce 2016, a nejnižší v roce 2009. Po roce 2008 měla míra nehod s kolizemi se zvěří klesající trend, ale od roku 2010 se opět rychle zvýšila. Dalším zjištěním je, že k největším škodám na majetku došlo v roce 2016 ve výši 13 974 886 EUR, nejméně

v roce 2009 ve výši 4 225 259 EUR. Pokud se zaměříme na zdraví a bezpečnost lidí, což je nejvyšší prioritou výzkumu, zjistili jsme, že ve sledovaném období bylo zraněno celkem 923 osob, z nichž bohužel 5 osob zemřelo, další výsledky výzkumu jsou uvedeny v textu.

Keywords: zvěř, kolize, pozemní komunikace, dopravní prostředek, bezpečnost provozu, prevence, bezpečnostní opatření, turismus, destinace

INTRODUCTION

Road traffic density is continuously rising at such a rate that it is not possible to respond adequately and quickly to this problem. Road transport can generally be divided into freight and passenger transport; in passenger transport, the main reasons are business and recreational trips. In Europe, the major means of transport for individual recreation is the passenger car (75% in 2017), to a lesser extent bus and airplane. The journeys are mainly organised individually (80%), and only about 15% are purchased from travel agencies and operators (Palatková, Zichová, 2014). Individual passenger car tourism is a significant accident risk factor.

The ever increasing need to build all types of roads is not adequately considered and designed beforehand in such a manner as to ensure mainly the safety of the transported people and subsequently also to protect wild game and prevent fatal collisions. A significant role in safety is also landscaping, especially landscaping of highways and motorways (Anděl et al., 2006).

It is also necessary to consider the potential consequences of absolute isolation of animals by fencing and preventing their access to the road. On the other hand, when migration structures are used, there is still a risk of animal mortality. Both an adequate number of migration objects and fencing of the roads have their justification, and it is necessary to combine them very prudently considering both risks (Gorčicová, 2011).

The study focuses on a comparison of the accident rate in connection with the collisions of motor vehicles with game in the past, i.e. since 2007 for the reason that these events were not digitally recorded before this date and the data are practically unavailable at present. Since 2007, collisions and accidents have been digitally processed and in time information has been expanded, especially in the form of the specification of the precise sites of the events, the visibility at the time of the accident, weather conditions, damage incurred and the like. Unfortunately, to date no information about the specific animal involved in the collision is recorded anywhere. Such information would be significant especially in terms of accident prevention and the implementation of specific measures.

The decisive factor is timely and quality media coverage of the current situation in the Czech Republic. This shall be one of the major preventive measures to help reduce these collisions, significantly increase the safety of people using means of transport and save dozens of animals every day.

The objective of the study was to collect and evaluate data about animal collisions with motor vehicles in the entire Czech Republic for the period of 2007-2016. To process this data in the minutest detail possible and try to ascertain the causes of these events. Furthermore, to evaluate the collision trend and obtain data about damage occurring to personal property and health in order to specify the consequences of the collisions and how dangerous they can be. To make an effort to design the most effective and simple measures to prevent or at least significantly reduce these collisions.

Traffic infrastructure in the Czech Republic and its impact on the animal population

The developing infrastructure of the Czech Republic in many cases is an almost insurmountable obstacle for migrating animals. This mainly concerns roads but also the railway network. The transport infrastructure is one of the significant factors of regional development because it connects people and business entities in space within the scope of business and recreational journeys.

It is thus necessary to continuously develop the road network. One of the possibilities is either to modernize the current roads or build new roads to reduce the load on the current network (Košňovský, 2014). Frequented roads constitute a barrier for many animals and prevent them from free movement through landscape; further impacts include direct annexation of biotopes during the construction of roads (Zikeš, 2002). The animals subsequently seek ways in which to overcome these barriers, or search for “weak points” in the barriers, which then creates a higher risk for road users.

Roads as a barrier

We can define a barrier in the landscape, for example, as a certain obstacle, hindrance or barrier preventing animals from moving from one place to another. On the other hand, the barriers may play a role in protecting animals from entering roads. It is thus significant to determine the degree to which the barrier acts as a barrier for the animals – potential risk and the extent to which it acts as protection from such risk.

Another concept of roads as barriers according Ascenao et al. (2017) may be that the barrier is a raised edge or restriction that has a negative effect on the loss of natural sites and

may create a barrier effect because of interference and thus increase the mortality rate of animals. It may also concern so-called invisible barriers, i.e. noise barriers that restrict the animals to the same extent, but due to gradual domestication, animals get used to this type of barrier and subsequently stop perceiving it with their senses (Ilgurel, 2016). On the other hand, many research studies are considering whether the barriers that prevent animals from entering the roads are even safe also for travellers in cars (Nycz, 2016).

An artificial man-made barrier has a significant negative impact on the population of game to which the individual species cannot or do not adequately adapt. Highly frequented roads such as highways and motorways, whose density in the landscape continues to grow disproportionately, are insurmountable obstacles for many species of migrating animals (Anděl et al., 2005).

For many large mammals, the transport barrier is not insurmountable (Tab. 1), but the traffic density and vehicle speed make it dangerous for the animals and road users (Aanen, 1991).

Table 1 Factors that impact road migration according to Martolose et al.

Factors	Probability of animals entering the communication		
	Increases 	Without influence 	Decreases 
Landscape type	Heterogeneous landscape, the predominance of natural elements	Homogeneous landscape	Urbanized landscape
Accompanying vegetation of road	In field	In woods	Without vegetation
Traffic intensity	Low	Medium	High
Level of communication	At terrain level, on a slight slit or embankment	In a deep cut	On high embankment
Fence of road	Without fence	Partly fence	Fully fence
Migration objects	Without migration objects	-	With migration objects
Day time	Twilight, sunrise	Night	Day
Season	Spring, autumn	Summer	Weather

Source: Martolos et al., 2014

Animal mortality rate caused by collisions with means of transport

If an animal collides with a motor vehicle, in 99% of the cases it entails the death of the animal and in many cases also injury to the persons involved as well as significant material damage.

From 2007 to 2016, 14 people died, 82 suffered serious injuries and 841 suffered minor injuries as a result of collisions with animals on our roads. The total number of accidents was

63,599. It is quite certain that the animals are not to blame for all these collisions; if the drivers respected the road traffic rules and anticipated such a collision in these dangerous sections, this would reduce the accident rate. But there is an acute lack of adequate information about the dangerous sections and risk of collision with animals in the Czech Republic, which substantially differs from many other European countries (Germany, Netherlands).

Lima (2015) discusses the response of the animal to collision with a vehicle. According to him, in many cases, the animal is capable of avoiding the collision by natural instinct. Naturally, this also depends on the response of the driver and electronic detection of the vehicles. According to him, modern systems in motor vehicles give mammals a greater chance of survival when crossing roads.

In the Czech Republic, the animals that are most frequently hit are wild boar (*Sus scrofa*), European hare (*Lepus europaeus*), red fox (*Vulpes vulpes*) and European roe deer (*Capreolus capreolus*) (Anděl et al., 2011). It is clear from his research that suitable fencing in combination with an eco-duct has the consequence of reducing the risk of accidents.

Animal migration and roads are very complicated systems that should mutually respect each other in every crossing design, and the local conditions must be evaluated during each case of construction planning for maximum coherence between the landscape and the roads (Anděl et al., 2006).

The behaviour of migrating animals in relation to the highway was also described by Zikěš (2002) in his work, in which he states that if the migrating animal encounters a highway, it may solve the arising problem in various ways, for example:

- By changing direction of movement and abandon – if the animal does not have a clear migration destination.
- The individual may move along the highway until it finds a suitable migration object for crossing the obstacle.
- It runs across the highway surface, which may result in a collision with a motor vehicle.

Planting vegetation along roads is an important form of protection for animals and a method for preventing collisions. Desai et al. (2012) states that it is necessary to plant vegetation, not only along the roads, but also at sites with industrial zones.

Currently, this situation is often solved by fencing the roads and highways, thus blocking animal migration. However, the biggest disadvantages are high costs and maintenance (Kostečka, 2015).

Actual field research revealed many deficiencies, which do not make the fences around the roads “protection for the animals”, but rather their killers. It is not possible to build a fence in such a manner that it terminates a few metres before the start of the next measure in the form of, for example, a crash barrier. Such a gap is a fatal point for the animals, which enter the road where the other side is completely fenced off and the animal thus has no chance to find its way back, naturally resulting in 99% of cases with a collision with passing vehicles. The fences around the roads are described by Ascenao et al. (2013), who states that it is the most effective method for preventing such collisions, but he emphasises that their construction must be designed perfectly to prevent unnecessary deaths due to poor realisation and subsequent maintenance.

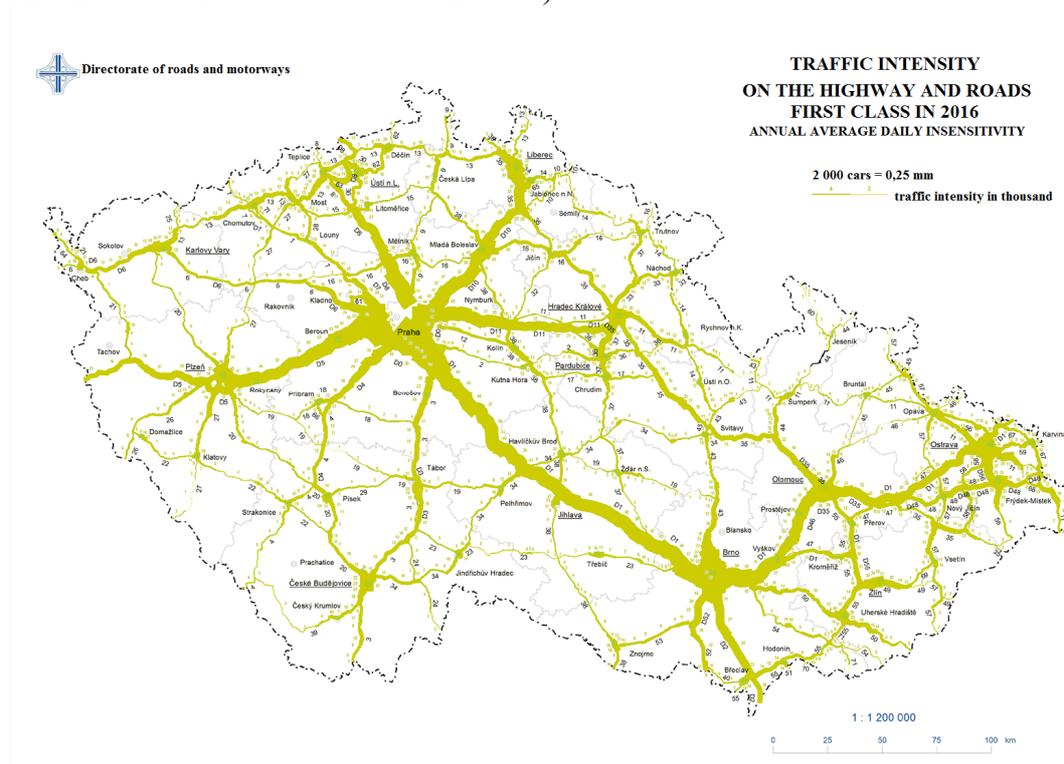
Traffic density and its impact on collisions and animal mortality rate

The traffic density or intensity is a major indicator of road load. According to the Internet resource www.ceskedalnice.cz, it is most commonly presented as the, so-called, annual average daily intensities. However, the destination and journey distance are not evaluated in relation to the accident rate, i.e., the ratio of recreational trips to the total load and accident rate is not considered.

Concerning the visitation rate of the individual tourist destinations, people mostly travel by passenger car. Naturally, this is related to the problem of collisions between vehicles and animals on the roads. According to CzechTourism, the most visited places in the Czech Republic are Prague followed by the ZOO in Zlín, industrial monuments in Dolní Vítkovice and the latest top destination – Aqualand Moravia. Significant destinations are also the mountain regions (Šumava, Krkonoše), which are very popular with tourists in the Czech Republic (Klufová, 2016), and the spa regions (Bozóti, 2015). Further destinations for mainly the local population are significant recreational regions such as Sázava and the Upper Vltava catchment areas, Bohemian Paradise, Lipno, South Moravia and the like. The journeys by passenger car to these areas are associated with a high risk of collision with animals because the holiday-makers often depart on Friday in the late afternoon hours and return on Sunday in the evening, often in low visibility conditions and without adequate physical rest.

According to the Road and Motorway Directorate, motorways and first-class roads are the most frequented.

Figure 1 Traffic intensity on the motorways and first-class roads in 2016 (the thickness of the line indicates the relative load of the road).



Source: www.ceskedalnice.cz

The highest number of accidents occurred on first- and second-class roads, which is naturally influenced by the fact that these are the most common roads in the Czech Republic. The total distance of motorways and roads in the Czech Republic is almost 56,000 km, of which 1,250 km are motorways, 5,811 km are first-class roads, 14,587 km are second-class roads, and 34,130 km are third class roads (www.rsd.cz). Generally, the Czech Republic ranks 21stst in terms of the number of fatal traffic accidents in the EU (www.autoklub.cz). The Tab. 2 shows the number of collisions in relation to the distance of the individual types of roads.

Table 2 Number of collisions (2007-2016) converted to 1 km of total road distance

Types of roads	Number of collisions	Length of roads (km)	Number of collisions 1 km
Motorway	3380	1250	12,8
1. class	22676	5811	3,9
2. class	19967	14587	1,3
3. class	14473	34130	0,42

Source: Own processing.

METHODOLOGY

The Czech Republic has an area of 74,864 km², and more than 55,000 km of roads. The data used in the research was acquired from the Police of the Czech Republic and the author's own

field research. At present, the Police records the accidents – collisions of animals with motor vehicles in a high-quality manner; the location is ascertained with a precision of 1 m, the weather conditions at the time of the accidents, light conditions and many other attributes that can be applied very well in various statistics and research. Unfortunately, only collisions to which the police were called and in which people were injured or major damage to property occurred are recorded. There is no record of the type of animal involved in the collision. The author's own research revealed that most of the cases involve medium or large animal species, i.e., species from the size of a hare, fox, otter or badger. Upon collision, the smaller animal species cause almost no damage at all and for this reason, these events are not recorded anywhere.

The basis of this work was the acquisition and processing of data on collisions of motor vehicles with animals from 2007 to 2016 in the entire territory of the Czech Republic. The data were acquired from the author's own field research on the individual roads and the study of police statistics, which contain records of the events that resulted in death or personal injury and also those events that resulted in damage to property. The data were subsequently processed and separated into several groups for a more detailed analysis:

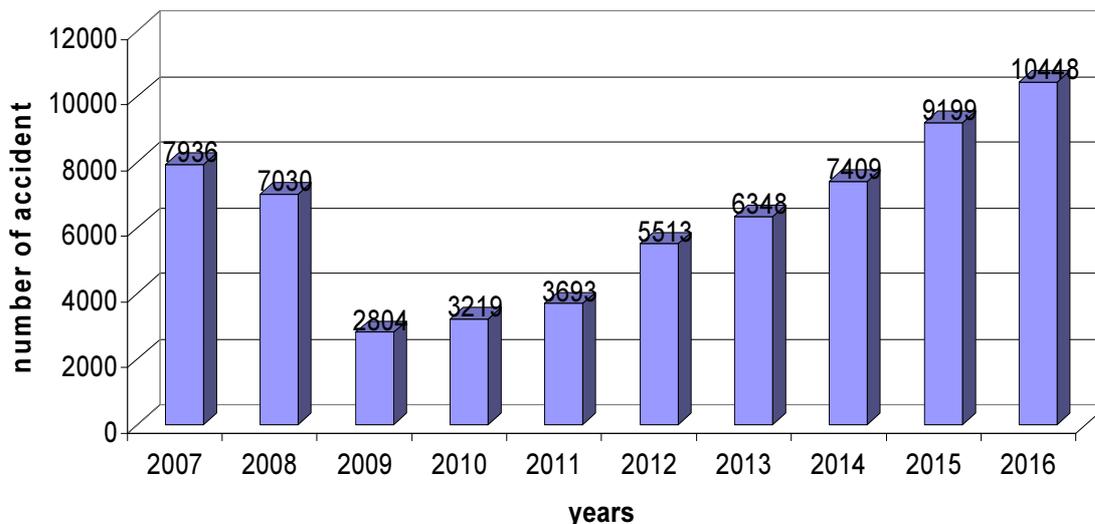
- map co-ordinates
- date of the event
- time of the event
- type of road on which the event occurred
- vehicle type
- death toll
- persons with severe injuries
- persons with minor injuries
- total material damage in hundreds of crowns
- weather conditions at the time of the accident
- visibility

The map data from the ARC GIS system were used for the clearer representation and processing of the data.

RESULTS AND DISCUSSIONS

After processing the source data into the form in which it is used, several comparisons and visualisations of individual years were made for the entire Czech Republic.

Figure 2 Number of collisions for the individual years in the period 2007 – 2016 for the entire Czech Republic.

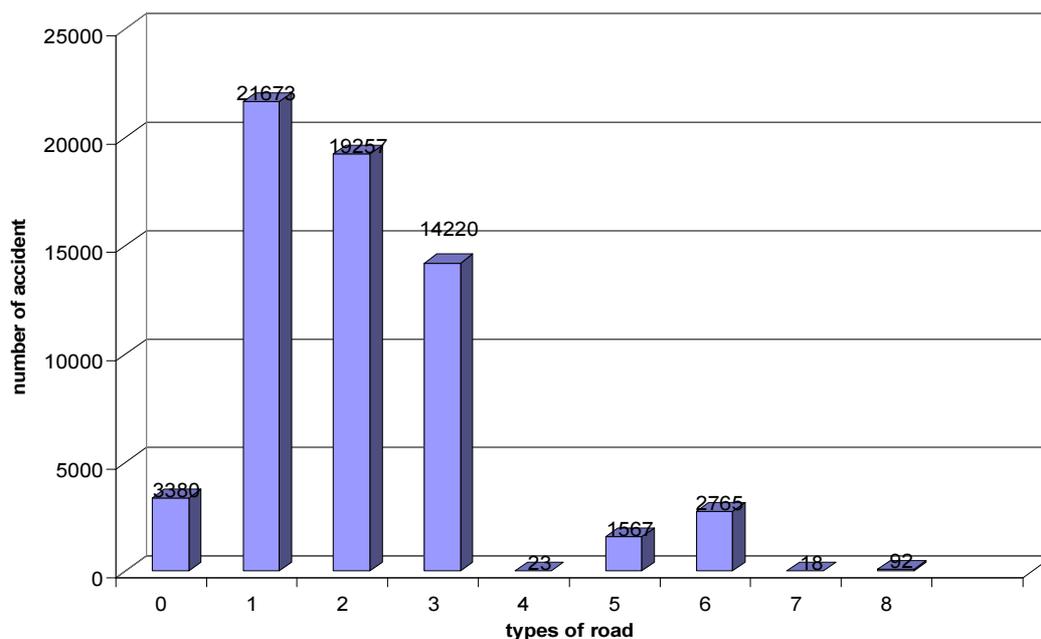


Source: Own processing.

The highest number of accidents was recorded in 2016, the lowest in 2009. After 2008, the rate of accidents involving collisions with animals had a declining trend, but rapidly increased again from 2010. According to the traffic police, this situation is due to the disproportionate increase in road traffic.

Figure 3 Number of collisions in the period 2007-2016 on all types of roads in the Czech Republic.

(0 - Motorway, 1 – First-class roads, 2 – Second-class roads, 3 – Third-class roads, 4 – Node (i.e. a monitored crossroads in selected towns), 5 – Road monitored in selected towns, 6 – Local road, 7 – Utility road, 8 - Other parts of roads)



Source: Own processing.

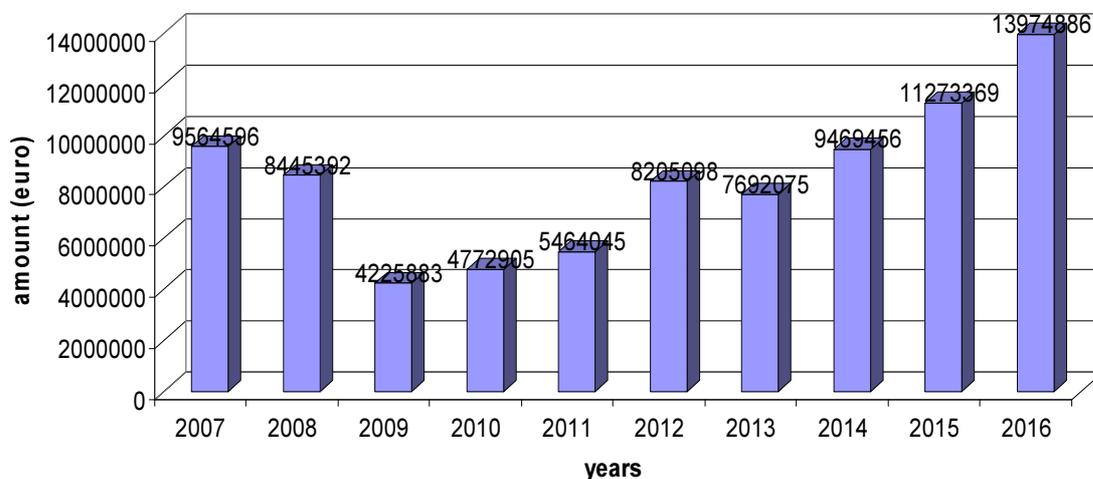
Kušta (2011) states that collisions between animals and motor vehicles are most often influenced by the time of the event and month in which the collision occurred. He states that accidents mostly occurred at about 10 p.m. and the second wave of collisions occurred at about 6 a.m. It is further stated that collisions occurred most frequently in April and May, and the next month in line was December. From the results for the entire Czech Republic, which we processed, it is possible to agree with this claim. On the contrary, from the results of the Prague East District (Šmíd 2013), these data differ, since in 2008, for instance, May had the highest rainfall followed by November, in 2009 the largest number of accidents occurred in May followed by October.

According to my data analysis, the highest number of accidents occurred at night, without public lighting, and the visibility was not influenced in any way by the weather conditions. A surprise is the ascertained fact that a very high number of accidents occurred during the daytime when the visibility was also not influenced in any way by the weather conditions (Šmíd et al., 2014).

Similar results for Central Europe are presented by Hothorn et al. (2012) and Pokorný (2006). The reasons may be not only the lower daily intensity of transport, but also worse driving conditions and less passable roads in winter when vehicles run at lower speeds (this applies mainly to first-, second- and third-class and other roads). Nevertheless, other authors contend that there is a mild increase in the occurrence of collisions with animals in the winter, for example, in Sweden (Wahlström and Liberg, 1995).

The highest number of collisions on first-class roads in the Czech Republic for the given period – 22,676. During the classification of the roads according to Act No. 13/1997 Coll., the Road Act, the largest part of the Czech road network is composed of first-class roads; the result shall certainly be impacted by this factor.

Figure 4 The scope of damage to property in the period 2007-2016 for the entire Czech Republic (in Euro).

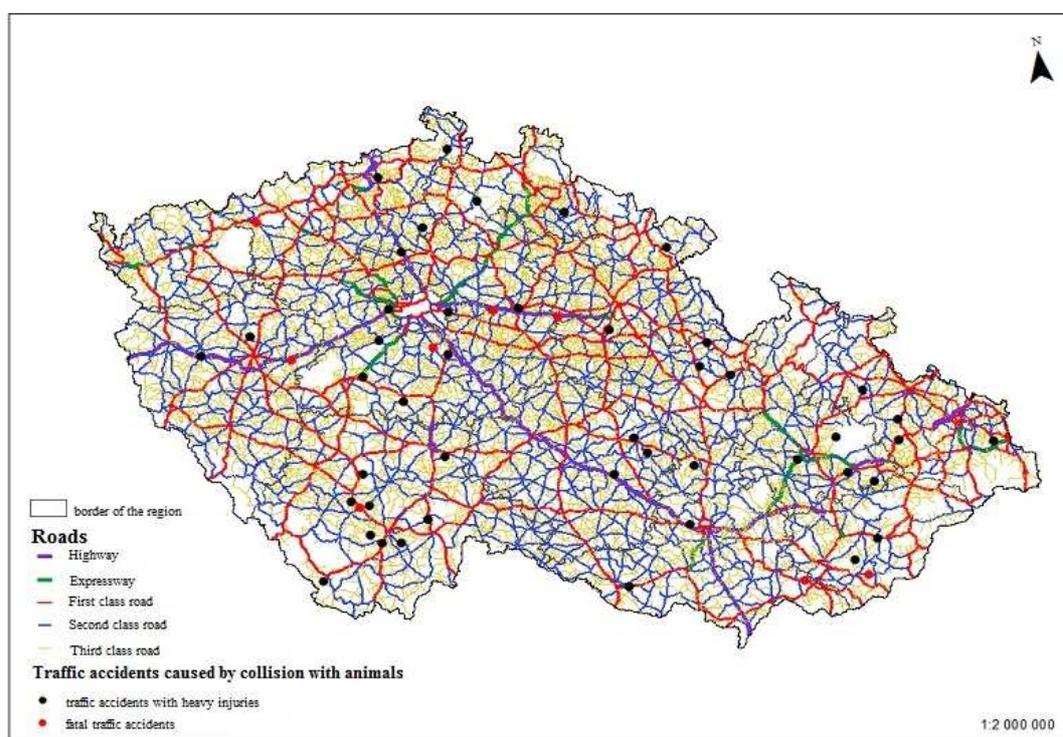


Source: Own processing.

The highest damage to property occurred in 2016 in the amount of €13,974,886, while the least was in 2009 in the amount of €4,225,879. The total damage in the period 2007-2016 in connection with collisions with animals on the roads for the entire Czech Republic is €83,087,709. On average, one traffic accident results in damage amounting to €1,306.

If we focus on the health and safety of people, which is the highest priority of the research, we ascertained that in the period in question a total of 923 people were injured, of whom 5 people unfortunately died of their injuries.

Figure 5 Collisions between animals and vehicles 2010-2016 resulting in death or severe injury of people.



Source: Own processing.

Fig. 5 shows the places where severe injury (black spots) or death of people (red spots) occurred in connection with the collision of a vehicle with an animal.

Table 3 Number of collisions (2007-2016) - comparison of the summer holidays (with a higher road usage associated with tourism) and selected months (before and after the holidays)

Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Summer holiday	1369	1111	438	885	558	885	1027	1277	1558	1691
March – April	1428	1036	447	436	611	813	969	1242	1371	1808
September - October	1436	1294	482	708	641	1221	1169	1385	1803	1954

Source: Own processing.

Tab. 3 shows the number of accidents that occurred during the summer holidays when the traffic on the roads should have been higher for reason of travel (holidays, transport of children going for holidays and the like). For comparison, the periods April-May and September-October were selected at random. We determined that the holidays do not have any significant impact on the number of accidents – collisions with animals. The holiday period is not even different in the overall number of traffic accidents (www.autoklub.cz). Overall, in the period 2007-2016 there were **10,799** collisions during the summer holidays; during the selected months of April and May **22,892** collisions occurred and in September and October there were **12,093** collisions. The reason for the lower number of incidents may thus on the contrary be lower traffic on the roads during the summer holidays than in other months during the year. People are taking holiday and are not travelling to work every day. On the contrary, in the period of April-May, animals are highly active (migration) and weather conditions are generally worse. These results are also confirmed by the accident statistics of the Autoklub ČR (www.autoklub.cz).

Table 4 Number of collisions (2007-2016) - comparison of the Christmas season and the same days in the selected month (May)

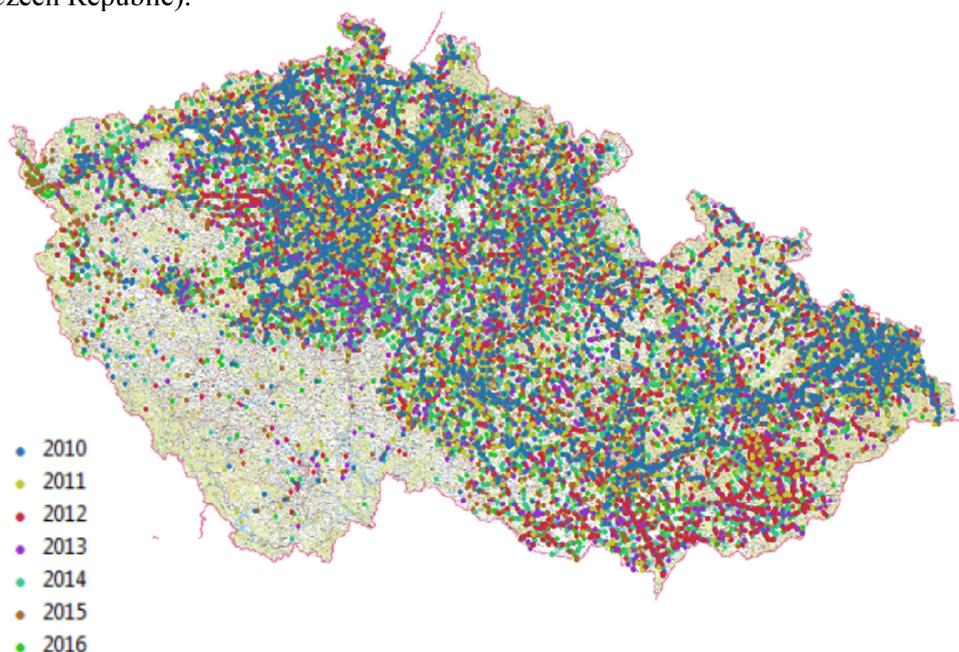
Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Christmas 24, 25, 26	53	45	22	18	22	38	42	55	70	44
May 24, 25, 26	76	65	21	31	31	57	75	50	87	94

Source: Own processing.

A further comparison was between the Christmas season, when road traffic should have been higher again, especially for reason of family visits and trips to winter resorts. Tab. 4 shows that the number of collisions does not differ significantly and, on the contrary, the number of collisions on the same day of a month selected at random (May) is higher. Overall, the Christmas season in the years in question registered 409 collisions, and 587 collisions occurred on the same days in another month.

From the stated results, we can thus state that the free days or summer holidays do not have any significant impact on the higher number of accidents in connection with collisions between animals and motor vehicles. The problem is year-round and it is not possible to focus only on individual months because the result shall not differ in any way.

Figure 6 Graphic representation of collisions for the period of 2007-2016 (available data from the Czech Republic).



Source: Own processing.

The coloured spots in the Fig. 6 show the accidents in the individual years in the entire territory of the Czech Republic. By plotting the precise GPS co-ordinates, it was possible to get an overview of the density of these collisions. Unfortunately, this data is missing in part of South Bohemia, the reason being the recording of data on so-called “Euro forms”, where the accidents are recorded by hand on a form and are not digitalized. These data are currently unavailable, and their subsequent processing will be very difficult. However, for quality research and a clear view of the situation in the Czech Republic, these data are indispensable because field research allows us to get only an idea of these events but not the precise situation.

CONCLUSION

In this paper, we confirmed the fact that collisions with animals on the roads in the Czech Republic have a continuously rising trend. At the beginning of research, (Šmíd, 2012), we ascertained that the great majority of roads are not in any way protected against collision with animals and drivers are not even warned of this danger. Road signs to reduce speed or any signs warning about the possible presence of an animal were virtually absent. On the contrary, there was a decline in the number of warning traffic signs although the concerned road sections are still registering accidents.

A great trend at present is fencing of the motorways, but unfortunately the fences are not completed everywhere. The result of this measure shall be verified only in subsequent years. There is fear that the result of this measure shall not be significantly positive because the fences are not safely completed at many points and animals can without any difficulty enter the road at these points. These places are extremely risky because drivers do not assume danger in the form of animals on the road. If such a situation arises, the animal is incapable of finding its way back through the fence and away from dozens of passing motor vehicles.

A similar trend is so-called “scent fences” on the lowerclass roads, which, however, require continuous maintenance. Wild game (especially roe deer and wild boar) quickly get accustomed to this obstacle and stops perceiving it. For this reason, it is almost impossible to permanently complete this research; instead, it must be but continued into the future along with monitoring the development of the situation in connection with the implemented measures. For road users, these blue illuminated fences mean safety against collision and reduced attention.

The basis of prevention must be quality awareness of the population. The warnings for drivers that collision with an animal may occur should be posted at points most frequented by the drivers. Various leaflets carrying this information at petrol stations, at least in three world languages, would be a good start for this prevention. It is further necessary to inform the public in the media, such as, on the radio, television and internet. We have never heard any warning of such a problem on traffic radio broadcasts for drivers. A great benefit could also be so-called unsolicited text messages in which the operator sends SMS messages containing various types of information at random according to the current location of the mobile telephone users. In the course of our research we did not register any warnings on digital information signs installed on the most frequented Czech roads and motorways in recent years, not even during normal travel (average personal travel distance of approx. 100,000 km). A further potential solution, one that needn't be so expensive, is road signs warning drivers about the potential danger of collisions with animals. These signs cost only tens of euro, but may be a very useful source of information.

In conclusion, it is also necessary to state that we cannot only blame the animals as such for these collisions, as people are much more to blame – excessive speed that is unsuitable for the road conditions, inattentive driving, the poor technical condition of the vehicle and the like. If a system were established in the Czech Republic that is identical to those that exist, for example, in Norway, where the insurance company reduces indemnity in a relatively drastic

way upon determining a violation of the road traffic conditions stipulated by law (for example, excessive speed), the number of accidents could be significantly lowered.

REFERENCES

- Aanen, P., Alberts, W., Bekker, G. J., van Bohemen, H. D., & Melman, P. J. M. (1991). *Nature engineering and civil engineering works*. Pudoc Wageningen, Wageningen, Netherlands
- Anděl, P., Hlaváč, V. & Lenner, R. (2006). *Migrační objekty pro zajištění průchodnosti dálnic a silnic pro volně žijící živočichy - TP 180*. Liberec, Evernia.
- Anděl, P., Belková, H., Gorčicová, I., Hlaváč, V., Libosvár, T., Rozínek, R., ...Vojar, J. (2011). Průchodnost silnic a dálnic pro volně žijící živočichy. Liberec, Evernia, 154 s
- Anděl, P., Gorčicová, I., Hlaváč, V., Miko, L., & Andělová, H. (2005). Hodnocení fragmentace krajiny dopravou. Praha, Agentura ochrany přírody a krajiny, 99 p.
- Ascensão, F., Lucas, P. S., Costa, A., & Bager, A. (2017). The effect of roads on edge permeability and movement patterns for small mammals: a case study with Montane Akodont. *Landscape Ecology*, 32(4), 781-790.
- Ascensão, F., Clevenger, A., Santos-Reis, M., Urbano, P., & Jackson, N. (2013). Wildlife–vehicle collision mitigation: Is partial fencing the answer? An agent-based model approach. *Ecological Modelling*, 257, 36-43.
- Autoklub (2016). Statistika nehodovosti za rok 2016, Retrieved from: <http://www.autoklub.cz/dokument/12022-statistika-nehodovosti-za-rok-2016.html>
- Bozóti, A. (2015). Health Tourism Competitiveness – A Complex Approach. *Deturope*, 7, 2, 157-174.
- České dálnice (2015). Intenzity dopravy 2016, Retrieved from: <http://www.autoklub.cz/dokument/12022-statistika-nehodovosti-za-rok-2016.html>
- Desai T. B., & Nandikar, M. (2012). Impact of urbanization on avenue trees and its role in carbon sequestration: a case study in Kolhapur city. *International journal of environmental sciences*. 3(1), 481-486.
- Gorčicová, I. (2011). *Průchodnost silnic a dálnic pro volně žijící živočichy*. Liberec, Evernia s.r.o.
- İlgürel, N., Yügrük, A., & Neşe, A. (2016). Evaluation of noise exposure before and after noise barriers, a simulation study in Istanbul. *Journal of Environmental Engineering and Landscape Management*, 24.4, 293-302.
- Kostečka, J., & Prášil, M. (2015). PPK-PLO. *Požadavky na provedení a kvalitu plotů pro zabránění průniku zvěře a osob na dálnicích a silnicích ve správě Ředitelství silnic a dálnic ČR*. 04/2015
- Košnovský, M. (2014). *Silnice v uspořádání 2 + 1*. Brno, 82 p., annexes: 28 p. *Doctoral thesis*. Vysoké učení technické v Brně, Fakulta stavební, Ústav pozemních komunikací.
- Klufová, R. (2016). Destination attractiveness of the South Bohemian region from the viewpoint of spatial data analysis. *Deturope*, 8(1), 92-111.
- Lima, S. L., Blackwell B. F., DeVault, T. L., & Fernández-Jurísic, E. (2015). Animal reactions to oncoming vehicles: a conceptual review. *Biological Reviews*, 90(1), 60-76.
- Martolos, J., Šikula, T., Libosvár, T., Anděl, P. (2014): Optimization of Measures to Prevent Collisions of Animals and Road Traffic. *Transactions on Transport Sciences*, 2014, 7(4): 125-134
- Nycz, D. B. (2016). Influence of impact angle and humidity on TB11 virtual cash tests for SP-05/2 road safety barrier. *The Archives of Automotive Engineering–Archiwum Motoryzacji*, 73(3), 71-88.

- Palatková, M., & Zichová, J. (2014). *Ekonomika turismu: turismus České republiky*. Praha: Grada Publishing.
- Police of the Czech Republic, Police presidium of the Czech republic, Statistic 2017
- Ředitelství silnic a dálnic ČR (2017). Silnice a dálnice > Délky a další data komunikací, Access from: <http://www.rsd.cz/wps/portal/web/Silnice-a-dalnice/delky-a-dalsi-data-komunikaci>
- Šmíd, P. (2011). Analýza příčin a prevence střetu motorových vozidel se zvěří v okrese Praha východ, *Diplomová práce*, Fakulta životního prostředí, Katedra aplikované ekologie, Česká zemědělská univerzita v Praze
- Smid, P., & Pecharova, E. (2013). Analysis of the potential causes and prevention of conflicts of motor vehicles with the game in the district of Prague-East. *13th International Multidisciplinary Scientific Geoconference and EXPO*, SGEM 2013; Albena; Bulgaria; 16 June 2013 through 22 June 2013, 1, 63-70
- Smid, P., Pecharova, E., Vykouk, M., Faltova, K. (2014) The causes analysis and collisions prevention of the wildlife with motor vehicles the eastern part of the central region of the Czech Republic, *14th International Multidisciplinary Scientific GeoConference SGEM 2014*, www.sgem.org, SGEM2014 Conference Proceedings, ISBN 978-619-7105-17-9 / ISSN 1314-2704, June 19-25, Book 5, Vol. 1, 673-680.
- Zikeš, P. (2002). Problém průchodnosti dálničních a rychlostních komunikací pro volně žijící živočichy, *Dopravní fakulta Jana Pernera v Pardubicích*
- Zákon č. 13/1997 Sb. o pozemních komunikacích v platném znění