USE OF FAUNA PASSAGES ALONG WATERWAYS UNDER HIGHWAYS

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Abstract

Since 1975, the Ministry of Transport, Public Works and Water Management in the Netherlands has been building fauna passages crossing under or over highways and also adapting viaducts, bridges and culverts for joint use by fauna. The use of specific fauna passages like ecoducts and badger and amphibian tunnels is relatively well-known, but with respect to adapted passages, until 1997 we knew very little about which species use them, and their frequency of use.

To fill in this gap in that year a survey was carried out throughout the Netherlands on passageways along waterways crossing under highways, since many culverts and bridges were adapted in the nineties. One well-known and two rather new methods were used. Movements of animals were recorded with adapted infrared detectors. More detailed information was obtained from footprints and tracks, left in sandbeds and on paper, fixed on both sides of an 'ink' bed on the passageway. The target group of the footprint survey were mammals, though we collected tracks of amphibians as well. In 1998 an experimental study started to find out the optimal width of a passageway under a bridge and the effect of cover material put on an extended bank on the frequency of use. Again sandbeds and the ink method were used.

The tested investigation methods for faunal movements worked well, provided the (larger) underpass was not heavily used by humans. All investigated passageways were used, but the broader they were, the more frequently they were used and the more species were found. Amphibians did not show this relationship between width and use of passageways. Extended banks seem to be most attractive: most species were found there.

The experimental study will be continued.

Introduction

The Netherlands have a dense road net with a total length of 113,419 kms of paved roads in 1996. The total length of highways amounted to 2207km (CBS, 1999). The length of unpaved roads is, contrasting with that of paved ones, declining and amounted in 1996 to 11,111km. Per square kilometer the length of paved roads averages out at 2,5km. By comparison, for the Federal States of German these lengths vary between 0.4 and 0.9 (Georgii, 1999) and for Norway it is 0.08 (Iull, 1999). In 1990, the concept of an Ecological Main Structure (EMS) was introduced in the governmental Nature Policy Plan (LNV, 1990). Core areas, nature development areas and connecting zones to be developed were distinguished. Concerning nature protection and development these areas will have priority. Nevertheless roads are yet intersecting these areas causing among others problems to movements of animals between the different parts of their habitats. In 1990 too the government laid down the policy to tackle among others these fragmentation problems in the Second Transport Structure Plan. This policy was formulated as follows: in the short term there is to be no further fragmentation of the countryside and in the longer term fragmentation is to be reduced (V&W, 1990). As a consequence of this governmental decision mitigating the impacts of highways has been intensified during the last decade resulting in many more faunal passageways.

The use of specific fauna passages like ecoducts and badger and amphibian tunnels is relatively well-known (Nieuwenhuizen & Van Apeldoorn, 1995; Bekker & Canters, 1997; Vos & Chardon, 1994), but with respect to adapted passages, until 1997 we knew very little about which species use them, and their frequency of use (Smit, 1996; Veenbaas & Brandjes, 1997). This was the reason we carried out a survey in 1997 to investigate the use of fauna passages along waterways crossing under highways as these types of wildlife passageways are relatively numerous in the Netherlands. As target species or group of species of these type of fauna passages are mentioned: mustelids [polecat *(Mustela putorius)*, stoat *(M. erminea)*, weasel *(M. nivalis)*, beech marten *(Martes foina)*], badger *(Meles meles)*, otter *(Lutra lutra)*, hare *(Lepus europaeus)*, hedgehog *(Erinaceus europaeus)*, roe deer *(Capreolus capreolus)*, small mammals [water shrew *(Neomys fodiens)*, bank vole *(Clethrionomys glareolus)*], amphibians and grass snake *(Natrix natrix)* (Brandjes and Veenbaas, 1998).

The study aimed to discover which mammal species or group of species were using these fauna passages, and how frequently they were passing through them. Furthermore, attention was also paid to species which do not use these passages, although they apparently are present in the area according to atlases and other references, and while their habitat seems to be available near the passageway. Correlations between the use of the passages and their layout, age, substrate and other presumed important factors were investigated.

A second goal of the survey was to test two new investigation methods in practice.
Based on the results of the first survey we started in the following year an experimental research to find out optimal width of wooden passageways and if cover material on extended banks improves the frequency of faunal use.

Locations and types of wildlife passageways

In the first survey we selected 20 sites throughout the Netherlands including 31 fauna passages of several different types. There were extended banks (photo 1), unpaved and paved, with a width of 150 - 350 cm; planks fixed on the bridge or culvert wall (photo 2) and with a varying width of 25 to 60 cm; planks floating on the water surface, width 29 cm; concrete passageways, 40 - 130 cm wide and plastic gutters covered with sand, 24 cm wide. The width as well as the height of the whole underpasses was varying too at the different locations and that goes also for the length of the passageways.

In the second study foot print data were collected from 22 wooden passageways, nearly all fixed on the bridge or culvert wall, width varying from 20 to 60 cm and 24 so-called extended banks with a substrate consisting of soil, sand, bricks and asphalt or concrete and asphalt. The width of these passageways varied strongly (72 - 1220 cm). In the widest ones there is a municipal road as well crossing under the highway.

Methods

In addition to the well-known method of sandbeds to get information from footprints, new or adapted methods were used: infrared detectors were adapted for recording faunal movements and an 'ink' method to get footprints on paper. In the survey of 1997 the whole investigation period ran from week 27 to 44. In the experimental research the next year investigation of the wooden passageways were carried out in September until half of October; that of the extended banks from half of October till half of December.

Photo 1. Extended bank under a bridge.

Photo 2. Plank fixed on the wall of a culvert as a fauna passage.

Infrared detectors

Standard infrared detectors were modified to be able to record the movements of small animals. Movements were stored in memories that could be read-out by a special receiver combined with a portable computer. After some weeks the detectors were further improved: they also recorded date and time of movements. The detectors were fixed on the undersides of bridges or in the culverts above passageways. Mostly they were read out weekly to limit loss of information in case the detectors were stolen. The maximum recording period per passageway was eighteen weeks, although in some cases it was as little as three weeks.

Ink method

On straight passageways not wider than 1 m, the new ink method was used: a mix of liquid paraffin with some carbon powder (40 gr/l oil) was spread out on a plasticized sheet of paper with a small upright rounded edge or (in 1998) a kitchen towel saturated with this mix was put on a plastic container of the required size fitted with a small brim. On either side of this ink container sheets of paper were fixed. The ink bed and paper covered the whole width of the passageway, and their length was respectively 35 and (2x) 102 cm.

The paper sheets were checked weekly for prints and tracks and sheets were replaced with new ones if more than about three tracks were printed. In the first survey for most of the fauna passages the monitoring period was eleven or twelve weeks in total; for one passage it was nine weeks. In the second survey tracks were monitored during four weeks. Tracks and prints were determined in the office and in some cases determination was checked by another expert in footprints.

Silver sandbeds

Sandbeds were used on the banks of waterways, extended under bridges, sometimes paved and on sandy faunal passageways. A fine kind of sand (silver sand) was used to get prints of small mammals. This type of sand does not harden on drying out. Sandbeds were checked weekly for foot prints and tracks, which were determined to species level, if possible. Afterwards, the sand was equalised and rolled to smoothen the surface. In the first survey the monitoring period was seven weeks for four passages and for the other two it was five and six weeks. In the second survey monitoring period ranged from four to seven weeks (mostly five).

Results: Methods

Some of the study sites, especially some large underpasses, turned out to be unsuitable for the used investigation methods as too many humans were using the sites, destroying the animal tracks and/or removing the infrared detectors.

Infrared detectors

Registration of movements with adapted infrared detectors works well for larger animals and/or animals that move not too slow. Newts were not always (or never?) recorded and it is not clear if toads and frogs are detected. The average number of electronic registrations was about 2.5 times as much as the number of tracks. In some cases, depending on the outlay of the underpass, possibly some swimming or flying birds could have been registered. It is also possible that animals, strolling near the detector, are recorded, once or maybe even more times, but do not pass through the passageway. Another reason is that some individuals of larger species (cats, polecats and stoats) managed to jump over the sand or ink bed (Brandjes *et al*., 1999): this individuals are registered by the infrared detector, not in the sand or on paper.

Nevertheless this method gave a good rough insight in time of passing of animals. Most passages were used most frequently in the evening or night, but some were frequented by day as well as at night.

Ink method

The ink method gave good prints of mammals. Tracks of larger species often could be determined on species level. Even for some smaller ones this was possible (prints of adult water shrews *(Neomys fodiens)* for instance). We did not expect to find prints of amphibians, but we found rather many! These tracks could mostly be determined as from >toad=, >frog= (photo 3) or >newt= and sometimes >newt= was obviously not a smooth newt *(Triturus vulgaris)*, but a larger species. We did not find indications that the ink bed acts as a barrier for the target species.

Frog Toad

Stoat

Photo 3. Ink prints of a stoat, frog and toad.

Silver sandbed

The silver sandbeds too gave good prints of mammals, even of smaller ones. If the sand was put on the soil, it did not dry out and prints were kept well. But in this slightly moist silver sand tracks of amphibians were unclear. If the underground was paved, the sand dried out and tracks of mammals were less clear. On the contrary, tracks of amphibians were clearer then (Brandjes *et al*, 1999). Sand containing loam turned out (in a test) to harden after a while; silver sand did not for all the time.

Results: use of faunapassages

In 1997 we got data of tracks from 22 passages. As in autumn in 1998 precipitations were extremely heavy and long-lasting, most waterways had a high water level and some banks were partly or completely inundated. As a result from 5 extended banks we could not get enough data; from 19 passages of this type we had information of at least four weeks.

All investigated fauna passages were used by mammals; 62% were used by individuals of target mammal species or - groups. About 75% were used by amphibians too (excluded extended banks in 1998, as the investigation period was too late for this group). Underpasses with the largest relative diameter were used most frequently by mammals. (Relative diameter is defined as: width of whole underpass multiplied by height and divided by the length of the passageway.) For amphibians we did not find this relationship.

For mammals there was as well a positive relation between width of the passageway and frequency of use. We did not find a relation between substrate type and frequency of use.

Most of the investigated fauna passages are frequently used by the brown rat *(Rattus norvegicus)* and many also by mice or voles, while some are frequented by birds too, for instance the blue heron *(Ardea cinerea)* and coot *(Fulica atra)* (Table 1).

In the first survey target species of the mustelids seem to require wider planks: tracks of stoats (photo 3) were not found on planks narrower than 40 cm and tracks of polecat not on planks narrower than 60 cm. In the second investigation however stoats frequently passed through planks of 20 cm wide; polecats did that too, but only incidently. Table 1 gives an overview of the total number of tracks of mammal species (pets and humans excluded) found in the group of fauna passages consisting of the (mostly narrower) wooden or concrete passageways and the plastic gutters, and on the other hand the group of the extended banks. This number is translated in the index per species. This is the number of tracks of that species divided by the total number of investigation days for that group of fauna passages in that year. (One week with no problems with the ink - of sandbed gives seven investigation days for one fauna passage.) It is clear that polecats and beech martens frequent extended banks more than the other group of fauna passages. For stoats (and red squirrels, but they pass only incidently) it is less clear.

The table shows as well the total number of the investigated species per group of fauna passages. It is obvious that extended banks are attractive or suitable to more species than the other types of passageways.

Discussion

The improved ink method with a saturated mat worked very well. Possibly this mat inhibits animals less than the firstly used plastified sheet of paper with the slippery =ink=. It gave also less adverse effects on invertebrates.

Silver sand was found to give good prints, especially from small mammals. But in case of strong winds it was blown away, leaving no or unclear prints.

The infrared detectors are useful to get a first idea of any use of the fauna passage. Moreover they can give extra information (time of passing) in combination with more specific investigation methods. They also could be used to start a photo or video camera.

Although the otter is mentioned as a target species this species rather recently became extinct in the Netherlands. There are plans though, to reintroduce the otter and in his potential habitat fauna passages suitable for otters are constructed or planned.

It is clear that for use of fauna passages by target species, presence of suitable habitat in the surroundings of the passage and presence of the species in that area are important factors. Pine marten is restricted to some rather small areas and beech martens and badgers are not widespread in the Netherlands so these species can only be expected to pass in some areas.

It is striking that only very few tracks of hedgehogs were found while this species is widespread in the Netherlands. Possibly hedgehogs do not prefer the near surroundings of waterways. The passageways their tracks were found on, are relatively wide: 60 and 80 cm.

Remarkable too is that no tracks of snakes were found although on several sites suitable habitat for grass snakes was available. They possibly need other types of passages.

Conclusion

Bridges and culverts adapted for use as a fauna passageway can function for several species. The following overall conclusion can roughly be drawn: The wider the whole underpass and the wider the passageway itself, the better the fauna passage can function.

Follow-up

The investigation of 1998 was the first part of an experimental research. In the current year the fauna passages will be adapted: a part of the investigated wooden planks are widened to 70 respectively 100 cm and half of the extended banks will be supplied with cover material like tree trunks. Next year the investigation will be repeated to find an optimal width for planks and an optimal design for extended banks.

As several highways are widened last years or will be so in the next future, questions of optimal relative diameter of underpasses and maximum length of a passageway become more and more urgent. There is also a need for combining functions as space is very scarce. Questions of combining faunal and recreational use of constructions like ecoducts are rising.

Last but not least: we have to know effectiveness of fauna passages: will local or regional populations persist thanks to (among others) built fauna passages? We try to set up research to answer this question for one or some species (as indicator species). The first step to answer that question (knowledge of which species do use which type of fauna passage and, if possible, under which circumstances) is important and current investigations contributed to this step.

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Photo 1. Extended bank under a bridge.

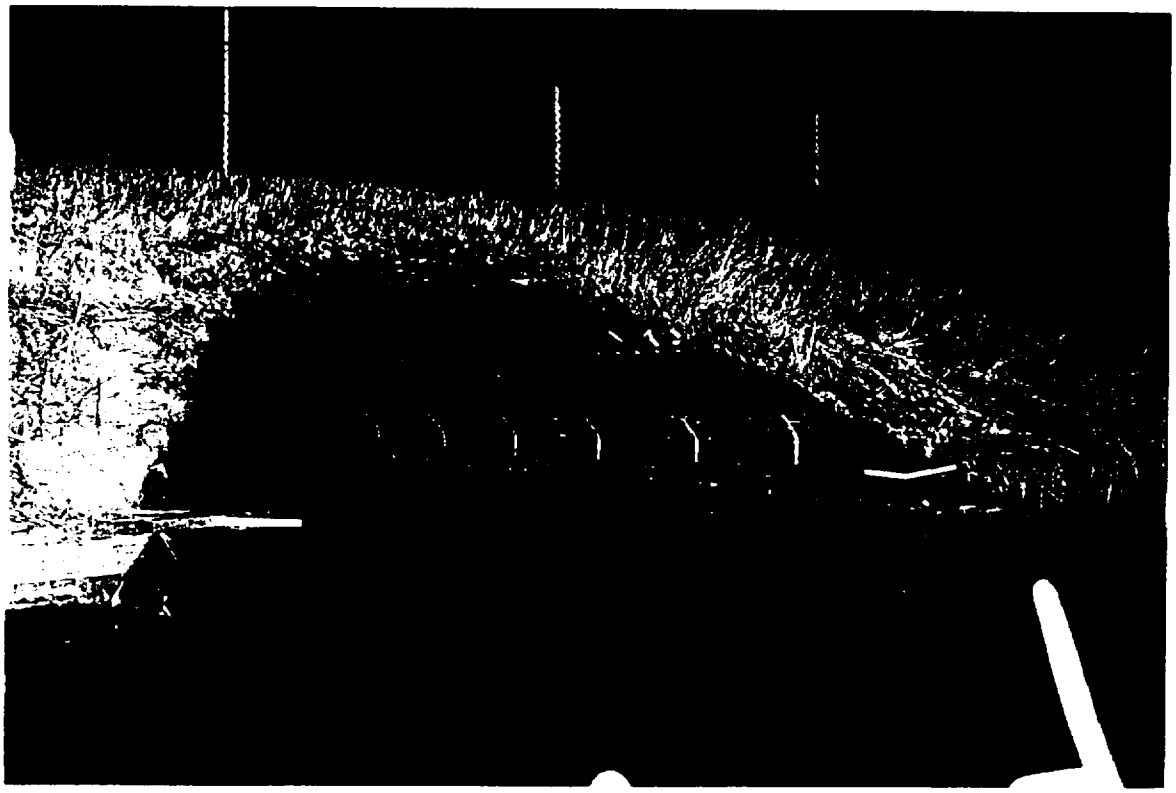

Photo 2. Plank fixed on the wall of a culvert as a fauna passage.

	wooden passageways						extended banks					
	N tracks '97	index '97	*N passages '97*	N tracks '98	index '98	*N passages '98*	N tracks '97	index '97	*N passages '97*	N tracks '98	index '98	*N passages '98*
water shrew *(Neomys fodiens)*				24	0.038	*2*						
muskrat *(Ondatra zibethicus)*							9	0.023	3	*	*	*3*
weasel *(Mustela nivalis)*				11	0.017	*5*				4	0.006	*3*
stoat *(Mustela erminea)*	23	0.017	*4*	65	0.102	*7*	22	0.057	2	2	0.003	*2*
polecat *(Mustela putorius)*	10	0.008	*4*	13	0.020	*6*	65	0.169	7	84	0.116	*9*
beech marten *(Martes foina)*				9	0.014	*3*	1	0.003	1	27	0.037	*4*
red squirrel *(Sciurus vulgaris)*				3	0.005	*1*				5	0.007	*1*
water vole *(Arvicola terrestris)*	2	0.002	*1*	*		*1*	9	0.023	3	*	*	*1*
hedgehog *(Erinaceus europaeus)*	3	0.002	2									
mice, voles	**	**		787	1.235	*22*	**	**		453	0.627	*19*
brown rat *(Rattus norvegicus)*	466	0.352	*14*	**	**	*16*	107	0.278	6	**	**	
hare *(Lepus europaeus)*										4	0.006	*3*
rabbit *(Oryctolagus cuniculus)*										55	0.076	*10*
roe deer *(Capreolus capreolus)*										4	0.006	*1*
mole *(Talpa europaea)*										7	0.010	*5*
red fox *(Vulpes vulpes)*										17	0.024	*8*
investigated passageways/banks		*16*			*22*			*6*			*19*	
total investigation days		*1323*			*637*			*385*			*723*	
number of species (excl. mice/voles)		*5*			*8*			*6*			*13*	

Table 1. Use of the investigated fauna passages by mammals (excluded pets and humans). N tracks = number of tracks per species and type of passageway. In the data of wooden passageways 1997 are data of concrete passages and plastic gutters included. Index = number of tracks divided by number of all investigation days of all the passages of that type investigated that year. (One week for fauna passage without problems with sandbed or paper sheets means seven investigation days) *, **: tracks (few respectively many) of species found not counted. N passages = number of passages where tracks were found.