Short research contribution

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ROAD MORTALITY OF HEDGEHOGS *ERINACEUS* SPP. IN FARMLAND IN LOWER SILESIA (SOUTH-WESTERN POLAND)

ABSTRACT: The paper presents the results of studies on mortality of hedgehogs Erinaceus spp. on roads in the agricultural landscape of Lower Silesia (south-west Poland). The investigation was carried out in 2001–2003 on a 48.8 km road network. The overall number of hedgehogs found killed was 75. Ninety three percent of all casualties (n = 70) was documented in built-up areas. For the whole period of investigation the average number of victims per 1 km road was 1.54, while in 2002 – 0.76. The average number of victims per 1 km road in built-up area was 37 times greater that in undeveloped area (5.4 *vs.* 0.14 casualties/1 km road). Based on the data obtained, it was calculated with the multiple regression method that hedgehog mortality on the 22 road sections studied in built-up areas was in 90% determined by the level of variation in the mean 24 hour traffic volume and lengths of the road sections.

KEY WORDS: hedgehogs, *Erinaceus europaeus, Erinaceus concolor*, road mortality, traffic volume

Nowadays, roads with the traffic carry constitute ecological barriers for a number of living organisms, which can result in a significant fall in population of many animal groups – amphibians, reptiles, birds, mammals, and also insects (Mader 1979, Hels and Buchwald 2001, Clevenger *et al.* 2003). Apart from road mortality of animals, the negative effects of roads include (according to: Trombulak and Frissel 1999, Underhill and Angold 2000): 1) restriction of animal movements, that affects gene transmission and increases isolation, 2) the pollution by car exhause (heavy metals, hydrocarbons), 3) changes in the physical and chemical environment due to accumulation of chemical substances, 4) changes in animal behaviour especially due to heavy noise (e.g., Reijnen *et al.* 1996, Forman *et al.* 2002).

In Poland, despite the relatively dense road network and increasing number of vehicles, the issues related to the effect of roads and traffic on fauna are not recognized well enough. In view of the upcoming modernization and road network expansion in Poland it seems reasonable to undertake comprehensive studies aimed at determination of the scale of the effect of roads on the natural environment.

Among those particulary affected by the road traffic in Europe are two hedgehog species – the western hedgehog *Erinaceus europaeus* L. and the eastern *E. concolor* Martin 1838. It is estimated that each year on the roads of The Netherlands 113.000 to 340.000 western hedgehogs are killed (Huijser and Bergers 1998), while in Belgium that number is between 230.000 and 350.000 animals (Holsbeek *et al.* 1999).

Lower Silesia is a place of sympatric occurrence of the two hedgehog species (Ruprecht 1973). However, nowadays in western Poland the areas of occurrence of both hedgehog species are not precisely known (D. Jakubiec – pers. inf.).

The aim of the present work was to determine: 1) numbers, 2) places and 3) dates of hedgehog collisions, on selected road sections of different traffic volume and land management, and 4) to formulate initial recommendations for fauna protection against the harmful effect of roads and traffic.

The investigation was carried out on 48.8 km road network (Table 1, Fig. 1), localized in Święta Katarzyna and the outskirts of Wrocław – Jagodno and Lamowice (Wrocław Plain, Lower Silesia Province, south-west Poland). The studied road sections crossed 20 settlements (17 villages and 3 districts of Wrocław). The overall lenght of roads studied on built-up areas was 12.9 km long – 26.4% of the total (Table 1).

Table 1. Characteristics of studied road sections

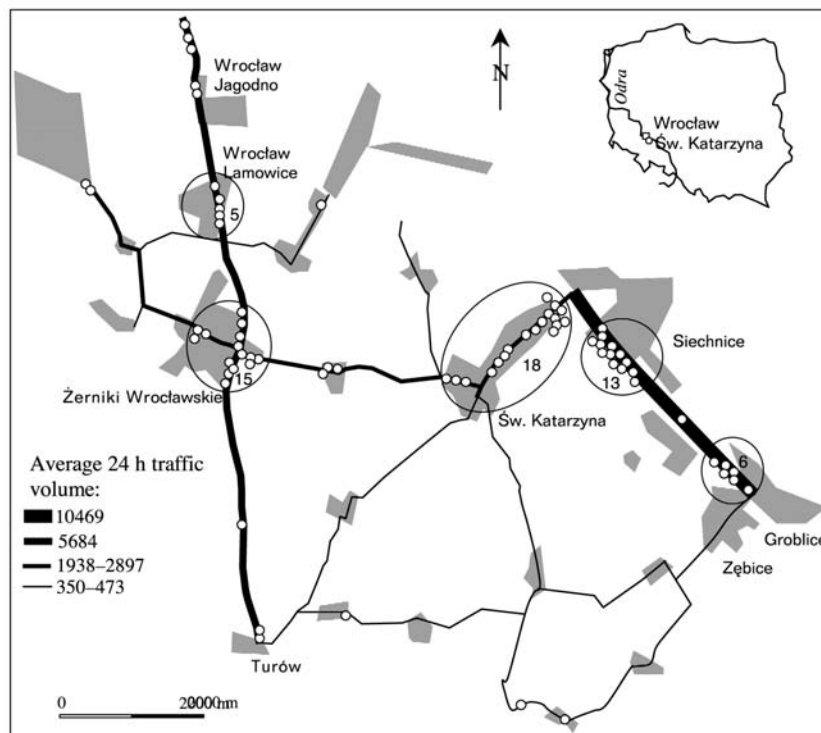| Average 24 h traffic volume	Length of roads (m)	Share (%)	Built-up areas (m)	Number of settlements on a given road section
10469	3750	7.7	1600	2
5684	8350	17.1	1750	4
1938–2897	9600	19.6	4600	5
350–473	27100	55.6	4950	11
Total	48800	100	12900	22

Fig. 1. Places of hedgehog *Erinaceus* spp. collisions (white circles) in the network of the roads studied in Lower Silesia. Grey colour denotes built-up areas, dashed line – places where the number of victims was especially high (digits indicate the total number of victims on a given sections of road); Traffic volume = number of vehicles.

According to regionalization by Kondracki (1988) the discussed area is located within two mezoregions – Primordial Valley of Odra and Wrocław Plain, which belong to a greater physiographic unit called Silesian Lowland. The dominant form of land use in the study area is arable land, constituting about 92% of the territory. Wrocław Plain, including the area studied, is characterised by 1.6% forest share, which is one of the lowest in Poland. The number of inhabitants in the respective localities (villages) where the surveyed roads passed was from 17 (Radomierzyce) to 3921 (Siechnice) (Fig. 1).

Table 2. Number of hedgehogs *Erinaceus* spp. killed in the respective months of the year. The level of hedgehog road-kill per year (months July–Dec. of 2001 and Jan.–July of 2002 and 2003) remained almost the same (Wilcoxon's test for matched pairs, $P > 0.1$).

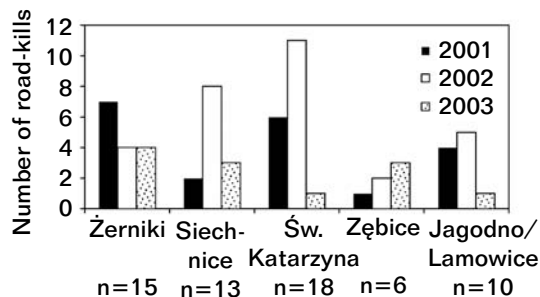| Month	Year			Total
	2001	2002	2003	
Jan.	–	0	0	0
Feb.	–	0	0	0
March	–	0	0	0
Apr.	–	5	4	9
May	1	4	4	9
June	–	2	1	3
July	1	9	5	15
Aug.	2	3	–	5
Sept.	7	6	–	13
Oct.	8	4	–	12
Nov.	4	3	–	7
Dec.	1	1	–	2
Total	24	37	14	75

Fig. 2. Comparison of hedgehog road-kill on selected road sections crossing built-up areas, including data from the whole period of study. Digits indicate the overall victim number on specific road section. Żerniki, Siechnice, Św. Katarzyna, Zębice, Jagodno/Lamowice – local names indicating the relevant road section (see Fig. 1).

The investigation was conducted since June 24, 2001, till August 18, 2003. The roads were surveyed from a car driven at 20 to 50 km/h. From the second half of March untill the end of September all the road sections were checked three times a week. In the other part of the year the number of controls was 1 to 2 per week. The duration of a control depended on the number of casualties found and on weather conditions, being 1.5 to 3 hours on average. Places of hedgehog collisions were marked on a map (1:25 000). In order to avoid double counts, all dead animals were removed from the road. Some of the killed hedgehogs were taken to the Department of Zoology and Ecology of Wrocław Agricultural University to determine which species they belonged to.

The traffic volume expressed as the number of vehicles per 24 h was determined using data from the Wrocław Branch of Public Road Administration, from provincial branches, and the Wrocław Administration District. The data used were from the year 2000. The highest traffic volume was on the state road sections (over 10000 vehicles per 24 h) Siechnice-Groblice (road No 94) (Fig. 1, Table 1). On over half of the studied roads the average 24 h traffic volume was many times lower (about 350 vehicles per 24 h).

On the whole, in the entire period of study 75 hedgehogs were found, including 64 eastern hedgehogs and 7 western hedgehogs. In 4 cases the species could not be determined. In one case a wounded animal was found (*E. europaeus* – juv., 24.09.2002), which died due to injuries. The earliest-found killed hedgehog was on April 17, 2002, and in 2003 – on April 29. The latest dates are December 3, 2001, and December 2, 2002. The largest number of victims (n = 12) was documented in September (Table 2). Ninety three percent of all victims (n = 70) were found on roads in built-up areas (Fig. 1). Outside the built-up areas the victim number was 14 times lower (n = 5). That difference was statistically significant ($\chi^2 = 112.7$, df = 1, $P < 0.001$). The highest mortality was documented on roads with big traffic volume, in large settlements (villages) – Święta Katarzyna, Siechnice and Żerniki (Fig. 2). Straight sections were characteristic for those roads, where vehicles moved faster than the speed limit 60 km/h allowed in built-up areas.

The average number of victims per 1 km road for the whole study period was 1.54, and 0.76 animal in 2002 (Fig. 3). That number in built-up areas was 37 times higher than in undeveloped areas (5.4 *vs.* 0.14/1 km road; χ^2 with Yates's correction = 6.40, df = 1, P = 0.001).
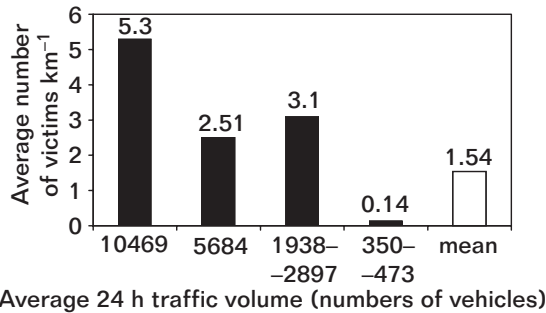

Fig. 3. Mean number of hedgehogs killed per 1 km road of various traffic volume. Data comprise the whole study period.

On the basis of the quantitative data obtained, it was calculated by the method of multiple regression that the hedgehog mortality on 22 investigated road sections in built-up areas is in 90% determined by the level of differentiation in traffic volume and length of the section. The equation obtained assumes the form:

Number of victims = − 2.64 + 0.00655 − (Road length in m) + 0.00071 (Average 24 h traffic volume − number of vehicles)

where $r^2 = 0.90$, $F_{2.19} = 83.94$, $P < 0.0001$ (Fig. 4). A high, statistically significant correlation was also obtained between the number of hedgehogs killed and number of inhabitants of the localities where the surveyed roads passed (Fig. 5).
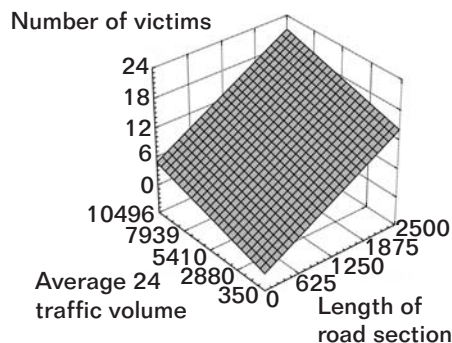

Fig. 4. Relationship between the number of hedgehogs killed and road length and mean 24 h traffic volume on 22 road stretches located in built-up area.
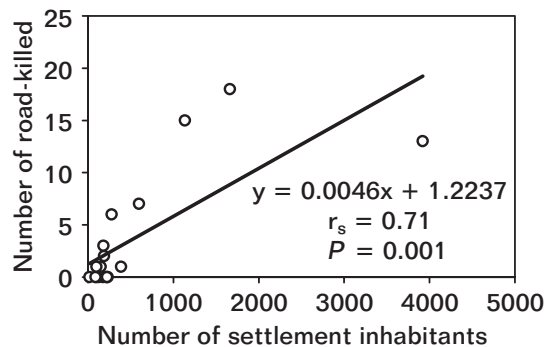

Fig. 5. Relationship between the number of hedgehogs killed and the number of inhabitants of the 17 settlements studied in the years 2001–2003.

The obtained results reflect habitat preferences of hedgehogs. They indicate that presently in the agricultural landscape of Wrocław Plain hedgehog populations are restricted mainly to urban areas. This fact is confirmed in papers dealing with hedgehog populations in the highly developed landscapes of western Europe, where, like in Wrocław Plain, they live mainly in urban and settlement areas (R e e v e 1994, B e c h e r and G r i f f i t h 1998).

In a compilation by R e e v e (1994) the average hedgehog mortality for European roads varied from 0.01 to 5.6 animal per 1 km per year. The highest mortality was recorded in areas of large villages. That picture is in line with the results obtained in Wrocław Plain (compare Fig. 3). R e e v e (1994) claims that the high hedgehog mortality on roads does not result in total disappearance of local hedgehog populations, although some data from village areas indicate that 17 to 33% of the animals from small populations (23–30 individuals) die on roads. It seems that nowadays, in view of the lack of natural predators, the road mortality is an essential factor that stabilises hedgehog populations in rural areas. In western Europe the average population density of hedgehogs in village areas is around 30 animals per 1 km² (H u i j s e r 1999). In detached houses of Wrocław rich in trees and gardens the population of hedgehogs was markedly higher and amounted to 100–200 animals per 1 km², whereas in park areas it was ten times lower (10–20 per 1 km²) (D. Jakubiec – unpublished data). Assuming the mean population of hedgehogs in villages of the studied areas at 30 animals per 1 km² and extrapolating this data to the two largest neighbouring

settlements (Św. Katarzyna and Siechnice, see Fig. 1), which cover the area of 260 ha, we get 78 animals. In 2002, in those localities the overall number of 19 killed hedgehogs was recorded, meaning that the annual loss constituted 24% of the population.

In genetic studies conducted in Oxfordshire (England) it was shown that big differences in genotype exist between hedgehog populations living in village areas which are not so far apart. This indicates that the transfer of genetic material between neighbouring populations is not large and the hedgehog's ability to migrate is small (Becher and Griffiths 1998).

The level of hedgehog losses on the studied road sections in built-up areas depended first of all on the traffic volume. The high correlation found between the number of victims and the number of inhabitants in 17 villages and housing estates reflects differences in size of the settlements. Though hedgehog occurrence was shown to be by 35% lower near roads (Huijser and Bergers 2000), that does not prevent them from crossing the roads and consequently getting killed by the traffic. Studies conducted with telemetric methods showed that in urban areas hedgehogs move mainly along linear elements of the landscape, which thus constitute their ecological corridors (roads, fences, embankments, hedges), avoiding the open spaces of crop fields (Doncaster *et al.* 2001). In large town areas the boundaries of territories run, in general, along the roads with large traffic volume, which are avoided by the hedgehogs during their night feeding (Rondini and Doncaster 2002).

Data from Great Britain and The Netherlands indicate that the highest hedgehog mortality is recorded in July and August, and a steep fall in collisions in September and October (Reeve and Huijser 1999). In the area of Wrocław Plain, like in western Europe, a high mortality was recorded in July. However, contrary to those countries, it was also high in September and October. Rondini and Doncaster (2002) suggest that high hedgehog mortality in autumn is due to the increased hedgehog activity connected with searching for places to feed intensively and hibernate.

Studies carried out in The Netherlands on 30 populations of western hedgehogs have shown that construction of fences along the roads reduced hedgehog mortality. But it also caused a marked decrease in local populations (Bergers and Nieuwenhuizen 1999). Rondini and Doncaster (2002) emphasise that the main drawback of the efforts to reduce mortality (fencing the roads) is the increase of isolation of hedgehog populations.

Main conclusions from this research are following:
1. Currently in Poland, hedgehogs are killed mainly on roads in built-up areas.
2. Animal mortality, including that of hedgehogs, can be decreased by:
a) speed limit to 40 km/h in places of frequent collisions with animals,
b) information signs on routes of animal migration,
c) creation of linear barriers that deter animals from getting on the roads, and construction of passes (under and above road),
d) undertaking and promotion of local actions, mainly by school children, to catch and remove animals from roads and adjacent areas during their migration periods (mainly amphibians).

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