

**Title: The spatial and temporal distribution of mammal roadkills in the Kwakuchinja
Wildlife Corridor in Tanzania**

Running head: Mammal roadkills in Kwakuchinja Wildlife Corridor

Henry Kenneth Njovu^a Alex W. Kisingo^a, Thomas Hesselberg^b and Abraham Eustace^{c,*}

^aCollege of African Wildlife Management, Mweka, P. O. Box 3031 Moshi, Fax.
+255272974133, E-mail: hnjovu@mwekawildlife.ac.tz, ORCID ID: 0000-0002-7240-3058

^aCollege of African Wildlife Management, Mweka, P. O. Box 3031 Moshi. Fax +255272974133,
E-mail: akisingo@mwekawildlife.ac.tz, ORCID ID: [0000-0003-4891-244X](https://orcid.org/0000-0003-4891-244X)

^bDepartment of Zoology, University of Oxford, South Parks Road, Oxford, OX1 2PS, United
Kingdom, E-mail: thomas.hesselberg@zoo.ox.ac.uk

^cZonal [Anti-Poaching Unit of Serengeti, Tanzania Wildlife Management Authority \(TAWA\)](#),
[P.O. Box 454 Bunda, Mara, Tanzania](#). E-mail: abrah15@gmail.com, ORCID: 0000-0002-6980-
[0503](https://orcid.org/0503)

*Corresponding author: Abraham Eustace, E-mail: abrah15@gmail.com

Acknowledgement

We greatly thank the College of African Wildlife Management, Mweka for funding and Augustino Mwageni, Nassoro Kapinga, Deo B. Tarimo, Phillip Malley and Jacob Ulomi for their significant contribution to this study. We are grateful for the suggestions from two anonymous reviewers, which greatly improved the manuscript. We would also like to thank AuthorAID for helping to establish the initial contact between the two senior authors.

Keywords: Roadkills, spatial and temporal patterns, Kwakuchinja Wildlife Corridor, vehicle-wildlife collisions.

INTRODUCTION

Vehicle-wildlife collisions have been reported to be a great threat to wildlife survival and traffic safety in many countries (Seiler, 2005; Das, Ahmed, Lahkar, & Sharma, 2007; Hobday & Minstrell, 2008). Studies have shown that, vehicle-wildlife collisions vary in space and time (Seiler, 2005). Mysterud (2004) reported that temporal patterns of vehicle-wildlife collisions correlate with mating and breeding seasons, dispersal of the young, seasonal migrations, changing food availability, temperature, rainfall and snow cover. Elseways, spatial determinants of vehicle-wildlife collisions encompass variation in animal abundance, the location of preferred foraging habitats, human settlements, landscape topography, road and traffic characteristics and fence location (Hubbard, Danielson, & Schmitz, 2000; Nielsen, Anderson, & Grund, 2003). However, patterns of the vehicle-wildlife collisions are sometimes nonlinear and ambiguous and can vary depending on the scale of the study, type of road and biology of the species (Clevenger, Chruszcz, & Gunson, 2003; Seiler, 2004).

Several mitigation measures have been suggested to reduce vehicle-wildlife collisions. For instance, Newmark (2008) suggested that changing human behaviour (by limiting vehicle speed) or animal behaviour (by manipulating vegetation) can reduce vehicle-wildlife collisions while Clevenger (2005); Bissonette and Adair (2008) suggested the introduction of wildlife crossings in locations where wildlife are frequently cross the road. However, Seiler (2005) stressed that successful management intervention requires an understanding and awareness of roadkill patterns in the specific area. Although relatively many studies related to wildlife have been conducted in the Kwakuchinja Wildlife Corridor: see for example Hassan (2003); Newmark (2008); Morrison et al. (2016); Kiffner et al. (2016); Bond et al. (2017), including some on roadkill (Kioko, Kiffner, Jenkins & Collinson, 2015a; Kioko et al., 2015b), the patterns of

roadkill remain poorly understood and do not receive proper attention from the public (Kioko et al., 2015b). This study aims at collecting spatial and temporal patterns of roadkill in order to develop effective mitigation measures in the Kwakuchinja Wildlife Corridor. Specifically, this study seeks to record species and describe spatial and temporal patterns of roadkills. We hypothesised that, roadkill encounter rate varies between road stretches and that the number of roadkill varies seasonally. We expect that, our findings will serve as empirical evidence to inform wildlife managers, road managers and the public on the patterns of roadkill in the Kwakuchinja Wildlife Corridor.

METHODOLOGY

Study Area

The Kwakuchinja Wildlife Corridor also known as the Tarangire–Manyara Wildlife Corridor is in northern Tanzania, Manyara region between latitudes 03 35' 38" and 03 48' 02" South and longitudes 35 48' 21" and 35 59' 25" East . The corridor connects Lake Manyara and Tarangire National Parks and it is a part of Kwakuchinja Open Area which covers 600 km². This corridor is bisected by a two-laned tarmac road connecting Arusha and Manyara regions and is placed within the specified boundaries of Burunge Wildlife Management Area (WMA) (Figure 1). This study was conducted on a 8.5 km long strip of the corridor traversed by the road (A104).

The study area is wildlife rich as it has influx of wildlife from bordering protected areas including the Tarangire and the Lake Manyara National Parks, the Manyara Ranch, the Mbugwe-Kwakuchinja Open Area and the Burunge WMA. Caro, Jones, & Davenport (2009) considered the corridor condition to be critical. Threats to the corridor include land use conflicts (Caro et al., 2009) such as conversion of wildlife lands to agriculture (Msoffe et al., 2011), bushmeat poaching (Kiffner et al., 2015) and rapid human population increase (Mwalyosi, 1991). Pittiglio, Skidmore, van Gils, & Prins (2012) classified the vegetation of the area into microphyllous and broadleaf deciduous savannas. Most parts of study area are floodplain with an altitude of 960-1020 m.a.s.l. The rainfall pattern includes short rains (November to January) and long rains (February to April). On average the area receives an annual rainfall of 729 mm (with March and April being the wettest months and July and August being the driest months) (Prins & Loth, 1988).

Data Collection

A total of 364 daily foot surveys each covering 8.5 km (the total distance covered during the study period was 3094 km) were conducted from 17-August-2014 to 16-August-2015. Two observers each walked on each side of the road. Our study covered the Makuyuni–Babati Road (A104) from Mdori to Minjingu (Figure 1). We covered 3.7 km within the specified boundaries of Burunge WMA and 4.8 km in the village land outside. The entire road stretch was systematically surveyed from 6:00 am to 8:00 am daily and the data obtained were used to calculate roadkill encounter rate (n/km) (Hobday & Minstrell, 2008) and frequency of medium/large sized wild mammals only (> 1 kg). Spotted roadkill was recorded and removed from the road to avoid double-counting. If there was any signs of roadkill and the carcass was not seen, the tracks were followed until the carcass was found (maximum distance followed was 4 km). To identify roadkill hotspots, a GPS (Garmin 12 Channels) was used to mark the location of roadkill. We also determined the variation in the number of roadkill between the dry (January, June to October) and wet (February-May and November-December) seasons.

Data Analyses

Data were analysed with the `glmer()` function of the `lme4` package (Bates et al., 2018) in R v 3.4.0 (R Development Core team, 2017) using a mixed effect model with survey day as a random variable due to non-independence of daily count data. Zero-inflated data necessitated a binomial model with daily presence/absence of roadkill on two road stretches (location: within and outside the specified Burunge WMA boundaries), season (wet/dry) and day (Monday to Sunday) and interactions between location and season and location and day. Overestimates from the road within the Burunge WMA being 20% shorter were accounted for by dividing by road length and converting to proportion of daily encounter rate. Stepwise backward elimination of model

components was based on P values from the Type II Wald Chi-square test. QGIS 2.1.8 (QGIS Development Team, 2016) was used to create the roadkill pattern map.

RESULTS

Roadkill species and their conservation status

A total of 82 roadkills comprising of 16 species were recorded, of which 27% were carnivores (Table 1). On average, one vehicle collision with a medium/large wild mammal occurred approximately every four days at an encounter rate of 0.03 animals/km. The majority of roadkill species were nocturnal (79%) and most were categorized as Least Concern by IUCN (2017). African savanna hare (*Lepus microtis*), kirk's dik-dik (*Madoqua kirkii*) and impala (*Aepyceros melampus*) were the most prone species to collisions accounted for 69% of all recorded roadkill. Interestingly, only one migratory ungulate (plain zebra) was recorded killed in our study.

Spatial variation in roadkill occurrences

We encountered about twice as many roadkills inside the boundaries of Burunge WMA (0.04 roadkill/km) than in the village land outside it (0.02 roadkill/km). Therefore, location had a significant influence on the daily chance of encountering roadkill (glmm-b: $\chi^2 = 6.06$, $df = 1$, $N = 728$, $P = 0.024$, Figure 1 and 2). There was no significant interaction between location and season (glmm-b: $\chi^2 = 0.011$, $df = 1$, $N = 728$, $P = 0.916$) or between location and day (glmm-b: $\chi^2 = 5.74$, $df = 6$, $N = 728$, $P = 0.453$).

Seasonal variation in the number roadkill

Our model demonstrated significant variation in the daily chance of encountering roadkill between dry and wet seasons (glmm-b: $\chi^2 = 6.72$, $df = 1$, $N = 728$, $P = 0.01$) (Figure 2) with the number of roadkill being higher in the former, suggesting that roadkill incidents are not evenly

distributed between months of the year (Figure 3). Our model did suggest that, the chance of encountering roadkill was evenly distributed across the week as no significance of day of the week was found (glmm-b: $\chi^2 = 8.73$, $df = 6$, $N = 728$, $P = 0.189$).

DISCUSSION

We recorded twice as many roadkills inside the specified boundaries of Burunge WMA than in the village land outside it, possibly because higher densities of wildlife occur within, compared to outside, the Burunge WMA (Lee, 2018). However, since a significant number still occurred in the village land, managers should consider the entire highway stretch that crosses the corridor when implementing strategies aimed at curbing roadkill. The encounter rates of 0.04 and 0.02 animals/kilometer are considerably lower than that found by Kioko et al. (2015a) in the same ecosystem (0.13 roadkill/km). Our study, however, only considered medium/large sized wild mammals, whereas Kioko et al. (2015a) included small mammals and other vertebrates. When considering mammals only, the encounter rate of Kioko et al. (2015a) was similar to the one we found inside Burunge WMA (0.04 animals/km). We also noted that, most of the recorded species of roadkill were nocturnal (79%), suggesting that most deaths occurred during dark hours. With regard to the conservation status of the recorded species, two species were listed as Near Threatened (striped hyena and plain zebra) and 14 species were listed as Least Concern (IUCN, 2017). The low number of migratory ungulates in roadkills is probably because drivers are likely to stop when they see wildebeests or zebras passing across the road (Kioko et al. 2015b).

As predicted, seasonal variations in roadkill numbers occurred, with numbers increasing as rainfall declined, similarly to Keyyu et al. (2015) findings from Mikumi National Park in

Tanzania. During the dry season, animals experience food scarcity and therefore engage in more exploratory wanderings. They might therefore increase home range size as a compensatory mechanism to acquire enough high-quality food resources. For instance, Gaidet & Lecomte (2013) observed that impalas move beyond their normal home ranges in search of forage and water during dry season. A similar pattern is seen in other species with seasonal movements of animals in response to food availability (Parker, Barboza, & Gillingham, 2009) and water shortage (Gaylard, Owen-Smith, & Redfern, 2003). Peak tourism season which cause more traffic might be responsible for higher roadkills in July-September (Figure 3).

Management Implications

With more than 29 mammal species found in Burunge WMA (Kiffner, O'Connor & Kissui, 2014), the two-laned Arusha-Manyara tarmac road poses risk to wildlife survival. Our study highlighted that African savanna hares, impalas and kirks dik-diks are major victims in the Kwakuchinja Wildlife Corridor. When considering the entire Tarangire-Manyara ecosystem, reports show that a total of 161 roadkillls were recorded in 75 km tarmac road passing through the Tarangire-Manyara ecosystem (Kioko et al., 2015b). Thus, there is a need to reduce wildlife-vehicle collisions in the area. The most effective method might be construction of highway crossing structures (underpasses/overpasses) and erection of extensive wildlife exclusion fences (Riginos et al., 2018). However considering the cost involved, wildlife and road managers have opted to deploy less expensive methods which attempt to modify driver and animal behaviours. The methods include driver warning signs, reduced speed limits, mirrors, and reflectors. However, warning signs and reflectors do not reduce roadkills by a relevant amount (Benten, Annighöfer, & Vor, 2018; Benten, Hothorn, Vor, & Ammer, 2018). As currently there is insufficient permanent mitigation measures at Kwakuchinja Wildlife Corridor, we propose the

construction of additional road bumps (surveyed area had three road bumps), the use of fixed speed cameras (none is available) and the erection of conspicuous and reflective signposts (ten are available (five per each lane)) along the highway. Additionally, we recommend the clearance of a verge and immediate removal of roadkill carcass on or along the highway as its persistence invites scavengers rendering them prone to vehicular collisions as well. However, the implementation of these measures might have significant financial implications making them unlikely to be adopted by the Tanzanian Government in the short-term. For example, the installation of a fixed speed camera costs about \$75,000 while the annual running cost is nearly \$16,000 (Tang, 2017). In any case, successful reduction of vehicle-wildlife collisions relies largely on changing people's behaviour through education, public awareness campaigns, and other legal measures such as fines.

We suggest the involvement of different stakeholders such as road authorities, legal and policy makers, conservation authorities and the general public in the implementation of roadkill mitigations.

REFERENCES

- Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R.H.B., Singmann, H., Dai, B., Scheipl, F., & Grothendieck, G. (2018). Package 'lme4'. Available from: <https://cran.r-project.org/web/packages/lme4/lme4.pdf> [Accessed on 23 Jan. 2019]
- Benten, A., Annighöfer, P., & Vor, T. (2018). Wildlife Warning Reflectors Potential to Mitigate Wildlife-Vehicle Collisions - A Review on the Evaluation Methods. *Frontiers in Ecology and Evolution*, 6:37. doi: 10.3389/fevo.2018.00037
- Benten, A., Hothorn, T., Vor, T., & Ammer, C. (2018). Wildlife warning reflectors do not mitigate wildlife-vehicle collisions on roads. *Accident Analysis & Prevention*, 120: 68-73. doi.org/10.1016/j.aap.2018.08.003
- Bissonette, J.A., & Adair, W. (2008). Restoring habitat permeability to roaded landscapes with isometrically-scaled wildlife crossings. *Biological Conservation*, 141, 482-488. doi: <https://doi.org/10.1016/j.biocon.2007.10.019>
- Bond, M.L., Bradley, C., Kiffner, C., Morrison, T.A., & Lee, D.E. (2017). A multi-method approach to delineate and validate migratory corridors. *Landscape Ecology*, 32, 1705-1721. <https://doi.org/10.1007/s10980-017-0537-4>
- Caro, T., Jones, T., & Davenport, T.R. (2009). Realities of documenting wildlife corridors in tropical countries. *Biological Conservation*, 142, 2807-2811. doi: <https://doi.org/10.1016/j.biocon.2009.06.011>
- Clevenger, A.P. (2005). Conservation value of wildlife crossings: measures of performance and research directions. *GAIA-Ecological Perspectives for Science and Society*, 14, 124-129. doi: <https://doi.org/10.14512/gaia.14.2.12>

- Clevenger, A.P., Chruszcz, B., & Gunson, K.E. (2003). Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. *Biological. Conservation*, 109, 15-26. doi: [https://doi.org/10.1016/S0006-3207\(02\)00127-1](https://doi.org/10.1016/S0006-3207(02)00127-1)
- Das, A., Ahmed, M.F., Lahkar, B.P., & Sharma, P. (2007). A preliminary report of reptilian mortality on road due to vehicular movement near Kaziranga National Park, Assam, India. *Zoos' Print Journal*, 22, 2742-2744.
- Estes, R.D., Wilson, E.O., & Otte, D. (2012). The behavior guide to African mammals including hoofed mammals, carnivores, primates: 20th Anniversary Edition. University of California Press, Oakland, CA.
- Gaidet, N., & Lecomte, P. (2013). Benefits of migration in a partially -migratory tropical ungulate. *BMC Ecology*, 13:36. doi: <https://doi.org/10.1186/1472-6785-13-36>
- Gaylard A., Owen-Smith N., & Redfern J. (2003). Surface water availability: implications for heterogeneity and ecosystem processes. In J. T. du Toit, K. H. Rogers, & H. C. Biggs (Eds.), *The Kruger experience: ecology and management of savanna heterogeneity* (pp. 171–188). Washington, DC: Island Press.
- Hassan, S.N. (2003). Impacts of space use by humans on the large mammal species diversity in the Kwakuchinja-Mbungwe wildlife corridor, northern Tanzania. *Tanzania Journal of Forestry and Nature Conservation*, 76, 134-143.
- Hobday, J. A., & Minstrell, M. L. (2008). Distribution and abundance of roadkill on Tasmanian highways: human management options. *Wildlife Research*, 35, 712–726. doi: <https://doi.org/10.1071/WR08067>

- Hubbard, M.W., Danielson, B.J., & Schmitz, R.A. (2000). Factors influencing the location of deer-vehicle accidents in Iowa. *The Journal of Wildlife Management*, 64, 707-713. doi: 10.2307/3802740
- IUCN (2017). *The IUCN Red List of Threatened Species. Version 2017-3*.
<<http://www.iucnredlist.org>>. Downloaded on 05 December 2017.
- Keyyu, J.D., Hape, G., Mofulu, F., Mwinuka, C., & Malugu, L. (2015) Impacts of the Tanzania-Zambia tarmac road on wildlife road kills and littering in Mikumi National Park. In: J. Keyyu, V. Kakengi, J. Ntalwila, A. Mwakatobe, Z. Bugwesa, J. Bukombe, D. Mtui, R. Fyumagwa, A. Nkwabi, E. Eblate, S. Liseki, M. Msuha, C. Mumbi, E. Kohi. Proceedings of the 10th TAWIRI scientific conference, 2nd – 4th December 2015, Naura Springs Hotel, Arusha, Tanzania. Tanzania Wildlife Research Institute, pp. 254-263.
- Kiffner, C., Nagar, S., Kollmar, C., & Kioko, J. (2016). Wildlife species richness and densities in wildlife corridors of northern Tanzania. *Journal for Nature Conservation*, 31, 29-37.
<https://doi.org/10.1016/j.jnc.2016.02.006>
- Kiffner, C., O'Connor, V., & Kissui, B. (2014). Report on wildlife population counts in Burunge Wildlife Management Area 2011-2014. The School for Field Studies Centre for Wildlife Management Studies, Karatu, Tanzania.
- Kiffner, C., Peters, L., Strohming, A., & Kioko, J. (2015) Bushmeat consumption in the Tarangire-Manyara ecosystem, Tanzania. *Tropical Conservation Science* 8, 318-332
- Kioko, J., Kiffner, C., Jenkins, N., & Collinson, W.J. (2015a). Wildlife roadkill patterns on a major highway in northern Tanzania. *African Zoology*, 50, 17-22. doi: <http://dx.doi.org/10.1080/15627020.2015.1021161>

- Kioko, J., Kiffner, C., Phillips, P., Patterson-Abrolat, C., Collinson, W., & Katers, S. (2015b) Driver knowledge and attitudes on animal vehicle collisions in northern Tanzania. *Tropical Conservation Science*, 8, 352-366. <https://doi.org/10.1177/194008291500800206>
- Lee, D.E. (2018). Evaluating conservation effectiveness in a Tanzanian community wildlife management area. *The Journal of Wildlife Management*, 82, 1767–1774. doi: 10.1002/jwmg.21549
- Morrison, T.A., Link, W.A., Newmark, W.D., Foley, C.A.H., & Bolger, D.T. (2016). Tarangire revisited: Consequences of declining connectivity in a tropical ungulate population. *Biological Conservation*, 197, 53-60. <https://doi.org/10.1016/j.biocon.2016.02.034>
- Mwalyosi R.B.B. (1991) Ecological evaluation for wildlife corridors and buffer zones for Lake Manyara National Park, Tanzania, and its immediate environment. *Biological Conservation* 57, 171-186
- Mysterud, A. (2004). Temporal variation in the number of car-killed red deer *Cervus elaphus* in Norway. *Wildlife. Biology*, 10, 203–211.
- Newmark, W. D. (2008). Isolation of African protected areas. *Frontiers in Ecology and the Environment*, 6, 321-328. doi: 10.1890/070003
- Nielsen, C.K., Anderson, R.G., & Grund, M.D. (2003). Landscape influences on deer-vehicle accident areas in an urban environment. *The Journal of Wildlife Management*, 67, 46-51. doi: 10.2307/3803060
- Parker, K. L., Barboza, P. S., & Gillingham, M. P. (2009). Nutrition integrates environmental responses of ungulates. *Functional Ecology*, 23, 57–69. doi:10.1111/j.1365-2435.2009.01528.x

Pittiglio, C., Skidmore, A.K., van Gils, H.A., & Prins, H.H. (2012). Identifying transit corridors for elephant using a long time-series. *International Journal of Applied Earth Observation and Geoinformation*, 14, 61-72. doi: <https://doi.org/10.1016/j.jag.2011.08.006>

Prins, H.H.T., & Loth, P.E. (1988). Rainfall patterns as background to plant phenology in northern Tanzania. *Journal of Biogeography*, 15:451–463.

QGIS Development Core Team (2016). QGIS 2.18 Las Palmas. Free Software Foundation, Inc., Boston, USA, <https://qgis.org/en/site/>

Riginos, C., Graham, M. W., Davis, M. J., Johnson, A. B., May, A. B., Ryer, K. W., & Hall, L. E. (2018). Wildlife warning reflectors and white canvas reduce deer–vehicle collisions and risky road-crossing behavior. *Wildlife Society Bulletin*, 42: 119-130. doi:10.1002/wsb.862

R Development Core Team. (2017). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing, Vienna, Austria, www.R-project.org/

Seiler, A. (2004). Trends and spatial pattern in ungulate–vehicle collisions in Sweden. *Wildlife Biology*, 10, 301–313.

Seiler, A. (2005). Predicting locations of moose–vehicle collisions in Sweden. *Journal of Applied Ecology*, 42, 371–382. doi: 10.1111/j.1365-2664.2005.01013.x

Tang, C.K. (2017). Do speed cameras save lives? Spatial Economics Research Centre Discussion Paper

221.

TABLE

Table 1: Mammal species recorded as a roadkill during a year-long survey across the 8.5 km highway stretch crossing the Kwakuchinja Wildlife Corridor.

Common name	Scientific name	Quantity	Conservation status [†]	Behaviour [§]
Aardwolf	<i>Proteles cristata</i>	1	Least Concern	Nocturnal
African Civet	<i>Civettictis civetta</i>	2	Least concern	Nocturnal
Caracal	<i>Caracal caracal</i>	1	Least concern	Nocturnal
African Savanna Hare	<i>Lepus microtis</i>	34	Least concern	Nocturnal
Common Genet	<i>Genetta genetta</i>	3	Least concern	Nocturnal
Kirk's Dik-dik	<i>Madoqua kirkii</i>	10	Least Concern	Nocturnal
Honey Badger	<i>Mellivora capensis</i>	2	Least Concern	Nocturnal
Impala	<i>Aepyceros melampus</i>	12	Least Concern	Diurnal
Black-backed Jackal	<i>Canis mesomelas</i>	5	Least Concern	Nocturnal
Common Dwarf Mongoose	<i>Helogale parvula</i>	2	Least Concern	Diurnal
White-tailed Mongoose	<i>Ichneumia albicauda</i>	3	Least Concern	Nocturnal
Spotted Hyaena	<i>Crocuta crocuta</i>	2	Least Concern	Nocturnal
Striped Hyaena	<i>Hyaena hyaena</i>	1	Near Threatened	Nocturnal

Common Warthog	<i>Phacochoerus africanus</i>	2	Least Concern	Diurnal
Plain Zebra	<i>Equus quagga</i>	1	Near Threatened	Diurnal
Bat-Eared Fox	<i>Otocyon megalotis</i>	1	Least Concern	Nocturnal
Total		82		

[†]IUCN (2017)

[§]Estes, Wilson, & Otte (2012).

FIGURES

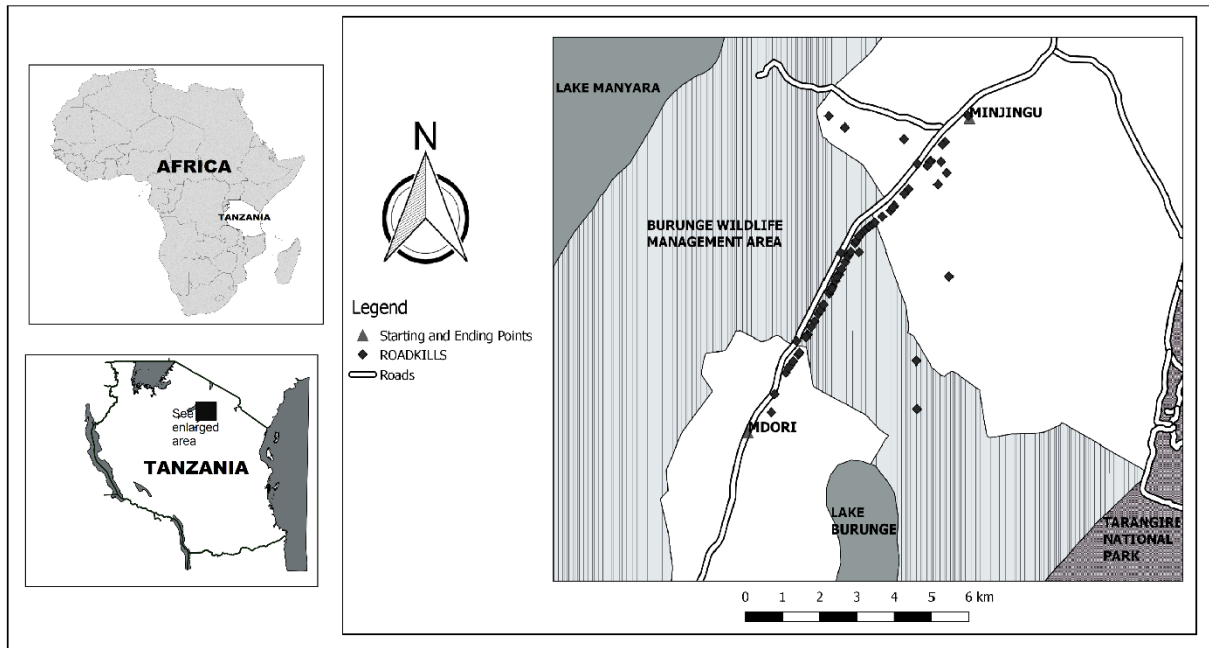


Figure 1: Location of the roadkills recorded during a year-long daily survey along a stretch of the road from Mdori to Minjingu (i.e. Tarangire - Manyara Wildlife Corridor/Kwakuchinja Wildlife Corridor). The roadkills which are far from the road were located by tracking them from the point of collision. The two insets to the left are the map of Africa (top left) showing location of Tanzania and the bottom left is the map of Tanzania showing the location of study area (black square).

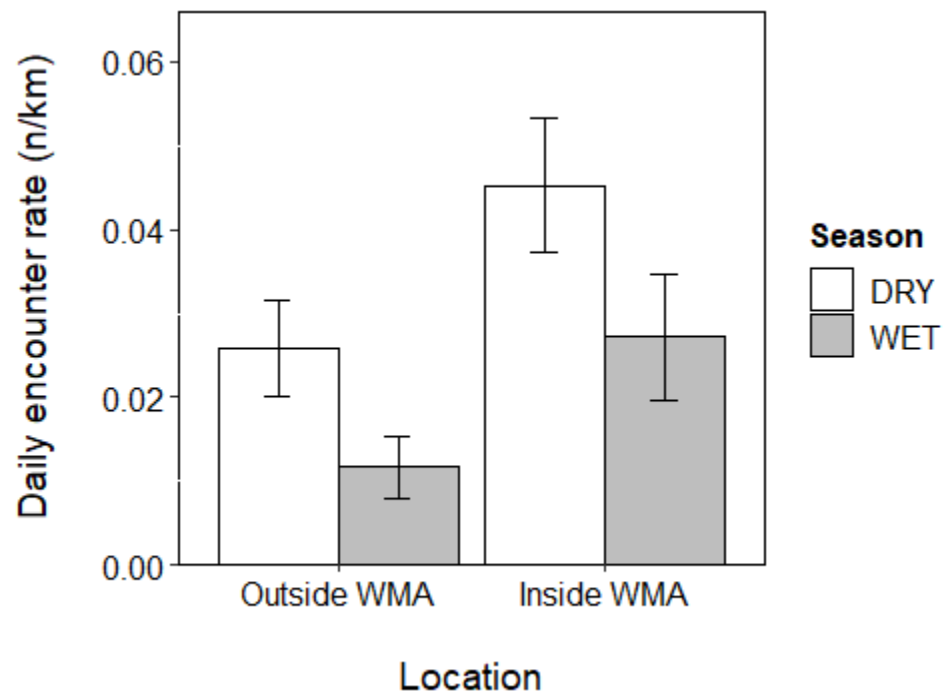


Figure 2: The daily encounter rate of roadkills inside and outside of the specified boundaries of Burunge WMA in the wet and dry seasons. A total of 82 roadkills were encountered during the study period. Error bars indicate standard error from the mean.

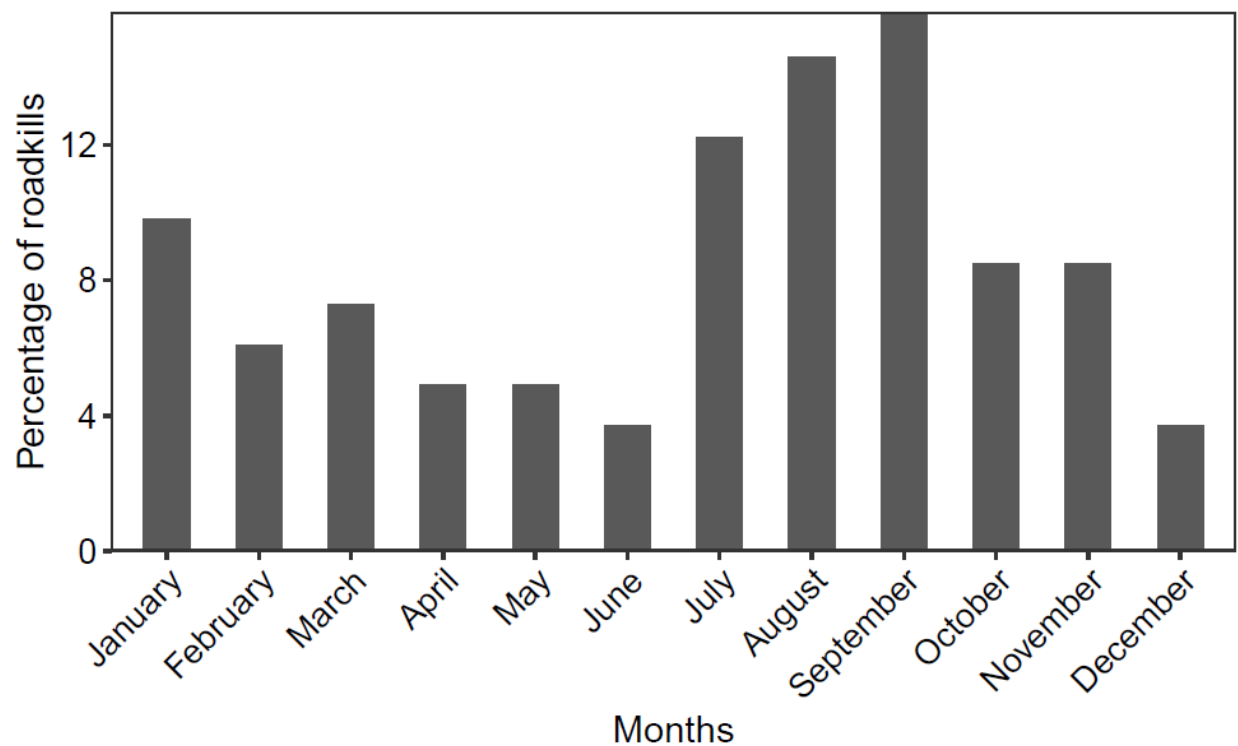


Figure 3: Percentage of roadkill per month on the combined inside and outside stretches of the Burunge WMA road stretches. The total number of roadkills across the year was 82.