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Research article

An evaluation of odor repellent effectiveness in prevention of wildlife-vehicle collisions

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ABSTRACT

Wildlife-vehicle collisions (WVC) amount to 11% of all registered traffic crashes in the Czech Republic causing, apart from numerous deaths and serious injuries to animals, property damage and injuries to car passengers. Odor repellents have the potential to lower the overall number of WVC and allow animals to cross roads at the same time.

We tested the effectiveness of odor repellent preparation in prevention of WVC. 18 places were selected on the Czech road network where WVC were concentrated on the basis of traffic crash data. Control sections on the same road segments were also delimited in order to keep the traffic intensities constant.

We applied a Before-After-Control-Impact (BACI) study design to control not only the effect of the measures but also the expected natural variations in wildlife populations over time. Data were compared before and after odor repellent installations. Wildlife carcass gathering was carried out during the spring and autumn. We also used the police crash database to supplement carcass data when no field works were carried out. 201 killed mammals (roe deer and wild boars) were identified in total over 47 months.

We applied a Bayesian approach as only a limited numbers of WVC were available. A WVC decrease between 26 – 43% can be expected on the treated road sections. These numbers are, however, up to three-times lower than those claimed by producers of odor preparations.

1. Introduction

Wildlife-vehicle collisions (WVC) are a safety issue in many countries. Collisions with large mammals, ungulates in particular, result in traffic crashes with property damage, car passenger injuries and even fatalities. Several measures have been recommended to decrease the number of WVC. They can be divided into three elementary groups: measures affecting animal behavior, alert systems for drivers and systems protecting the infrastructure from animals entering. For a summary of the above-mentioned methods, we recommend works by Hedlund et al. (2004) and Huijser et al. (2007).

The best results in lowering WVC numbers (up to 83%) were achieved using fencing combined with over- and underpasses (Rytwinski et al., 2016). It is also apparent that the overall costs of these highly effective measures would be unacceptable specifically for the majority of secondary roads. Landscape connectivity and the securing of the possibility of wild animals crossing roads is another factor as to why fencing is only recommended for primary roads. Affordable countermeasures, such as repellents, which should both warn animals and allow them to cross roads are therefore suitable for secondary roads.

1.1. Current research on odor repellent effectiveness

Repellents can be chemical, visual, acoustic or a combination (Mason, 1989). Taste repellents were used as useful tools in preventing damage to plants and odor repellents in reducing WVC (Hedlund et al., 2004). The majority of papers have been focused on taste repellents inducing a gastrointestinal malaise, whereas chemical repellents are tested only occasionally (e.g., Nolte and Wagner, 2000; Kinley et al., 2003).

We focused on chemical odor repellents as this is a financially affordable measure, especially when compared to fencing and other civil structures. Odor repellents, which are based on a foam carrier releasing an unpleasant scent, are popular in certain

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European countries where they are widely applied along roads as well as on crop fields or on young forests (Mason, 1998).

Chemical repellents seem to be a socially appealing alternative to reduce ungulates crossing the road where they are less visible to drivers (Reidinger and Miller, 2013). New products are continually becoming available, but their ability to repel wildlife is extremely variable, as they are based on various active substances (e.g., bittering agents, garlic, particulates, natural predator excretions, or putrescent egg). Odors associated with the mutual behavior of vertebrates consist of allelochemics (Whittaker, 1970), particularly important odors for interactions between organisms of different species. Allelochemics are thus odors in which the individuals of one species affect, among other things, the behavior of another species (see Whittaker and Feeny, 1971). Many of the odor repellents are based on the kairomones of different predators. Unfortunately, it has been shown that certain prey adapt themselves to the presence of kairomones in the environment (Brown et al., 1970). When the prey detects the presence of kairomones in the environment, it will change its behavior (e.g., Oriazola and Braña, 2003). If odor repellents are used, additional contact with a potential predator is lacking (visual, acoustic) and therefore the prey should cross a road with higher caution. The animals, particularly ungulates, should be warned by the released scent with a predator or human odors that a danger exists (Clark and Avery, 2013). No behavior study was, to the best of our knowledge, conducted in this sense thus far.

1.2. Odor repellent effectiveness in prevention of traffic crashes involving animals

There have not been many rigorous studies on odor repellent effectiveness in prevention of WVC. The effectiveness of odor repellent in moose-vehicle collisions has been reported by Andreassen et al. (2005). Elmeros et al. (2011) published a field study where they tested two odor repellents (Mota FL and Wolf Urine) and evaluated their effectiveness on roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*). The authors concluded that both species tended to grow used to the scent and that both odor repellent types would also not work, as expected, in prevention of wildlife-vehicle collisions on roads. The ineffectiveness of the two odor repellent types was also demonstrated in a work conducted by Brown et al. (2000) in Alberta (Canada), as well as in a meta study conducted by Huijser et al. (2007, see page 113 and Table 11).

Information on odor repellent effectiveness often comes, however, from data provided by their producers (e.g., Putman, 1997). Producers claim that predator scent, which is continuously released from a foam installed along a road, will increase the vigilance of ungulates. Direct monitoring of ungulate behavior is usually impossible and therefore the repellent effectiveness is evaluated on the basis of carcasses found along roads or traffic crash data. Study designs concerning the effectiveness of repellents are often inappropriate, e.g., they do not contain control sections for elimination of confounding factors (e.g., Kušta et al., 2015) and therefore the decrease in the number of animal carcasses cannot be explicitly attributed to the effect of odor repellent.

1.3. WVC in the Czech Republic

Wildlife-vehicle collisions make up approximately 11% (data for 2016) of all registered crashes on roads in the police crash database in the Czech Republic. Roe deer were the majority of the species involved, followed by wild boar (*Sus scrofa*). The overall numbers of crashes with wildlife are on the rise. Between 2007 and 2016, the ratio of WVC to all registered traffic crashes rose from 4% to 11%. The ratio for domestic animals remains the same (approx. 1%) over the time interval. The rise in the overall number of individuals is the highest for wild boar which is becoming a Europe-wide problem (Massei et al., 2014). The problem of WVC is therefore urgent. Details about locations, dates of crashes and species can be seen at www.srazenazver.cz website (see Bíl et al., 2017) which is a web-map application gathering and analyzing data on WVC in the Czech Republic.

The aim of this study is to test the effectiveness of a particular preparation of odor repellents using a rigorously designed experiment as a Before-After-Control-Impact (BACI) study.

2. Data

WVC occur in a spatial pattern along roads (Gunson et al., 2010; Bíl et al., 2016). Places where WVC (and any other crashes) concentrate are called clusters (Elvik, 2008; Erdogan et al., 2008; Bíl et al., 2013). We computed the clusters from existing WVC data between 2009 and 2012 in order to identify suitable locations for odor repellent installation. These clusters (WVC hotspots) were used as the main sections. Certain methodological issues concerning the evaluation of safety measures along roads exist. We therefore used the system of a Before-After-Control-Impact study (e.g., Rytwinski et al., 2016) which should reflect possible changes in general trends of animal populations and other factors. Each control section, where no odor repellents were applied, was consequently selected on the same road segment as the main section (Fig. 1).

Eight road segments, with main and control sections, were selected. The overall length of the main sections was 1936 m and 3425 m for the controls. We noticed here (and explain further in the data analysis) that there is no need to have the overall lengths the same for the main and control sections.

The WVC data from the period 2009–2012 suggest that the majority of crashes occur during May and November. The first peak concurs with roe deer life activity and the second one with wild boar life activity (Bíl et al., 2016). The phases of the carcass monitoring along roads were therefore selected to include May and November.

In total, there were five phases with six weeks of monitoring each (i.e., 30 weeks of monitoring in total). Phases 1 and 2 of monitoring (autumn 2014 and spring 2015) were conducted without any application of the odor repellent. The odor repellent was then activated on the main sections two weeks before the third phase of the monitoring and three phases of monitoring (autumn 2015, spring 2016 and autumn 2016) followed. The rejuvenations of the odor repellent took place every second month until the last phase of the monitoring. Field workers monitored once a week all the sections over six weeks during each phase.

The company whose product was tested on the eight above-mentioned segments also applied their repellents to sections on another ten road segments which were previously selected on the basis of the KDE+ (Bíl et al., 2016) WVC cluster identification. We used these additional ten road segments, because the results for the

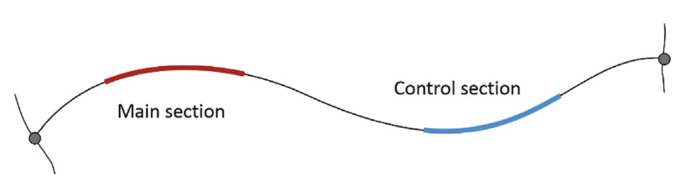

Fig. 1. Each main section had a control section located at the same road segment. The road segments were defined between neighboring intersections to keep traffic volume (exposure) constant for both sections.