Protection against the Intrusion of Animals into Expressways in Poland

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Abstract

The ever-increasing traffic on Polish roads, coupled with the constant expansion and growth of the road network across Poland, is contributing substantially to habitat fragmentation, among other impacts. The expansion of the road network, with new roads being built and existing ones being improved, separates the existing ecosystems and disconnects wildlife and migration corridors. The extensive use of such solutions as embankments, earthworks, safety fences, noise barriers and traffic barriers adds to this habitat fragmentation and the barrier effect. Animals crossing roads create a traffic hazard and often cause vehicle collisions. In most cases, animals are killed by vehicles, and sometimes such collisions involve human fatalities. As far as limited-access roads (expressways) and controlled-access highways (motorways) are concerned, the only effective way to prevent traffic users from hitting animals is to fence off roads entirely and build wildlife crossings.

Keywords: Animals, Expressways, Motorways, Road accidents, Road collisions.
Roads – A Driver of Economic Growth and a Barrier Effect for Wildlife

An increase in traffic on Polish roads over the last 25 years has made it necessary to develop the road infrastructure across Poland. This has been a prerequisite for Poland to pursue its economic development, which is substantially driven by road transport. Situated on the transit routes of east-west and north-south, for a dozen-odd years Poland has seen a constant increase in the volume of materials carried by road transport, and in overall transport performance (CSO, Eurostat) (see Figure 1). The number of registered vehicles in Poland is growing at a steady pace and does not show any signs of slowing down. Poland's road network, of both national and international importance, still requires improvements to provide the desired travelling comfort. Polish roads are ranked among the most dangerous in the EU (0.088 killed per 1000 habitants, 25 place in EU countries in 2013) (Eurostat, OECD/ITF). Due to the increased road-traffic volumes, road-traffic safety must be improved. Accordingly, subsequent Governments have imposed many road-speed limits and lorry-traffic restrictions in the recent years. On the one hand, these restrictions have contributed to a drop in the number of road traffic accidents and casualties. On the other hand, they have also caused increased costs for transport companies and extended travel times for private road users. These effects show that it is essential to further develop a high-quality road network (bypasses, expressways and motorways) in order to support economic development, as well as to ensure traffic safety and reduce long-distance travel times.

The development of the road network is also a major contributor to habitat fragmentation.

The expansion of the road network, with new roads being built and existing ones being improved, separates the existing ecosystems and disconnects wildlife and migration corridors (Iuell et al., 2003).

Figure 1. Road Transport of Goods and Road Transport Performance in Poland (Central Statistical Office; Eurostat)
Roads exert a heavy impact on the surroundings and nature of the adjacent areas. The degree of impact depends on the location of road projects, traffic volumes and design solutions. The adverse impacts of roads on wildlife can be divided into direct and indirect impacts. Direct impacts involve preventing or impeding the passage of animals across the road (animal deaths caused by impacts from vehicles). Indirect impacts involve the structural discontinuation of wildlife corridors and habitats and in particular the destruction and degradation of habitats within the range of the existing infrastructure, and within areas with higher concentration of emissions caused by road traffic. The development of the road infrastructure is also contributing to the expansion of synanthropes (Bohatkiewicz et al., 2008).

Wildlife barriers cause a range of adverse incidents, including road-traffic incidents and accidents with ecological impacts. A road-related wildlife barrier can be defined as a complex effect comprising animal mortality, physical limitations, alterations to the environment and impacts which restrict movements of animals of certain species across roads, thereby impacting on the range, location and size of their populations (Bohatkiewicz et al., 2008). Building wildlife crossings is one of the possible ways to mitigate these adverse impacts.

**Accidents Involving Animals in Poland, based on Police Statistics**

Animals migrate in the search for places where they can feed and reproduce. In this process, they cross transport routes, often being hit and killed by vehicles. Moreover, in many cases, such accidents cause human casualties. Police statistics show that the number of road traffic incidents is growing. There has been a trend in Poland in which accidents involving animals have been growing year by year, whereas the overall number of road-traffic accidents has been on the decline (see Figure 2).

**Figure 2. The Number of Accidents and Collisions on Polish Roads (Police Headquarters)**

![Graph showing the number of accidents and collisions on Polish roads](image-url)
Although the number of accidents involving animals does not seem to be substantial in relation to the overall number of accidents, one should bear in mind that the overall number of collisions with animals is on the rise (Borowska, 2010). The growing number of incidents involving animals has caused a rise in such accidents, potentially resulting in increased numbers of accident casualties and fatalities. Figure 3 shows the number of collisions involving animals in relation to the overall number of road traffic collisions.

In the case of wildlife-vehicle collisions, an assumption can be made that in addition to possible human casualties, each incident causes damage to property, including vehicles and the road infrastructure, and generates costs for emergency medical services. Most animals hit by vehicles die.

From a technical point of view, a potential reduction in the number of accidents involving animals can be achieved primarily through (Putman et al., 2004; Huijser et al., 2007):

- fencing high-speed roads,
- building overpasses and underpasses (and, in some cases, structures that serve other purposes, in addition to being wildlife crossings),
- imposing speed limits and installing wildlife warning signs showing the lengths of potentially hazardous sections. These signs have the drawback of being widespread, which often makes drivers ignore or underestimate the potential hazard they indicate.
- road signs coupled with light signalling.
- an active wildlife warning system (rarely found in Poland, its use is still being considered).
- chemical barriers (e.g. the urine of predators).
The Development of the Road Network in Poland

Over the last 25 years Poland has seen a steady growth in the number of cars. The number of passenger cars registered since 2000 has doubled from 10 to 20 million and wheeled vehicles in general from 14.1 to 26.5 million. Accompanying this development has been an expansion in the road network in Poland. This expansion is, however, still not enough, and is far from meeting the needs of road--traffic users.

Figure 4 shows the growth trends for the numbers of cars and lorries relative to the development of the road network, including motorways and expressways.

Figure 4. The Number of Vehicles and Roads in Poland (Central Statistical Office, Eurostat)

An analysis of Figure 4 leads to the conclusion that while the growth in the number of registered vehicles in Poland has been rather steady, the network of the roads of national and international importance grew at a constantly slow pace up until 2008. The year 2008 proved to be a turning point, as the road network has been growing substantially since then. This development is attributable primarily to the use of EU funding allocated for infrastructure development in 2007-2013.

The length of the expressways and motorways in Poland in 2000 amounted to 193 kilometres (0.61 km/1,000 km²) and 358 kilometres (1.13 km/1,000 km²), respectively. Combined, they constituted 0.22 percent of all paved roads in Poland. Between 2000 and 2007 the lengths of expressways and motorways increased by 137 and 305 kilometres, respectively. Between 2007 and 2014, in turn, the lengths of expressways and motorways increased by further 1,118 and 893 kilometres, respectively. In 2014 motorways and expressways in Poland constituted 1.06 percent of all paved roads in Poland. The length-to-area ratios for expressways and motorways at the end of 2014 were 4.63 km/1,000 km² and 4.98/1,000 km², respectively.
The plan by 2023 is to further expand the network of expressways and motorways to reach 15 km/1,000 km², of which 10 km/1,000 km² will be the expressways. The length of motorways is planned to slightly increase by 2023, whereas the length of expressways is planned to increase to over 3,000 kilometres, which is more than a two-fold increase in relation to 2014. Over EUR 28 bn has been spent since 2007 on the development of the road network (NCRP, 2015).

**Measures to Prevent Wildlife Intrusion into Roads**

There has been substantial habitat fragmentation in recent years as a result of the extensive development of the road infrastructure, the emergence of the barrier effect and wildlife mortality from road collisions. This creates a major hazard to both drivers and animals. It is extremely important that the road planning and designing process involve designers, planners and road operators who know the locations of wildlife-migration routes, as well as forestry authorities and naturalists specialising in animal protection. It is also essential to collect detailed information on collisions and accidents involving animals. Analyses and studies should be undertaken to provide effective methods of protecting both traffic users and animals (Czarnecka, 2015).

Based on the available information, only a few of the newly built national roads are fenced well enough to prevent animals from encroaching onto roads. As a result of the lack of structures allowing safe wildlife passage, especially along migration corridors, road incidents involving animals happen on both less-frequented lower-class roads and higher-class roads.

An effective solution to prevent road accidents involving animals is to build fencing to guide animals to flyovers or underpasses. This type of structure is particularly important on expressways and motorways, where cars travel at high speeds and drivers have little time to react when an animal suddenly encroaches onto the road.

Almost every expressway and motorway that has been built in Poland since 2007 has been equipped with fencing and wildlife crossings.

Wildlife crossings have two basic ecological functions. They allow species and individual creatures to dwell in their natural habitats that are crossed by roads, and also let animals cover long distances to migrate, roam and disperse (Kurek, 2010). Moreover, they effectively prevent animals from going onto roads.

A total of 67 kilometres of the S-17 expressway was built near Lublin between 2010 and 2014. Situated within the route between Warsaw and Lviv, the S-17 national road is the major road of the Lublin Province. The underlying objective of building this road was to facilitate the development of Lublin and the neighbouring areas by providing a good-quality road infrastructure that the region used to lack. The S-17 national road is still being expanded on a further 100-km-long section to become an expressway to Warsaw, i.e. along the entire section from Lublin to Warsaw.
Regarding this section of the expressway, wildlife crossings are an important measure to prevent the barrier effect that has emerged following the construction of the newly laid road, within a sparsely built-up area where wildlife used to have free passage.

Due to the lie of the land and the vertical alignment of the expressway, all the sections in question are furnished only with underpasses. The S-17 expressway features both crossings that are intended only for wildlife and crossings that are intended for utility purposes as well as for animals. The purpose of the existing structures depends on the size of the large animals, i.e. ungulates (including elks) and predators (e.g. wolves and lynxes), and medium-sized animals (wild boars, roe deer).

For underpasses intended for large and medium-sized animals, the recommended horizontal clearances are ≥ 15.0 m and ≥ 6.0 m, respectively, the vertical clearances are ≥ 5.0 m and ≥ 3.5 m, respectively, and the recommended openness ratios (width x height / length) are ≥ 1.5 and ≥ 0.7, respectively (Kurek, 2010). The dimensions of these structures are shown in Table 1. Figures 5 and 6 illustrate examples of structures intended for large and medium-sized animals.

**Figure 5. Bridge Intended for Utility Purposes and as a Wildlife Crossing for Large Animals**
Table 1. A List of Parameters for Wildlife Crossings for Large and Medium-Sized Animals on the S17 Expressway between the “Kurów Zachód” and “Lublin Felin” Junctions (Kowal and Karas, 2016)

<table>
<thead>
<tr>
<th>Structure</th>
<th>Obstacle</th>
<th>Structures’ horizontal clearance [m]</th>
<th>Crossings’ horizontal clearance [m]</th>
<th>Crossings’ vertical clearance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-02</td>
<td>W, Ro</td>
<td>33.60</td>
<td>19.00</td>
<td>6.80</td>
</tr>
<tr>
<td>MS-04</td>
<td>W</td>
<td>21.76</td>
<td>17.48</td>
<td>5.60</td>
</tr>
<tr>
<td>MD-04a</td>
<td>W</td>
<td>21.80</td>
<td>17.60</td>
<td>5.40</td>
</tr>
<tr>
<td>MS-05</td>
<td>Rv</td>
<td>21.76</td>
<td>16.26</td>
<td>5.40</td>
</tr>
<tr>
<td>MS-10</td>
<td>Rv</td>
<td>21.80</td>
<td>16.80</td>
<td>3.00</td>
</tr>
<tr>
<td>MS-14</td>
<td>Rv</td>
<td>33.20</td>
<td>20.00</td>
<td>4.20</td>
</tr>
<tr>
<td>PZSzd4</td>
<td>W</td>
<td>15.82</td>
<td>9.42</td>
<td>6.50</td>
</tr>
<tr>
<td>MS-16a</td>
<td>W</td>
<td>17.62</td>
<td>13.82</td>
<td>7.20</td>
</tr>
<tr>
<td>MS-02</td>
<td>Rv</td>
<td>29.70</td>
<td>20.20</td>
<td>4.45</td>
</tr>
<tr>
<td>PZSzd6</td>
<td>W</td>
<td>14.50</td>
<td>9.60</td>
<td>3.80</td>
</tr>
<tr>
<td>PZSzd8</td>
<td>Dw</td>
<td>11.50</td>
<td>11.50</td>
<td>5.00</td>
</tr>
<tr>
<td>WS-07</td>
<td>V, Ro</td>
<td>140.00</td>
<td>40.00</td>
<td>4.45</td>
</tr>
<tr>
<td>PZSzd10A</td>
<td>T</td>
<td>10.20</td>
<td>10.60</td>
<td>3.00</td>
</tr>
<tr>
<td>PZSzd10B</td>
<td>T</td>
<td>10.20</td>
<td>40.10</td>
<td>3.00</td>
</tr>
<tr>
<td>PZSzd10C</td>
<td>T</td>
<td>10.20</td>
<td>9.10</td>
<td>3.00</td>
</tr>
<tr>
<td>PZSzd11A</td>
<td>T</td>
<td>10.20</td>
<td>9.10</td>
<td>3.00</td>
</tr>
<tr>
<td>PZSzd11B</td>
<td>T</td>
<td>10.20</td>
<td>40.60</td>
<td>3.00</td>
</tr>
<tr>
<td>PZSzd11C</td>
<td>T</td>
<td>10.20</td>
<td>11.10</td>
<td>3.00</td>
</tr>
<tr>
<td>MS-16</td>
<td>V</td>
<td>975.00</td>
<td>830.00</td>
<td>5.00</td>
</tr>
<tr>
<td>WS-20</td>
<td>T, R, Rr</td>
<td>188.00</td>
<td>10.00</td>
<td>3.50</td>
</tr>
</tbody>
</table>

Dw – dry watercourse; Ro – road; Rr – railroad; Rv – river; T – terrain; V – valley; W – watercourse; MS, MD – bridge; WS – viaduct; PZSzd – wildlife crossing
A range of crossings for smaller animals have also been built along the finished section of the expressway. The purpose of these structures is primarily to allow connections between habitats and migration routes for small insectivorous mammals, Mustelidae, and also rodents and semi-aquatic mammals. These crossings are also intended for medium-sized mammals living in burrows (mainly foxes), amphibians and terrestrial invertebrates. Crossings for small animals are coupled with culverts through which, occasionally or permanently, water flows. A total of 32 complexes of crossings, and also 20 individual steel structures and 26 reinforced-concrete structures (rigid-frame bridges included) for small animals have been built. Figure 7 illustrates examples of structures for small animals.

Along the 55-kilometre-long intact and undeveloped section of the 67-kilometre-long route, a total of 20 crossings for large and medium-sized animals, and 46 crossings for small animals have been erected. On average, this amounts to 0.36 crossings per km for large and medium-sized animals and 0.84 crossings per km for small animals.
Fencing is another simple but effective solution to prevent animals from encroaching onto roads (Clevenge et al., 2001). The opened section of the S17 expressway is fenced on both sides of the road along almost the entire length of 67 kilometres. The fencing has the form of a metal mesh with a height of 2.20÷2.50 m. Mesh fencing was not installed along sections featuring noise barriers, unless such fencing was needed to guide animals to underpasses. Figure 8 illustrates fencing used to guide animals to crossings under the expressway.

**Figure 8. Fences Guiding Animals to Crossings**

The Adequacy and Costs of the Solutions

In 2016 it will be three years since the S17 expressway will have been opened for traffic. This is a sufficiently long period to allow a preliminary assessment of the effectiveness of the solutions employed. These solutions serve their intended purpose as wildlife crossings. Animals have grown accustomed to these structures. They are used by wild boars and roe deer, among other animals. (see Figures 9 and 10).

**Figure 9a. The Crossing for Medium Sized Animals PZSzd 1**
**Figure 9b. Animal Tracks in the Area of PZSzd 1**

**Figure 10a. The Crossing for Medium Sized Animals PZSzd 37**
Figure 10b. Animal Tracks in the Area of PZM 37

In terms of road-traffic safety, no incidents or accidents involving the intrusion of wildlife into roads were recorded. The costs of the employed solutions depend on a number of factors:

- the static diagram and dimensions of bridge structures (depending on such factors as the required vertical and horizontal clearances for animals);
- the purpose of the structure – whether the structure is to serve as a wildlife crossing only, or for other, utility, purposes as well;
- the materials and technologies used.

At about EUR 570,000/km, almost 10 percent of the overall project costs were the costs of the structures for animals.

The fencing of the expressway cost EUR 31,000/km, which is about 0.5 percent of the overall project costs.

It is difficult to assess whether these costs are low or high based only on their relation to the overall project costs. While admitting that it is difficult to consider the price of human life at all, the authors of this paper believe these costs are acceptable.

Summary

The construction of expressways and motorways substantially improve living standards and safety levels for road traffic on major transit routes across Poland. An assessment of the real impact of the newly built expressways and motorways in terms of reducing road-traffic incidents and accidents involving animals will be feasible within the horizon of the next couple of years.

Designers are careful to make sure that the new expressways and motorways are safe for the environment and habitats, with as little environmental impact as possible. Designers also select appropriate solutions ensuring a sufficient level of road-traffic safety. In addition to the proper signage and geometric features of roads, these solutions involve measures to prevent wildlife from intruding into roads. The costs of fulfilling all the
requirements under environmental protection and road-traffic safety laws constitute a major portion of the overall project costs (up to as much as 27 percent (Kowal, 2014)). However, people, fauna, flora, water and air should be protected against the adverse impacts of the existence and use of high-class roads whatever the cost. It should be borne in mind that the maintenance of a balanced natural environment, which by definition involves efforts to keep the water and air clean, and to take care of small, medium-sized and large animals, ultimately influences the human environment. When monitoring and analysing the already built expressways and motorways, reliable and cost-effective solutions should be identified and used in future road-construction projects (Iuell et al., 2003).

An assessment of the effectiveness of environmental protection and road-traffic safety measures in the form of wildlife crossings and fencing leads to the conclusion that, despite the substantial costs involved, these measures serve their intended purpose. The number of animals that cross a structure, be it one or hundreds of animals, should not be the basis for assessing the usefulness of these solutions. What is evident, however, from the above-discussed example of an expressway section, is that if a dozen-odd thousands of vehicles pass along the expressway every day, and that there have been no collisions and accidents involving animals throughout the couple of years the road has been in use, then the safety measures are clearly serving their purpose, and their costs are being paid back.

Moreover, every bridge structure serving as a wildlife crossing can be equipped in the future with special equipment to serve as an "environmental checkpoint", as mentioned by the authors of this paper in (Karas and Kowal, 2015), or as a road-traffic measurement post.

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