Ecological Engineering 95 (2016) 738–742

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

# An anti-predation device to facilitate and secure the crossing of small mammals in motorway wildlife underpasses. (I) Lab tests of basic design features

Mathilde L. Tissier[a,b,*], Jonathan Jumeau[a,b,c,*], Caroline Croguennec[a,b], Odile Petit[a,b], Caroline Habold[a,b], Yves Handrich[a,b]

[a] Université de Strasbourg, IPHC, 23 rue Becquerel, 67087 Strasbourg, Cedex 2, France
[b] CNRS, UMR7178, 67087 Strasbourg, France
[c] Conseil Départemental du Bas-Rhin, France

ARTICLE INFO

*Article history:*
Received 11 February 2016
Received in revised form 27 June 2016
Accepted 23 July 2016
Available online 5 August 2016

*Keywords:*
Underpasses
*Cricetus cricetus*
Fragmentation
Conservation
Road
Highway

ABSTRACT

A great number of wildlife underpasses are used to mitigate the environmental impact of urbanization and road infrastructure expansion, thus restoring ecological connectivity. However, the simultaneous use of these structures by small mammals and their predators could result in increased predation rates in these passages or lead small mammals to avoid using them. This would be particularly harmful to small populations or threatened species such as the European hamster (*Cricetus cricetus*). To overcome this problem and to provide lateral escape opportunities along the length of the underpasses, we developed an anti-predation tube. We tested the features (shape and size) of this device under laboratory conditions and validated its use by captive European hamsters. Our results reveal that the optimal anti-predation tube has a diameter of 10 cm, a curved shape and lateral openings. This device will be tested under field conditions to validate its efficiency to protect small mammals using wildlife underpasses. If confirmed, this system could considerably improve crossing conditions in bigger tunnels and on bridges such as agricultural under- or overpasses, which have been unsuitable for small animals until now.


## 1. Introduction

The high demographic growth of human populations has produced soaring urbanization and road infrastructure development since the beginning of the 20th century (Seiler and Folkeson, 2006), causing substantial habitat loss. The development of the road infrastructure entails the accidental killing of animals by vehicles and causes fragmentation, leading to the isolation of wild populations, the loss of genetic diversity and border effects with a consequent repercussion on population dynamics and survival (Coffin, 2007; Frankham et al., 2002; Haddad et al., 2015). These negative effects are particularly harmful to endangered or small populations (Frankham et al., 2002; Jaeger and Fahrig, 2004), which are highly sensitive to environmental stochasticity (Courchamp et al., 1999; De Roos et al., 2003).

The European hamster (*Cricetus cricetus*) is one such species. It is critically endangered in Western-Europe (Villemey et al., 2013), and the French area of this species (*i.e.* in the Alsace Region) has decreased by 94% since 1972 to current levels of less than 1500 individuals (Reiners et al., 2014). The road transport network developed at an alarmingly high rate during the same period (Carsignol, 2006, 2005; Saussol and Pineau, 2007). In Alsace, a major motorway project is currently underway in one of the relict population core areas of this species (Dantec, 2014). In order to avoid the isolation of wild individuals and take mitigation and compensation measures for road construction, wildlife under- and overpasses have been built to restore connectivity in Alsace (DREAL, 2011; Gilbert-Norton et al., 2010; Saussol and Pineau, 2007). These structures – and other non-specific passages such as culverts, which are known to be suitable for the crossing of small mammals (Mata et al., 2008) – allow the dispersion and migration of a wide range of species (Carsignol, 2006; Forman et al., 2002; Mata et al., 2008). The simultaneous presence of prey species (*e.g.* small mammals such as rodents and shrews) and their predators (*i.e.* fox, cats, mustelids) in wildlife underpasses (Carsignol, 2005; Grilo et al., 2008; Little, 2003; Little et al., 2002; Mata et al., 2008) entails an

* Corresponding authors at: Université de Strasbourg, IPHC, 23 rue Becquerel, 67087 Strasbourg, Cedex 2, France.
*E-mail addresses:* mathilde.tissier@iphc.cnrs.fr (M.L. Tissier), jumeau.jonathan@gmail.com (J. Jumeau).

http://dx.doi.org/10.1016/j.ecoleng.2016.07.012
0925-8574/

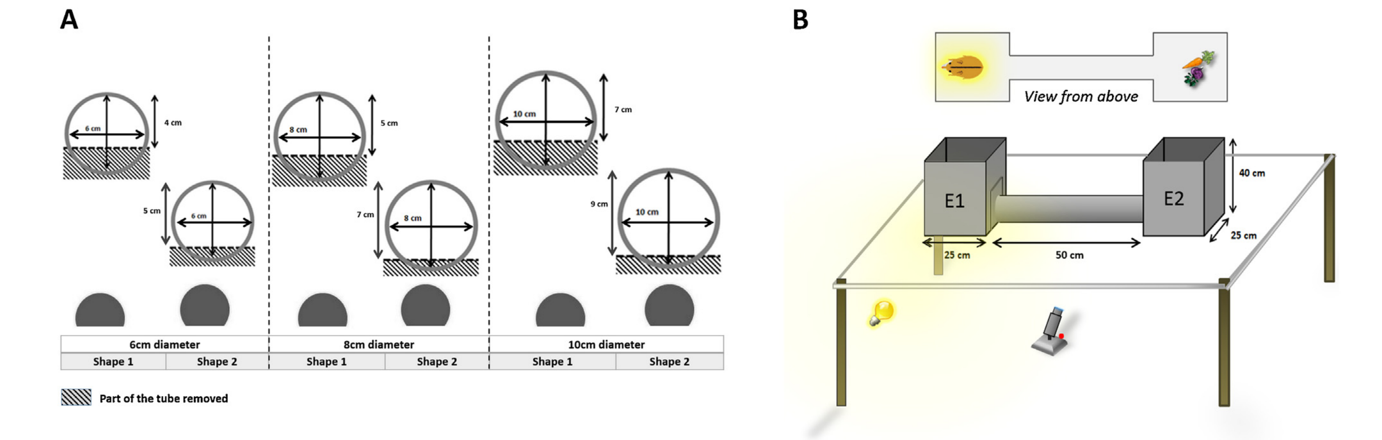


**Fig. 1.** Experimental design to validate the optimal shape and size of the APT. The three diameters and two shapes tested in Experiment 1 (6 combinations) are shown in **A**. The design in which each hamster was tested for the 6 combinations is shown in **B**.

increased predation risk for small mammals using these infrastructures. Consequently, small mammals may avoid these underpasses (Ruiz-Capillas et al., 2013) which might become potential ecological traps (Little, 2003). Although this idea has been widely debated (Little et al., 2002), particularly with regard to large mammals, very little is known regarding rodents. In the specific case of endangered species, the risk of possible predation cannot be ignored. A variety of road-crossing structures are available, and those targeting aquatic organisms and amphibians are apparently much more prevalent than those designed for terrestrial animals (Ward et al., 2015). More attention should thus be paid to providing suitable crossing structures for terrestrial animals. As indicated by Mata and collaborators (Mata et al., 2008), the adaptation or enrichment of culverts should not be ignored given the significance of these structures for certain species (such as badgers or small mammals) and their relatively low cost.

In this context, we developed a "sub-tunnel" type anti-predation device, *i.e.* a small tube to be placed inside the passages that mimics the natural galleries used by wild European hamsters. This article presents the tests carried out in captivity to determine the optimal features of this anti-predation tube (APT) and determine whether hamsters use it spontaneously. This is the preliminary step before field tests and the potential recommendation to implement this type of device on a large scale. The APT should ultimately enable hamsters and other small mammals to avoid or escape any predators they encounter in the passage by either using the APT for the entire crossing (avoidance) or by entering this tube through lateral openings when in danger in the underground passage (escape). This APT has been developed as part of a conservation program (LIFE+ Alister) for the European hamster in France which aims at restoring the connection of wild populations of the species in Alsace, France.

## 2. Material and methods

### 2.1. Animals and husbandry conditions

The experiment was performed on 18 unrelated captive European hamsters (9 males and 9 females). Males weighed on average 443 ± 139.9 g and females 352.8 ± 66.9 g. Individuals were housed in transparent Plexiglas cages (420*265*180 mm, D*W*H) and their environment was enriched with wood and shredded paper. Animals were provided with an *ad libitum* supply of water and food pellets (N° 105, from Safe, Augy, France). The experimental protocols followed EU Directive 2010/63/EU guidelines for animal experiments and the care and use of laboratory animals, and were approved by the Ethical Committee (CREMEAS) under agreement number 02015033110486252 (A PA FIS#397). 01.

### 2.2. Experiment 1: shape and size of the APT

The goal of this first experiment was to find the ideal size and shape of the APT. We aimed to create a device that would not affect the crossing of animals larger than hamsters, and would be inaccessible to relatively small predators. Consequently, it had to be as small as possible whilst allowing the crossing of small mammals of various sizes, including the European hamster, which is one of the largest rodents in France (Fenyk-Melody, 2012). The device should also be low cost and easy to clean for a widespread use in wildlife underpasses and culverts. European hamster galleries in the wild vary in shape, and diameters range from 4 to 10 cm (Marquet, 2014). We therefore tested two shapes and three diameters of plastic PVC tubes (Fig. 1A) using the device shown in Fig. 1B (based on the Chiaroscuro tests in rodents). This first experiment used unperforated 50 cm lengths of tube. A sample of 10 hamsters (5 males and 5 females) of varying corpulence (from 249 g to 608 g) was used for this experiment. Each hamster was randomly tested for the 6 combinations of tubes for 5 min in each tube (60 tests in total) and were never tested twice on the same day. Each subject was placed at one end of the tube (E1, see Fig. 1B) while appetizing food items (onions and carrots) were placed at the other end (E2, see Fig. 1B) to motivate the animals to cross the tube. The device was cleaned with ethanol after each trial. The experimental design was set up on a transparent table to enable filming during the tests, which were carried out in low light conditions (20W-light bulb) and at ambient temperature (19 °C ± 2 °C).

### 2.3. Experiment 2: spontaneous use of the APT

The goals of this second experiment were to test whether hamsters spontaneously used the APT and the lateral entrance/exits. Our APT prototype consisted of 2.78m-long sections of PVC tubing with a diameter of 10 cm (see 3.1 of Results section for further details). Holes of the same diameter were cut on alternate sides of the tube every 1 m to allow the lateral entrance/exit of individuals. The device was then placed in an artificial enclosure that reproduced the shape of a classic wildlife underpass (1 m wide × 0.40 m high × 3 m long; Fig. 2). Eight hamsters (4 males and 4 females) were randomly placed in the enclosure for habituation one day before the trials. Each individual was then randomly tested for 12 min in 3 conditions (see Fig. 2): left (**L** = the individual was placed in the enclosure, on the left of the anti-predation device), right