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Vegetated fauna overpass enhances habitat connectivity for forest dwelling herpetofauna

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HIGHLIGHTS

- We investigated whether herpetofauna used a fauna overpass as an extension of natural habitat.
- Overpass supported higher species diversity and capture rates compared with forests.
- Species accumulation curves demonstrated a strong, consistent rate of new species on the overpass.
- Findings demonstrate that the fauna overpass provides suitable habitat for diverse herpetofauna.
- This vegetated fauna overpass provides enhanced habitat connectivity.

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ABSTRACT

The ecological impact of roads and traffic is now widely acknowledged, with a variety of mitigation strategies such as purpose designed fauna underpasses and overpasses commonly installed to facilitate animal movement. Despite often being designed for larger mammals, crossing structures appear to enable safe crossings for a range of smaller, ground dwelling species that exhibit high vulnerability to roads. Less attention has been paid to the extent to which fauna overpasses function as habitat in their own right, an issue particularly relevant to reptiles and amphibians. The Compton Road fauna array (Brisbane, Australia) includes a vegetated fauna overpass which connects two urban forest reserves and traverses a major four lane arterial road. The aim of this study was to quantify the extent to which colonisation of the Compton Road fauna overpass by reptile and amphibian species living in adjacent forests occurred. Pitfall sampling at seven sampling sites occurred between June 2005 and February 2010, starting approximately six months after overpass construction, with additional observational detections throughout this period. The overpass yielded higher species diversity and capture rates compared with the forest areas. Species accumulation curves demonstrated a strong and consistent colonisation rate of the overpass throughout the six year monitoring period, while persistent occupation by species on the overpass throughout the six years suggests permanent colonisation of the vegetated structure as an extension of the natural forest habitat. These outcomes demonstrate that the fauna overpass at Compton Road provides suitable habitat for diverse local herpetofauna communities and suggest enhanced habitat connectivity across the road.

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1. Introduction

The ecological impact of roads and of the traffic they carry is now widely acknowledged (Forman and Alexander, 1998; Beckman et al., 2010; van der Ree et al., 2015). Most conspicuously, animals attempting to cross roads are at risk of being killed or injured by collisions with vehicles (Coffin, 2007; Glista et al., 2009). Roads can also disrupt or prevent daily and seasonal movements and, where the roadway acts as a significant barrier, may isolate populations, potentially increasing the chances of local extinction (Benítez-López et al., 2010; van der Ree et al., 2015). Attempts to mitigate these effects have included the erection of exclusion fencing to prevent animals from accessing the road surface, and the construction of various forms of structures designed to facilitate the safe movement of animals across the road (Mata et al., 2008; Corlatti et al., 2009; Glista et al., 2009). The most widely implemented purpose-built fauna passages are underpasses and overpasses, installed specifically to facilitate animal movement, as opposed to drainage culverts or similar structures which are sometimes used opportunistically (Yanes et al., 1995). These purpose-built structures are now found throughout the world (Corlatti et al., 2009; Beckman et al., 2010). The primary aim of such structures is to overcome the barrier effect associated with roads, thereby improving the permeability of the road network; although their effectiveness varies greatly between taxa (Bissonette and Adair, 2008; Glista et al., 2009; van der Ree et al., 2015).

Reptiles and amphibians (herpetofauna) are especially vulnerable to the effects of roads (Woltz et al., 2008; Eigenbrod et al., 2009; Hamer et al., 2015; Andrews et al., 2015). Being typically slow moving and ground dwelling, these taxa are particularly prone to being killed while attempting to cross roads (Goldingay and Taylor, 2006; Roe and Georges, 2007; Clark et al., 2010). Additionally, herpetofauna are uniquely at risk of road effects due to thermoregulatory requirements that attract them to warm road surfaces (Forman et al., 2003; Andrews et al., 2015). These impacts have been shown to significantly alter the genetic diversity of populations separated by roads (Steen and Gibbs, 2004; Clark et al., 2010) and has been strongly implicated in the sudden decline of several species (Beaudry et al., 2008; Corlatti et al., 2009).

Although some fauna crossing structures have been designed specifically for certain taxa (e.g. Ball and Goldingay, 2008 and van der Ree et al., 2009), most are installed for larger mammal species, especially deer and carnivores (Forman et al., 2003). Nonetheless, many species of herpetofauna have been detected using both underpasses and overpasses (Bond and Jones, 2008; Mata et al., 2008) and have taken advantage of existing drainage culverts and water flow infrastructure (Yanes et al., 1995). Among the most abundant and successful crossing structures are specialised amphibian tunnels especially common in Europe which, when used in conjunction with guide fencing, have significantly reduced road kill rates and enhanced adjacent populations (Woltz et al., 2008).

Herpetofauna use of fauna overpasses is less well studied (Beckman et al., 2010), with the important exception of the famous Groene Woud in the Netherlands (50 m wide, 65 m long, and spanning a major motorway), which was designed specifically to provide habitat and connectivity for local amphibian populations (van der Grift et al., 2009). An important component of the Groene Woud was the provision of a series of ponds and waterways across the length of the overpass. The maintenance of such necessary environmental conditions requires specialised pumping and ongoing management (Schellekens et al., 2005), yet resulted in the establishment of six amphibian species (van der Grift et al., 2009).

Fauna overpasses are the largest and most effective crossing structures, as they able to benefit the greatest diversity of species (Glista et al., 2009; Hayes and Goldingay, 2009). Traditionally, many of these structures were designed primarily to facilitate the movements of larger mammals. Planted vegetation is typically open in structure, providing maximum visibility preferred by the main target species (Beckman et al., 2010). However, research on the capacity for fauna overpasses to enhance the movements of other taxa has indicated that a wide range of animals also use these structures to cross roads (Jacobson, 2005; Tremblay and St Clair, 2009), including the important discovery that many species of smaller forest dwelling passerines routinely use overpasses where the structure of the plantings resembles that of the surrounding habitat (Jones and Bond, 2010; Jones and Pickvance, 2013; Pell and Jones, 2015). Information about herpetofauna use of vegetated overpasses remains, however, extremely limited.

Despite the dramatic increase of purpose designed fauna crossing structures in Australia over the last decade (Jones et al., 2010), only five fauna overpasses have been constructed to date. Although all are fully vegetated, only two have been monitored (Hayes and Goldingay, 2009). The most intensively studied of the Australian fauna overpasses is that at Compton Road (Fig. 1), located on the outskirts of Brisbane in subtropical Queensland (Veage and Jones, 2007; Bond and Jones, 2008). Ongoing research since the construction of the overpass in 2005 has reported on a comprehensive suite of taxa regularly using the structure including terrestrial and arboreal mammals, invertebrates and birds (Veage and Jones, 2007; Bond and Jones, 2008; Taylor and Goldingay, 2010; Jones and Pickvance, 2013; Pell and Jones, 2015).

Given that the primary objective of most fauna crossing structures is to enhance wildlife movements through increasing the landscape permeability of roads (Garcia-Gonzalez et al., 2012), much of the focus of the associated monitoring tends to be on verifying the passage of animals across roads and on the long term implications of such movements, including but not limited to gene flow and population persistence (Eigenbrod et al., 2009). Apart from the notable Dutch example mentioned above, very little attention has been paid to fauna overpasses acting as habitat in their own right as opposed to a means of enabling movement. However, these often substantial structures, if appropriately designed and maintained, may also represent suitable habitat for occupation as well as potential corridors for gene flow and connectivity, a fundamental goal of restoration ecology (Forman et al., 2003). This is especially relevant for herpetofauna, which tend to be smaller in size and with relatively small regular home ranges (Ross et al., 2000).