# How often does a strictly arboreal mammal voluntarily cross roads? New insights into the behaviour of the hazel dormouse in roadside habitats

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# How often does a strictly arboreal mammal voluntarily cross roads? New insights into the behaviour of the hazel dormouse in roadside habitats

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**Abstract.** Roads are a threat to biological diversity. Especially the hazel dormouse (*Muscardinus avellanarius*) can be badly influenced by fragmentation due to its strictly arboreal activity. In this study a Northern German dormouse population living in roadside habitats and on road islands at crossroads was investigated to find out if road crossing is an exceptional behaviour or if it happens regularly. With capture-mark-recapture-method 30 crossings (mostly across a federal highway, three of them across a federal motorway) and via telemetry 27 crossings over federal highway and smaller streets were observed. Our study gives evidence, that road crossing can be a relatively frequent behaviour, as 18 % of the mark-recaptured and 60 % of the radio marked animals crossed roads, but it remains unclear, under which circumstances road crossing takes place.

**Key words:** *Muscardinus avellanarius*, road ecology, barrier effect, motorway

## Introduction

One of the main factors threatening mammal biodiversity especially in densely populated areas of central Europe is the impact of roads (Benítez-López et al. 2010). Among the main reasons, why roads can influence populations, are the fragmentation, size reduction and quality detraction of habitats and population decrease due to road mortality (Reck & Kaule 1993, Iuell et al. 2003, Coffin 2007). Few studies show, that there can also be positive effects of suitable roadside habitats on populations (Bissonette & Rosa 2009) and single populations even show adaption processes to roads (Brady 2012).

The study object of this investigation, the hazel dormouse, is a strictly protected species in Europe (Habitats Directive annex IV, Bern Convention annex III) and in the northern German federal state of Schleswig-Holstein it is endangered (Borkenhagen 2014). It is a strictly arboreal species living in the canopy and the edge of forests and in shrubs (Juškaitis 2014). Movements onto and over the ground are a rarely observed behaviour (Bright 1998), but must have occurred at different places also over longer distances (Büchner 2008, Juškaitis 2014).

Movement studies on the hazel dormouse assumed that even small forest pathways function as a significant barrier (Bright et al. 2006), and it is generally accepted, that all kind of bigger roads function as total barriers. Only few studies have given direct and indirect proof, that roads are no total barrier (Chanin & Gubert 2012). As it is still not known, how often and under what circumstances dormice do safely cross roads and thus overcome barriers, we conducted this study on a site, where dormice are known to live in different roadside habitats (Schulz et al. 2012).

## Study Area

In this study we present data from 2014 on the hazel dormouse at a junction of the federal motorway A21 and the federal highway B205 (Fig. 1) close to Bad Segeberg (Northern Germany). Overall traffic load on the motorway and on the highway is rounded 15000

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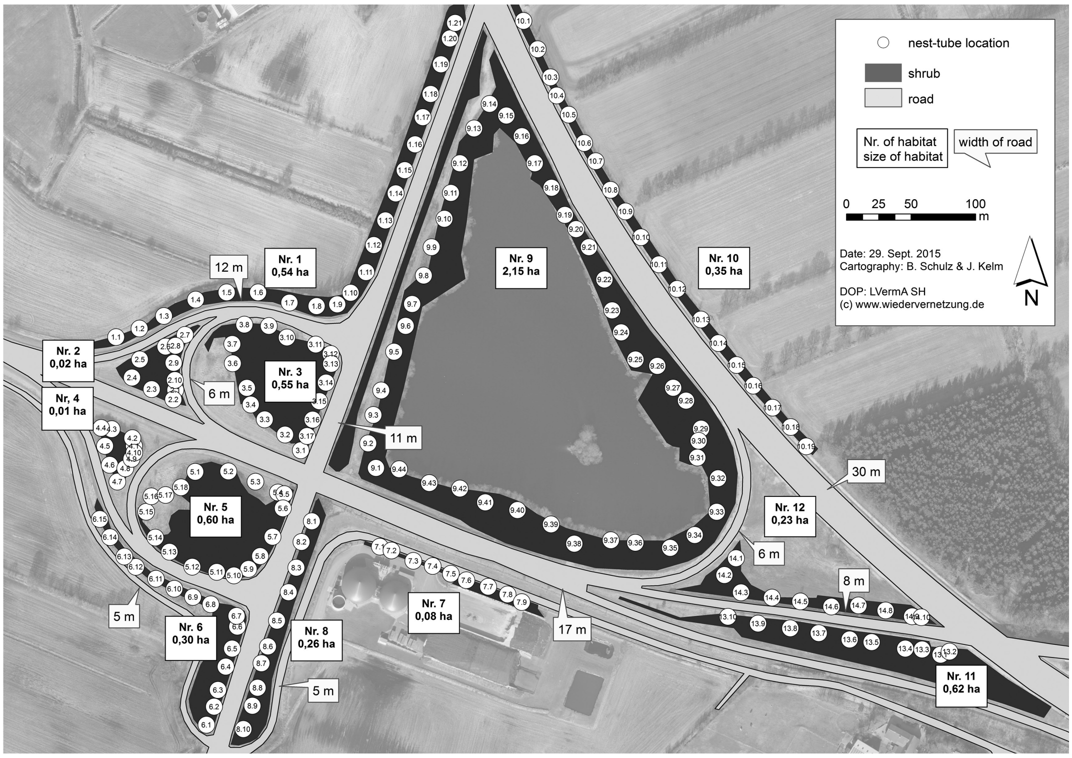


**Fig. 1.** The study site north of Bad Segeberg (Schleswig-Holstein, Germany).

cars per day (BASt 2013), whereas during night hours traffic load can be below 50 cars per hour (Table 1).

For all geographical analysis we used aerial photos on GIS (ArcGIS 10). We considered only areas covered with shrubs and trees as habitats. The habitat quality was high, as there was an overall high structural and species diversity of between seven to nine different shrub species per site. We identified twelve different habitat patches, all of them being islands isolated from other habitats by different types of roads between 6 m and 30 m wide. Apart from deer fences there were no further obstacles like central concrete walls or palisade trenches that could prevent small animals from entering the roads. This junction is surrounded by agricultural landscape with a typical hedgerow network and with single forests.

On the habitat islands we installed nest-tubes for capture-mark-recapture-studies from May 2014 to October 2014. All in all 194 nest-tubes were set up, at least 10 nest tubes per habitat island with distances to each other of 20-25 m (Fig. 1). All nest-tubes were generally checked twice a week.

The captured animals were individually marked (ear holes by biopsy punch for later genetic analysis with 2 mm diameter), single animals additionally with coloured dots in the ear with animal marker pencils (AgnTho's AB) and after marking animals were released inside the nest-tube, in which they were found. Before release nest-tubes were closed for some minutes to let the animal calm down, so that animals were not forced to move.

At the end of the season from September on we conducted additional telemetry-studies on 10 different animals (Table 2). A receiver VR-500 (YAESU) with antenna HB9CV and ten transmitters (Telemetrie-Service Dessau, V2 200 microwatt, 60 days, 0.6 to 0.8 g) with individual frequencies where used. No animals below 17.5 g were used for this telemetry study. Study animals had their hair cut in the neck area for properly gluing the sender with spirit gum (SAUER CONTINENCE). The animals

**Table 1.** Traffic densities (vehicles per hour) at study site.

| Time | Motorway (A21) | Federal highway (B205) | Exit of federal highway |
|---|---|---|---|
| 20:00-22:00 | 205 | 253 | 50 |
| 22:00-24:00 | 75 | 65 | 10 |
| 00:00-02:00 | 4 | 26 | 3 |
| 02:00-04:00 | 24 | 7 | 3 |
| 04:00-06:00 | 30 | 41 | 8 |
| Night average (8 p.m. until 06 a.m.) | 34 | 39 | 7 |
| All day average (BASt 2013) | 688 | no data | no data |

**Table 2.** Animals and data of telemetry periods.

| Animal label | A 67 | A 68 | A 69 | A 2 | A 73 | A 81 | A 82 | A 83 | A 84 | A 85 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sex | male | male | male | male | male | female | female | male | male | female |
| Age | subadult | subadult | subadult | adult | subadult | adult | adult | adult | adult | adult |
| Frequency | 150.191 | 150.154 | 150.066 | 150.206 | 150.010 | 150.218 | 150.175 | 150.041 | 150.031 | 150.057 |
| Date of transmitter setting | 9/4/14 | 9/4/14 | 9/4/14 | 9/4/14 | 9/4/14 | 9/19/14 | 9/18/14 | 9/18/14 | 9/18/14 | 9/19/14 |
| Last day of reception | 10/1/14 | 10/8/14 | 9/18/14 | 10/6/14 | 10/7/14 | 10/7/14 | 10/7/14 | 10/19/14 | 10/7/14 | 9/19/14 |
| Sum of days with telemetry data | 13 | 17 | 10 | 15 | 16 | 6 | 6 | 1 | 6 | 1 |

**Table 3.** Results of telemetry study, only data before and after detected road crossings are given.

| Animal number | Date | Time | Habitat number |
|---|---|---|---|
| A.67 | 9/4/14 | 09:30 | 4 |
| | 9/5/14 | 23:28 | 3 |
| | 9/6/14 | 00:15 | 5 |
| | 9/8/14 | 03:10 | 4 |
| | | 04:08 | 5 |
| A.68 | 9/5/14 | 03:40 | 3 |
| | | 04:15 | 8 |
| | | 04:35 | 3 |
| A.69 | 9/4/14 | 10:20 | 4 |
| | | 22:45 | 5 |
| | 9/5/14 | 00:40 | 4 |
| | 9/6/14 | 22:30 | 5 |
| | 9/7/14 | 20:41 | 4 |
| | 9/9/14 | 01:16 | 2 |
| | | 02:10 | 4 |
| A.2 | 9/4/14 | 10:50 | 2 |
| | | 22:45 | 4 |
| | 9/5/14 | 00:09 | 1 |
| | 9/23/14 | 20:32 | 2 |
| | 10/1/14 | 09:46 | 1 |
| A.73 | 9/4/14 | 11:10 | 8 |
| | 9/8/14 | 20:18 | 6 |
| | | 21:20 | 8 |
| | | 23:22 | 6 |
| | 9/9/14 | 05:31 | 1 |
| | | 20:16 | 6 |
| | | 21:48 | 8 |
| | 9/16/14 | 21:43 | 5 |
| | 9/17/14 | 20:00 | 8 |
| A.84 | 9/18/14 | 11:45 | 9 |
| | 9/19/14 | 10:50 | 3 |
| | 9/23/14 | 22:18 | 5 |
| | 10/1/14 | 09:34 | 3 |

were released at the capture site after the gum had hardened. For five days they were checked from around 20.00 to 05.00 nearly every hour. After this intensive tracking they were checked twice a week from 20.00 to 23.00 and other days once during the day. Telemetry was carried out as long as one animal could be found. Lost animals where searched for in the wider surroundings (5 km in every direction at most suitable places). We used the homing-in method to find out on which habitat island the animal was situated. We resigned from a more precise localisation of an animal on the habitat island, hence, no further analysis of individual movement was possible. Nocturnal traffic density was estimated for five days by irregularly (between 20:00-21:59, 22:00-23:59, 24:00-01:59, 02.00-03:59 and 04:00-05:59) counting cars and trucks for ten minutes for the motorway, federal road and exit roads.

## Results

*Determining road crossings by long-term capture-mark-recapture studies*

During the whole season we recorded 171 different animals inside the nest tubes, of which 64 were too young to be marked, and 107 were marked. 47 of the marked animals were recaptured (with a total of 110 re-captures), 24 of them only once. We proved 30 cases of road crossings, three of them via the federal motorway, 27 of them via minor roads. Crossing of roads was recorded for 19 different animals and more often for males than for females (Fig. 2 and 3).

*Determining road crossings by telemetry studies*

Ten different animals were radio-tracked over a total of 20 days. Six of these showed road crossings, two of them three or four times, four of them between four to six times and one animal was recorded crossing a street eight times (Table 3). In total 27 road crosses were recorded (Fig. 4).

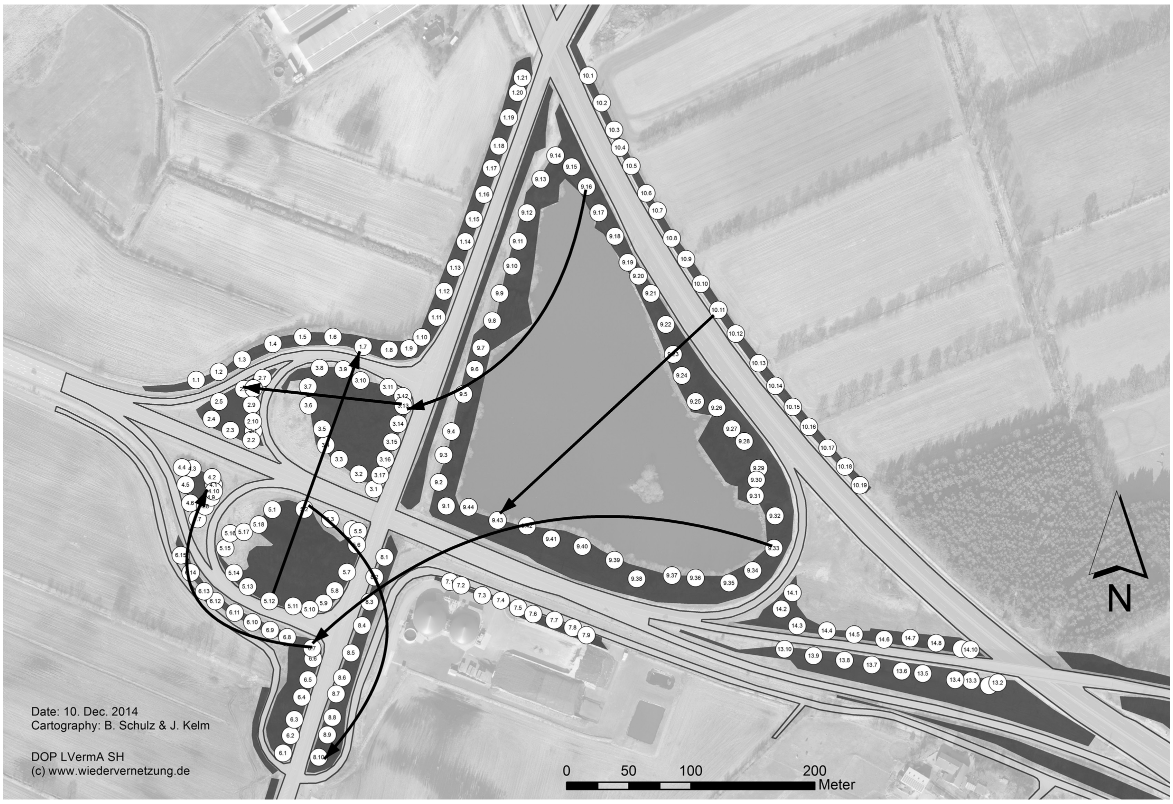


**Fig. 2.** Results of mark-recapture-analysis: only movements with road crossings of female hazel dormice are shown, all other movements are neglected (15.05.-24.10.2014).

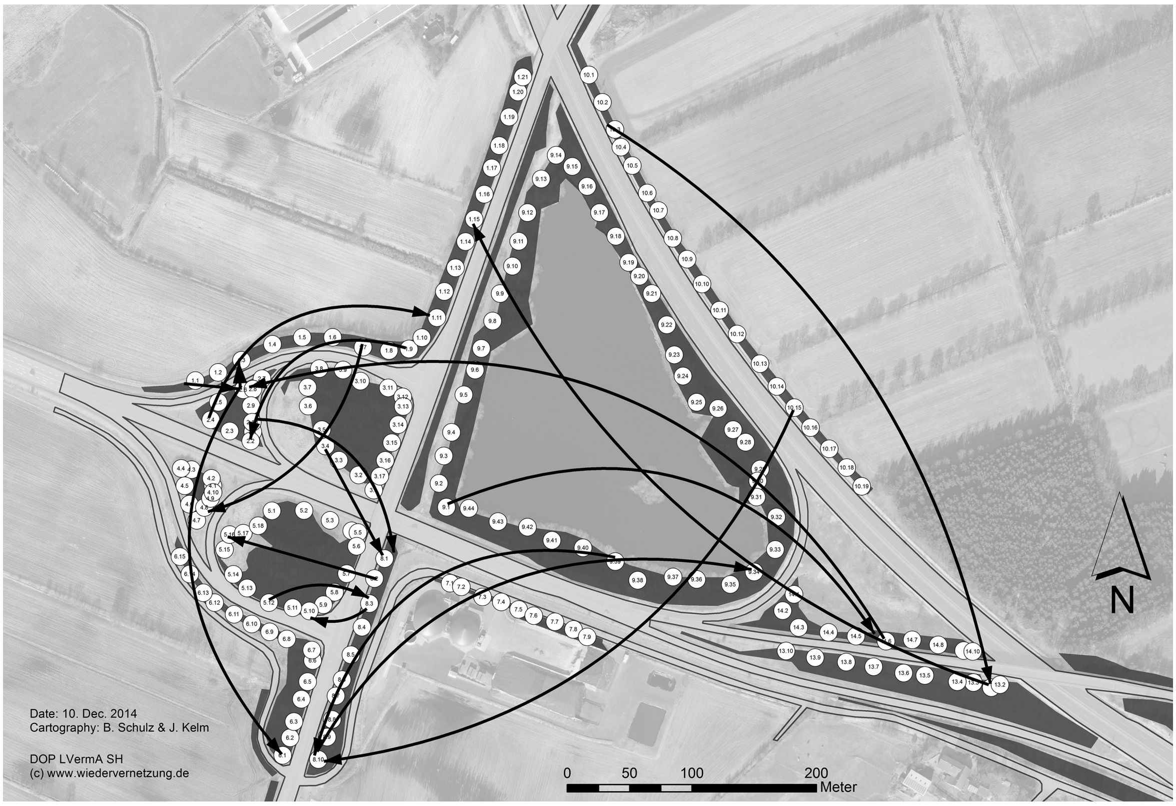


**Fig. 3.** Results of mark-recapture-analysis: road crossings of male hazel dormice are shown, all other movements are neglected (15.05.-24.10.2014).

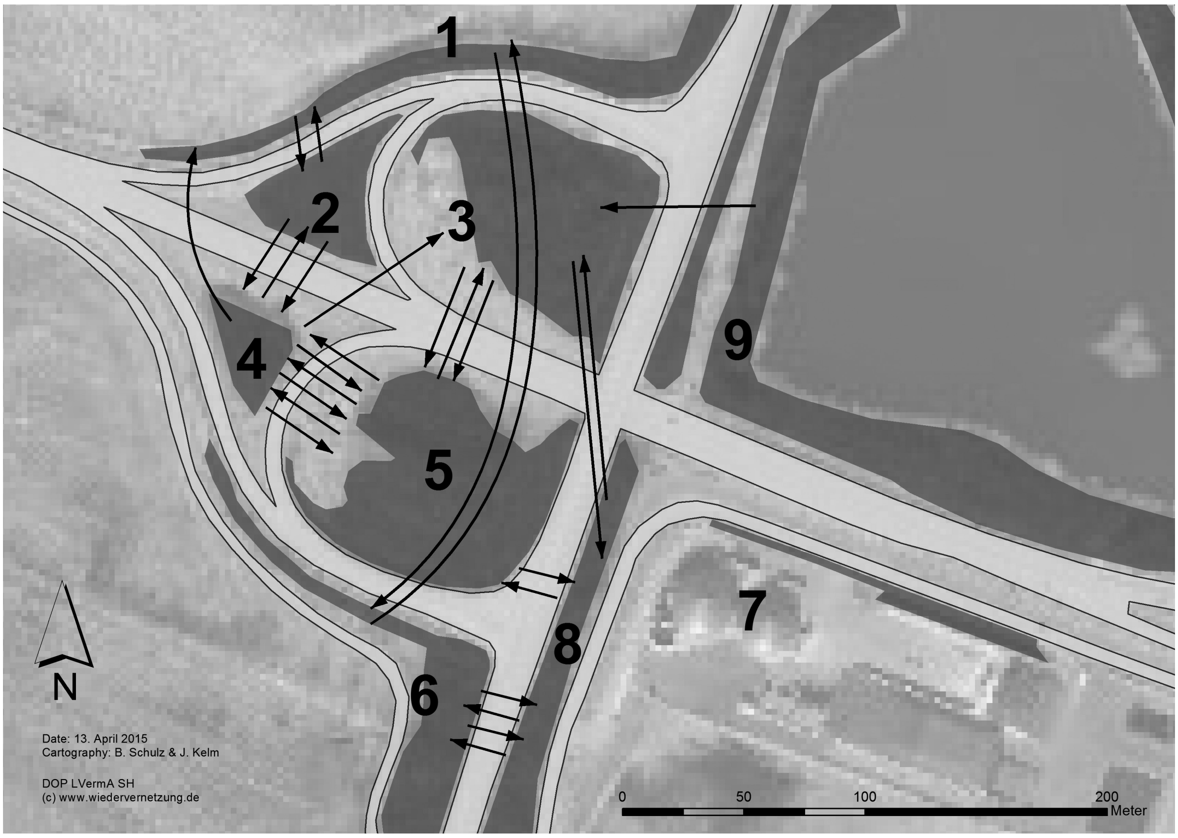


**Fig. 4.** Results of telemetry study: road crossings of hazel dormice (04.09.-15.10.2014), only males were observed crossing roads.

*Traffic densities at night*
Compared to the total daily average number of 688 vehicles per hour (BASt 2013), the average traffic density during night hours was very low with about seven vehicles per hour (exit roads), 37 vehicles (motorway) and 39 vehicles (highway) and a minimum from 0:00 until 04:00 with temporarily less than ten vehicles per hour.

*Movements into adjacent habitats*
Additional 95 tubes were placed in August into suitable habitats surrounding the study site. Here no marked animals were observed during the controls from August until December.

*Population size estimation and population density*
Recapture data were not sufficient for reliable population size calculation. But as we marked 107 different adult (> 17 g) animals in the study area of 5.71 ha habitat, we know that population density was at least 18.7 adult individuals/ha, which is very high according to Bright et al. (2006).

## Discussion

Although the hazel dormouse is regarded as a very strict arboreal species (Bright 1998), we got evidence that at least some animals repeatedly moved on the ground and that they did cross even broad roads up to 30 m. In our study, road crossing was not a rare behaviour, as 18 % of the mark-recaptured and 60 % of the radio-marked animals crossed roads.

We have no proof for road kill. If road mortality is a function of traffic density, road mortality at our study site should be low due to low traffic density during night which is the main activity period of the hazel dormouse. This coincides with McGregor et al. (2004), who translocated different small mammals across roads, and found only few single evidence of returns of animal at traffic density higher than 5.000 AADT (average annual traffic density), a high rate of successful return was given at traffic density of < 2.000 AADT. Richardson et al. (1997) determined high road crossing rates (68 % of all 22 translocated animals), but emphasized the unknown fate of 18 %. According to Rico et al. (2007) also the road width plays a crucial role. In their study with animal translocation experiments, highways wider than 40 m were never crossed, thus they regard wide roads as a barrier on population level.

Our results suggest that an exchange of individuals across barriers like roads is possible. This seems to depend mainly on two factors: The existence of highly suitable habitats surrounding the roads and periods of low traffic density during the activity time of the species on focus. However insurmountable barriers (e.g. concrete walls or palisade trenches) along the road verges or the medial strip would inhibit any exchange and thus lead to strong isolation of populations. So we recommend the abandonment of protective barriers for small animals along roads, as long as there is a realistic chance for successful crossing and no trap-effect. The high percentage of animals only found once and the rapid loss of three radio-marked animals while having no evidence of dispersal into adjacent habitats could be explained by road mortality.

In our study site hazel dormice seem to be able to compensate losses on roads due to good habitat quality and effective reproduction. So in our opinion it is also important to draw the focus on, what we could not find out. Future research should help to answer our following questions:

What happened to the 24 % of the population, that we observed only once, 60 % of them unexperienced subadults? Finding out more about individuals with an unknown fate is crucial for the evaluation what role roads and roadside habitats can play for hazel dormouse populations.

Why were we able to find numerous different crossing animals, while other studies claim the inability of hazel dormice to cross (major) roads? Could habituation or learning effect in the short run and tradition or even selection in the long run play a major role?

What draws the animals to move on the ground and to enter roads? Is our study site very special because of different small island situations, where juveniles are forced to migrate when leaving parental habitat?

How do animals behave when attempting to cross roads? Are crossings happening by accident or do dormice learn or know how to cross roads most safely? Multiple crossings lead to the assumption that at least single animals know very well how and where to cross.

In conclusion, roads on the one hand must be significant barriers for hazel dormice as – according to literature natural crossings are rare and always dangerous – but hard data on this phenomenon is still lacking. On the other hand at least roads with lower traffic density should not always be regarded as insurmountable barriers, under specific circumstances they are to a certain level permeable barriers. The observed crossing rates should be sufficient for genetic exchange, so that is unlikely that roads generally must lead to genetic isolation (Friebe 2015).

Still it remains unclear, what exact circumstances lead to natural road crossing behaviour. As reproduction takes part in even small but apart from the size very suitable habitat islands it is likely that juvenile and sometime adult dormice are forced to migrate from these islands and thus road crossing is unavoidable. And it is also likely that crossing is not an accidental occasion.

Last but not least on the one hand it must be emphasized that the best way to mitigate the negative effect of roads would be not to build any new roads, the removal of existing roads or the construction of a coherent system of fauna passages linked to a habitat network in the existing road network. On the other hand we must question if large-scale intensive agriculture creates much more severe barriers than minor highways and if in such intensively used agro-landscapes sympathetic management of roadside hedgerows can lead to source habitats and pathways for dispersal, supporting the survival of some threatened species.

## Acknowledgements

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