WILDLIFE-VEHICLE COLLISON RESEARCH PROJECT

on highways managed by Hungarian State Motorway Management Company

SUMMARY OF THE DETAILED REPORT

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1. Foreword and introduction

The challenging wildlife-vehicle (WVC) collision study started in September 2009 and closed with clear results and by a report in March 2012 which is summarized now. It was successful in highlighting the root of the problem and in finding methods, which are able to mitigate it effectively.

In the report we summarized and interpreted the latest WVC mitigation measures which were published in the related international literature till 2012; besides, the methods were tested by our group and the current state of our own developments were described in details. The research started with a spatiotemporal statistical analysis which was essential for the better understanding of the problem and for the targeted treatment. It is maybe enough to think about the following questions: why is the number of WVCs increasing or why do many roadkills cluster in some places while on others there was not even a single case? During the project the WVCs occurred between 2006 and 2011 were mapped and hotspots were identified based on the GIS database. For the 40 most dangerous sections case specific mitigation methods were proposed.

Nevertheless, we do not consider this WVC study is closed and finished. Although the proposals are supported by facts, further studies need to improve the effectiveness. WVC is a significant social problem, the solution of which is not solely the task of the road managers.

2. Spatial analysis of WVCs

Wildlife-vehicle collision (WVC) hotspots on Hungarian highways were mapped and the spatial frequencies were analysed with Poisson regression. This study is unique in the fact that only fenced roads were studied and similar research is little known. In general, most WVCs and almost all of the roe deer fatalities occurred at highway intersections, or in interchanges. Red fox casualties also occurred at interchanges as well as at passages. Wild boar fatalities were not particularly frequent at interchanges, but were recorded near railways that parallel highways; otter-vehicle collision hotspots were found near their habitats and migration corridors such as streams. For otter, badger and wild boar we were able to examine the role of local population density; most WVCs happened in areas of high population density. The badger model predicted that badger kills were more likely where the fence was not buried into the soil. A general objective is that most WVCs occur at interchanges because wildlife enters the right-of-way (ROW) at fence ends; or it enters at a fence gap and runs along the inside of fence and becomes funnelled onto the ROW at the interchanges. Interruption in the continuity and linearity are important factors in both cases. We concluded that the number of WVCs can be reduced significantly if animals were prevented from entering highway interchanges and proposals for mitigation was made.

Table 1
Parameters in WVC spatial models (x= not involved in the models).

	Interchange	Passage	Railway	Habitat	Pop. density	Stream	Unburied fence
Roe deer					x		
Red fox					x		
Red deer					x		
Wild boar							
Otter							
Badger							

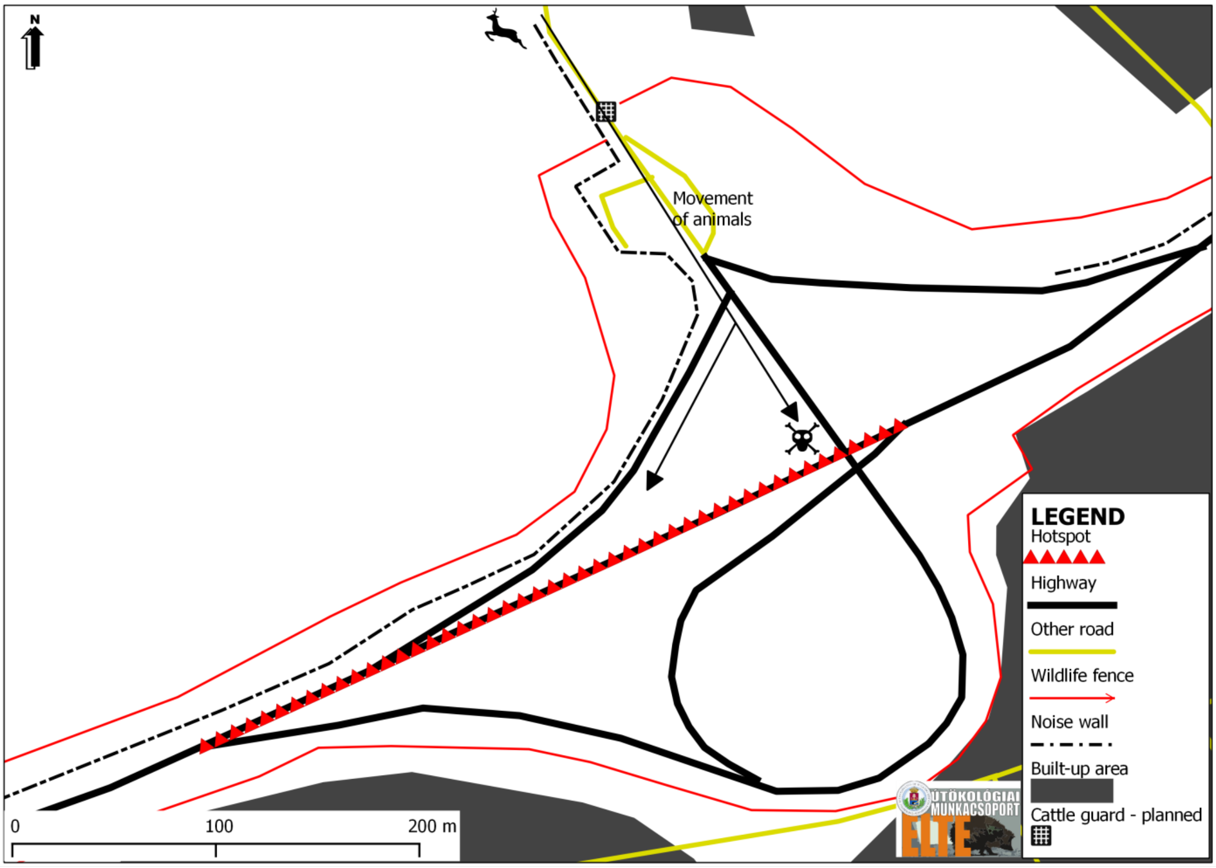

Figure 1. The most dangerous highway section in Hungary (M3, 39 km post, interchange „Bag”): WVCs in a fenced interchange. Installing a cattle guard in the only entering point is a possible mitigation measures in situations like this.

Figure 2. Fox kills are frequent at passages. Here the gaps, through which animals can enter the road, must be closed; the wildlife fence should be elongated in order to prevent animals from getting inside.

WVCs that occur at interchanges can be divided into two groups in regard to their relation to the interchange: 1) WVCs that occur when animals pass directly into the interchange and are killed on the spot and 2) pass into other locations such as gaps and drainage tunnels but are killed at interchanges. Even if the junction of highways is continuously protected by fencing (see Fig. 3), or there is an interchange with ramps, the linear nature of the highway and of the fencing drives the animals along the ROW to an interchange where the linearity is discontinued by another road. In the junction of highways (Fig. 3), the animals entering inside of the one highway at other places along the fence, even far from the junction, are led to the ROW of the another highway and they are killed there. The access roads also drive the animals to the highway.

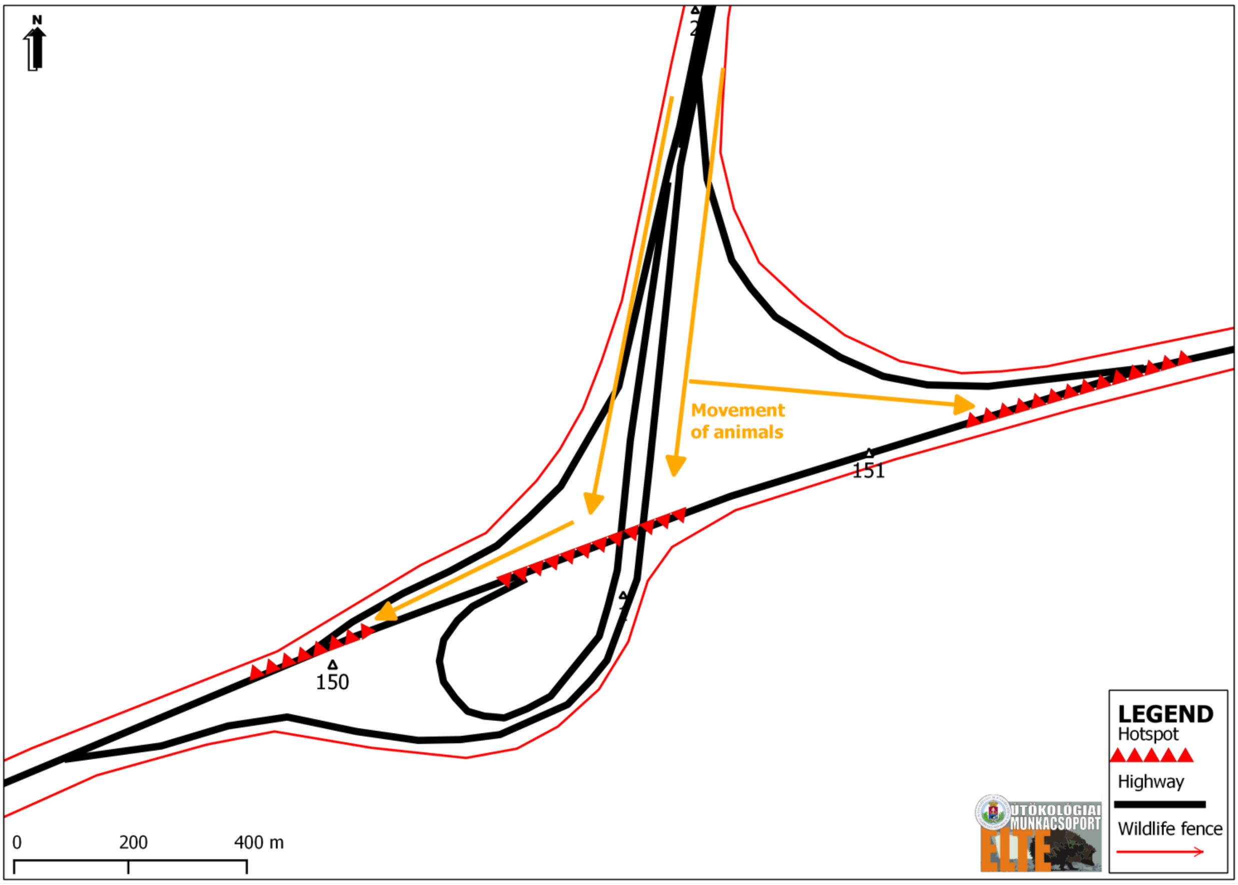

Figure 3. Highway section at the junction of M3 and M30 highways, where most WVCs occurred. Despite the continuous fencing, the frequency of WVCs is extremely high; so it is not the fence end effect which prevails here. We believe that animals passed through the fence at other locations and migrated along the side of the road, and they attempted to cross at the junction of the two roads.

3. WVC hotspots

Highway sections were evaluated separately by the frequency and by the severity of WVCs occurred between 2006-2010. (However, the created WVC Risk Index also contains both of these.) Two kinds of hotspots were distinguished: 1) WVCs are frequent; many fox kills, lesser property damages and rare human injuries are revealing. 2) big game kills are dominant, less cases, but the accidents cause high property damages and human injuries are frequent.

Table 2.
Ranking highway sections by the frequency of WVCs.

	HW	km	# cases
1	M3	150-151	20
2	M7	138-139	18
3	M7	129-130	17
4	M7	134-135	17
5	M7	70-71	15
6	M3	102-103	15
7	M3	164-165	15
8	M3	78-79	14
9	M1	77-78	13
10	M7	15-16	13

Table 3.
Ranking highway sections by the severity of WVCs (≈frequency of wild boar roadkills).

	HW	km	WVC Risk Index
1	M3	39-40	67
2	M3	35-36	50
3	M3	38-39	49
4	M7	70-71	44
5	M1	60-61	43
6	M3	29-30	42
7	M3	113-114	42
8	M30	2-3	38
9	M1	21-22	36
10	M1	56-57	35

4. Where can the animals enter the highway?

Five main groups of access possibilities were found during the survey of dangerous highway sections: 1) fence end sin interchanges, 2) other fence ends, 3) purposive injuries, 4) drainage tunnels and 5) fence joints.

Figure 4. Red fox gets through a gap under the noise barrier (M7 1/17km + 115m).

Figure 5. M1, 21 kmsz: Gap in a drainage tunnel causes high traffic safety risk because larger animals can enter to the ROW across it. The hanged pieces of metal do not prevent the entering of animals.

5. Annual trends in WVCs

WVC-trends are determined by a combination of many factors, among which the population density, the traffic volume, the speed of vehicles and the weather were proved decisive. In our analysis the role of population density could not be demonstrated directly. However, the correlations among WVCs occurred on the two independent corridors (highway and railway) indirectly show that population density nevertheless is an important factor, because WVCs of both network draw on the same source, on the same populations. Thus we believe that the population estimations based on hunting datasets cannot estimate sufficiently exact the population sizes and trends. WVCs becoming more frequent by the rising mean temperature predict that if the climate change will amount to warming, as the actual data suggest (Root et al. 2003), and we cannot reduce game populations adequately, further increase must be expected in the trends of WVCs.

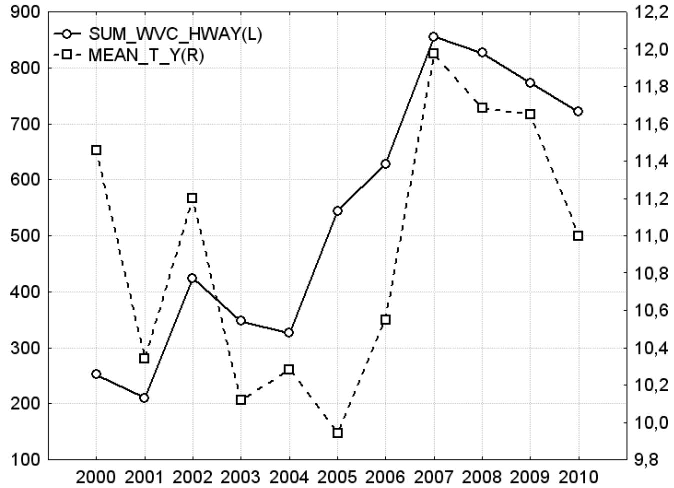

Figure 6. The number of WVCs in Hungary correlates with the mean temperature of the year.

The number of wildlife-vehicle collisions (WVCs) constantly grows in countries with dense road networks, causing serious and more serious traffic safety, social-economic, conservation and wildlife management problems (Groot-Bruinderink and Hazebroek 1996, Huijser et al. 2008, Seiler and Helldin 2005, Putman 1997). The increase in WVCs is partly due to the range expansion and to the increase of the population size of big game species such as the moose (*Alces alces*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) in most part of Europe because of habitat conversations, extermination of top predators, wrong game management (just think of the supplementary feeding) and also of the climate change like the global warming (Côté et al. 2004, Jedrzejewska et al. 1997, Saez-Royuela and Telleríla 1986, Milner et al. 2006).

6. Optical reflectors

The optical reflectors belong to the group of methods which were invented to take out the fencing. Conceptually, they intended to block the crossing of the animals when a vehicle approaches; so in contrast to the fencing, they do not prevent the crossing possibility in traffic-free periods, reducing thereby the isolation effect of the roads. As the highways are lined with fence, they do not belong to the scope of road types where the reflectors may be in principle effective.

Optical reflectors are often installed for mitigative purposes but most studies show that these devices did not reduce significantly the number of WVCs (Anderson, 1993; Armstrong, 1992; Cottrell, 2003; Ford and Villa, 1993; Reeve and Gilbert, 1982; Rodgers, 2004; Waring et al., 1991). In contrast only two studies (Gladfelter, 1984; Schafer and Penland, 1985) reported that optical reflectors resulted in fewer accidents. Several studies investigated the response of ungulates (e.g., Ujvári et al., 1998; Zacks, 1986); however, they did not report any behavioral changes on the part of animals that might reduce the number of WVCs.

In our study the number of WVCs was analyzed after and before the reflector installations (WEGO and SWAREFLEX). In 2 sections 4-4 years, in 2 sections 3-3 years and in 7 sections 2-2 year long datasets were examined. The data totalized from the sections: 105 WVCs (2.1/km/year) occurred before the installation and 113 (1.9/km/year) happened after the installation; and the difference was not significant. Based on these results we can conclude that reflectors had no effect on the number of WVCs, they could not keep out wildlife from the ROW. Installation of additional devices is not recommended.

7. Swareflex acoustic reflector

The device, mounted on road delineator posts, sounds a short acoustic but not an ultrasonic signal activated by the headlights of vehicles. There is no available reference on its effectiveness and the manufacturer has not shown any results by it, either.

Figure 7. Swareflex optic and acoustic reflector.

During tests on deer feeders, such a system was compiled for the examination, which activated after dusk. The animals' behaviour was recorded by IR cameras (Bushnell and Scoutguard). The first animal appeared 6 hours after the installation on the spot and the device did not trigger any observable reaction on the animal. Other animals went to the feeder only the following night, also fed without interruption, without escape reaction. Deer got used to the to the sound of the wildlife warning system in a day.

The device was tested on feeding stations in 3 days active and 3 days inactive periods (test and control periods), irrespectively. During the control and test periods nearly the same numbers of recordings were taken: 108 and 106 in average. Ninety recordings were made in average which supported the ineffectiveness of the device and 0 records supports the effectiveness. These experiments carried out on game feeders showed quick addiction and complete ineffectiveness.

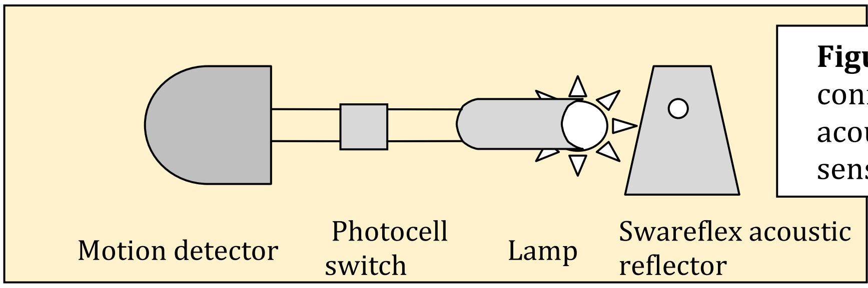

Figure 8. Experimental configuration of Swareflex acoustic reflector with light sensor for field-tests.

On the monitored highways sections there were not enough cases till now for the statistical analysis; however, it is clear that the number of WVCs did not decrease after the installation. Due to these results and to the high cost of the device, its application is not recommended on highways.

8. Ultrasonic animal repellents

More types of devices were tested than it was planned earlier because the preliminary studies with smaller sample size on the originally selected repellents proved their inconvenience. With the Weitech 051 ultrasonic repellent we could measure the habituation every few minutes. It kept away the animals from the game feeder in the first 3 minutes. Up to this point it triggered escape reactions. In the next 5-6 minutes the animals went closer and closer to the feeder and they also fed. They noticed the sound of the alarm, but did not escape. After the 10th minute no reaction was observed. Escape reaction was noticed only in 1% of records.

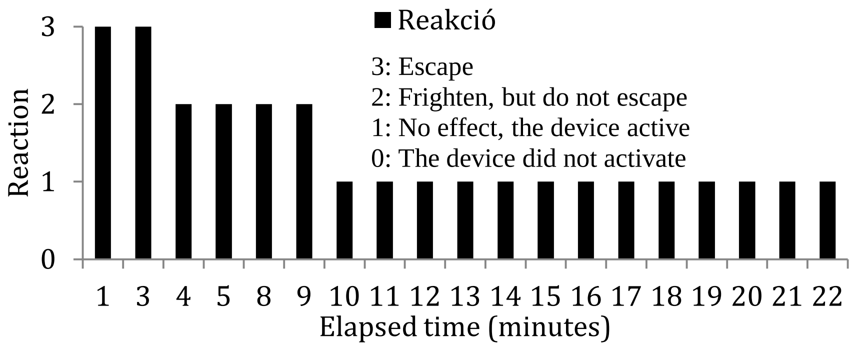

Figure 9. Habituation in case of roe deer.

Figure 10. A red fox and a domestic cat pay attention to the active ultrasonic wildlife repellent.

The motion detector did not detect the animals and did not activate the ultrasonic generator in 25-60% of the cases which is a special problem of the devices available on the market.

Figure 11. A dog is resting in front of the active Weitech 051 (frame from a camera record).

Figure 12. Weitech has no influence on roe deer.

The tested compact devices designed for garden usage are not suitable for keeping away animals in the surrounding of highways because their motion detectors, which detect in small angle, have low sensitivity and efficiency. Most of the devices provide low volume ultrasound, the warning effect of which does not alarm the animals. Due to the results their application is not recommended on highways.

9. INKE acoustic wildlife repellents

9.1. INKE-1

The tested devices were equipped with photocell switch, so they functioned only from dusk to dawn when most of the WVCs occurred. They emitted a sharp sound in every minutes, which is also unpleasant for humans but the drivers do not perceive the alarm.

The device was tested both on game feeders and on highways and it proved effective for roe deer because there was 10-fold significant difference between active and control periods.

In the study area at highway M1, where the roe deer is dominant, in active periods 79% fewer animals approached the experimental area than in the control periods. Habituation was not observed. However, for wild boar the INKE-1 was not effective, because during active periods the same amount of animals moved in the experimental area like during the control periods.

The INKE-1 was installed in highways relatively late; the first installation was on 13th October 2010 in an interchange of highway M7. Prior to the installation there were 12 WVCs on the section, after that only 5 in a same time period and no big game road kill occurred. So far the number of WVCs was reduced by 58%. In an other interchange of M7, there were 6 WVCs prior to the installation and 0 after it but the studied period is still too short. In an involved interchange of highways M1 a critical gap was also being repaired during the test period, so the test lost its independence, the data can not be evaluated, although no WVC occurred after the installation.

Figure 13. An INKE-1 mounted on W-shaped crash barrier in an interchange at fence end. The barrier also drives the sound well.

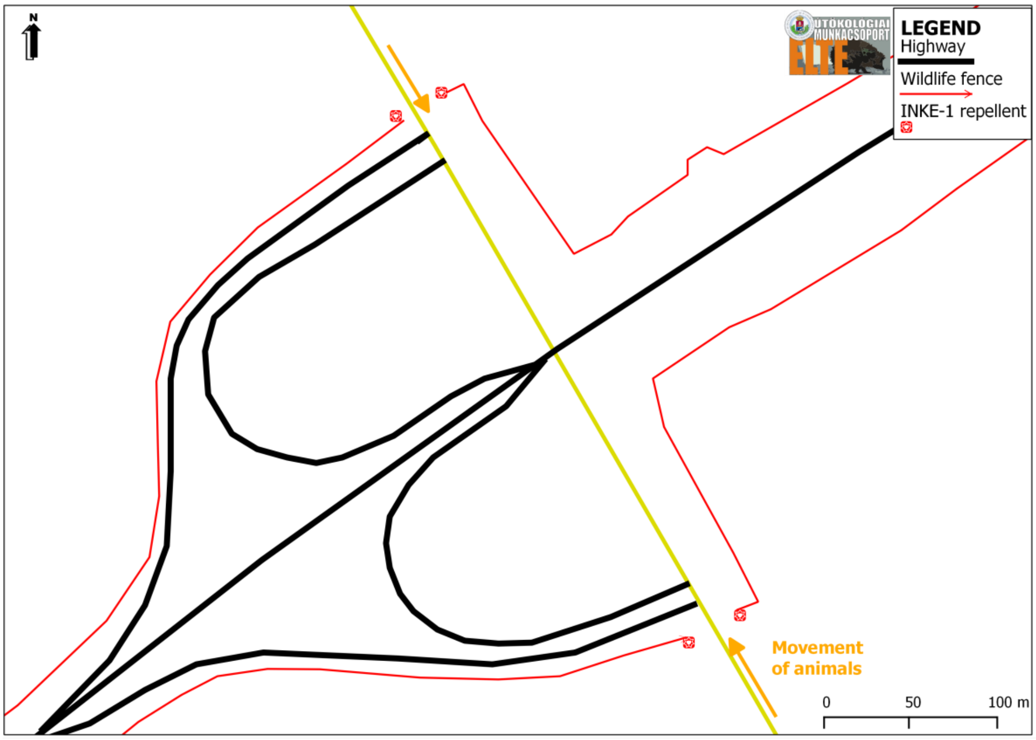

Figure 14. INKE-1 wildlife repellents installed in junction legs of a highway.

9.2. INKE-3

As a development of the method a reliable motion sensor was attached to the higher volume INKE-2 operating from 12V.

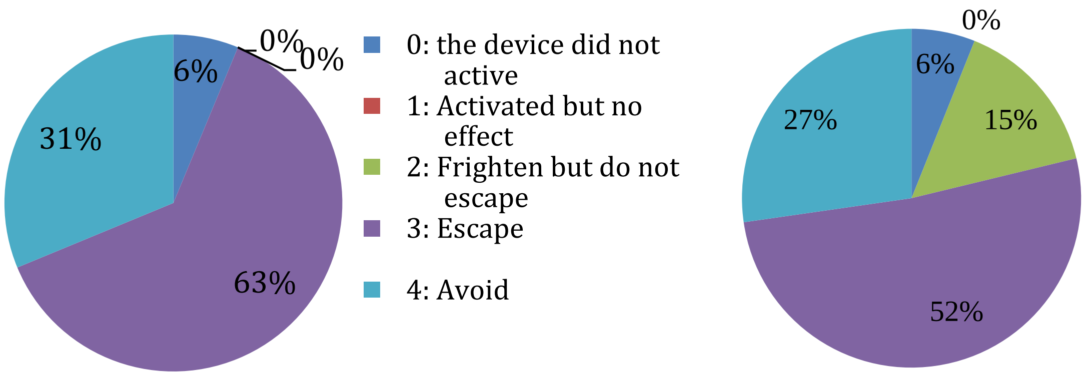

Figure 15. The efficiency of INKE-3 for roe deer (left) and for the other species (wild boar, red fox, badger, dog, domestic cat, red deer). For rating the observed reaction on camera records, a 4th category was introduced, the avoidance. This is the opposite of habituation; the animals „remember” the repellent and keep away from it.

According to the current tests, the high volume acoustic repellent with motion sensor is generally suitable for keeping away animals. Suggested application: fence ends in highways interchanges outside a built-up area. In built-up areas the sharp sound may be disturbing for pedestrians.

10. Fence modifications

Minor modifications of wildlife fence can also contribute to the reduction in the number of WVCs and the fragmentation. Retrofitting the fence fittings at overpasses (Fig. 2) and drainage tunnels (Fig. 5) were done in many locations. It is untested but recurving the fence endings can theoretically reduce the number of entering animals.

During field-surveys several locations were found where the occurrence of hotspot was due to the wrong design of the fence or the lack of fence. Below 2 cases are displayed where the hotspot formed due to the insufficient fencing. In the M0-M7 intersection the animals could enter through underpasses among the junction legs where actually nothing prevents them from entering the ROW (Fig. 16). In interchange "Sasfészek" M1 highway 21 km the misplaced fence means a free way for the animals (Fig. 17). This latter is a good example for the fact that fencing should be erected in accordance to the local conditions because general designs reduce the effectiveness and the traffic safety.

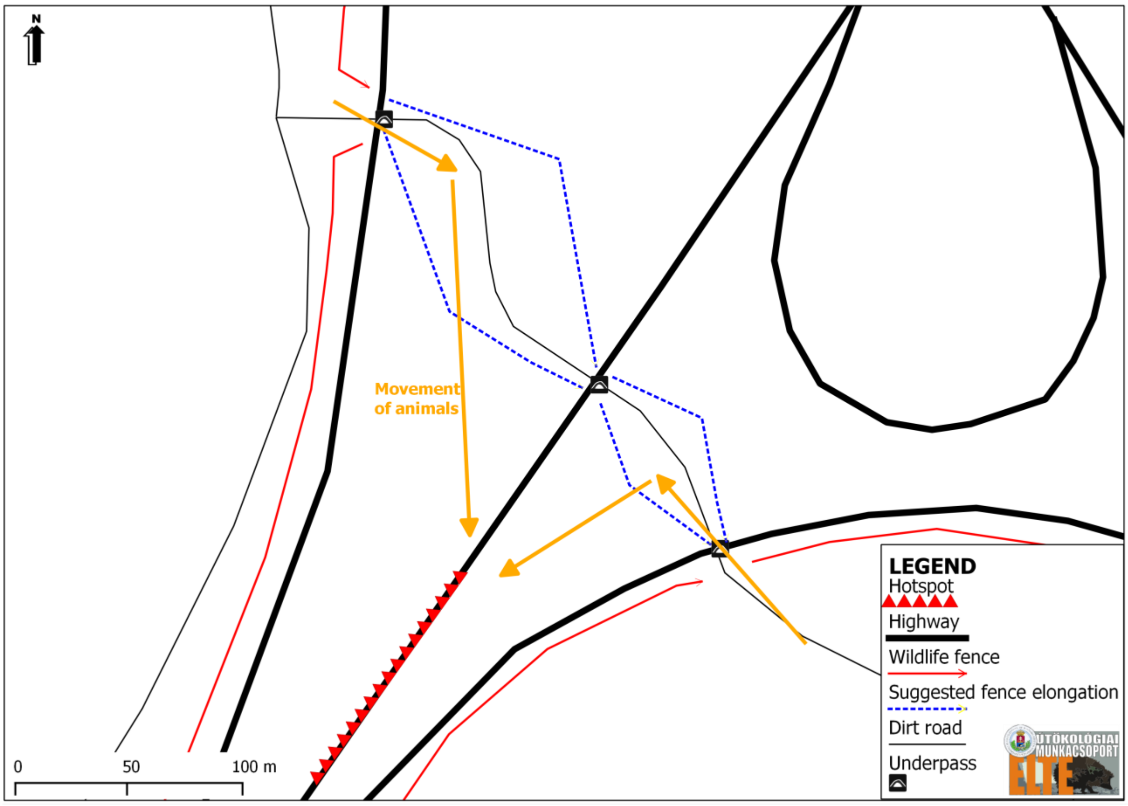

Figure 16. Intersection of M7-M0 highways (M7 16 kmsz): there is no fencing or just dilapidated in the inner nodes of the interchange.

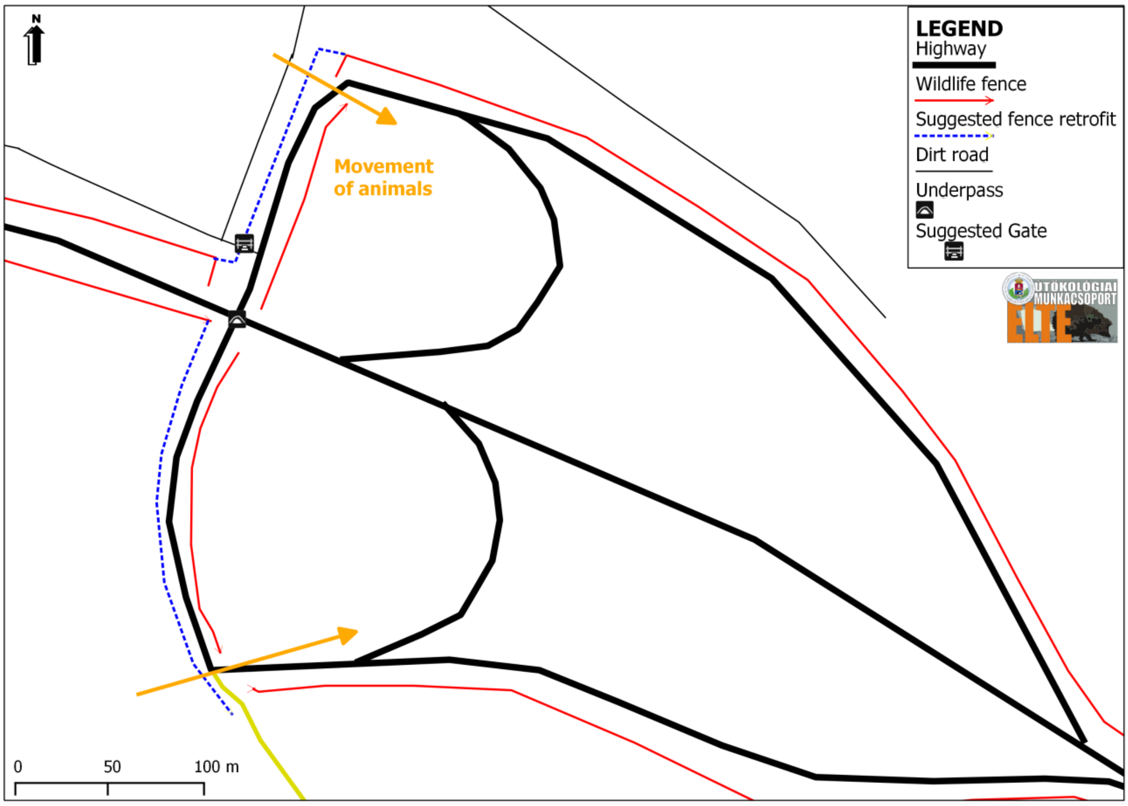

Figure 17. Two, out of the 3 access points can be terminated by relocating two fence sections.

11. Cattle guard

In order to prevent animals from traversing between fenced areas through permanent openings, cattle guards can be installed at the openings. This structure consists of a network of parallel tubes at ground level above a trench. Animals are afraid to cross these structures but vehicles can roll over them at a low speed. This old, but proven method has been used for more than a hundred year to limit the movement of livestock (Hoy, 1982). Clevenger et al. (2001) reports that cattle guards were placed in the road, where fencing intersects roads, leading to the Trans-Canada highway passing through the Banff National Park. Reed et al. (1979) and Ward (1982) claim that cattle guards are not too effective against deer because they can simply jump over the cattle guards. This was denied by Belant et al. (1998), Seamans and Helon (2008), Peterson et al. (2003), Silvy and Sebesta (2000) who reported that cattle guards are 88-100% effective for deer. A cattle guard is in planning stage at a critical interchange of our investigated area (Fig. 3), and if it is successful more of these structures will be installed in other high risk highway interchange.

So far there were no WVCs at the only existing Hungarian cattle guard (highway M9; fig. 15).

Figure18. Cattle guard in the M9 highway (source: SMMC Ltd.).

12. Suggested mitigation methods for the Hungarian highways

Beyond the fence repair and modification, the following mitigation methods were recommended by the related references and our own tests for the highway network managed by the SMMC: INKE-3, and its improved versions; cattle guard/electric mat; and after our own tests: boulder field, escape ramp. Electric fence is recommended only as a temporary replacement of wildlife fence, for example when workings accompanied with disassembly of the fence.

Using wildlife repellents and other mitigation methods has mainly Implication in interchanges, fence ends and in their surroundings. In any other places the maintenance and minor modification of the existing fences is more (cost-) effective.

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Red deer (Cervus elaphus)

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