Amphibians crossing under motorways: solutions for migration or dispersion?

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Abstract. Since 1975, the Ministry of Transport, Public Works and Water Management in the Netherlands has been building fauna passageways crossing under or over motorways and has also adapted viaducts, bridges and culverts for joint use by fauna. Most fauna passageways are realised over and under 4-lane highways with intensive traffic and concern badger pipes, fauna strips under bridges and in culverts and stub walls alongside the road crossings under viaducts. All are constructed primarily aiming for a save passage of mammalian species. Surveys have been carried out, using different methods, to evaluate the use of fauna passageways by target species. Amphibians use a significant number of fauna passageways as well, including badger pipes longer than 40 meters. Detailed information of amphibian use was obtained from footprints and tracks on paper using an 'ink bed' or on sand beds on the passageway. These methods work well to distinguish prints of the species groups 'frog', 'toad' and 'newt'. These methods are not suitable to distinguish individual amphibian species. For the most frequently used passages the number of passages is 1 amphibian in 3 to 4 days, which equals 20 or more animals in the research period. Toads use fauna passageways more frequently than frogs and newts. Newts were not recorded in fauna pipes. The frequency of amphibian use for passages under motorways is considerably lower than expected for seasonal migration. On the other hand for 'occasional use' the requirements of a fauna passageway seem less strict, compared with passages for seasonal migration. The results indicate that different types of fauna passageways play a role in mitigating the barrier effect of motorways by facilitating potential dispersion of amphibians. For choosing the best solution for a fauna passageway the requirements for amphibians next to mammalian target species are important. Fauna passageways should be located near suitable habitat.

Key words: fauna passageway, amphibians, The Netherlands

1. Introduction

In the Netherlands many fauna passageways are constructed crossing under or over motorways. This includes new passages as ecoducts and fauna pipes as well as the adaptation of existing viaducts, bridges and culverts for joint use by fauna. The Road and Hydraulic Engineering Institute of the Dutch Ministry of Transport, Public Works and Water Management commissioned several systematic studies to evaluate the use and effectiveness of the fauna passageways. The results are used to improve layout, design and maintenance of existing and planned passageways.

In this paper we discuss the effectiveness for amphibians of fauna passageways costructed under 4-lane motorways with intensive traffic. These motorways are considered to be effective and absolute barriers for terrestrial animals resulting in complete isolation of populations at both sides of the motorway (Fig. 1).

Fig. 1. Motorways are efficient barriers for terrestrial fauna

Fauna pipe

A fauna strip (wood beam) in a culvert

Stubwall under viaduct

Fig. 2. The fauna passageways

The fauna passageways include fauna (badger) pipes, fauna strips under bridges and in culverts, and stubwalls alongside road crossings under viaducts (Fig. 2). The lengths of all fauna passageways vary from 40 up to 80 meters. The fauna pipes have a diameter of 30 up to 100 cm. Pipes with a diameter of 40 cm are most commonly applied. The fauna strips along waterway crossings vary from 25 cm wide wooden strips to extended banks under bridges with a width of several meters.

Most passageways are constructed primarily aiming for a save passage of mammalian target species. Field studies carried out to assess the use by target species revealed the use by unexpected species, for example Eurasian red squirrel and pine marten in fauna pipes. The first field studies also revealed that toads, frogs and newts visit the passageways under motorways (Brandjes *et al*. 2000). Though the locations for the fauna passageways were not selected for the presence of amphibian habitat, amphibian visits were common.

We will compile the results of different studies and discuss the implications for selecting solutions for amphibian target species. Field studies have been carried out in 1997, 1998 and 2000, 2001 and 2002. A total of 120 passages (64 underpasses under bridges and culverts, 50 badger pipes, 3 stubwalls, 3 non adapted tunnels) were investigated.

2. Methods

All passageways are surveyed for tracks using sand beds (Fig. 3A-B) or track boards with ink and paper (Fig. 3C-D) (Brandjes *et al*. 1999). Amphibian footprints are identified as 'toad', 'frog' or 'newt' (Fig. 3E). The method does not allow for identification at species level. All field studies are carried out in the autumn period for 6 to 8 weeks. In a study of 50 fauna pipes spring was included in the survey period and the results of both periods were compared (Veenbaas *et al*. 2003).

Each location is visited weekly. At each visit the tracks on sand beds were directly identified, registered and erased to prepare the sand bed for recording new tracks. Track boards were supplied with fresh ink and paper. Each track board had two paper sheets, one on either side of the ink zone. The paper was marked with location, date and a direction key (arrow in or arrow out). This way at each visit paper could be collected when tracks were identified later in terms of numbers of animals moving in or out the passage way. Usually only one track board was placed at a passageway. The difference in number of tracks in and out a passageway is considered as the minimum number of animals to have crossed the complete passageway.

Results of different studies can be indexed and compared using the number of recorded passages per week. Brandjes *et al*. (2002) use the following index: animal use is considered *occasional* if 1 or 2 passages were recorded in the survey period (<0.3 passages/week); animal use is considered *regular* with a maximum 1 recorded passage per week (0.3-1 passages/week); animal use is considered *frequent* with an average of more than 1 recorded passage per week (>1 passages/week).

3. Results

In a systematic study of 45 fauna strips under culverts and bridges (Brandjes *et al*. 2000; Brandjes *et al*. 2001), for 70% of the passageways visits of amphibians were recorded in 1998. This included 27 wood beams and 5 extended banks. Toads are the most frequent users of locations with wood beams (48% of all tracks) followed by newts (29%) and frogs (23%). For most locations the visits were occasional (50%). Frequent visits of wood beams were recorded at a few locations. At 6 locations toad tracks were recorded more than once a week. The maximum frequency was 1.6 animals per week. At 3 locations newt tracks were recorded more than once a week. The frequency varied from 1.6 up to 2.0 animals per week. Frequent visits of frogs were only recorded for 1 location (1.2 per week). In 2000 a selection of locations was optimised for animal passages in general by adding shelter material or broadening the wood beams. For amphibians these measures did not show significant effect on the use of the passageways, though positive effects were recorded for mammals (Brandjes *et al*. 2001).

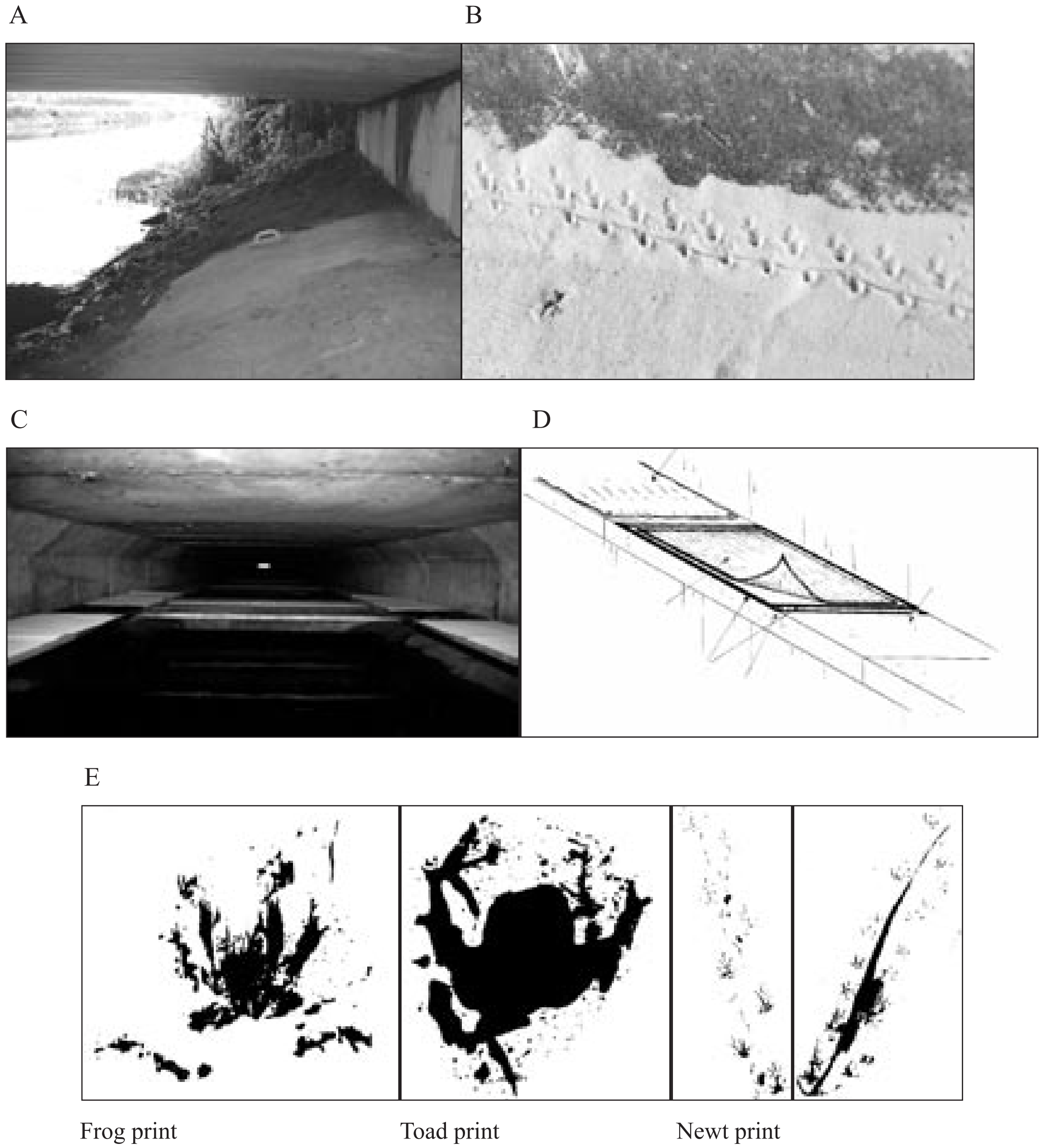

Fig. 3. Research methods of using to amphibian passages

In a systematic study of 50 fauna pipes amphibian passages were recorded at 12 locations. Toads were recorded at 9 locations and frogs at 10 locations. No newt tracks were recorded in fauna pipes but did occur at reference track boards in the direct surroundings (Brandjes *et al*. 2002). The use varied from occasional to frequent. The maximum toad frequency was 1.9 visits per week. For frogs the maximum frequency was 2.0 visits per week. The frequency of toad and frog visits was highest in pipes with high humidity. At each location the numbers of 'tracks in' and 'tracks out' were different which indicates real passages. The study included some pipes under regional roads of less than 40 meter length. The average frequency of visits in these pipes was higher than in the longer pipes. Spring was included in the study period, but the results did not show any difference in amphibian use between spring and autumn.

Several other studies are carried out to assess the use of individual fauna passageways. One study includes 3 locations with stubwalls under viaducts (Ottburg & Smit 2000). All amphibian groups frequently visited the stubwalls. At one location the number of newt visits was with 4.0 per week remarkably high. Both other locations had only occasional visits for newts. The maximum number of visits for toads and frogs was also recorded at this location and was 2.3 visits per week. The stubwall at this location was extended to a pond near the verge of the motorway, thus fitting optimal in the landscape.

Some studies are concerned with non-adapted situations. The results of one study show that amphibians use tunnels for local traffic in a nature area (Van Eekelen & Smit 2000). The intensity of traffic is expected to be very low, a few vehicles per day. At 3 studied locations toads, frogs and salamander visit the tunnels regular to frequent. The maximum number of visits is registered at one crossing. Newts, toads and frogs are recorded with 3.0 visits per week and 1.3 and 1.0 visits respectively. Also mammals where recorded frequently. Probably due to the low traffic intensity combined with the relatively high dimensions the tunnels function as fauna passageways.

4. Discussion

Toads, frogs and newts use a wide variety of fauna passageways under motorways. The numbers of visits vary from once in a study period of several weeks up to several visits a week. There are no known passageways under motorways with large numbers of recorded amphibian passages. Large numbers of amphibian crossings are known in The Netherlands from local roads, especially in spring time when hundreds of toads migrate within a short period to their spawning site. In autumn, with a maximum of 4 individual visits, most fauna passageways under motorways are used by only a small group of individuals. Only one study included the spring period. This frequency of visits of fauna pipes was relatively low in spring as well as in autumn.

Taking into account the relatively low numbers of toad, frog and newt visits and the average low density of fauna passageways under motorways (less than 1 per kilometre) there is no indication that fauna passageways under motorways play a role in seasonal migration of amphibians between hibernation site and spawning sites.

The use of fauna pipes in these studies by frogs and toads is remarkable. The dimension of the studied pipes (average 40 cm) is significantly smaller than recommended for amphibian tunnels under motorways. For amphibian tunnels Vos & Chardon (1994) recommend a diameter of 100 cm. Tunnels with this diameter are effective to facilitate seasonal migration under local roads (Glandt *et al*. 2003).

The results discussed in this paper show that toads, frogs and newts, use fauna passag ways under motorways that are primarily designed for mammals. Amphibian tracks are also registered in non-adapted tunnels with occasional traffic. The relatively low number of registered passages indicates that the passageways have a potential role in the dispersion of amphibians rather than in seasonal migration. We assume that the acceptance of the studied fauna pipes by toads and frogs follows from dispersing animals. The requirements of fauna passageways are expected to be lower for dispersing individuals than in case of migration.

Several studies emphasize the role of roads in fragmenting amphibian habitat. Vos and Chardon (1998) showed that the barrier effect of roads could explain the local distribution pattern of the moor frog in The Netherlands. The high mortality of amphibians crossing roads is considered as the main factor in habitat fragmentation. In this respect motorways can be considered as highly effective barriers. However where a fauna passageway is present the barrier effect is mitigated to the level of potential dispersion. Exchange of individuals between populations on either side of the passageway is possible.

For dispersion of animals in general the motorway will be a bottleneck. The end of the fauna passageway can be considered as a local starting point for dispersing animals on the other side of the road. Given the low density of fauna passageways under motorways the effect is expected to be local. The effectiveness will depend from the distance to the nearest population and the resistance of the habitat in between. In general it can be expected that the closer a passageway is located to a population site, as a pond or other reproduction site, the more it will be used by amphibians. The relative high frequency of newt visits of a stubwall next to a pond supports this.

The results of the different field studies, with amphibians as an example, show the importance of carefully defining the targets before choosing the best solution. For species with limited mobility as amphibians, fauna passageways under large barriers as motorways can facilitate dispersion. In choosing the best solution, the location of a passageway near suitable habitat (in case of amphibians a reproduction site) can be more important than the type of passageway. The following practical recommendations can be given: (*i*) choose target species with comparable habitat requirements; (*ii*) define for each species a dispersion either migration target; (*iii*) choose the best possible design for the local situation; (*iv*) make sure suitable habitat is easy accessible – it can be available or created in the direct surroundings of the passageway.

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