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Roe deer-vehicle collisions in Slovenia: situation, mitigation strategy and countermeasures

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ABSTRACT

In Slovenia, between 4,000 and 6,000 roe deer are killed on roads each year. Although this number exceeds 15% of the annual hunting bag and presents a high risk for drivers, no mitigation measures have been systematically implemented on a national scale until recently. Therefore, deer-vehicle collisions were systematically recorded all over the country in the 1999–2001 period. Beside determination of the most problematic sections of Slovene roads, some statistical analyses were also performed. The most indicative results obtained by the analysis of 7,759 records on roe deer road-killed are as follows: (a) Frequency of roe deer-vehicle collisions (expressed by the average number of roe deer killed annually on roads for every 1,000 ha of the surface) is the highest in sub-Alpine and sub-Panonic regions. (b) The risk of collision with roe deer varies over the year – the majority of crashes occur in April and May; however, the risk is high during the summer and autumn as well. (c) The daily pattern of roe deer-vehicle collisions has a pronounced bimodal distribution with peaks at dawn (5 a.m. – 7 a.m.) and dusk (6 p.m. – 10 p.m.). (d) The risk for collision with roe deer is higher in a fragmented landscape, where the forest edge is very long. Considering the recent situation, a strategy for mitigation of the problem of roe deer-vehicle collisions was defined. To achieve its main goal (50% decline in the number of collisions on a national scale), the most important issues will be as follows: (i) testing the effectiveness of different mitigation measures in a wide range of landscapes and habitat types, adjacent to roads; and (ii) implementation of adequate countermeasures all over the country.

Key words: roe deer, deer-vehicle collision, road, mitigation strategy, Slovenia

Introduction

Worldwide, collisions of vehicles with wild-living deer (deer-vehicle collisions, DVC) present an enormous and ever increasing problem, which is the consequence of permanent changes in landscape structure (e.g. natural overgrowth of agricultural areas,

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increasing length of forest edge due to the fragmentation of forests), increased numbers and spread of populations of wild-living ruminants as well as the ever rising volume of road traffic in both urban and rural areas. Indeed, in Europe (excluding Russia) close to half a million deer are estimated to be hit by vehicles every year, leading to over 300 human fatalities, 30,000 human injuries and with damage to property exceeding $1 billion (GROOT-BRUINDERINK and HAZEBROEK, 1996). Recently, the number of DVC per year is estimated to exceed 3,500 in Norway, 10,000 in Switzerland, 10,000 in Denmark, 30,000 in Britain, 35,000 in Austria, 55,000 in Sweden, and 140,000 (!) in Germany, respectively (for a review, see LANGBEIN and PUTMAN, 2005).

Until recently accurate information on the extent and the distribution of deer-vehicle collisions in Slovenia has been lacking. As in many other countries, there is at present no legal requirement to report collisions with animals to any authority. Moreover, neither police nor insurance companies maintain detailed records of such collisions in ways enabling the necessary insight into the problem on a national scale (e.g. locations of black spots, total number, spatial and temporal distribution of DVC). Therefore, the only reliable information can be obtained from well-maintained statistics of both local and regional hunter's authorities; however, these statistics are based on the number of game carcasses found close to roads, thus it reflects the number of road-killed animals rather than the total number of DVC, which is estimated to be at least several times higher (BOLČINA and MEHLE, 2000). Nevertheless, from these data it is also clear that ungulate (particularly roe deer) related accidents do present a major cause for concern both in terms of road safety as well as animal welfare. For example, at the beginning of the millennium the numbers of wild-living ungulates recorded that are killed annually in Slovenia due to collision with a vehicle were as follows: 3,600 – 4,800 roe deer (*Capreolus capreolus*), 91 – 116 red deer (*Cervus elaphus*), 6 – 7 fallow deer (*Dama dama*), 4 – 17 chamois (*Rupicapra rupicapra*), 3 – 8 moufflons (*Ovis musimon*), and 19 – 62 wild boars (*Sus scrofa*), respectively (POKORNY, 2002).

The lack of accurate records for DVC posed a major handicap to the development of an effective and systematic countermeasure programme on the national scale. This was also recognised by the Directorate of the Republic of Slovenia for Roads, which initiated the project "Game on Roads" in 2002 to collate reliable information on DVC all over the country. Interestingly, very similarly to the "National Deer Collisions Project" launched in Britain almost at the same time (see LANGBEIN and PUTMAN, 2005), the key objectives of the Slovene project were as follows: (i) to assess the geographic distribution of DVC all over Slovenia; (ii) to identify black spots (i.e. very problematic sections of roads) where future mitigation efforts should be targeted; (iii) to identify key risk factors, which may help to increase public awareness about DVC and how to avoid them; (iv) to prepare strategy for systematic and well-grounded engagement with the issue of DVC; and (v) to assess the effectiveness of different already existing as well as newly developed countermeasures employed to reduce animal road kills on several test sections of Slovene main roads.

Materials and methods

Although summarized numerical data on the national annual hunting bag (including road kills) are available from Slovene Hunters Associations, this central database does not enable either the insight into the number of DVC per single hunting ground or the identification of local black spots and identification of factors, which may influence the risk for DVC. Therefore, data on game road kills were collected for the 1999 – 2001 period from the official statistics on two spatial levels – i.e. the primary level in individual hunting grounds (data extracted from the obligatory Evidence books on big game kill), and the secondary level in regional hunter associations (data obtained from the electronic version of the Hunting Informative System). On the secondary level, only numerical data on road-kill of each species per individual hunting ground were collected. However, inside hunting grounds the following attributive data per single road-killed animal were collected: species, age, sex, location, date and hour (when available) of killed animal; besides, precise locations of collisions were also drawn on 1:25,000 maps. Moreover, all local hunting authorities were asked to provide their personal experiences (with numerical data, if possible) on the effectiveness of the preventive measures, which had been employed in their hunting grounds. In the initial phase of the project we managed to collect numerical data on road-killed ungulates for 423 of 428 hunting grounds, representing 2 002 449 ha or 98.8% of the Slovene surface. These data allowed assessment of the risk for DVC in each single hunting ground with the calculation of yearly density of road-killed ungulates per 1,000 ha of hunting ground surface (for roe deer, see Figure 1). However, the response of individual hunting grounds was much worse, since only 216 of them (51%) answered the questionnaire properly (i.e. providing all requested attributive data per single road-killed animal), and 158 of them (37%, 696 688 ha) provided also locations of known DVC on geographic maps.

All attributive data on big game killed due to collision with a vehicle in the 1999 – 2001 period were entered into the electronic database. This database contains 8,027 records on road-killed ungulates, including 7,759 roe deer, 196 red deer, 61 wild boars, 8 fallow deer, and 3 chamois, respectively. The high number of records for roe deer assures reliability of the results obtained by the treatment of data for this species, while for other species the number of records is too low for any well-grounded conclusions. Therefore, only roe deer (which is, however, the most problematic species regarding DVC in Central

Europe) is emphasised in the following sections.

Besides providing an overview of the recent situation in Slovenia, a strategy for systematic mitigation of the DVC as well as a background for testing effectiveness of different countermeasures were established in the first phase of the project. For both issues the most essential information was obtained from recent review articles/publications (e.g. GROOT BRUINDERINK and HAZEBROEK, 1996; PUTMAN, 1997; DANIELSON and HUBBARD, 1998; STAINES et al., 2001; FARRELL, 2002).

Results

According to data provided by local hunting authorities, 4,820, 4,940 and 4,560 roe deer were killed in Slovenia due to collisions with vehicles in 1999, 2000 and 2001, respectively. However, many crashes do not results in the (instant) death of the animal; moreover, many carcasses are stolen by drivers before they could be recorded by hunters, therefore these figures represent only a small proportion of the total number of DVC in Slovenia, which seems to exceed 10,000 cases per year. Although problematic sections of roads can be found in all Slovene regions, the frequency of roe deer-vehicle collisions (expressed by the average number of roe deer yearly killed on roads on every 1,000 ha of the surface) is the highest in sub-Alpine and sub-Panonic regions (north-eastern and central Slovenia), while it is evidently lower in Dinaric, Alpine and Mediterranean regions (western and southern Slovenia), respectively (Fig. 1).

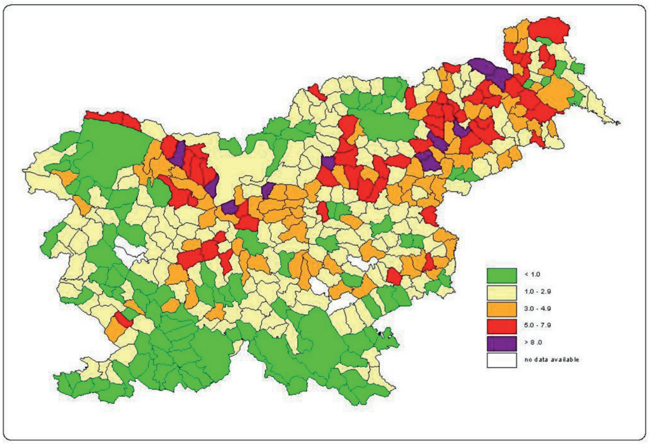

Fig. 1. Average number of roe deer (individuals per 1,000 ha), annually road-killed in Slovene hunting grounds

The daily pattern of roe deer-vehicle collisions has a pronounced bimodal distribution with peaks at dawn (5 a.m. – 7 a.m.) and dusk (6 p.m. – 10 p.m.) (Fig. 2). However, the risk for collision with roe deer varies over the year – the majority of crashes occur in April and May; nevertheless, the risk is high during the summer and autumn as well (Fig. 3). On the contrary, temporal distribution of red deer vehicle collisions has a pronounced peak in early autumn, which coincides fairly well with the rut period (Fig. 4).

Considering experiences of Slovene population managers with different countermeasures it should be noted that only 48 out of 216 hunting grounds (22%) answering the questionnaires have not used any preventive devices so far. The most commonly used countermeasures were standard deer warning road signs (77 hunting grounds, 36%) and chemical deterrents (75 hunting grounds, 35%); however, both of them were criticized as almost ineffective (positive experiences were reported only by 10% and 21% of hunting grounds which had employed warning signs and deterrents, respectively). Some other countermeasures which have been used in Slovenia are as follows: warning silhouettes of roe deer (16 hunting grounds; although some of them were stolen within one year, they were generally reported as very effective in the short term); intensifying of deer cull in the vicinity of roads (13 hunting grounds; however, none of them has been able to judge its effectiveness as yet); high tensile roadside fencing (2 hunting grounds, which both managed to drastically reduce the road-kill); deer warning reflectors (2 hunting grounds; in both cases all reflectors were stolen shortly after installation, thus their effectiveness is not known); and cutting of woody plants from a margin at the road edge (1 hunting ground, which reported the very positive effect of vegetation management on reducing the number of DVC).

Discussion

Fig. 1 indicates that enormous differences in roe deer vehicle collisions exist among Slovene hunting grounds, which is the consequence of differences in landscape and ecological characteristics, length of roads, volume and density of traffic as well as population density of the species in a single hunting ground. For example, by spatial regression analysis of 6,031 records on the exact position of DVC in 9,639 1 x 1 km quadrants (situated only in those hunting grounds, which provided exact locations of DVC for the period 1999 – 2001) it has already been demonstrated that among 40 independent variables (which mainly determine characteristics of the landscape) the density of roads in a single quadrant predominantly determine the number of roe deer vehicle collisions in the same quadrant (for details, see POKORNY et al., 2003). Indeed, the density of roads and the speed of the traffic have already been demonstrated as the main risk factors for DVC (e.g. ROMIN and BISSONETTE, 1996; LODE, 2000; HAFNER, 2002).

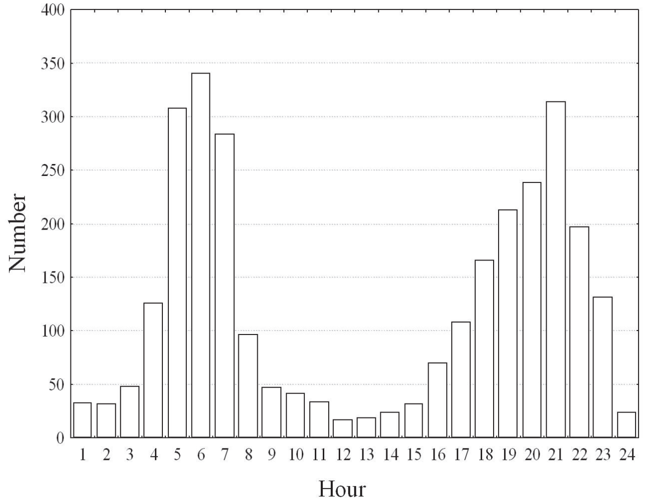

Fig. 2. Daily dynamic of the number of road-killed roe deer in the period 1999–2001 in Slovenia (2,947 animals for which the exact time of death is known)

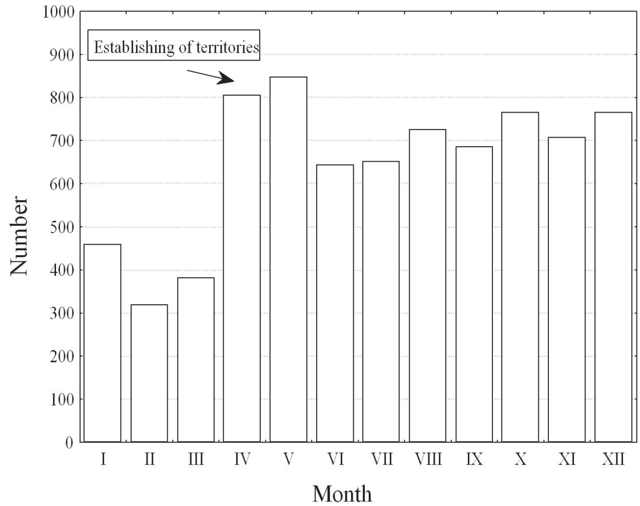

Fig. 3. Yearly dynamic of the number of road-killed roe deer in the period 1999–2001 in Slovenia (7,739 animals for which a day of death is known)

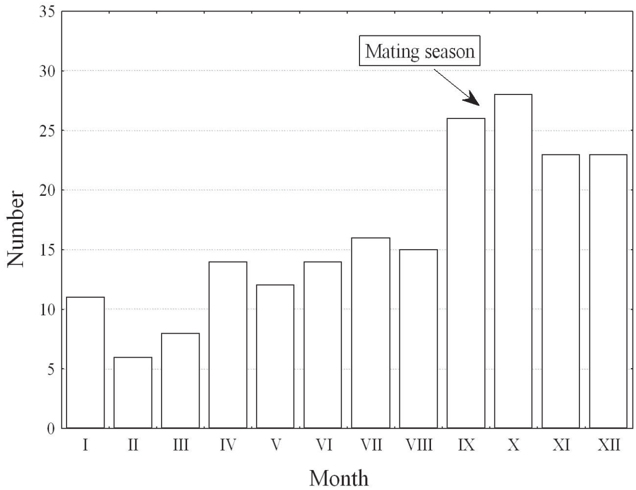

Fig. 4. Yearly dynamic of the number of road-killed red deer in the period 1999–2001 in Slovenia (196 animals for which a day of death is known)

Other factors influencing probability for DVC in Slovenia are as follows: variability of the relief (high gradient increases the probability for DVC), average slope of the relief (with steep areas having lower number of DVC), structure of adjacent forests (higher proportion of conifers slightly increases the probability for DVC), and relative surfaces of fields, meadows and forests in nearby quadrants (number of DVC increases with increasing surface covered by any of these ecosystems) (POKORNY et al., 2003). Accordingly, it can be concluded that the risk for collision with deer is higher in fragmented landscape, where the forest edge is very long (see also ROMIN and BISSONETTE, 1996; FINDER et al., 1999; MADSEN et al., 2002).

Considering the temporal risk for DVC it is clear that it has a very obvious seasonal as well as daily pattern, which is the consequence of the rhythm of life of the targeted species (e.g. daily feeding cycles, mating activities, seasonal migrations due to searching for favourable living conditions or empty territories etc.). The daily distribution of roe deer vehicle collisions in Slovenia (Fig. 2) confirms that the risk for DVC is higher in the dark part of a day (GARRETT and CONWAY, 1999), and it is particularly high soon after sunset (HAIKONEN and SUMMALA, 2001) as well as early in the morning.

Intensive activities (moving) due to intensive feeding, dispersal movements of sub-adult bucks as well as establishing of territories of adult bucks and does around calving times cause April and May to be the most dangerous months for collisions with roe deer (Fig. 3; see also LANGBEIN and PUTMAN, 2005); indeed, in these two months more than 50% of roe deer vehicle collisions occur in Europe (GROOT BRUINDERINK and HAZEBROEK, 1996). However, the risk is also high during the summer (particularly in the rut period) and autumn (primarily due to the greater activity of fawns and clearing of maize fields). Interestingly, although winter months are generally non-problematic in terms of roe deer vehicle collisions (which is the effect of lower activity of animals due to high snow cover, limited availability of food sources, and physiologically determined lower energetic needs in the winter time; see HOLAND, 1992), this does not hold true for the Alpine region, where the otherwise untypical seasonal migration of the species to lower altitudes (with a higher density of roads as a rule) do occur in the rough season (HAFNER, 2002). Indeed, in the Alpine region (hunting management area of Gorenjska) December was revealed as the peak month for the number of roe deer vehicle collisions, which is in strong contrast to all other Slovene regions.

Due to its different life rhythm red deer has a completely different seasonal pattern of DVC in comparison with roe deer, with the pronounced peak in the early autumn (Fig. 4), which coincides fairly well with the rut period of the species. Interestingly, a very similar seasonal pattern was revealed for red deer as well as other species with their mating season in the autumn (e.g. fallow and sika deer) in Britain (LANGBEIN and PUTMAN, 2005).

Although clear temporal patterns and different ecological relationships suggest that there could be some benefit in seasonal enhancement of preventive measures as well as in building up a needed geographical information system, we are not merely seeking to grasp the actual number of incidents occurring or to assess the spatial and temporal distribution of DVC. As well as attempting to understand the factors influencing accident risk, a further objective of the project is to explore the effectiveness of different measures, which may be employed to reduce accident risk. However, since no systematic and adequate mitigation programme has been implemented in Slovenia so far, a strategy for reducing the number of DVC was also defined in the first phase of the project (see POKORNY et al., 2003). Therein, the main objectives were stated as follows: (1) Strategic goal: initiation of systematic, continuous and interdisciplinary programme to reduce the number of DVC; this programme should reduce the risk for crashes with roe deer (certainly with other wildlife as well) and contribute to lower economical loss as well as to higher safety for both drivers and wildlife all over Slovenia. (2) Long-term goal: implementation of previously tested and proven mitigation measures, which will assure the drastic reduction (>50%) of road-killed roe deer in all Slovene hunting grounds. (3) Short-term goals as follows: testing of effectiveness of several mitigation measures in different environmental conditions; raising public awareness and consequently changing drivers' behaviour; and improving the current system of data collecting, which will enable rapid and exact input of all essential information (e.g. exact locations of crashes, descriptive data on killed animals) in the central database directly by local game managers.

To achieve the main goal (50% reduction in the number of roe deer-vehicle collisions on a national scale), the most important issues in the near future will be as follows: (i) testing the effectiveness of different mitigation measures (see below) in a wide range of landscapes and habitat types, adjacent to roads; (ii) determination of the most effective countermeasure for each problematic section of Slovene main and regional roads; and (iii) implementation of adequate measures all over the country. In autumn 2004, testing of several mitigation measures (deer warning reflectors, chemical repellents, averting roadside devices emitting ultrasound and terrestrial vibration, and warning panels with dynamic/changeable content) started on 42 sections of roads, dispersed all over Slovenia. Due to the very short period of exposure we are not yet able to present some well-grounded conclusions; however, the preliminary results indicate that ultrasound emitting devices, which are installed directly into road indicators (columns), may be a promising (although still very expensive) solution for reducing roe deer-vehicle collisions.

Although costs for a drastic reduction of the number of DVC on the national scale would be pretty high, we believe this issue is worth the money. Indeed, concern in preventing collisions between road traffic and wildlife has in the past often tended to be treated mainly as an animal welfare issue, therefore funding allocations for mitigation efforts tended to be minimal. However, recently it is becoming very clear that in the addition to the animal welfare implications and the effects of road-kill on population sizes on some endangered species, DVC also represent real major costs to the economy (LANGBEIN and PUTMAN, 2005). Although an assessment of economical loss due to DVC is very complex and should consider both easily-defined costs (e.g. damage to vehicles, loss of venison and trophies, costs for medical treatments of injured persons, costs due to loss of working capability of employee) as well as many other almost unknown values of road-killed animals (e.g. their importance for functioning of ecosystems or their importance as a recreational or an educational objects) (see PUTMAN, 1997), some recently conducted economical analyses reveal that the average total economical loss due to DVC reaches as much as € 2000 per collision (DANIELSON and HUBBARD, 1998; WU, 1998). Therefore, greater consideration and expenditure on measures to reduce deer and other animal road casualties seems well justified not merely for ecological reasons, but based on substantial potential savings and benefits through enhanced road safety as well (LANGBEIN and PUTMAN, 2005). In this respect, we are very satisfied that tremendous progress has been achieved in Slovenia in recent years.

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SAŽETAK

Između 4 000 i 6 000 srna nastrada svake godine na prometnicama u Sloveniji. Iako taj broj predstavlja više od 15 % godišnje odstrijeljenih srna kao i velik rizik za ljude u prometu, sve do nedavno nisu uvedene mjere za ublažavanje ovoga problema na državnoj razini. Zbog toga, prometne nezgode u kojima je sudjelovala divljač sustavno su bilježene u cijeloj državi u razdoblju od 1999. do 2001. godine. Osim određivanja najproblematičnijih prometnica, provođene su i određene statističke analize. Najznačajniji su pokazatelji prikupljeni pri stradavanju 7 759 srna na prometnicama: (a) učestalost prometnih nezgoda (izražena kao prosječan broj srna nastradalih tijekom godine na svakih 1,000 ha površine) najveća je u pod-alpskoj i pod-panonskoj regiji; (b) rizik naleta vozila na srne koleba ovisno o godišnjem dobu – glavnina se zbiva u travnju i svibnju, iako je rizik visok i tijekom ljeta i jeseni; (c) promatrano po danu, rizik od naleta vozila na srne pokazuje dvostruku raspodjelu, s vrhuncem rizika u zoru (od 5 do 7 sati ujutro) i u sumrak (od 18 do 22 sata); (d) rizik je također veći u rascjepkanom krajobrazu s dugom granicom šume. Poznavajući trenutnu situaciju određena je strategija za smanjenje učestalosti naleta vozila na srneću divljač. Za ostvarenje glavnog cilja (smanjenje broja naleta vozila na srne na državnoj razini za 50 %) potrebito je: (i) provjeriti učinkovitost različitih mjera za smanjenje broja naleta u ovisnosti o krajobraznim razlikama, tipu staništa i blizini prometnica, te (ii) uvesti odgovarajuće protumjere na razini cijele države.

Ključne riječi: srna, prometne nezgode, prometnice, mjere ublažavanja, Slovenija

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