Beiträge zur
JAGD
&WILD
forschung · 32

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# The impacts of the construction and traffic loading of new Slovenian-Hungarian railway connection in northeastern Slovenia upon the populations of large mammals

Key words: railway, ungulate-train collisions, foraging on slopes, northeastern Slovenia

## 1. Introduction

With the modernization of railways in Europe and particularly with the increase of train speeds, the problems concerning the collisions of trains with large mammals became more pronounced. In France where the T.G.V. Atlantique high-speed train line splits the habitats and corridors of large mammals, the railway is fenced in the same way as the highways, with wildlife-proof fences (Desire, Mallet 1991). In northern Europe (Jaren et al. 1991, Andersen et al. 1991), as well as in North America (Muzzi, Bisset 1990, Child et al 1991, Becker, Grauvogel 1991, Del Frate, Spraker 1991, Modafferi 1991, etc.), possible causes for repeated collisions on defined railway sections have been carefully studied.

The railway connection between Slovenia and Hungary, which was built in the period 1999 – 2001, was the first opportunity to study the impacts of mega structures on wildlife after 1967, when the railway Presnica-Koper (Capodistria) was built in southwestern Slovenia. On the Slovenian side, the railway section is situated in the Goričko Nature Park, established in 2003 by the Government of the Republic of Slovenia. About 40 % of the study area is covered by forests, with the majority scattered as forest patches across rural areas. Arable land with different crops prevails in the area.

Since Prekmurje, a vast area stretching eastwards from the Mura river, is settled by the Panonian genotype of red deer (Adamič et al. 2007), the very species was the key target of our study. Red deer of the Prekmurje population is on average 14 kg (21.6 %) heavier than red deer from other Slovenian populations (Jerina 2006). It is also known by its antler weight. The density of red deer in Goricko is related to that on the Hungarian side, but locally it depends on the extent and sizes of forests patches on arable land. The greatest part of the forests in the area belongs to dry Scots pine forest type, with modest above-ground vegetation.

Although red deer is a typical forest dwelling species, the red deer in Prekmurje feed extensively on agronomic crops growing on surrounding arable land. Food conditions inside the forests are poor in general, therefore nocturnal feeding on crops is crucial for red deer, but also for other ungulates in the area. The extent of wildlife crop damages in the area is increasing, although the ungulates are intensively harvested and fed supplementary. In the last 10 years it became evident that repeated sum-

mer droughts affected the yearly extents of crop damage (Gönter 2002).
The railway section Puconci-Hodos-State border with Hungary runs through different landscapes, providing different habitat types for ungulates, including densely settled urban areas, forest patches, forest edge and open agricultural space. Direct and indirect impacts of railway traffic upon wildlife populations are thus related to the seasonal use of different habitat types.

## 2. Methods

According to the planned construction of the railway connection with Hungary in the course of the 5th European Traffic Corridor, the Slovenian Railway Company launched in early spring 1997 the identification and monitoring of wildlife trails in the wide area of the planned railway line. It was for the first time in Slovenia that any large-scale project was accompanied by a previous environmental impact assessment study, and thus gathered suggestions were taken into account during the construction. Fourteen main wildlife crossings with a total length of 8300 m were mapped and monitored in the period up to December 2006.
Each of the railway sections was visited monthly. The whole section was walked in both directions. Reliable footprints of wildlife in the mud, snow or soil were registered in relation to 100-metre segments of the railway line. The signs on railway stones (e.g. km 59.6 – km 59.7, etc.) were used as orientations.
The locations of wildlife kills on the rails were registered with the assistance of district game wardens in Wildlife Reserve Kompas-Peskovci and local Hunters Clubs, as well by the information gathered by railway inspectors. Reported kill spots were visited, photographed and mapped. Seasonal distribution of crops and other important spatial variables in the area of kills were registered. The crossing intensity of red deer was monitored on the sample wildlife passage Hodos-State border, in km 68.8-69.1. The passage was chosen due to its position close to the State border, and since the largest piece of arable land (with a surface of about 25 ha) in the wider area was cut by the railway. The activity of the passage was monitored once per month. In the period July 2001 – December 2006, 65 regular monthly monitoring days plus 12 additional visits in winter snow periods were performed. Fresh tracks of wildlife were counted and registered along the 300-metre length of the passage during the visits. Nocturnal migrations of red deer between forests and arable land were monitored by 4 hinds, three of them mounted with Vectronic GPS collars and one with a Sirtrack VHF radio-collar.

## 3. Results

In July 2001 the railway was opened for traffic and the monitoring of the impacts upon large ungulates was started (Adamič 2003). Three key sections of the railway line on the Slovenian side were defined. Differences in the densities of wildlife in surrounding habitats were used as the criteria for sectioning.
**Section no. 1** – situated between the State border line near the Hodos railway station and the railway bridge on Peskovski potok (km 69.1 – 57.8), the section represents the area of permanent presence of red deer, roe deer and fallow deer and of periodic presence of wild boar. Due to the vicinity of forest patches, with some of them touching the railway line, the section no. 1 is expected to be most exposed to wildlife-train collisions.
**Section no. 2** – between km 57.7 and km 53.7, this section is located within typical roe deer habitats. Red deer and wild boar are less frequent in the area. Several settlements of different sizes are scattered on both sides of the railway. Roe deer prevailed among killed animals, although the animals killed on the section also included a few red deer.
**Section no. 3** – between the crossings of local roads to Stanjevci and to Puconci (km 53.6 – 45.3), this section runs across densely settled flatlands, crossed by several local roads. Forest patches are found on hilly edges of the area. Roe deer is found in surrounding habitats, whereas red deer and wild boar are of rare occurrence. A few, seasonally active wildlife crossings were detected on the Section no. 3. The locations of wildlife crossings were changing in relation to the diversity of crops on both sides of the railway.

Taking into account the results of the monitoring in the period July 2001 – December 2006, two possible causes of the wildlife-train collisions on the railway section Puconci-Hodos-State border with Hungary might be taken into account.

1) Daily trails, connecting shelter areas and feeding areas of wildlife are separated by the railway. Access to water sources may also be affected. At dawn and dusk, as well as during the night, the visibility might be further reduced by the fog or rain. The railway is crossed by wildlife at least twice in 24 hours and therefore the chances of train hits also depend on the frequency of night traffic.

2) The soil on the slopes of railway dikes is stabilized by the vegetation, which might be composed by attractive food plants. Wildlife, feeding on the dikes gradually get habituated to the noise of the trains and their primary flight reactions are thus suppressed.

### *3.1. Monthly distribution of ungulate-train collisions*

Monthly distribution of ungulates killed by the train is evident in Table 1. Ungulate-train collisions (train kills) were registered throughout the whole year, but with pronounced peaks in March-May and October periods. A great part of the railway section was built on the dikes with soil banks, which were greened with grass-legume mixtures to stabilize the soil. Many of the plant species used proved to be an attractive food source for ungulates (alfalfa, clovers, forage kale, oilseed rape, etc.). Slopes, particularly those facing south are warmer in cooler periods of the year. Early growth of vegetation on sun-exposed slopes, compared with that on the ground, attracted wildlife.

By our own observations of the reactions of wildlife grazing on the dikes, it seems that the animals have slowly habituated to the noise and lights of the trains. Retarded escapes of ungulate groups, foraging on the slopes away from approaching trains have triggered the great extent of traffic kills. Currently, the railway traffic is not very dense. According to our observations, we estimate that the frequency is less than 40 trains, passing the section in 24 hours. We believe that the collisions in the sense of *Russian roulette*, or accidental contacts of wildlife and the trains on rails are scarce. Only one incident involving a wild boar which was definitively not grazing on the slopes was registered in the whole monitoring period.

Seventy-four animals in total have been hit by trains and found dead in the period July 2001 – December 2006 (Table 1). The intensity of railway crossings by wildlife varied seasonally, but is also connected to the weather conditions (snow cover depth, extended summer drought periods, etc.) as well as to the growth stages of preferred crops on the surrounding fields. Among wildlife killed on the rails one wild boar, 15 roe deer, 29 red deer and 29 fallow deer were registered. The size of roe deer kills was probably underestimated, since the remains of these animals might be easily consumed by foxes, dogs, and ravens.

### *3.2. Seasonal patterns of the use of wildlife passages*

Among 14 registered wildlife passages over the railway line, we concentrated on the red deer passage *Hodos-border area*, between km 68.8 and km 69.1 in the section between the Hodos railway station and the state border with Hungary. It was selected due to the surrounding

*Table 1 Monthly distribution of ungulate train kills on the rails*

| Wildlife | I. | II. | III. | IV. | V. | VI. | VII. | VIII | IX. | X. | XI. | XII. | Σ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Red deer | | 1 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 8 | 2 | 2 | 29 |
| Fallow deer | | 1 | 5 | 5 | 4 | 3 | 3 | | | 4 | 2 | 2 | 29 |
| Roe deer | 2 | 2 | 1 | 3 | 3 | 2 | 1 | | | | | 1 | 15 |
| Wild boar | | | | | | | | | | | 1 | | 1 |
| Σ | 2 | 4 | 8 | 11 | 8 | 6 | 7 | 3 | 3 | 12 | 5 | 5 | **74** |

surfaces of arable land, which with its 25 ha represents the largest field block in the area. The peak of the crossing activity was registered during winter months (January – March), but nearly no activity of passage was registered in May-July period. In other parts of the year the crossing activity was moderate. According to the patterns of red deer crossing activity, it was evident that train frequencies, as well the human presence in the wide area of the passage had limited impact on the functioning of the passage.

Although the lightning towers were put on the previously dark section of the railway in spring 2005, no changes of activity have been registered since.

The Hodos passage might be treated as yearlong active and passed by the flocks of deer, but no wildlife-train collisions have been registered on it. We speculate that the animals approaching the dike, which is situated in open space, have good sighting opportunities to notice the trains and avoid collisions.

The effects of mitigation measures which were realized during the railway's construction were also tested during monitoring. The ramps – additional gentle slopes to enable gradual and safer mounting of wildlife on the tops of steeper dike segments – were not used exclusively, since surrounding parts of the crossings were left unfenced. The fencing of longer parts of the railways was avoided because the fence might act as a trap for wildlife, rendering the individuals inside the fence impossible to escape the train.

### *3.3. Radio-telemetric studies of red deer movements in the wider area of the railway section*

In the period January 2005 – December 2006 we captured four red deer females and fitted them with radio collars; one with a classic Sirtrack VHF transmitter and three with GPS Vectronic transmitters (Table 2).

According to current results of the action, it seems that the hinds performed similar strategies in the use of habitats. Nocturnal positions of the animals were tied to arable land, where they probably fed on agronomic crops. Daybeds were situated in the forests and thickets. During their daily and seasonal movements the railway sections 1 and 3 were crossed several times.

## 4. Conclusions

In general we can conclude that the railway with its traffic activity represented no serious obstacles for ungulates, if we exclude the possibility of ungulate-train collisions which regularly ended with the deaths of involved animals.

Small surfaces of home ranges of four hinds (all sexually mature animals) proved that red deer in the area performed a kind of cryptic behavior, and stayed in the close vicinity of humans. This kind of behavior might be successful due to good habitat conditions. During their daily and seasonal movements, the animals often crossed the railway sections.

We believe that there exist different triggers for red deer and roe deer kills on the railway. Red

*Table 2 Basic results of the radio-telemetric study of the movements of four hinds in the area of Wildlife Reserve Kompas – Goricko Nature Park.*

| ID | Start of telemetry | End of telemetry | Days of monitoring | Number of recorded locations | Home range size (fix kernel meth.; P = 0.95) |
|---|---|---|---|---|---|
| VHF | 26.4.04 | 9.10.05 | 531 | 48 | 419 |
| GPS_1 | 3.3.04 | 16.3.05 | 378 | 4900 | 403 |
| GPS_2 | 17.2.06 | 26.3.06 | 37* | 629 | 424 |
| GPS_3 | 1.2.06 | 9.1.07 (still running) | 342 | 5682 | 713 |
| | | | Σ 1288 | Σ 11,259 | Average: 490 ha |

*Hind GPS2 was shot (probably by local poachers) and found dead out of the hunting season.

deer is probably hit when crossing the dike on its way to feed on fields and/or on the return towards day beds. Red deer feeding on surrounding fields are thus exposed to train collisions twice per night. The daytime and the extent of red deer feeding on field crops fluctuate between the seasons of the year. In pre-winter and winter periods it might be started in early afternoon, when railway traffic is more frequent than in nocturnal periods. The extent of potential encounters among red deer groups and trains thus varies noticeably within the year.

Roe deer and fallow deer have often been sighted during the feeding on the slopes of the railway dike.

To consolidate the soil on the slopes, the sides of the dike were sown by rich mixtures of edible plant species, e.g. clovers, kale, rape, grasses, which are an attractive food source for ungulates. When the train is approaching and is noticed by the grazing individuals, the animals try to escape from the dike. If the escaping tactics was false, the animal might be killed on the rails. We expect that roe deer and other ungulates will become habituated to approaching trains and will cease to react in their elementary intensity.

The effects of mitigation works and constructions, which were proposed and realized in the course of the building of railway, were also tested during the monitoring. The ramps – additional gentle slopes, constructed on regularly used crossings, which would enable gradual and safer mounting of wildlife to the tops of steeper dike segments, were not used exclusively, since the surrounding parts of the crossings were not fenced. The trees on forest edges close to the railway line were removed, since we expected that train kills would be reduced due to improved visibility of the railway section and thus also the trains approaching. In general the fencing of longer parts of the railways was avoided, since the fence might act as a trap for wildlife, rendering the individuals inside the fence impossible to escape the train. But according to repeated train kills on the railway segment km 59.7 – 60.7, where the forest edge has previously been moved away in the distance of an average tree height, we propose that the forest edges surrounding the rails should be fenced in total length.

## Acknowledgements:

The project was partly financed by the Ministry of the Republic of Slovenia for the Science and Technology. The start of the project was initiated and financially supported by the Slovenian Railway Company. In 2001 – 2002 and 2005 – 2006 the project was included in the Slovenian – Hungarian Intergovernmental Scientific & Technological Cooperation Program (SLO-HUN 13/2001 – 2002 and 2005 – 2006), between the University of Ljubljana, Biotechnical Faculty, and the University of West Hungary, Sopron – Forestry Faculty.

We are indebted to the staff of the Wildlife Reserve Kompas-Peskovci for their assistance during the project field works, particularly at the registration of train-killed wildlife and valuable discussions.

## Summary

The construction operations on the railway section Puconci-Hodos-State border with Hungary in the length of 25 km were launched in mid-1998 and the railway was opened for traffic in July 2001. In pre-construction period in early spring 1997, we started with the identification and monitoring of wildlife trails in the wider area of the planned railway line. It was for the first time in Slovenia that any large-scale project was accompanied by a previous environmental impact assessment study, and thus gathered suggestions were taken into account during the construction.

Fourteen main wildlife crossings with a total length of 8300 m were mapped and monitored monthly in the period July 2001 – December 2006. We found that the intensity of railway crossings by wildlife varied seasonally, but was also connected to the weather conditions (snow cover depth, extended summer drought periods, etc.), as well as to the growth stages of preferred crops on the surrounding fields.

Ungulate-train collisions were registered throughout the whole year, but with pronounced peaks in April – May period. A great part of the railway section was put on the dikes with soil banks, which were sown with the grass-legume mixtures to stabilize the soil. Many of the plant species used for the greening proved to be a very

attractive ungulate food source (alfalfa, clovers, forage kale, oilseed rape, etc.). Early growth of vegetation on sun-exposed slopes, compared with that on the ground, attracted wildlife. According to our own observations we believe that foraging of ungulate groups on the slopes and their retarded escape movements away from approaching trains have caused the great extent of traffic kills.

Collision spots are scattered. Seventy-four animals were hit by trains and found dead in the period July 2001 – December 2006. Among wildlife killed on the rails one wild boar, 15 roe deer, 29 red deer and 29 fallow deer were registered. The size of roe deer kills was probably underestimated, since the remains of the animals might be quickly consumed by foxes, dogs, and ravens. In general we can conclude that the railway with its traffic represented no serious obstacles for ungulates, if we exclude the possibility of ungulate-train collisions. The wild boar is probably the only species affected by the railway operations, since the spatial extent of crop damage caused by wild boars was re-distributed away from the railway area. It is also evident that only one individual boar was killed on the rails, despite elevated densities of the species in wider space.

## Zusammenfassung

**Die Auswirkungen des Baus und der Verkehrsbelastung der neuen slowenisch-ungarischen Eisenbahnstrecke im Nordosten Sloweniens auf die Populationen von großen Säugetieren**

Der Bau der 25 km langen Eisenbahnstrecke Puconci-Hodos-Ungarische Staatsgrenze begann Mitte des Jahres 1998. Die Eröffnung fand dann im Juli 2001 statt. Von Juli 2001 bis Dezember 2006 wurden 14 bedeutende Wildüberquerungen auf einer Länge von 8300 m verzeichnet und monatlich beobachtet.

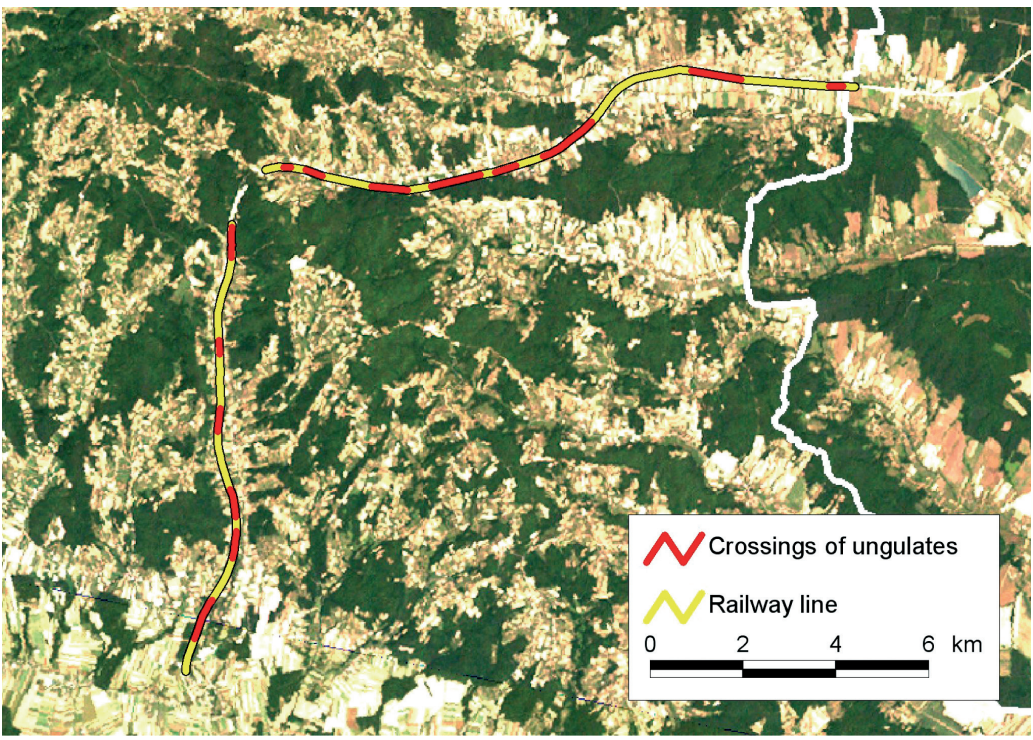


*Figure 1 Registered crossings of wildlife on railway section Puconci-Hodos-State border*

Zusammenstöße mit Huftieren ereigneten sich das ganze Jahr über, verstärkt jedoch in den Monaten April und Mai.

Ein großer Teil der Eisenbahnstrecke wurde auf Bahndämmen verlegt, auf denen eine attraktive Gras- und Kräutermischung gesät wurde. Das Weiden von Huftieren auf den Bahnhängen und ihre verlangsamte Fluchtfähigkeit vor dem sich nähernden Zug sind wahrscheinlich die Ursache für die hohe Anzahl der durch Unfälle getöteten Tiere. Von Juli 2001 bis Dezember 2006 wurden 74 Tiere vom Zug erfasst und tot aufgefunden. Unter den getöteten Wildtieren waren ein Keiler, 15 Rehe, 29 Stück Rotwild und 29 Stück Damwild.

Die Eisenbahn und der Zugverkehr stellten im Allgemeinen keine ernsthaftere Bedrohung für die Huftiere dar, von eventuellen Zusammenstößen mal abgesehen. Der Keiler ist vermutlich die einzige Tierart, die vom Bau der Eisenbahnstrecke betroffen ist. Der Umkreis der durch Schwarzwild verursachten Ernteschäden hat sich weit weg von den Bahngleisen verlagert. Und obwohl es zahlreiche Schwarzwild in der Gegend gibt, wurde nur ein einziges Tier vom Zug getötet.

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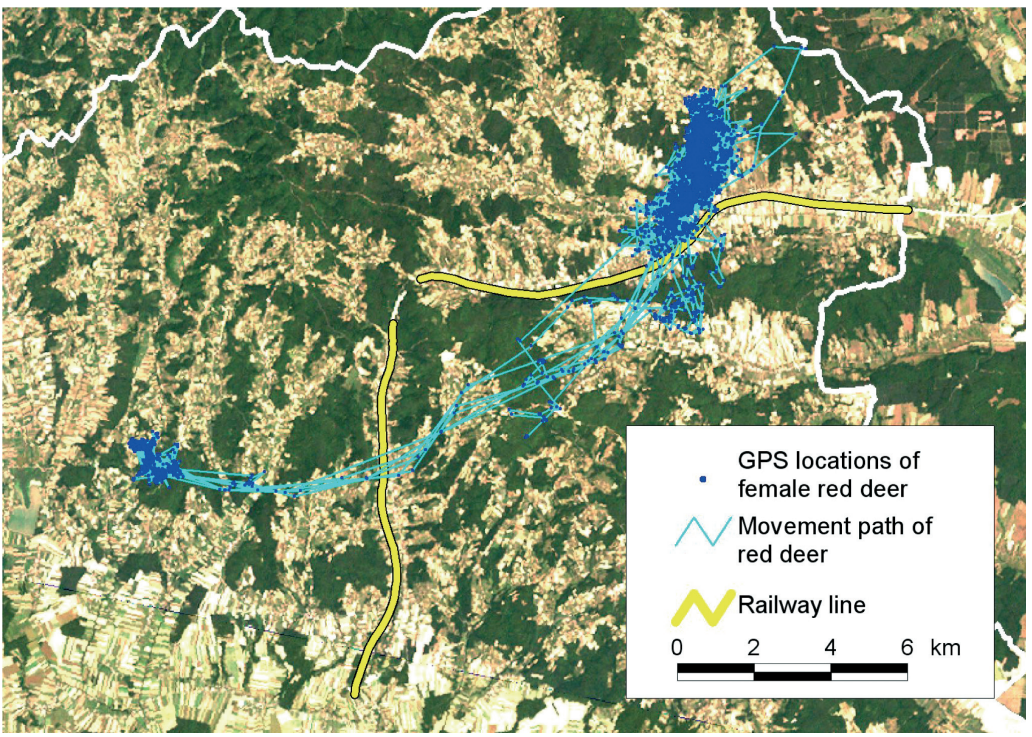


*Figure 2 Locations of hind in the research area gathered by the GPS telemetry*

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