CENTER for LARGE LANDSCAPE CONSERVATION

A.P.E. Project

(Assess. Protect. Evaluate.)

Artificial Canopy Bridges: An Effective and Economic Mitigation Measure to Reduce Monkey-Vehicle Collisions in Diani, Kenya

March 2023

Acknowledgements

Thank you to Colobus Conservation and Pamela Cunneyworth.

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Introduction

The coastal forests of East Africa are recognized as a Global Biodiversity Hotspot, containing many unique plants and animals. However, these forests are threatened by a wide range of anthropogenic activities. In the coastal town of Diani, Kenya, urbanization threatens its unique primate assemblage, consisting of four species of monkeys and two galagos. Though Diani is only 7 km^2, approximately 1,500 monkeys live among Diani's houses, businesses, and hotels. There is, quite literally, a monkey on every corner.

In 1971, Diani's Beach Road was constructed through primary forest, bisecting the town north to south, obligating the primates to cross the road to access resources such as water, foraging areas, and sleeping sites. By 1996, the number of monkeys involved in vehicle collisions had risen so drastically that residents rallied for action. This resulted in the formation of a not-for-profit primate and forest conservation organization - Colobus Conservation - to innovate a solution to the crisis.

Figure 1. Location of Diani Beach Road

By the beginning of 1997, a horizontal-ladder bridge design was created that linked tree canopies on opposite sides of the road, encouraging primates to cross the road by the bridge rather than on the ground. The elaborate bridge design specifically targeted the colobus, which as a typical colobine monkey, lacks a thumb.

Over the years, the number of canopy bridges increased when funding became available, and as of 2023, Colobus Conservation has installed 30 bridges along Diani's 9 km section of asphalt road. The bridges are thought to reduce the monkey-vehicle collisions and the road barrier effect. Together these protect populations from local extinctions by increasing gene flow between groups living on opposite sides of the road and safely extending home ranges across the road, giving access to a greater range of resources.

While bridges help facilitate movement across the roadway, the number of monkey-vehicle collisions has remained stable over time, despite the increase in bridges over the years. On average, Colobus Conservation continues to respond to three collision incidents every month.

To better understand this phenomenon, Colobus Conservation studied the road impacts on Diani's monkeys and how the canopy bridges were influencing that impact. Observers collected data on the number of vehicles on the road and the number of monkey crossings on the ground and the bridges. This data was correlated with the organization's long-term data on monkey-vehicle collisions.

Of the four species of monkeys living in Diani (colobus: *Colobus angolensis palliatus*, Sykes' monkey: *Cercopithecus mitis albogularis*, vervet: *Chlorocebus pygerythrus hilgerti*, and baboon: *Papio cynocephalus cynocephalus*), they found that only three use the bridges: colobus, Sykes' monkey, and vervet. Baboons rarely do so. Each species, however, crosses the road on the ground and bridges in a species-specific manner.

For the arboreal species (colobus and Sykes' monkey), 3% of the local population is injured or killed by vehicles annually, whereas for the more terrestrial species (vervet, and baboon) that percentage is much lower–2% and 1.75%, respectively. These percentage differences are likely because terrestrial species have evolved adaptations to avoid ground-dwelling predators, which in this case, are vehicles. Both vervets and baboons look for oncoming vehicles before crossing, a behavior not generally observed among colobus and Sykes' monkeys. Vervets and baboons cross the road more successfully at higher vehicle volumes than colobus and Sykes' monkeys likely because of their cautionary behavior.

The degree of terrestrialism also appears to affect species rates of bridge use because individuals already on the roadside cross directly rather than seeking to use a bridge. However, the degree of terrestrialism is not the only factor predicting bridge use; body mass appears implicated as a predictor because larger individuals appear less stable on the bridges. This consideration implies that canopy bridge use is most frequent at the 'sweet spot' where increasing arborealism and decreasing body mass intersect.

Vehicle volume passing under the bridges also affects bridge crossing rates, implying that bridges effectively mitigate the road impacts on primates only within specific vehicle volume limits. Colobus almost always cross the road on bridges once vehicle volumes exceed ~240 vehicles/hour, but importantly, above 465 vehicles/hour, bridge crossing rates for colobus are much less likely. Without bridges, the colobus on opposite sides of Diani's Beach Road would be isolated, putting this v*ulnerable* species at risk of local extinction. Vehicle volume has a lower effect on bridge crossings for Sykes' monkeys and vervets than colobus. These differences emphasize the point that disparate responses by species within a single taxonomic group could vary so that when multi-species road mitigations are used, species-specific patterns need consideration.

Bridges reduce the road barrier effect and monkey-vehicle collision hotspots. Surprisingly, bridges may also generate monkey-vehicle collision hotspots in new locations after installation. Colobus Conservation suggests this may occur due to competition for bridge use among a group attempting to cross the road. During these crossing events, some individuals may cross the road on the ground, increasing their potential to be involved in a monkey-vehicle collision and creating a new collision hotspot.

Canopy Bridge Design

The canopy bridge design, locally known as a 'colobridge,' uses 3/16" galvanized cable covered with PVC conduit pipe along the ladder's side rails. These materials can withstand Diani's coastal environment of high temperatures, humidity, and salinity. At 30 cm intervals, the galvanized chain is threaded through the cable to create a rung and alternately covered with 45 cm pressure pipes and 30 cm rubber pipes. Alternating the rung material with the pressure and rubber pipes creates more grip for the monkey, while their different sizes resist

torsion for the bridge lengths necessary to cross the road. Turnbuckles are placed at the end of the bridge, and the bridge is anchored and tensioned to the anchor tree utilizing T-brackets.

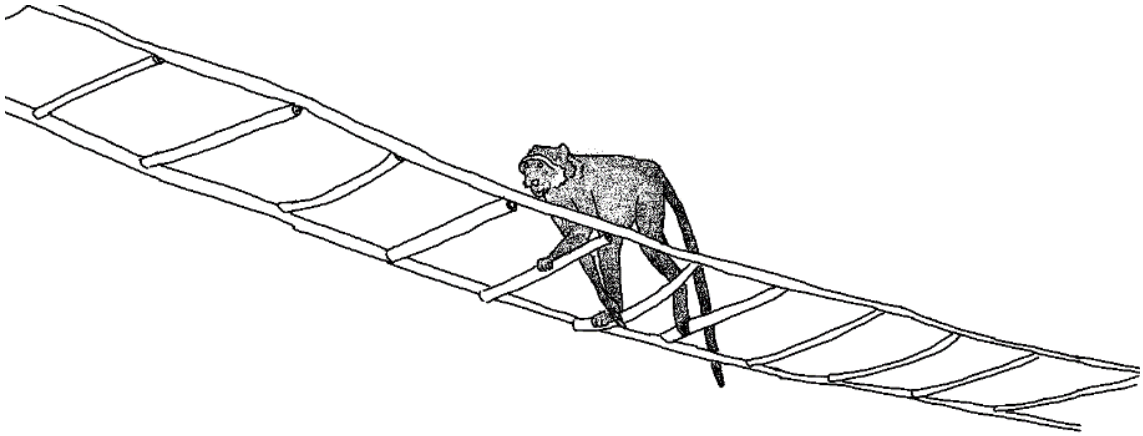

Figure 2. Drawing of a vervet monkey crossing a colobridge.

Site selection

Selecting appropriate locations for installing canopy bridges is essential for their success in managing the road barrier effect and collision risk. Colobus Conservation uses four criteria to determine whether a location is suitable.

1. Bridge cannot be located near electrical infrastructure;
2. Anchor tree must be large enough to support the bridge;
3. Tree canopy must extend beyond the anchor tree;
4. Bridge length must be less than or equal to 40 m.

If the bridge location no longer meets all of the above requirements, then the bridge is relocated.

Cost and Maintenance

Colobus Conservation estimates that >200,000 crossings occur annually on the 30 bridges currently installed along Beach Road. Each bridge costs an average of USD 157 annually for construction and maintenance (after amortizing over five years). The cost-effectiveness ratio, therefore, indicates that each crossing costs < 5¢ (USD).

Conclusion

Canopy bridges are an economical mitigation to the road barrier effect and for reducing collisions for monkeys. However, other factors need consideration to understand the extent that they do so, including species attributes, social dynamics, road crossing behaviors, home range size, road features, and vehicle volume.

References

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