University of Venda
Creating Future Leaders

UNIVERSITY OF VENDA
LIBRARY
CALL No.
ACC No.

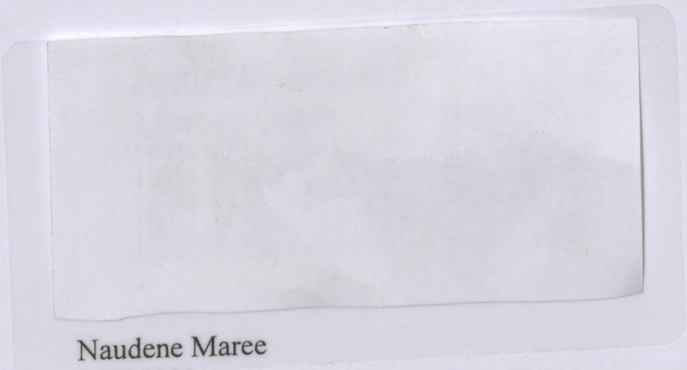
Meso-carnivore diversity and occupancy in an agro-ecological landscape

Thesis submitted in fulfilment of the requirements for the degree of

Master of Science

Department of Zoology

School of Mathematical and Natural Sciences



Name: Naudene Maree
Student number: 14014931

Supervisors: Prof. Peter J. Taylor (SARCHI Chair)
Dr. Lourens H. Swanepoel (SARCHI Chair & Department Zoology)
Dr. Mark Keith (Centre for Wildlife Management, University of Pretoria)

© University of Venda

University of Venda
Creating Future Leaders

DECLARATION

I, Naudene Maree, hereby declare that the dissertation for the degree of Master of Zoology at the University of Venda, hereby submitted by me, has not been previously submitted for a degree at this university or any other university, that it is my own work in design and execution and that all reference material contained therein has been duly acknowledged.

Signature..Maree N.....

Date..01/09/2011.....

© University of Venda

University of Venda
Creating Future Leaders

ACKNOWLEDGMENTS

This research project was mainly funded by a Sasol Agriculture Trust grant that was awarded to Dr L H Swanepoel. I further acknowledge the financial and logistic support of the National Research Foundation (NRF) and the Department of Science & Technology (DST) through the South African Research Chairs Initiative (SARChI) Chair on Biodiversity Value and Change in the Vhembe Biosphere Reserve, hosted and supported by the University of Venda and co-hosted by the Centre for Invasion Biology (C·I·B) at Stellenbosch University.

Thanks to the StopRats project (Sustainable Technology to Overcome Pest Rodents in Africa through Science) and SPACES - Limpopo Living Landscapes (LLL) project for their support and opportunities to learn different skills and methods in ecology. I want to also thank them for the privilege I had to work with them. The insight they gave into the Limpopo province information in rural areas and community education in sustainable practices of this area was truly amazing.

Professor Taylor for his willingness to do anything to help, thank you. Whether it was to give me a place to stay or much needed motivation he was always ready to help. To Doctor Lourens thank you for always understanding and helping without fail and also thank you for choosing me for this project and your support. Doctor Keith thank you for all the advice, support and ideas. Thank you Prof. Peter, Dr. Lourens and Dr. Mark for everything, I would have been lost without all of your help and patience.

The Vuwani Science Resource Centre and every one of the wonderful people working there. Thank you for allowing me to camp at your facility and the use of your kitchen. You all were great and I really appreciate everything you did for me.

At Ka-Ndengeza settlement we got permission to camp at the Tribal House. Thanks to the Chief for allowing us to stay there and also for allowing us to do our study in the settlement. To the amazing people working there thanks for the help, support and understanding.

Vyeboom settlement also gets my grateful thanks for allowing us to conduct our study there. Thank you Chief for granting us permission and also for inviting us to the meeting for introductions. Also thanks to Caswell and his family that welcomed us with open arms and for going beyond anything we expected. Thank you so much.

© University of Venda

University of Venda
Creating Future Leaders

A very special person who helped me a lot is lecturer Mr. Colin Schoeman, at University of Venda. Thank you for always being there when I needed you. You have become a close friend and I admire you so much. Also thanks to Gerhard for being my voice box and introducing me to this study opportunity. For helping when asked and understanding by just looking at my face.

To Evans and Lesly a special thanks for the education in Venda culture and the help with sometimes unpleasant work. Evans you made camping worthwhile and Lesly you were my rock in a place where I was an alien. Thank you guys. Alain and Cavin deserve a special thanks for their help. Alain for the support and good conversations after a long day in the field. Cavin for his help with only a moment's notice and his energetic personality that motivated me up "mountains".

My home based support structure of my Moo and my Dad, thanks for the understanding, loans, constant nagging and motivation. When I was negative, moody and a moaner you listened and tried to help. Thank you for always being there even when I don't realize it.

To the rest of the home based support team that made me laugh when I felt like crying thank you for the help. Lielie thank you for reminding me where I have been and what I have achieved. Burgert thank you for forcing me to aim higher and do better. Cassie and Alicia thank you for being not only the example of what I could and want to be (happy, successful and loved) but also for keeping me motivated to the end.

While I was growing up I had what people called an "impossible dream" of being Dr. Dolittle and talking to animals. Thank you Mr. Hugh Lofting for inspiring my dream and for giving me something to aim for. This MSc is another step closer to achieving it.

Thank you to everyone who helped me with this project, I appreciate all of your help.

© University of Venda

University of Venda







DEDICATION

I want to dedicate this to everyone who believed in this crazy girl and helped me to keep believing in myself.

© University of Venda

University of Venda
Creating Future Leaders

ABSTRACT

Worldwide, anthropogenic activities have caused great declines in mammal diversity and abundance. It has become increasingly important to quantify such declines, as well as how different mammal species respond to such anthropogenic driven changes. This is because diverse animal communities can play important roles in ecosystem stability and associated ecosystem services. Animal communities in agricultural matrixes are playing more important roles as bio-control agents and pollinators. It is therefore necessary to determine the effects agricultural matrixes have on the smaller mammals, like the small carnivores, which may be more abundant in the absence of larger carnivores (meso-predator release hypothesis). In this study, camera trapping was used to investigate the occupancy and diversity of different small carnivores within a gradient of land use change in two different rural settlements in Limpopo. Furthermore, occupancy of small carnivores was modelled using different environmental variables to investigate the effect of land use on small carnivores' presence and abundance within agricultural matrixes. The highest species richness for small carnivores were found to be in the cropping land use, followed by the grazing land use in both villages. The settlement land use had the lowest small carnivore species richness for both villages. The cropping land use also had the largest positive effect on the occupancy of the large-spotted genet and the slender mongoose. The importance of other covariates varied between villages and species. The questionnaire results indicated the need for environmental information to support the community members in management practices.

Keywords: Small carnivores, diversity, occupancy, human-dominated habitats, predation, ecology

© University of Venda

University of Venda
Creating Future Leaders

TABLE OF CONTENTS PAGES

DECLARATION I

ACKNOWLEDGMENTS II

DEDICATION IV

ABSTRACT V

LIST OF FIGURES 5

LIST OF TABLES 7

CHAPTER ONE: INTRODUCTION 9

1.1 BACKGROUND TO THE STUDY 9

1.2 STATEMENT OF THE RESEARCH PROBLEM 11

1.3 AIMS 11

1.4 SPECIFIC OBJECTIVES 12

1.5 RESEARCH NULL HYPOTHESES 12

1.6 JUSTIFICATION 12

CHAPTER TWO: LITERATURE REVIEW 14

2.1 RISE OF THE SMALL CARNIVORES 14

2.2 ROLE OF SMALL CARNIVORES 14

2.3 SMALL CARNIVORE DIVERSITY (APPENDIX A) 15

2.4 EFFECT OF SMALL CARNIVORES ON RURAL COMMUNITIES 16

2.5 DIVERSITY OF SMALL CARNIVORES DIETS 17

2.6 ECONOMIC IMPORTANCE OF SMALL CARNIVORES: ECOSYSTEM SERVICES 19

© University of Venda

University of Venda
Creating Future Leaders

CHAPTER THREE: ECOLOGICAL SETTING OF THE STUDY AREAS 21

3.1 LOCATION OF THE STUDY AREAS 21

3.2 GEOLOGY AND SOIL 22

3.3 CLIMATE 23

3.4 VEGETATION 24

3.5 LAND-USE IN VHEMBE MUNICIPALITY 25

3.6 STUDY SITES 25

3.6.1 Vyeboom 25

3.6.2 Ka-Ndengeza 27

CHAPTER FOUR: RESEARCH METHODOLOGY 29

4.1 INTRODUCTION 29

4.2 METHODS 30

4.2.1 Camera trapping and deployment of camera traps 30

4.2.2 Community questionnaire 34

4.3 DATA ANALYSIS 34

4.3.1 Predictor variables 35

4.3.2 Deriving GIS based environmental variables 36

4.3.3 Occupancy modelling 38

4.3.5 Predicted maps 39

4.3.6 Species richness estimation 39

4.3.7 Questionnaire analysis 43

CHAPTER FIVE: RESULTS 44

© University of Venda

University of Venda
Creating Future Leaders

5.1 SUMMARY OF CAMERA TRAPPING RESULTS 44

5.1.1 General results 44

5.1.2 Small carnivore species richness 45

5.2 OCCUPANCY RESULTS 50

5.2.1. Detection probability results 50

5.2.2. Occupancy 54

5.2.3 Model selection 62

5.4 QUESTIONNAIRE RESULTS 68

5.4.1 Small carnivore questions 68

5.4.2 Human perception of the impact of small carnivores 71

CHAPTER SIX: DISCUSSION 72

6.1 SPECIES RICHNESS 72

6.2 DETECTION AND OCCUPANCY 73

6.2.1 Habitat vs Food vs Competition 74

6.2.2 Large-spotted genet 76

6.2.3 Slender mongoose 78

6.3 QUESTIONNAIRES 79

CHAPTER SEVEN: CONCLUSIONS AND SUGGESTIONS 81

REFERENCES 84

APPENDIX A: MESO-PREDATOR CLASSIFICATION AND PHOTO INDEX, USED WITH THE QUESTIONNAIRES FOR CLEAR IDENTIFICATION OF DIFFERENT SPECIES TO THE COMMUNITY MEMBERS (KINGDON & HOFFMANN, 2013). 100

1. Family: CANIDAE 100

© University of Venda

University of Venda
Creating Future Leaders

2. Family: MUSTELIDAE 102

3. Family: FELIDAE 103

4. Family: VIVERRIDAE 105

APPENDIX B: COMMUNITY QUESTIONNAIRE USED FOR SMALL CARNIVORE SURVEYS IN THE TWO VILLAGES VYEBOOM AND KA-NDENGEZA, LIMPOPO 109

© University of Venda

University of Venda
Creating Future Leaders

LIST OF FIGURES

Figure 1: Map of Limpopo Province in South Africa showing study sites Vyeboom and Ka-Ndengeza.

Figure 2: Monthly mean temperatures in Degree Celsius (°C) for 2009–2014 and the rainfall per month in millimetres of 2009 as measured by the Levubu Weather Station.

Figure 3: Regional locality map of Vyeboom in the Limpopo Province.

Figure 4: Regional locality map of Ka-Ndengeza village in the Limpopo Province.

Figure 5: Grid layout (300 m x 300 m) overlaid on study site to deploy camera traps (red dots) in the Vyeboom study site across the three land use types.

Figure 6: Grid layout (300 m x 300 m) overlaid on study site to deploy camera traps (red dots) in the Ka-Ndengeza study site across the three land use types.

Figure 7: Comparison of the species accumulation curves, for the 85 first samples, across different land-uses for Ka-Ndengeza (7a) and Vyeboom (7b). The second pair of graphs is also a comparison of the species accumulation curves but, in contrast to using the individual small carnivore samples, the samples were divided by days across different land-uses at Ka-Ndengeza (7c) and Vyeboom (7d). In the third pair of graphs the Coleman rarefaction curves of Ka-Ndengeza (7e) and Vyeboom (7f) for each land-use in produced by EstimateS are shown. The last pair of graphs show the Chao-2 estimator value for each land-use at Ka-Ndengeza (7g) and Vyeboom (7h).

© University of Venda

Figure 8: Influence of distance (in meters) to the nearest border edge of crops and grazing on the detection probability of the large-spotted genet at Ka-Ndengeza (crops (a); grazing (b)) and Vyeboom (crops (c) and grazing (d)).

Figure 9: Influence of distance (in meters) to the nearest border edge of grazing, crops and settlement on the detection probability of the slender mongoose at Ka-Ndengeza (grazing (a)) and Vyeboom (crops (b), grazing (c) and settlement (d)).

Figure 10: Estimated occupancy of the large-spotted genet (*Genetta maculata*) at Ka-Ndengeza, with darker green indicating higher estimates of occupancy.

Figure 11: Estimated occupancy of the large-spotted genet (*Genetta maculata*) at Vyeboom, with darker green indicating higher estimates of occupancy.

Figure 12: Estimated occupancy of the slender mongoose (*Galerella sanguinea*) at Ka-Ndengeza, with darker green indicating higher estimates of occupancy.

© University of Venda

LIST OF TABLES

Table 1: List of small carnivores that occur in the study area according to literature with their scientific names, home ranges, IUCN status and references of the home ranges.

Table 2: List of small carnivores indicating some of their dietary facts, human tolerance (low is equal to hunted and high is beneficial) with reasons, their activity patterns and socialization.

Table 3: Covariates used in calculating the occupancy estimates of the small carnivores were divided into three broad themes namely habitat, food and competition.

Table 4: Total survey effort at each study site for each land-use.

Table 5: Species list of all mammals captured on camera traps in the settlement, crops and grazing land uses, as well as the frequency of photos taken (expressed as the number of photos taken per 1000 camera trap days).

Table 6: Detection probability values with habitat variables (constant psi), for the large-spotted genet at Ka-Ndengeza (KN) and Vyeboom (VYE).

Table 7: Detection probability values with habitat variables (constant psi), for the slender mongoose at Ka-Ndengeza (KN) and Vyeboom (VYE).

Table 8: Top occupancy (psi) models of the predefined factors, with a constant detection probability, for the large-spotted genet at Ka-Ndengeza (KN; p(crops + grazing)) and Vyeboom (VYE; p(.)) with the beta values.

Table 9: Weight ranking of factors according to impact on occupancy modelling by using the sum of all the model weights containing the covariate (AICwt), and converting to percentage.

Table 10: Top occupancy (psi) models of the predefined factors, with a constant detection probability (p), for the slender mongoose at Ka-Ndengeza (KN; p(grazing)) and Vyeboom (VYE; p(crops + grazing + settlement)) with the beta values.

© University of Venda

Table 11: Weight ranking of factors according to impact on occupancy modelling by using the sum of all the model weights containing the covariate (AICwt), and converting to percentage.

Table 12: Estimates of beta coefficients on the logit scale and standard error (SE) of covariates contained in the final models of large-spotted genet (LSG) and slender mongoose (SM) occupancy in the two villages of Ka-Ndengeza (KN) and Vyeboom (VYE).

Table 13: Pearson's chi-squared test values for the questionnaire answers for each species of small carnivore.

Table 14: The percentage of sightings of the small carnivores (seen) the accompanied by the frequency of the sightings on a daily basis. The percentage of people who think the small carnivores do eat rodents (kill rodents), and if they are considered positive or negative to the community members livelihoods.

© University of Venda

University of Venda
Creating Future Leaders

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Habitat destruction is one of the largest threats to biological diversity worldwide (Krauss et al., 2010; Blaum et al., 2006). The natural occurring vegetation is reduced mainly for agricultural purposes (e.g. grazing of livestock, farming and woodcutting) to support the growing population of people (Boserup, 2005). Overgrazing by livestock can lead to shrub encroachment that is seen as one of the most serious forms of rangeland degradation in southern Africa (Blaum et al., 2006). Such shrub encroachment can in turn lead to habitat loss and fragmentation for many species of the area (Blaum et al., 2006). In agricultural landscapes the combined effect of shrub encroachment and land clearing are one of the major contributors to declining mammal populations in Africa and other countries (Blaum et al., 2006).

Agricultural landscapes are usually formed by a matrix of different human modified ecosystems infused with remnant patches of native vegetation (Verdade et al., 2011). While the ever increasing extent of agricultural matrixes might be detrimental to some mammal species (e.g. large mammals), it can be quite positive for other groups of small mammals (e.g. rodents and small carnivores). It is therefore important to understand the response of mammals to the conversion of native habitat to human dominated agricultural matrixes.

In agricultural areas it is expected that large-sized carnivores (e.g. lions [*Panthera leo*] and leopard [*Panthera pardus*]) will be at low densities or totally extirpated (Ripple et al., 2014). Large carnivores are extinction prone due to inherent biological factors like low reproduction rates, large area requirements and low natural occurring densities (Verdade et al., 2011; Purvis et al., 2000). The effects of these biological factors is exacerbated in the presence of anthropogenic impacts like retaliatory killings, agricultural expansion and the illegal trade in skin, bones and other body parts (Verdade et al., 2011). These combined effects can lead to the local extinction of top predators than can have an indirect and negative effect on prey animals, ecosystem function and structure and community assemblages (Ripple et al., 2014).

© University of Venda

One such predicted change of particular importance to the agricultural landscapes is the rise of meso-carnivore abundance (via the meso-carnivore release hypotheses; Crooks & Soule, 1999). It is predicted that without large carnivores the small carnivores will be released from predation and increase in abundance (Brook et al., 2012; Crooks & Soule, 1999). Small carnivores (medium to small-sized carnivores, e.g. mongooses, foxes, badgers and polecats) are some of the species identified that might benefit from land use change (Brook et al., 2012; Verdade et al., 2011) and the absence of the large-sized carnivores (Shuette et al., 2012; Verdade et al., 2011; Blaum et al., 2006). Smaller generalist predators will benefit the most from the land use changes, as the smaller prey species' population size will increase and diversify to adapt to this change in food resource availability (Verdade et al., 2011) and with no fear of being hunted themselves the small predators can invest more energy in finding food than hiding from larger predators (Brook et al., 2012; Verdade et al., 2011). The typical small carnivores have a high degree of adaptability and plasticity in their behaviour (Ćirović et al., 2016). This behaviour is key to why these small carnivores can be beneficial in human dominated landscapes where there are higher quantities of biological waste like animal carcasses. They can benefit from this newly created niche without people knowing that they are there (Ćirović et al., 2016; Brook et al., 2012).

While large carnivores have been studied extensively, little attention has been paid to small predators (Sarmento et al., 2010). Especially in agricultural matrices little is known about the small carnivores' occupancy and diversity where they can deliver important ecosystem services such as seed dispersal (Roemer et al., 2014) and controlling population sizes of prey species (Sarmento et al., 2010; Blaum et al., 2009; Miller et al., 2001). They may also play an essential role in waste management, which has not been studied yet. Because the importance of these small carnivores as beneficial ecosystem service providers are under studied, the impact the loss of these carnivores might have is unknown and could be catastrophic.

Camera-trapping is used successfully in detecting presence and monitoring abundance of carnivore species, as well as occupancy and environmental factors associated with it (Abi-Said et al., 2012; Sarmento et al., 2010; Symmank et al., 2008). Abundance and diversity are used to determine the health of an ecosystem and the occupancy of a site provides an unbiased and cost-effective alternative method for multispecies monitoring on a large-scale

© University of Venda

(Sarmento et al., 2010). Occupancy also provides an estimation of the population status and trends (Sarmento et al., 2010). Camera trapping has been successfully used in numerous carnivore studies world-wide, addressing topics such as species inventory, abundance, distribution, population structure, habitat use and behaviour (Thorn et al., 2009).

The main objective of this study was to determine the effect of different land uses (settlement, cropping and grazing) on small carnivore occupancy and diversity. This was achieved by using camera-traps underpinned by an occupancy modelling framework. These data were supplemented with questionnaires from local communities on the effect of small carnivores on their livelihoods.

1.2 Statement of the research problem

Little work has been done on small carnivores within human dominated landscapes, especially agricultural matrixes (Fahrig et al., 2011). Understanding the response of small carnivores diversity and occupancy to the different land uses in the agricultural matrix (which include varying human activities, e.g. woodcutting, livestock, farming and housing) are becoming more important since these carnivores can either positively or negatively affect human communities. Furthermore, large carnivores, have been decimated from most agricultural, ecological communities in South Africa which may release small carnivores populations from large carnivore predation (direct and indirect) leading to increased small carnivores abundance and associated impact on the ecosystem (small carnivores release; Sarmento et al., 2011; Verdade et al., 2011).

1.3 Aims

1. To determine effect of land use on small carnivores;
2. To investigate effect of small carnivores on human livelihood.

© University of Venda

1.4 Specific objectives

1. Estimate small carnivore richness in the study area;
2. Investigate the effect of competition (domestic carnivores, livestock and humans), food sources (cropping areas and poultry) and land use (crops, grazing and settlement) on small carnivore occupancy;
3. Investigate the effect of land use on small carnivore species diversity;
4. Evaluate the impact of human presence on domestic and wild small carnivores' occupancy;
5. Estimate the tolerance of community members towards small carnivores' presence.

1.5 Research null hypotheses

1. Land use will have no effect on small carnivore community assemblages;
2. Land use specific variables (e.g. livestock, cropping, domestic carnivores; See Table 4) will not affect small carnivore occupancy probabilities;
3. Communities will perceive small carnivores as negative.

1.6 Justification

Rural communities in Limpopo province (Figure 1) are strongly dependent on their surrounding environment for food and other resources such as fire wood and grazing (Blaum et al., 2006). This dependence inadvertently leads to changes in the land use from natural to agricultural land and/or grazing to abandoned land. In the savannah biome (Rutherford & Mucina, 2006) livestock overgrazing often results in shrub encroachment, which for example is the increase of unpalatable woody vegetation at the cost of palatable herbaceous vegetation (Mostert et al., 2008; Blaum et al., 2006). With expanding rural populations in Limpopo province (Mostert et al., 2008) there is an increased demand for housing, which leads to increased resource extraction (Semenya & Potgieter, 2014). This exaggerates land use changes which will similarly affect small carnivore assemblages (Korpimäki & Krebs, 1996)

© University of Venda

and also affect human tolerance towards these species (Verdade et al., 2011; Blaum et al., 2006). While such can be negative towards many species (Ripple et al., 2014; Brook et al., 2012), it can also open up niches for other human-tolerant species (Verdade et al., 2011). These animals could deliver valuable ecosystem services in this changed environment and to determine the impact of these changes and the importance thereof in the northern Limpopo region, a study needed to be done which could inform future land use planning in the human dominated landscapes.

© University of Venda

University of Venda
Creating Future Leaders

CHAPTER TWO: LITERATURE REVIEW

2.1 Rise of the small carnivores

Globally large carnivores have been decimated by human activities (Verdade et al., 2011; Ripple et al., 2014). The disappearance of large carnivores have triggered cascade effects throughout some ecosystems, which included changes to species composition, and this leads to a change in ecosystem structure and functionality (Verdade et al., 2011). This can be direct effects on a single species like destruction of reproduction sites or indirect changes to trophic level interactions. This trophic level interaction refers to where a specialist predator changes to a generalist seasonally or a nomadic/migratory predator that follows the increase in prey populations is excluded (Blaum et al., 2006; Korpimäki & Krebs, 1996). Population increase of some prey species can occur if the specialist predator is excluded, like in the case of some rodents where this increase leads to conflict with humans (Belmain, 2006). Among these cascading effects have been the increase in meso-carnivore densities due to the meso-carnivore release phenomenon (Verdade et al., 2011; Sarmento et al., 2010). Combined with the fact that small carnivores are less noticeable and threatening to the farmers and their livestock, this has led to the proliferation of small and medium carnivores across many landscapes (Verdade et al., 2011). Furthermore, the potential diet of small carnivores is broad and can include small mammals, reptiles, birds, amphibians and insects (Skinner & Chimimba, 2005). In combination, these effects have caused small and meduim carnivores to increase in abundance in many human dominated landscapes (Blaum et al., 2006).

2.2 Role of small carnivores

Large and small carnivores have a vital part to play in an ecosystem (Miller et al., 2001). Small carnivores deliver ecological services like pest control (Blaum et al., 2009), seed dispersal (Miller et al., 2001) and may take the role of top predator in modified landscapes (Verdade et al., 2011). Interactions in ecosystems that determine abundance, distribution and diversity through different trophic levels are often associated with the terms top-down or

© University of Venda

bottom-up regulation (Miller et al., 2001; Power, 1992; Hunter and Price, 1992). Top-down regulation refers to the kind of system where herbivores (this may include insects, reptiles and mammals) regulate the biomass of the plants and the herbivores are regulated through carnivores (small and medium carnivores included; Miller et al., 2001; Power, 1992; Hunter and Price, 1992). Small carnivores might not be as visible as the larger carnivores but their effect is just as great on the smaller prey species that they prey on (Palomares et al., 1995; Andersson & Erlinge, 1977).

Carnivores regulate the prey species numbers through direct methods like hunting and indirect methods by making prey more alert (Miller, et al., 2001). This is also known as behaviourally-mediated trophic cascades which has also been documented in ocean ecosystems (Byrnes et al., 2006). Being at the top of the food chain, carnivores prevent prey species from out competing each other for resources. In doing so carnivores establish ecological boundaries to protect weaker competitors from competitive exclusion (Miller et al., 2001). Carnivore presence also indirectly alters movements of seed distributors and cause plants to be spread further (Miller et al., 2001).

2.3 Small carnivore diversity (Appendix A)

According to distribution maps, small carnivores from 5 different families should occur in the study area (Table 1; Skinner & Chimimba, 2005; Stuart & Stuart, 2006; Apps, 2012; Cillie, 2013; Kingdon & Hoffman, 2013). These families are the Canidae (3 species, excluding the domestic dog), Mustelidae (3 species), Felidae (4 species, excluding the domestic cat), Viverridae (3 species) and Herpestidae (8 species).

The small spotted cat or black footed cat (*Felis nigripes*) from the Felidae family is listed as Vulnerable (International Union for Conservation of Nature Red list of threatened species; IUCN) and is included in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) with the African wild cat (*Felis silvestris*). The caracal (*Caracal caracal*) and serval (*Leptailurus serval*), both from the Felidae family, are included in Appendix II of CITES. The honey badger (*Mellivora capensis*; Mustelidae

© University of Venda

family) and African civet (*Civettictis civetta*; Viverridae family) are included in Appendix III of CITES.

Table 1: List of small carnivores that occur in the study area according to literature with their scientific names, home range sizes, IUCN status and references for the home range data.

Common name	Scientific name	Home range size (km²)	IUCN Red List	CITES	References
CANIDAE					
Black-backed jackal	*Canis mesomelas*	0.2 - 11	Least concern	Not listed	Stuart & Stuart, 2006
Cape fox	*Vulpes chama*	1.0 - 4.6	Least concern	Not listed	Stuart & Stuart, 2006
Bat-eared fox	*Otocyon megalotis*	0.25 - 3	Least concern	Not listed	Stuart & Stuart, 2006
MUSTELIDAE					
Striped polecat	*Ictonyx striatus*	-	Least concern	Not listed	-
African striped weasel	*Poecilogale albinucha*	-	Least concern	Not listed	-
Honey badger	*Mellivora capensis*	10 -30	Least concern	Appendix III	Apps, 2012
FELIDAE					
Caracal	*Caracal caracal*	15 - 65	Least concern	Appendix II	Apps, 2012
Serval	*Leptailurus serval*	2 - 30	Least concern	Appendix II	Apps, 2012
Small spotted cat	*Felis nigripes*	10 - 21	Vulnerable	Appendix I	Apps, 2012
African wild cat	*Felis silvestris*	6 - 10	Least concern	Appendix I	Apps, 2012
VIVERRIDAE					
Small-spotted genet	*Genetta genetta*	1.13 - 7.8	Least concern	Not listed	Camps, 2008
Large-spotted genet	*Genetta maculata*	0.5 - 1	Least concern	Not listed	Apps, 2012
African civet	*Civettictis civetta*	5.0 - 11.1	Least concern	Appendix III	Admasu et al., 2004
HERPESTIDAE					
Water mongoose	*Atilax paludinosus*	1.5 - 2.0	Least concern	Not listed	Apps, 2012
Slender mongoose	*Galerella sanguinea*	0.5 - 1	Least concern	Not listed	Apps, 2012
Meller's mongoose	*Rhynchogale melleri*	-	Least concern	Not listed	-
Yellow mongoose	*Cynictis penicillata*	0.27 - 3.0	Least concern	Not listed	Apps, 2012
Selous' mongoose	*Paracynictis selousi*	-	Least concern	Not listed	-
White-tailed mongoose	*Ichneumia albicauda*	4 - 8	Least concern	Not listed	Apps, 2012
Banded mongoose	*Mungos mungo*	0.8 - 4.0	Least concern	Not listed	Stuart & Stuart, 2006
Dwarf mongoose	*Helogale parvula*	1 - 3	Least concern	Not listed	Apps, 2012

2.4 Effect of small carnivores on rural communities

Human-carnivore conflict is a major driver of declining carnivore populations globally (Treves et al., 2006; Crooks, 2002). While the effect of large carnivores on human activities have been extensively studied (Sarmento et al., 2010), little is known about the effect of small carnivores on rural-livelihoods (Sarmento et al., 2010; Belmain, 2006; Treves et al., 2006).

© University of Venda

Recent questionnaire data have suggested that some small carnivores negatively affect rural communities (Blaum et al., 2009; Songorwa, 1999). However, Africa has a rich small carnivore guild and it is unknown if damage-causing animals are limited to certain species, or all species. Furthermore, a large proportion of Africa's small carnivores look similar and it is not known whether community members can differentiate between species correctly. Killing methods of problem carnivores are not species specific (Apps, 2012; Stuart & Stuart, 2006; Skinner & Chimimba, 2005).

According to Linkie et al. (2009), human–carnivore conflict is considered to be a major conservation and rural livelihood issue, because many carnivore species have been heavily persecuted due to elevated conflict levels with communities. This is due to poultry killing by small carnivores in rural areas, which causes close encounters with humans (Apps, 2012; Skinner & Chimimba, 2005). With the expansion of human populations more pressure is placed on the environment and human-carnivore conflict increases due to encroachment on existing carnivore populations in rural areas (Linkie et al., 2009).

It is also evident that humans sometimes identify the wrong culprits that contribute to their losses in livelihoods (i.e. killing of livestock and poultry by domestic dogs and cats) and the impact of the diseases and parasites that are carried by some small carnivores are underestimated in this regard (Apps, 2012; Linkie et al., 2009).

2.5 Diversity of small carnivores diets

The functional traits of the expected small carnivores potentially inhabiting the study area (Table 1 & Table 2) can play an important ecological role and determine the tolerance towards these species. For example, small carnivores would be expected to negatively impact rural communities (e.g. poultry predation), but similarly they can provide important ecosystem services through pest predation (Verdade et al., 2011). The expected small carnivores have a diverse diet but most include rodents to some extent (Table 2; Skinner & Chimimba, 2005). Diets of the small- to medium carnivores fluctuate with seasonal change (Van de Ven et al., 2013).

© University of Venda

Table 2: List of small carnivores indicating some of their dietary facts, human tolerance (low is equal to hunted and high is beneficial) with reasons, their activity patterns and socialization.

Common name	Scientific name	% rodents in diet	Carrion (Yes/No)	Human tolerance	Causes for tolerance level	Active (D:Diurnal; N:Nocturnal; C:Crepuscular)	Socialization
CANIDAE							
Black-backed jackal	*Canis mesomelas*	31	Yes	Low	Eat livestock	D & N	Solitary
Cape fox	*Vulpes chama*	54	Yes	Low	Eat livestock	N	Solitary
Bat-eared fox	*Otocyon megalotis*	15	No	High	Eat insect pest	D & N	Group
MUSTELIDAE							
Striped polecat	*Ictonyx striatus*	33	No	Low	Smells bad	N	Solitary
African striped weasel	*Poecilogale albinucha*	80	No	Unknown		N	Solitary
Honey badger	*Mellivora capensis*	30	Yes	Low	Eat bee hives	N	Solitary
FELIDAE							
Caracal	*Caracal caracal*	50	Yes	Low	Eat livestock	N	Solitary
Serval	*Leptailurus serval*	97	No	Low	Eat poultry	N & C	Solitary
Small spotted cat	*Felis nigripes*	76	Yes	Unknown		N	Solitary
African wild cat	*Felis silvestris*	74	Yes	Unknown		N	Solitary
VIVERRIDAE							
Small-spotted genet	*Genetta genetta*	60	Yes	Low	Eat poultry	N	Solitary
Large-spotted genet	*Genetta maculata*	68	No	Low	Eat poultry	N	Solitary
African civet	*Civettictis civetta*	41	Yes	Low	Eat poultry	N	Solitary
HERPESTIDAE							
Water mongoose	*Atilax paludinosus*	26	Yes	Low	Eat poultry	C	Solitary
Slender mongoose	*Galerella sanguinea*	25	Yes	Low	Eat poultry	D	Solitary
Meller's mongoose	*Rhynchogale melleri*	2	No	Unknown		N	Solitary
Yellow mongoose	*Cynictis penicillata*	15	Yes	High	Eat insect pest	D	Group
Selous'e mongoose	*Paracynictis selousi*	-	No	Unknown		N	Solitary
White tailed mongoose	*Ichneumia albicauda*	18	Yes	Low	Eat poultry	N	Solitary
Banded mongoose	*Mungos mungo*	-	Yes	Unknown		D	Group
Dwarf mongoose	*Helogale parvula*	4	No	Low	Eat eggs	D	Group

Bat-eared foxes specializes in termites, but will eat rodents if they are available (Table 2; Skinner & Chimimba, 2005). They contribute to the ecosystem by making burrows from the termite mounds that other animals can use as shelter. The honey badger eats rodents (Table 2; Skinner & Chimimba, 2005), but may specializes in finding and eating honey and bee larvae which makes it a pest to humans although strategies have been implemented to protect the badgers and the bee farmer's bee hives (Apps, 2012). Other specialist hunters, that could be beneficial to humans, are the black-footed cat which eats up to 8 rodents a night (Apps, 2012)

© University of Venda

University of Venda
Creating Future Leaders

and the African striped weasel which catches up to 4 rodents a night (Apps, 2012). The serval is also considered a specialist hunter of rodents because rodents make up 90% of its diet (Bowland & Perrin, 1993), but has been reported and regarded as a pest on poultry farms and heavily prosecuted (Table 2; Holmern & Røskaft, 2014). The caracal, black-backed jackal and Cape fox have been identified as pests to small-livestock farms but are displaced by agriculture and urban development (Table 2).

Some of the small carnivores like the black-backed jackal, white-tailed mongoose and the yellow mongoose eat carrion in varying amounts if available which is an ecosystem service but also makes them susceptible to carcass poisoning (Table 2; Kingdon & Hoffman, 2013).

Most of the small carnivores identified are solitary except for the bat-eared fox, yellow mongoose, dwarf mongoose and banded mongoose (Table 2; Kingdon & Hoffman, 2013). These four species of small carnivores live in family groups and have a diet that includes anything that is available from beetles, termites, crickets and locusts to mice, ground birds and reptiles (opportunistic hunting strategy; Kingdon & Hoffman, 2013).

UNIVERSITY OF VENDA
LIBRARY

With the diverse diets and behaviours associated with these small carnivores, they are more flexible in adapting to the changing landscapes and human presence. Some small carnivores change their activity patterns to adapt to human presence, like the black-backed jackal that is normally both diurnal and nocturnal but when in conflict with humans it becomes completely nocturnal (Holmern & Røskaft, 2014).

2.6 Economic importance of small carnivores: Ecosystem services

Ecosystem services are defined as the benefits to human welfare provided by organisms interacting in ecosystems (Ćirović et al., 2016). As such, different behaviours exhibited by different species may directly benefit human welfare, for example pollination by bees. Similarly, predation by small carnivores can be beneficial to humans when such predation is directed towards rodent crop pests or disease-carrying rodents (Korpimäki & Krebs, 1996).

Small carnivores regulate the prey species (e.g. rodents, insects, reptiles and birds) and their numbers through direct methods like hunting and indirect methods by making prey more alert

© University of Venda

(Miller, et al., 2001; Byrnes et al., 2006) as well as through secondary impacts. These impacts are known as behaviourally-mediated trophic cascades that have been documented in different ecosystems (Van de Ven et al., 2013). By being on the top of the food chain, carnivores prevent prey species from out competing each other for resources (Miller et al., 2001). In doing so carnivores establish ecological boundaries to protect weaker competitors from competitive exclusion (Miller et al., 2001; Van de Ven et al., 2013). The presence of small carnivores also indirectly alters movements of seed distributors (e.g. birds and smaller mammals) and thereby facilitates seed distribution (Miller et al., 2001). Some of the small carnivores are seed dispersers by eating fruits (e.g. the African civet, white-tailed mongoose, and slender mongoose) and other small carnivores disperse seeds through their fur. Another ecosystem service is the removal of carrion as previously mentioned (Ćirović et al., 2016).

© University of Venda

CHAPTER THREE: ECOLOGICAL SETTING OF THE STUDY AREAS

3.1 Location of the study areas

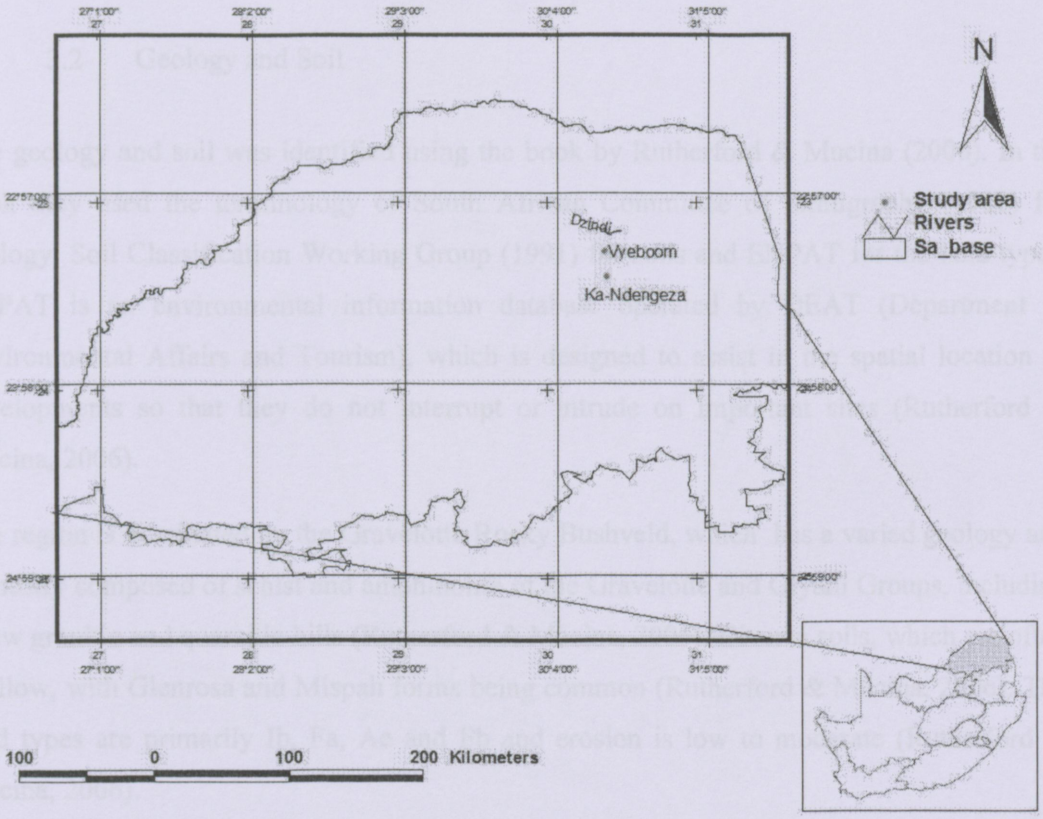


Figure 1: Map of Limpopo Province in South Africa showing study sites Vyeboom and Ka-Ndengeza.

The Limpopo Region (Figure 1) is dominated by the Savannah biome (Rutherford & Mucina, 2006) and this biome covers 32.8% of South Africa. The macroclimatic characteristics of a savannah biome comprise of alternating of wet, humid and hot summer and dry frost-free

© University of Venda

winter months, as well as low to no incidences of frost (Rutherford & Mucina, 2006). Altitudes of savannah in South Africa are mostly lower than 1500 m and this contributes to the temperate climate of this biome (Rutherford & Mucina, 2006). In October to March (warm and wet season) the temperatures are between 16°C between 30°C and during the cold and dry season (May to August) the temperatures are between 9°C between 25°C (Rutherford & Mucina, 2006).

3.2 Geology and Soil

The geology and soil was identified using the book by Rutherford & Mucina (2006). In the book they used the terminology of South African Committee of Stratigraphy (1980) for geology, Soil Classification Working Group (1991) for soils and ENPAT for the land types. ENPAT is an environmental information database operated by DEAT (Department of Environmental Affairs and Tourism), which is designed to assist in the spatial location of developments so that they do not interrupt or intrude on important sites (Rutherford & Mucina, 2006).

The region is dominated by the Gravelotte Rocky Bushveld, which has a varied geology and is mostly composed of schist and amphibolite of the Gravelotte and Giyani Groups, including a few granitic and quarzitic hills (Rutherford & Mucina, 2006). Diverse soils, which are often shallow, with Glenrosa and Mispah forms being common (Rutherford & Mucina, 2006). The land types are primarily Ib, Fa, Ae and Fb and erosion is low to moderate (Rutherford & Mucina, 2006).

Furthermore, the Granite Lowveld is composed of the Swazian Goudplaats Gneiss, Makhutswi Gneiss and Nelspruit Suite (granite gneiss and magmatite) from the north to the south (Rutherford & Mucina, 2006). The younger Mpuluzi Granite (Randian), further south, form the most important basement geology of the area (Rutherford & Mucina, 2006). The sandy soil in the high ground is formed by weathered Archaean granite and gneiss and clay soils in the lowlands are high in sodium content (Rutherford & Mucina, 2006).

© University of Venda

University of Venda
Creating Future Leaders

3.3 Climate

The Gravelotte Rocky Bushveld and Granite lowveld both have summer rainfall with dry winters (Rutherford & Mucina, 2006). The mean annual precipitation is 500 mm in the eastern parts to 900 mm in the western parts, but the rainfall is higher on the higher mountains with frost being uncommon (Rutherford & Mucina, 2006).

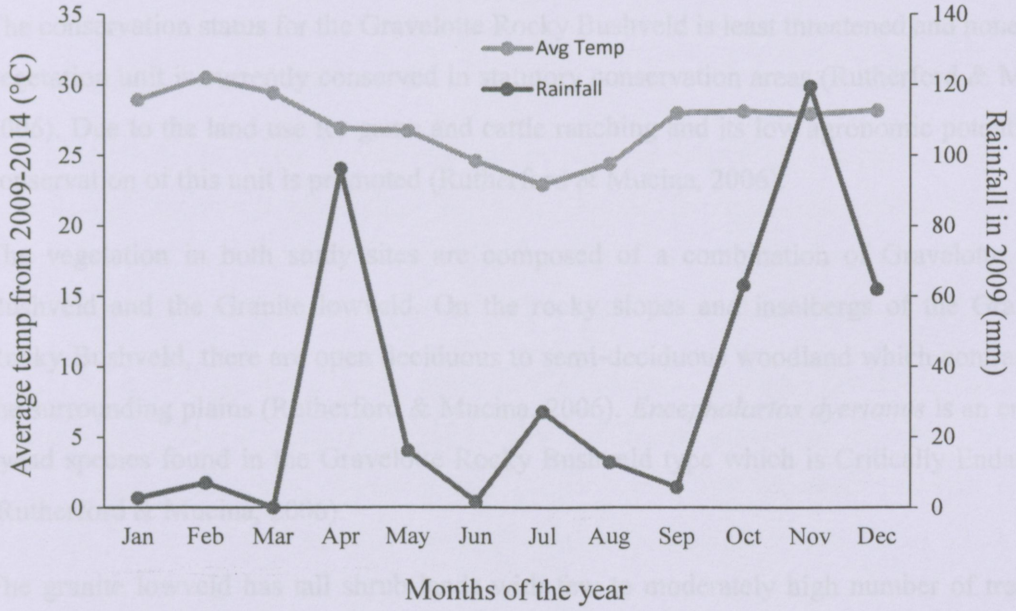


Figure 2: Monthly mean temperatures in Degrees Celsius (°C) for 2009–2014 and the rainfall per month in millimeters of 2009 as measured by the Levubu Weather Station.

In the summer months (October-March) in 1950–1999 the temperatures averaged 25 °C and year-round sunshine in Limpopo (Tshiala et al., 2011). The data plotted in Figure 2 are from the Levubu Weather Station which is the closest weather station to the study sites. The

© University of Venda

University of Venda
Creating Future Leaders

coldest months in the Levubu area were June to August with a temperature of 15 ºC, this falls in the general normal temperature average for the area (Tshiala et al., 2011).

3.4 Vegetation

The distribution of the Gravelotte Rocky Bushveld is the Murchison Range (a well-known hill in the Limpopo Province) in the Gravelotte area which includes surrounding hills and mountains including Ga-Mashishimale north of Seribana and Mica (Figure 3 & 4; Rutherford & Mucina, 2006). The Gravelotte Rocky Bushveld extends north towards Thohoyandou as isolated hills including Mangombe and Sionwe and the altitudes of the mountains and hills vary between 450–950 m (Figure 3 & 4; Rutherford & Mucina, 2006).

The conservation status for the Gravelotte Rocky Bushveld is least threatened and none of the vegetation unit is currently conserved in statutory conservation areas (Rutherford & Mucina, 2006). Due to the land use for game and cattle ranching and its low agronomic potential, the conservation of this unit is promoted (Rutherford & Mucina, 2006).

UNIVERSITY OF VENDA
LIBRARY

The vegetation in both study sites are composed of a combination of Gravelotte Rocky Bushveld and the Granite lowveld. On the rocky slopes and inselbergs of the Gravelotte Rocky Bushveld, there are open deciduous to semi-deciduous woodland which contrast with the surrounding plains (Rutherford & Mucina, 2006). *Encephalartos dyerianus* is an endemic cycad species found in the Gravelotte Rocky Bushveld type which is Critically Endangered (Rutherford & Mucina, 2006).

The granite lowveld has tall shrub lands with few to moderately high number of trees that form a dense low woodland on the deep sandy highlands (Rutherford & Mucina, 2006). The species of plants on the highlands are *Terminalia sericea, Combretum zeyheri and C. apiculatum* and ground layer including *Pogonarthria squarrosa, Tricholaena monachne* and *Eragrostis rigidior* (Rutherford & Mucina, 2006). In the lowlands, the vegetation vary between dense thicket to open savanna with a woody layer composed of plant species such as *Senegalia* (*Acacia*) *nigrescens, Dichrostachys cinerea* and *Grewia bicolor* (Rutherford & Mucina, 2006). The dominant *Digitaria eriantha, Panicum maximum* and *Aristida congesta* are found in the dense herbaceous layer on fine–textured soils (Rutherford & Mucina, 2006).

© University of Venda

Brackish lowlands have *Sporobolus nitens, Urochloa mosambicensis* and *Chloris virgate* in the herbaceous layer (Rutherford & Mucina, 2006).

3.5 Land-use in Vhembe Municipality

The Granite lowveld has a conservation status of vulnerable. About 17% is statutorily conserved in Kruger National Park. The Selati, Klaserie, Timbavati, Mala Mala, Sabi-Sand and Manyeleti Reserves collectively conserve about the same area as Kruger Park (Rutherford & Mucina, 2006). It is found that more than 20% is already transformed by mainly cultivation and settlement development (Rutherford & Mucina, 2006). The Gravelotte Rocky Bushveld is about 15% transformed by development of settlements and cultivation (Rutherford & Mucina, 2006).

The smallholder farms are generally found in old homeland areas for example the Venda homeland (Odhiambo & Magandini, 2008). Smallholder farming is categorized by low level production and small farm sizes of approximately 1.5 ha and production is basically for subsistence with little marketable surplus (Odhiambo & Magandini, 2008).

Maize is the primary cereal grain although the district is prone to dry and drought agro-ecology (Odhiambo & Magandini, 2008). The smallholder farmers grow leguminous crops which include groundnuts, Bambara nuts and cow pea, and vegetable crops of spinach, tomatoes, onions and cabbage (Odhiambo & Magandini, 2008).

3.6 Study sites

3.6.1 Vyeboom

General geographical coordinates of Vyeboom (Figure 3) are S 23.14407°, E 30.37657° and the study site is situated at an altitude of ±611 m above sea-level (asl). The settlement is located approximately 4 km from Vuwani (closest town) and is in the Makhado municipality. Vyeboom has an extrapolated mean annual precipitation of ±791 mm (Hijmans et al., 2005).

© University of Venda

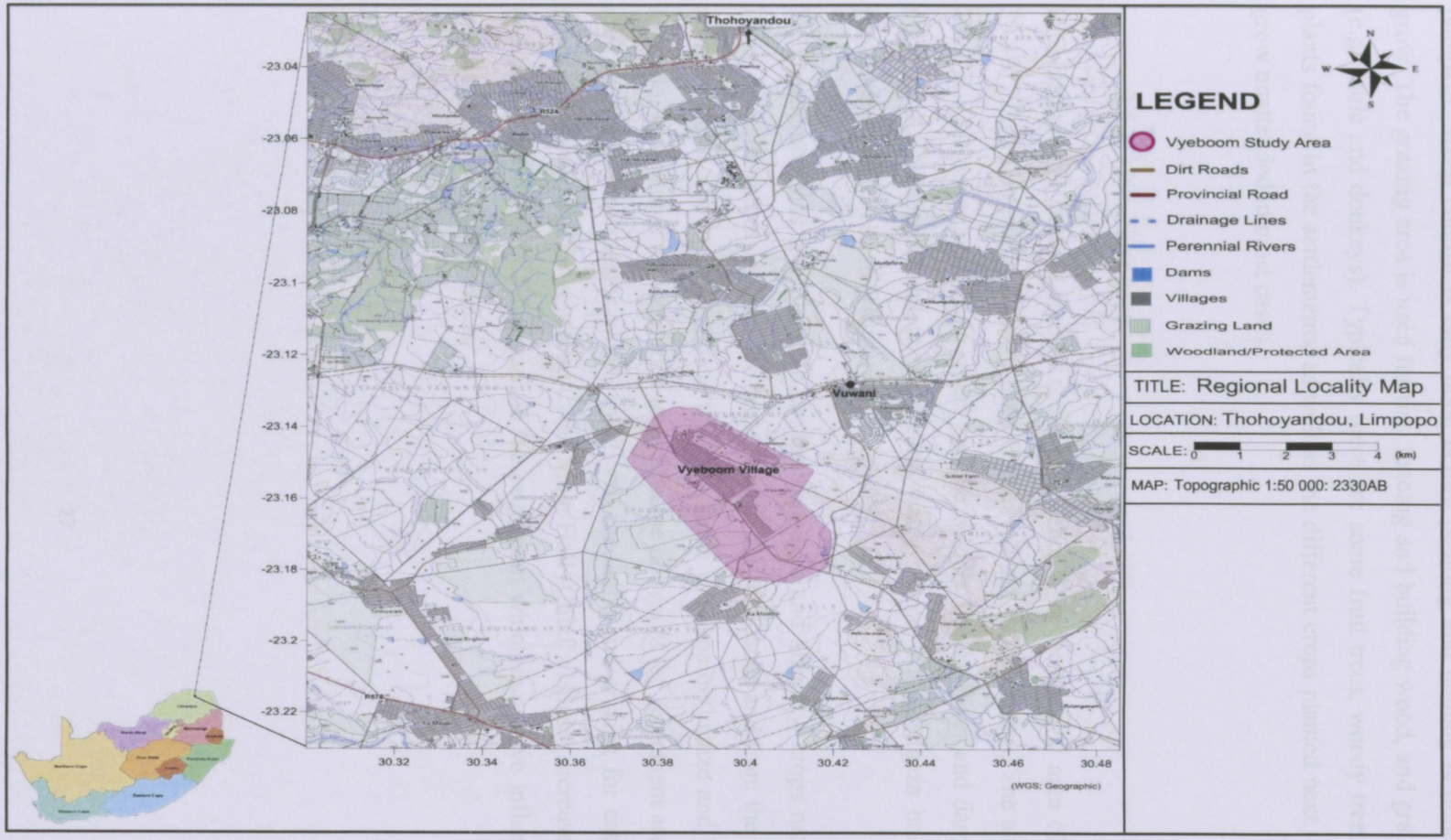


Figure 3: Regional locality map of Vyeboom in the Limpopo Province.

© University of Venda

In the Vyeboom study site, there is variation in plant diversity between crop lands, abandoned crop lands and grazing areas. Crops planted are a mixture of maize, beans, watermelon and pumpkin. Weed control is only done before planting and nothing is done after the plants grow. The grazing area is used for fire, fencing and building wood, and grazing for livestock (e.g. cattle and donkeys). Typically there are some fruit trees, woody trees and herbaceous plants found in the settlements, as well as the different crops planted next to the houses that grow unattended in most cases.

3.6.2 Ka–Ndengeza

Ka-Ndengeza is situated further south of Vyeboom in the general area of S 23.30389°, E 30.40779°, which is 30 km away from Giyani (closest urban center). The altitude above sea-level at Ka-Ndengeza is ±546 m asl and the Middle Letaba River and dam are 2 km to the north of Ka-Ndengeza and is the closest water source. Ka-Ndengeza has a mean annual precipitation of ±718mm (Hijmans et al., 2005).

This settlement has few plants in the housing area and also few crops next to the houses. Plant diversity increases from the settlement to the crop lands and from the crop lands to the grazing areas. The crops found on the crop lands were mainly maize and beans with some avocado, macadamia and tangerine trees at some houses in the settlement area. In the grazing area the trees are used for wood, traditional medicine and grazing for cattle, donkeys and goats. Construction of a new road to the Main Hall (Chief's House) increased the noise level and blocked off some of the roads in the settlement which may have influenced the normal roaming pattern of the animals.

© University of Venda

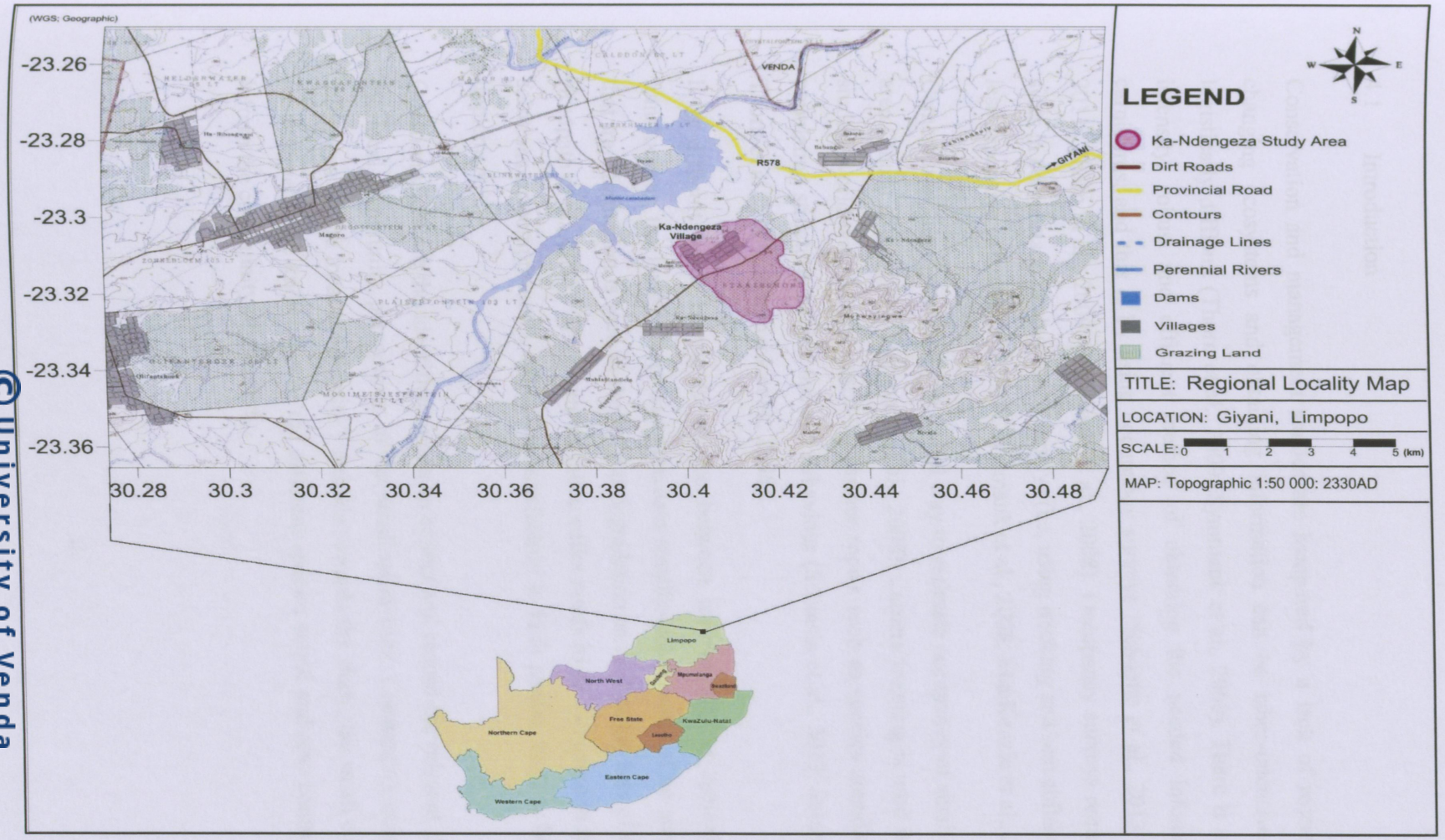


Figure 4: Regional locality map of Ka-Ndengeza village in the Limpopo Province.

© University of Venda

University of Venda
Creating Future Leaders

4.1 Introduction

Conservation and management studies are hampered by a lack of recent information on changing ecosystems and obtaining information can be labor-intensive, expensive and logistically difficult (Thorn et al., 2009; Symmank et al., 2008). There is a potentially low–intensity, robust and efficient method of obtaining the needed information, on small carnivores, and this is by using occupancy surveys (Schuette et al., 2013; Sarmento et al., 2011; Thorn et al., 2009; Symmank et al., 2008). Occupancy surveys require lower sample sizes in comparison to abundance surveys (i.e. using tracking and scat collection) and are thus less expensive (Thorn et al., 2009; Symmank et al., 2008; MacKenzie et al., 2002).

Camera trapping is regarded as a useful way to estimate occupancy of small carnivores in the area (Thorn et al., 2009; Symmank et al., 2008). Camera trapping is used in many carnivore studies world-wide, that focused on various topics such as species abundance, distribution, population structure, habitat use and behaviour (Schuette et al., 2013; Sarmento et al., 2011; Thorn et al., 2009; Symmank et al., 2008).

It is difficult when having to choose between maintaining the natural ecosystem and transforming the landscape to accommodate smallholder farmers of an area. The impact of that transformation is seen in the habitat degradation as well as the loss of native animal life (Redpath et al., 2015). The extent of this conflict needs to be estimated in the areas and then solutions or compromises, which are satisfactory to both parties, need to be formulated and implemented.

Questionnaires are the identified means to collect and record the relevant information about the local community perceptions of the small carnivores. Community questionnaires could inform us on the local community's attitude towards the study, the small carnivore presence (if observed), the knowledge of the different species found and also contribute as a way to inform the community of our study.

© University of Venda

University of Venda
Creating Future Leaders

4.2 Methods

4.2.1 Camera trapping and deployment of camera traps

Camera trapping was done in three different land use types in the two different settlements. The two settlements, Vyeboom and Ka-Ndengeza, were divided using aerial photography with a Geographic Information System (GIS) into a crop lands, settlement and grazing/least disturbed area (Figure 5 & 6). A 300 m × 300 m block grid (90000 m^2 = 9 ha) was overlaid onto aerial photographs and then the crop lands, settlement and grazing areas were marked and numbered. The size of the block grid was estimated based on the home range estimates of most of the small carnivores, derived from literature reviewed (see Table 1). The home ranges were used to adhere to the assumptions of an occupancy survey where each station must be independent (MacKenzie & Royle; 2005). For nine days the cameras were set up in 30 of the 300 m x 300 m blocks in the grid as was determined by MacKenzie & Royle (2005). The aim was 90 camera traps for each settlement (Vyeboom & Ka-Ndengeza), which is 30 per identified land use (settlement, cropping and grazing).

Black flash cameras (Cuddeback, Ambush 1194, Game Cameras) were used in the settlements. This was done in order to lower the impact of the study on the settlement inhabitants. White flash cameras (Cuddeback, Ambush 1170, Game Camera) were used in the grazing and crops areas. The white flash increased photo quality which helped to correctly identify animals. SanDisk SDHC Card with a size of 8GB were used.

The black flash cameras were baited to improve the quality of the images. The animals would stop to smell the bait and hold still for a photo. Sardines in oil have been successfully used in camera trapping (Gerber et al., 2012). Wooden blocks dipped in the oil and sardines were placed 2-3 m away from the camera and held in place by an iron rod of 30 cm. The white flash cameras were not baited as the photographic quality was good even when the animals were moving past.

A Python cable lock (Master lock 8419DPF) was used to lock the boxes containing the cameras to a tree near a pathway with wildlife tracks. The camera needs a clear view of the path and if the path has tracks it is assumed that it is used by the animals. Camera trapping

© University of Venda

University of Venda
Creating Future Leaders

was started at Ka-Ndengeza (June 2014) with 9 days per 3 land use types and then moved to Vyeboom in July 2014, which we also had 9 days per 3 land use types.

Camera Base (Tobler, 2007), a camera trapping program, was used to catalogue the different species captured by the camera trapping stations for each of the land uses. For further analysis the photo data were exported to Excel for basic statistical analysis. In Excel the number of different small carnivores species captured in the nine days was determined and also which species was found the most by determining the number of photos per species.

© University of Venda

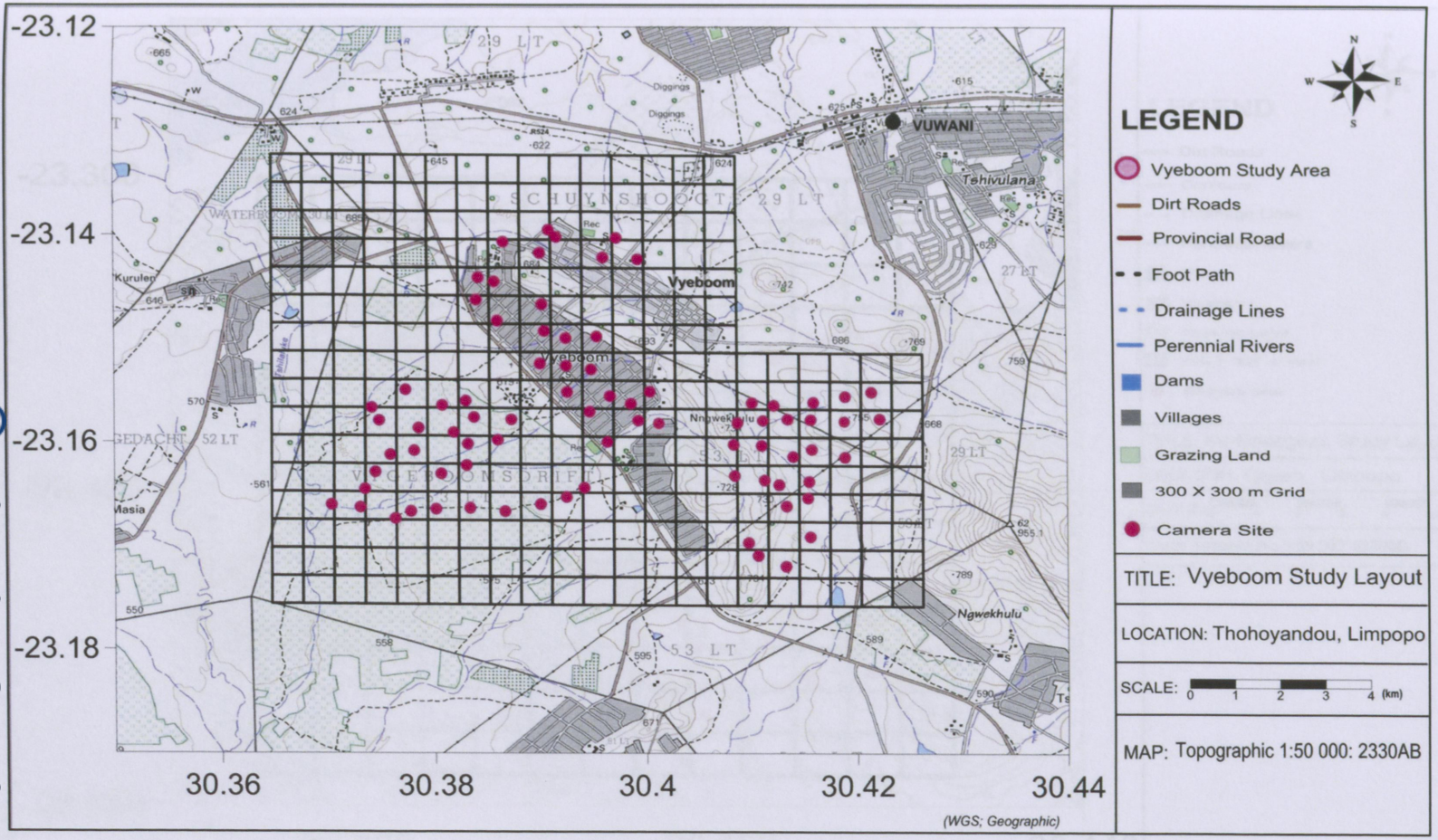


Figure 5: Grid layout (300 m x 300 m) overlaid on study site to deploy camera traps (red dots) in the Vyeboom study site across the three land use types.

© University of Venda

University of Venda
Creating Future Leaders

4.2.2 Community questionnaire

The attitude of local community members towards small carnivores was assessed by using a structured questionnaire (see Appendix B). The impact of the small carnivores on people's livelihoods and vice versa were determined form a smallholder farmer's perspective through a questionnaires (Appendix I). The questionnaire also collected information on ownership of domestic cats and/or dogs, as well as number of livestock and poultry.

After the necessary ethics approval was received from the Ethics Committee of University of Venda (approval number SMNS/14/ZOO/03/2803), the village chiefs of the two settlements were asked for permission to conduct the study there. With the Chief's approval received the smallholder farmers were approached and asked if they would be involved in the research questionnaire.

People in some of the grid blocks were given questionnaires to answer by themselves. It was to be answered individually and a picture guide of the small carnivores (Appendix A) aided in bridging the language gap. See attached Appendix B for an example of the questionnaire.

The answers to the questions were divided into categorical variables of 1 if "Yes", 2 if "Unsure" and 0 if "No" was selected. The variables included were: (1) negative and positive impact of identified small carnivores, (2) killing of small carnivores, (3) the number of livestock and poultry owned, (4) the loss of poultry to small carnivores and (5) the feeding of domestic small carnivores and number owned.

4.3 Data analysis

Occupancy is defined as the overall proportion of an area that is occupied by a given species (Schuette et al., 2013; Sarmento et al., 2011; Thorn et al., 2009). However, occupancy probability is strongly affected by the detection probability which can be defined as the probability of a species being detected at the site (i) at a certain time (t) given it is present (Symmank et al., 2008). In essence occupancy models use presence/absence accounts to effectively deal with 'false absences' and temporal or spatial differences in detection probability (Thorn et al., 2009; MacKenzie et al., 2002). Occupancy data can be used to make strong interpretations about several variables such as distribution, population size, resource

LIBRARY
© University of Venda

University of Venda
Creating Future Leaders

selection and species interaction (Thorn et al., 2009; MacKenzie et al., 2002). For each camera-trap site there was a series of detections and non-detections (MacKenzie et al., 2003) which form a detection history (Xi). These detections can be attributed to different factors that are present (e.g. water, vegetation cover and food) or absent (e.g. humans, livestock, other carnivores, and domestic (or feral) cats or dogs) from the camera-trap site (MacKenzie et al., 2003). These factors are referred to as covariates and are used to formulate the occupancy model (MacKenzie et al., 2003).

4.3.1 Predictor variables

We expected small carnivore occupancy and diversity to be affected by various human associated and environmental variables. These three themes were namely HABITAT, FOOD and COMPETITION (Table 3). All the recorded covariates were classified under one or more of these themes.

The habitat considerations of small carnivores are species dependant, but general considerations of the ideal habitat for the expected small carnivore species were grouped under the theme of HABITAT (Table 3). This includes the human activities in the area (general land use), such as housing (Settlement), agricultural practices (Cropping) and livestock grazing (Grazing). These covariates were taken as the distance, in a straight line, to the nearest border of each land use (Table 3) for each camera trapping station.

The dog abundance and human abundance were determined by frequency of photos taken at each camera trapping station (Table 3) and were grouped together under the theme of COMPETITION. Dogs are usually kept as pets and follow their owners to the field or help herd the livestock or used to hunt, (observed while conducting study). Some small carnivores are hunted for their skin and bones as clothing and medicine (Table 2; Apps, 2012). The dogs were also included in the study as they also contribute to the Competition, t - for resource overlap with the small carnivores This can be broadened to domestic cats which are kept as pest control in the settlement area, but cats roam further than the individual house/s of the owner/s and were identified as a threat to the wild fauna (Dickman, 1996) and thus cats were also added as a Competition covariate. Livestock trample vegetation and damage burrows of the small carnivores, decreasing vegetation cover (Blaum et al., 2007a). This impact of the livestock was also categorized as Competition.

© University of Venda

University of Venda
Creating Future Leaders

Some small carnivores were classified as pests as they are reported to kill poultry while others are known for killing livestock (see Table 2 & Table 3; Apps, 2012). Because poultry maybe a source of food for the small carnivores it was added to the theme of FOOD. As such, the relative abundance of poultry may either negatively (through retaliatory killing) or positively (as a food source) affect small carnivore occupancy or habitat use (see Table 3). Rodents, which are prey to the small carnivores, are drawn to the food resources of the crops (Aplin et al., 2003). This is why crops are seen as an area where food is abundant for small carnivores and thus placed under the theme of FOOD. Another resource to consider is water which may play a bigger role in territory selection than vegetation cover (Stuart & Stuart, 2006) for some small carnivores. It was measured as the distance to closest water source which could be drainage lines, dams and water taps of the village. This variable wasn't used in the modelling of occupancy. This was because there was too much uncertainty about where all the water resources were that the animals might be using.

4.3.2 Deriving GIS based environmental variables

For GIS created variables we first digitized the different land use types (cropping, grazing and settlement). We used a Spot 5 2.5 satellite image (taken from August 2005 to June 2006; AIRBUS Intelligence, 2017) and digitized each crop field, the grazing area and the settlements (Sarmento et al., 2010). We classified crops lands as active and abandoned fields that still showed agricultural activity. The distance from the camera trap coordinates to the closest border of each land use was identified using X-Tools and geoprocessing extensions in QGIS. The calculated covariates were used to create candidate models for occupancy estimations (Sarmento et al., 2010). Distance to each digitized land use was used to indicate the influence land use has on occupancy of the small carnivores.

The distance to the nearest settlement border was used, as well as the relative abundance of humans, to indicate human disturbance (Table 3; competition). The distance to the nearest border of the crops in meters was used as cropping (Table 3; food). Poultry photo frequency was also used and named frequency poultry (Table 3; food).

© University of Venda

Table 3: Covariates used in calculating the occupancy estimates of the small carnivores were divided into three broad themes namely habitat, food and competition.

Covariates	Abbreviation	Description	Target species
		Theme 1: Habitat	
Grain and vegetable patches	Cropping	Combination of different crops cultivated by community members; taken as a straight line distance form each camera trap to the nearest crop field (in meters).	Large-spotted genet and Slender mongoose
Grazing fields	Grazing	Communal land-used as livestock grazing; taken as a straight line distance form each camera trap to the nearest edge of a grazing field (in meters).	Large-spotted genet and Slender mongoose
Settlement	Settlement	Urban housing; taken as a straight line distance form each camera trap to the nearest edge of a settlement area (in meters).	Large-spotted genet and Slender mongoose
		Theme 2: Food	
Grain and vegetable patches	Cropping	Combination of different crops cultivated by community members; taken as a straight line distance form each camera trap to the nearest crop field (in meters). Rodents/Insects normally associated with crops which can act as food source.	Large-spotted genet and Slender mongoose
Poultry	FreqPoultry	Number of poultry captures per 100 trap days	Large-spotted genet and Slender mongoose
		Theme 3: Competition	
Human abundance	FreqHumans	Number of human captures per 100 trap days	Large-spotted genet and Slender mongoose
Domestic dog abundance	FreqDog	Number of domestic dog captures per 100 trap days	Large-spotted genet and Slender mongoose
Domestic cat abundance	FreqCat	Number of domestic cat captures per 100 trap days	Large-spotted genet and Slender mongoose
Livestock abundance	FreqLivestock	Number of domestic livestock captures per 100 trap days; Livestock trample burrows and decrease vegetation cover (Blaum et al., 2007)	Large-spotted genet and Slender mongoose

© University of Venda

University of Venda
Creating Future Leaders

4.3.3 Occupancy modelling

We used a maximum likelihood based occupancy model to investigate the effect of our selected predicator variables on small carnivore occupancy and detection probabilities (Sarmento et al., 2010; MacKenzie et al., 2002). We used a single season occupancy modelling and the detection histories of the targeted species were constructed for each camera-trap site over a 9-day consecutive period with each day becoming a sampling occasion (Sarmento et al., 2010).

Each camera-trap site had covariates associated with habitat, food resource and competition allocated in accordance with Table 3. The covariates were identified from literature of each species to develop the predictor covariates that are related to a species ecological requirements (Sarmento et al., 2010; Skinner & Chimimba, 2005; Apps, 2012). Occupancy modelling was done with R statistical software, using the 'unmarked' package (Fiske & Chandler, 2011), while 'ggplot2' (Wickham, 2009) was used to plot predicted responses.

We used a two-step approach to analyse the data (Sarmento et al., 2010). In step 1 we investigated the effect of land use on small carnivore detection probabilities. Most studies have shown that land use change has an impact on the small carnivores (Thorn et al., 2009; Ripple et al., 2014; Brook et al., 2012; Ćirović et al., 2016). In these models we kept occupancy probabilities constant (e.g. ψ [.]p [land use variable]). This was done to determine the effect habitat has on detection probabilities without varying occupancy probability. We constructed a set of candidate models for each of the small carnivore species with adequate sample sizes (Sarmento et al., 2010).

In the second step we used the best-fitting detection model and we then varied covariates affecting occupancy in each of the themes, either individually or in combination (Table 3) (Sarmento et al., 2010). We started by testing HABITAT covariates (theme 1), and retained the most important variables. We repeated the process for FOOD and COMPETITION themes. From these steps we retained the most parsimonious set of variables in each theme which was then combined to construct the most parsimonious model which was used for final model inference. This nested model selection approach was used to avoid the large number of candidate models associated with many independent predictor variables. Finally we created a null model where both occupancy and detection probability were held constant (Sarmento et al., 2010). We used Akaike information criterion (further referred to as AIC) to rank models

© University of Venda

University of Venda
Creating Future Leaders

and to retain important variables. We regarded models with a ΔAICc <2 as having equal support and the variables in these models were retained for final model fitting (e.g. in each theme) (Sarmento et al., 2010). We furthermore used Akaike's weights (ω) to interpret the relative importance of each variable in the theme specific models (Sarmento et al., 2010). Akaike's weights is the weight of evidence in favour of a model being the best approximating model given a set of variables (Burnham & Anderson, 2002). Unless a model had a weight >0.9 all other theme specific models were considered. We also calculated the relative importance of theme specific variables by summing the normalised values of ω for each model that contained that variable (Burnham & Anderson, 2002). The "importance" function of the "AICcmodavg" (Mazerolle, 2016) package was used to calculate importance of variables.

The one value indicates the collective weights of all the models with the covariate (ω+) and the other indicates the collective weights of all the models without the covariate (ω-). If the value of the models with the covariate was equal to, or above, 0.5 (≥ 0.5) it was identified as having a strong influence on the occupancy of the selected species. The relative importance of each covariate was calculated by adding the weights (ω) of every model containing that covariate (Sarmento et al., 2010).

UNIVERSITY OF VENDA
LIBRARY

4.3.5 Predicted maps

The averaged site occupancy estimates of the final selected models were used to produce occupancy maps by interpolating the data using the inverse distance weighted interpolation (I.W.D.; Sarmento et al., 2010). It is assumed that the interpolating surface is likely influenced by nearby points, more than distant points, which is a key assumption of this I.W.D. method (Sarmento et al., 2010). The map will thus show a colour scale of high occupancy estimates to low occupancy estimates. GRASS GIS software was used for the maps after the occupancy interpolation was done in R (Neteler et al., 2012).

4.3.6 Species richness estimation

Estimates of species diversity and richness are essential to ecology and are frequently used in conservation planning (Iknayan et al., 2013; Gotelli & Colwell, 2011). Commonly used

© University of Venda

University of Venda
Creating Future Leaders

diversity metrics account for undetected species mainly by regulating the sampling effort (Iknayan et al., 2013; Gotelli & Colwell, 2011). This is important since the probability of detecting an individual can differ among species, observers, survey methods, and sites (Iknayan et al., 2013; Gotelli & Colwell, 2011).

Estimating species richness can use two types of data: 1) incidence data, in which a species detected is simply noted as being present, and 2) abundance data, in which the abundance of each species within each sample is added together (Gotelli & Colwell, 2011). Of course, abundance data can always be converted to incidence data, but not the reverse (Gotelli & Colwel, 2011).

Species accumulation curves are focused on the accumulation rates of new species of the sampled land use and they are species identity-dependent (Ugland et al., 2003; Figure 3). Thus as more individuals are sampled (x-axes: number of individuals), the total number of species recorded (y-axes: cumulative number of species recorded) increases and a (sample based) species accumulation curve is created (Gotelli & Colwell, 2011). The more species in the land use, the more even the species abundance distribution and the more rapidly this curve will rise (Gotelli & Colwell, 2011). In contrast, if the species abundance distribution is very uneven (a few common species and many rare ones, for example), the curve will rise slowly, even at the start (Gotelli & Colwell, 2011). This is because most of the individuals sampled will represent more common species that have already been added to the sample, rather than rarer ones that have not yet to be detected (Gotelli & Colwell, 2011).

It is also found that measures reported as 'species richness' are effectively measures of species density: the number of species collected in a particular total area (Gotelli & Colwell, 2011). For quadrat samples or other methods that sample a fixed area, species density is expressed in units of species per specified area or, in the case of this study, land use and is the ratio of richness to area (Gotelli & Colwell, 2011).

Sample-based rarefaction calculates the expected number of species $s*$ when $m*$ samples ($1 \leq m* \leq M$) are drawn at random (without replacement) from a set of samples that are representative of an accumulation (Gotelli & Colwell, 2011; Colwell et al., 2004). The sample-based rarefaction preserves the spatial structure of the data (Gotelli & Colwell, 2011). For sample-based rarefaction, $E(s*|m*)$ is the expected number of species for $m*$ pooled samples that express the same patterns as the observed set of samples (Gotelli & Colwell,

© University of Venda

University of Venda
Creating Future Leaders

2011). For these reasons, sample-based rarefaction is a more realistic treatment of the independent sampling elements used in most biodiversity studies, than individual-based rarefaction (Gotelli & Colwell, 2011). Because sample-based rarefaction requires only incidence data, it can also be used for clonal organisms or for species in which individuals in a sample cannot be easily distinguished or counted (Gotelli & Colwell, 2011).

Estimate-S (Colwell, 2013) was used to calculate the diversity and a rarefaction curve was created from the Chao-2 estimator values, as well as a species accumulation curve from the Coleman rarefaction values. In Estimate-S, an all-inclusive series of both classic and bias-corrected forms of the richness estimators (Chao-1, Chao-2, ACE, ICE and Jack1) are calculated (Colwell, 2013). This includes a log-linear 95% confidence interval (Colwell, 2013). The rarefaction curves (one for each land use at each settlement) that were created from the Chao-2 values were used to determine the amount of days necessary to include all the species present. Computed Coleman rarefaction curves for sample-based abundance data are curves that estimate the number of species in samples, with the assumption that all individuals in all samples are randomly mixed (Colwell, 2013).

Rarefaction curves are the asymptotic richness estimators when calculating the true species richness of the assemblage that a reference sample represents (Colwell, 2013). Whereas the Chao-1, Chao-2, ACE, ICE or Jack1 estimators (from EstimateS output file), for example, estimate total species richness, including species not present in any one of the samples (Colwell, 2013).

Rarefaction curves estimate species richness for a sub-sample of the pooled total species richness, based on an empirical reference sample which is a smaller piece of a whole (Colwell, 2013). It is necessary to note that richness is computed by using analysis and logical reasoning (Colwell, 2013). Whereas Shannon and Simpson diversities are computed by resampling, which estimate the precision of sample statistics by using subsets of available data (Colwell, 2013). The Shannon diversity index is defined as an index that is commonly used to characterize species diversity in a community (Rosenzweig, 1995). Simpson's diversity index is a measure of diversity like the Shannon index and is used in ecology to quantify the biodiversity of a habitat (Rosenzweig, 1995). The Shannon and Simpson's indexes, both account for the number of species, the abundance and evenness of the species present (Rosenzweig, 1995).

© University of Venda

University of Venda
Creating Future Leaders

The Chao value is a non-parametric estimator for species richness that is used by Colwell (2013) in EstimateS. To calculate the Chao estimator values require 1) the number of species observed (Sobs), 2) the number of species observed once (a) and 3) the number of species observed twice (b) put together in the following formula:

$$S*1 = Sobs + (2a/2b).$$

The Chao-1 estimator was used when on a single collection of samples (Colwell & Coddington, 1994), whereas the Chao-2 estimator was used for several collections. In Chao-2 the formula changed 2a and 2b from "observed once (a)/twice (b)" to "observed in one (a)/two (b) collections" (Colwell, 2013). With both Chao-1 and Chao-2 the standard deviation is computed using the following formula (Colwell, 2013):

$$SD = b [4(a / (4b)) + 3(a/b) + 2(a / (2b))]$$

To use rarefaction to compare species richness of two (or more) samples or accumulations the following assumptions should be met:

1. Sufficient sampling: When using sample-based rarefaction it is preferred to use 20 samples or more (Gotelli & Colwell, 2011).

2. Comparable sampling methods: Rarefaction can't compare sample that used different methods of sampling, however it can compare between different sampling method effectiveness in the same area (Gotelli & Colwell, 2011). Thus identical sampling and pooling procedures must to be used to compare two composite groups (Gotelli & Colwell, 2011).

3. Taxonomic similarity: The accumulations represented by the two samples should be taxonomically 'similar' (Gotelli & Colwell, 2011). To test directly for differences in species composition there are powerful methods now available (Gotelli & Colwell, 2011).

4. Closed communities of discrete individuals. The accumulations being sampled should have consistent membership which is that species presence in multiple samples must be detectable (Gotelli & Colwell, 2011).

5. Random placement: Employing sampling areas that are large enough to overcome small-scale aggregation (Gotelli & Colwell, 2011).

© University of Venda

University of Venda
Creating Future Leaders

6. Independent and random sampling: Samples should be collected randomly and independently (Gotelli & Colwell, 2011). The sample-based method assumes that sampling, from nature, does not affect the relative abundance of species (Gotelli & Colwell, 2011).

A comparison of the different methods of species richness will be done to identify the best method for presenting the results found in the study as reference for future studies and also the illustrate the differences in the information available from the graphs after plotting the results calculated.

4.3.7 Questionnaire analysis

The questionnaire was divided into two parts for analysis, small carnivore questions and domestic animal questions. The small carnivore questions pertain to the specific species of carnivore and the domestic animal questions are more focused on the animals owned by the community members. The number of animals owned and lost to predation were also included to relate later with the reported tolerance to small carnivores. The questionnaire also included avian predators that were grouped in to four categories as species specific identification of avian predators by the community members were not always possible. The categories of avian predators were crow (referred to as black and white), owl (identified as active at night), eagle (large predator bird, about the same size as a crow) and falcon (small predator bird).

The small carnivore section addressed firstly identification (seen) of the small carnivore and then an estimation of how often the small carnivore was seen (often). The species specific identification of the mongoose species by most of the respondents was uncertain. The study also assessed the basic knowledge of the small carnivores by asking about the small carnivore's eating habits (kill poultry) which in turn classified the small carnivores into negative or positive.

The questionnaire section of domestic animals was analyzed separately for each settlement. The Pearson's chi-squared test was used to assess differences, if any, in the frequencies of questionnaire responses between the two villages for the interviewed community members. Thus the Pearson' chi-squared test tested if the data from Ka-Ndengeza and Vyeboom were independent of each other with regards to the people seeing a certain small carnivore and also the frequency of sightings.

© University of Venda

5.1 Summary of camera trapping results

5.1.1 General results

Ka-Ndengeza had the most photos taken but had the lowest small carnivore richness per land use and overall (Table 4; Figure 3). In the settlement land use of Ka-Ndengeza only *Canis lupus familiaris* and *Felis catus* were recorded (Table 5), while crops had the highest carnivore species richness (Table 4; Figure 3). In the crops the following carnivore species were detected: *Canis lupus familiaris, Genetta maculata, Galerella sanguinea, Paracynictis selousi, Helogale parvula, Ichneumia albicauda* and *Rhynchogale melleri* (Table 5).

The Vyeboom settlement has the highest small carnivore species richness, overall and in each land use (Table 4; Figure 3). The settlement at Vyeboom had *Canis lupus familiaris*, *Felis catus*, *Genetta maculata*, *Ichneumia albicauda and Helogale parvula* (Table 5). In the grazing areas of Vyeboom there was the same species not including *Felis catus*, but *Galerella sanguinea* and *Mellivora capensis.* In the crops areas of Vyeboom there were the same species as in the settlement with the addition of *Galerella sanguinea, Paracynictis selousi*, *Ictonyx striatus* and *Civettictis civetta* (Table 5).

© University of Venda

University of Venda
Creating Future Leaders

Table 4: Total survey effort at each study site for each land-use.

Survey sites		Settlement	Cropping	Grazing
Ka-Ndengeza (Low rainfall)	Total photos taken	19861	2181	844
	Camera stations	30	30	30
	Days active	9	9	9
(Total camera trap days: 810)	Camera trap days	270	270	270
	Species richness*	2	7	5
(Total area: 19.25km²)	Area (km²)	5.75	5.75	5.75
Vyeboom (High rainfall)	Total photos taken	19012	1539	395
	Camera stations	28	27	27
	Days active	9	9	9
(Total camera trap days: 738)	Camera trap days	257	255	237
	Species richness*	5	8	7
(Total area: 17.25km²)	Area (km²)	6.42	6.42	6.42

*Includes wild and domestic animals

5.1.2 Small carnivore species richness

The amount of activity for each camera trapping station per day is different for each land use and for each settlement (Table 4). Rarefaction and accumulation curves were used to compare the species richness of the two settlements, and also the methods of presenting species richness results in different ways (Figure 7). The general trend of all the graphs for each settlement is similar, but the information presented differs.

With this in mind an accumulation curve (Coleman rarefaction) for each settlement was plotted to illustrate the difference in survey effort needed which is similar to the Chao-2 estimation (Ka-Ndengeza: Figure 7e & 7g and Vyeboom: Figure 7f & 7h).

The total number of individual small carnivore photos sampled at Ka-Ndengeza (1187 individuals) and Vyeboom (1568 individuals) were too many to graphically show all capture events on one graph. Thus we extracted the first 400 individual capture events for each land use, at both of the villages, and attempted to plot them (Figure 7a and Figure 7b). This 400 individual capture events sample include all species detected in each land use.

For both settlement land uses, at Ka-Ndengeza and Vyeboom, all the small carnivore species present were recorded within the first 50 individual photo events sampled and in the cropping land uses at both villages it took 150 individual photo events sampled (Figure 7a and Figure

© University of Venda

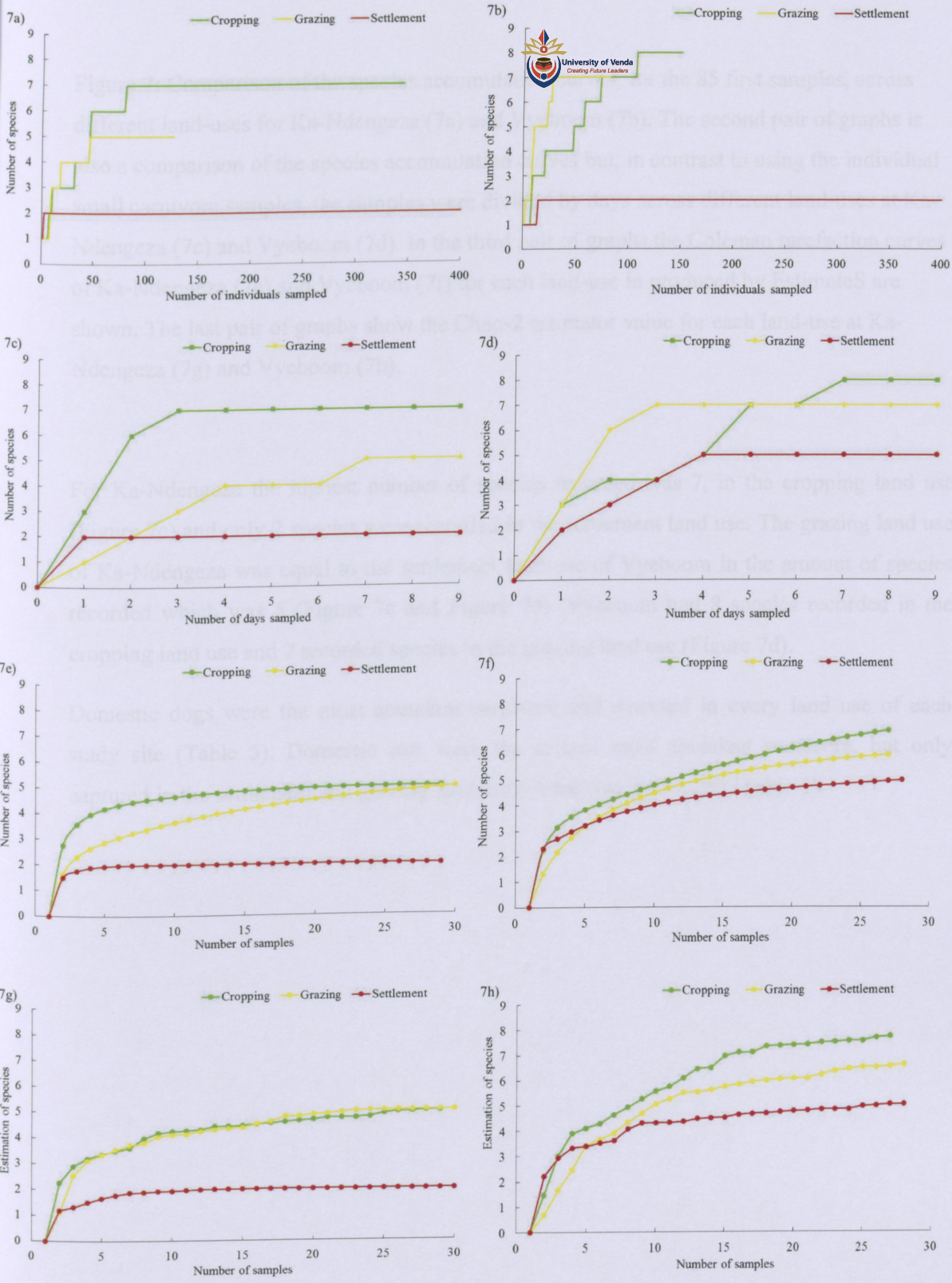
University of Venda
Creating Future Leaders

7b). The grazing land use recorded all the small carnivore species present within the first 100 individual photo events sampled at Ka-Ndengeza (Figure 7a) and at Vyeboom it was the first 75 individual photo events samples (Figure 7b).

Another method of presenting the species richness is by dividing the individual photo events sampled into sample days, which basically adds all the species identified together for different days. On the first day of sampling all the species are new (Figure 7c and Figure 7d). The new species found on the following sampling days get added to the previous day's total and recorded as the next sample.

At Ka-Ndengeza in the cropping land use it took 4 days, in the grazing land use it took 8 days and in the settlement it took only 3 days to observe all the species detected (Figure 7c). In comparison to Vyeboom where the grazing land use needed 4 days, the settlement land use needed 5 and cropping land use needed 8 days, which is the most days needed to record all species detected (Figure 7d).

© University of Venda



University of Venda
Creating Future Leaders
UNIVERSITY OF VENDA
LIBRARY
© University of Venda

University of Venda

Figure 7: Comparison of the species accumulation curves for the 85 first samples, across different land-uses for Ka-Ndengeza (7a) and Vyeboom (7b). The second pair of graphs is also a comparison of the species accumulation curves but, in contrast to using the individual small carnivore samples, the samples were divided by days across different land-uses at Ka-Ndengeza (7c) and Vyeboom (7d). In the third pair of graphs the Coleman rarefaction curves of Ka-Ndengeza (7e) and Vyeboom (7f) for each land-use in produced by EstimateS are shown. The last pair of graphs show the Chao-2 estimator value for each land-use at Ka-Ndengeza (7g) and Vyeboom (7h).

For Ka-Ndengeza the highest number of species recorded was 7, in the cropping land use (Figure 7c) and only 2 species were recorded in the settlement land use. The grazing land use of Ka-Ndengeza was equal to the settlement land use of Vyeboom in the amount of species recorded which was 5 (Figure 7c and Figure 7d). Vyeboom had 8 species recorded in the cropping land use and 7 recorded species in the grazing land use (Figure 7d).

Domestic dogs were the most abundant carnivore and detected in every land use of each study site (Table 5). Domestic cats were the second most abundant carnivore, but only captured in the settlement and grazing land uses of the two study sites (Table 5).

© University of Venda

University of Venda

Table 5: Species list of all mammals captured on camera traps in the settlement, crops and grazing land uses, as well as the frequency of photos taken (expressed as the number of photos taken per 1000 camera trap days).

Small carnivores		Ka-Ndengeza			Vyeboom		
Scientific name	Common name	Settlement	Cropping	Grazing	Settlement	Cropping	Grazing
CANIDAE							
Canis domesticus	Domesic dog	9324.10	1269.80	308.10	5160.00	201.70	37.00
MUSTELIDAE							
Ictonyx striatus	Striped polecat	0	0	5.10	0	8.20	0
Mellivora capensis	Honey badger	0	0	0	0	0	6.20
FELIDAE							
Felis domesticus	Domestic cat	324.10	0	10.10	720.00	0	6.20
VIVERRIDAE							
Genetta maculate	Large-spotted genet	0	642.90	217.20	22.20	172.80	228.40
Civetictic civetta	African civet	0	0	0	0	8.20	0
HERPESTIDAE							
Herpestes sanguineus	Slender mongoose	0	254.00	25.30	0	148.20	86.40
Rhynchogale melleri	Meller's mongoose	0	47.60	0	0	0	0
Paracynictis selousi	Selous' mongoose	0	71.40	0	0	32.90	0
Ichneumia albicauda	White-tailed mongoose	0	150.80	0	26.70	8.20	18.50
Helogale parvula	Dwarf mongoose	0	31.80	0	4.40	4.10	30.90

At Vyeboom, *Genetta maculata* (large-spotted genet), *Helogale parvula* (dwarf mongoose) and *Ichneumia albicauda* (white-tailed mongoose) were found in all three the land uses (Table 5). At Ka-Ndengeza, large-spotted genet and white-tailed mongoose were only found in the crops and grazing sites, with the dwarf mongoose only being found in the crops sites (Table 5). *Galerella sanguinea* (slender mongoose) was only found in two land uses, namely the crops and grazing of Vyeboom and Ka-Ndengeza (Table 5).

The large-spotted genet had the second highest number of photographs taken in the crops and grazing sites of Ka-Ndengeza (Table 5). The large-spotted genet had the highest number of photographs taken in the grazing sites and second highest number of photos taken in the crops sites of Vyeboom (Table 5).

The white-tailed mongoose had the third highest number of photographs taken at the settlement and grazing sites in Vyeboom (Table 5). The slender mongoose had the third highest number of photos taken in the crops and grazing sites of Ka-Ndengeza (Table 5).

© University of Venda

University of Venda

Vyeboom had the slender mongoose as the third highest number of photos taken in the crops sites and the second highest number of photos taken in the grazing sites (Table 5).

Paracynictis selousi (Selous' mongoose), which was found in the crops sites at Vyeboom and Ka-Ndengeza, and then *Ictonyx striatus* (striped polecat or Zorilla), which was found in the crop land use sites at Vyeboom and in the grazing sites at Ka-Ndengeza, were the only animals captured in one land use per study site (Table 5).

The African civet (*Civettictis civetta*) and honey badger (*Mellivora capensis*) were only found at Vyeboom in the crops and grazing sites respectively (Table 5). Meller's mongoose (*Rhynchogale melleri*) was only detected in the cropping land use at Ka-Ndengeza (Table 5).

5.2 Occupancy results

After the camera trapping and photo analysis was done, occupancy modelling was performed only with the species that had enough capture events to be tested. Only two small carnivore species attained sufficient sample sizes to model occupancy; the large-spotted genet and the slender mongoose.

5.2.1. Detection probability results

a) Large-spotted genet

At Ka-Ndengeza it was found that large-spotted genet detection probability was affected by distance to nearest crop and distance to nearest grazing sites (Table 6). We found no evidence that other factors affected large-spotted genet detection probabilities at Ka-Ndengeza (Table 6). There was a negative relationship between distance to crop edge and detection probability (β = -0.00387; SE = 0.000856; $p < 0.00001$; Fig. *8*a). Similarly, there was a negative relationship between distance to grazing edge and detection probability (β = -0.00430; SE = 0.000917; $p < 0.00001$; Fig *8*b). Both relationships suggest that detection probability of large-spotted genets decrease with increased distance from the crop/grazing edge, suggesting higher detections inside crops and grazing areas.

© University of Venda

University of Venda

At Vyeboom it was found equal support that effect distance to crop or distance to grazing affect large-spotted genet detection probability (Table 6). We found no evidence that other factors affected large-spotted genet detection probabilities at Vyeboom (Table 6).

There was a slight negative relationship between distance to crop edge (β = 0.000494; SE = 0.000483) at Vyeboom, and the ρ-value was 0.3069 which suggests that distance to crop edge is not a significant factor affecting detection (p) (Fig 8c).

There was also a negative relationship between distance to grazing edge and detection probability (β = -0.00109; SE = 0.000711) at Vyeboom, and the ρ-value was 0.125 which suggests that distance to grazing edge is not significant factor affecting detection (p) (Fig 8d).

The standard model with no covariates and constant psi (p (.) *psi* (.)) had the third lowest AIC value (Table 6). The model with grazing had the lowest AIC value and that with crops had a slightly higher value (0.12 difference in AIC).

Table 6: Detection probability values with habitat variables (constant *psi*), for the large-spotted genet at Ka-Ndengeza (KN) and Vyeboom (VYE).

Name	Model	(-2log-likelihood)	K	ΔAIC	Akaike weight
	DETECTION				
KNLSG1	psi(.) p(Crops + Grazing D)	288.29	4	0	0.750
KNLSG2	psi(.) p(Crops + Settlement + GrazingD)	290.54	5	2.25	0.240
	DETECTION				
VYELSG1	psi(.) p(GrazingD)	273.41	3	0	0.224
VYELSG2	psi(.) p(Crops)	273.53	3	0.12	0.211
VYELSG3	psi(.) p(.)	273.83	2	0.43	0.181
VYELSG4	psi(.) p(Crops + Settlement)	274.42	4	1.02	0.135
VYELSG5	psi(.) p(Settlement + GrazingD)	275.19	4	1.78	0.092
VYELSG6	psi(.) p(Settlement)	275.87	3	2.47	0.065

© University of Venda

University of Venda
Creating Future Leaders

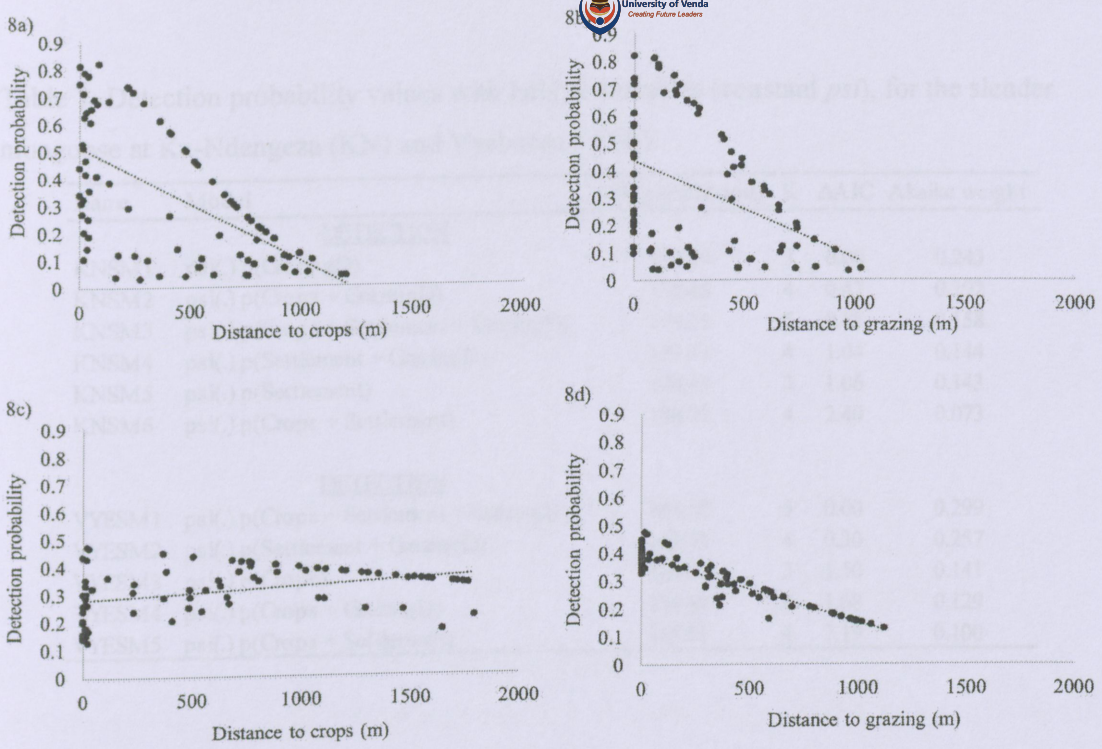


Figure 8: Influence of distance (in meters) to the nearest border edge of crops and grazing on the detection probability of the large-spotted genet at Ka-Ndengeza (crops (a); grazing (b)) and Vyeboom (crops (c) and grazing (d)).

b) Slender mongoose

At Ka-Ndengeza it was found that slender mongoose detection probability was affected by distance to grazing (Table 7). We found no evidence that other factors affected slender mongoose detection probabilities (Table 7).

There is negative relationship between distance to grazing edge and detection probability (β = -0.00277; SE = 0.00117) at Ka-Ndengeza, and the ρ-value of 0.0177 suggests that distance to grazing edge is a significant factor affecting detection (p) (Fig 9a).

At Vyeboom it was found that slender mongoose detection probability was affected by all habitat covariates together, that includes distance to grazing, distance to crops, and distance to settlement (Table 7).

© University of Venda

University of Venda
Creating Future Leaders

Table 7: Detection probability values with habitat variables (constant *psi*), for the slender mongoose at Ka-Ndengeza (KN) and Vyeboom (VYE).

Name	Model	(-2log-likelihood)	K	ΔAIC	Akaike weight
	DETECTION				
KNSM1	psi(.) p(GrazingD)	178.39	3	0.00	0.243
KNSM2	psi(.) p(Crops + GrazingD)	178.86	4	0.47	0.192
KNSM3	psi(.) p(Crops + Settlement + GrazingD)	179.25	5	0.85	0.158
KNSM4	psi(.) p(Settlement + GrazingD)	179.43	4	1.04	0.144
KNSM5	psi(.) p(Settlement)	179.45	3	1.06	0.143
KNSM6	psi(.) p(Crops + Settlement)	180.79	4	2.40	0.073
	DETECTION				
VYESM1	psi(.) p(Crops + Settlement + GrazingD)	163.12	5	0.00	0.299
VYESM2	psi(.) p(Settlement + GrazingD)	163.42	4	0.30	0.257
VYESM3	psi(.) p(Crops)	164.62	3	1.50	0.141
VYESM4	psi(.) p(Crops + GrazingD)	164.80	4	1.68	0.129
VYESM5	psi(.) p(Crops + Settlement)	165.31	4	2.19	0.100

There is negative relationship between distance to grazing edge and detection probability (β = -0.004006; SE = 0.001820) at Vyeboom, and the ρ-value of 0.0277 suggests that distance to grazing edge is a significant factor affecting detection (p) (Fig 9b).

There is positive relationship between distance to crop edge and detection probability (β = 0.000801; SE = 0.000895) at Vyeboom, and the ρ-value of 0.3710 suggests that distance to crops edge may not be a significant factor affecting detection (p) (Fig 9c).

There is negative relationship between distance to settlement edge and detection probability (β = -0.001585; SE = 0.000737) at Vyeboom, and the ρ-value of 0.0315 suggests that distance to settlement edge is a significant factor affecting detection (p) (Fig 9d).

© University of Venda

University of Venda
Creating Future Leaders

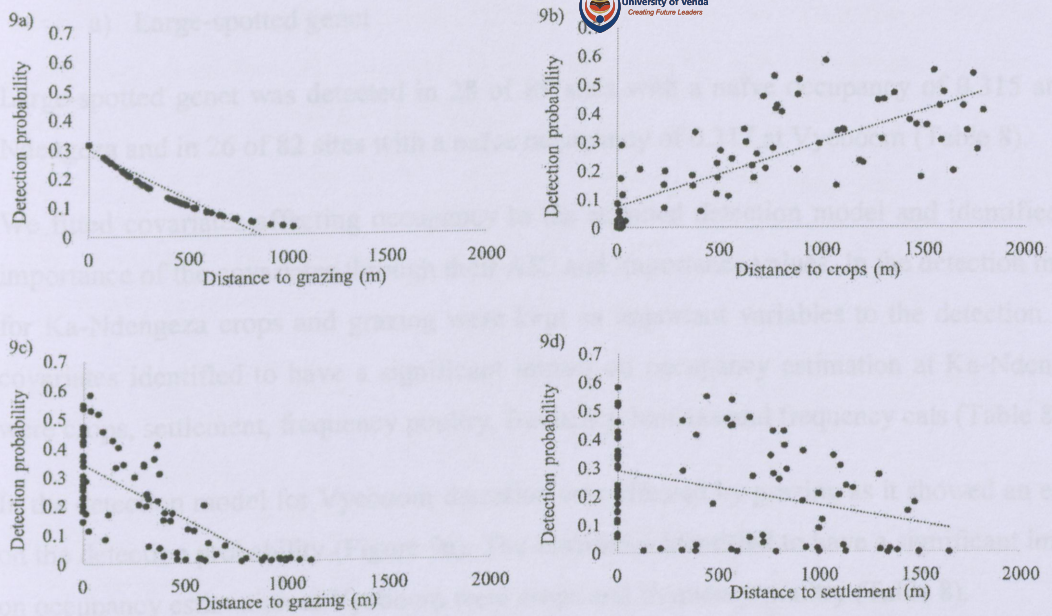


Figure 9: Influence of distance (in meters) to the nearest border edge of grazing, crops and settlement on the detection probability of the slender mongoose at Ka-Ndengeza (grazing (a)) and Vyeboom (crops (b), grazing (c) and settlement (d)).

5.2.2. Occupancy

Models with detection probabilities below 0.15 do not produce valid site occupancy and this makes it hard to distinguish between true absence and poor detection of the species (MacKenzie et al., 2002; O'Connell et al., 2006; Sarmento et al., 2011). This is why we included only the large-spotted genet and slender mongoose in our study.

The occupancy estimation was first done for the large-spotted genet, at Ka-Ndengeza and Vyeboom, then the same steps were followed for the slender mongoose.

© University of Venda

University of Venda
Creating Future Leaders

a) Large-spotted genet

Large-spotted genet was detected in 28 of 89 sites with a naïve occupancy of 0.315 at Ka-Ndengeza and in 26 of 82 sites with a naïve occupancy of 0.317 at Vyeboom (Table 8).

We fitted covariates affecting occupancy to the retained detection model and identified the importance of the covariates through their AIC and importance values. In the detection model for Ka-Ndengeza crops and grazing were kept as important variables to the detection. The covariates identified to have a significant impact on occupancy estimation at Ka-Ndengeza were crops, settlement, frequency poultry, frequency humans and frequency cats (Table 8).

In the detection model for Vyeboom detection was affected by grazing as it showed an effect on the detection probability (Figure 9a). The covariates identified to have a significant impact on occupancy estimation at Vyeboom were crops and frequency poultry (Table 8).

© University of Venda

University of Venda
Knowledge Transformation

Table 8: Top occupancy (*psi*) models of the predicted factors, with a constant detection probability, for the large-spotted genet at Ka-Ndengeza (KN; p(crops + grazing)) and Vyeboom (VYE; p(.)) with the beta values.

Name	Model	K	(-2log-likelihood)	ΔAIC	Akaike weight	Naïve occupancy	Beta values Ψ (SE)	p (+/-SE)
	HABITAT							
KNLSG3	p(Crops + GrazingD) psi(Crops + Settlement)	6	284.82	0	0.396		-0.720 (0.492)	1.380 (0.469)
KNLSG4	p(Crops + GrazingD) psi(Settlement + GrazingD)	6	286.52	1.70	0.169		-2.285 (0.814)	1.721 (0.459)
KNLSG5	p(Crops + GrazingD) psi(Crops + Settlement + GrazingD)	7	286.58	1.76	0.164		-1.672 (1.031)	1.466 (0.494)
KNLSG6	p(Crops + GrazingD) psi(Settlement)	5	287.58	2.76	0.099		-1.115 (0.490)	1.617 (0.465)
	FOOD							
KNLSG7	p(Crops + GrazingD) psi(FreqPoultry)	5	273.48	0	0.584		0.282 (0.339)	1.577 (0.449)
KNLSG8	p(Crops + GrazingD) psi(Crops + FreqPoultry)	6	274.16	0.68	0.415		0.565 (0.430)	1.464 (0.461)
KNLSG9	p(Crops + GrazingD) psi(.)	4	288.29	14.81	0.000		-0.175 (0.304)	1.863 (0.450)
	COMPETITION							
KNLSG10	p(Crops + GrazingD) psi(FreqHuman + FreqCat)	6	274.78	0	0.244		0.273 (0.300)	1.254 (0.451)
KNLSG11	p(Crops + GrazingD) psi(FreqHuman)	5	275.83	1.05	0.144		0.217 (0.298)	1.339 (0.454)
KNLSG12	p(Crops + GrazingD) psi(FreqHuman + FreqCat + FreqLivestock)	7	276.01	1.22	0.132		0.022 (0.371)	1.281 (0.454)
KNLSG13	p(Crops + GrazingD) psi(FreqHuman + FreqLivestock)	6	276.06	1.28	0.129		-0.036 (0.369)	1.302 (0.455)
KNLSG14	p(Crops + GrazingD) psi(FreqHuman + FreqDog + FreqCat)	7	276.33	1.55	0.113		0.151 (0.334)	1.317 (0.453)
KNLSG15	p(Crops + GrazingD) psi(FreqHuman + FreqDog)	6	276.91	2.12	0.084		0.124 (0.335)	1.333 (0.454)
						0.3146		
	HABITAT							
VYELSG	p(GrazingD) psi(Crops)	4	272.91	0	0.265		-1.161 (0.450)	-0.554 (0.270)
VYELSG	p(GrazingD) psi(.)	3	273.41	0.5	0.207		-0.440 (0.297)	-0.512 (0.249)
VYELSG	p(GrazingD) psi(GrazingD)	4	273.94	1.03	0.158		-0.175 (0.360)	-0.548 (0.258)
VYELSG	p(GrazingD) psi(Crops + Settlement)	5	274.78	1.87	0.104		-1.130 (0.526)	-0.529 (0.264)
VYELSG	p(GrazingD) psi(Crops + GrazingD)	5	274.98	2.07	0.094		-1.250 (0.817)	-0.576 (0.273)
	FOOD							
VYELSG	p(GrazingD) psi(Crops)	4	272.91	0	0.320		-1.264 (0.423)	-0.704 (0.230)
VYELSG	p(GrazingD) psi(Crops + FreqPoultry)	5	273.39	0.48	0.250		-1.348 (0.483)	-0.552 (0.268)
VYELSG	p(GrazingD) psi(.)	3	273.41	0.5	0.250		-0.440 (0.297)	-0.512 (0.249)
VYELSG	p(GrazingD) psi(FreqPoultry)	4	274.24	1.33	0.170		-0.588 (0.326)	-0.514 (0.249)
	COMPETITION							
VYELSG	p(GrazingD) psi(.)	3	273.41	0	0.204		-0.440 (0.297)	-0.512 (0.249)
VYELSG	p(GrazingD) psi(FreqCat)	4	274.02	0.61	0.150		-0.694 (0.295)	-0.516 (0.249)
VYELSG	p(GrazingD) psi(FreqLivestock)	4	275.14	1.74	0.086		-0.538 (0.354)	-0.511 (0.248)
VYELSG	p(GrazingD) psi(FreqHuman)	4	275.17	1.76	0.085		-0.547 (0.334)	-0.514 (0.251)
VYELSG	p(GrazingD) psi(FreqDog + FreqCat)	5	275.32	1.91	0.078		-0.487 (0.340)	-0.517 (0.250)
VYELSG	p(GrazingD) psi(FreqDog)	4	275.33	1.93	0.078		-0.485 (0.340)	-0.512 (0.249)
VYELSG	p(GrazingD) psi(FreqHuman + FreqCat)	5	275.78	2.37	0.062		-0.524 (0.338)	-0.514 (0.250)
						0.3171		

The importance of the different covariates in the themes were ranked using two methods. The first is the importance value and the second is AICwt (Table 9). The importance of the covariates, under each theme, was computed and this helped determine which covariates to retain in the final model (Table 9; Importance). The importance value is given as w+ (models with the covariate) and w- (models without the covariate). The covariates were ranked according to the highest w+ to the lowest. The two importance values combined is equal to 1.

© University of Venda

University of Venda

Table 9: Weight ranking of factors according to impact on occupancy modelling by using the sum of all the model weights containing the covariate (AICwt), and converting to percentage.

	Ka-Ndengeza						Vyeboom					
	Importance			AICwt ranking			Importance			AICwt ranking		
	w+	w-	Rank	Total	Average	Rank	w+	w-	Rank	Total	Average	Rank
DETECTION												
Grazing	1.00	0.00	1	0.99	0.25	2	0.39	0.61	5	0.41	0.10	5
Cropping	1.00	0.00	1	0.99	0.25	2	0.42	0.58	3	0.44	0.11	4
Settlement	0.22	0.78	9	0.24	0.06	8	0.30	0.70	7	0.32	0.08	7
HABITAT												
Grazing	0.35	0.65	7	0.38	0.10	6	0.32	0.68	6	0.35	0.09	6
Cropping	0.80	0.20	3	0.63	0.16	4	0.47	0.53	2	0.50	0.13	3
Settlement	0.60	0.40	4	0.83	0.21	3	0.25	0.75	8	0.28	0.07	8
FOOD												
Cropping	0.38	0.62	6	0.42	0.21	3	0.55	0.45	1	0.90	0.45	1
Frequency poultry	1.00	0.00	1	1.00	0.50	1	0.39	0.61	5	0.42	0.21	2
COMPETITION												
Frequency human	0.95	0.05	2	0.96	0.12	5	0.25	0.75	9	0.27	0.03	11
Frequency cat	0.54	0.46	5	0.58	0.07	7	0.41	0.59	4	0.44	0.06	9
Frequency livestock	0.35	0.65	7	0.39	0.05	9	0.27	0.73	8	0.29	0.04	10
Frequency dog	0.31	0.69	8	0.35	0.04	10	0.27	0.73	8	0.30	0.04	10

The AIC weights of the covariates computed, under each theme, in model selection is also equal to 1. For the AICwt ranking the total AICwt of each model containing the covariate in a theme (DETECTION, HABITAT, FOOD and COMPETITION) was added up (Table 9; Total) and divided by the number of models containing the covariate (Table 9; Average). The average weight is calculated to make the covariates comparable across themes. Using the averaged AIC weights for each covariate, at the two settlements, they were ranked from the highest to the lowest (Table 9; Rank).

The most important covariate at Ka-Ndengeza is frequency poultry (Total AICwt = 1.00; Average AICwt = 0.5 and Rank = 1) according to AICwt (Table 9) and tied in second place is cropping and grazing (Total AICwt = 0.99; Average AICwt = 0.25 and Rank = 2). When using the importance values, frequency poultry (w+ = 1; w- = 0; Rank =1) is still first but, cropping and grazing are tied with it at first place. The least important covariate is frequency

© University of Venda

University of Venda

dog when using AICwt (Total AICwt = 0.35; Average AICwt = 0.04; Rank = 10) and settlement if the importance values are used (w+ = 0.22; w- = 0.88; Rank = 9).

The covariate identified as most important at Vyeboom was cropping that was ranked first by both methods of importance testing (w+ = 0.55; w- = 0.45; Total AICwt = 0.90; Average AICwt = 0.45). Cropping is very important in the different themes, ranking second in theme HABITAT (w+ = 0.47; w- = 0.53) and third in theme DETECTION (w+ = 0.42; w- = 0.58) when using importance values. The fourth place is frequency cats according to the importance values (w+ =0.41; w- = 0.59). Second most important when using AICwt was frequency poultry (Total AICwt = 0.42; Average AICwt = 0.21). Third place and fourth place was cropping in the themes HABITAT (Total AICwt = 0.50; Average AICwt = 0.13; Rank = 2) and DETECTION (Total AICwt = 0.44; Average AICwt = 0.11; Rank = 3) respectively.

The covariate ranked highest at Vyeboom was cropping as it was included as the top ranked covariate in all the themes it is present. This means in relation to the other covariates in the themes cropping was most important. At Ka-Ndengeza however it was ranked sixth under the FOOD theme, after frequency humans (w+ = 0.95; w- = 0.05; Rank = 2), settlement (w+ = 0.60; w- = 0.40; Rank = 4) and frequency cats (w+ = 0.54; w- = 0.46; Rank = 5).

The lowest ranking covariate at Vyeboom is frequency humans (w+ = 0.25; w- = 0.75; Total AICwt = 0.27; Average AICwt = 0.03) in both methods, followed by frequency livestock and frequency dog tied at second lowest in both AICwt and importance.

The biggest difference in covariate ranking is frequency humans which is ranked second, in importance value, at Ka-Ndengeza and ninth at Vyeboom (Table 8). The AIC weights also differed significantly from an average AICwt of 0.12 at Ka-Ndengeza to 0.03 at Vyeboom (Table 8). Frequency cats at Vyeboom was ranked fourth in importance values but ninth in AICwt average. At Vyeboom the two highest ranked covariates according to AICwt are both in the theme of FOOD.

© University of Venda

University of Venda
Creating Future Leaders

b) Slender mongoose

The slender mongoose was detected in 16 of 89 sites with a naïve occupancy of 0.1798 at Ka-Ndengeza and in 14 of 82 sites with a naïve occupancy of 0.1707 at Vyeboom (Table 10).

We fitted covariates affecting occupancy to the retained detection model and identified the importance of the covariates through their AIC weights and importance values. In the detection model for Ka-Ndengeza only grazing was kept as an important variable to the detection of the slender mongoose. The covariates identified to have a significant impact on occupancy estimation at Ka-Ndengeza were crops, frequency cats and frequency livestock (Table 10).

In the detection model for Vyeboom crops, grazing and settlement were kept as they were all identified as significant. There were no covariates identified to have a significant impact on occupancy estimation at Vyeboom thus the standard occupancy estimation model (psi (.)) for each theme (i.e. HABITAT, FOOD and COMPETITION) was retained (Table 10).

UNIVERSITY OF VENDA
LIBRARY

© University of Venda

University of Venda
Creating Future Leaders

Table 10: Top occupancy (psi) models of the predefined factors, with a constant detection probability (p), for the slender mongoose at Ka-Ndengeza (KN; p(grazing)) and Vyeboom (VYE; p(crops + grazing + settlement)) with the beta values.

						Beta values	
Name	Model	K	(-2log-likelihood)	ΔAIC	Akaike weight	Naïve occupancy	Ψ(SE)	p (+/-SE)
	HABITAT							
KNSM7	p(GrazingD) psi(Crops)	4	178.31	0	0.223		-0.107 (0.685)	-0.792 (0.356)
KNSM8	p(GrazingD) psi(.)	3	178.39	0.08	0.214		-0.908 (0.377)	-0.779 (0.355)
KNSM9	p(GrazingD) psi(Crops + Settlement)	5	179.21	0.9	0.142		-0.613 (0.806)	-0.794 (0.383)
KNSM10	p(GrazingD) psi(Settlement)	4	179.26	0.94	0.139		-1.392 (0.554)	-0.791 (0.392)
KNSM11	p(GrazingD) psi(Crops + GrazingD)	5	180.1	1.79	0.091		0.072 (0.751)	-0.799 (0.361)
KNSM12	p(GrazingD) psi(GrazingD)	4	180.39	2.08	0.079		-0.927 (0.434)	-0.771 (0.355)
	FOOD							
KNSM13	p(GrazingD) psi(Crops)	4	178.31	0	0.37		-0.107 (0.685)	-0.792 (0.356)
KNSM14	p(GrazingD) psi(.)	3	178.39	0.08	0.35		-0.908 (0.377)	-0.779 (0.355)
KNSM15	p(GrazingD) psi(FreqPoultry)	4	180.08	1.77	0.15		-0.849 (0.388)	-0.778 (0.355)
KNSM16	p(GrazingD) psi(Crops + FreqPoultry)	5	180.33	2.02	0.13		-0.098 (0.694)	-0.792 (0.354)
	COMPETITION							
KNSM17	p(GrazingD) psi(FreqCat + FreqLivestock)	5	173.03	0	0.238		-0.257 (0.446)	-0.811 (0.373)
KNSM18	p(GrazingD) psi(FreqLivestock)	4	173.92	0.89	0.152		-0.372 (0.431)	-0.809 (0.372)
KNSM19	p(GrazingD) psi(FreqDog + FreqCat + FreqLivestock)	6	174.74	1.72	0.101		-0.248 (0.447)	-0.812 (0.373)
KNSM20	p(GrazingD) psi(FreqHuman)	4	175.42	2.39	0.072		-0.727 (0.389)	-0.743 (0.351)
						0.1798		
	HABITAT							
VYESM6	p(Crops + Settlement + GrazingD) psi(.)	5	163.12	0	0.316		-0.853 (0.386)	-0.355 (1.215)
VYESM7	p(Crops + Settlement + GrazingD) psi(Settlement)	6	164.37	1.25	0.169		-1.252 (0.539)	-0.217 (1.122)
VYESM8	p(Crops + Settlement + GrazingD) psi(GrazingD)	6	164.4	1.28	0.167		-0.646 (0.426)	-0.201 (1.330)
VYESM9	p(Crops + Settlement + GrazingD) psi(Crops)	6	164.99	1.87	0.124		-1.352 (1.060)	0.005 (1.494)
VYESM1	p(Crops + Settlement + GrazingD) psi(Settlement + GrazingD)	7	166.21	3.09	0.068		-0.943 (1.026)	-0.202 (1.223)
	FOOD							
VYESM1	p(Crops + Settlement + GrazingD) psi(.)	5	163.12	0	0.521		-0.853 (0.386)	-0.355 (1.215)
VYESM1	p(Crops + Settlement + GrazingD) psi(Crops)	6	164.99	1.87	0.205		-1.352 (1.060)	0.005 (1.494)
VYESM1	p(Crops + Settlement + GrazingD) psi(FreqPoultry)	6	165.06	1.94	0.198		-0.810 (0.413)	-0.329 (1.179)
VYESM1	p(Crops + Settlement + GrazingD) psi(Crops + FreqPoultry)	7	166.96	3.83	0.077		-1.258 (1.160)	-0.031 (1.540)
	COMPETITION							
VYESM1	p(Crops + Settlement + GrazingD) psi(.)	5	163.12	0	0.2508		-0.853 (0.386)	-0.355 (1.215)
VYESM1	p(Crops + Settlement + GrazingD) psi(FreqLivestock)	6	164.68	1.56	0.1152		-0.713 (0.427)	-0.234 (1.220)
VYESM1	p(Crops + Settlement + GrazingD) psi(FreqDog)	6	164.98	1.86	0.099		-0.755 (0.434)	-0.316 (1.197)
VYESM1	p(Crops + Settlement + GrazingD) psi(FreqCat)	6	165.01	1.89	0.0976		-0.791 (0.420)	-0.338 (1.214)
VYESM1	p(Crops + Settlement + GrazingD) psi(FreqHuman)	6	165.02	1.89	0.0973		-0.631 (0.440)	-0.228 (1.234)
VYESM2	p(Crops + Settlement + GrazingD) psi(FreqDog + FreqLivestock)	7	166.2	3.08	0.0538		-0.738 (0.433)	-0.067 (1.279)
						0.1707		

The importance of the different covariates in the themes were determined using two methods namely importance and AICwt. The importance of the covariates, under each theme, was computed and this helped determine which covariates to retain in the final model (Table 10; Importance). The importance value is given as a value of w+ (models with the covariate) and w- (models without the covariate). The covariates were ranked according to the highest w+ to the lowest. The two importance values combined is equal to 1.

© University of Venda

University of Venda
Creating Future Leaders

Table 11: Weight ranking of factors according to impact on occupancy modelling by using the sum of all the model weights containing the covariate (AICwt), and converting to percentage.

	Ka-Ndengeza						Vyeboom					
	Importance			AICwt ranking			Importance			AICwt ranking		
	w+	w-	Rank	Total	Average	Rank	w+	w-	Rank	Total	Average	Rank
DETECTION												
Grazing	0.72	0.28	1	0.74	0.18	2	0.71	0.29	1	0.74	0.18	1
Cropping	0.41	0.59	7	0.44	0.11	6	0.65	0.35	2	0.67	0.17	2
Settlement	0.50	0.50	4	0.52	0.13	5	0.64	0.36	3	0.66	0.17	2
HABITAT												
Grazing	0.26	0.74	11	0.28	0.07	9	0.29	0.71	4	0.33	0.08	4
Cropping	0.48	0.52	5	0.60	0.15	3	0.24	0.76	7	0.28	0.07	5
Settlement	0.37	0.63	8	0.39	0.10	7	0.29	0.71	4	0.33	0.08	4
FOOD												
Cropping	0.47	0.53	6	0.50	0.25	1	0.25	0.75	6	0.28	0.14	3
Frequency poultry	0.26	0.74	11	0.28	0.14	4	0.24	0.76	7	0.28	0.14	3
COMPETITION												
Frequency human	0.29	0.71	10	0.30	0.04	10	0.25	0.75	6	0.29	0.04	6
Frequency cat	0.57	0.43	3	0.60	0.08	9	0.24	0.76	7	0.27	0.03	7
Frequency livestock	0.66	0.34	2	0.68	0.09	8	0.27	0.73	5	0.31	0.04	6
Frequency dog	0.30	0.70	9	0.32	0.04	10	0.27	0.73	5	0.32	0.04	6

The AIC weights of the covariates computed, under each theme, in model selection is also equal to 1. For the AICwt ranking the total AICwt of each model containing the covariate in a theme (DETECTION, HABITAT, FOOD and COMPETITION) was added up (Table 10; Total) and divided by the number of models containing the covariate (Table 10; Average). The average weight is calculated to make the covariates comparable across themes. Using the averaged AIC weights for each covariate, at the two settlements, they were ranked from the highest to the lowest (Table 10; Rank).

The highest importance ranked covariate in both Ka-Ndengeza (w+ = 0.72; w- = 0.28) and Vyeboom (w+ = 0.71; w- = 0.39) was grazing. Using the AIC weight it is also the highest ranked at Vyeboom (Total AICwt = 0.74, Average AICwt = 0.18) and second highest at Ka-Ndengeza (Total AICwt = 0.74; Average AICwt = 0.18).

© University of Venda

University of Venda
Creating Future Leaders

The covariate ranked first at Ka-Ndengeza using average AIC weight was grazing with an average of 0.18 (Table 11). The second ranked covariate at Ka-Ndengeza, using importance, was frequency livestock which had a weight of 0.66 for models containing the covariate. For Vyeboom the second place is a tie between settlement and cropping from the same theme. All three the most important covariates are contained in the theme DETECTION at Vyeboom followed by the theme FOOD and HABITAT according to AICwt ranking.

The covariates with the highest AIC weights in Ka-Ndengeza are crops (AICwt = 0.50; Rank = 1), frequency poultry (AICwt = 0.280; Rank = 2), settlement (AICwt = 0.394; Rank = 3) and grazing (AICwt = 0.283; Rank = 4) which doesn't correlate with the model selection (Table 10). This is regarding the frequency cats (AICwt = 0.600; Rank = 6) and frequency livestock (AICwt = 0.680; Rank = 5) that are ranked higher in model selection than frequency poultry, settlement and grazing (Table 11).

The covariates with the highest AIC weights in Vyeboom are frequency poultry (AICwt = 0.275; Rank = 1), crops (AICwt = 0.562; Rank = 2), grazing (AICwt = 0.328; Rank = 3) and settlement (AICwt = 0.327; Rank = 4) (Table11).

5.2.3 Model selection

The final models combine the covariates with the most impact on the large-spotted genet and slender mongoose respectively. This is done for Ka-Ndengeza and Vyeboom, which means there are four final models.

The large-spotted genet had a final model that included cropping, grazing and settlement at Ka-Ndengeza (Table 12; KNLSG16). At Vyeboom the final model included just cropping and a constant detection probability of 1 (Table 12; VYELSG23). With the selected models the occupancy estimates were projected onto a map of each village. The large-spotted genet occupancy estimates were projected and mapped for Ka-Ndengeza (Figure 10) and Vyeboom (Figure 11). The Ka-Ndengeza map of occupancy estimates (Figure 10) supports the importance of cropping as a positive impacting factor, whereas the Vyeboom map of occupancy estimates shows a low occupancy estimate in the cropping land use. When the

© University of Venda

University of Venda
Creating Future Leaders

colour scale of 0.2 to 0.8 is taken into account it indicates a lot of model uncertainty and that the large-spotted is detected in every land use.

The final model for the slender mongoose at Ka-Ndengeza (Table 12; KNSM21) contained cropping, grazing, frequency cat and frequency livestock. The Vyeboom final model (Table 12; VYESM21) had cropping, grazing and settlement, but the occupancy estimate was kept constant as 1. Because the slender mongoose had a constant occupancy (*psi*) at Vyeboom, occupancy estimates were only projected and mapped for Ka-Ndengeza (Figure 12). The Ka-Ndengeza map of occupancy estimates shows occupancy decreasing in the village (Figure 12).

© University of Venda

Table 12: Estimates of beta coefficients on the logit scale and standard error (SE) of covariates contained in the final models of large-spotted genet (LSG) and slender mongoose (SM) occupancy in the two villages of Ka-Ndengeza (KN) and Vyeboom (VYE).

		Occupancy estimates (Beta values)										Detection probability (Beta values)							
Name	Model	Intercept	(SE)	Cropping	(SE)	Settlement	(SE)	FreqCat	(SE)	FreqLivestock	(SE)	Intercept	(SE)	Cropping	(SE)	Grazing	(SE)	Settlement	(SE)
	LARGE-SPOTTED GENET																		
KNLSG16	p(Crops + GrazingD) psi(Crops + Settlement)	-0.720	0.492	-0.002	0.001	0.001	0.001					1.380	0.469	-0.003	0.001	-0.003	0.001		
VYELSG23	p(.) psi(Crops)	-1.264	0.423	0.001	0.001							-0.704	0.230						
	SLENDER MONGOOSE																		
KNSM21	p(GrazingD) psi(Crops + FreqCat + FreqLivestock)	0.119	0.655	-0.001	0.001			-0.432	0.639	-0.007	0.004	-0.781	0.364			-0.002	0.001		
VYESM21	p(Crops + GrazingD + Settlement) psi(.)	-0.853	0.386									-0.355	1.215	0.001	0.001	-0.004	0.002	-0.002	0.001

© University of Venda

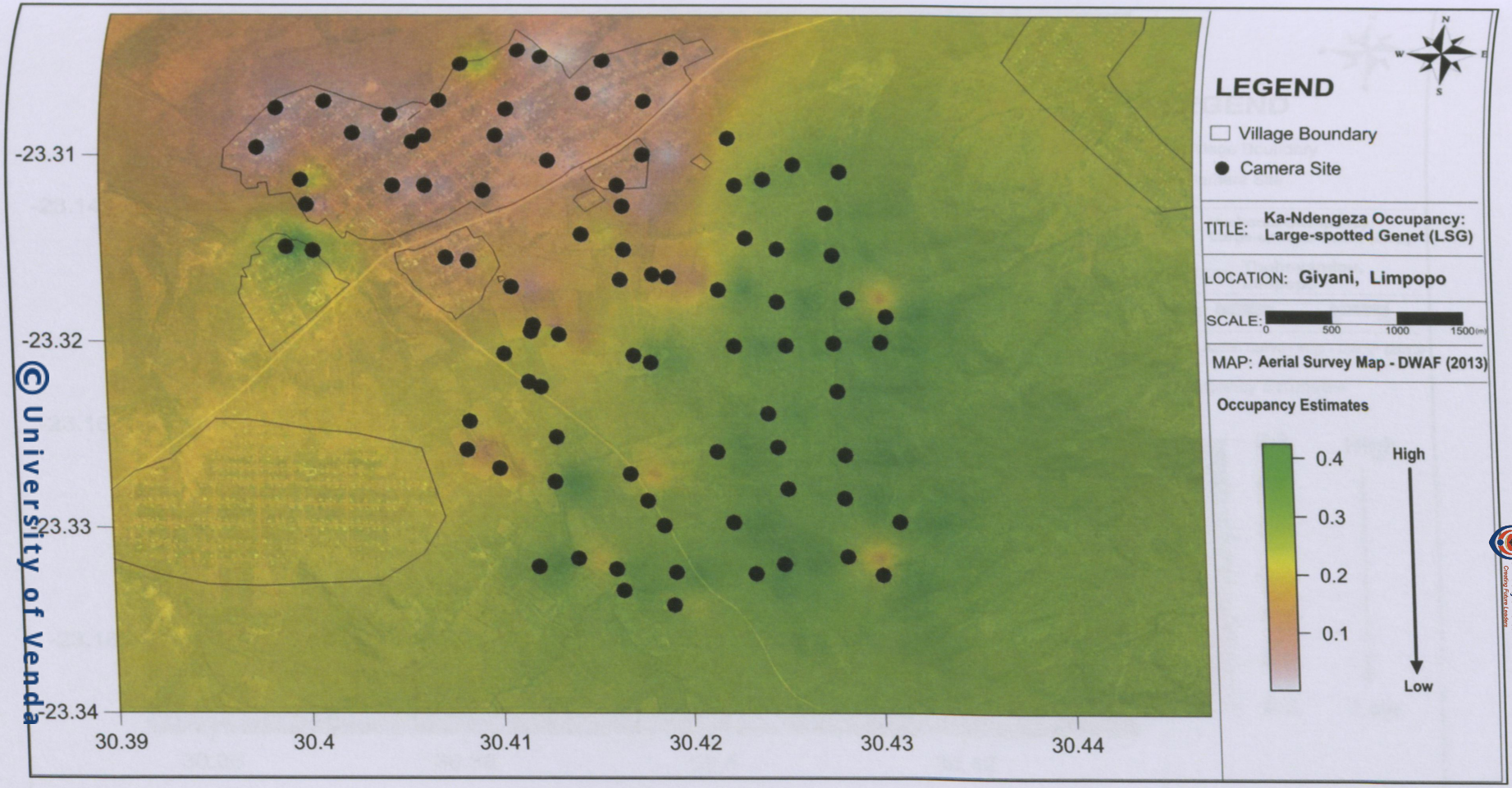
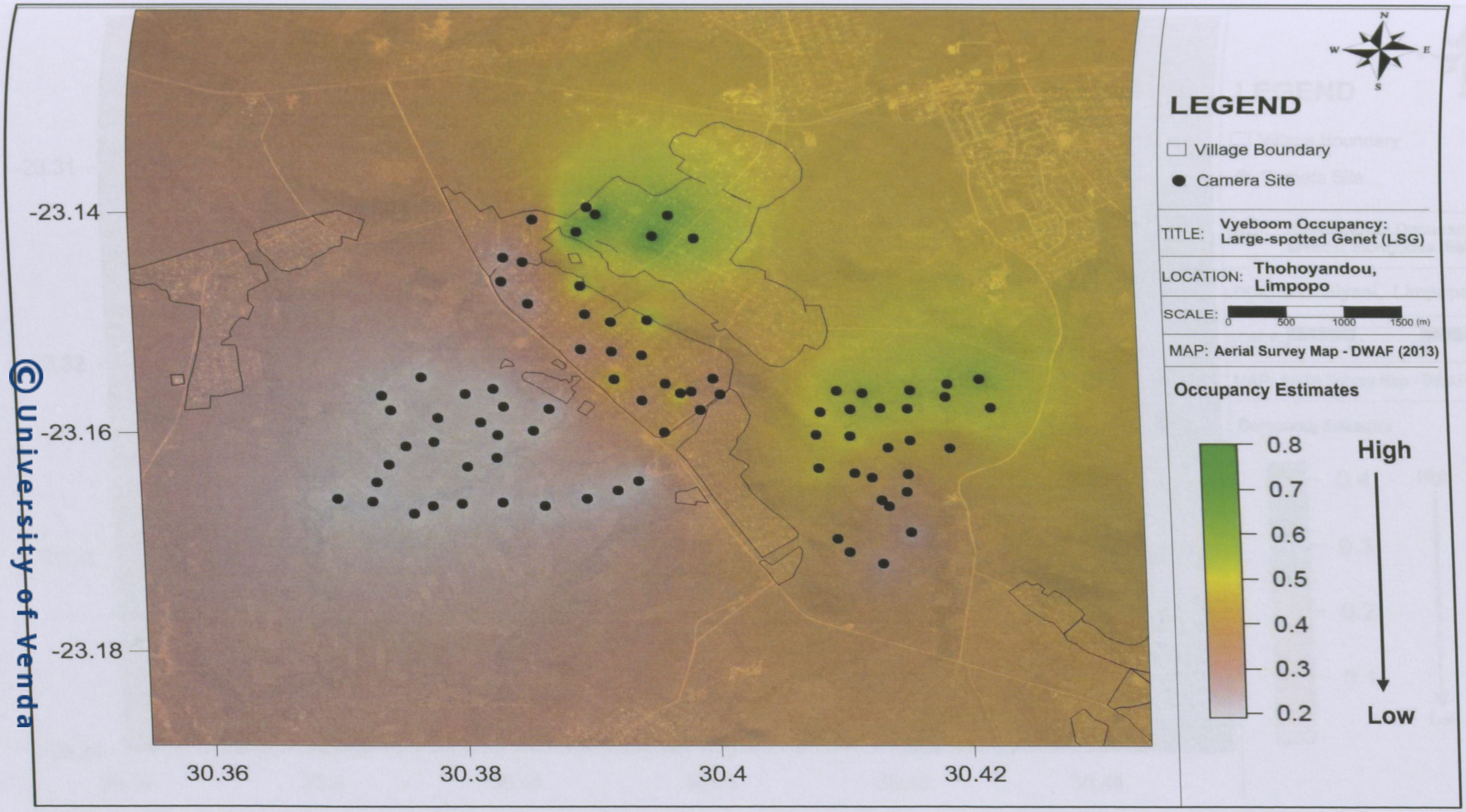
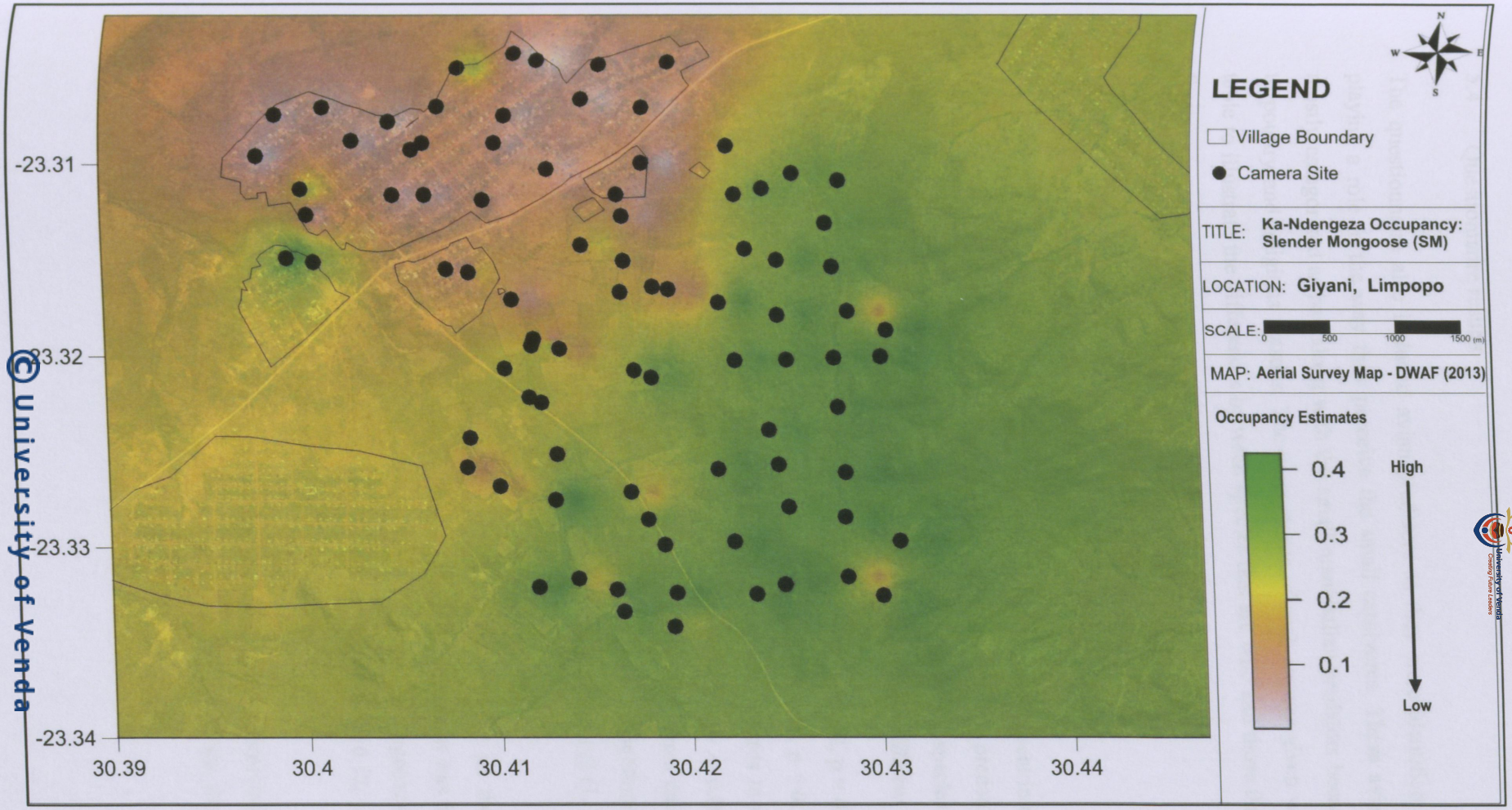


Figure 10: Estimated occupancy of the large-spotted genet at Ka-Ndengeza, with darker green indicating higher estimates of occupancy.



© University of Venda

Figure 11: Estimated occupancy of the large-spotted genet at Vyeboom, with darker green indicating higher estimates of occupancy.



© University of Venda

Figure 12: Estimated occupancy of the slender mongoose at Ka-Ndengeza, with darker green indicating higher estimates of occupancy.

University of Venda
Creating Future Leaders

5.4 Questionnaire results

The questionnaire also included avian predators as they were identified by the people as playing a role in the way they perceive the small carnivores. These avian predators were mostly categorized as bad along with the small mammalian predators because of their threat to poultry and religious reasons. The percentages of each answer given was displayed in a table to illustrate the differences between species that are wild and those that are domestic or feral.

5.4.1 Small carnivore questions

The small carnivores were divided into "detected" (identified as present in occupancy study), "unsure presence" (not detected in occupancy study) and "avian predators" categories to simplify the results (Table 13). Eagles and falcons were not species specific due to identification problems of the community members, each having a different description.

In the "detected" category, the honey badger ($\chi 2$ (1, N = 127) = 0.02, p = 0.88), domestic cat ($\chi 2$ (1, N = 127) = 0.95, p = 0.33) and dog ($\chi 2$ (1, N = 127) = 0.95, p = 0.33) were the only three that were not independent of the different villages with regards to sightings ("seen"; Table 13). The yellow mongoose ($\chi 2$ (2, N = 127) = 30.43, $p < 0.0001$) and banded mongoose ($\chi 2$ (2, N = 127) = 38.66, $p < 0.0001$) were the only small carnivores of unsure presence that were independent of the villages with regards to sightings. With the avian predators the falcon ($\chi 2$ (1, N = 127) = 12.98, $p < 0.0002$) and eagle ($\chi 2$ (1, N = 127) = 14.39, $p < 0.0004$) were also independent of the villages.

When the frequency of sightings ("often"; Table 13) was tested all the avian predators showed independence of village. In the category of unsure presence it was found that only the yellow mongoose ($\chi 2$ (2, N = 127) = 27.05, $p < 0.0001$), banded mongoose ($\chi 2$ (2, N = 127) = 12.98, $p < 0.0001$) and the black-backed jackal ($\chi 2$ (1, N = 127) = 10.12, p = 0.006) showed that the village had an impact of the frequency of sightings.

With regards to the general knowledge of the diet of the small carnivores ("kill rodents"; Table 13) all the avian predators were independent of which village the study was done. The

© University of Venda

University of Venda
Creating Future Leaders

same is true of the yellow mongoose ($\chi 2$ (2, N = 127) = 22.40, $p < 0.0001$), banded mongoose ($\chi 2$ (1, N = 127) = 8.21, $p = 0.004$) and black-backed jackal ($\chi 2$ (2, N = 127) = 12.58, $p < 0.001$) in the category of unsure presence. With the detected small carnivores five were independent of the village and the ρ-values of these small carnivores were all < 0.001 except for the slender mongoose which was $p < 0.01$, $\chi 2$ (2, N = 127) = 9.27.

The small carnivore perception of being positive ("positive"; Table 13) was not independent and thus was not just one village's opinion. The only small carnivores that showed independence of village were domestic cat ($\chi 2$ (1, N = 127) = 36.60, $p < 0.001$) and dog ($\chi 2$ (1, N = 127) = 29.30, $p < 0.001$).

Negative perceptions ("negative"; Table 13) were more varied overall. The avian predators had only one animal independent which was the owl ($\chi 2$ (2, N = 127) = 45.21, $p < 0.001$). The banded mongoose ($\chi 2$ (1, N = 127) = 6.40, $p = 0.011$) and the African wild cat ($\chi 2$ (1, N = 127) = 19.69, $p < 0.0001$) were both independent of village with regards to perceived negative impact. The striped polecat, honey badger, domestic cat and dog were all dependent on the village for their perceived negative impact.

UNIVERSITY OF VENDA
LIBRARY

© University of Venda

Table 13: Pearson's chi-squared test values for the questionnaire answers for each species of small carnivore.

	Seen			Often			Kill rodent			Positive			Negative		
Species	X^2	df	p-value	X^2	df	p-value	X^2	df	p-value	X^2	df	p-value	X^2	df	p-value
Detected															
Dwarf mongoose	50.89	2	0.000	55.44	3	0.000	22.41	2	0.000	0.95	1	0.329	56.38	2	0.000
Slender mongoose	15.39	2	0.000	6.16	3	0.104	9.27	2	0.010	0.95	1	0.329	8.02	2	0.018
White-tailed mongoose	40.31	1	0.000	42.96	3	0.000	19.19	2	0.000	0.95	1	0.329	29.61	1	0.000
African civet	11.14	2	0.004	0.01	1	0.930	0.95	1	0.329	0.95	1	0.329	8.21	1	0.004
Genet	20.50	2	0.000	13.57	2	0.001	15.48	2	0.000	0.95	1	0.329	11.14	2	0.004
Striped polecat	17.88	1	0.000	20.33	2	0.000	21.90	2	0.000	0.95	1	0.329	0.95	1	0.329
Honey badger	0.02	1	0.879	3.23	2	0.199	0.01	1	0.930	0.95	1	0.329	0.95	1	0.329
Domestic cat	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	36.60	1	0.000	1.24	1	0.265
Domestic dog	0.95	1	0.329	0.95	1	0.329	3.66	2	0.161	29.30	1	0.000	2.18	1	0.140
Unsure presence															
Banded mongoose	38.66	2	0.000	28.96	3	0.000	8.21	1	0.004	0.95	1	0.329	6.40	1	0.011
Yellow mongoose	30.43	2	0.000	27.05	4	0.000	20.40	2	0.000	0.95	1	0.329	0.01	1	0.930
Marsh mongoose	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329
Black-backed jackal	2.10	1	0.147	10.12	2	0.006	12.58	1	0.000	0.95	1	0.329	1.83	1	0.176
Caracal	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329
Serval	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329	0.95	1	0.329
African wild cat	4.02	2	0.134	66.23	3	0.000	4.71	2	0.095	0.95	1	0.329	19.69	1	0.000
Avian predators															
Eagle	14.39	1	0.000	53.59	3	0.000	31.44	2	0.000	0.95	1	0.329	0.05	1	0.817
Falcon	12.98	1	0.000	72.95	3	0.000	47.33	2	0.000	0.95	1	0.329	0.47	1	0.492
Owl	0.01	1	0.930	37.03	3	0.000	18.05	2	0.000	0.95	1	0.329	45.21	2	0.000
Crow	0.95	1	0.329	6.65	1	0.010	64.73	2	0.000	0.95	1	0.329	0.00	1	1.000
All together	62.22	2	0.000	115.05	4	0.000	25.08	2	0.000	15.76	1	0.000	47.44	2	0.000

© University of Venda

University of Venda
Creating Future Leaders

5.4.2 Human perception of the impact of small carnivores

In the sightings question it was seen that the small carnivores are active even with people present (Table 14) and little is known about the small carnivore diet preference. This leads to a perception of a threat to poultry and thus no small carnivore, except the domestic cat and dog, is positive. The lack of diet preference knowledge was identified under the "kill rodents" questions were most community members answered unsure or no, except for the domestic cat, the African wild cat and the avian predators (Table 14).

Table 14: The percentage of sightings of the small carnivores (seen) the accompanied by the frequency of the sightings on a daily basis. The percentage of people who think the small carnivores do eat rodents (kill rodents), and if they are considered positive or negative to the community members livelihoods.

Detected	Seen	Often	Kill rodent	Positive	Negative
Dwarf mongoose	75	55	11	0	67
Slender mongoose	87	67	20	0	84
White-tailed mongoose	49	13	10	0	50
African civet	1	0	0	0	0
Genet	19	0	6	0	1
Striped polecat	14	0	13	0	0
Honey badger	2	0	0	0	0
Domestic cat	100	100	100	77	4
Domestic dog	100	100	2	80	5
Unsure presence					
Banded mongoose	29	2	9	0	33
Yellow mongoose	37	13	7	0	0
Marsh mongoose	0	0	0	0	0
Black-backed jackal	26	0	0	0	3
Caracal	0	0	0	0	0
Serval	0	0	0	0	0
African wild cat	55	33	54	0	27
Avian predators					
Eagle	83	55	42	0	74
Falcon	84	62	43	0	76
Owl	99	80	81	0	75
Crow	100	94	35	0	95

© University of Venda

University of Venda
Creating Future Leaders

CHAPTER SIX: DISCUSSION

The basic aims of this study were firstly to document species richness (rarefaction estimation) and small carnivore tolerance towards people and vice versa (questionnaires), and then to identify the factors impacting small carnivore occupancy and detection probability in a human-dominated landscape. The four pairs of species richness graphs displayed different methods of species richness estimation (Figure 3).

The detection/non-detection method, through camera trapping, is a good estimator of the impact a covariate has on a species occupancy. It also has the potential to be a very effective and efficient monitoring method of small carnivore populations in long-term studies (Sarmento et al., 2011). Through this study it was identified that, for a clear understanding of small carnivore ecology, one should examine not only relationships of small carnivores to habitat factors, but also the relationship between the different species distribution patterns (Sarmento et al., 2011).

It must be noted that the flash cameras that were used in the village areas had been baited. This was an effort to mediate the effect of the flash on the small carnivores. The animal's reaction to the flash from the cameras was observed and most seemed unaffected staying for more than one photo.

6.1 Species richness

Four methods of species richness estimation and graphic displays were utilized and comparisons were made. All the methods concluded the same basic trend of higher species richness in cropping areas followed by grazing and then settlements. The species richness at Vyeboom in all land uses was generally higher than at Ka-Ndengeza.

The higher species richness in agricultural land is similar to what was found in other studies on the agricultural land use and the potential small mammal population dynamics in relation to carnivore predation (Prevedello et al., 2013; Salo et al., 2010; Belmain, 2006; Blaum et al.,

© University of Venda

University of Venda
Creating Future Leaders

2006; Blaum et al., 2007a; Andersson & Erling, 1977). Thus the small carnivores as a form of ecological based rodent management can be considered. The small carnivores are present in this high food resource land use and the diet of small carnivores include rodents and carrion, making them a viable option for ecological based rodent management (Ćirović et al., 2016; Mateo-Tomás et al., 2015; Blanco & Cortes, 2007; Blaum et al., 2007b; Brown et al., 2007).

Another reason for the higher species richness in the cropping land use is the exclusion of the domestic cat that was not detected in the agricultural area (occupancy study results). The cat diet comprises of mainly small mammals, reptiles and birds which is caught in the wild, which is supplemented by food provided by community members in the settlement area (questionnaire results). This could be why the cats do not compete with the native small carnivores because, the food requirements are met without expenditure unnecessary energy (Dickman, 1996).

Vegetation structure has been suggested as influential on predator-predator interactions (Thompson & Gese, 2007; Finke & Denno, 2002; Roda et al., 2000). There is more vegetation in the cropping and grazing land uses in relation to the settlement land use. This could explain the increase in species richness across land uses. In aerial photos of the study sites, Vyeboom showed more general vegetation than Ka-Ndengeza, and the village layout might also play a role in the species richness differences between the two villages.

For choosing a species richness estimator it is necessary to decide what is needed for your results. In the case of this study the Cole rarefaction estimation provided the information needed, which was to determine if the time allocation was enough to detect all small carnivore species present and also identifying which land use had the highest species richness. The Chao-2 also agreed with this result but had model uncertainty at Vyeboom.

As a general note having time allocation in days rather than individuals sampled is more realistic when planning a survey. The days of work needed is better for budgeting and time frame estimation.

6.2 Detection and occupancy

© University of Venda

University of Venda
Creating Future Leaders

The themes, created from the different factors, were identified from literature and were a starting point for the occupancy study (Sarmento et al., 2011). Habitat selection led to food resource preference, which in turn led to competition for a suitable habitat and food resources. As such each one of the three themes is supported in literature as having an influence on occupancy. The factors identified (in each theme) had differing effectiveness in explaining the detection and non-detection of the large-spotted genet and slender mongoose.

6.2.1 Habitat vs Food vs Competition

Habitat was identified as the most influential theme with regards to detection (Ćirović et al., 2016; Walker, 2009; Stuart & Stuart, 2006; Skinner & Chimimba, 2005). The habitat factors (or detection theme) identified in this study are basic, but still showed a very prominent impact on the detection of the small carnivores. The rural land uses are often structurally complex and heterogeneous (Donald, 2004) that seems to support higher animal diversity (Norris, 2008). The plant resources of a habitat contribute to its complexity. Changes in habitat complexity can make small carnivores and prey more visible and that leads to more being killed (Thompson & Gese, 2007; Van de Ven et al., 2013). Most small carnivores are opportunists and capable of exploiting a range of habitats with varying complexities, which contributes to general lack of information on habitat complexity's influence and effect on small carnivores (Byrnes et al., 2006; Thompson & Gese, 2007).

The habitat complexity regulates the strength or effectiveness of predator-predator and predator-prey interactions (Thompson & Gese, 2007). Thus estimating competition effectiveness is harder in more complex habitats with a diverse assemblage of mammals present (Byrnes et al., 2006; Thompson & Gese, 2007). This influence of habitat complexity on intra-guild predation has been well established in arthropod (Thompson & Gese, 2007; Langellotto & Dennon, 2004; Gratton & Denno, 2003) and aquatic systems (Thompson & Gese, 2007; Hampton, 2004), but not in terrestrial vertebrate systems as such.

Traditional predator-prey models often predict that predators are most abundant in high quality prey habitat (Byrnes et al., 2006; Thompson & Gese, 2007). The cropping land use (high quality prey habitat) supports a diverse and high rodent abundance, especially in our

© University of Venda

University of Venda
Creating Future Leaders

study areas (Belmain, 2006), which can support small carnivores (Blaum et al., 2007a). The increased predation risk diminishes the advantage of habitat quality, and thus more evenly distributes the prey (Thompson & Gese, 2007; Sih, 1998). This effect has been observed in many linear trophic relationships (Thompson & Gese, 2007; Kitchell et al., 1994).

Non-linear relationship appear to be more common in natural systems (Thompson & Gese, 2007; Polis & Strong, 1996; Rosenheim et al., 1995). Behavior such as intra-guild predation has the capacity to complicate predator-prey dynamics (Thompson & Gese, 2007).

Intra-guild predation, and thus competition, between small carnivores is a powerful evolutionary force capable of influencing abundance, distribution, and behaviour (Thompson & Gese, 2007; Navarrette et al., 2000; Polis et al., 1989). There is accumulated evidence that intra-guild predation exists and plays an important role in shaping terrestrial predator guilds, but as a result of the uncertainty in reasons for the interaction most evidence stops at documenting the interaction (Thompson & Gese, 2007; Macdonald & Sillero-Zubiri, 2004).

In particular, with predation between small carnivores, where the time-based and spatial scale of two or more species must be considered (Thompson & Gese, 2007). The time of the detection (photo capture event) in camera trapping may suggest a predator-predator interaction or it might just indicate a preference (Thompson & Gese, 2007; Fedriani et al., 2000; Creel & Creel, 1996). This is also true for the non-detection or avoidance of an area where other species were detected (Thompson & Gese, 2007; Fedriani et al., 2000; Creel & Creel, 1996).

In systems where the intra-guild predation pressure is unbalanced or asymmetrical, selection is expected to favour behavioural responses by intermediate predators (Thompson & Gese, 2007; Gerber & Echternacht, 2000; Polis & McCormick, 1987). The behavioural responses that reduce the probability of an interaction with a higher-order predator is favoured (Thompson & Gese, 2007; Gerber & Echternacht, 2000; Polis & McCormick, 1987).

Similar responses have been suggested in red fox-coyote (Thompson & Gese, 2007; Voigt & Earle, 1983), coyote-wolf (Thompson & Gese, 2007; Switalski, 2003) and cheetah-lion (Thompson & Gese, 2007; Durant, 2000) interactions. The behavioural response of the

© University of Venda

University of Venda
Creating Future Leaders

intermediate predator and mechanism of avoidance were not directly addressed (Thompson & Gese, 2007).

Theoretical work has outlined two paths to system stability under intra-guild predation or, in the case of our study, competition (Thompson & Gese, 2007). One is that intermediate predators must specialize and outcompete top predators for the shared basal prey in order to persist (Thompson & Gese, 2007; Holt & Polis, 1997). The second is that intermediate predators must dissociate from the more linear top predator-basal prey relationship and do what has been termed "safety-matching", selecting habitat based on security from predation rather than resource availability (Thompson & Gese, 2007; Rosenheim, 2004; Heithaus, 2001). Domestic dogs and cats were not restricted to the settlement areas, which suggests there may have been competitive exclusion and competition with small carnivores (Glen and Dickman, 2005; Vanak and Gompper, 2010).

In our study it seems that generally, predator-prey dynamics appear to strongly conform to the second prediction where intermediate predators "safety-match" (Thompson & Gese, 2007). Different species respond differently to covariates effecting occupancy. This is shown in the total importance of the different covariates towards the large-spotted genet and the slender mongoose individually.

The small mammalian carnivores are wide ranging in habitat selection, diet preferences and adaptability level (Ćirović et al., 2016; Walker, 2009; Stuart & Stuart, 2006; Skinner & Chimimba, 2005). This combined with the secretive behaviour, make experimental research on community interactions difficult (Thompson & Gese, 2007; Switalski, 2003; Fedriani et al., 2000). The camera trapping in conjunction with occupancy studies have simplified the detection of small carnivores, but the behavioural aspects are open to interpretation.

6.2.2 Large-spotted genet

The modelling covariate that had the most impact on the large-spotted genet, at both villages, was cropping (in the habitat theme at Ka-Ndengeza and food theme at Vyeboom). This supports the prediction by Thompson & Gese (2007) that the predator will be more abundant

© University of Venda

University of Venda
Creating Future Leaders

where food is more abundant and the "safety-match" effect is also apparent. The cropping land use was the preferred habitat and also the preferred food source.

The free range poultry in the settlement land use might be tempting to the large-spotted genet as a food source (Apps, 2012). But the avoidance of a prey-rich area has been documented in wild dogs (Thompson & Gese, 2007; Mills & Gorman, 1997). In the case of the wild dogs it was done to avoid lions, the primary source of wild dog mortality (Thompson & Gese, 2007; Mills & Gorman, 1997). The large-spotted genet may also be avoiding life-threatening interactions.

Settlement areas were avoided by the large-spotted genet in Ka-Ndengeza. There might be several reasons for the avoidance that include persecution (Holmern & Røskaft, 2014), hunting pressure (Ćirović et al., 2016) and competition (Durant, 2000; Fedriani et al., 2000). The hunting for skins of this small carnivores and persecution because of the perceived threat to poultry (questionnaire results; Apps, 2012) is evident in the frequency humans having a negative impact on the large-spotted genet occupancy at Ka-Ndengeza. The frequency of poultry was identified as an important factor but, it is necessary to note that at Ka-Ndengeza no large-spotted genets were identified inside the settlement area. This could indicate that the avoidance of the settlement area, where human frequency is very high, is larger than the attraction of poultry inside the area (Thompson & Gese, 2007). Small carnivores have altered their habitat use before to avoid food supplements, a contradiction that was only explained when the higher-order predator was taken into account (Thompson & Gese, 2007; Morris, 2005). In the study it appears that the large-spotted genet follows the predictions of resource and safety matching, which was previously outlined (Rosenheim, 2004; Heithaus, 2001). This is supported by our results, where human frequency was the second most important factor with regards to large-spotted genet occupancy.

Domestic cat frequency was identified as a factor affecting large-spotted genet occupancy. The effect might not be exclusively towards the large-spotted genet but, rather a dynamic interaction of the large-spotted genet with the domestic cat's occupancy. The domestic cat frequency was 0 in the cropping areas that were identified as the large-spotted genet's preferred habitat.

© University of Venda

University of Venda
Creating Future Leaders

To this extent the competition theme that identified frequency humans and frequency domestic cats as important, supports that habitat and competition are the main driving forces of the large-spotted genet occupancy at Ka-Ndengeza.

The detection of the large-spotted genet at Vyeboom was largely impacted by the grazing land use. The most important factors with regards to large-spotted genet occupancy at Vyeboom were cropping and frequency of poultry. This could indicate that intra-guild predation effectiveness or strength is less at Vyeboom, thus food resources alone influence habitat selection.

6.2.3 Slender mongoose

The modelling of covariates that have an impact on the slender mongoose had been divided into themes that influenced its detection and occupancy. At Ka-Ndengeza the grazing land use had the largest impact on detection probability of the slender mongoose.

There can be several reasons why the slender mongoose prefer cropping areas. The first is the cropping areas are an abundant food resource (Prevedello et al., 2013; Salo et al., 2010; Blaum et al., 2007a; Belmain, 2006; Blaum et al., 2006; Andersson & Erlinge, 1977). The second is the lack of competition from domestic camivores such as the domestic cat (Dickman, 1996). The cat was not detected in the cropping land use in this study.

The third reason for this preference to cropping is the vegetation complexity (Thompson & Gese, 2007; Fedriani et al., 2000; Creel & Creel, 1996). The cropping areas generally have more open habitat, and thus more movement areas and more foot paths, as oppose to the grazing land use. The slender mongoose is active during the day along with humans, livestock, domestic dogs and domestic cats. As a result slender mongoose may have adapted its route/path to avoid predation and/or conflict interactions (Thompson & Gese, 2007).

The cropping land use maybe the preferred habitat of the slender mongoose which coincides with the availability of food in this land use (Thompson & Gese, 2007). This habitat preference could change over time due to increased predator-predator interaction/conflict. The domestic cat and the slender mongoose could be competing for the same food resources

© University of Venda

University of Venda
Creating Future Leaders

due to diet preferences, this can in turn lead to the first path of system stability under intra-guild predation (Thompson & Gese, 2007; Holt & Polis, 1997). This path suggests that the intermediate predator must specialize and outcompete the other predators for the shared basal prey in order to persist (Thompson & Gese, 2007; Holt & Polis, 1997). It could be concluded that the domestic cat is in the process of outcompeting the slender mongoose in the cropping land use. This theory is supported by the results showing that the domestic cat is an important factor to slender mongoose occupancy.

Livestock trample burrows and are also active during the day like the slender mongoose (Blaum et al., 2007a). This could account for the results indicating that the frequency livestock is an important influence in slender mongoose occupancy. The frequency of poultry had no impact on the slender mongoose at Ka-Ndengeza. This in conjunction with the frequency livestock could indicate the "safety-matching" response in the slender mongoose (Thompson & Gese, 2007).

The slender mongoose is active and detected in every land use at Vyeboom. No preference is shown to any of the different land uses with regard to detection. Food resources like cropping and frequency poultry showed some importance to the slender mongoose occupancy at Vyeboom, which further classifies it as a generalist species. The grazing and settlement habitats were somewhat important to the occupancy of the slender mongoose at Vyeboom that could indicate a shift in habitat preference or a shift to having no habitat preference. As a result it is accepted that the slender mongoose is adapted to the human-influenced habitat change. The slender mongoose could be classified as a generalist because habitat and prey had little to no impact on the slender mongoose occupancy (Sarmento et al., 2011).

6.3 Questionnaires

With the results of the Pearson's chi-squared test the reasons for the carnivore conflict can be identified as the same for both villages. Many of the people do not know that the identified animals are different species or that they eat rodents to some degree. The mammalian carnivores where most identified as just mongoose. In the Venda language there is differentiation between the dwarf and slender mongoose with regards to traditional names.

UNIVERSITY OF VENDA
LIBRARY

© University of Venda

University of Venda
Creating Future Leaders

The avian predators were hard to differentiate between except for the crows (black and white) and owls (active at night). The falcons and eagles were addressed as groups because descriptions differed widely and had a lot of uncertainty.

With this mentioned lack of information about the animals there was still an overwhelming agreement that all the animals are problem causing or negative. The most important driving force was raiding poultry, which is a general fear of the community members (Kingdon and Hoffman, 2013; Sarmento et al., 2011). Poultry is identified as their main source of protein for community members, at both villages, and a lot of money is invested in the raising of the chicks (observed). The perceived negative impact of owls is not only the eating of poultry, but also religious reasons. It is believed, by the people of both villages, that if an owl lands on your roof someone in the house will die.

There was only one person that actually killed the small carnivores (two dwarf mongooses a month) with jaw traps. The other people questioned said they would kill the animals, if they could, to protect the chickens that roam freely. The method the mongoose uses to catch the chickens, according the interviewed people of Vyeboom, is elaborate and they are called clever and hard to kill. They believe that the mongoose lifts up its tail to show the reddish to pink colour of the anus to lure the chicken to eat there. Once the chicken pecks in the opening the mongoose pinches the beak in the anus and runs off, breaking the neck of the chicken in the process.

Of the people interviewed 39.1% have lost chickens to predation by small carnivores. This percentage could be an exaggeration of small carnivore guilt (Dickman, 2010). Most members do state that they cannot be sure which animal took the poultry. It was determined through the questionnaires that the only small carnivores that have a perceived positive impact is the domestic cats and dogs. The dogs are positive because they protect the house and the cats because they eat rodents. There is an agreement with all members interviewed that even though they have cats they still have a rodent problem. Of the percentage people that own dogs only 66.7% feed their dogs daily and 58.3% of the cat owners feed their cats weekly. Hungry animals scavenge for food and could lead to poultry raiding and small mammal hunting (carnivores and rodents).

© University of Venda

University of Venda
Creating Future Leaders

CHAPTER SEVEN: CONCLUSIONS AND SUGGESTIONS

Surveys that incorporate detection probabilities in an occupancy framework provide a suitable framework and basis to conduct effective biological inventories and subsequent monitoring. This is found in our study and supported by Sarmento et al. (2011). The proportion of sites occupied is useful as a state variable in monitoring context but, some factors such as species detectability for species that are more difficult to detect should be taken into consideration. Models with detection probabilities below 0.15 did not produce valid site occupancy estimates for the current study and this made distinguishing between true absence and lower detection probabilities more difficult (MacKenzie et al., 2002; O'Connell et al., 2006; Sarmento et al., 2011).

Using clearly defined habitat factors may lead to better models to estimate small carnivore occupancy. The themes (habitat, food and competition) showed an impact on detection and occupancy but, by refining the covariates more accurate results might be obtained. A complete vegetation analysis could be done at each camera trapping site to estimate vegetation cover and the impact on occupancy (Sarmento et al., 2010).

There was a difference in impacting factors between species and between villages. An example of this is the frequency humans having an impact on the large-spotted genet at Ka-Ndengeza but not at Vyeboom. Another example is that the frequency poultry had an impact on the large-spotted genet but not the slender mongoose. The small carnivores subject to a variety of factors, are often species of concern, and the mechanism by which they avoid higher-order predation is of direct concern to management (Thompson & Gese, 2007).

The factor that had an impact on both the large-spotted genet and the slender mongoose was cropping. This could be an indication of a food resource (high rodent population) created by the cropping land use (Belmain, 2006; Andersson & Erlinge, 1977). The preliminary results indicating the cropping land use was a more selected habitat due to increased prey availability for small carnivores should be investigated by undertaking a more focused study into the rodent populations/abundance in the different land uses in this study.

© University of Venda

University of Venda
Creating Future Leaders

It is suggested that poultry be kept inside the owners property and thus providing information to community members' with regards to the perceived large-spotted genet threat to their livelihoods. A further study should be done to examine the difference in poultry lost due to predation from free range, as opposed to caged poltry and if the small carnivores are actually attempting to use the poultry as food source.

The principles of successful collaborative conflict management are communication, transparency, inclusiveness, influence and trust (Redpath et al. 2015). Communication is very important to not only share information and ideas but also to show respect and willingness to collaborate (Redpath et al., 2015). The study achieved this by following the correct protocol when approaching the community. The Chief was asked for permission to conduct the study first, followed by all the community members at the community meeting. This is where they were informed of the study and asked to participate.

Transparency from every one included in the conflict could lead to meaningful collaboration and solutions to benefit most of the people involved (Salafsky, 2011). The study was explained and thus transparency of our goals were given. The participation by some of the community members were required for the answering of the questionnaires and the protection of the cameras. Inclusiveness lets every participant feel part of the decision making process. The Chief's house (Vyeboom) and the pastor's house(Ka-Ndengeza) was included in the study because, by including relevant high authority people the discussion will be more meaningful (Richards et al., 2004). Influence is defined as someone's opinion or perspective changing or influencing another's (Young, 2000). This was achieved through explaining after the questionnaires were done, that the small carnivores do eat rodents and could be beneficial. But it is also understanding that some ecologically basel rodent management options are not viable like owls, snakes and striped polecats. This is because of religious reasons.

Trust is established through using independent mediators or facilitators in the discussion process (Reed, 2008). This final step will only be achieved after the study is done by giving the community members the necessary information to make informed choices and then discussing the way forward. With almost all of the principles achieved the starting point to successful collaborative conflict management is created.

© University of Venda

University of Venda
Creating Future Leaders

The questionnaires determined the community member's opinions of small carnivores as well as their knowledge of the small carnivores present regarding diet and general appearance. The lack of information about the two villages' small carnivore assemblages makes the community perceive the small carnivore as a threat and in some cases it is religious superstition that causes the conflict (Semenya & Potgieter, 2014). The questionnaire helped identify the reasons for the zero tolerance attitude and also served as an informal information session that provided the information about the small carnivores in the area and the benefits of having small carnivores in the area. With the questionnaire an awareness was created with the community members about how many small carnivores exist in the area and that not all of them are negative. To further mediate the conflict situation between the community members and the small carnivores more information must be provided to the communities in the format that is informative to the public.

The presence of many small carnivore species in the cropping land use, the preference of the selected small carnivores to use the cropping land use, and the literature supporting the cropping land use as a food resource for the small carnivores, indicates that the small carnivores are a viable option for ecological based rodent management. With the information provided by this study on the diet and distribution of the small carnivores, community members can be approached to implement these suggestions on a trail basis.

© University of Venda

University of Venda
Creating Future Leaders

References

Abi-Said, M. & Amr, Z., 2012. Camera trapping in assessing the diversity of mammals in Jabal Moussa Bioshere Reserve. *Vertebrate Zoology,* 62(1), pp. 145-152.

Admasu, E., Thirgood , S. J., Bekele , A. & Laurenson, K. M., 2004a. A note on the spatial ecology of African civet *Civettictis civetta* and common genet *Genetta genetta* in farmland in the Ethiopian Highlands. *African Journal of Ecology,* 42(2), pp. 160-162.

Admasu, E., Thirgood, S. J., Bekele, A. & Laurenson, M. K., 2004b. Spatial ecology of white-tailed mongoose in farmland in the Ethiopian Highlands. *African Journal of Ecology,* 42(2), pp. 153-159.

Airbus Defence and Space, 2017. *AIRBUS Intelligence*. [Online] Available at: www.astrium-geo.com

Anderson, D. R. & Burnham, K. P., 2002. Avoiding pitfalls when using information-theoretic methods. *The Journal of Wildlife Management,* 66(3), pp. 912-918.

Andersson, M. & Erlinge, S., 1977. Influence of predation on rodent populations. *Oikos,* 29(3), pp. 591-597.

Aplin, K.P., Brown, P.R., Jacob, J., Krebs, C.J. & Singleton, G.R., 2003. Field methods for rodent studies in Asia and the Indo-Pacific.

Apps, P., 2012. *Smithers' mammals of southern Africa.* Cape Town: Struik Nature.

Baptiste, A., 2016. *gridExtra: Miscellaneous Functions for "Grid" Graphics. R package version 2.2.1.* [Online] Available at: https://CRAN.R-project.org/package=gridExtra. [Accessed 12 02 2017].

Bates, D. & Maechler, M., 2016. *Matrix: Sparse and Dense Matrix Classes and Methods. R package version 1.2-4.*. [Online] Available at: https://CRAN.R-project.org/package=Matrix [Accessed 12 02 2017].

© University of Venda

University of Venda
Creating Future Leaders

Beckmann, J. P. & Berger, J., 2003. Rapid ecological and behavioural changes in carnivores: the responses of black bears (Ursus americanus) to altered food. *Journal of Zoology,* 261(2), pp. 207-212.

Belmain, S.R., 2006. Rats and human health in Africa: proceedings of an international workshop on rodent-borne diseases and the RatZooMan research project. The Natural Resources Institute, Greenwich.

Berger, K. M., 2006. Carnivore-livestock conflicts: effects of subsidized predator control and economic correlates on the sheep industry. *Conservation Biology,* 20(3), pp. 751-761.

Best, J., 2005. *Atrium Biodiversity Information System.* [Online] Available at: http://www.atrium-biodiversity.org/tools/camerabase/

Bivand, R., Keitt, T. & Rowlingson, B., 2015. *rgdal: Bindings for the Geospatial Data Abstraction Library. R package version 1.1-3.* [Online] Available at: https://CRAN.R-project.org/package=rgdal [Accessed 17 02 2017].

Bivand, R. & Lewin-Koh, N., 2015. *maptools: Tools for Reading and Handling Spatial Objects. R package version 0.8-34.* [Online] Available at: https://CRAN.R-project.org/package=maptools [Accessed 12 02 2017].

Blanco, J. C. & Cortes, Y., 2007. Dispersal patterns, social structure and mortality of wolves living in agricultural habitats in Spain. *Journal of Zoology,* 273(1), pp. 114-124.

Blaum, N., Rossmanith, E. & Jeltsch, F., 2006. Land use affects rodent communities in Kalahari savannah rangelands. *African Journal of Ecology,* 45(2), pp. 189-195.

Blaum, N., Rossmanith, E., Popp, A. & Jeltsch, F., 2007a. Shrub encroachment affects mammalian carnivore abundance and species richness in semiarid rangelands. *Actao ecologica,* 31(1), pp. 86-92.

Blaum, N., Rossmanith, E., Schwager, M. & Jeltsch, F., 2007b. Responses of mammalian carnivores to land use in arid savanna rangelands. *Basic and applied ecology,* 8(6), pp. 552-564.

© University of Venda

University of Venda
Creating Future Leaders

Boserup, E., 2005. *The conditions of agricultural growth: The economics of agrarian change under population pressure.* Transaction Publishers.

Bowland, J. M. & Perrin, M. R., 1993. Wetlands as reservoirs of small-mammal populations in the Natal Drakensberg. *South African Journal of Wildlife Research,* 23(2), pp. 39-43.

Brook, L. A., Johnson, C. N. & Ritchie, E. G., 2012. Effects of predator control on behaviour of an apex predator and indirect consequences for mesopredator suppression. *Journal of Applied Ecology,* 49(6), pp. 1278-1286.

Brown, P.R., Huth, N.I., Banks, P.B. & Singleton, G.R., 2007. Relationship between abundance of rodents and damage to agricultural crops. *Agriculture, Ecosystems & Environment*, 120(2), pp. 405-415.

Burton, A.C., Sam, M.K., Kpelle, D.G., Balangtaa, C., Buedi, E.B. & Brashares, J.S., 2011. Evaluating persistence and its predictors in a West African carnivore community. *Biological Conservation*, 144(9), pp. 2344-2353.

Byrnes, J., Stachowicz, J.J., Hultgren, K.M., Randall Hughes, A., Olyarnik, S.V. and Thornber, C.S., 2006. Predator diversity strengthens trophic cascades in kelp forests by modifying herbivore behaviour. *Ecology letters*, 9(1), pp. 61-71.

Canty, A. & Ripley, B., 2016. *boot: Bootstrap R (S-Plus) Functions. R package version 1.3-18.*. [Online] Available at: https://CRAN.R-project.org/package=boot [Accessed 12 02 2017].

Carbone, C. & Gittleman, J. L., 2002. A common rule for the scaling of carnivore density. *Science,* 295(5563), pp. 2273-2276.

Caro, T. M. & Stoner, C. J., 2003. The potential for interspecific competition among African carnivores. *Biological Conservation,* 110(1), pp. 67-75.

Cillié, B., 2013. *The mammal guide of southern Africa.* Pretoria (Gauteng): Briza.

Cincotta, R. P., Wisnewski, J. & Engelman, R., 2000. Human population in the biodiversity hotspots. *Nature,* 404(6781), pp. 990-992.

© University of Venda

University of Venda
Creating Future Leaders

Ćirović, D., Penezić, A. & Krofel, M., 2016. Jackals as cleaners: Ecosystem services provided by a mesocarnivore in human-dominated landscapes. *Biological Conservation,* 199, pp. 51-55.

Colwell, R. K., 2013. *EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.* [Online] Available at: http://purl.oclc.org/estimates. [Accessed 12 02 2017].

Colwell, R. K. & Coddington, J. A., 1994. Estimating terrestrial biodiversity through extrapolation. *Biological Sciences,* 345(1311), pp. 101-118.

Colwell, R. K., Mao, C. X. & Chang, J., 2004. Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology,* 85(10), pp. 2717-2727.

Craft, M. E., 2008. Capture and rapid handling of jackals (*Canis mesomelas* and *Canis adustus*) without chemical immobilization. *African Journal of Ecology,* 46(2), p. 214.

Creel, S. M. & Creel, N., 1996. Limitations of African wild dogs by competition with larger carnivores. *Conservation Biology*, 10(2), pp. 526-538.

Crooks, K. R., 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. *Conservation Biology,* 16(2), pp. 488-502.

Crooks, K. R. & Soule, M. E., 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature,* 400(6744), pp. 563-566.

Dalerum, F., Cameron, E. Z., Kunkel, K. & Somers, M. J., 2009. Diversity and depletions in continental carnivore guilds: implications for prioritizing global carnivore conservation. *Biology letters,* 5(1), pp. 35-38.

Dar, N. I., Minhas, R. A., Zaman, Q. & Linkie, M., 2009. Predicting the patterns, perceptions and causes of human-carnivore conflict in and around Machiara National Park, Pakistan. *Biological Conservation,* 10(142), pp. 2076-2082.

Davison, A. C. & Hinkley, D. V., 1997. *Bootstrap Methods and Their Applications,* Cambridge: Cambridge University Press. ISBN 0-521-57391-2.

© University of Venda

University of Venda
Creating Future Leaders

Dickman, C. R., 1996. *Overview of the impacts of feral cats on the Australian native fauna,* Canberra: Australian Nature Conservation Agency.

Donald, P.F., 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology*, 18(1), pp.17-38.

Durant, S. M., 2000. Living with the enemy: avoidance of hyenas and lions by cheetahs in the Serengeti. *Behavioral Ecology*, 11(6), pp. 624-632.

Fahrig, L., Baudry, J., Brotons, L., Burel, F. G., Crist, T. O., Fuller, R. J., Sirami, C., Siriwardena, G.M. & Martin, J. L., 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. *Ecology letters*, 14(2), pp. 101-112.

Fedriani, J. M., Fuller, T. K., Sauvajot, R. M. & York, E. C., 2000. Competition and intraguild predation amoung three sympartic carnivores. *Oecologia*, 125(2), pp. 258-270.

Finke, D. L. & Denno, R. F., 2002. Intraguild predation diminished in complex-structured vegetation: implications for prey suppression. *Ecology*, 83(3), pp. 643-652.

Fiske, I. & Chandler, R., 2011. unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. *Journal of Statistical Software,* 43(10), pp. 1-23.

Forman, R. T. T., 2014. *Land Mosaics: The Ecology of Landscapes and Regions (1995)*. Island Press. p. 217.

Gascon, C., Lovejoy, T.E., Bierregaard Jr, R.O., Malcolm, J.R., Stouffer, P.C., Vasconcelos, H.L., Laurance, W.F., Zimmerman, B., Tocher, M. & Borges, S., 1999. Matrix habitat and species richness in tropical forest remnants. *Biological conservation*, 91(2), pp. 223-229.

Gehring, T. M. & Swihart, R. K., 2003. Body size, niche breath, and ecologically scaled response to habitat fragmentation: mammalian predators in an agricultural landscape. *Biological Conservation,* 109(2), pp. 283-295.

Gehrt, S.D. and Clark, W.R., 2003. Raccoons, coyotes, and reflections on the mesopredator release hypothesis. *Wildlife Society Bulletin (1973-2006)*, 31(3), pp.836-842.

© University of Venda

University of Venda
Creating Future Leaders

Gerber, G. P. and Echternacht, A. C., 2000. Evidence for asymmetrical intraguild predation between native and introduced Anolis lizards. *Oecologia*, 124(4), pp. 599-607.

Gerber, B. D., Karpanty, S. M. and Kelly, M. J., 2012. Evaluating the potential biases in carnivore capture–recapture studies associated with the use of lure and varying density estimation techniques using photographic-sampling data of the Malagasy civet. *Population Ecology*, 54(1), pp.43-54.

Glen, A. S. & Dickman, C. R., 2005. Complex interactions among mammalian carnivores in Australia, and their implications for wildlife management. *Biological Reviews*, 80(3), pp. 387-401.

Gotelli, N. J. & Colwell, R. K., 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology letters,* 4(4), pp. 379-391.

Gotelli, N. J. & Colwell, R. K., 2011. Chapter 4: Estimating species richness. In: B.J. McGill & A.E. Magurran, eds. *Biological Diversity: Frontiers in measuring biodiversity.* New York: Oxford University Press, pp. 39-54.

Gratton, C. & Denno. R. F., 2003. Seasonal shift from bottom-up to top-down impact in phytophagous insect populations. *Oecologia*, 134(4), pp. 487-495.

Hampton, S. E., 2004. Habitat overlap of enemies: temporal patterns and the role of spatial complexity. *Oecologia*, 138(3), pp. 475-484.

Heitheus, M. R., 2001. Habitat selection by predators and prey in communities with asymmetrical intraguild predation. *Oikos*, 92(3), pp. 542-554.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G. & Jarvis, A., 2005. Very high resolution interpolated climate surfaces for global land areas. *International journal of climatology*, 25(15), pp. 1965-1978.

Holmern, T. & Røskaft, E., 2014. The poultry thief: Subsistence farmers' perceptions of depredation outside the Serengeti National Park, Tanzania. *African Journal of Ecology,* 52(3), pp. 334-342.

LIBRARY

© University of Venda

University of Venda
Creating Future Leaders

Holt, R. D. & Polis, G. A., 1997. A theoretial framework for intraguild predation. *American Naturalist*, 149(4), pp. 745-764.

Hunter, M. D. & Price, P. W., 1992. Playing chutes and ladders: heterogeneity and the relative roles of bottum-up and top-down forces in natural communities. *Ecology,* 73(3), pp. 723-732.

Iknayan, K. J., Tingley, M. W., Furnas, B. J. & Beissinger, S. R., 2014. Detecting diversity: emerging methods to estimate species diversity. *Trends in Ecology & Evolution,* 29(2), pp. 97-106.

IUCN, Conservation International, Arizoa State University, Texas A&M University, University of Rome, University of Virginia Zoological Society London. 2008. An Analysis of Mammals on the 2008 IUCN Red List <www.iucnredlist.org/mammals>. Downloaded on 19 December 2016.

Khorozyan, I., Soofi, M., Hamidi, A.K., Ghoddousi, A. & Waltert, M., 2015. Dissatisfaction with veterinary services is associated with leopard (*Panthera pardus*) predation on domestic animals. *PloS one*, 10(6), p.e0129221.

Kingdom, J. & Hoffman, M., 2013. *Mammals of Africa: Volume V.* New York: Bloomsbury.

Kirkpatrick, J. B., 1995. *A continent transformed: human impact on the natural vegetation of Australia.* New York: Oxford University Press..

Kitchell, J. F., Eby, L. A., He, X., Schinder, D. E. & Wright, R. A., 1994. Predator-prey dynamics in an ecosystem context. *Journal of Fish Biology*, 45, pp. 209-226.

Korpimäki, E. & Krebs, C. J., 1996. Predation and Population Cycles of Small Mammals. *BioScience,* 46(10), pp. 754-764.

Krauss, J., Bommarco, R., Guardiola, M, Heikkinen, R. K., Helm, A., Kuussaari, M., Lindborg, R., Öckinger, E., Pärtel, M. & Pino, J., 2010. Habitat fragmentation causes immediate and time-delayed biodiversity loss at different trophic levels. *Ecology Letters,* 13(5), pp. 597-605.

© University of Venda

University of Venda
Creating Future Leaders

Krebs, C. J., Gaines, M. S., Keller, B. L., Myers, J. H. & Tamarin, R. H., 1973. Population Cycles in Small Rodents. *Science,* 5 January, 179(4068), pp. 35-41.

Langellotto, G. A. & Denno, R. F., 2004. Responses of invertabrate natural enemies to complex-structured habitats: meta-analytical synthesis. *Oecologia*, 139(1), pp. 1-10.

Linkie, M. & Ridout, M. S., 2009. Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological and Environmental Statistics,* 14(3), pp. 322-337.

Litvaitis, J. A. & Villafuerte, R., 1996. Intraguild predation, mesopredator release and prey stability. *Conservation Biology,* 10(2), pp. 676-677.

Macdonald, D. W. & Sillero-Zubiri, C., 2004. Biology and conservation of wild canids. Oxford (UK): Oxford University Press.

MacKenzie, D. I. & Bailey, L. L., 2004. Assessing the Fit of Site-Occupancy Models. *Journal of Agricultural, Biological, and Environmental Statistics,* 9(3), pp. 300-318.

MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Royle, A. J. & Langtimm, C. A., 2002. Estimating site occupancy rates when detection when detection probabilities are less than one. *Ecology,* 83(8), p. 2248–2255.

MacKenzie, D. I. & Royle, J. A., 2005. Designing occupancy studies: general advice and allocating survey effort. *Journal of Applied Ecology,* 6(42), pp. 1105-1114.

Marino, J., 2003. Threatened Ethiopian wolves persist in small isolated Afroalpine enclaves. *Oryx,* 37(1), pp. 62-71.

Mateo-Tomás, P., Olea, P.P., Moleón, M., Vicente, J., Botella, F., Selva, N., Viñuela, J. and Sánchez-Zapata, J.A., 2015. From regional to global patterns in vertebrate scavenger communities subsidized by big game hunting. *Diversity and Distributions*, 21(8), pp.913-924.

Mazerolle, M. J. & Mazerolle, M. J., 2016. *AICcmodavg: Model selection and multimodel inference based on (Q)AIC(c). R package version 2.1-0.* [Online] Available at: https://cran.r-project.org/package=AICcmodavg [Accessed 12 02 2017].

© University of Venda

University of Venda
Creating Future Leaders

McDougal, P. T., Reale, D., Sol, D. & Reader, S. M., 2006. Wildlife conservation and animal temperament: causes and consequences of evolutionary change for captive reintroduced and wild populations. *Animal Conservation,* 9(1), pp. 39-48.

Mendenhall, C.D., Karp, D.S., Meyer, C.F., Hadly, E.A. & Daily, G.C., 2014. Predicting biodiversity change and averting collapse in agricultural landscapes. *Nature*, 509(7499), pp. 213-217.

Miller, B., Dugelby, B., Foreman, D., del Río, C. M., Noss, R., Phillips, M., Reading, R., Soulé, M. E., Terborgh, J. & Willcox, L., 2001. The Importance of Large Carnivores to Healthy. *Endangered Species UPDATE,* 18(5), pp. 202-210.

Mills, M. G. L. & Gorman, M. L., 1997. Factors affecting the density and distribution of wild dogs in the Kruger National Park. *Conservation Biology*, 11(6), pp. 1397-1406.

Moguel, P. & Toledo, V. M., 1999. Biodiversity conservation in traditional coffee systems of Mexico. *Conservation Biology,* 13(1), pp. 11-21.

Moran-Lopez, R., Guzman, J. M., Borrego, E. C. & Sanchez, A. V., 2006. Nest-site selection of endangered cinereous vulture populations affected by anthropogenic distrurbance: present and future conservation implications. *Animal Conservation,* 9(1), pp. 29-37.

Morris, D. W., 2005. Paradoxical avoidance of enriched habitats: have we failed to appreciate omnivores? *Ecology*, 86(10), pp. 2568-2577.

Morris, R. J., 2010. Anthropogenic impacts on tropical forest biodiversity: a network structure and ecosystem functioning perspective. *Biological Sciences,* 365(1558), pp. 3709-3718.

Navarrette S. A., Menge, B. A. & Daley, B. A., 2000. Species interactions in intertidal food web: prey or predation regulation of intermediate predators? *Ecology*, 81(8), pp. 2264-2277.

Neteler, M., Bowman, M.H., Landa, M. & Metz, M., 2012. GRASS GIS: A multi-purpose open source GIS. *Environmental Modelling & Software*, 31, pp. 124–130.

Norris, K., 2008. Agriculture and biodiversity conservation: opportunity knocks. *Conservation letters*, 1(1), pp. 2-11.

© University of Venda

University of Venda
Creating Future Leaders

Odhiambo, J. J. & Magandini, V. N., 2008. An assessment of the use of mineral and organic fertilizers by smallholder farmers in Vhembe district, Limpopo province, South Africa. African Journal of Agricultural Research. *African Journal of Agricultural Research,* 3(5), pp. 357-362.

Oehler, J. & Litvaitis, J., 1996. The role of spatial scale in understanding responses of medium-sized carnivores to forest fragmentation. *Canadian Journal of Zoology,* 74(11), pp. 2017-2079.

Ordeñana, M. A., Crooks, K. R., Boydston, E. E., Fisher, R. N., Lyren, L. M., Siudyla, S., Haas, C. D., Harris, S., Hathaway, S. A., Turschak, G. M. & Miles, A. K., 2010. Effects of urbanization on carnivore species distribution and richness. *Journal of Mammalogy*, 91(6), pp. 1322-1331.

Palomares, F., Ferreras, P., Fedriani, J. M. & Delibes, M., 1996. Spatial relationships between iberian lynx and other carnivores in an area of south-Western Spain. *Journal of Applied Ecology,* 33(1), pp. 5-13.

Palomares, F., Gaona, P., Ferreras, P. & Delibes, M., 1995. Positive effects on game species of top predators by controlling smaller predator population: an example with lynx, mongooses, and rabbits. *Conservation Biology,* 9(2), pp. 295-305.

Pebesma, E. J., 2004. Multivariable geostatistics in S: the gstat package. *Computers & Geosciences,* 30(7), pp. 683-691.

Polis, G. A. & McCormick, S. J., 1987. Intraguild predation and competition among desert scorpions. *Ecology*, 68(2), pp. 332-343.

Polis, G. A., Meyers, C. A. & Holt, R. D., 1989. The ecology and evolution of intraguild predation: potential competitors that eat each other. *Annual Review of Ecology and Systematics*, 20(1), pp. 297-330.

Polis, G. A. & Strong, D. R., 1996. Food web complexity and community dynamics. *American Naturalist*, 147(5), pp. 813-846.

© University of Venda

University of Venda
Creating Future Leaders

Power, M. E., 1992. Top-down and bottom-up forces in food webs: do plants have primacy. *Ecology,* 73(3), pp. 733-746.

Prevedello, J.A., Dickman, C.R., Vieira, M.V. and Vieira, E.M., 2013. Population responses of small mammals to food supply and predators: a global meta-analysis. *Journal of Animal Ecology*, 82(5), pp.927-936.

Prugh, L. R., Stoner, C. J., Epps, C. W., Bean, W. T., Ripple, W. J., Laliberte, A. S. & Brashares, J. S., 2009. The rise of the mesopredator. *Bioscience*, 59(9), pp. 779-791.

Purvis, A. J., Gittleman, J. L., Cowlishaw, G. & Mace, G. M., 2000. Predicting extinction risk in declining species. *Biological Sciences,* 267(1456), pp. 1947-1952.

R Core Team, 2014. *R: A language and environment for statistical computing.* [Online] Available at: http://www.R-project.org/ [Accessed January 2014].

Redpath, S. M., Bhatia, S. & Yong, J., 2014. Tilting at wildlife: reconsidering human-wildlife conflict. *Oryx. DOI: 1001017/S003O605314000799.*

Redpath, S. M., Gutiérrez, R. J., Wood, K. A. and Young, J. C. eds., 2015. *Conflicts in conservation: navigating towards solutions*. Cambridge University Press. p. 333.

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H. & Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of environmental management*, 90(5), pp.1933-1949.

Reid, W. V., 1998. Biodiversity hotspots. *Trends in Ecology & Evolution,* 13(7), pp. 275-280.

Ripple, W.J., Estes, J.A., Beschta, R.L., Wilmers, C.C., Ritchie, E.G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M.P. & Schmitz, O.J., 2014. Status and ecological effects of the world's largest carnivores. *Science*, 343(6167), p. 124-148.

Roda, A., Nyrop, J., Dicke, M. & English-Loch, G., 2000. Trichomes and spidermite webbing protect predatory mite eggs from intraguild predation. *Oecologia*, 125(3), pp. 428-435.

© University of Venda

University of Venda
Creating Future Leaders

Roemer, G. W., Gompper, M. E. & Van Valkenburgh, B., 2009. The ecological role of the mammalian mesocarnivore. *Bioscience,* 59(2), pp. 165-173.

Rosenheim, J. A., 2001. Source-sink dynamics for a generalist insect predator in habitats with strong higher-order predation. *Ecological Monographs*, 71(1), pp. 93-116.

Rosenheim, J. A., Kaya, H. K., Ehler, L. E., Marois, J. J. & Jaffee, B. A., 1995. Intraguild predation among biological-control agents: theory and evidence. *Biological Control*, 5(3), pp. 303-335.

Rosenzweig, M.L., 1995. *Species diversity in space and time*. Cambridge University Press.

Rutherford, M. C. & Mucina, L., 2006. *The vegetation of South Africa, Lesotho and Swaziland.* 19 ed. Pretoria(Gauteng): SANBI.

Salafsky, N., 2011. Integrating development with conservation: a means to a conservation end, or a mean end to conservation? *Biological Conservation,* 144(3), pp. 973-978.

Salo, P., Banks, P. B., Dickman, C. R. & Korpimaki, E., 2010. Predator manipulation experiments: impacts on populations of terrestrial vertebrate prey. *Ecological Monographs,* November, 80(4), pp. 531-546.

Sarmento, P. B., Cruz, J., Eira, C. & Fonseca, C., 2011. Modeling the occupancy of sympatric carnivorans. *European Journal of Wildlife Research,* 57(1), pp. 119-131.

Schuette, P., Wagner, A. P. & Creel, S., 2013. Occupancy patterns and niche partitioning within a diverse carnivore community exposed to anthropogenic pressures. *Biological Conservation,* 158, pp. 301-312.

Semenya, S. S. & Potgieter, M. J., 2014. Bapedi traditional healers in the Limpopo Province, South Africa: Their socio-cultural profile and traditional healing practice. *Journal of Ethnobiology and Ethnomedicine,* 10(4), pp. 1-12.

Shannon, G., Lewis, J. S. & Gerber, B. D., 2014. Recommended survey designs for occupancy modelling using motion-activated cameras: insights from empirical wildlife data. *PeerJ 2:e532 DIO: 10.7717/peerj.532.*

© University of Venda

University of Venda
Creating Future Leaders

Sih, A., 1998. Game theory and predator-prey response races. In: L. A. Dugatin and H. K. Reeve, eds. *Game theory and animal behavior.* New York: Oxford University Press, pp. 221-238.

Skinner, J. D. & Chimimba, C. T., 2005. *The mammals of southern African subregion.* Cambridge: Cambridge University Press.

Smith, M. J., White, A., Lambin, X., Sherratt, J. A. & Begon, M., 2006. Delayed density-dependent season length alone can lead to rodent population cycles. *The American Naturalist*, 167(5), pp. 695-704.

Sodhi, N. S., Brook, B. W. & Bradshaw, C. J., 2009. Causes and consequences of species extinctions. *The Princeton Guide to Ecology,* 1, pp. 514-520.

Soil Classification Working Group and Macvicar, C.N., 1991. *Soil classification: a taxonomic system for South Africa.* Department of Agricultural Development. Pretoria.

Songorwa, A. N., 1999. Community-Based Wildlife Management (CWM) in Tanzania: Are the Communities Interested? *Wold development,* 27(12), pp. 2061-2079.

South African Committee of Stratigraphy (SACS) (compiled by Kent, L.E.), 1980. Stratigraphy of South Africa. Part 1. Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda. *Handb. Geol. S. Afr.* 8. pp. 1-690.

Stuart, C. & Stuart, T., 2006. *Field guide to the larger mammals of Africa.* Cape Town (Eastern Cape): StruikNature.

Switalski, T. A., 2003. Coyote foraging ecology and vigilance in response to gray wolf reintroduction in Yellostone National Park. *Canadian Journal of Zoology*, 81(6), pp. 985-993.

Symmank, M. E., Comer, C. E., and Kroll, J. C., 2008. Estimating Bobcat Abundance in East Texas Using Infrared-triggered Cameras. *Faculty Publications*, Paper 294, pp. 64-69. http://scholarworks.sfasu.edu/forestry/294

© University of Venda

University of Venda
Creating Future Leaders

Tabeni, S. & Ojeda, R. A., 2005. Ecology of the Monte desert small mammals in disturbed and undisturbed habitats. *Journal of Arid Environmental,* 63(1), pp. 244-255.

Terborgh, J., 2000. The fate of tropical forest: a matter of stewardship. *Conservation Biology,* 14(5), pp. 1358-1361.

Therneau, T., 2015. *A Package for Survival Analysis in S. version 2.38.* [Online] Available at: http://CRAN.R-project.org/package=survival [Accessed 12 02 2017].

Therneau, T. M. & Grambsch, P. M., 2000. *Modeling Survival Data: Extending the Cox Model.* New York: Springer. ISBN 0-387-98784-3.

Thompson, C. M. & Gese, E. M., 2007. Food webs and intraguild predation: community interactions of a native mesocarnivore. *Ecology*, 88(2), pp. 334-346.

Thorn, M., Green, M., Bateman, P. W., Waite, S. & Scott, D. M., 2011. Brown hyaenas on roads: estimating carnivore occupancy and abundance using spatially auto-correlated sign survey replicates. *Biological Conservation*, 144(6), pp. 1799-1807.

Tobler, M. W., 2007. *Camera base version 1.3.* [Online] Available at: http://www.atrium - biodiversity.org/tools/camerabase/. [Accessed 21 03 2014].

Treves, A., Wallace, R. B., Naughton-Treves, L. & Morales, A., 2006. Co-managing human–wildlife conflicts: a review. *Human Dimensions of Wildlife,* 11(6), pp. 383-396.

Tshiala, M. F., Olwoch, J. M. & Engelbrecht, F. A., 2011. Analysis of temperature trends over Limpopo Province, South Africa. *Journal of geography and geology,* 3(1), pp. 13-21.

Ugland, K. I., Gray, J. S. & Ellingsen, K. E., 2003. The species–accumulation curve and estimation of species richness. *Journal of Animal Ecology,* 72(5), pp. 888-897.

Van de Ven, T. M., Tambling, C. J. and Kerley, G. I., 2013. Seasonal diet of black-backed jackal in the Eastern Karoo, South Africa. *Journal of arid environments*, 99, pp.23-27.

Van Jaarsveld, A. S., Freitag, S., Chown, S. L., Muller, C., Koch, S., Hull, H., Bellamy, C., Krüger, M., Endrödy-Younga, S., Mansell, M. W. & Scholtz, C. H., 1998. Biodiversity assessment and conservation strategies. *Science*, 279(5359), pp. 2106-2108.

© University of Venda

University of Venda
Creating Future Leaders

Vanak, A. T. and Gompper, M. E., 2010. Interference competition at the landscape level: the effect of free-ranging dogs on a native mesocarnivore. *Journal of Applied Ecology*, 47(6), pp. 1225-1232.

Venables, W. N. & Ripley, B. D., 2002. *Modern Applied Statistics with S.* 4 ed. New York: Springer. ISBN 0-387-95457-0.

Verdade, L. M. & Dotta, G., 2011. Medium to large-sized mammals in agricultural landscapes of south-eastern Brazil. *Mammalia,* 75(4), p. 345.

Verdade, L. M., Rosalino, L. M., Gheler-Costa, C., Pedroso, N. M. & Lyra-Jorge, M. C., 2011. Adaptation of mesocarnivores (Mammalia: Carnivora) to agricultural landscapes of Mediterranean Europe and Southeastern Brazil: a trophic perspective. Middle-sized carnivores in agricultural landscapes. *Nova Science Publishers*, New York, pp. 1-38.

Voigt, D. R. & Earle, B. D., 1983. Avoidance of coyotes by red fox families. *Journal of Wildlife Management*, 47(3), pp. 852-857.

Walker, C., 2009. *Signs of the wild.* Cape Town (Eastern Cape): StruikNature.

Whitman, K., Starfield, A. M., Quadling, H. S. & Packer, C., 2004. Sustainable trophy hunting of African lions. *Nature,* 428(6979), pp. 175-178.

Wickham, H., 2007. Reshaping data with the reshape package. *Journal of Statistical Software,* 21(12), pp. 1-20.

Wickham, H., 2009. *ggplot2: elegant graphics for data analysis,* New York: Springer, 1(2), p. 3.

Wickham, H., 2011. The Split-Apply-Combine Strategy for Data Analysis. *Journal of Statistical Software,* 40(1), pp. 1-29.

Wickham, H., 2016. *scales: Scale Functions for Visualization. R package version 0.4.0.* [Online] Available at: https://CRAN.R-project.org/package=scales [Accessed 15 01 2017].

© University of Venda

University of Venda
Creating Future Leaders

Wickham, H. & Francios, R., 2015. *dplyr: A Grammar of Data Manipulation. R package version 0.4.3.* [Online] Available at: https://CRAN.R-project.org/package=dplyr [Accessed 15 01 2017].

Wright, S. J., Gompper, M. E. & DeLeon, B., 1994. Are large predators keystone species in neotropical forest? The evidence from barro Colorado Island. *Oikos,* 71(2), pp. 279-294.

Young, I. M., 2000. *Inclusion and democracy.* Oxford, Oxford University Press.

© University of Venda

University of Venda
Creating Future Leaders

APPENDIX A: Meso-predator classification and photo index, used with the questionnaires for clear identification of different species to the community members (Kingdon & Hoffmann, 2013).

Cohort: FEREUUNGULATA

Superorder: FERAE

Order: CARNIVORA

Suborder: CANIFORMIA

1. Family: CANIDAE

1.1. Genus: *Canis*

Species: *C. mesomelas*

Common: Black-backed Jackal



© University of Venda

1.2. Genus: *Vulpes*

Species: *V. chama*

Common: Cape Fox



1.3. Genus: *Otocyon*

Species: *O. megalotis*

Common: Bat-eared Fox



© University of Venda

University of Venda
Creating Future Leaders

2. Family: MUSTELIDAE

Subfamily: ICTONYCHINAE

2.1. Genus: *Ictonyx*

Species: *I. striatus*

Common: Zorilla



2.2. Genus: *Poecilogale*

Species: *P. albinucha*

Common: African Striped Weasel



Subfamily: MELLIVORINAE

2.3. Genus: *Mellivora*

Species: *M. capensis*



© University of Venda

University of Venda
Creating Future Leaders

3. Family: FELIDAE

Subfamily: FELINAE

Tribe: FELINI

3.1. Genus: *Caracal*

Specie: *C. caracal*

Common: Caracal



3.2. Genus: *Leptailurus*

Species: *L. serval*

Common: Serval



LIBRARY

© University of Venda

University of Venda
Creating Future Leaders

3.3. Genus: *Felis*

Species: *F. nigripes*

Common: Black-footed Cat



3.4. Genus: *Felis*

Species: *F. silvestris*

Common: African Wildcat



© University of Venda

University of Venda
Creating Future Leaders

4. Family: VIVERRIDAE

Subfamily: GENETTINAE

4.1. Genus: *Genetta*

Species: *G. genetta*

Common: Small-spotted Genet



4.2. Genus: *Genetta*

Species: *G. maculata*

Common: Large-spotted Genet



Subfamily: VIVERRINAE

4.3. Genus: *Civetictis*

Species: *C. civetta*

Common: African Civet.



© University of Venda

University of Venda
Creating Future Leaders

Subamily: HERPESTIDAE

Subfamily: HERPESTINAE

5.1. Genus: *Atilax*

Species: *A. paludinosus*

Common: Marsh Mongoose



5.2. Genus: *Herpestes*

Species: *H. sanguineus*

Common: Slender Mongoose



5.3. Genus: *Bdeogale*

Species: *B. crassicauda*

Common: Bushy-tailed Mongoose



5.4. Genus: *Rhynchogale*

Species: *R. melleri*

Common: Meller's Mongoose



© University of Venda

University of Venda
Creating Future Leaders

5.5. Genus: *Cynictis*

Species: *C. penicillata*

Common: Yellow Mongoose



5.6. Genus: *Paracynictis*

Species: *P. selousi*

Common: Selous's Mongoose



5.7. Genus: *Ichneumia*

Species: *I. albicauda*

Common: White-tailed Mongoose





© University of Venda

University of Venda
Creating Future Leaders

Subfamily: MUNGOTINAE (Social Mongooses)

5.8. Genus: *Mungos*

Species: *M. mungo*

Common: Banded Mongoose



5.9. Genus: *Helogale*

Species: *H. parvula*

Common: Dwarf Mongoose



© University of Venda

University of Venda
Creating Future Leaders

APPENDIX B: Community questionnaire used for small carnivore surveys in the two villages Vyeboom and Ka-Ndengeza, Limpopo.

1) Have you seen any of these carnivores/animals? **2) How often?** **3) Kill rodents?**

Mongooses

- Banded mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Dwarf mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Slender mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Yellow mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- White tailed mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Water/Marsh mongoose Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure

Jackal

- Black backed jackal Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure

Genets/Civet/polecats

- African civet Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Small spotted genet Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Striped polecat Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure

Felids/other

- Caracal Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Serval Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- African wildcat Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Honey badger Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- House cats Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- House dogs Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure

Birds of Prey

- Eagles Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Falcons Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Owls Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure
- Crows Yes/No/Unsure Daily/weekly/monthly/>monthly Yes/No/Unsure

© University of Venda

	4) Do they impact you negatively?	5) Why?	6) Nr
Mongooses			
• Banded mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
• Dwarf mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
• Slender mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
Yellow mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
White tailed mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
Water/Marsh mongoose	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……
Jackal			
• Black backed jackal	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
Genets/Civet/polecats			
• African civet	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Small spotted genet	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Striped polecat	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
Felids/other			
• Caracal	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Serval	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• African wildcat	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Honey badger	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• House cats	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• House dogs	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
Birds of Prey			
• Eagle	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Falcon	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Owls	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..
• Crows	Yes/No/Unsure	Kill poultry /Kill pets /Ethnic; religious	Nr……..

© University of Venda

University of Venda
Creating Future Leaders

7) Are any carnivores killed? **8) Why?** **9) Nr**

Mongooses

- Banded mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Dwarf mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Slender mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Yellow mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- White tailed mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Water/Marsh mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..

Jackal

- Black backed jackal Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..

Genets/Civet/polecats

- African civet Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Small spotted genet Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Striped polecat Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..

Felids/other

- Caracal Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Serval Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- African wildcat Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Honey badger Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- House cats Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- House dogs Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..

Birds of Prey

- Eagle Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Falcon Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Owls Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..
- Crows Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious Nr……..

© University of Venda

University of Venda
Creating Future Leaders

9) Are any of the carnivores good for community? 10) Why?

Mongooses

- Banded mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Dwarf mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Slender mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Yellow mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- White tailed mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Water/Marsh mongoose Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious

Jackal

- Black backed jackal Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious

Genets/Civet/polecats

- African civet Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Small spotted genet Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Striped polecat Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious

Felids/other

- Caracal Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Serval Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- African wildcat Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Honey badger Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- House cats Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- House dogs Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious

Birds of prey

- Eagles Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Falcons Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Owls Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious
- Crows Yes/No/Unsure Kill poultry /Kill pets /Ethnic; religious

© University of Venda

University of Venda
Creating Future Leaders

11) Do you own: **12) How many?** **13) Do you feed them?**

- Cat Yes/No/Communally owned Male: …….. Female: …… Yes/No Daily/Weekly/>
- Dog Yes/No/Communally owned Male: …….. Female: …… Yes/No Daily/Weekly/>

13) You don't have a rodent problem because you have cats? Yes/No/UN

14) Does cat bring prey to house? Yes/No **15) What?** Birds /Reptiles /Rodents /Other ……..

16) Do you own livestock? **17) Do you own poultry?** **18) Are poultry free ranging?**

- Cattle Nr……. Chickens Nr…….. Yes
- Pigs Nr……. Geese Nr…….. No
- Sheep/goats Nr…… Other Nr…….. Where do they sleep……..

19) Is poultry and important protein source? Yes/No

UNIVERSITY LIBRARY

© University of Venda