INTERIM REPORT ON CAMERA TRAP SURVEYS IN THE ZAMBEZI VALLEY, ZIMBABWE

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Wildlife Conservation Research Unit

Interim report on camera trap surveys in the Zambezi Valley, Zimbabwe

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Abstract

Systematic camera trap surveys were undertaken across the Zambezi Valley from Charara Safari Area to Sapi Safari Area in the dry season of 2022. This report provides a list of mammal species detected during the surveys as well as the spatial and diel distributions of detections for each species. The densities of lions, leopards and wild dogs were estimated to be 2.7/100km^2, 4.6/100km^2 and 0.6/100km^2 respectively. Comparisons of predator population estimates from comparable camera trap surveys undertaken in Mana Pools National Park in 2015 suggest that the lion population in the National Park has remained stable or slightly increased, the leopard population has also remained stable or slightly increased, and the wild dog population density has drastically declined. Only three individual cheetahs were detected across the entire survey area.

Acknowledgements

We are grateful to the organisations that funded our surveys and assisted with fieldwork.

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Introduction

An extensive camera trap survey was undertaken in the Zambezi Valley during the 2022 dry season covering the Sapi, Hurungwe (Nyakasanga and Rifa), Charara Safari Areas and Mana Pools National Park. Further surveys in the Chewore and Dande Safari Areas will be undertaken during 2023 to complete the survey. The primary objective of the survey was to estimate population density and distribution of key predator species as a baseline for further monitoring. Although predators were the focus of the survey, a large amount of data on non-target species was also collected which can offer insight into the relative abundance and distribution of the wider mammal community within the region. Here we provide a report on all the mammal/carnivore species detected during the survey including density estimates of lions, leopards, and wild dogs.

Survey Methodology

The Zambezi Valley was surveyed between 11 June and 8 November 2022 using multiple rolling camera trap grids covering the entire valley area south of the Zambezi River, between Charara SA and Sapi SA covering an area of ~8000km^2 (see Figure 1). Camera trap stations in the grid were spaced approximately 4-5kms apart as this spacing is optimal for effective detection of large and medium sized carnivores (du Preez et al. 2014) and allows comparison with surveys undertaken across Zimbabwe and other countries.

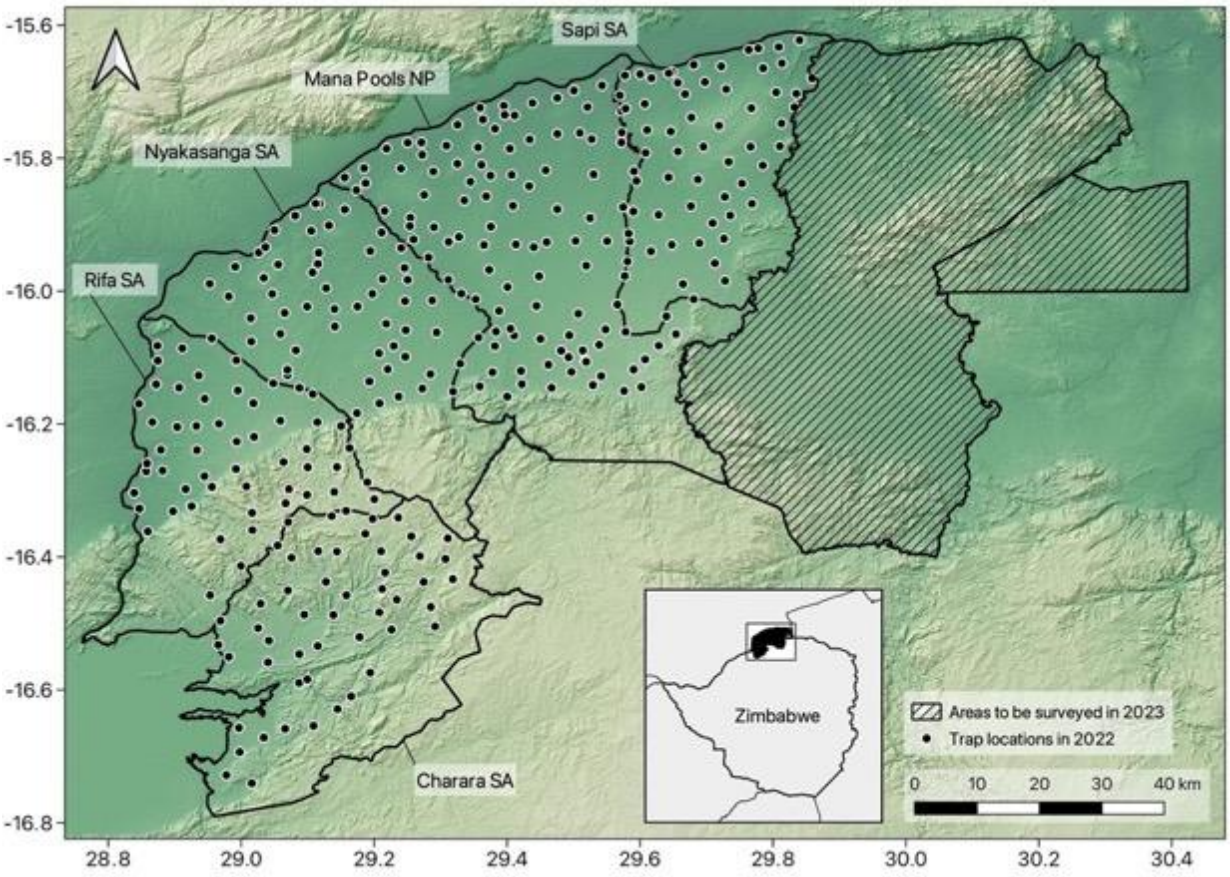

Figure 1. Camera trap locations during the 2022 Zambezi Valley camera trap survey. Inset map shows location of the survey area in Zimbabwe.

Prior to deploying the camera traps, the proposed trap positions were examined on Google Earth and the final trap position optimised within a 500 m radius of the originally selected point to position the camera station along game trails and where trails cross the tracks. This was done to maximise the captures as it is known that large predators frequently use roads and tracks (Cusack et al. 2015).

Additionally, use of sites on or near roads ensured that subsequent monitoring was easier and more time effective.

Each camera trap station consisted of two cameras, approximately 9-10 metres apart, facing each other though slightly off-set from one another to limit interference from the flash at night. The cameras were attached to metal fencing standards hammered into the ground or, where substrate was too hard for use of fence posts, they were strapped to a suitable tree or stump. All cameras were set at approximately 60 cm above ground level. The cameras and the metal standards were then covered with logs and branches so that they blended into the background as much as possible, while the area between the cameras was cleared of any obstructions.

Four different models of trail camera were used for the survey including: Cuddeback models 1125, 1149 and C1 (Non-Typical, WI, USA); Panthera V4 (Panthera, NY, USA). All the Cuddeback cameras used standard "white or colour" flash for the night images. All cameras were housed in protective metal boxes, primarily to protect them from damage caused by elephants and hyaena. All the cameras are triggered by a motion sensor when an animal moves across the cleared "capture zone". The recycle interval for all the cameras used in the survey was 5 seconds, apart from the older model Cuddeback 1125 and 1149 cameras that only recycle after 30 and 15 second intervals respectively. The older Cuddeback 1125 and 1149 cameras were always paired with a model of camera that could recycle at 5 second intervals. Each survey block consisted of between 51 and 56 trap sites (Table 1). The survey blocks in Mana Pools North and South repeated a camera survey undertaken in 2015 using the same method (Loveridge et al. 2019). This facilitates comparisons of large predator populations between the years of 2015 and 2022.

Table 1: Details of each survey block completed in 2022.

Survey	Dates		Number of paired trap stations per survey	Total number of raw images taken per survey
	Start	End		
Sapi	11/06/22	13/08/22	55	43,768
Mana North	20/06/22	19/08/22	55	65,762
Mana South	26/06/22	26/08/22	56	150,094
Nyakasanga	27/08/22	23/10/22	54	63,014
Rifa	03/09/22	30/10/22	55	47,127
Charara	11/09/22	08/11/22	51	83,461
Total			326	453,226

Data Management

All images captured during the survey were uploaded to TrapTagger (traptagger.co.uk), an open-source Artificial Intelligence (AI) platform designed to rapidly process and classify camera trap images according to species. Once the software has automatically tagged all images, the species classifications are checked to ensure that any errors in AI identification are corrected. For spotted hyaena and lion

images, we also recorded instances where the animal had a clear snare wound scar. Following the tagging process, a datasheet was exported from the program for analysis.

We individually identified all lions, leopards, wild dogs and cheetah by differentiating between individuals based on unique markings such as whisker spots (lions) and pelage patterns (Miththapala et al. 1989; Pennycuick and Rudnai 1970). These data were analysed in a spatially explicit mark recapture framework to generate estimates of population density.

Spatial and Temporal Distribution Analysis

The first stage of the analysis involved generating a list of all the mammal species detected during the survey. We calculated the total number of raw images captured and the proportion of the dataset represented by each species.

To visualise the spatial distribution of photographic detections for each species we used a relative abundance index (RAI) which is defined as the number of independent detection events of a particular species at a camera station per 100 trap days:

$$RAI = \frac{Independent\ detections}{Trap\ days} \times 100$$

All images of the same species at a camera station captured within 30 minutes of each other are classified as being part of the same detection event (independent detection). Put simply, RAI is a measure of how many capture events of a particular species would be expected if a trap was operational for 100 days in a particular area.

Some studies have shown that RAI can be used as a crude indicator of animal abundance when a species' density and photographic detection rate are directly proportional (Carbone et al. 2001; O'Brien et al. 2003; Rovero & Marshall 2009; Palmer et al. 2018). If the direct relationship between abundance and detection rate holds true, a higher RAI would point to a greater number of individuals occupying a particular area while a lower RAI would suggest that fewer individuals are present. However, it is important to note that detection probabilities (the likelihood of a species being detected by a camera trap) can vary across space and time because of changes in animal behaviour, environmental conditions, and the study method (Sollmann et al. 2013; Mann et al. 2015). In such instances, RAI would be an unreliable indicator of absolute abundance but can nevertheless still provide a measure of how frequently a species was photographed. We advise readers to be cognisant of this caveat when interpreting RAI results.

In addition to visualising the spatial distribution of each species we also calculated the temporal (diel – 24 hour) distribution of detections which provides an indication of a species' activity pattern. We aggregated photo bursts/successive captures into independent detection events (all images of the same species at a camera station captured within 30 minutes of each other are part of the same detection event) and plotted the frequency of detections against hour of the day.

To explore potential patterns of snaring pressure in the region, we plotted all camera trap locations where at least one image contained an animal (lion or spotted hyaena) with an obvious snare wound scar.

Density Analysis

To estimate density, we used two spatially explicit population density models, using maximum likelihood-based inference implemented in the R package 'secr' (Efford and Fewster 2013, Efford 2017) and Bayesian inference implemented in the R package 'SPACECAP' (Gopalaswamy et al. 2012). A data matrix with ID, trapping period (date), and detector (camera station) was generated and analysed using Spatially Explicit –Mark Recapture statistical software (SPACECAP and/or secr) which allows robust population density estimates to be derived for the survey area (Efford and Fewster 2013; Gopalaswamy et al. 2012). For density estimation, at each survey site, a state-space mask was created to represent the available habitat with buffer distances (calculated with the 'suggest buffer' function corresponding to $4 \times \sigma$ (Efford, 2017)). The habitat mask, consisted of a 0.5 km^2 gridded area that encompassed the suggested buffer region around the trapping array and was further refined to exclude non-habitat regions, e.g., into community areas. We ran these models using only adult and subadult individuals as spatio-temporal variation in the presence of juveniles (cubs or pups) is highly variable.

Results

In total, 38 mammal species were detected during the survey with elephant and impala images comprising more than 50% of the dataset (Table 1). The spatial and diel distributions of species detections are shown in Figures 2-39.

Table 1. Mammal species list and data summary. 'Number of Images' refers to the total number of raw images captured for a species. 'Percentage of Dataset' is the proportion of the total number of raw survey images that were comprised of a particular species. 'Mean RAI' is the relative abundance index value (number of independent detections per 100 trap days) for each species averaged across all traps in the survey.

Species	Number of Images	Percentage of Dataset	Mean RAI
Impala	60,346	37.7139	37.641
Elephant	41,757	26.0965	47.100
Baboon	17,964	11.2268	13.686
Hyaena, spotted	7,230	4.5185	21.627
Hippopotamus	5,094	3.1836	13.500
Buffalo	4,979	3.1117	2.454
Kudu	4,592	2.8698	5.958
Warthog	3,672	2.2949	6.177
Zebra	1,823	1.1393	1.959
Bushbuck	1,592	0.9949	3.707
Duiker	1,395	0.8718	3.655
Porcupine	1,374	0.8587	5.332
Leopard	1,244	0.7775	4.442
Lion	1,142	0.7137	2.638
Sharpe's grysbok	1,064	0.6650	4.445
Civet	915	0.5718	4.702
Eland	893	0.5581	0.873
Waterbuck	581	0.3631	1.037
Nyala	458	0.2862	0.488

Species	Number of Images	Percentage of Dataset	Mean RAI
Scrub Hare	289	0.1806	1.315
Wild dog	265	0.1656	0.514
Wildcat	256	0.1600	1.304
Aardvark	227	0.1419	0.608
Genet, large-spotted	159	0.0994	0.913
Caracal	140	0.0875	0.600
Jackal, side-striped	106	0.0662	0.523
Honey badger	100	0.0625	0.473
Vervet monkey	99	0.0619	0.332
Bushpig	67	0.0419	0.120
Serval	59	0.0369	0.286
Klipspringer	31	0.0194	0.127
Mongoose, white-tailed	24	0.0150	0.137
Sable	22	0.0137	0.075
Roan	14	0.0087	0.029
Cheetah	13	0.0081	0.058
Mongoose, bushy-tailed	11	0.0069	0.048
Mongoose, banded	10	0.0062	0.052
Mongoose, slender	3	0.0019	0.017

Spatial and diel distributions of mammal detections

Lion - *Panthera leo*

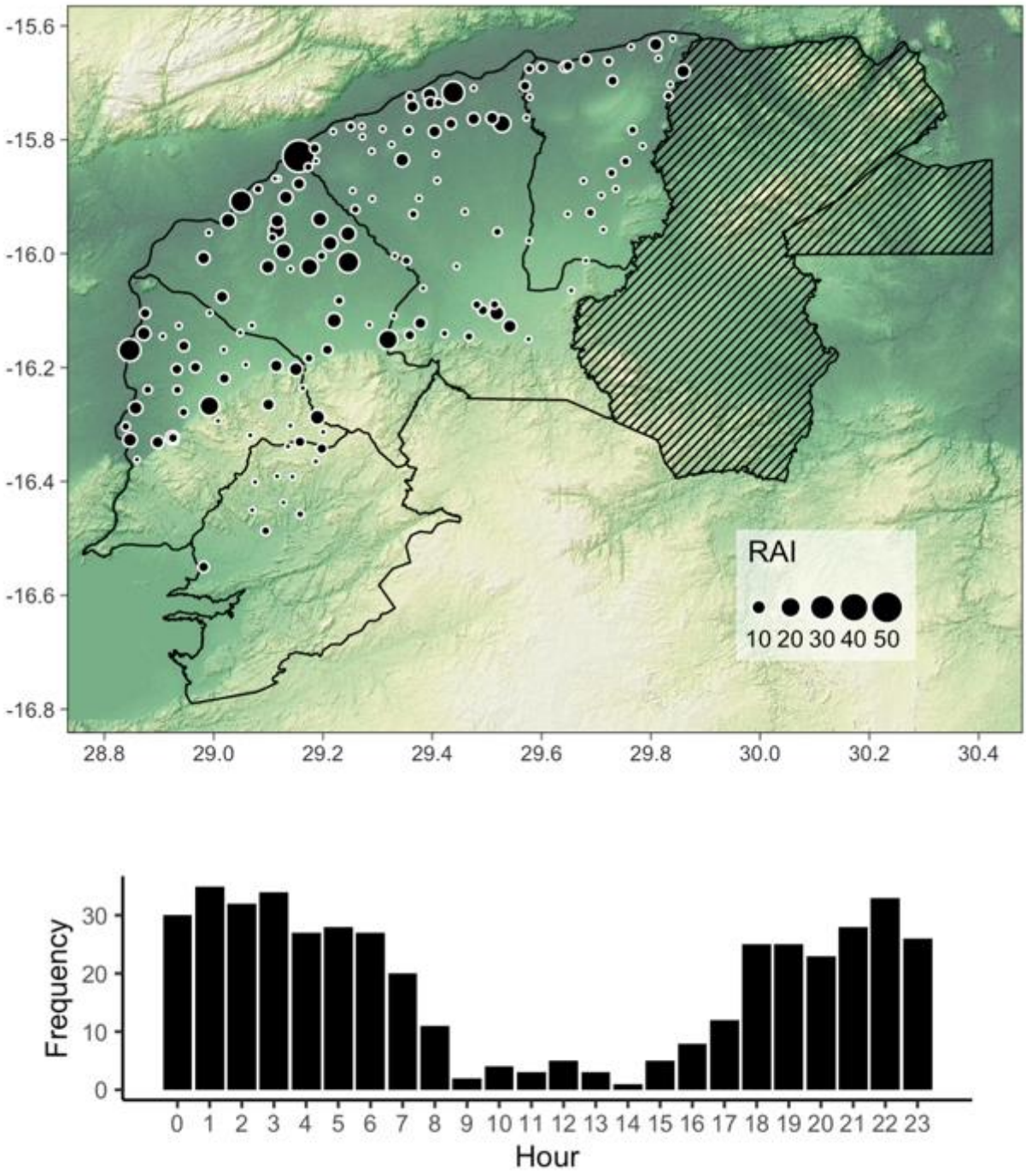

Figure 2. Spatial (top) and diel (bottom) distribution of lion detection events during the 2022 Zambezi Valley camera trap survey.

Leopard - *Panthera pardus*

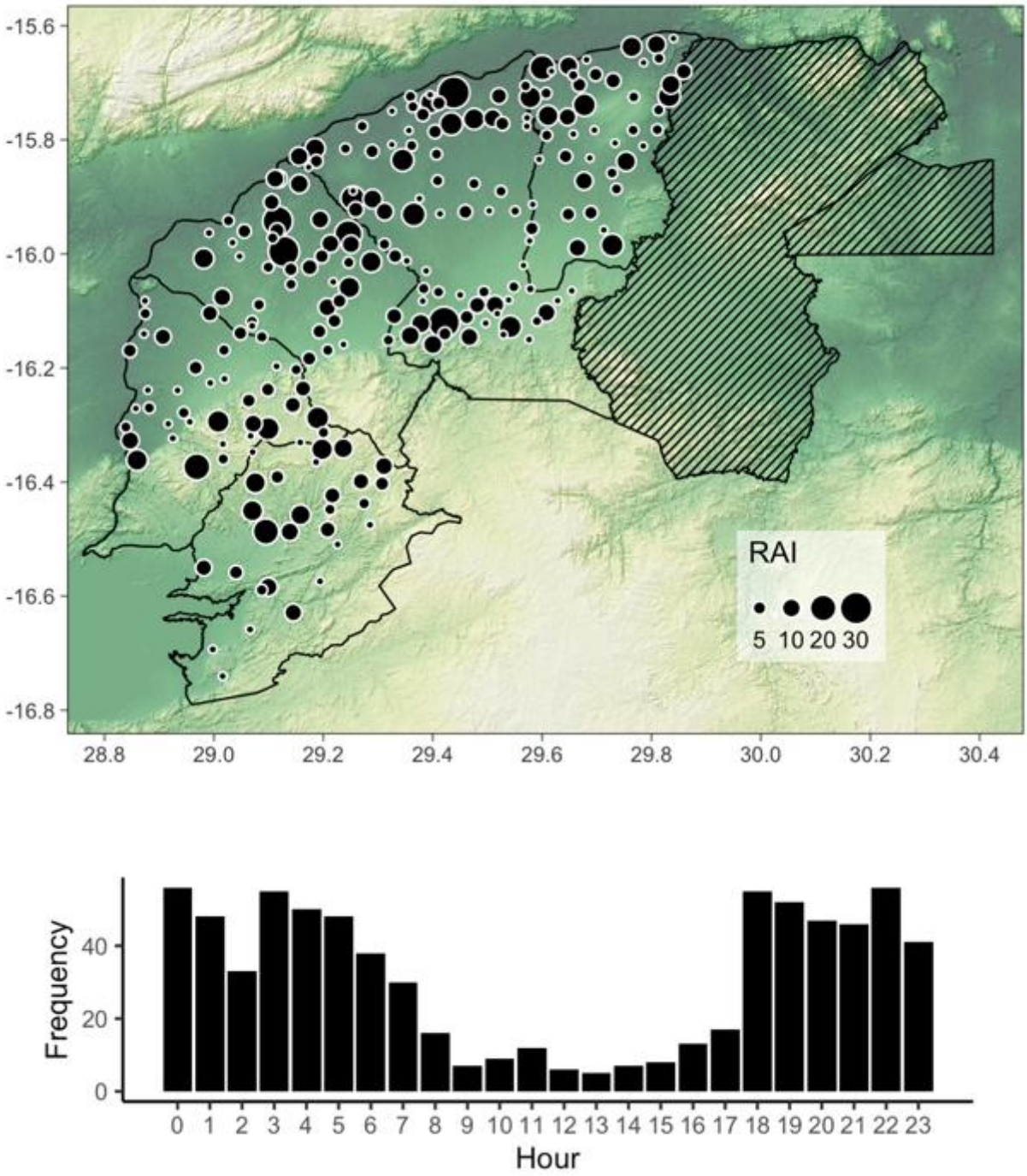

Figure 3. Spatial (top) and diel (bottom) distribution of leopard detection events during the 2022 Zambezi Valley camera trap survey.

Hyaena, spotted - *Crocuta crocuta*

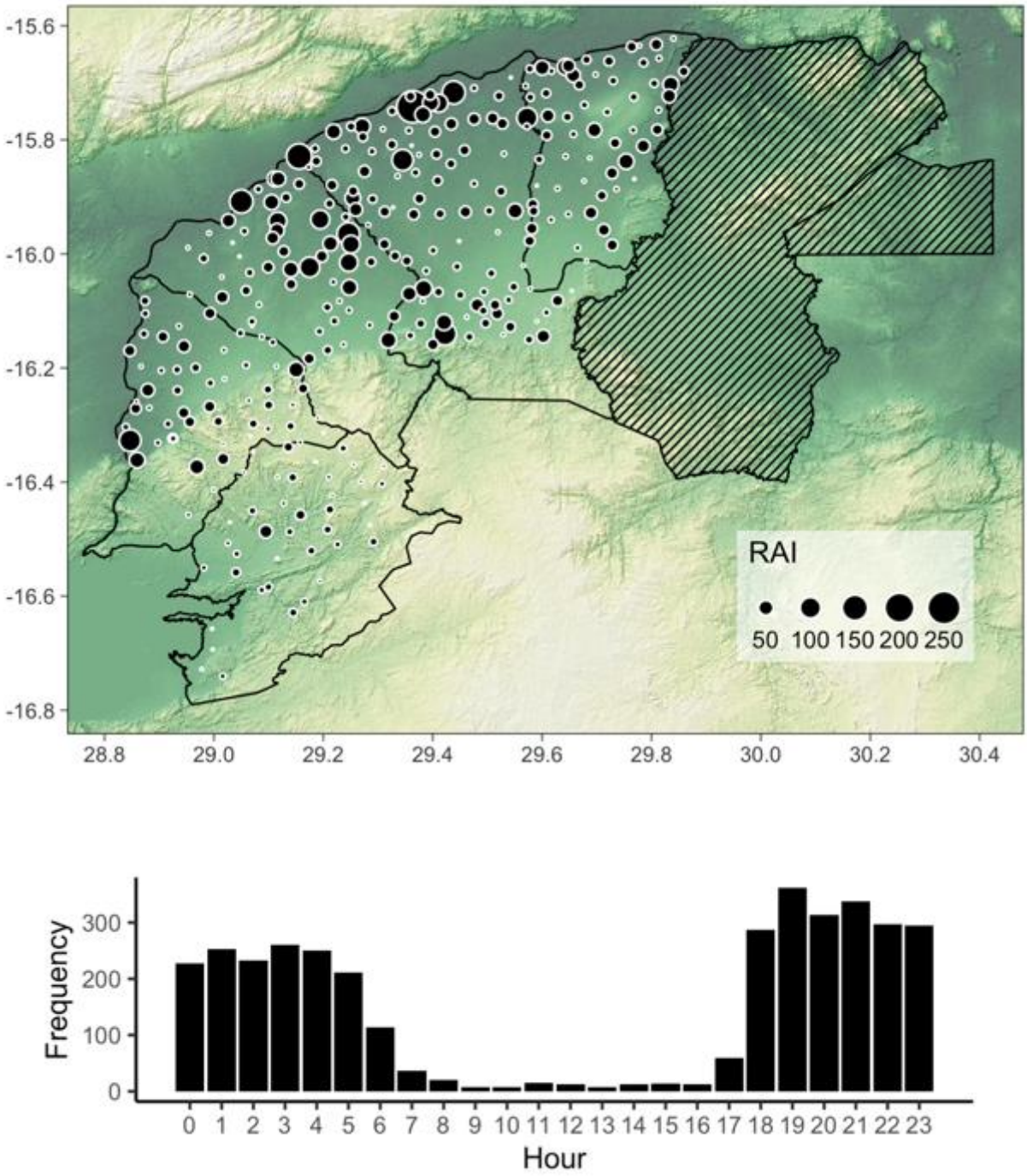

Figure 4. Spatial (top) and diel (bottom) distribution of spotted hyaena detection events during the 2022 Zambezi Valley camera trap survey.

Cheetah - *Acinonyx jubatus*

Three individual cheetahs were identified from images captured across the Zambezi Valley

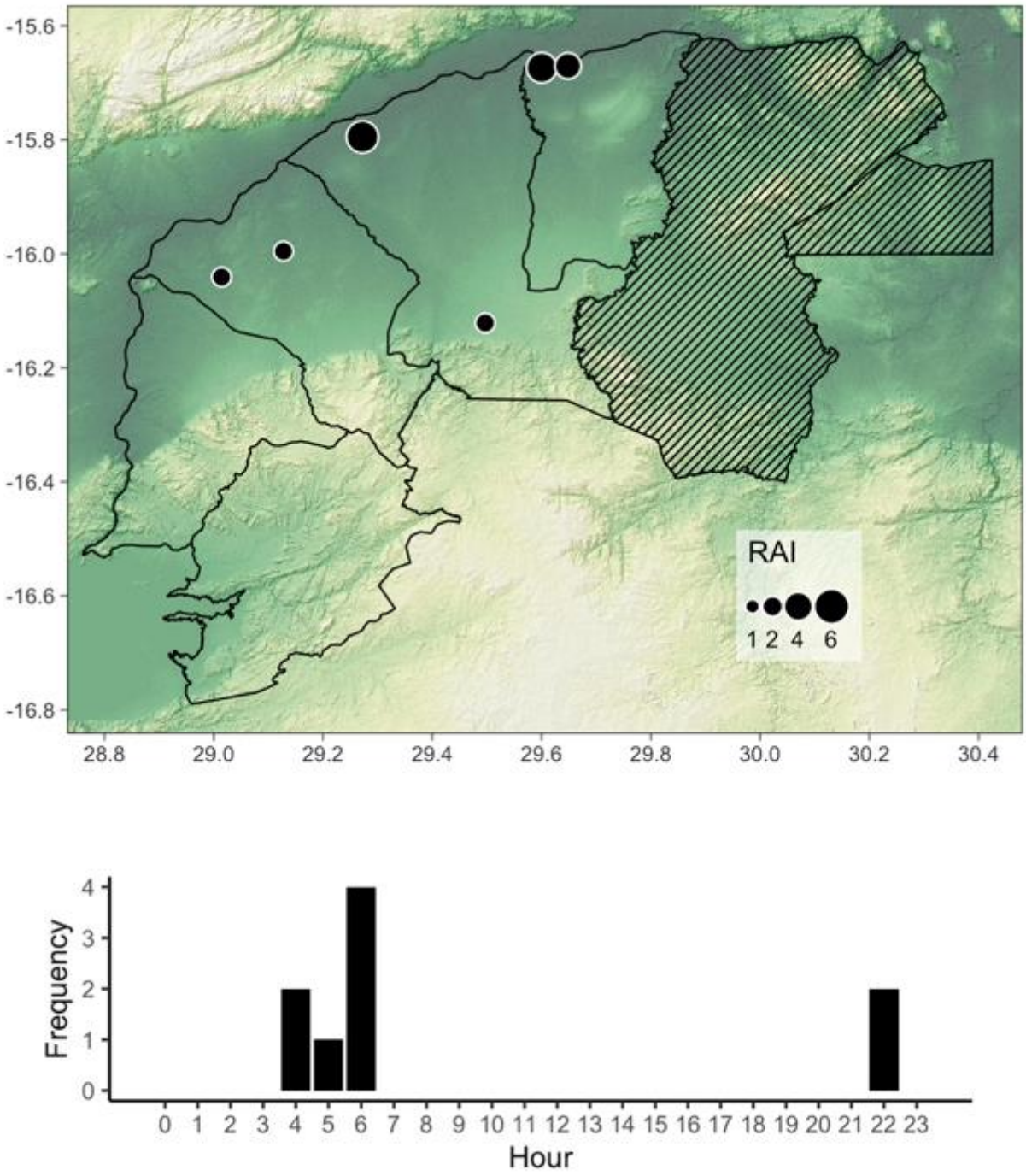

Figure 5. Spatial (top) and diel (bottom) distribution of cheetah detection events during the 2022 Zambezi Valley camera trap survey.

Wild dog - *Lycaon pictus*

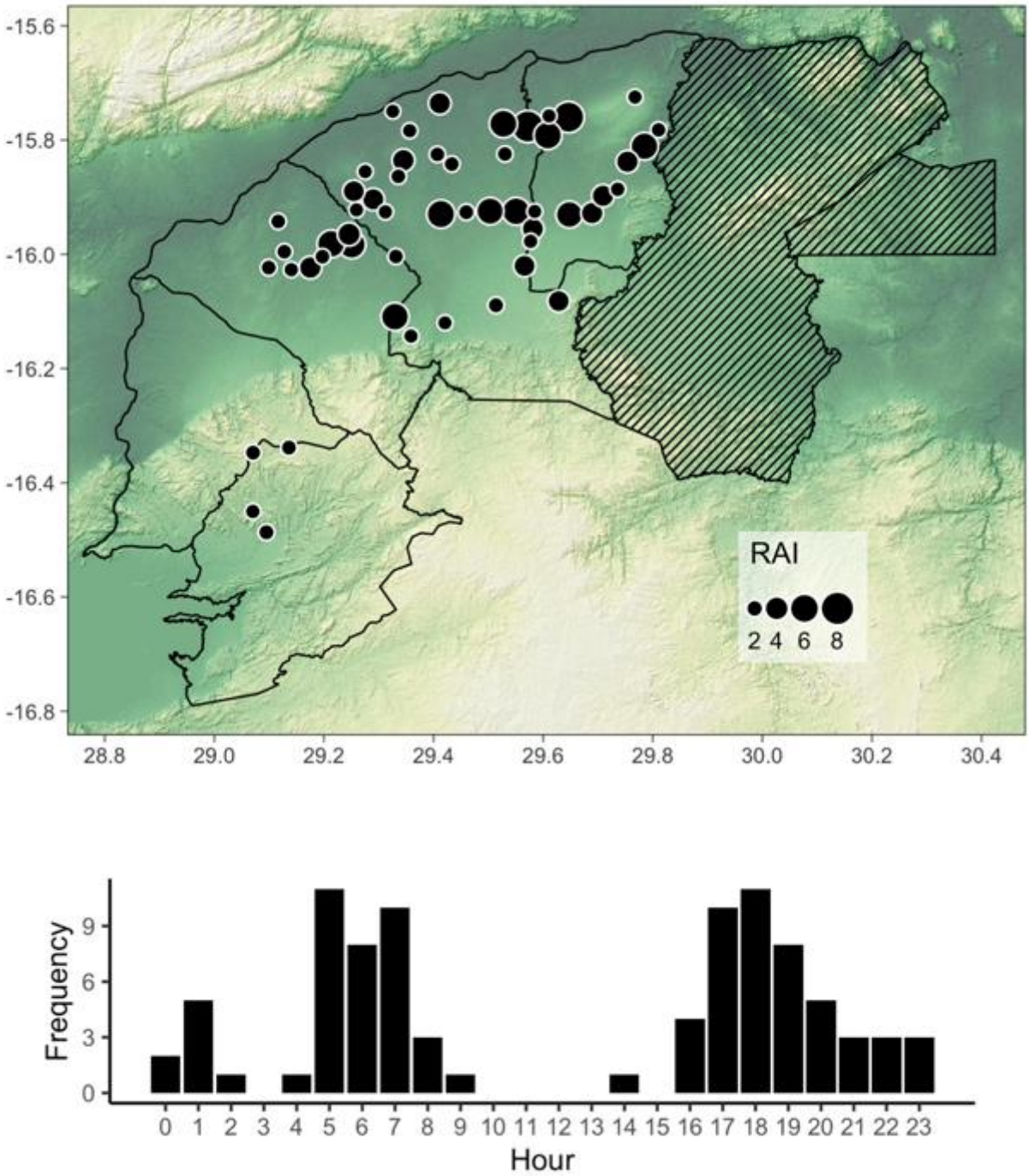

Figure 6. Spatial (top) and diel (bottom) distribution of wild dog detection events during the 2022 Zambezi Valley camera trap survey.

Jackal, side-striped - *Lupulella adusta*

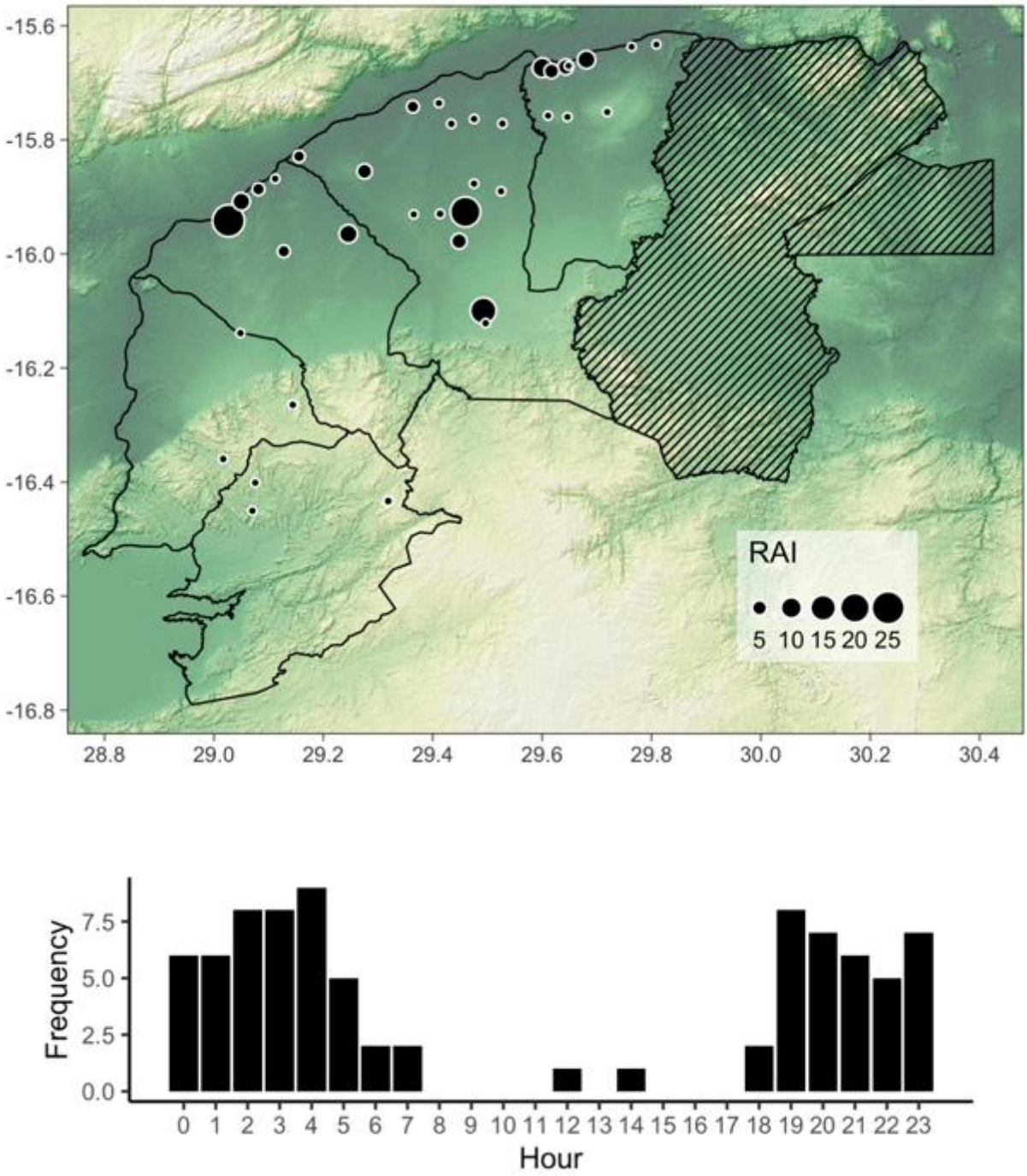

Figure 7. Spatial (top) and diel (bottom) distribution of side-striped jackal detection events during the 2022 Zambezi Valley camera trap survey.

Wildcat - *Felis lybica*

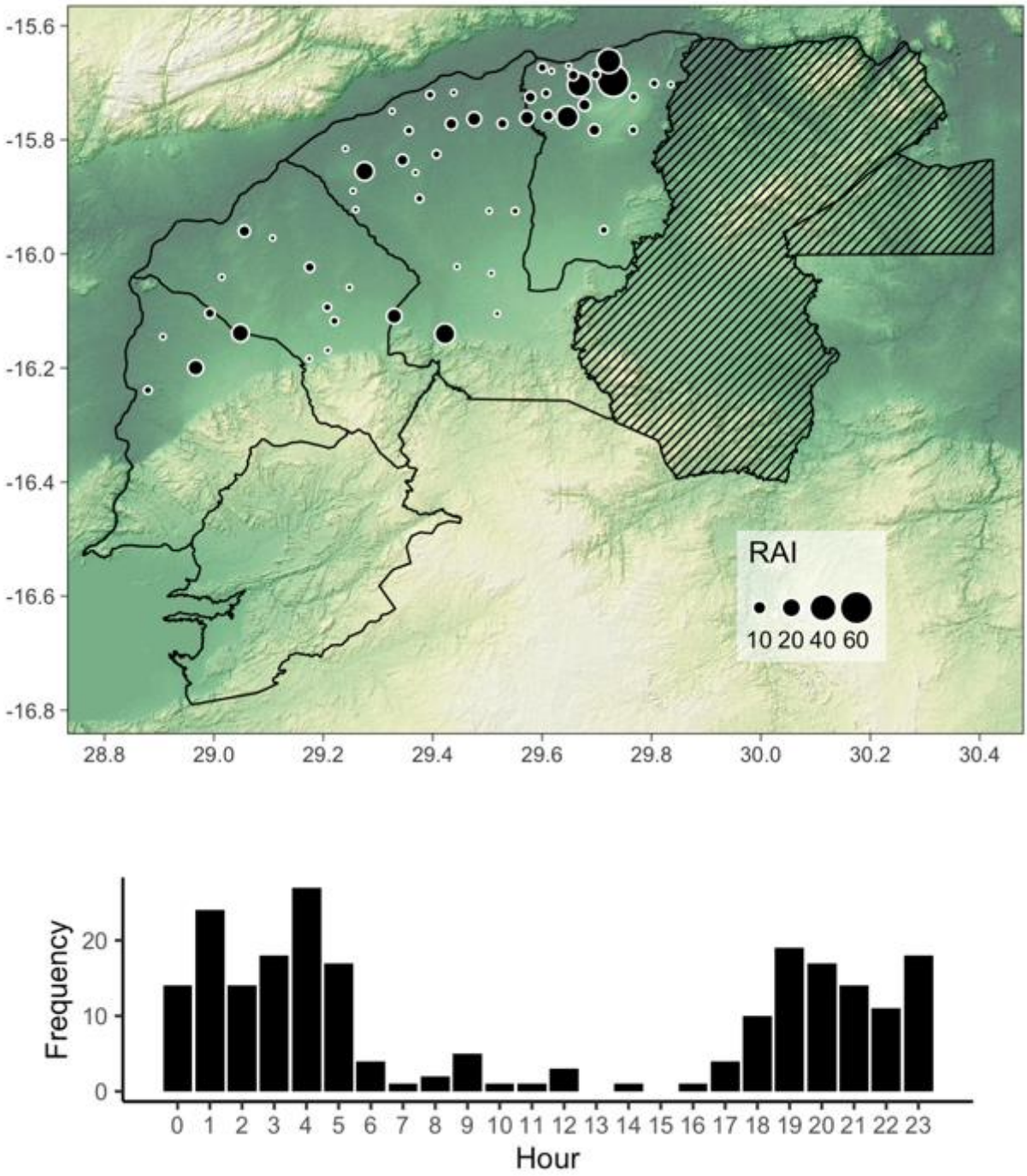

Figure 8. Spatial (top) and diel (bottom) distribution of wildcat detection events during the 2022 Zambezi Valley camera trap survey.

Serval - *Leptailurus serval*

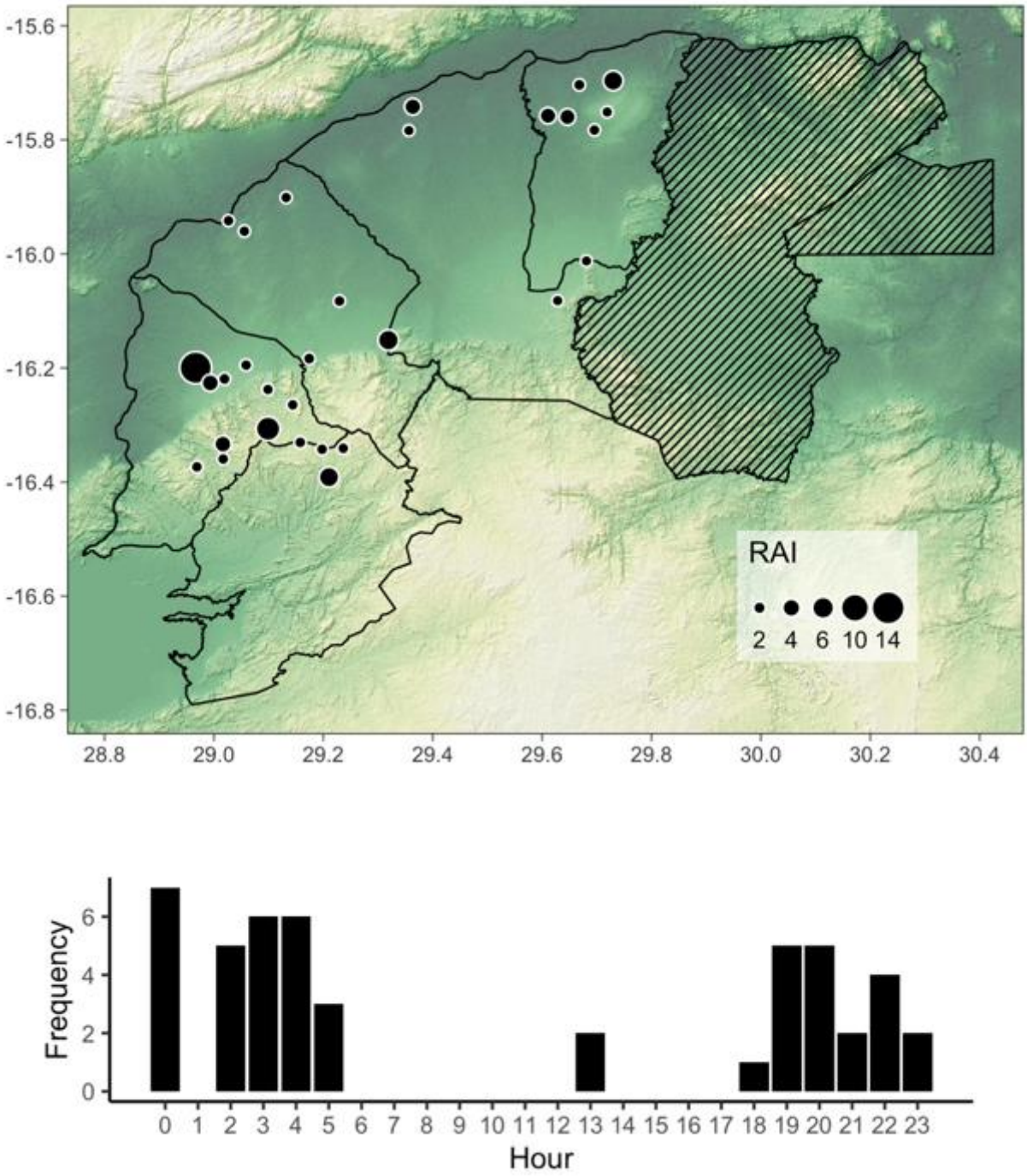

Figure 9. Spatial (top) and diel (bottom) distribution of serval detection events during the 2022 Zambezi Valley camera trap survey.

Civet - *Civettictis civetta*

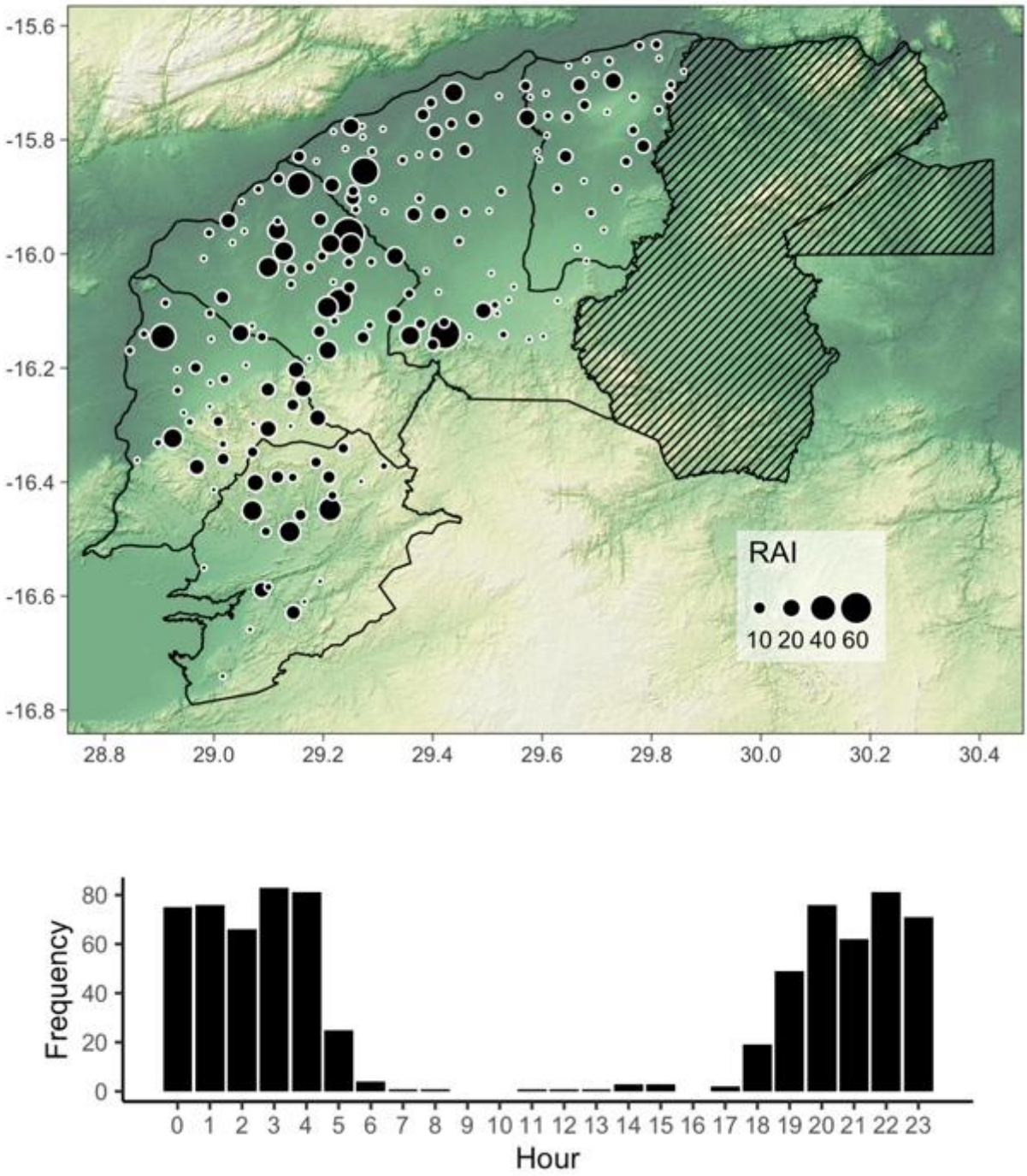

Figure 10. Spatial (top) and diel (bottom) distribution of civet detection events during the 2022 Zambezi Valley camera trap survey.

Honey badger - *Mellivora capensis*

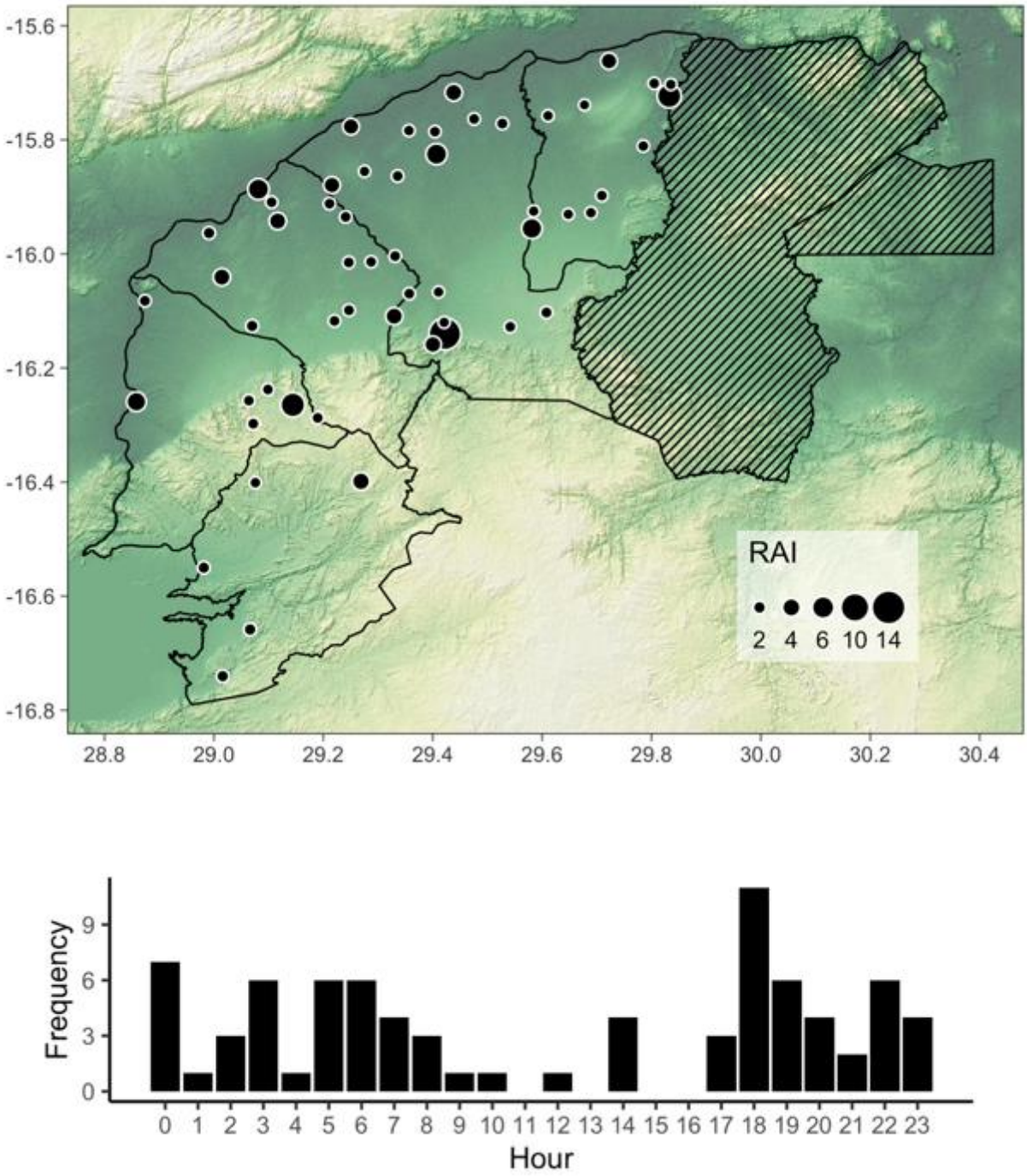

Figure 11. Spatial (top) and diel (bottom) distribution of honey badger detection events during the 2022 Zambezi Valley camera trap survey.

Caracal - *Caracal caracal*

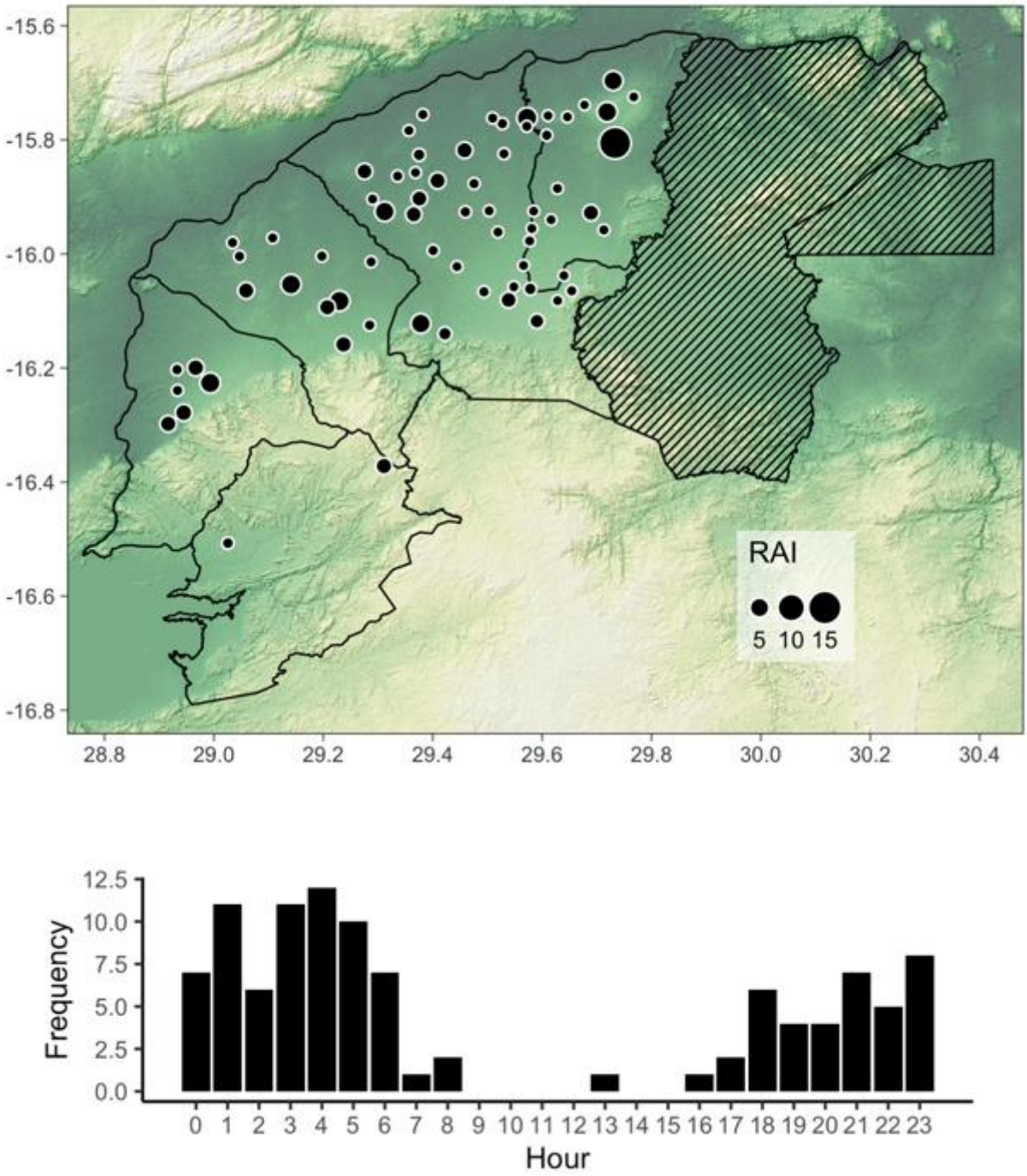

Figure 12. Spatial (top) and diel (bottom) distribution of caracal detection events during the 2022 Zambezi Valley camera trap survey.

Genet, large-spotted - *Genetta tigrina*

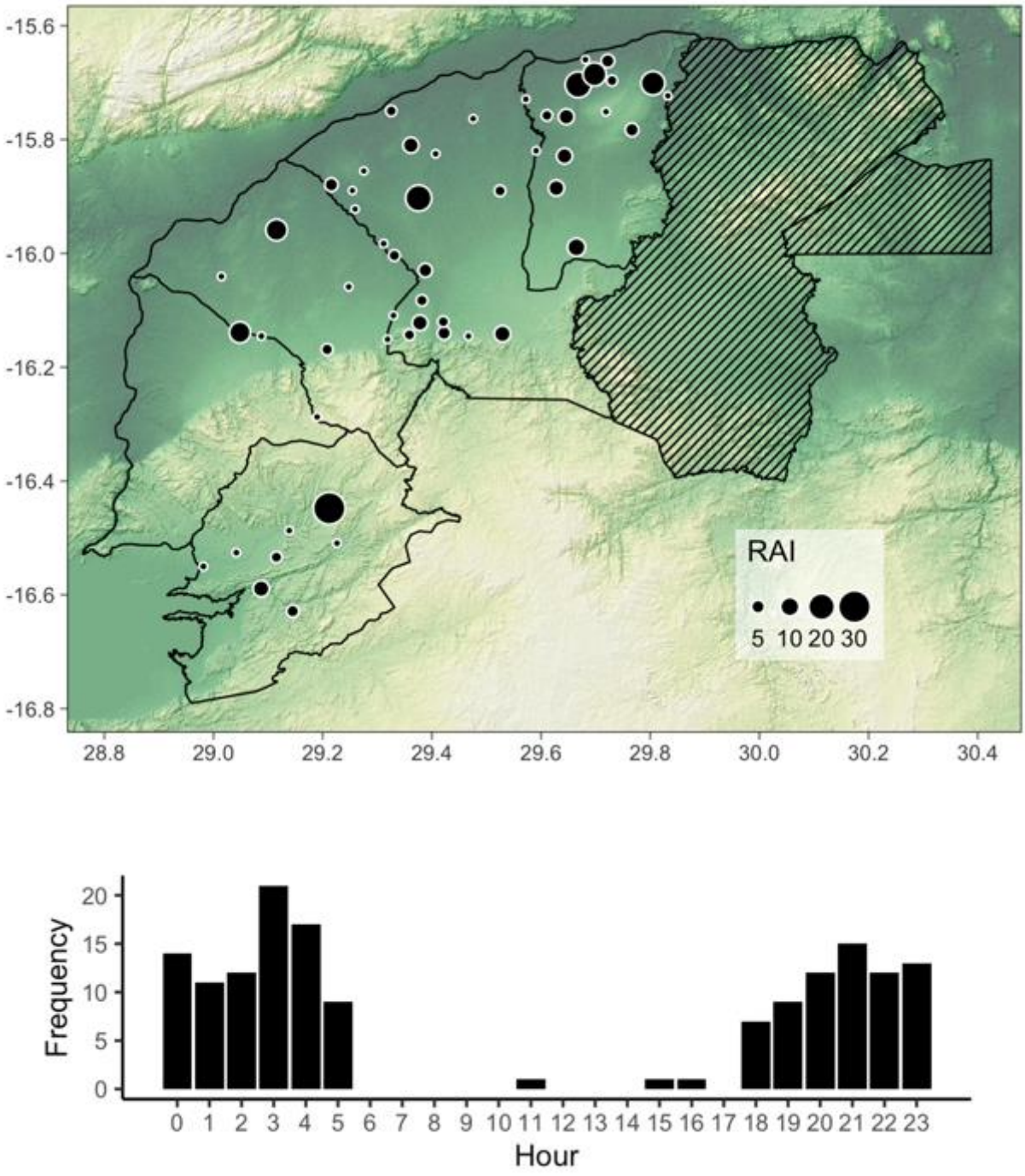

Figure 13. Spatial (top) and diel (bottom) distribution of large-spotted genet detection events during the 2022 Zambezi Valley camera trap survey.

Mongoose, banded - *Mungos mungo*

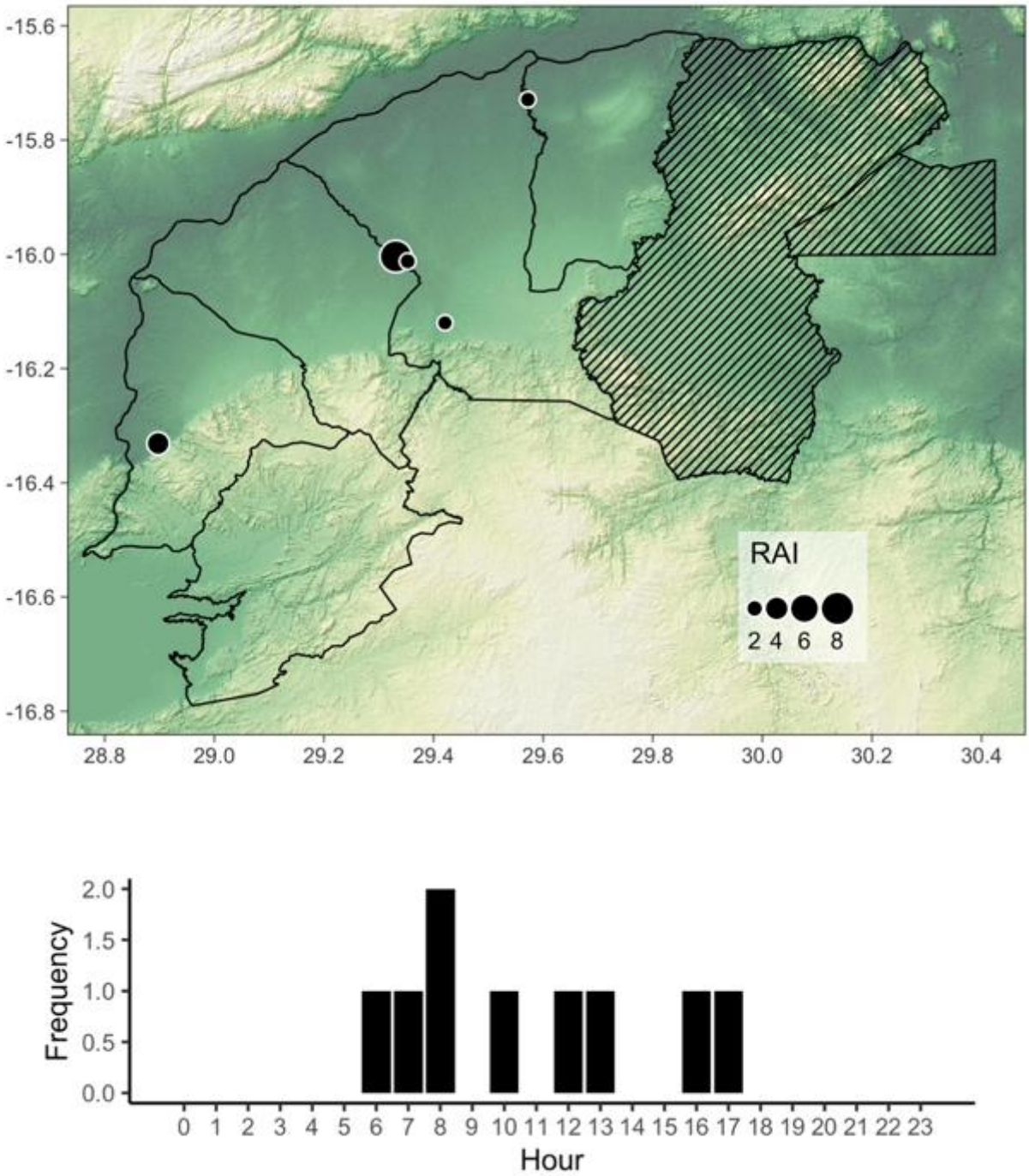

Figure 14. Spatial (top) and diel (bottom) distribution of banded mongoose detection events during the 2022 Zambezi Valley camera trap survey.

Mongoose, bushy-tailed - *Bdeogale crassicauda*

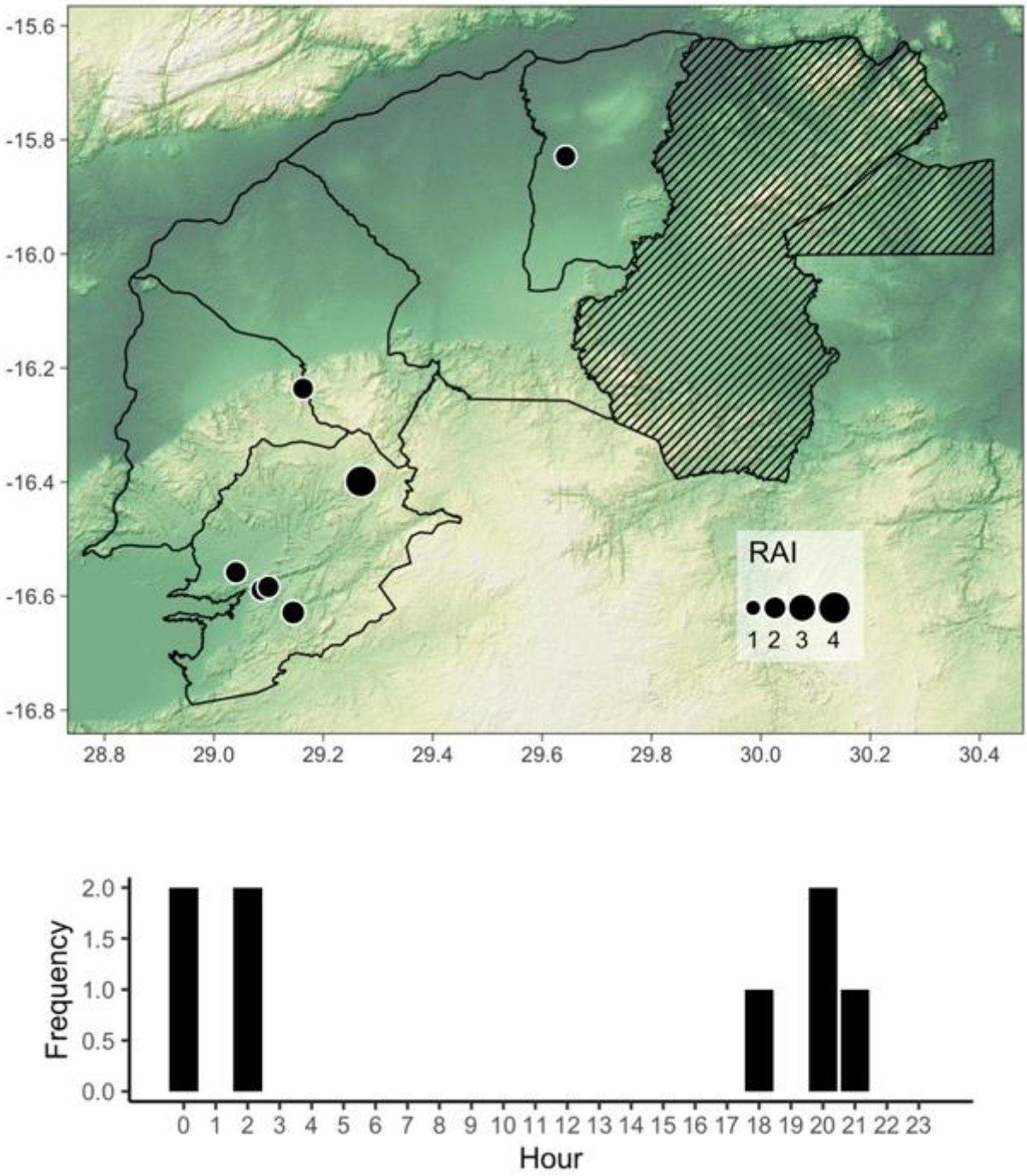

Figure 15. Spatial (top) and diel (bottom) distribution of bushy-tailed mongoose detection events during the 2022 Zambezi Valley camera trap survey.

Mongoose, slender - *Herpestes sanguineus*

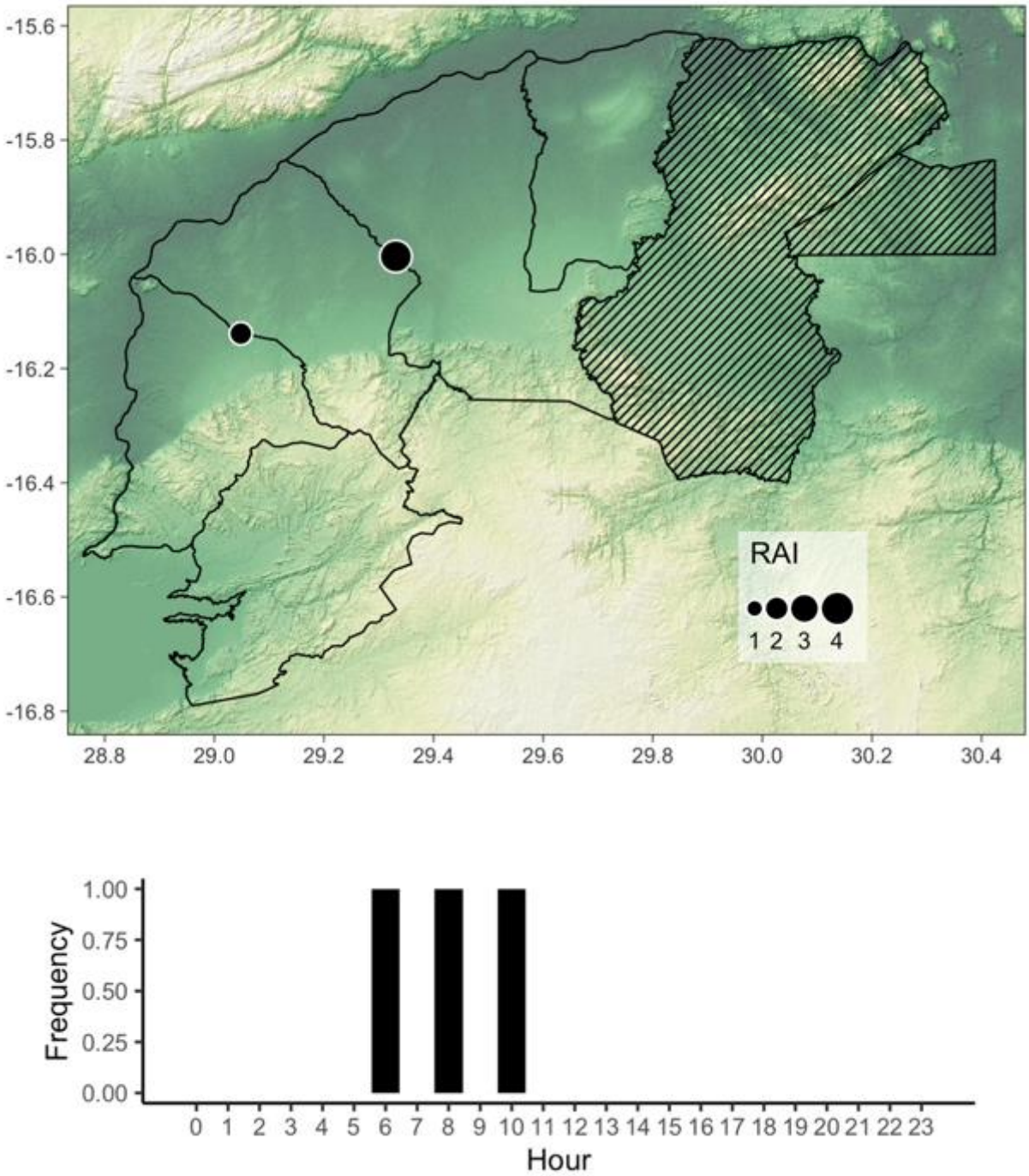

Figure 16. Spatial (top) and diel (bottom) distribution of slender mongoose detection events during the 2022 Zambezi Valley camera trap survey.

Mongoose, white-tailed - *Ichneumia albicauda*

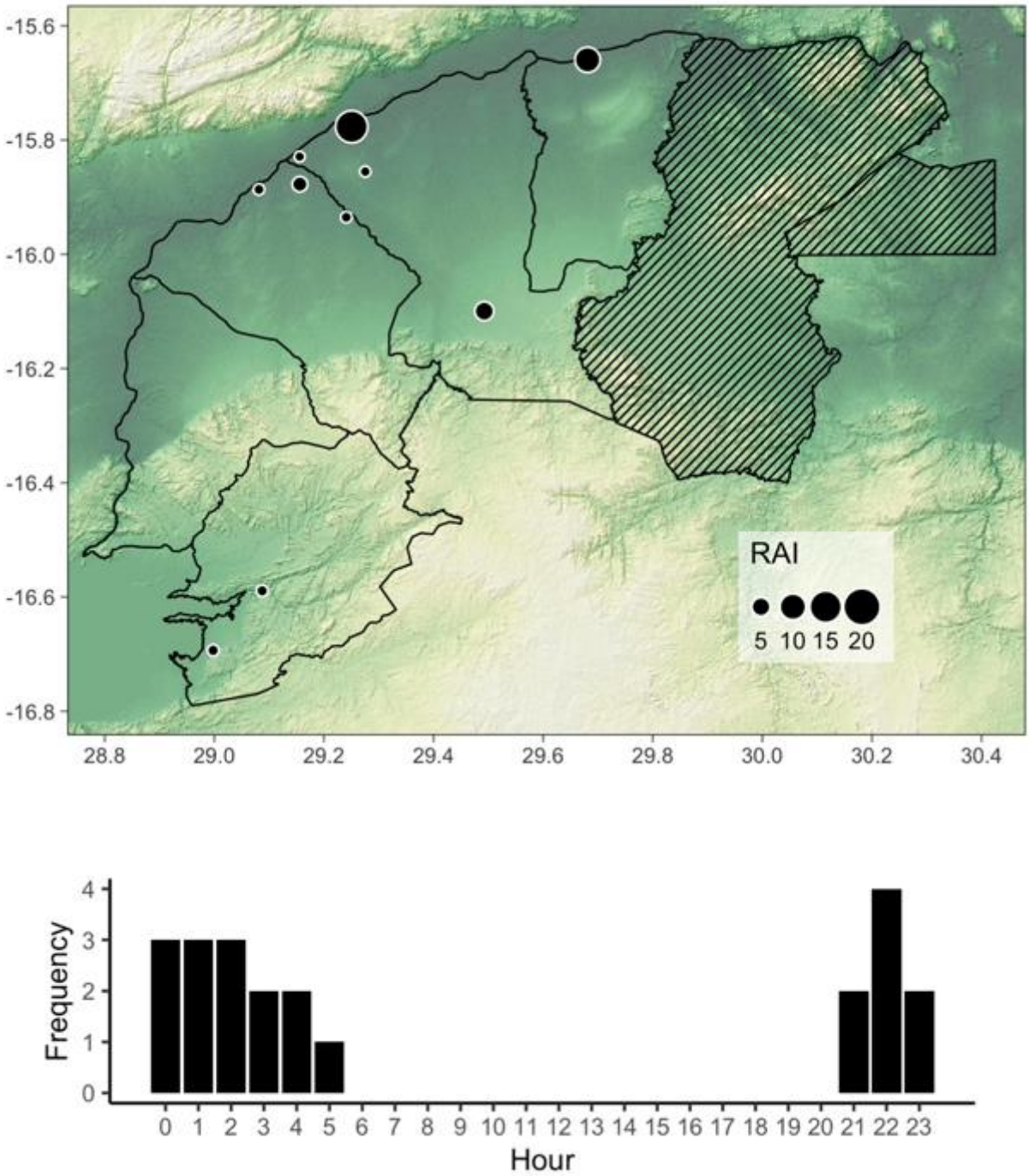

Figure 17. Spatial (top) and diel (bottom) distribution of white-tailed mongoose detection events during the 2022 Zambezi Valley camera trap survey.

Kudu - *Tragelaphus strepsiceros*

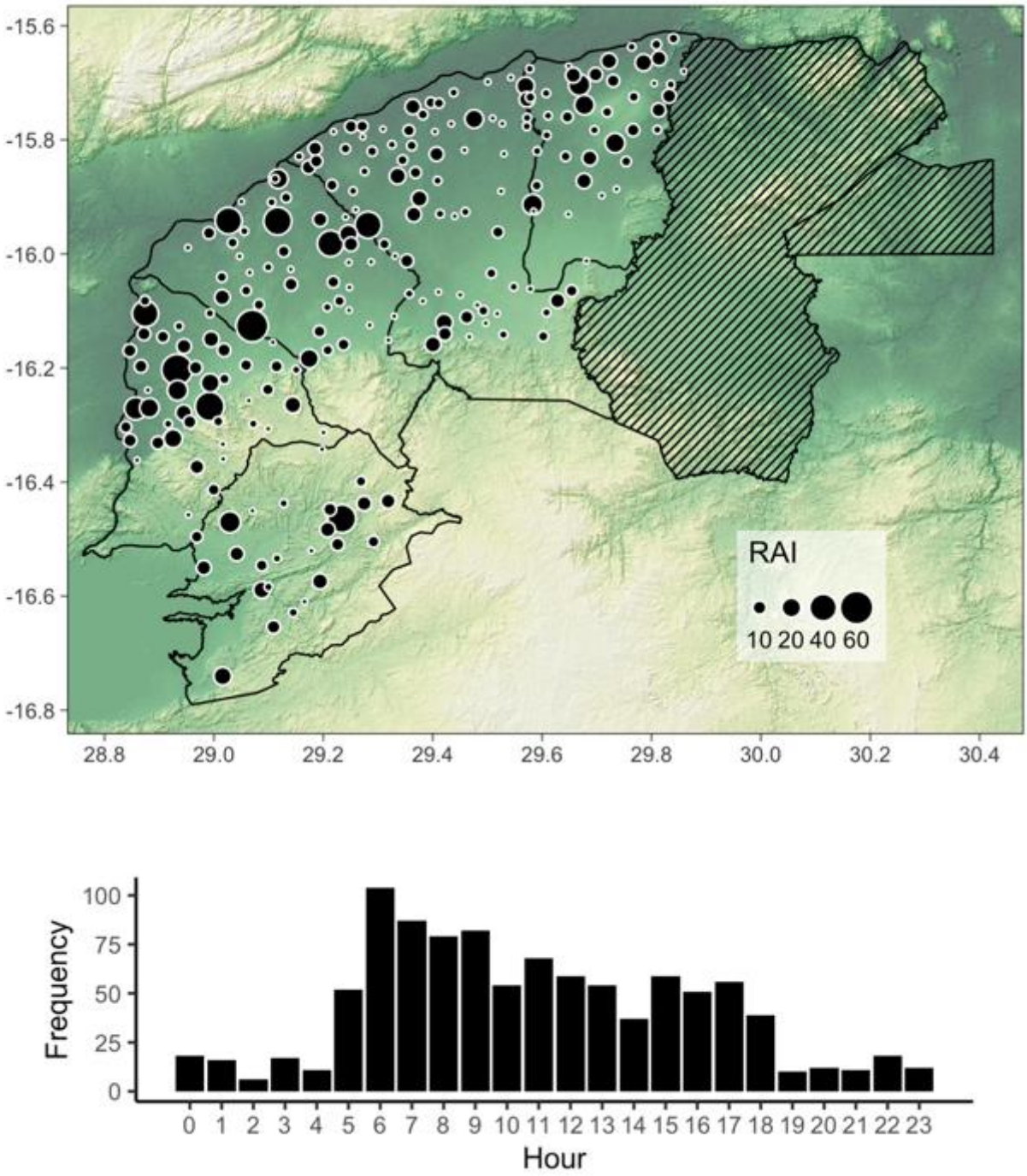

Figure 18. Spatial (top) and diel (bottom) distribution of kudu detection events during the 2022 Zambezi Valley camera trap survey.

Eland - *Taurotragus oryx*

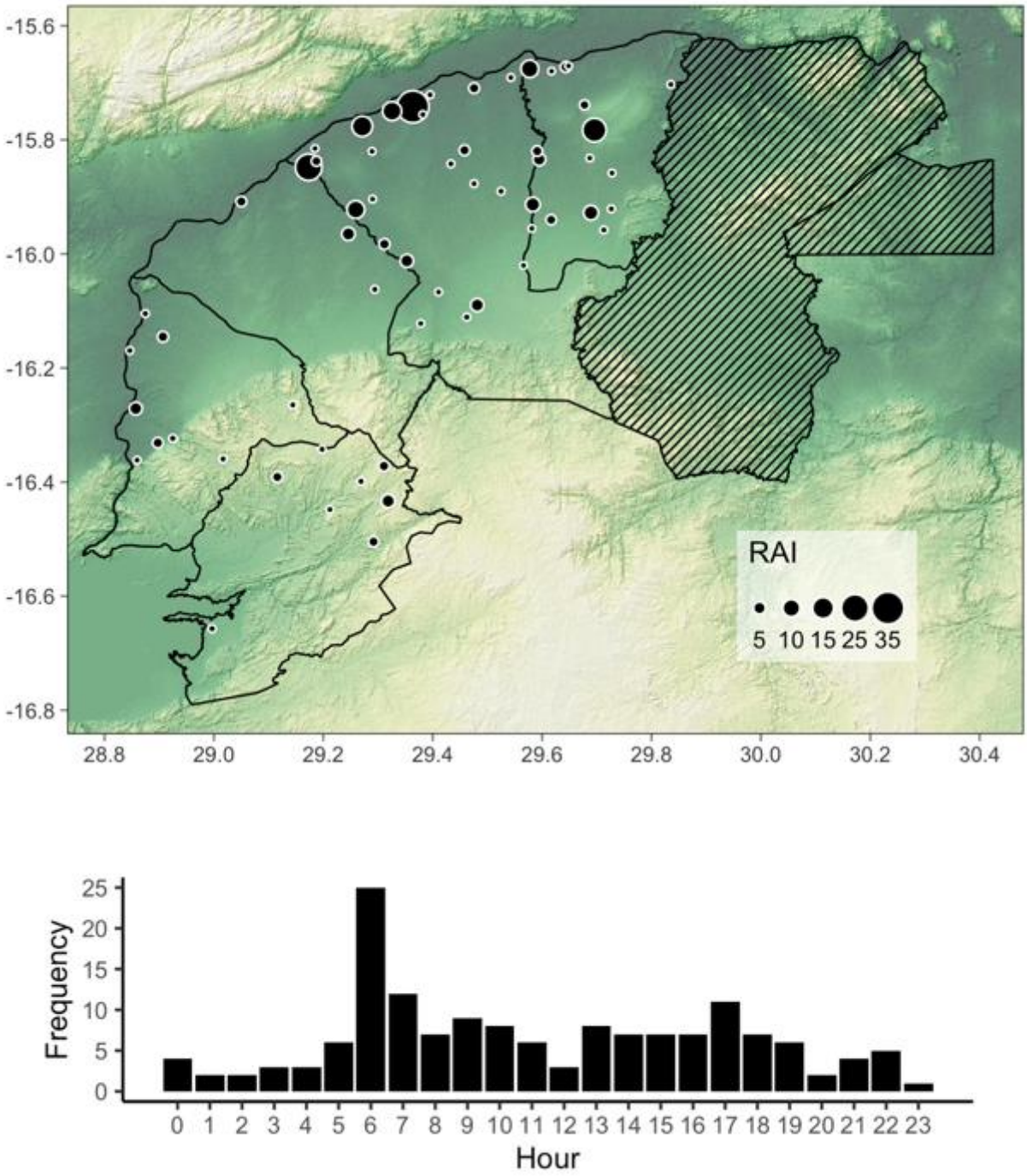

Figure 19. Spatial (top) and diel (bottom) distribution of eland detection events during the 2022 Zambezi Valley camera trap survey.

Waterbuck - *Kobus ellipsiprymnus*

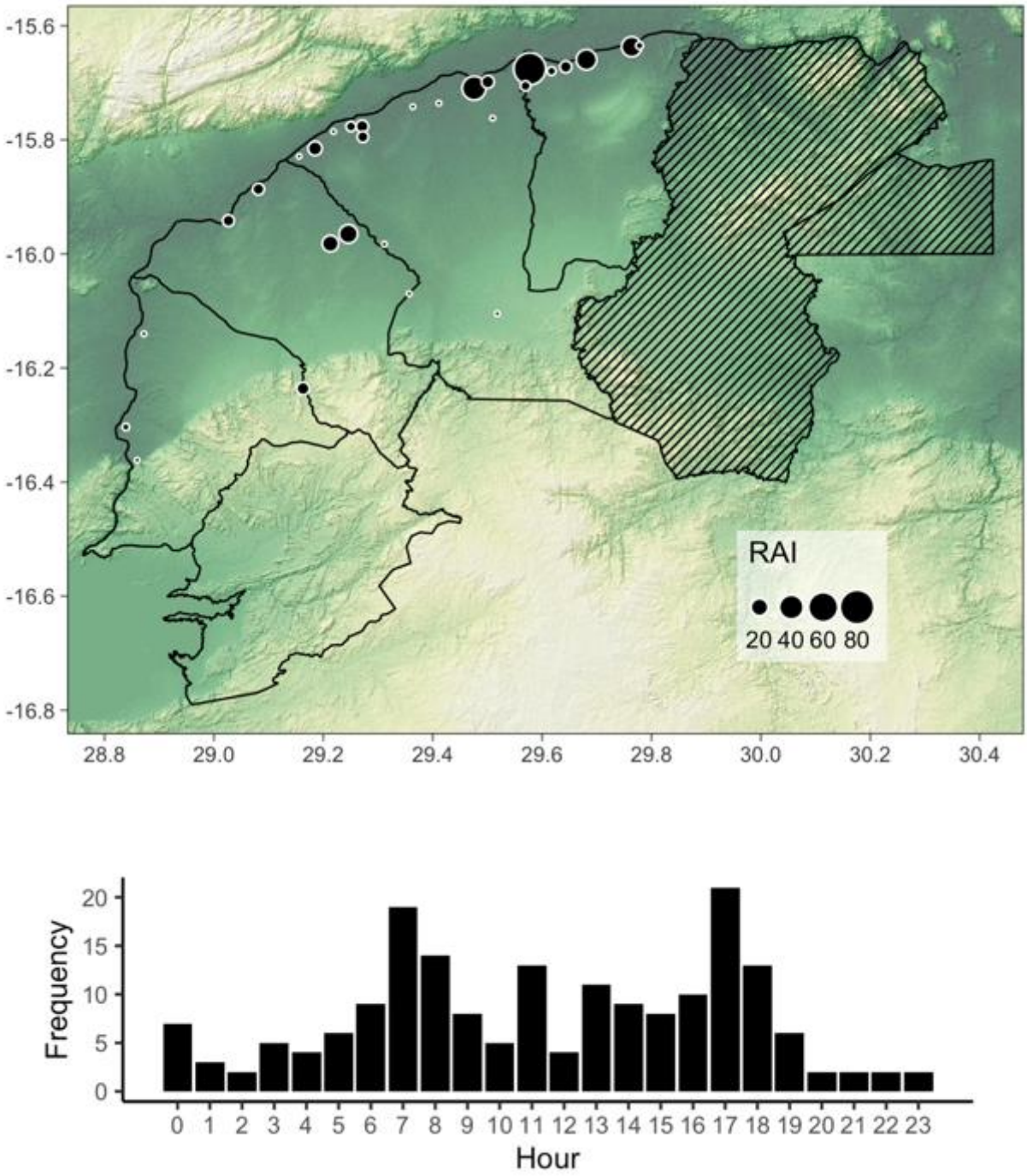

Figure 20. Spatial (top) and diel (bottom) distribution of waterbuck detection events during the 2022 Zambezi Valley camera trap survey.

Nyala - *Tragelaphus angasii*

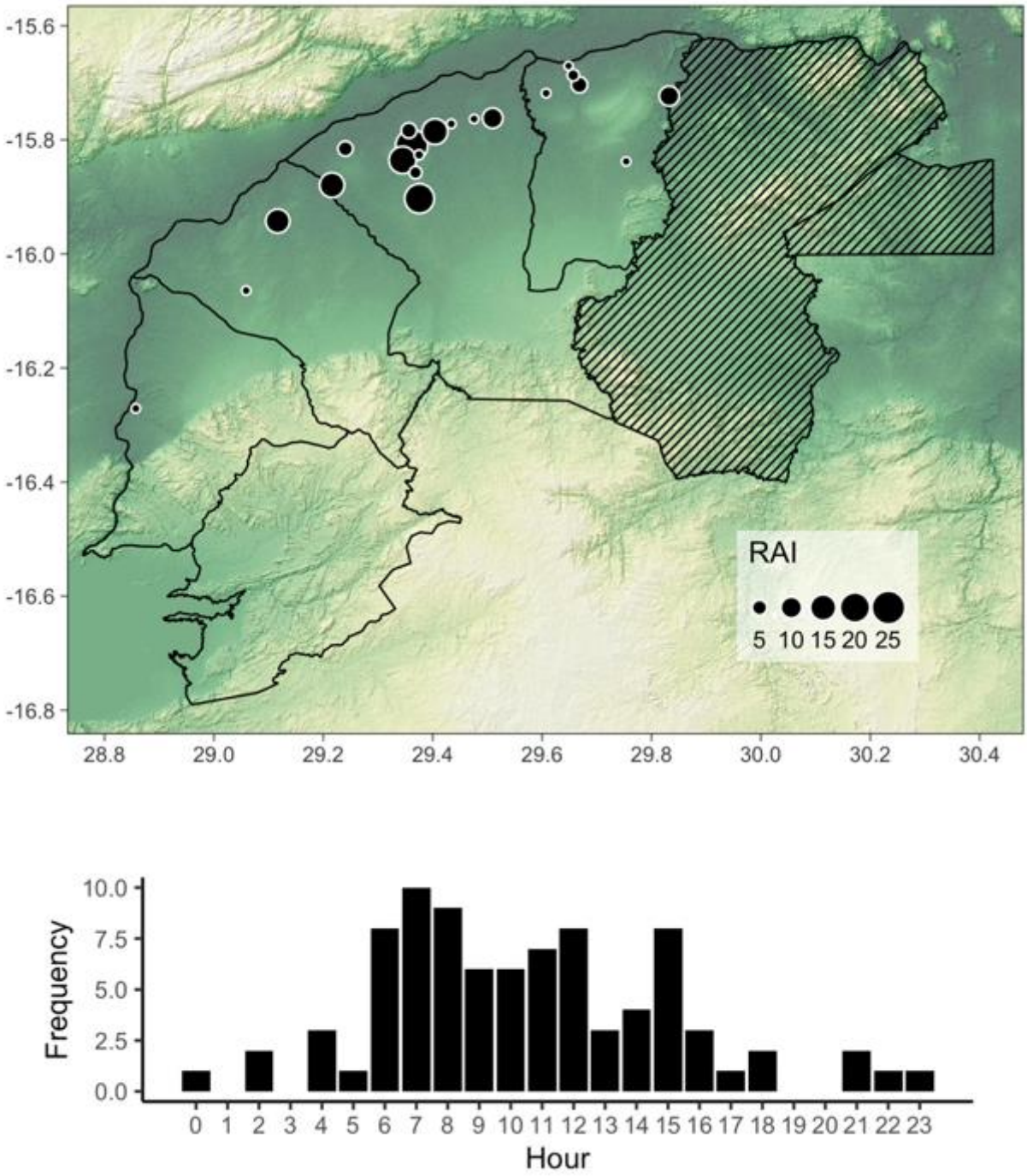

Figure 21. Spatial (top) and diel (bottom) distribution of nyala detection events during the 2022 Zambezi Valley camera trap survey.

Sable - *Hippotragus niger*

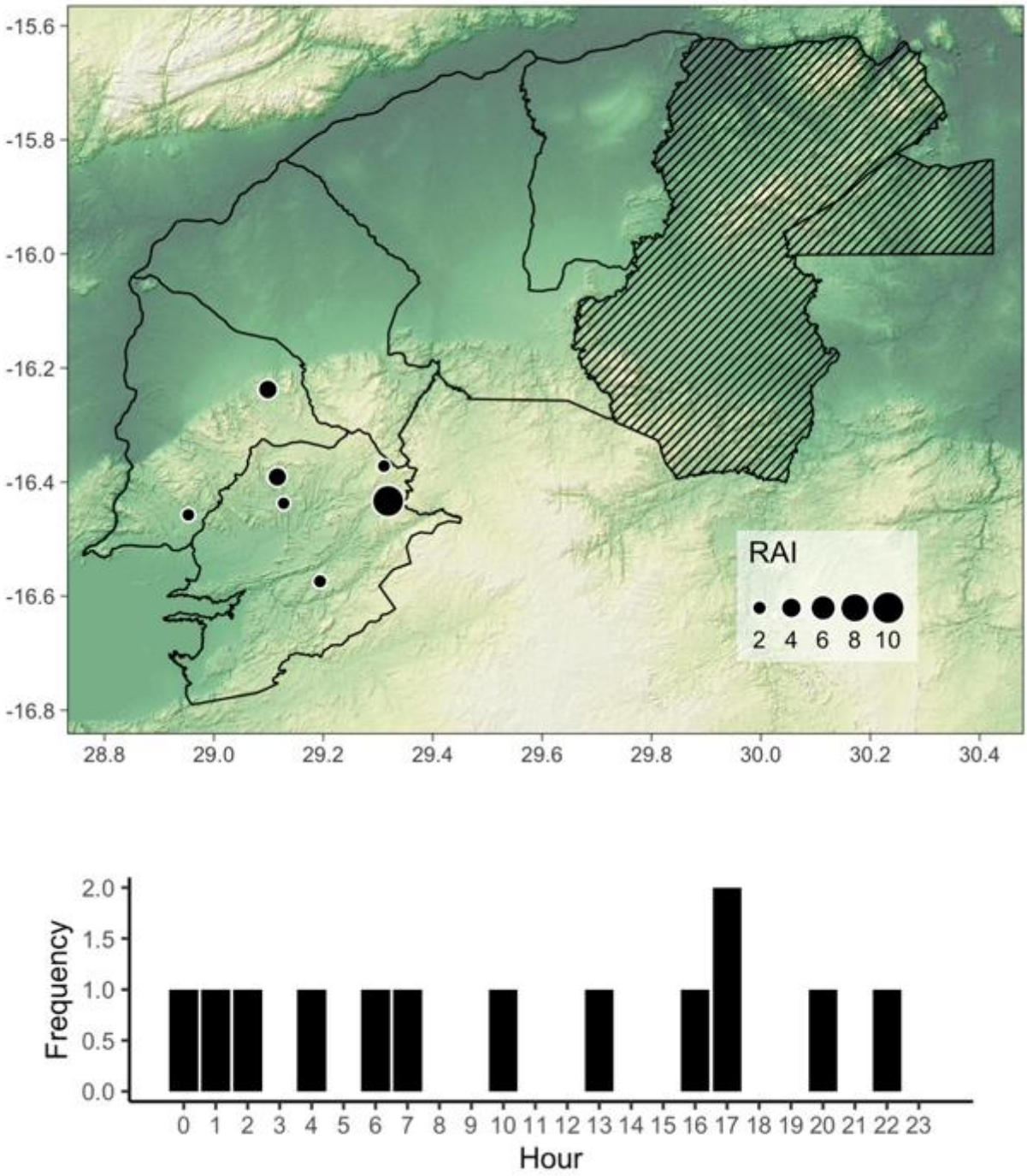

Figure 22. Spatial (top) and diel (bottom) distribution of sable detection events during the 2022 Zambezi Valley camera trap survey.

Roan - *Hippotragus equinus*

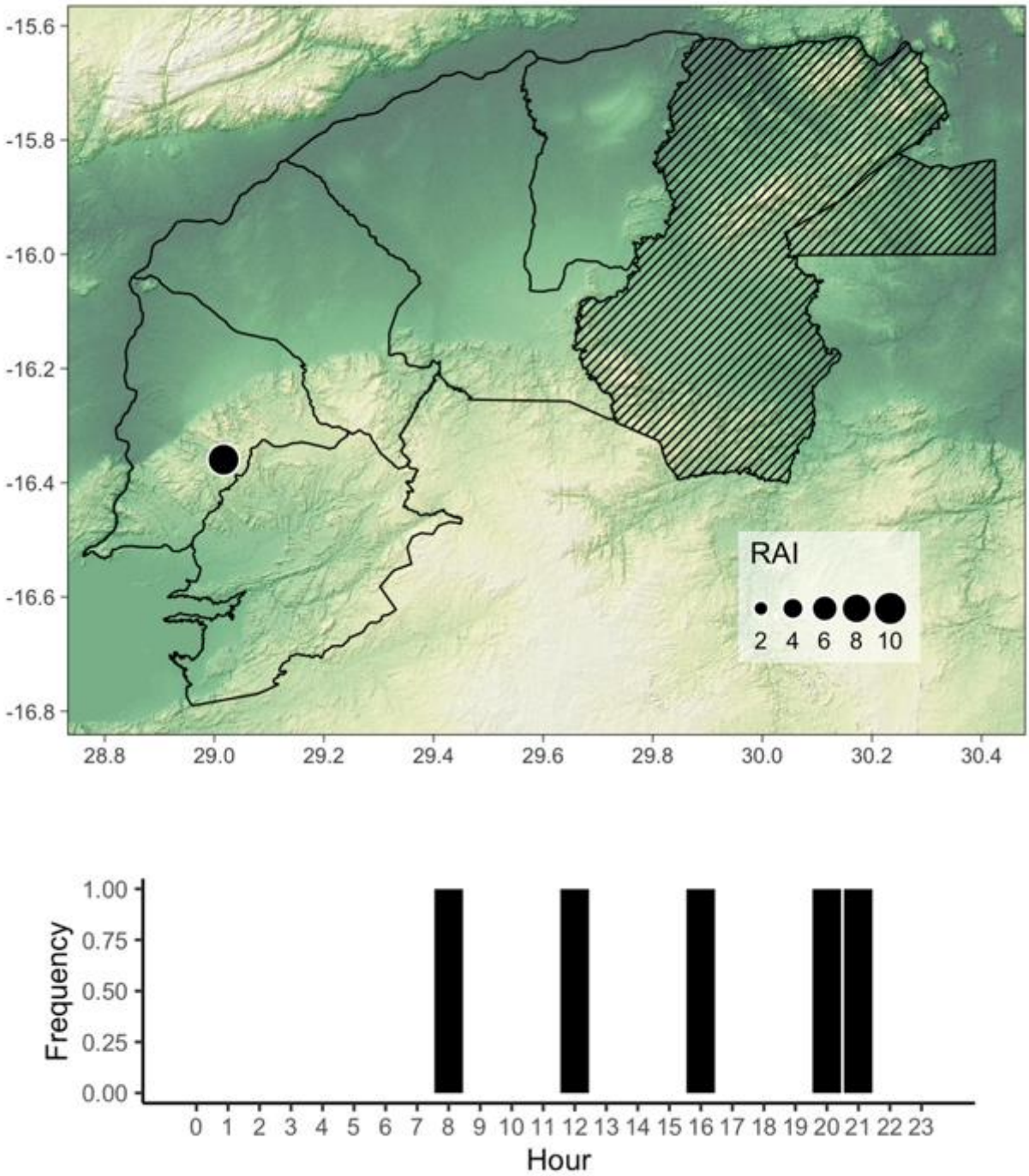

Figure 23. Spatial (top) and diel (bottom) distribution of roan detection events during the 2022 Zambezi Valley camera trap survey.

Impala - *Aepyceros melampus*

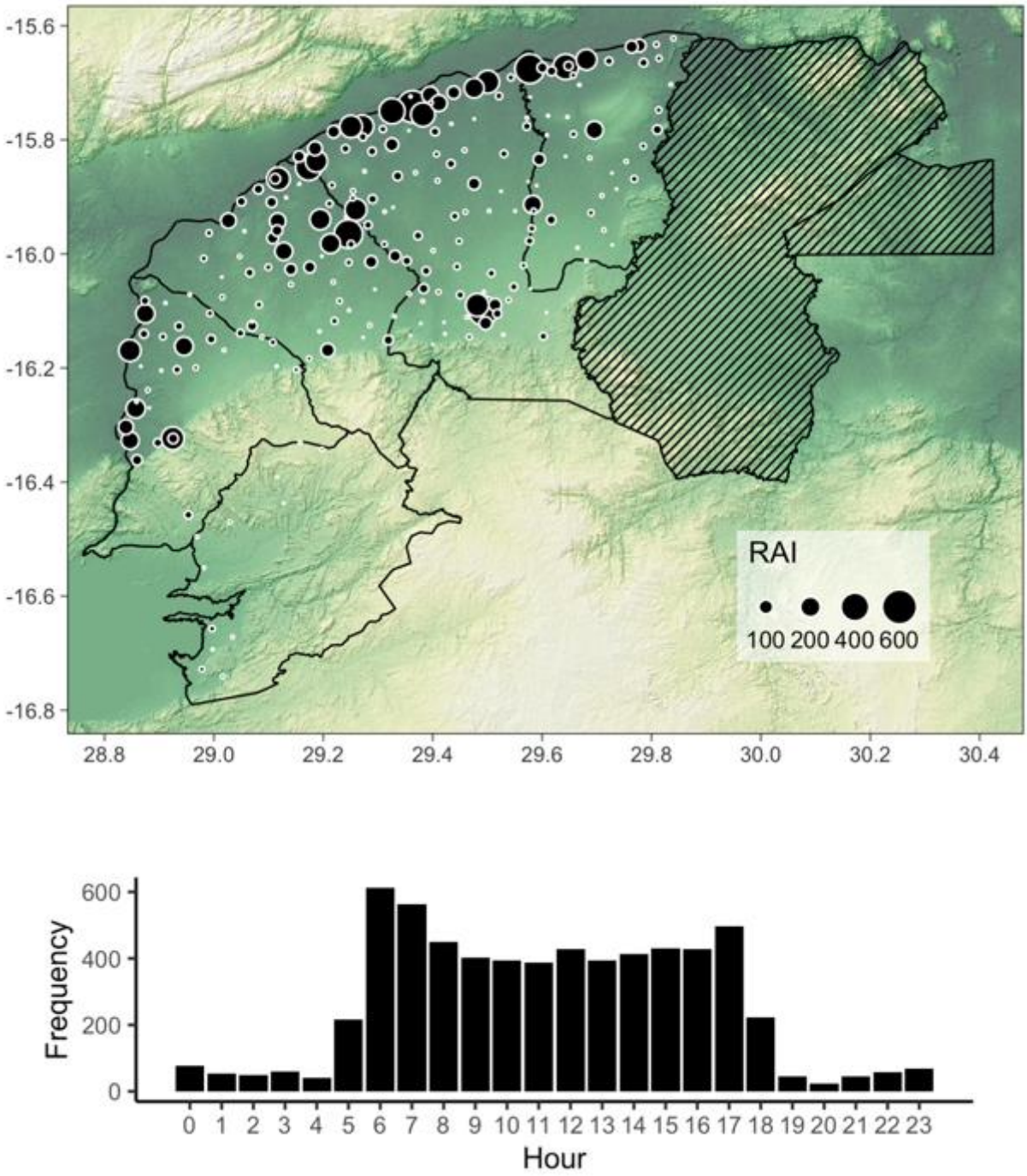

Figure 24. Spatial (top) and diel (bottom) distribution of impala detection events during the 2022 Zambezi Valley camera trap survey.

Duiker - *Sylvicapra grimmia*

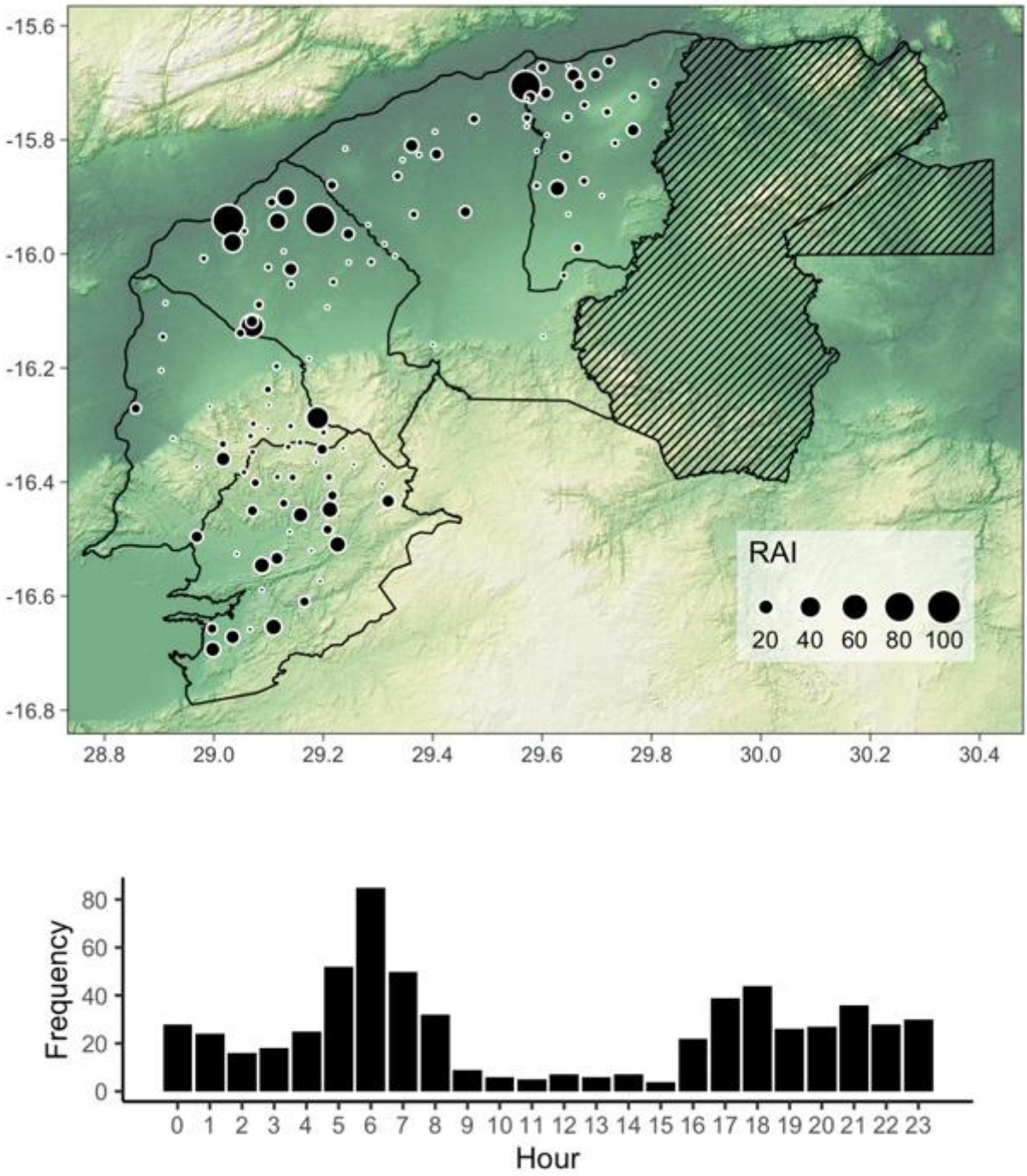

Figure 25. Spatial (top) and diel (bottom) distribution of duiker detection events during the 2022 Zambezi Valley camera trap survey.

Bushbuck - *Tragelaphus scriptus*

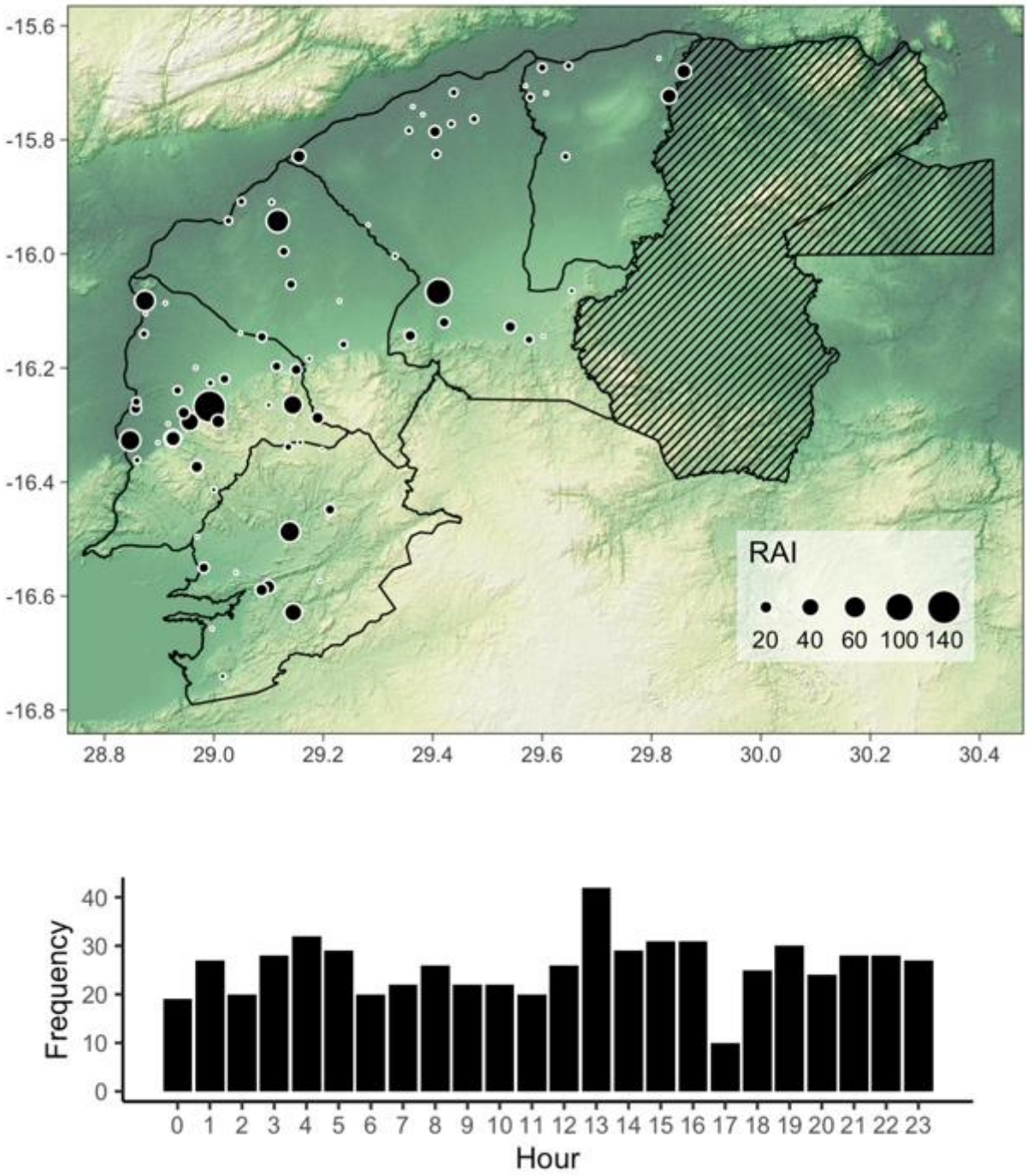

Figure 26. Spatial (top) and diel (bottom) distribution of bushbuck detection events during the 2022 Zambezi Valley camera trap survey.

Klipspringer - *Oreotragus oreotragus*

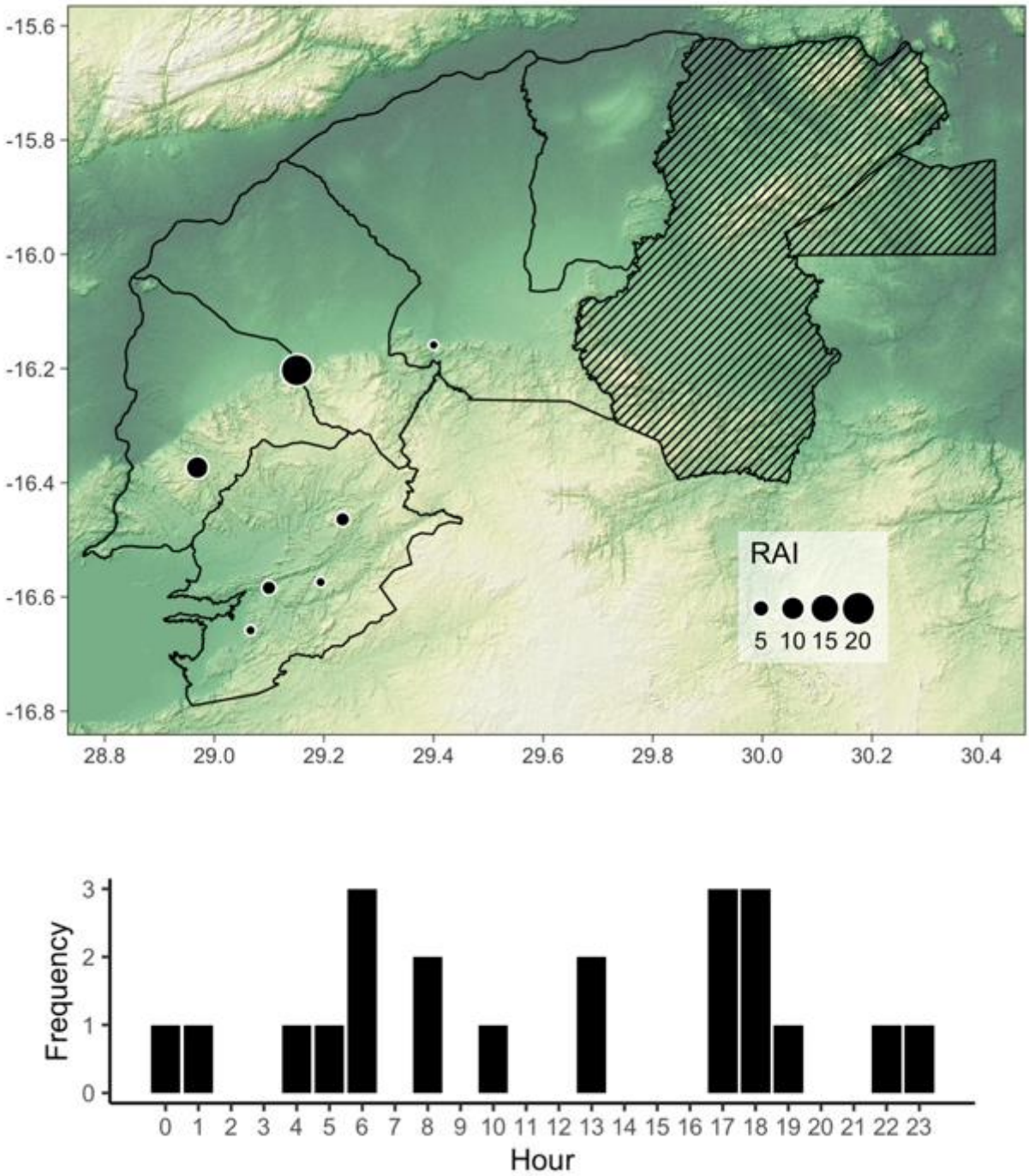

Figure 27. Spatial (top) and diel (bottom) distribution of klipspringer detection events during the 2022 Zambezi Valley camera trap survey.

Sharpe's grysbok - *Raphicerus sharpei*

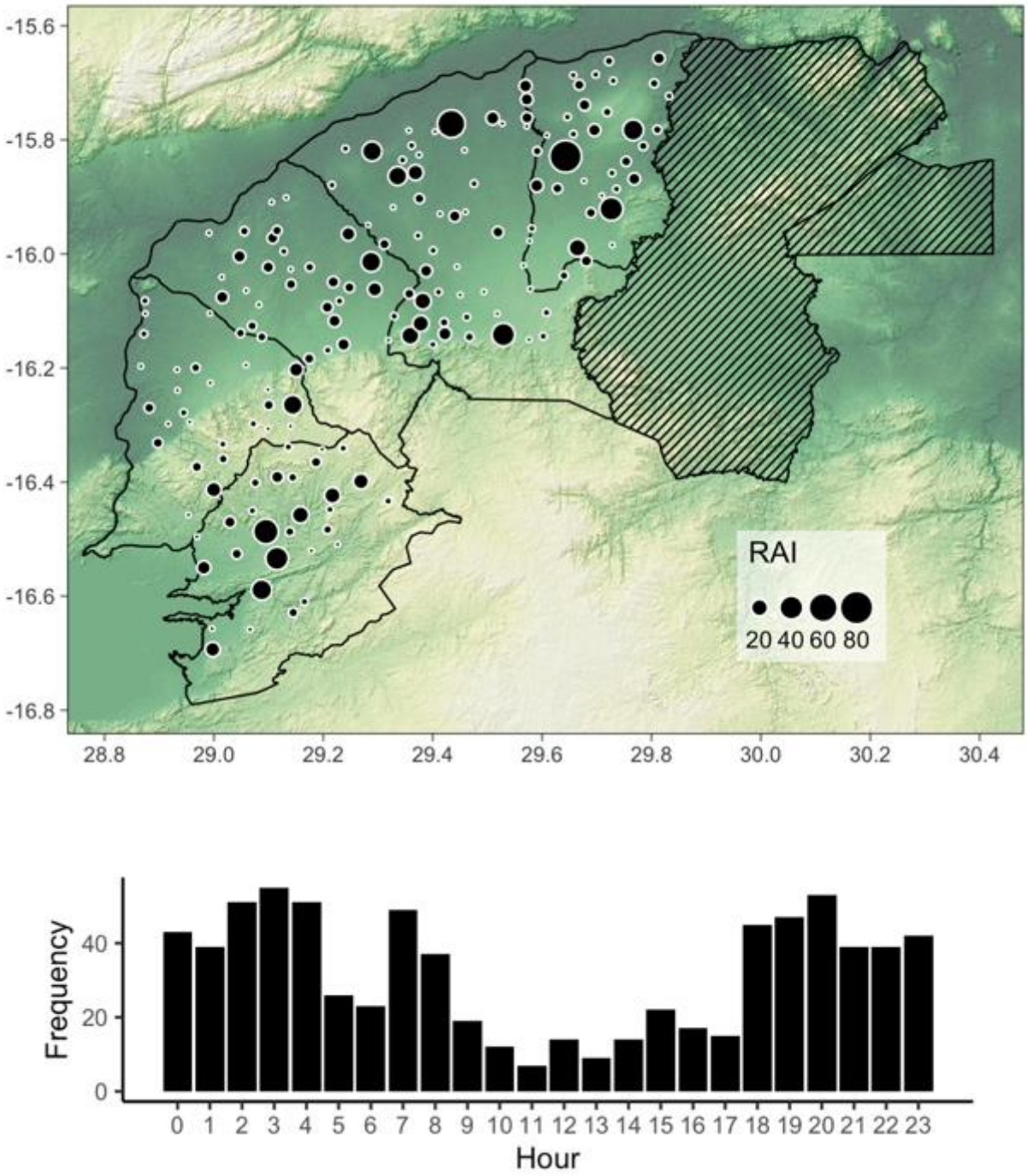

Figure 28. Spatial (top) and diel (bottom) distribution of Sharpe's grysbok detection events during the 2022 Zambezi Valley camera trap survey.

Elephant - *Loxodonta africana*

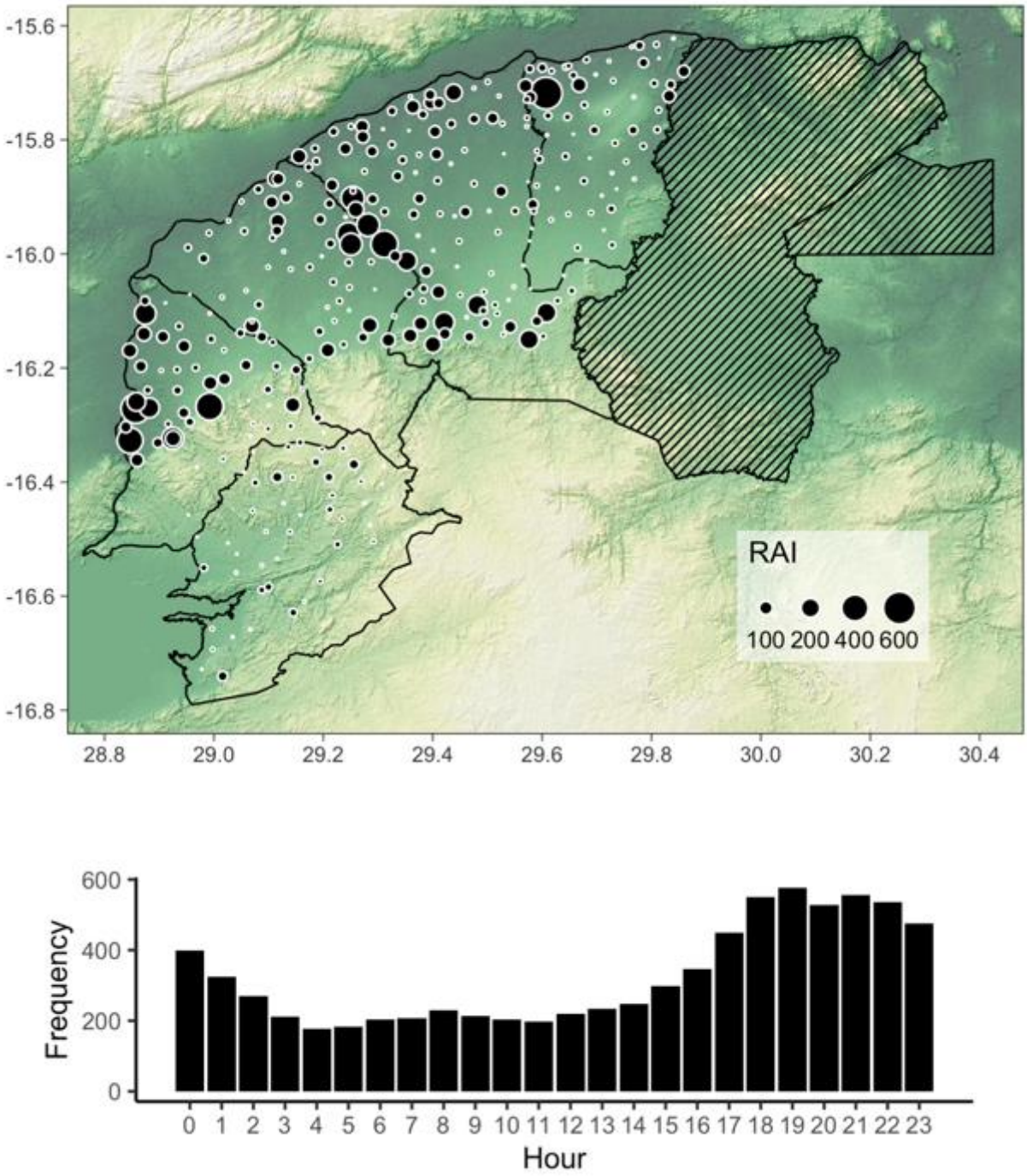

Figure 29. Spatial (top) and diel (bottom) distribution of elephant detection events during the 2022 Zambezi Valley camera trap survey.

Buffalo - *Syncerus caffer*

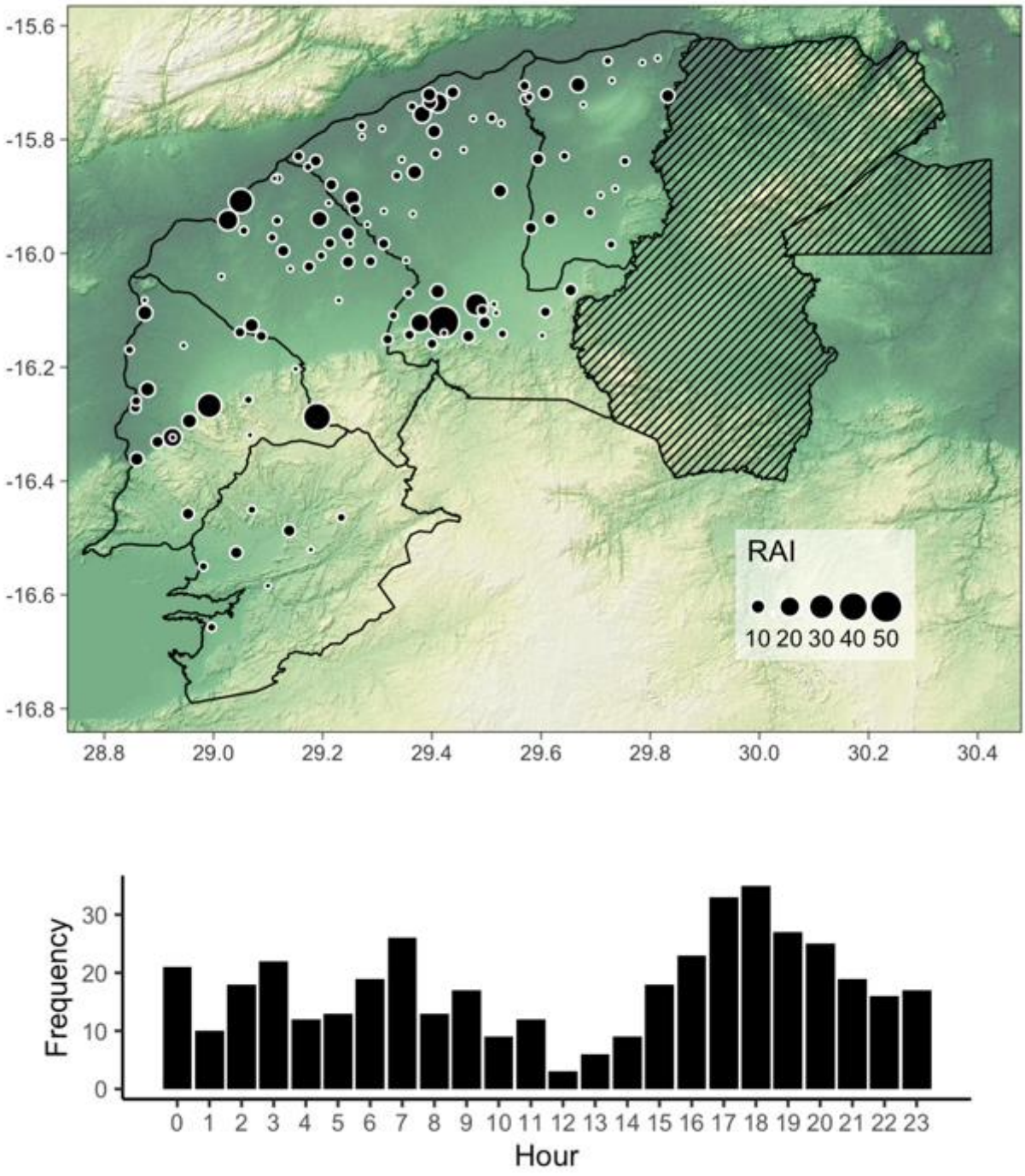

Figure 30. Spatial (top) and diel (bottom) distribution of buffalo detection events during the 2022 Zambezi Valley camera trap survey.

Hippopotamus - *Hippopotamus amphibius*

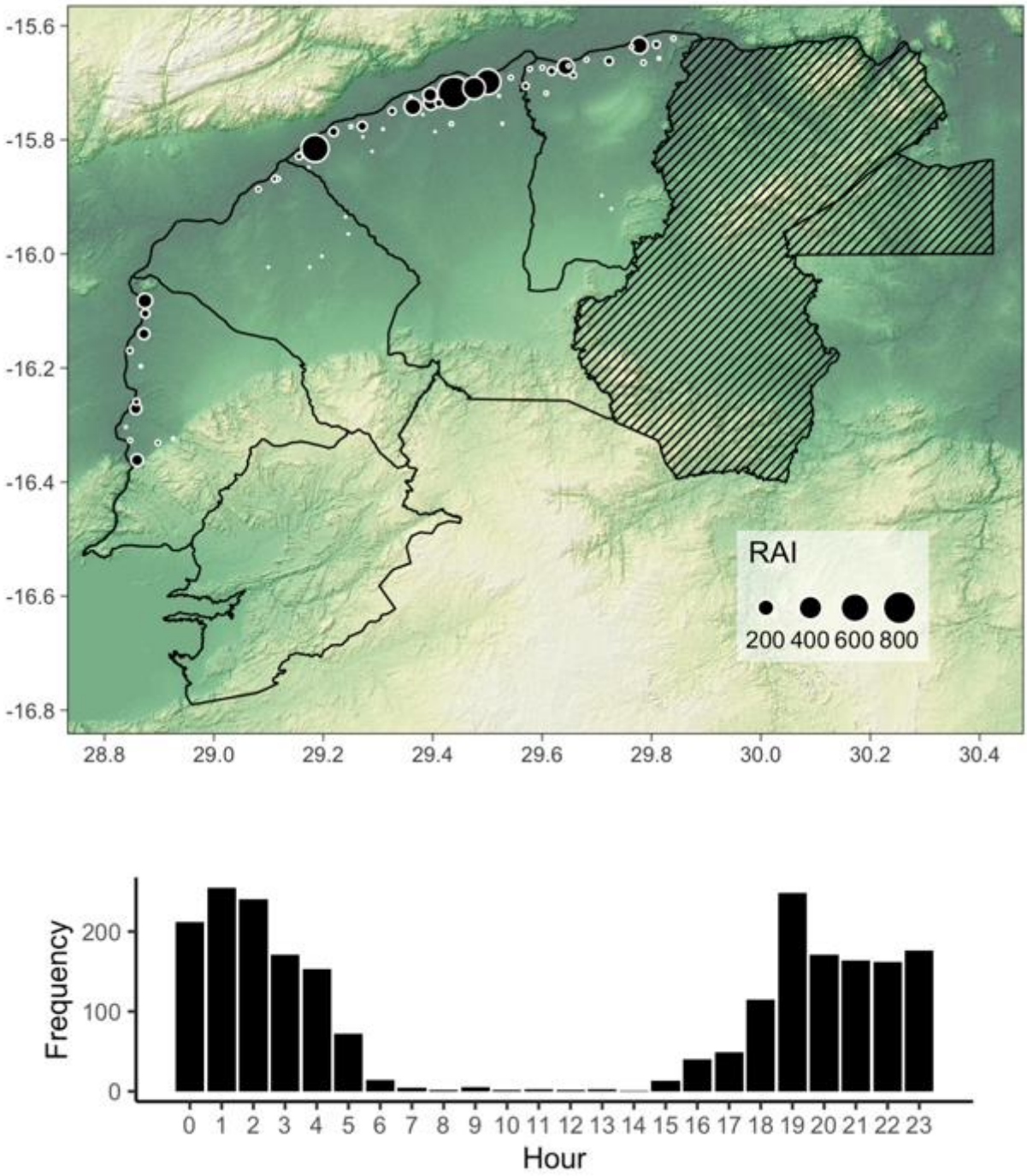

Figure 31. Spatial (top) and diel (bottom) distribution of hippopotamus detection events during the 2022 Zambezi Valley camera trap survey.

Zebra - *Equus quagga*

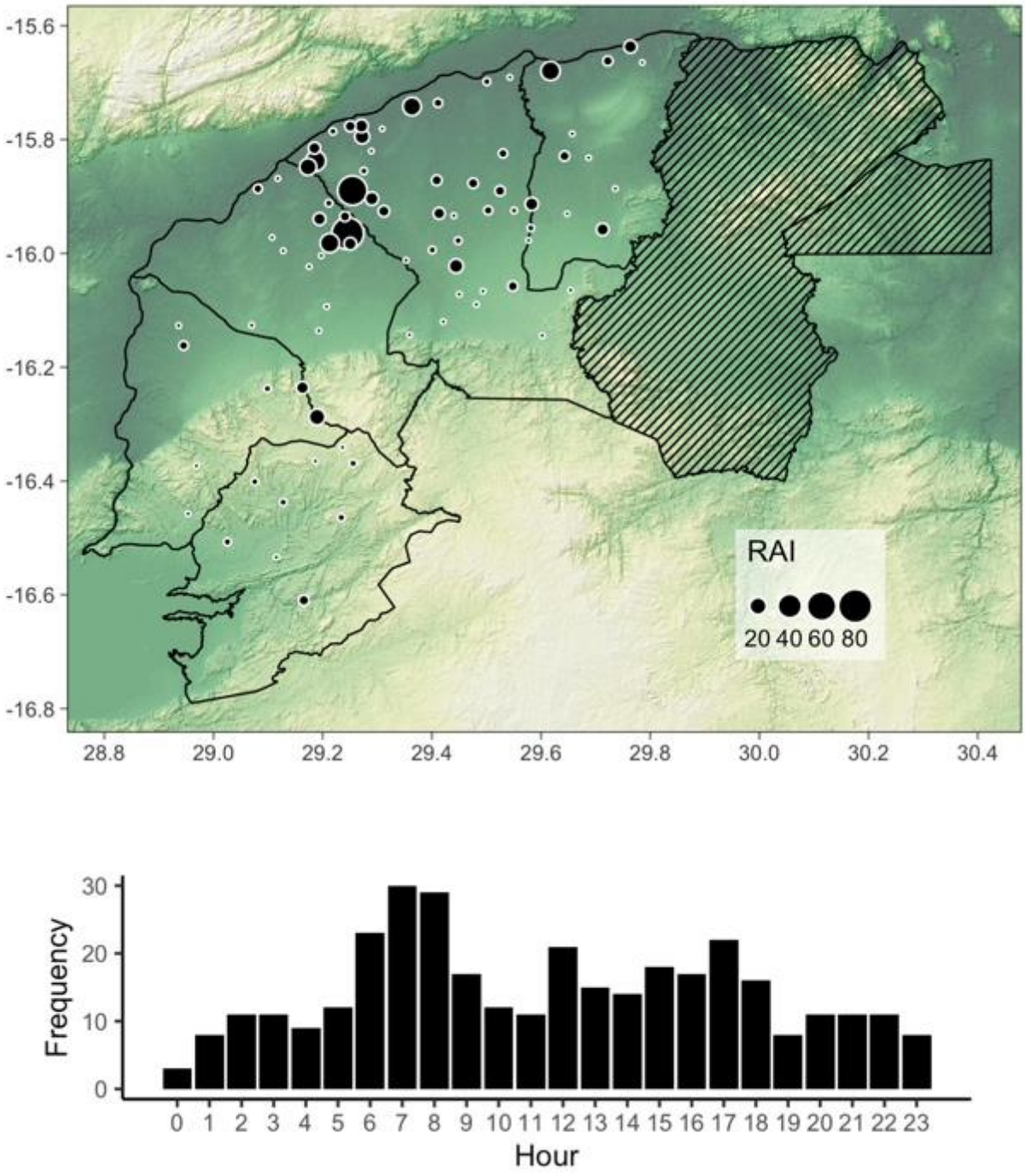

Figure 32. Spatial (top) and diel (bottom) distribution of zebra detection events during the 2022 Zambezi Valley camera trap survey.

Warthog - *Phacochoerus africanus*

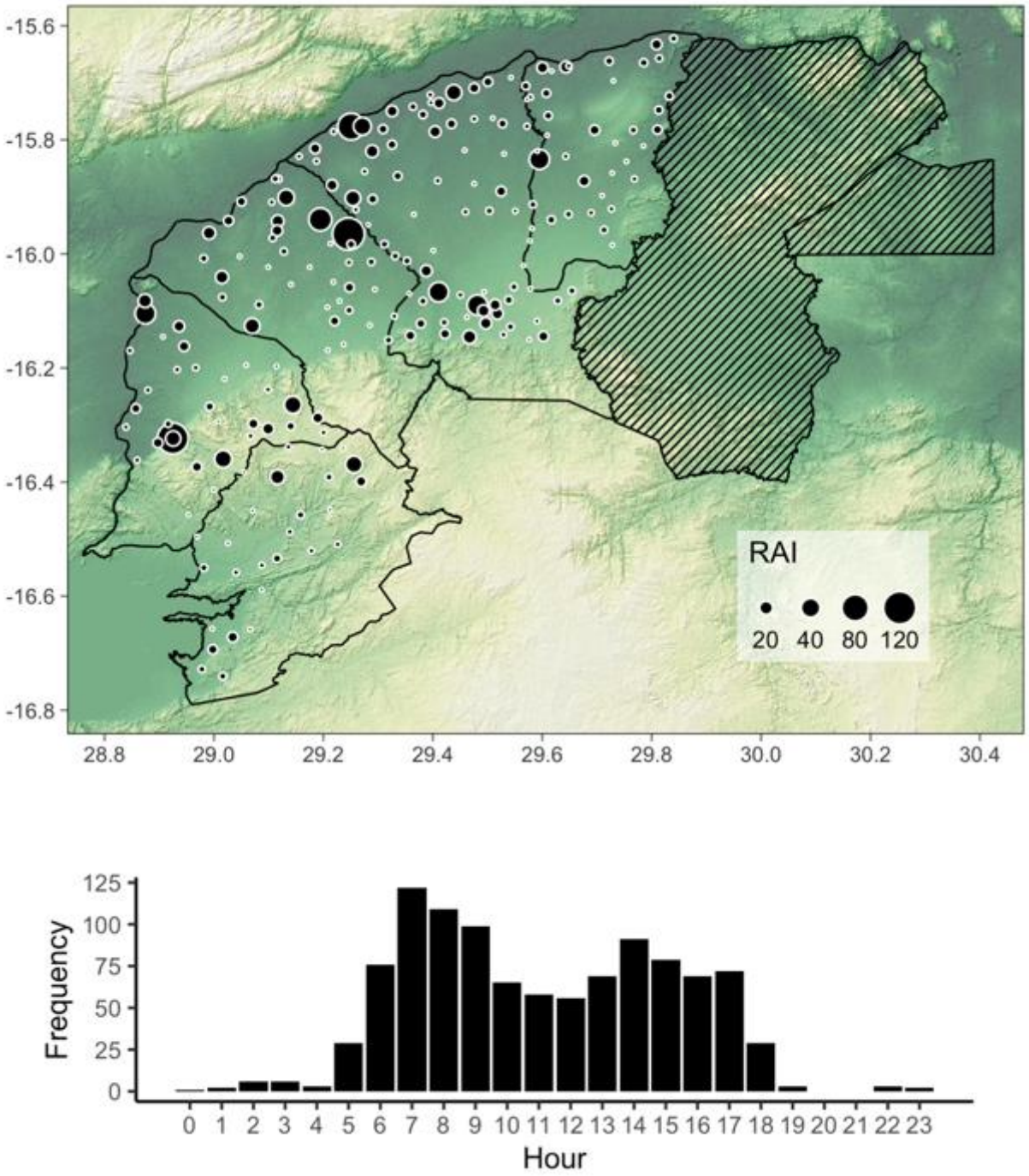

Figure 33. Spatial (top) and diel (bottom) distribution of warthog detection events during the 2022 Zambezi Valley camera trap survey.

Bushpig - *Potamochoerus larvatus*

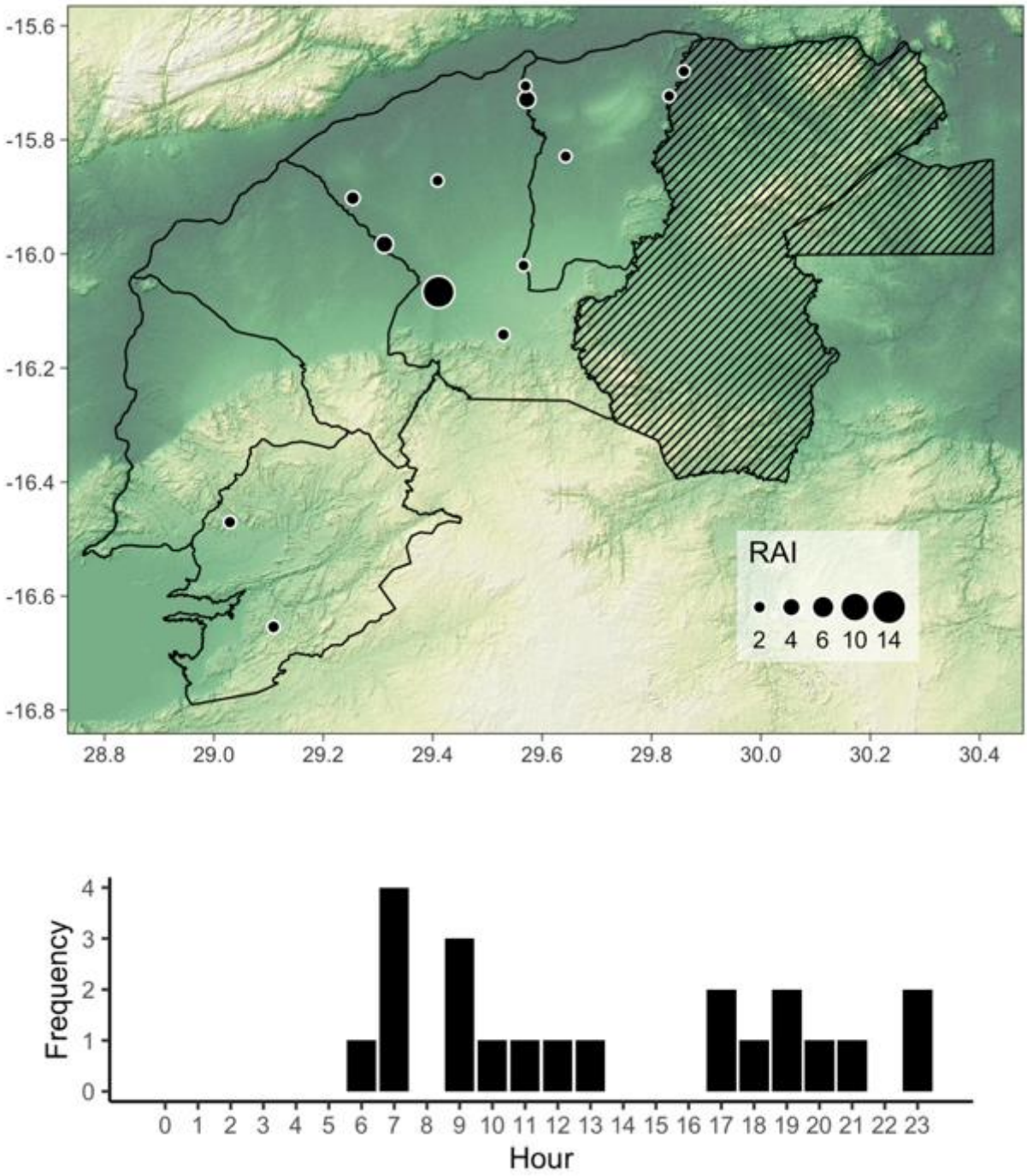

Figure 34. Spatial (top) and diel (bottom) distribution of bushpig detection events during the 2022 Zambezi Valley camera trap survey.

Scrub Hare - *Lepus saxatilis*

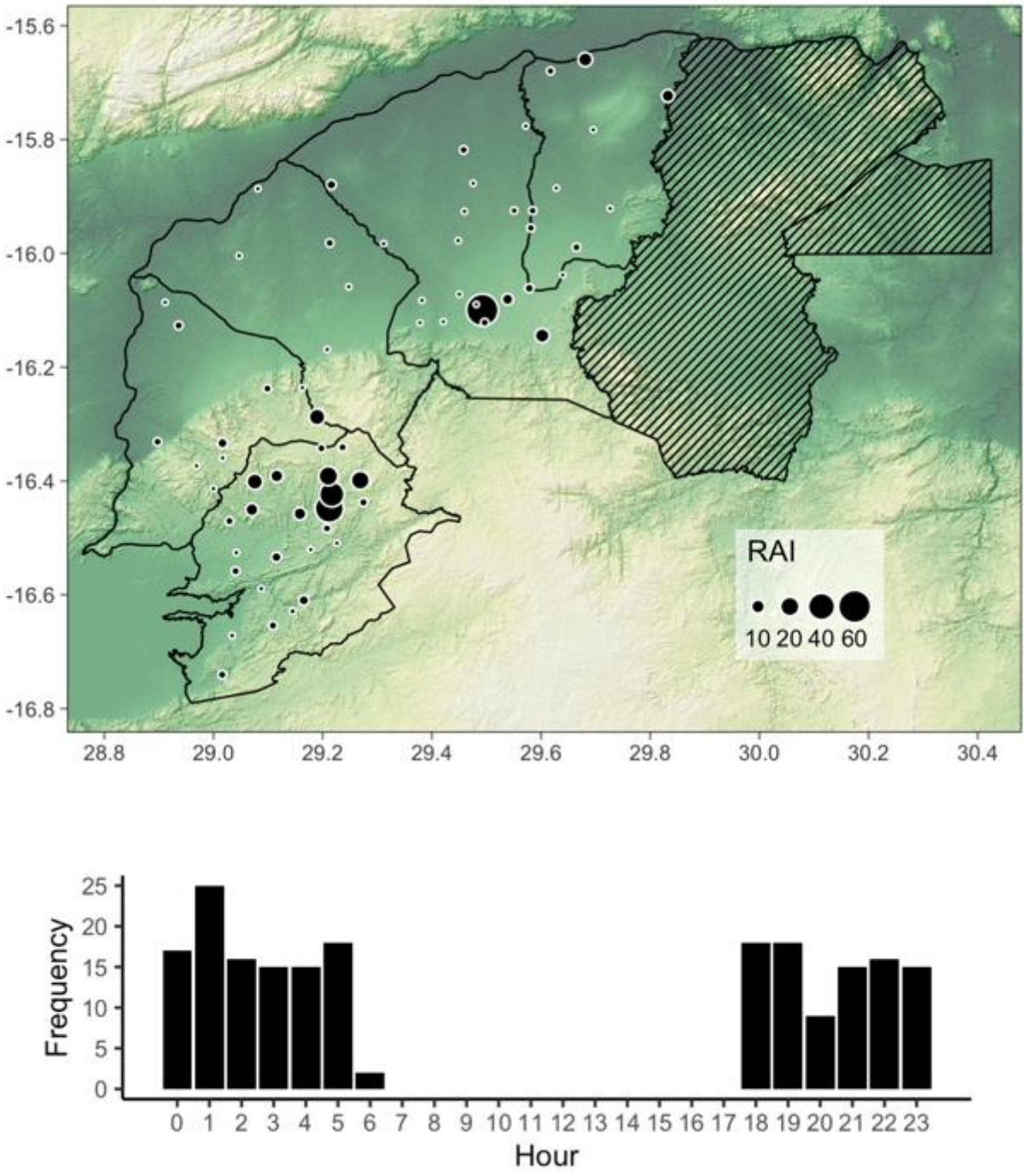

Figure 35. Spatial (top) and diel (bottom) distribution of scrub hare detection events during the 2022 Zambezi Valley camera trap survey.

Porcupine - *Hystrix africaeaustralis*

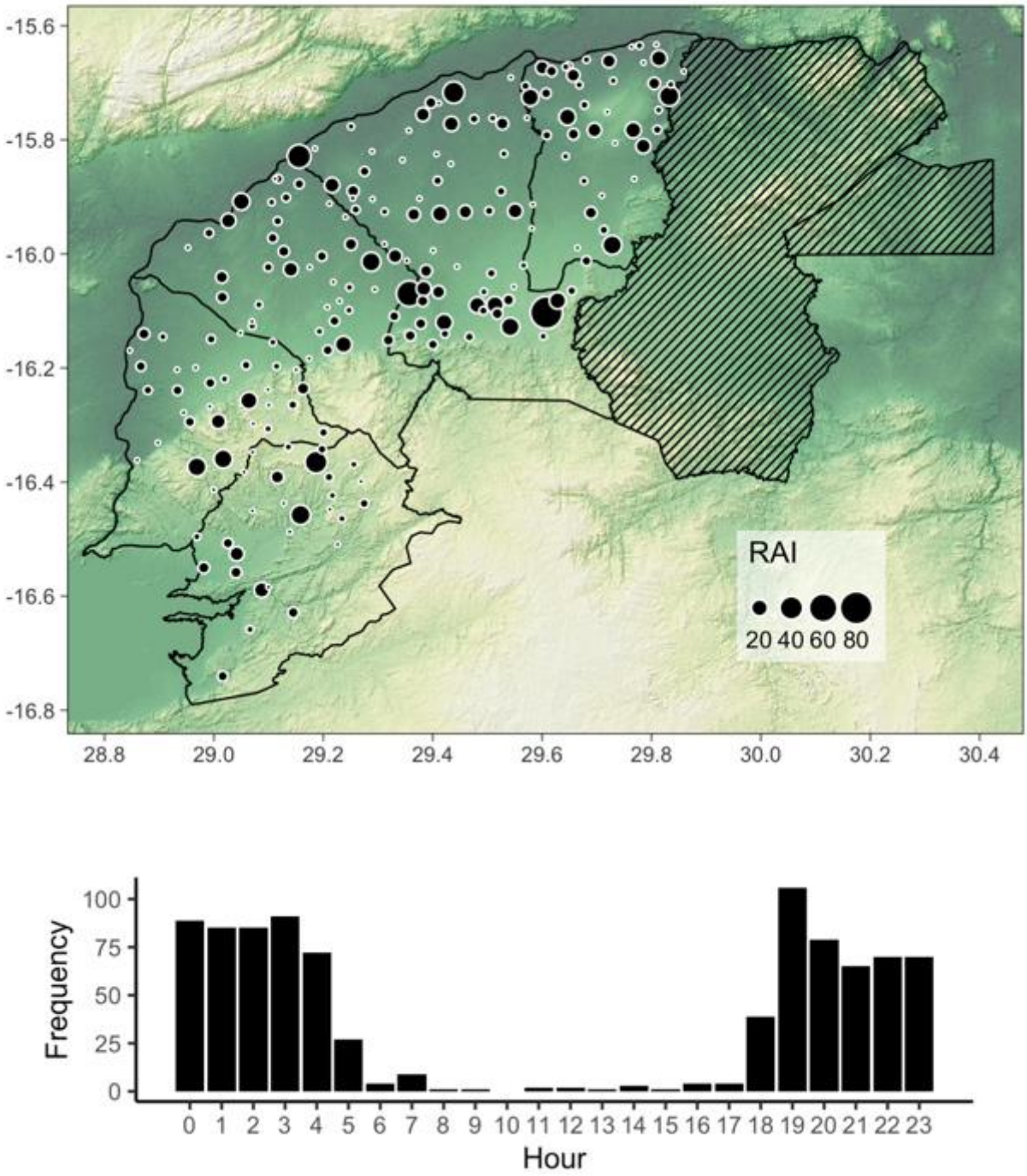

Figure 36. Spatial (top) and diel (bottom) distribution of porcupine detection events during the 2022 Zambezi Valley camera trap survey.

Baboon - *Papio ursinus*

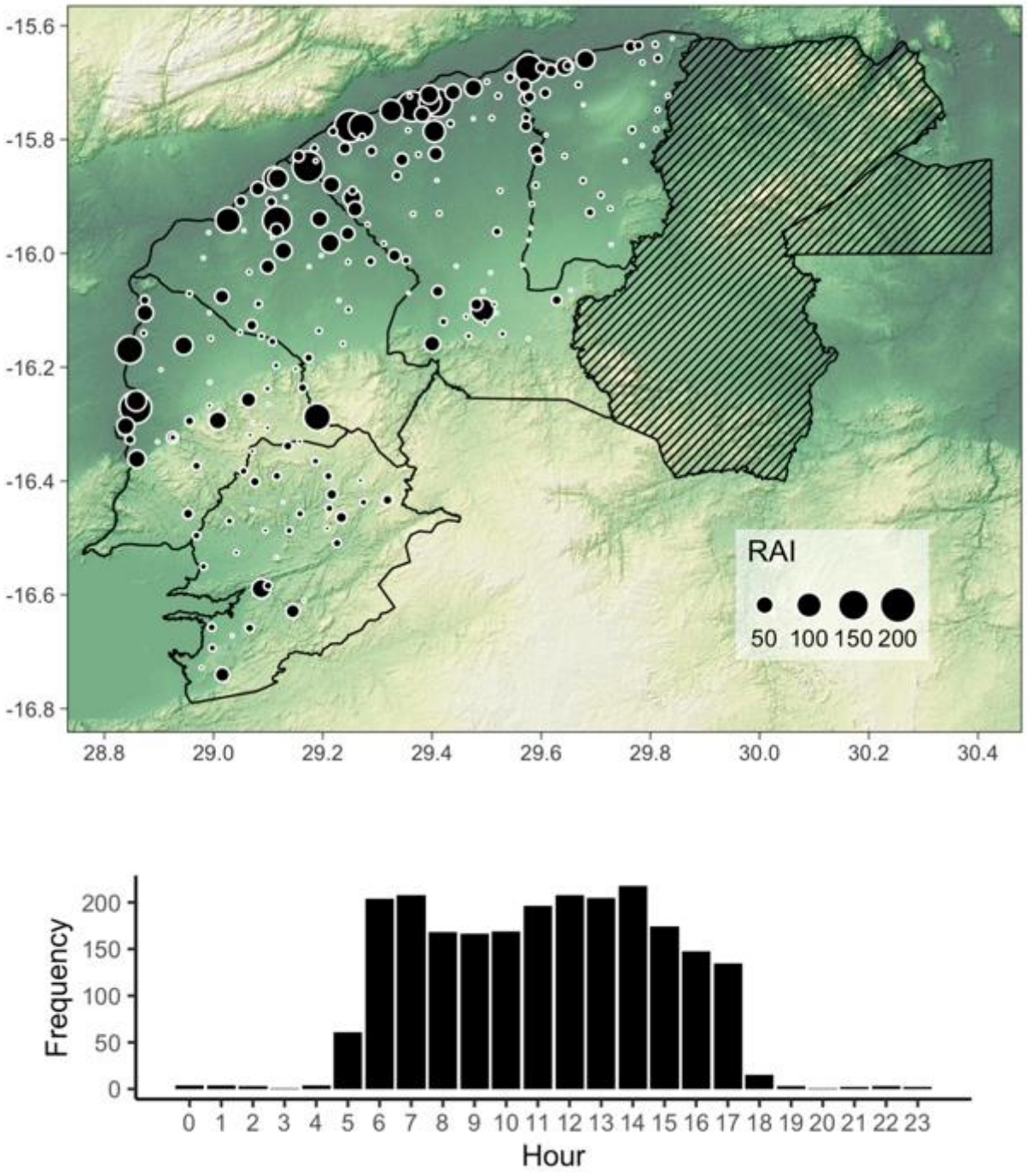

Figure 37. Spatial (top) and diel (bottom) distribution of baboon detection events during the 2022 Zambezi Valley camera trap survey.

Vervet monkey - *Chlorocebus pygerythrus*

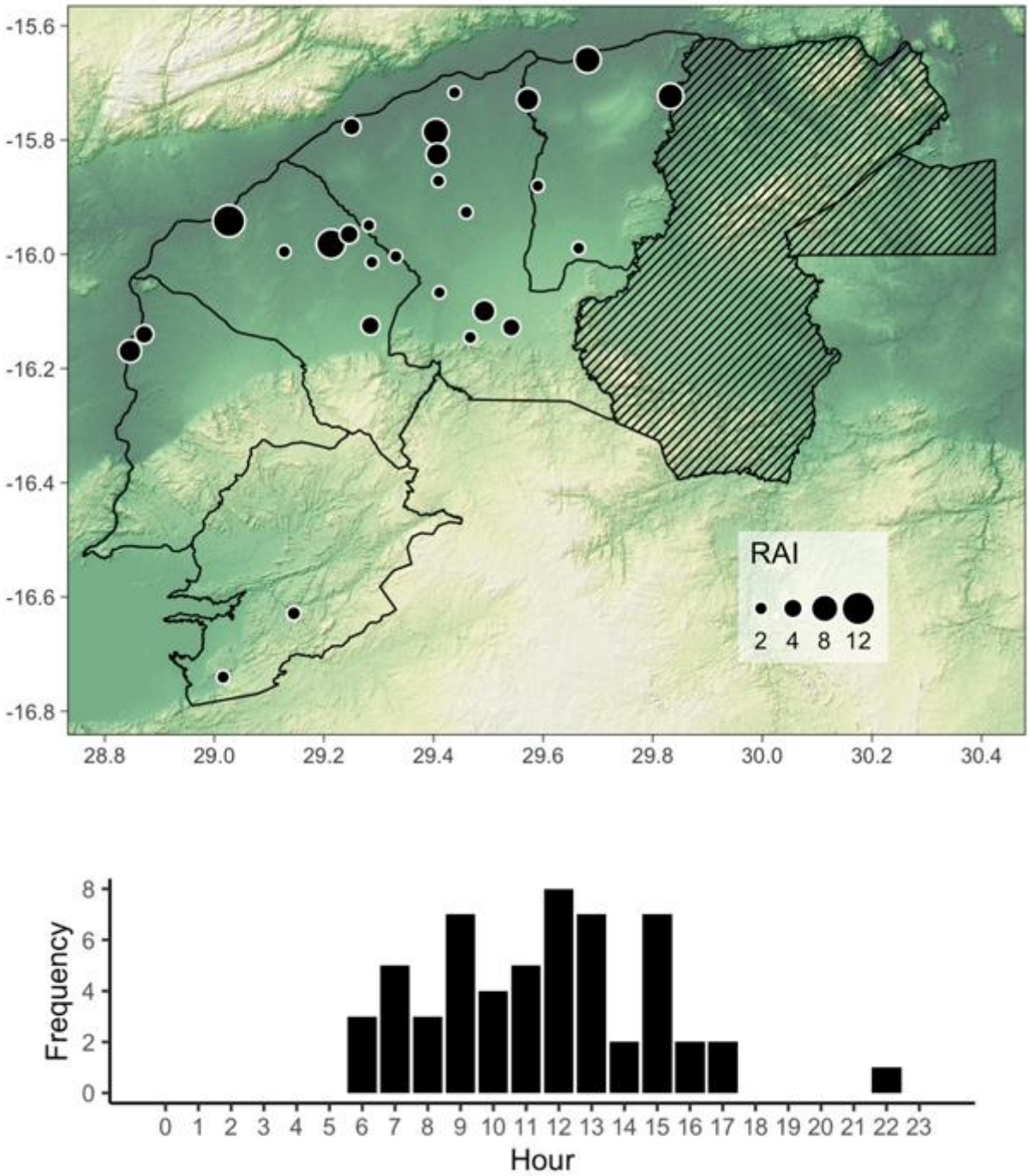

Figure 38. Spatial (top) and diel (bottom) distribution of vervet monkey detection events during the 2022 Zambezi Valley camera trap survey.

Aardvark - *Orycteropus afer*

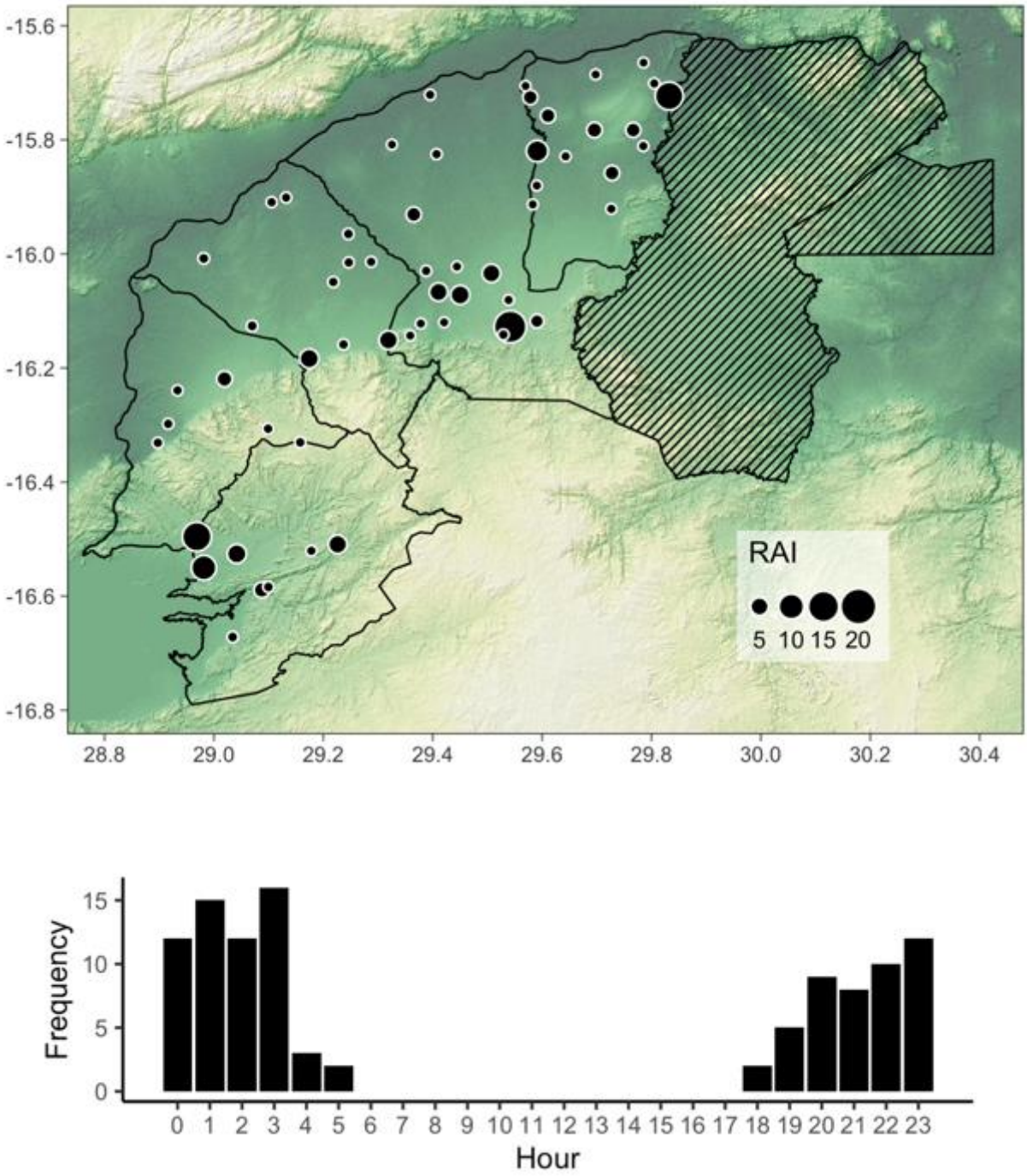

Figure 39. Spatial (top) and diel (bottom) distribution of aardvark detection events during the 2022 Zambezi Valley camera trap survey.

Density estimates

Lion - *Panthera leo*

Density estimates were calculated for lions for the entire study site from detections of uniquely identified individuals using a spatially explicit, mark-recapture approach. A total of 174 individually identified adults and subadults were detected. Maximum Likelihood (secr) estimates give a population density estimate of 0.027 lions/km^2 (SE 0.002, min = 0.023 max = 0.032). The Bayesian Framework (SPACECAP) gives very similar results for population density of 0.027 lions/ km^2 (±0.001, min 0.025-0.030). The density distribution of lions across survey sites, reveals high densities in the regions of Nyakasanga, Mana Pools and Rifa, and strikingly lower density in the Charara region. No lions were detected in camera traps deployed in the southern and eastern sectors of Charara Safari Area. Overall, there was a trend for lions to be detected along the Zambezi and major river systems with noticeable absence of detections in the dry mopane forests and jesse bush. This is likely to reflect spatial distributions of prey species. Comparison of population density estimates for lions within Mana Pools National Park between the 2015 and 2022 surveys suggest that the lion population density has remained relatively stable or slightly increased over this period from 0.028 lions/ km^2 (SE 0.004, min = 0.021, max = 0.037) to 0.032/ km^2 (SE 0.004, min = 0.026, max 0.041)

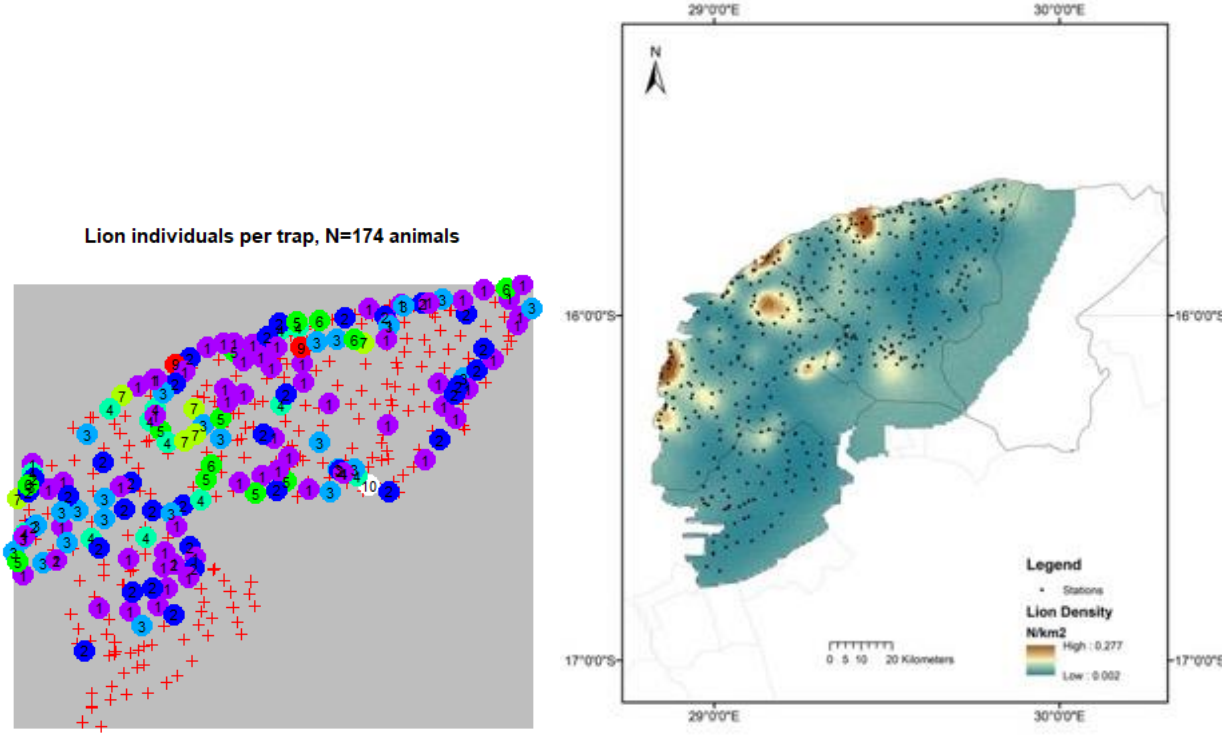

Figure 40. A colour-coded map showing the total number of individual lions (adults and subadults) detected per trap (left) and SPACECAP density surface plot for lions in the Zambezi Valley (right).

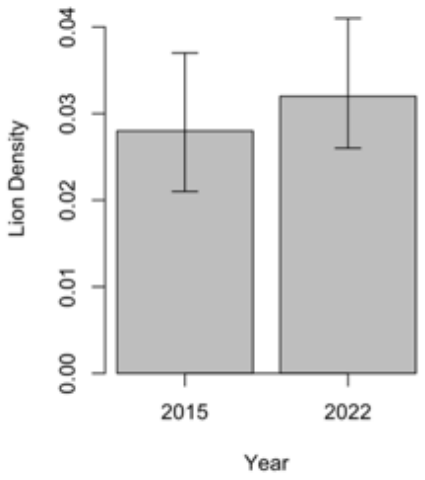

Figure 41. Mana pools lion density comparison between 2015 and 2022.

Leopard - *Panthera pardus*

Density estimates were calculated for leopards for the entire study site from detections of uniquely identified individuals using a spatially explicit, mark-recapture approach. A total of 268 individually identified adults and subadults were detected. Maximum Likelihood (secr) estimates give a population density estimate of 0.046 leopards/km^2 (SE 0.003, min = 0.041 max = 0.052). The Bayesian Framework (SPACECAP) analysis is computationally time consuming for such a large dataset and will be reported at a later stage. In general, leopards were widespread across the survey sites. Comparison of population density estimates for leopards within Mana Pools National Park between the 2015 and 2022 surveys suggest that the leopard population density has remained relatively stable or slightly increased from 0.036 leopards/ km^2 (SE 0.004, min = 0.029, max = 0.046) to 0.042/ km^2 (SE 0.004, min = 0.035, max 0.051).

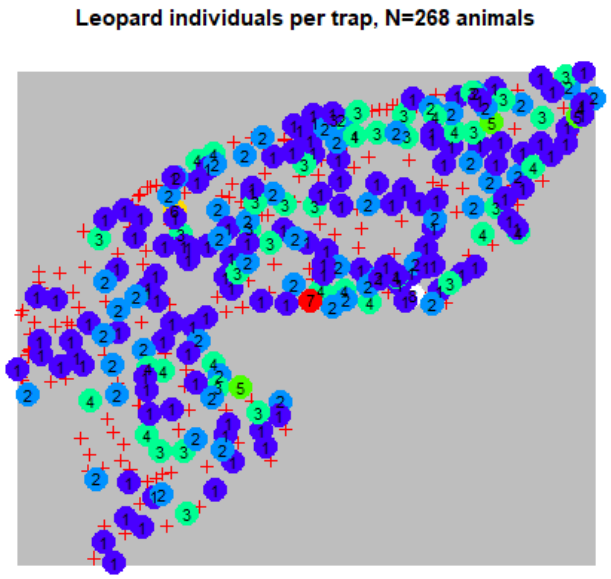

Figure 42. A colour-coded map showing the total number of individual leopards (adults and subadults) detected per trap.

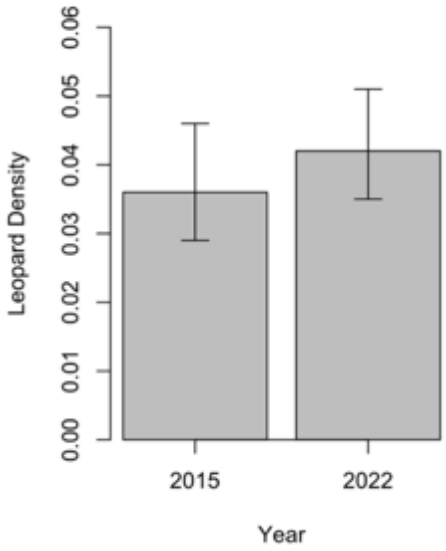

Figure 43. Mana pools leopard density comparison between 2015 and 2022.

Wild dog - *Lycaon pictus*

A total of 48 adult and sub adult wild dogs were identified in 346 detections over 152 occasions. Density estimates were calculated from the spatially explicit, mark-recapture data of wild dogs from this survey for the entire survey area. Maximum Likelihood (secr) estimates give a population density estimate of 0.006 dogs/km^2 (SE 0.001, min = 0.005 max = 0.008). The Bayesian Framework (SPACECAP) gives very similar results for population density of 0.007 dogs/ km^2 (±0.001, min 0.006-0.008, P= 0.9). The density distribution of wild dogs across the survey site reveals high densities in the region of Mana Pools. No dogs were found in the Rifa region and only two individuals were detected in Charara. Comparison of population density estimates for wild dogs within Mana Pools National Park between the 2015 and 2022 surveys suggest that wild dog population density has declined significantly from 0.02 dogs/km^2 (SE 0.0028, min = 0.0152, max = 0.0261) to 0.01 dogs/km^2 (SE 0.0017, min= 0.007, max = 0.014).

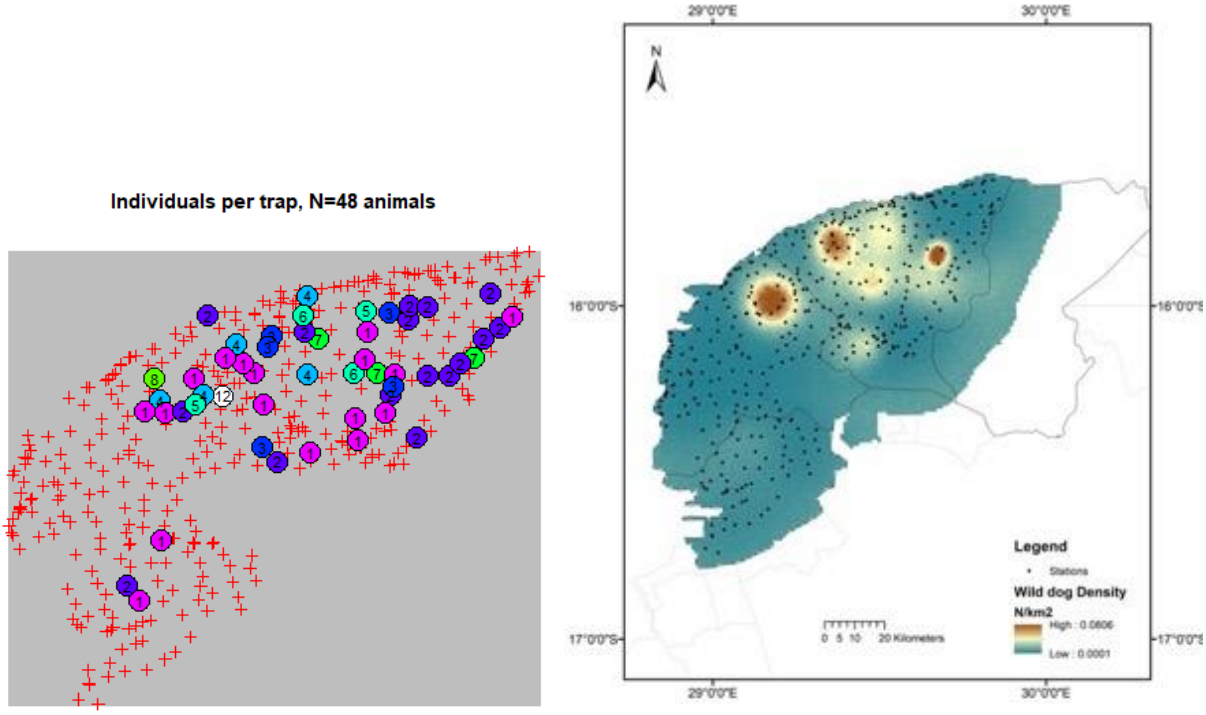

Figure 44. A colour-coded map showing the total number of individual wild dogs (adults and subadults) detected per trap (left) and SPACECAP density surface plot for wild dogs in the Zambezi Valley (right).

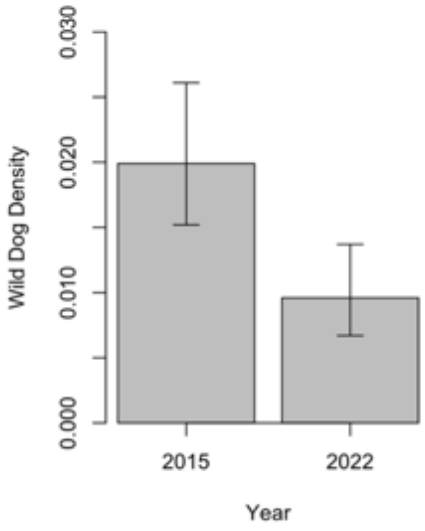

Figure 45. Mana Pools wild dog density comparison between 2015 and 2022.

Cheetah - *Acinonyx jubatus*

Only three individual cheetahs were detected across the entire survey site, with individual A01 detected in Sapi and Nyakasanga, individuals A02 and A03 in Mana Pools North and South respectively. Too few images of cheetahs were captured to allow further analysis of population density. The Mana Pools camera trap survey in 2015 detected only a single individual in Mana Pools North. It is likely that the species occurs at very low densities in the ecosystem.

Snaring

Animals with snare wounds were detected across the Charara SA and along the western boundary of the Rifa SA (Fig. 40). A small cluster of lions and spotted hyaenas with snare wounds were also detected in the south-western section of Mana Pools NP. It is important to note that the detection of snared animals does not necessarily reflect the number of snared individuals or the level of snaring pressure in an area as a single individual with a snare wound can be detected at multiple sites. Further analyses will be carried out at a later stage to assess potential snaring hotspots.

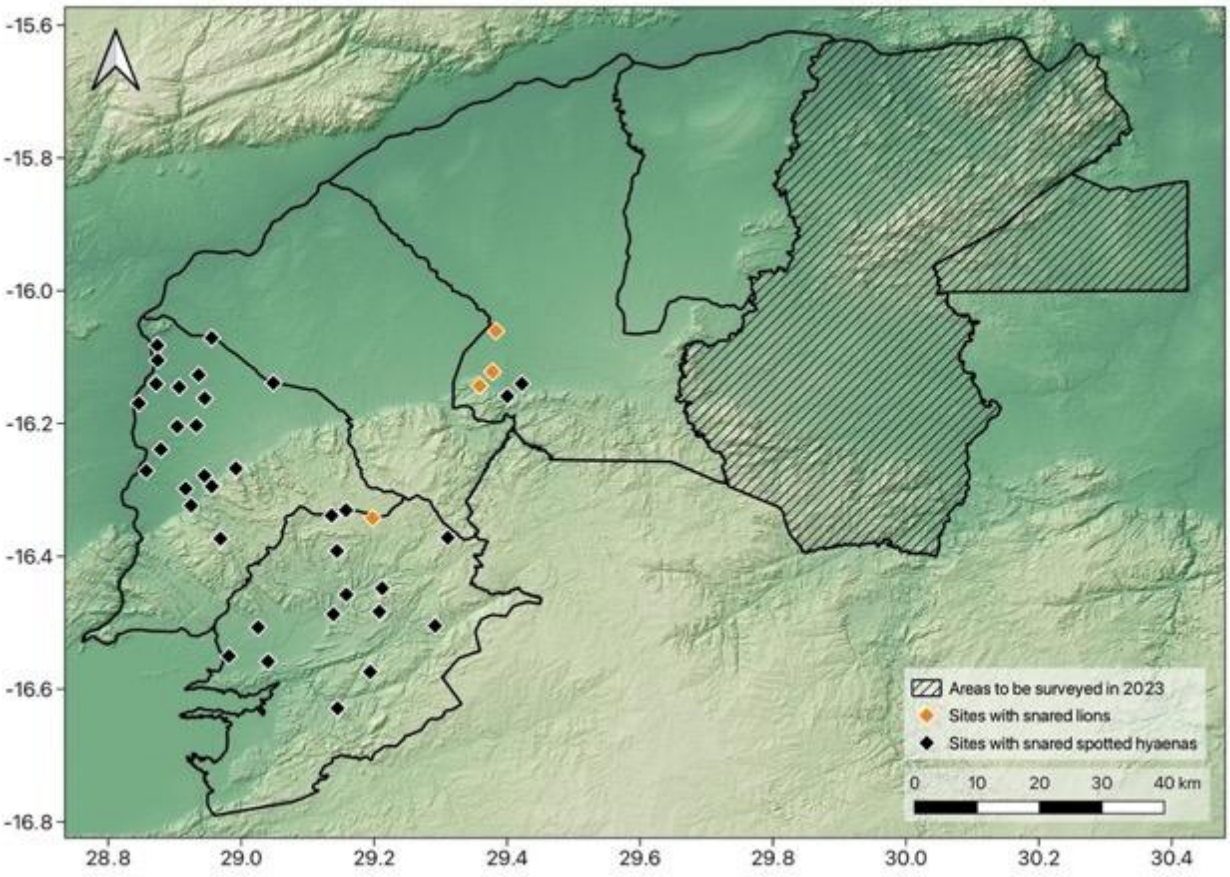

Figure 46. Sites where spotted hyaena and lions with obvious snare wound scars were detected during the 2022 Zambezi Valley camera trap survey.

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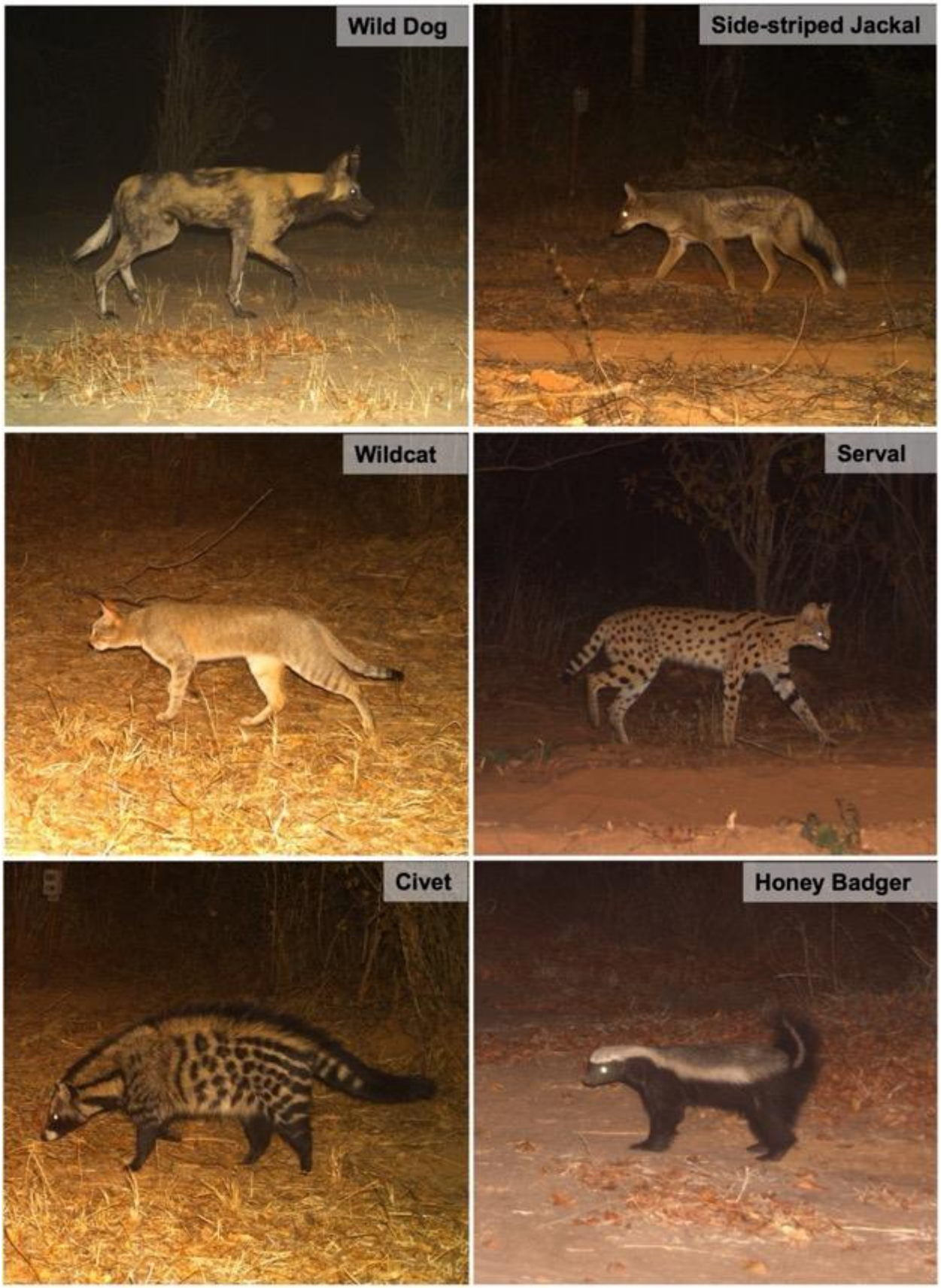
Gallery

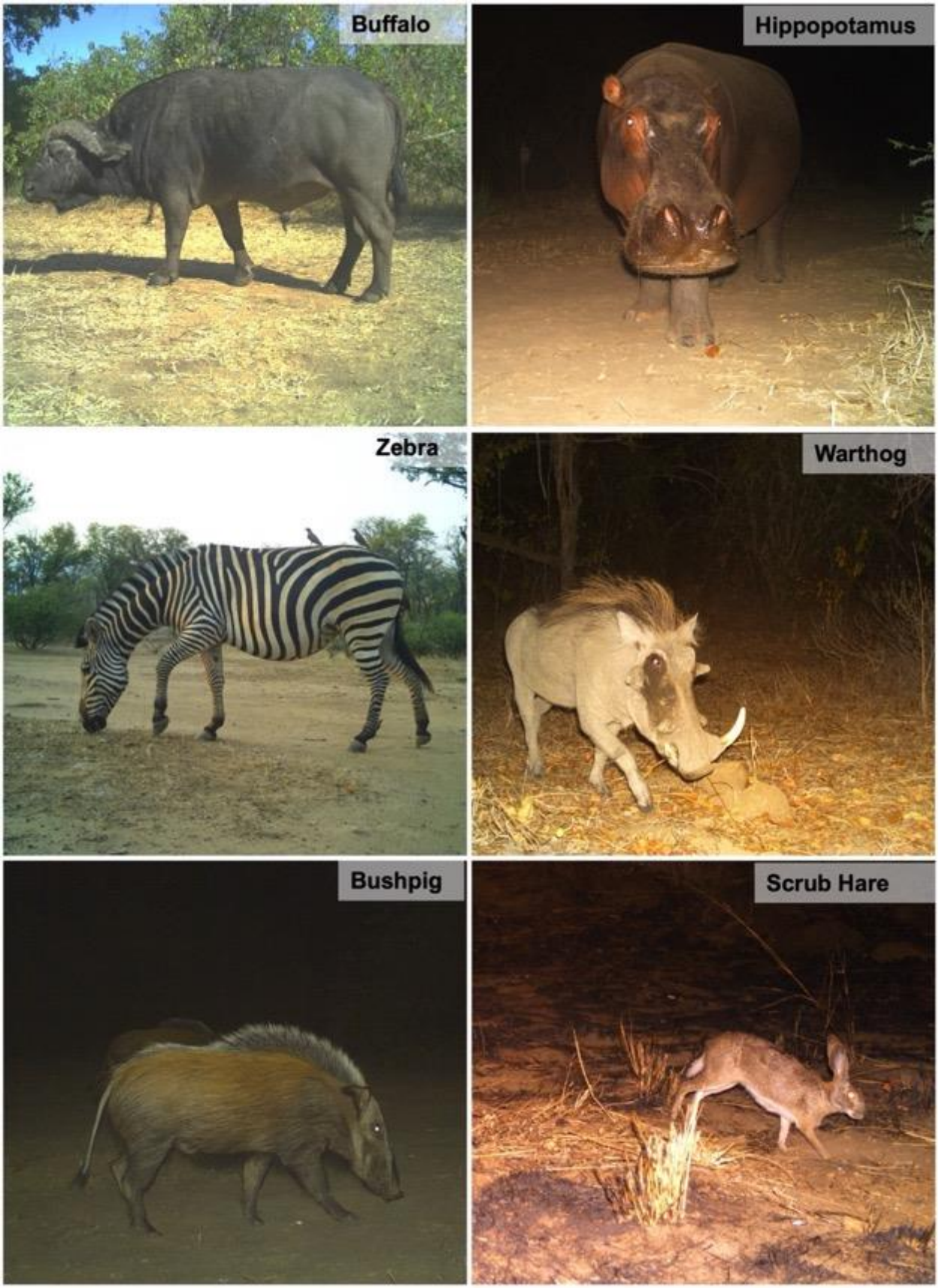
Images of each mammal species detected during the camera trap survey.


Wild Dog
Side-striped Jackal
Wildcat
Serval
Civet
Honey Badger


Caracal
Large-spotted Genet
Bushy-tailed Mongoose
Slender Mongoose
Banded Mongoose
White-tailed Mongoose


Kudu
Eland
Waterbuck
Nyala
Sable
Roan


Duiker
Bushbuck
Impala
Klipspringer
Sharpe's Grysbok
Elephant


Buffalo
Hippopotamus
Zebra
Warthog
Bushpig
Scrub Hare


Porcupine
Baboon
Vervet Monkey
Aardvark