Bridging the Gap – Malaysia's first urban canopy bridge to help arboreal animals to cross roads safely

A pilot project by Langur Project Penang (LPP) & Universiti Sains Malaysia (USM)

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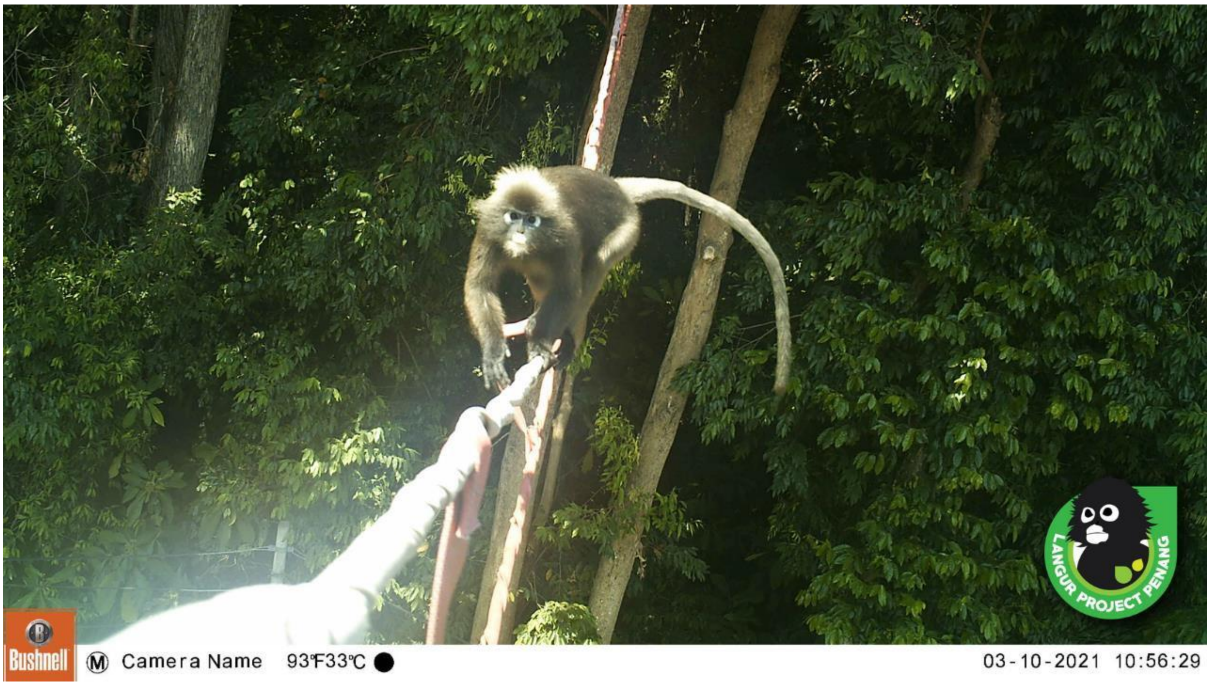
1st bridge prototype installation date: 28th February 2019

Bridge upgrade (2nd prototype): 19th August 2020



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1: Introduction

Roads enable us to access various parts of our country by driving, cycling, and walking. However, road development without proper consideration of wildlife movement may cause problems such as road kills, accidents, and human-wildlife conflicts. Especially in urban environments, wildlife struggles to move between fragmented habitats and is challenged by human development. While wildlife viaducts for terrestrial animals have been established in various parts of Peninsular Malaysia, there are no wildlife road crossings for arboreal animals living high up in the trees.

To assist treetop animals such as primates and rodents to cross the road, Langur Project Penang (LPP) submitted its detailed proposal for an urban firehose canopy bridges in Penang to JKR Pulau Pinang (Malaysian Work Department), which approved the permit in December 2018 and assisted LPP to build Malaysia's first urban canopy bridge on 28th February 2019. The bridge was upgraded from a single-firehose rope to a double-rope on 19th August 2020 to assess the effectiveness of the two designs. This prototype firehose bridge was financed with the aid of the Disney Conservation Fund and The Rufford Foundation and is located along the busy coastal road in Teluk Bahang, Penang. It was aptly named 'Ah Lai's Crossing' commemorating the alpha male "Ah Lai" in LPP's habituated langur study group at this site.

The objective of this road canopy bridge study was to 1) assess the canopy bridge usage of wildlife, and to 2) compare the two designs of the canopy bridge in terms of crossing frequencies. This study presents the bridge construction process and wildlife crossing results collected during the initial phase of the project using a first (i.e., single twisted liana design) and second (i.e., double twisted liana) bridge prototype and helps to determine whether this pilot project contributes to safer road crossings of arboreal wildlife and should therefore be implemented in other parts of Malaysia.

2: Methodology

Identification of wildlife crossing hotspots

This project has been conducted within the Langur Project Penang (LPP), a citizen-science working group aided by volunteer field assistants. We selected the site for the canopy bridge installation (5°27’48.82” N, 100°13’49.37” E) in Teluk Bahang, Penang after following a study group of dusky langurs for one year (Yap et al. 2019) and analysing their travel routes and frequencies of road crossing behaviours. As a result, we identified four crossing hotspots (Fig. 1) but could selected only one to install the canopy bridge due to permit conditions.

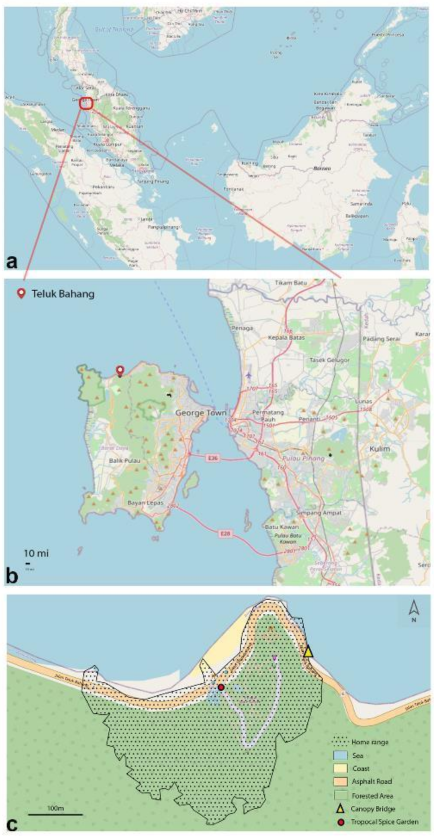


Figure 1: a) Map of Malaysia; b) Map of Penang and location of the study site, Teluk Bahang; c) Home range of the dusky langurs study troop in Teluk Bahang and location of the canopy bridge.

Bridge materials and cost

The first bridge design was a single twisted liana made of maroon, upcycled firehoses. The firehose was contributed by the Fire and Rescue Department Malaysia (Jabatan Bomba dan Penyelamat Malaysia), who regularly donates them the local social enterprise Animal Project & Environmental Education (APE Malaysia), for animal conservation projects. The firehose type was a combination of nitrile butadiene rubber (NBR) and a woven polyester jacket (cotton). These two materials ensure properties to combat burst and exposure to elements. In addition, firehose is flexible, lightweight, easily manageable under obstacles, and is designed for strength and resistance to abrasion and high temperature (Parker and Brown, 2001). Since this road canopy bridge is the first of its kind in Malaysia, the simple and light-weight single hose design acts as a testing prototype and minimises the risk of road accidents for motorists by bridge parts that could fall. The other materials used for the bridge design were a 40ft aluminium pole to anchor the bridge on one roadside, wire rope clips, nuts, and bolts. The first prototype (single twisted liana) was installed on 28 February 2019 and reinforced on 19 August 2020 into the second prototype (double twisted liana) to investigate the crossing activities by the animals. The same materials were used, with an additional row of the firehose parallel to the first rope and connecting ladders.

The cost for the prototype installation was MYR15,695 (ca. USD3,750), with the addition of MYR9,615.50 (ca. USD2,304) for the second prototype upgrade. The cost is inclusive of all bridge materials and service charges for installation, and a public liability insurance (PLI) in 2019 and 2020, excluding long-term maintenance cost.

Installation process and design

The bridge location did not offer mature tall trees at the coastal side to anchor the bridge. Therefore, a solid 12 m metal pole was constructed to tie the ends of the bridge across the road, (Fig. 2.a; pole constructed by JKR Pulau Pinang and CSG Chin Soon Trading, THB Maintenance Sdn. Bhd.) at the coastal road site. A certified arborist selected a mature and stable *Syzygium* tree at the forest road site to anchor the bridge. The distance between the pole and the *Syzygium* tree is 12.5 m. An emergency contact signage is installed on the metal pole to indicate to the public the contact details if any bridge-related accident occurs on the site.

We installed the first canopy bridge design on 28 February 2019. It was single twisted liana where a single fire hose was twisted to mimic the texture and size of liana branches (Fig. 2.b). The bridge was named "Ah Lai's Crossing" after the first alpha male of the study troop. We installed a camera trap (Bushnell Model 119537) on the top of the pole to capture the images and videos of wildlife crossing the bridge. The camera captures three images with one-second intervals, followed by 30-second video footage. Between April 2019 to May 2021, we retrieved the camera once per month for battery and memory card renewal and to ensure that the bridge and the camera were in good order.

On certain days, the camera stopped working due to technical issues. After one year and six months (on 19 August 2020), we reinforced the bridge into a second prototype, a double twisted firehose liana, to compare the activities with the single twisted liana design (Fig. 2.c). We then installed an additional mini solar panel on the top of the metal pole to charge the batteries of the camera trap (Fig. 2.d). Due to the Movement Control Order (MCO) implemented in Malaysia in March 2020 during the global outbreak of the COVID-19 pandemic, the camera trapping activity was suspended in January, February, March, and April 2020.

<u>Data analysis</u>

We analysed camera footage and photos twice a month, from April 2019 to May 2021. We compared the frequencies of crossing for the three mammal species throughout the study period in Penang: dusky langurs (*T. obscurus*), long-tailed macaques (*Macaca fascicularis*) and plantain squirrels (*Callosciurus notatus*) by Analysis of Variances (ANOVA), using R. The species and two bridge designs (single vs. double twisted liana) were then compared by Chi-Square Test of Independence in R, to test for the significant difference between the two variables. We also compared the frequencies of individual species crossing from coastal to forest, and forest to coastal by Dependent t-test in R.

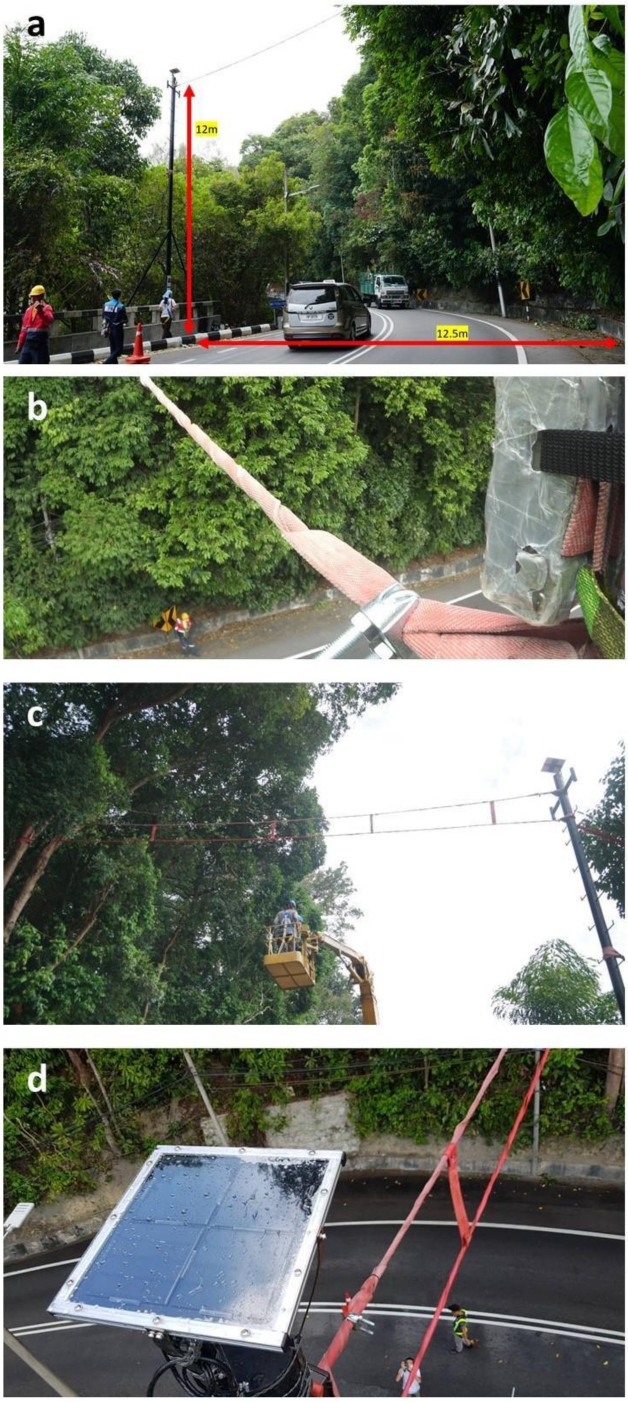


Figure 2: Road canopy bridge - Ah Lai's Crossing: a) Metal pole constructed at the coastal area to anchor the canopy bridge; b) The single-twisted liana canopy bridge (first design); c) A second firehose was used to upgrade the first prototype, the single twisted liana to a double twisted liana; d) Solar panel installed on the top of the pole to charge the batteries of camera trap.

3: Results from Camera Trap Data

We recorded 2,128 animal crossings in the 21,546 media data obtained during the 27 months study period, with a total of 16,954 photos and 4,592 videos taken, equivalent to 2,296 minutes of footage. The plantain squirrels were the most frequent bridge users, with 2,075 crossings, while the long-tailed macaques crossed 32 times and dusky langurs crossed 21 times. The overall crossing frequencies between April 2019 to May 2021 were significantly different between the three mammal species ($F(2,51) = [12.19]$, $p < 0.001$). There was no bridge-related road accident recorded during the 27 months, and no more wildlife roadkill in this area.

First bridge prototype

The first animal (an adult female long-tailed macaque) crossed the bridge on 4 March 2019 at 9:23 am (here and hereafter UTC+08:00), less than four days after installation. The first plantain squirrel crossed two months later, on 23 April 2019 at 8:32 am, and squirrels are now frequently observed crossing multiple times per day. The first dusky langur crossing was recorded on 20 November 2019 (Fig. 4), almost nine months after installation. The adult male langur made the first crossing at 4:59 pm, and another individual sat in front of the camera trap, inspecting the bridge, not long after the first male crossed, which was at 5:04 pm. We recorded 729 wildlife crossings for the first bridge prototype from 1 March 2019 to 19 August 2020, with 703 plantain squirrels, 20 long-tailed macaques and six dusky langurs.

The first bridge prototype's highest frequency of crossings for squirrels was in July 2020, when 201 crossings were recorded in one month. There was an increase in crossings for the long-tailed macaques every other month, with more macaques crossing in October 2019, December 2019, March 2020, and June 2020. For the dusky langurs, we only observed crossings in November 2019, December 2019, July 2020, and August 2020.

Second bridge prototype

We reinforced the bridge was into the second prototype, the double twisted liana, on 19 August 2020. In total, there we recorded 1,399 animal crossings between 19 August 2020 to 30 May 2021, with 1,372 plantain squirrels crossing, 12 long-tailed macaques, and 15 dusky langurs. The highest frequency of crossings for squirrels for the second bridge prototype was in January 2021, when we recorded 245 crossings. There was an increase in crossing frequency for the long-tailed macaques, with six crossings recorded in November 2020. We observed the highest number of crossings for dusky langurs in March 2021, with seven observations.

Comparison between the two bridge designs

A significantly higher number of animals crossed on the second bridge design (X^2 (2, 84) = [27.85], P<0.001). All three species showed a positively increasing trend line in the species crossing activities for the first bridge design (Fig. 3), with plantain squirrels showing the highest increase, a moderate increase for dusky langurs, and a weak increase for long-tailed macaques. Meanwhile for the second bridge design, there was an increasing trend in crossing frequency for plantain squirrels and dusky langurs, but a decreasing trend for long-tailed macaques.

Crossing directions and times

There are two possible directions to cross this road canopy bridge, 1) from the coast to the forest or 2) from the forest to the coast. There was an increasing trend of wildlife crossing frequencies over time for both directions. However, crossing frequency from coast to forest was significantly higher (M= 51, SD= 46; dependent t-test: t=5.16, p=2.2e^{-05}) than the other way (M= 26, SD= 33) and all species crossed more frequently from the coast to the forest (plantain squirrels N=1,364; long-tailed macaques N=30; dusky langurs N=13).

All three diurnal mammal species crossed the bridge similarly often in the mornings and afternoons with no significant time of preference (plantain squirrel, $N_{morning}$=1,042 vs. $N_{afternoon}$=1,033, long-tailed macaques N=13 vs. 19; dusky langurs N=13 vs. 8; dependent t-test: t=0.16, p=0.87;).

Results from Firehose Tensile Strength Test (Report prepared by Dr. Khairul Anuar Shariff)

The firehose tensile strength test was performed by School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia (USM). Three samples each 1) unused firehose of same material and 2) used/ twisted firehose was installed in an accessible location that mimics the condition of the installed firehose bridge, were tested for a pull-out strength test analysis.

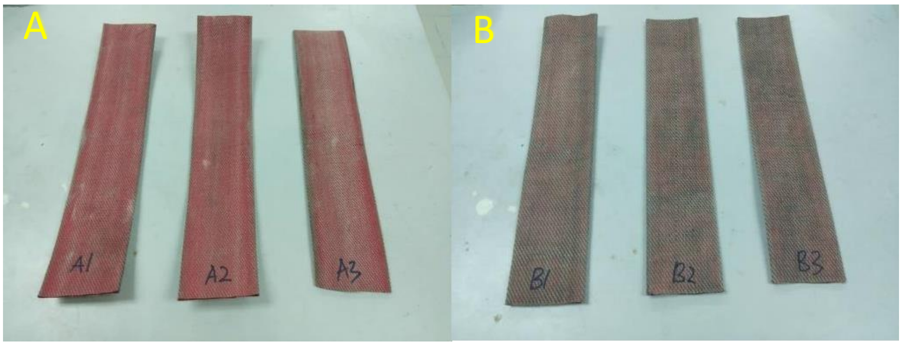
Test materials: A = unused firehose

B = used/ twisted firehose

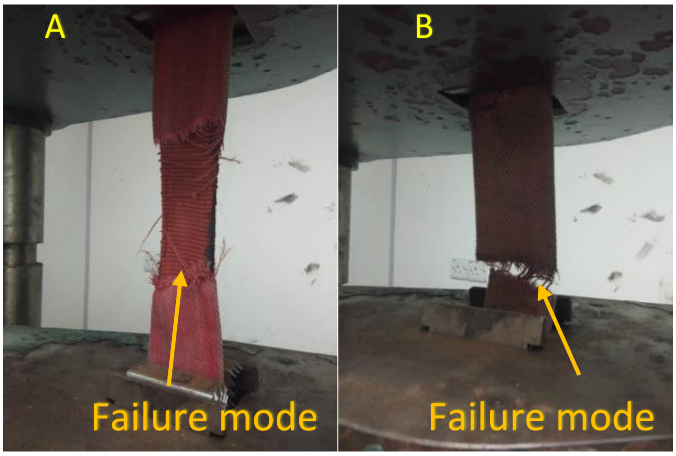
Test Parameters: Distance jaw-to-jaw (100 mm); pulling rate (10kg/minute)

Number of specimens: Three for each group

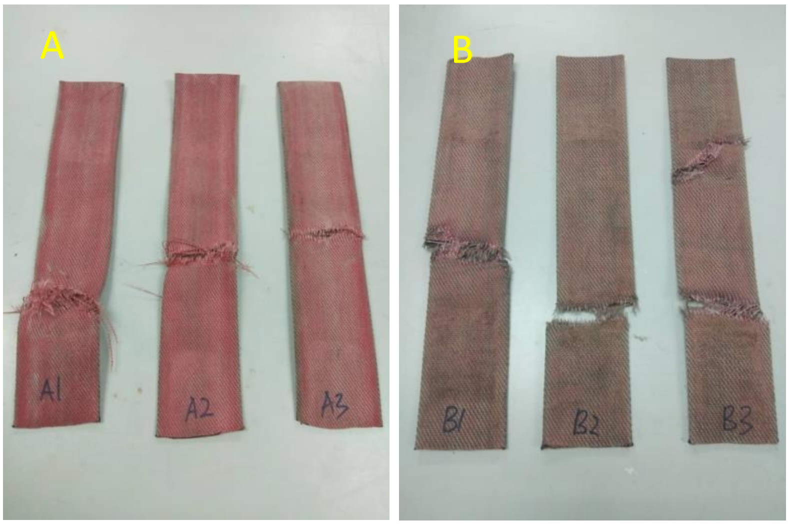
Before the pull-out test analysis:



During the pull-out test analysis:



After the pull-out test analysis:



Test Findings:

	Before installation (kg)	After installation (kg)
Average	1461.7	1436.7
Standard deviation	256.6	161.6

The pull-out test measurement shows that for the firehose specimen “before installation”, the maximum load that can be absorbed before material failure is 1,461.7 ± 256.6 kg. However, after installation and exposure to normal weather conditions for six months, the value of the carrying capacity load had slightly decreased to 1,436.7 ± 161.6 kg, a drop of 1.7%. Considering the standard deviation value of the specimens, i.e. the maximum value for the sample before installation is 1,718.3 kg, while for the specimens after installation is 1,598.3 kg, a similar trend was observed.

This report concludes that up to date 9 August 2019, the load loss after installation is not severe.

4: Discussion & Conclusion

Overall, this first urban canopy bridge project in Peninsular Malaysia serves to address the impact of habitat fragmentation on urban wildlife, representing a low-cost method to mitigate road accidents involving humans and nature. Our results provide vital data in images, videos, and statistical presentations for environmental education and environmental planning purposes. However, more investigations to be done especially on the long-term effectiveness of the canopy bridge, comparable to cable wire crossing and road running crossing behaviour by the wildlife. Using the data, we have organised public education programmes to highlight the importance of habitat connectivity and contribute to the bridge installation protocol with other Malaysian conservationists and researchers working on developing canopy bridge projects in their respective species and sites.

To conclude, it is crucial to have developed and urban areas designed to be wildlife-friendly and to protect and maintain natural corridors for the movement of animals, including connected tree canopy along roads. Implementing artificial mitigation solutions, such as unnatural canopy bridges, should only come after protecting natural habitat has already failed. Road and urban canopy bridges could be included as part of the town and state planning proposals to mitigate habitat fragmentation and raise more public awareness on the impact of roadkill and the expanding human-wildlife interface. The future of this work is to progress with citizen scientist participation and the data from the local wildlife department to identify more wildlife road crossing hotspots in Malaysia and to propose more canopy bridges and wildlife road crossing signage and educational materials for the public to mitigate the negative impacts of habitat fragmentation caused by development. The outcome of this study provides a better understanding about the necessity of conducting long-term road ecology studies on the threatened primate species in Malaysia, where hopefully, this canopy bridge initiative can serve as an example for conservation efforts to various states in Malaysia and other countries combating habitat fragmentation.

We sincerely thank PERHILITAN for granting us the permit to carry out this meaningful pilot project. We hope PERHILITAN would consider 1) to issue a new research permit, 2) approve the study to be expanded to other sites in Penang, and 3) provide advice to us on how to carry on from here.

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