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Differential use of highway underpasses by bats

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ABSTRACT

Roads can form barriers to movement for many species, and may reduce the ability of individuals to access foraging and breeding habitat. The impacts of roads on terrestrial fauna has been well studied, however little is known of the impact of roads on insectivorous bats. Wildlife crossing structures (e.g. fauna underpasses) may reduce the barrier impacts of roads and improve connectivity across roads. Use of underpasses by wildlife likely varies among species depending on their movement behaviour. In this study, we investigated whether the flight patterns of insectivorous bats influenced their use of underpasses. We monitored bat activity under and above 6 open-span bridges, 6 box culverts and 6 unmitigated sites along a major highway in Australia. We used Poisson regression models within a Bayesian framework of inference to compare the activity of 12 bat species (grouped into three guilds based on their flight patterns: clutter-adapted, edge-adapted, and open-adapted species) under the structures, over the road above the structures, above unmitigated segments of the highway, and in the vegetation adjacent to the roads. Bats were less active above the road than they were in the surrounding vegetation or under bridges. Two of the three guilds (i.e. seven species) crossed the highway more under bridges than they did under culverts or by going over the road, which suggests that bridges may reduce barrier effects of the road better than culverts. Installing bridges instead of culverts may better reduce the impacts of roads on multiple insectivorous bats species with a single structure type.

1. Introduction

Roads and traffic can reduce the persistence of wildlife populations, particularly when they restrict the access of individuals to breeding or foraging habitats (Forman et al., 2003). Fauna crossing structures are commonly installed to facilitate the safe movement of animals across landscapes fragmented by roads or other linear infrastructure, which helps to increase habitat accessibility (Smith et al., 2015). Environmental or structural factors, such as their position within the landscape, accessibility by individuals, and structure size, are often thought to influence the rate at which fauna crossing structures are used (e.g. Ascensão and Mira, 2007; Chambers and Bencini, 2015; Clevenger and Waltho, 2000, 2005), however, species traits and ecologies may also influence structure use (e.g. Abbott et al., 2012a; Abbott et al., 2012b). In addition to environmental factors, it may be informative to evaluate species' ecologies and behaviour in order to predict their response to roads (Rytwinski and Fahrig, 2012) and crossing structures (Abbott et al., 2012a; Abbott et al., 2012b).

Categorising species into guilds using ecological traits can help us to infer the response of a group of species to environmental change without having to study each species individually, increasing ecological transferability of knowledge. For example, ecological traits have been used to determine guilds of drought-tolerant plant species (e.g. Ouedraogo et al., 2013), urban-sensitive bat species (Caryl et al., 2016), and habitat-fragmentation-sensitive vertebrate species (e.g. Vetter et al., 2010), among others. These guilds can be used to guide conservation and management actions, and to identify threats that impact a group of similarly responsive species. This approach moves away from actions that are focused on a single species to those encompassing multiple species. In a similar way to anticipating or predicting the response to impacts, guilds can be used to predict the outcome of management or conservation strategies, such as the traits that influence the use of crossing structures along highways (Abbott et al., 2012a; Abbott et al., 2012b; Boonman, 2011; Kerth and Melber, 2009).

Roads can have a negative impact on the activity and movement of insectivorous bats (hereafter referred to as "bats"; e.g. Abbott et al., 2015, Bennett and Zurcher, 2013, Fensome and Mathews, 2016, Kitzes

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and Merenlender, 2014, Medinas et al., 2013). Some species are less active closer to a major road than they are further away from the road (Berthinussen and Altringham, 2012; Kitzes and Merenlender, 2014), with individuals often not crossing the road when traffic and/or lighting is present (Bennett and Zurcher, 2013; Hale et al., 2015; Zurcher et al., 2010). There is variation among species responses to the presence of a road. Some species are more sensitive to barrier effects, as they require continuous forest cover and are less likely to cross gaps in the canopy caused by roads (Bennett and Zurcher, 2013; Hale et al., 2015; Kerth and Melber, 2009). Alternatively, species that typically fly in open spaces, such as over the canopy, are likely to be more tolerant because gaps created by roads would be less of a barrier (Ciechanowski, 2015; Helbig-Bonitz et al., 2015; Kerth and Melber, 2009). For the more sensitive species, fauna crossing structures may mitigate the impacts of the road by providing a sheltered, connected pathway across a landscape that is otherwise fragmented. Using guilds may assist in predicting the impact of roads (e.g. Abbott et al., 2015; Kerth and Melber, 2009; Kitzes and Merenlender, 2014) and, as in the present study, the effectiveness of crossing structures to mitigate this impact for bats (Abbott et al., 2012a; Abbott et al., 2012b).

Bats can be classified into guilds based on their flight patterns which allow the individual species to occupy different niches within the shared environment (Denzinger and Schnitzler, 2013; Luck et al., 2013). These guilds may also predict a species' response to roads and underpasses (Abbott et al., 2012a; Boonman, 2011; Kerth and Melber, 2009). To date, most studies have investigated the use of culverts as crossing structures for bats (Abbott et al., 2012a; Boonman, 2011; Kerth and Melber, 2009), but few studies compare the use of different types of crossing structures by multiple guilds (see Abbott et al., 2012b for exception). By evaluating the response of guilds to multiple structure types, as opposed to single species and single type of structure, we can understand how several bat species respond to roads and crossing structures based on their ecological traits instead of environmental factors such as where in the landscape the crossing structures are located.

In this study, we recorded the activity of 12 bat species above the road and under the road using two types of underpasses: open-span bridges (n = 6) and box culverts (n = 6) (hereafter referred to as bridges and culverts, respectively; see Fig. 1) in south-east Australia. Our objectives were to determine if: i) bats travelled under underpasses; ii) the presence of underpasses reduced the activity of bats above the road (i.e. crossing at-grade); and iii) guilds varied in their level of activity under the two types of underpass and above the road. We assigned each species to one of three guilds based on flight patterns (i.e. clutter-adapted, edge-adapted or open-adapted, after Denzinger and Schnitzler, 2013, Luck et al., 2013), and compared the activity of each guild above the road and under bridges, culverts, and above segments of the road that were unmitigated. We predicted that: i) clutter-adapted species would be more active under culverts than bridges due to the smaller, more enclosed shape of the culverts and these bats' ability to fly close to or within vegetation or other structures; ii) edge-adapted species would actively use bridges instead of culverts, due to the large size of the bridges and the foraging opportunity that may be available along the vegetated corridor; and iii) open-adapted species would not be active within either type of underpass but more active above the road because of their tendency to fly high above the tree canopy.

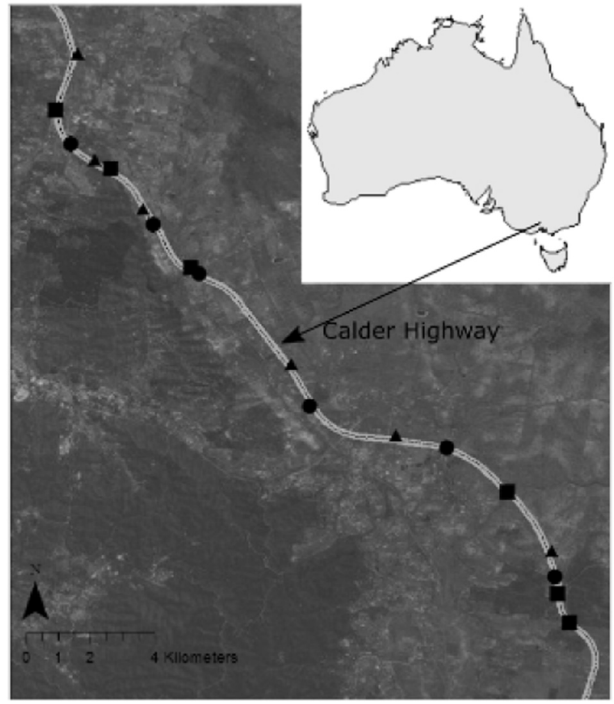

Fig. 2. The Calder Highway, in Victoria Australia. The highway extends approximately 150 km northwest from Melbourne. Map shows the 40 km span used in this study. The southernmost site is 120 km from Melbourne. Squares indicate bridge sites, triangles indicate culvert sites and circles indicate unmitigated sites. Inset shows study location within Australia. See Supplementary information for site-level images.
Source: Image from ARCMAP 10.2.2. and “maps” package in R.

Fig. 1. Examples of one of the open-span bridges (left) and one of the box culverts (right) where bat movement was studied along the Calder Highway, in Victoria, Australia. Photos not to scale.
Source: Photos by Lee Harrison.

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