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SafeBatPaths

Fumbling in the dark – effectiveness of bat mitigation measures on roads

Future research needs for the mitigation of the effects of roads on bats

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Executive summary

The *SafeBatPaths* project held a small workshop at Aarhus University, Kalø in February 2016. The aim of the workshop was to discuss the status of current road mitigation measures, our present knowledge on their effectiveness, future research needs and best practice for bat mitigation strategies.

In this note the four research themes identified at the workshop are presented:

1. Monitoring and research projects should focus on estimating the effectiveness of mitigation measures, and not focus solely on their use. There is a need for more consistent methods of measuring, analysing and reporting the studies of the use and effectiveness of mitigation measures to facilitate future meta-analyses.
2. There is a need to determine and understand the variability in functionality and effectiveness for some mitigation measures between sites.
3. Lighting of roads and mitigation measures may impact their effectiveness, but much is still unclear.
4. To improve and plan mitigation schemes more effectively, there is a need to elucidate the effects of roads and mitigation measures at the population levels.

1 Introduction

Road mitigation projects targeting bats are undertaken each year in many European countries. As the planning and construction of road schemes may span several years, the accumulation of experience within each country is slow. Furthermore, the present evidence of their effectiveness is limited.

A workshop was held in November 2016 for bat and road experts to combine and exchange experiences accumulated in several countries to achieve better convergence and effectiveness for future road mitigation projects for bats. The workshop was organised as part of a CEDR project that reviewed bat mitigation measures on roads.

Reviews of mitigating measures for bats in the construction or adaptation of infrastructure have shown that there is currently little evidence of the effectiveness of the mitigation strategies (e.g. Berthinussen et al. 2013, Møller et al. 2106). During the workshop on mitigation measures for bats in road construction and maintenance, futures research needs were discussed by experts amongst the workshop participants (Appendix 1).

In this note, these research needs are outlined and discussed in four main themes: monitoring and reporting of effectiveness of mitigation measures, the causes of differences in effectiveness of measures in different situations, the effects of light, and the effects of roads on bat populations.

2 Research topics and project considerations

2.1 Better monitoring and reporting

There is a fundamental need is to improve the way in which mitigation measures are tested. Many uncertain or contradictory results seem to stem from using an inadequate study designs and from unclear or incomplete reporting of the study method, the field situation, or the mitigation measure. If these issues are resolved, research and monitoring efforts may be pooled for better insight and meta-analysis.

Measure ‘effectiveness’ and not ‘use’

Often the functioning of mitigation measures for bats is measured by whether or not bats use the structure. Effective mitigation however only occurs when the number of animals that are using the measure and crossing safely is (much) greater than the number of animals that do not cross, or cross unsafely.

- Research and monitoring of mitigation measures should focus on their effectiveness, and therefore should include control sites, before-after comparisons and/or measurements.
- Preferably more replica of each mitigation type should examined to determine variability between sites.

Improve reporting

There is a need to bring more clarity in reporting. From the current monitoring and research of implemented measures, it is clear that some types of measures work well, while others are not effective or even used. A third group shows variation in use and effectiveness, and it is not always clear why they function in some situations, and not in others.

Much of the relevant information on the effectiveness and usage of mitigation measure is gathered for EIAs or during post-construction monitoring. Often in such reports, the setting (the road dimensions and layout, the construction activities, the mitigation measure form, dimensions, and location) are assumed to be known by the readers and therefore not described. Secondly, often there is a period of sometimes years between the initial study and description and the implementation phase. Monitoring studies of implemented measures can be very informative with a few minor improvements. A major improvement would involve measuring effectiveness rather than use of the measure and to include a detailed description of the study methods, the quantitative measurements, and the study site.

- We strongly recommend that road authorities request a clear summary in reports of studies they commission that includes explicit metrics of 'success'.

Some of the uncertainties in the knowledge of effectiveness of mitigation measures reflect inconsistencies in the terminology. Measures that seem to be similar in different reports are often totally different. The term "Hop-over" in particular is often used for a broad range of situations, from tall trees on road verges, natural gaps in hedgerows created by a road, to complicated structures and screens guiding the bats across roads above the traffic. Hop-overs may also include structures on the central reservation.

Another example is "screens". In some studies, it was unclear whether the screens were to block the bats from entering the road at unsafe heights (parallel to the road), to guide them to mitigation structures (perpendicular to the road), or to try to force the bats to cross the roads above the traffic.

Apart from this, there are a number of sources of variation that are often not explicitly reported: dimensions of measures are not given, and often, the total number of bats using a measure is reported, and not separated into species. A non-exhaustive list of sources of variation:

- the target species for the mitigation;
- the size of the gap to be crossed;
- dimensions of the structure;
- connectivity of the structure to flight route or landscape features;
- season;
- number of years since construction of the mitigation measure.

- In order to do more effective research, we propose that a standard terminology be agreed upon by member states (e.g. as in the COST 341 Handbook and the coming handbook extension) or a *pro forma* description of different mitigation measures be introduced to provide baseline information on mitigation measures.

2.2 Types of measures to be further studied

Some mitigation types are effective, in at least a number of cases. These measure merit further research.

Wildlife overpasses

These structures are reported to be used by crossing and hunting bats often. Use varies however, and it is unclear if the animals are using it for crossing, as a hunting habitat, or both. Often, controls are missing in the studies (e.g. how many bats crossed prior to con-

struction, how many cross unsafely), as are descriptions of vegetation on the bridges and connectivity to nearby bat habitats in some of the studies. To understand the effectiveness of green bridges, more systematic studies that include controls are needed. Research is also needed on the placement in relation to other bat habitat, the minimum and optimum sizes (width in particular) and the extent and nature of the vegetation and other habitat features (e.g. dead trees) that influence use by bats.

Underpasses

Underpasses have been shown to be quite effective as mitigation measure for clutter-adapted species to maintain commuting routes and road permeability for bats, but further studies on species specific size criteria (minimum height and width, maximum length) for the underpasses and monitoring of effectiveness will make the planning and construction much more cost-effective. Connectivity with nearby bat habitat is also important but often unreported.

Other factors that may affect the effectiveness of underpasses and merit further research include placement of the feature in relation to the original flight path, use of an artificial linear feature to guide bats during the construction phase and types of lighting that can be used in underpasses that may also be used by pedestrians, cyclists or occasional traffic, such as farm vehicles.

Hop-overs

Hop-overs, defined as trees and/or screens, seem to be used by some bats as anticipated, but the effectiveness is species dependent and variation between sites can be significant. Hop-overs are in fact a very diffuse group of measures and specific details on the site may influence the effectiveness of hop-overs.

- Knowledge on key factors for the effectiveness of hop-overs needs to be determined for various bat species, e.g. gap size, vegetation height and density on the road verges, traffic noise and street lights.
- Also there is a need for a standard terminology which specifically defines hop-overs.

Noise deterrence

Sound generating asphalt on roads at high-risk sites is an emerging measure. The purpose of the special asphalt is to generate ultrasound to warn approaching bats about an approaching car. Initial studies show some positive potential (ChiroMed 2014), but it is unclear how effective it is in reducing numbers of road-kills, and for which species and at which vehicle-speed range. Also, it is not clear if the method interferes with the road permeability and viability of populations, of bats or other species that hear ultrasound. These need immediate clarification:

- How effectively is the noise warning the bats of approaching cars, i.e. will bats learn to associate noise with danger or habituate? Or will there be habituation?
- If effective, do bats alter their behaviour by changing crossing location or flight height, or does the noise create a barrier?

Speed reduction

A mitigation measure that is often mentioned in studies of roads and their effects on terrestrial animals is reducing the speed limits for traffic. This measure seems successful in lowering the number of traffic victims in that group, and also in birds, but is untested in bats.

- Although there are sometimes concerns about the feasibility of implementing speed restrictions (especially on main roads), it is a method that merits more evaluation as a mitigation measure.

2.3 Effects of street lighting

Many roads are lit by artificial lighting to improve traffic safety. The effect of artificial lighting on bats is still an emerging research topic (Rowse et al. 2016, Light on Nature project of NIOO, The Netherlands), but it seems that lighting provides two stimuli to free flying bats: attraction and deterrence. Lighting can attract insects and therefor bats that prey on these insects. Light can deter bats, because they are more visible to predators or due to other, physiological effects. The effects lighting have will depend on the species, and the function the lit landscape has for that species. But it is also dependent on the light source, placement, intensity, part of the road that is lit, switching regime, the light spectrum (attracting insects or not, causing different responses in bats directly), and visibility for the bats. In the context of roads, light may then attract bats to unsafe hunting sites on or close to roads, or might form a barrier making it impossible to cross. Overall, the effect of lighting on bats is complex, and new designs of lighting armatures and different spectra are to be tested.

- To improve mitigation of the effects of roads, it is necessary to understand how different lighting designs affects bats in different situations, how the effects of lights can be mitigated and managed, or to determine if light could be used to deter bats from dangerous situations and guide them to safe crossings.

2.4 Effects of roads on bat populations and habitat quality

Mortality rates

Roads can affect bats by killing individuals and fragmenting habitats. How large these effects are at the population level is not known. It is a complex task to estimate acceptable traffic-related mortality rates and fragmentation effects of roads for bat populations, but this is technically feasible. However, a general lack of quantitative data on demographic rates, population dynamics, road effects and mitigation measures hampers the application of predictive population and landscape modelling to explicitly predict the most cost-effective mitigation strategy for a road scheme.

Presently, there are only two long-term studies that have addressed the mitigation of a road scheme at the population levels, in Wales and Saxony. Mortality studies are very few, and sensitive to bias due, for example, to carcass removal by scavengers (Prosser et al. 2008, Medinas et al. 2013) or carcasses becoming unrecognizable due to traffic, or carcasses sticking to and being moved by vehicles. Better estimates of road mortalities and other impacts of roads and the mitigation measures on population levels are urgently needed.

- Bat road-related mortality estimates should be corrected for carcass removal rates as is done in studies of wind turbines (Rodrigues, 2015).
- Studies on population density or activity before and after road construction/expansion and before and after mitigation are needed to quantify effects of mitigation on population sizes.

Habitat quality and bat density

Research from UK (bat activity) and Denmark (bat box usage) shows that bat activity or bat box usage is lowered up to one kilometre from the roads (Berthinussen & Altringham 2012, 2015; Christensen 2015). This is further than one would expect from the effects of sound or light, as road noise and light levels decrease significantly beyond a few hundred meters of roads.

It is not clear what causes this reduced bat activity/box usage up to 1000m from roads: are populations not roosting close to the road, is it an effect of decreased permeability of the landscape by the road, reduced foraging habitat quality or lowered bat density due to increased mortality for populations close to roads? These effects will often go unnoticed if only presence-absence data are collected in the road transects during the planning process. The 'far reaching' effects must be included in mitigation strategy for roads, but to do that effectively the cause or causes of the decline must be clarified.

3 Conclusion

Mitigating the effects of roads on bats is a topic that has had increasing attention from ecologists and roads constructors in the past 20 years. In those years, many local and even national mitigation attempts have been put in place, and a growing number are being more-effectively monitored and continually being improved. The data generated will facilitate improved mitigation if study methods (including a focus on the effectiveness of measures) and clarity and availability of reports are improved. New topics such as the effects of light are gaining attention and insight. However, to mitigate the detrimental effects of roads effectively, it is necessary to look at a larger scale, i.e. on the effects roads can have at the population level, and how mitigation measures affect death rates and population status.

4 Acknowledgements

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Annex A: Participant list

List of participants on the project workshop and their affiliations.

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