Short Communication

What type of amphibian tunnel could reduce road kills?

David Lesbarrères, Thierry Lodé and Juha Merilä

Abstract Increased traffic volumes worldwide are contributing to amphibian declines, and measures to reduce the occurrence of road kills are needed. One possible measure is the construction of underpasses through which animals can pass under roads, but little is known about whether amphibians will choose tunnels if given a choice or about their preferences for different tunnel types. We tested the preferences of three anuran species for two kinds of concrete amphibian tunnels currently used in France. One was a tunnel lined with soil, the other a bare concrete pipe. The animals could use the tunnels or bypass them over a grassy area. Water frogs *Rana esculenta* and common toads *Bufo bufo* showed a preference for the tunnels, whereas agile frogs *Rana dalmatina* avoided them. Among the individuals that chose either of the tunnels, all species showed a significant preference for the tunnel lined with soil. These results indicate that species differ in their preferences and in their likelihood of using underpasses when given a choice. This highlights the fact that there is no unique solution to the problem, and underpasses are only one of the possible mitigation measures that need to be assessed.

between February and May 2001. The experimental design consisted of two concrete tubes (diameter = 0.5 m, length = 2 m) placed next to each other on a grass surface (Fig. 1). The bottom of one of the tunnels was lined with sand and humus and the other had a plain concrete surface. We placed two 0.5 m lengths of drift fence at a 45° angle with respect to the tunnel openings (Fig. 1) to simulate highway fences and provide the same probability of choices. Animals could also choose to bypass the tunnels and pass across the grass (Fig. 1).

Adult males and females (sexes were pooled in all analyses as they did not differ in their choice in any of the species) in breeding condition were used (42 water frogs, 32 agile frogs and 41 common toads). During the test period animals were maintained in individual vivariums and released back to their native ponds after the experiments.

The experiments began by placing a single test animal 1.2 m in front of the tunnels. Each experiment lasted for 10 minutes and was repeated 4 days later, using the same individuals, to test for consistency of choice amongst individuals. We first tested each species’ preference for tunnels by comparing the number of individuals that chose either of the tunnels (2 alternatives; combined width 1 m) with the number of individuals that chose to bypass the tunnels across the lawn (2 alternatives; combined width 1 m; Fig. 1). After testing for potential preference for tunnels, we restricted the analyses to those individuals who chose either of the two tunnels, and tested for preference with respect to the substrate within the tunnel. In addition to testing the preference for a particular tunnel type, we also scored (on a scale of 1–5; Fig. 1) the distance that each individual that entered either of the tunnels had moved forward during the experiment. We called this measure ‘crossing success’.

Fig. 1 Schematic representation of the experimental design for the choice experiments. Tape recorded male calls of each species, as appropriate, were played from the other end of the tunnels during the experiments to create a soothing environment for the animals. All tests were carried out at night (22.00–03.00). Numbers (1–5) refer to ‘crossing success’ scores: the distance each individual that entered into either of the tunnels had moved forward during the experiment.

There was no evidence for differential choice between first and second trials in any of the species (Log-linear model: \( \chi^2 = 0.23, P = 0.89; \) Table 1) but there were significant inter-species differences in whether or not they entered the tunnels (Log-linear model: \( \chi^2 = 23.94, P < 0.001 \)). Both water frogs and common toads preferred tunnels to the grass, whereas agile frogs generally preferred the grass (significant for only one of the two trials; Table 1). Among the pooled sample of individuals of all species that entered the tunnels during the first trial, 68.4% preferred the tunnel lined with soil to the bare concrete tunnel (Log-linear model: \( \chi^2 = 11.48; P = 0.003 \)). The choice was significant for water frogs and agile frogs in both trials, but not for common toads (Table 1). The average crossing success during the first trial was always higher for the tunnel lined with soil than for bare concrete tunnels but differences were never significant (Mann-Whitney U-tests: \( z \leq -1.10, P \geq 0.27 \) for all three tests).

These results suggest that while agile frogs seem to avoid tunnels when given a choice, the two other species prefer tunnels. Furthermore, agile frogs and water frogs entering the tunnels preferred the tunnel lined with soil over the one with a bare concrete surface, whereas toads did not discriminate between the tunnels’ substrate. A possible explanation for this difference is that there is something in the concrete piping that acts as a deterrent for frogs, but does not influence toads as strongly. It has been suggested that the alkalinity of concrete deters frogs (Mougey, 1996), and it is possible that olfactory cues can influence movement towards tunnels (Dall’Antonia & Sinsch, 2001). French engineers constructing underpasses for amphibians already take this into account: during the installation process tunnels are sprinkled with water from nearby ponds to encourage the amphibians to use them (Mougey, 1996). Whatever the reason for preference or avoidance of particular type...
of tunnels, our results suggest that underpasses should be lined with soil substrate as suggested by Lesbarrères & Lodé (2000), and this has already been done in Switzerland where concrete pipes under roads have mud-lined interiors (Müller, 1992).

Apart from olfactory cues, other factors can also be involved in the choice or avoidance of particular tunnel types. These can include cues from magnetic fields (Fisher et al., 2001) and the intensity of light at the tunnel exit (Epain-Henry, 1992). Furthermore, it is also likely that moisture has a significant effect on tunnel choice. For instance, frogs are more sensitive to desiccation than toads because of the differences in their skin structure, and so could prefer soil to concrete because the former is likely to better maintain moisture levels. It is therefore possible that moist concrete tunnels in the wild are not avoided to the degree indicated by our experiments.

In conclusion, the results of this study show that although the three species tested show differential preference for entering tunnels, they all seem to prefer soil-lined to bare concrete tunnels. The results suggest that, for maintaining population connectivity, concrete tunnels could be improved, and that highway constructors should use soil-lined underpasses rather than plain concrete ones. Given the preference of agile frogs to bypass tunnels, and the much wider habitat tolerance of Bufo bufo when approaching roads, effective underpass construction should probably also involve fencing, forcing animals towards tunnels despite their preference for avoiding them. The results also show that, because of a species-specific preference for tunnel use, it may be difficult to propose a protective measure that works equally well for all species.

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References


Table 1 Results of the choice experiments using three species of anuran during two trials. Individuals (n = number) could either enter the tunnels (soil covered or bare) or bypass them by going around, over a lawn (see Fig. 1). Unsuccessful individuals either did not move or went backwards.

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Lawn (n)</th>
<th>Tunnels (n)</th>
<th>x²</th>
<th>Unsuccessful individuals (n)</th>
<th>Soil-covered tunnel (n)</th>
<th>Bare tunnel (n)</th>
<th>x²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water frog <em>Rana esculenta</em></td>
<td>1</td>
<td>14</td>
<td>26</td>
<td>3.60*</td>
<td>2</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>29</td>
<td>7.05**</td>
<td>1</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Common toad <em>Bufo bufo</em></td>
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<td>13</td>
<td>23</td>
<td>2.78*</td>
<td>5</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>31</td>
<td>10.76***</td>
<td>0</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Agile frog <em>Rana dalmatina</em></td>
<td>1</td>
<td>23</td>
<td>9</td>
<td>6.13*</td>
<td>0</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16</td>
<td>8</td>
<td>2.67</td>
<td>8</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

*P < 0.1, *P < 0.05, **P < 0.001, ***P < 0.0001
Amphibian tunnels and road kills


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**Biographical sketches**

D. Lesbarrères, T. Lodé and J. Merilä are evolutionary biologists who have been working with local adaptation, conservation and genetics of amphibians in France and Scandinavia over the past 5 years. They are particularly involved in conservation projects for the promotion of protected areas for amphibians near highways.