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Research Note

Targeted field testing of wildlife road-crossing structures: koalas and canopy rope-bridges

Ross L. Goldingay[A,B] *and Brendan D. Taylor*[A]

[A]School of Environment, Science and Engineering, Southern Cross University, Lismore, NSW 2480, Australia.
[B]Corresponding author. Email: ross.goldingay@scu.edu.au

Abstract. The suitability of structures installed to enable safe passage of wildlife across a road is most frequently determined by monitoring of structures after new roads are built. Rarely are new structures field tested before installation. We installed canopy rope-bridges in an area frequented by koalas (*Phascolarctos cinereus*) with the explicit aim of determining whether koalas might use such structures. Rope-bridges were of four different designs to maximise the likelihood that one might be used, as a precursor to further replication. Infrared cameras were installed on the rope-bridges as well as on two nearby reference trees to compare frequency of use. Over a monitoring period of 2.9 years no koalas were detected on the rope-bridges whereas koalas were recorded on the reference trees on 34 and 41 different 24-h periods. Rope-bridges may not be suited to an arboreal mammal that is inclined to travel along the ground to move between trees.

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Introduction

Road networks are expanding worldwide, leading to an increase in various adverse direct and indirect effects on vertebrate wildlife (Laurance *et al*. 2014). In many developed countries wildlife road-crossing structures are now commonly installed to reduce these impacts when major new roads are constructed (Taylor and Goldingay 2010; van der Grift *et al*. 2013). However, a sound knowledge of the most appropriate structures to be installed, in addition to knowledge of effective structure density and location in a landscape, are required for impact mitigation to be effective. In reality, knowledge of the use of structures is available for only a subset of species (e.g. Taylor and Goldingay 2010).

New designs of road-crossing structures for wildlife are typically tested when new roads are constructed based on some learning from a previous road project (e.g. Taylor and Goldingay 2003, 2013; Rytwinski *et al*. 2015). That is, new designs are rarely tested for suitability before they are permanently installed into a new road (but see Ball and Goldingay 2008; Hamer *et al*. 2014). This creates the potential problem of perpetuating the continued use of poor designs and imposing a long lag period before new designs might be trialled. Furthermore, subsequent evaluation may be hampered because infrequent use of a structure may reflect an avoidance of the structure, poor installation design of the structure (e.g. poor access or poor habitat connectivity: Taylor and Goldingay 2014), an absence of target species from the immediate area or all three factors. This uncertainty is best addressed by trialling structures at locations where target species are present and by varying some elements of structure design.

The koala (*Phascolarctos cinereus*) is a species of high conservation concern (DSEWPC 2012) that is highly vulnerable to road-kill (Dique *et al*. 2003; Preece 2007; Lassau *et al*. 2008) and the barrier effects of roads (Lee *et al*. 2010). Knowledge of its willingness to use various kinds of road crossing-structures (underpasses and land-bridges) is relatively scant (AMBS 2012). Recent studies have drawn attention to the ability of canopy rope-bridges to encourage arboreal mammals to cross roads and other canopy gaps (Weston *et al*. 2011; Goldingay *et al*. 2013; Soanes *et al*. 2013, 2015). Although koalas are highly mobile when on the ground they don't always need to descend to the ground to change trees. Where the habitat allows, koalas can traverse between trees using connecting branches or may make short jumps between closely spaced trees (R. Goldingay, pers. obs.). Therefore, it is possible that they may use canopy bridges to move between trees and even to cross large canopy-gaps associated with roads. Furthermore, there are many locations where koalas cross roads in urban areas and where it is impractical to construct underpasses or overpasses (see Preece 2007; Goldingay and Dobner 2014).

Rope-bridges have been installed and monitored on the Pacific Highway in New South Wales in areas where koalas occurred but koalas have not been detected on these rope-bridges (Goldingay *et al*. 2013). However, that absence of records could reflect unsuitable rope-bridge design, absence of koalas during monitoring or the availability of underpasses that may be preferred. The aim of the present study was to investigate whether koalas would use rope-bridges. We did this by conducting a small-scale trial at a location where rope-bridges could be installed among trees known to be used by koalas. Four different designs were installed and monitored by motion- and heat-sensing cameras. Using four designs maximised the likelihood that one might be used. Should one be used then replication of that design would occur with further field

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monitoring. Monitoring of koala activity in trees adjacent to the rope-bridges occurred to provide evidence of koala activity in the immediate area and to indicate whether rope-bridges were avoided.

Methods

Study area

This study was conducted on the Southern Cross University campus in Lismore, New South Wales. The area selected featured a patch of trees measuring 30 × 100 m located adjacent to the northern access road into the campus. The area is part of a bigger patch of trees measuring 150 × 200 m surrounding a compound of buildings. The dominant trees in both the immediate area of the rope-bridges and the broader patch were tallowwoods (*Eucalyptus microcorys*) and forest red gums (*E. tereticornis*). Spotlighting surveys on different occasions through the bigger patch have detected 5–6 koalas in a single night, with 2–3 koalas seen in the area where the rope-bridges were installed (R. Goldingay, pers. obs.).

Rope-bridge designs and monitoring

We trialled four different designs: one similar to that used in previous studies (e.g. Weston *et al*. 2011; Soanes *et al*. 2013) with an 8-cm gap between rope strands (Fig. 1*a, b*), one with a woven-mesh and 1-cm gap between strands (Fig. 1*c*), one that was a rope ladder wrapped around internal wires to produce a sausage shape (Fig. 1*d*), and 3-sided rope-bridge consisting of a woven mesh bridge with rope-ladder sides (Fig. 1*e, f*). These were manufactured and installed by Fauna Crossings (netting.com.au). The end of each rope-bridge was securely lashed to a tree using 10-mm silver rope and positioned ~5 m above ground level. Rope-bridges extended between two tallowwood trees except for the mesh design which connected between a tallowwood and a red gum. All extended 8–11 m between different pairs of trees.

Fig. 1. The four different rope-bridge designs: (*a*) rope-ladder (45 cm wide), (*b*) ground view of the rope-ladder, (*c*) woven rope-mesh (34 cm wide), (*d*) rope-sausage (28 cm wide), (*e*) 3-sided rope-bridge (51 cm wide), and (*f*) ground view of the 3-sided rope-bridge. Photographs by B. Taylor.

KeepGuard KG680V cameras (ScoutGuard, USA) were installed at each end of each rope-bridge. A camera was also mounted on each of two reference trees (both tallowwoods) located between where the rope-bridges were installed. A corflute collar that surrounded half the circumference of the tree was placed on each tree ~2 m above the ground. This restricted any ascending koalas to the side of the tree where a downward-facing camera was mounted ~1.5 m above the collar. This follows the procedure described in Goldingay *et al*. (2011). Camera monitoring occurred between December 2012 and February 2016. Only a single camera operated on each rope-bridge after July 2015. The frequency of koala records was compared for reference trees and rope-bridges. We pooled the number of 24-h monitoring periods for the rope-bridges and for the reference trees and performed a Chi-square test on the frequencies of the number of periods with and without koala detections. We have assumed that the use of the reference trees would be equivalent to use of the rope-bridge attachment trees so absence of detections on the rope-bridges would indicate that koalas did not move from the attachment trees to the rope-bridges.

Results

Monitoring of the four rope-bridges and two reference trees extended over at least 2.5 years (Table 1). No koalas were recorded on the rope bridges whereas we detected koalas ascending or descending the reference trees (Fig. 2) on 34 and 41 different 24-h periods. The frequency of koala detection was significantly dependent on whether monitoring a rope-bridge or reference tree ($\chi^2 = 146.2$, $P < 0.001$).

We detected northern mountain brushtail possums (*Trichosurus caninus*) (Fig. 3*a*) and common ringtail possums (*Pseudocheirus peregrinus*) (Fig. 3*b*) on several of the rope-bridges but not on the reference trees (Table 1). Squirrel gliders (*Petaurus norfolcensis*) were detected on 1–2 nights on each reference tree.

Discussion

Recent studies of canopy rope-bridges in Australia have revealed traverses of these structures by a wide range of arboreal mammals such as rainforest ringtail possums and squirrel gliders (Weston *et al*. 2011; Goldingay *et al*. 2013; Soanes *et al*. 2015). Our study revealed no use of rope-bridges by koalas but

Table 1. Duration of monitoring and number of passes (one per 24-h period) by different species

MBP, mountain brushtail possum; CRP, common ringtail possum; SqG, squirrel glider

Structure or tree	Duration (years)	Koala	MBP	CRP	SqG
Rope-mesh	2.8	–	1	–	–
Rope-ladder	3.1	–	–	–	–
Rope-sausage	2.8	–	17	1	–
3-sided	2.9	–	4	1	–
Tree 1	3.0	41	–	–	2
Tree 2	2.9	34	–	–	1

Fig. 2. Koalas detected on the two reference trees: (*a*), (*b*) ascending; (*c*), (*d*) descending.

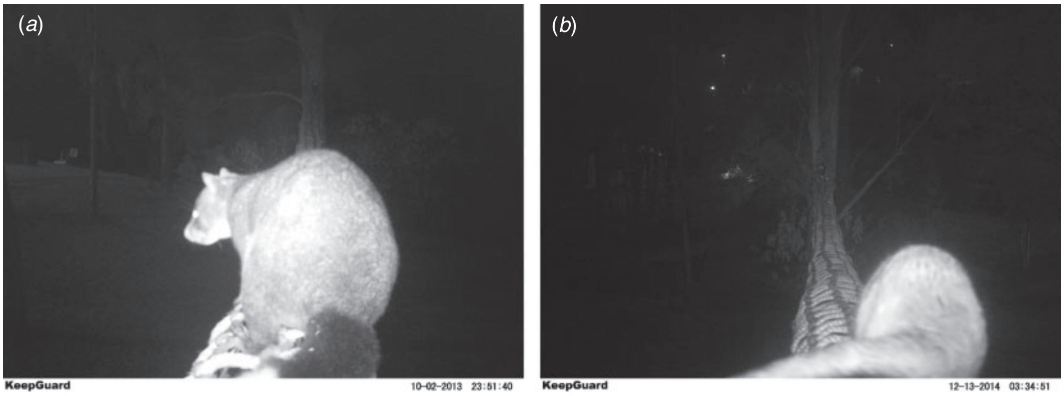

Fig. 3. A mountain brushtail possum (*a*) and a ringtail possum (*b*) on the rope-sausage.

use of two reference trees about once per month over a 3-year period. The trees connected by the rope-bridges did not enable direct movement through the canopy (i.e. along a branch or by a short jump). During the period in which cameras were positioned at each end of each rope-bridge (December 2012 to July 2015) it should have been possible to detect koalas exploring the other end of a rope-bridge if this occurred but no detections were made. Koalas may not have used the rope-bridges because: (1) trees connected by rope-bridges were unsuitable as consecutive feeding trees, (2) the rope-bridge connections to trees may have made it difficult for koalas to climb onto a bridge, (3) the rope-bridge was positioned too low (i.e. lower canopy level rather than mid–upper canopy level), (4) koalas may have a behavioural preference to descend to the ground and walk to another tree, or (5) koalas may have a lack of behavioural motivation (i.e. need) to rely on a rope-bridge.

Continuous tracking of eight koalas over 14 consecutive 24-h periods by Marsh *et al*. (2013) revealed no movement between the canopies of adjacent trees. The mean distance moved between trees by the eight koalas ranged from 19 to 54 m. Mitchell (1990) found that female koalas moved an average of 38 m ($n = 654$) and males 66 m ($n = 770$) between trees in consecutive daily locations. The concentrations of formylated phloroglucinol compounds in foliage influences feeding choices by koalas and these differ between neighbouring trees (Marsh *et al*. 2014). This suggests that koalas may be predisposed to move to a tree other than a neighbouring tree, which in our study would mean a tree other than one connected by a rope-bridge.

Koala access to the rope-bridges may have been impeded by the attachment designs, especially given the large size of koalas and that they descend a tree rump first (Fig. 2). Koalas may have been restricted from climbing onto the 3-sided bridge that contained several rope and metal attachments on the tree above the level of the bridge. Access was less restricted to the other three bridges. Habituation to the bridges over a period of >2.5 years produced no records. Koalas routinely travel along the ground (Mitchell 1990) and are highly mobile on the ground. Their large size and dietary requirements may have led to a behavioural preference to travel between trees along the ground.

The context of our installed rope-bridges was not analogous to installation over a major road. Road installations may provide for home range movements but, perhaps more importantly, are intended to enable dispersal by target species. In each case animals may be motivated to use a crossing structure because they seek food, shelter or reproductive opportunities not available on one side of a road. Wildlife road-crossing structures are routinely accompanied by exclusion fencing (Taylor and Goldingay 2003; Bond and Jones 2008) that can serve to funnel animals towards and through structures. Such behavioural motivation and funnelling were missing in our study. Whether one or all of the above factors led to avoidance of, or disinclination to use, the rope-bridges by koalas is unclear. However, our field testing suggests that rope-bridges are unsuited to the behaviour and ecology of the koala. Wildlife underpasses and overpasses that facilitate walking along the ground appear to be more suited to enable safe road-crossing by koalas.

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