Vegetation structure on overpasses is critical in overcoming the road barrier effect for small birds

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Introduction

Research into the impacts and influences of roads, road networks and traffic on biodiversity has been overwhelmingly dominated by studies focused on mammals, both large and small. Not surprisingly, concerns about road safety were associated with large mammals while smaller species, being far more susceptible to the effects of fragmentation, tend to have been studied for conservation reasons (Glista *et al.* 2009). For similar reasons, considerable attention has also been directly toward amphibian and reptile species which are especially vulnerable to the direct impacts of roads when attempting to cross (Corlatti *et al.* 2009).

To address these issues, a wide variety of purpose-designed crossing structures have been installed throughout the world, again with mammals predominating as the taxa of main concern. In general, it can be generalized that most underpasses are designed for small mammals while the majority of fauna overpasses are associated with allowing large species – primarily ungulates and certain predators – to move safely over roads (Mata *et al.* 2008).

Perhaps because of their ability to fly, birds have largely been ignored by road ecologists. The largely unstated assumption appears to be that birds, being able to fly over the road, are unaffected by the same impacts and influences as other taxa. Some important recent studies, however, have shown that birds are the taxa most frequently killed by collisions (Benítez-López *et al.* 2010), and that species differed greatly in their likelihood of crossing roads, with the width of the gap being of critical importance (Tremblay & St. Clair 2009). For many smaller, forest-dwelling species, even narrow roads represented a complete barrier (Laurance *et al.* 2004)

Fauna overpasses – or ‘wildlife bridges’, ‘land-bridges’ or ‘green bridges’ – are the largest and potentially the most complete style of crossing structures as they may provide the most integrated and seamless transition between the habitats on either side of the road being traversed. Indeed, a well-designed, fully vegetated ‘green bridge’ once mature can offer a movement corridor of continuous habitat for animals attempting to cross the road (Jones *et al*. 2010). Despite the apparently obvious benefits such overpasses would offer to birds, remarkably little attention has been paid to this taxa (cf. Keller *et al.* 1996), with most work again focused on mammals (see Bond & Jones 2008, Corlatti *et al.* 2009).

Overpasses are, however, are also by far the most expensive of all crossing structures as well as providing the most challenges in terms of installation and management. As a result, many road authorities have been reluctant to consider these structures in the absence of reliable information on their success or otherwise. This is not the case in Europe, however, where over 200 fauna built overpasses have been constructed, frequently with a range of innovative features and some of enormous scale (Carlatti *et al*. 2009). Although some of these structures have apparently been carefully monitored, unfortunately information on fauna use is often difficult to access from outside the country and sometimes even the specific region. In part, the present presentation represents a plea for more international collaboration among researchers monitoring fauna overpasses and for enhanced exchange of data and information that will be mutual benefit to all participants.

In this paper I summarise results from two years of observational monitoring of a fully vegetated fauna land-bridge located in subtropical coastal Australia, near the rapidly expanding city of Brisbane. This structure, which spans a four-lane arterial road and allows a wide range of fauna to cross between the forest reserves on either side (Veage & Jones 2007), is one of only four overpasses so far erected in Australia. It is also the most carefully monitored, with studies since 2004 demonstrating regular crossings by a variety of larger mammals (wallabies, kangaroos and marsupial gliders) as well as the establishment of more than 12 species of amphibian and reptile (Veage & Jones 2007, Bond & Jones 2008). Birds, however, were overlooked until 2008 when numerous small species were noted in the rapidly developing plantings. A preliminary study (Jones & Bond 2010) reported unexpectedly large numbers of birds, including several known to be disturbance-sensitive 'interior' species, detected within the vegetation. Here I provide an up-date on this work and seek to address the issue of which species are most likely to benefit from recreated forest-like structure.

Methods

The Compton Road Land-bridge (27° 36' 53.11" S, 153° 05' 03.12" E) is one component of the Compton Road Fauna Array which also includes two large purpose-designed underpasses, three road bridges and a suite of glider poles designed for use by gliding marsupials (Veage & Jones 2007). The array is located within 1.3 km of the four-lane Compton Road and allows safe movement of fauna from the forested reserves either side of the road. The road is fully enclosed in complete exclusion fencing.

The overpass is hour-glass in shape and 70m long, has a base width of 20m and is 15m wide at the mid-point. The height of the surface of the structure is 8m with a 5.4m clearance within both tunnels. The surface of the structure was covered in 30c to 1.3m of soil topped with hydromulch and planted at a density of 70 shrubs and 6 trees per $100m^2$. A detailed survey (Jones *et al.* 2010) of the recreated vegetation conducted four years later detected 45 species, most of which had been planted and most of the remainder self-propagated. The structure of the vegetation closely resembled that of the dense understory of the surrounding forest and was remarkably similar to the species richness (Jones *et al.* 2010).

Birds were surveyed weekly (from March 2008 until April 2010) by observing birds crossing the road away from the overpass (four 80 x 10m transects perpendicular to the road) and those using the overpass (four 20 x 10m transects positioned across the structure parallel to the road). All birds detected lower that canopy height were counted and identified during 5 min observation sessions. For those detected using the overpass, a distinction was made between birds observed within the vegetation and those flying above the vegetation. In this presentation, mean numbers are presented and have been compared by ANOVA. Qualitative comparisons are also made with month transect surveys undertaken between May 2005 and April 2010 in the forested reserves on either side of the road.

Results

A total of 18 species of bird were detected flying across the road independent of the overpass during the study. Although these species varied in size from the Pacific black duck *Anas supercilliosa* (1010g) to the welcome swallow *Hirundo neoxena* (15g), a clear majority of these birds were larger species with the median weight of 115g being similar to the most abundant species detected, the rainbow lorikeet *Trichoglossus haematodus*. This species comprised fully 38.2% of all birds recorded; combined with the Torresian crow *Corvus orru*, these two species made up almost 70% of all birds crossing the road away from the overpass.

In contrast, a total of 30 species were detected crossing the road within the foliage on the overpass; another seven species were detected on the surface or structures of the overpass while a further four species were recorded flying directly above the vegetation. The five most abundant of the foliage-associated species – all smaller insectivores – comprised 57.6% of the total with the most common species, the silvereye *Zosterops laeralis* (18.9%) weighing only 10g. Indeed, the median weight of these birds was 15g, equivalent to the second most abundant species, the yellow-faced honeyeater *Lichenostomus chrysops* (13.7%). The 30 species detected within the overpass vegetation represented 42.2% of the 71 species recorded from the forest reserves on either side of the road.

A mean of 1.43 ± 0.69SE birds per transect were detected crossing the road away from the overpass compared to 1.82 ± 2.48 birds detected per transect within the overpass foliage; these means were not significantly different. However, if all birds recorded using the overpass were included (foliage, surface and above), the resulting mean (3.06 ± 0.18 birds per transect) was significantly ($F = 12.20$, df = 3, 184, $p<0.001$) higher than the mean per transect recorded crossing the road away from the overpass.

Discussion

As with most fauna overpasses, the Compton Road Land-bridge was designed and constructed primarily for the passage of large mammals between the forested reserves on either side of the road while directing them away from the traffic. To facilitate this aim, the structure was planted with abundant vegetation eventually to provide a natural and seamless extension of the surrounding habitat (Jones *et al*. 2010). However, as movements by the main species of concern (wallabies and kangaroos) would be impeded by full coverage of dense understorey, approximately 30% of the surface area of the structure was left open and planted only with grasses (Jones *et al.* 2010).

Although some birds – mainly corvids, ducks and predatory species - were observed on the overpasses soon after construction, the first sightings of smaller species coincided with the development of a dense and mainly continuous expanse of mainly local native species of planted shrubs and tree saplings (D. Jones unpublished data). This relationship between the presence of a extensive belt of dense sheltering vegetation and the movement of smaller species of passerine birds was first suspected after about three years development of the vegetation when the structure of the rapidly growing shrubs and smaller trees resembled a typical early successional stage of the local subtropical eucalyptus forests of the region (Jones *et al.* 2010). These opportunistic observations lead to the first exploratory studies (see Jones & Bond 2010) and the on-going research reported here.

Although road ecologists have only recently turned their attention to birds, it has become obvious that roads present highly variable levels of permeability, from little or no hindrance to that of a complete barrier (St. Clair 2003). The species least likely to fly across a typical road are primarily forest-dwelling songbirds (Tremblay & St. Clair 2009), although many exceptions exist within guilds (see Laurance *et al.* 2004). Significantly, several studies have discerned critical gap-width thresholds beyond which a majority of birds will not fly with 45m being defining. As this distance is narrower than many roads, the barrier implications of roads in excess of two lanes may be critical for large numbers of smaller bird species.

In the present study, on average 1-2 birds were observed flying over the busy four-lane road each five minute observation session, crossing a forest-to-forest distance of about 80m. However, virtually all of these species were relatively large in size (median 115g): small passerines accounted for less than 5% of all crossings detected away from the overpass. In direct and obvious contrast, virtually all of the species detected crossing the road within the foliage on the overpass were small (median 15g). Also of interest was the discovery of relatively large numbers of birds crossing the road above the overpass, rather than within the foliage. Most of these species were again the larger species.

The unexpectedly positive results of this modest study suggest that the barrier and filter effects of many roads may be successfully reversed through the use of carefully vegetated overpasses. Perhaps more importantly, these results strongly suggest that many of the large number of fauna overpasses could be converted into safe passages over roads for a much larger proportion of the local biodiversity than has often been previously considered.

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