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Wildlife Trust

A PRELIMINARY SURVEY OF CARNIVORES (MAMMALIA: CARNIVORA) IN THE MATOBO HILLS, ZIMBABWE.

Slender mongoose © DWT

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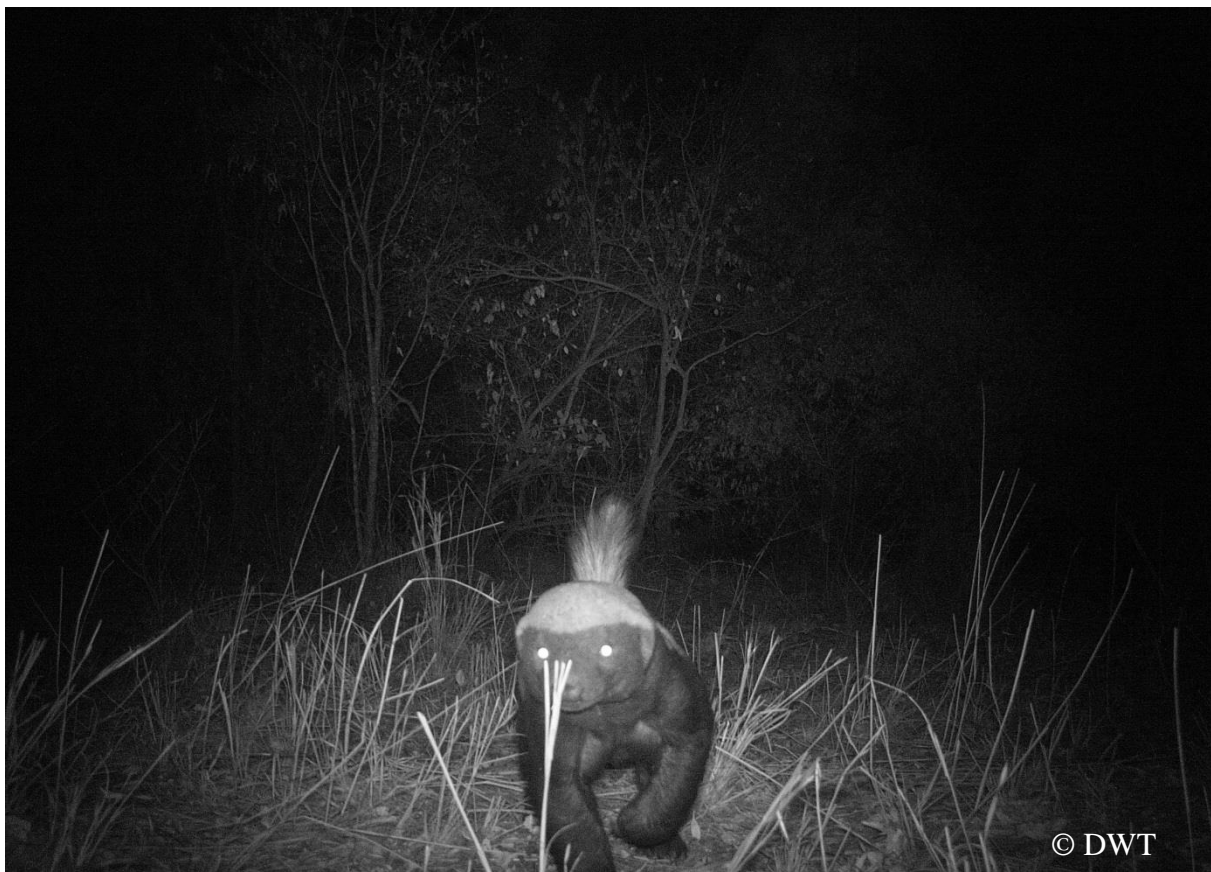
Photo 1: Honey badger or ratel (*Mellivora capensis*) investigating a camera.

1 Executive summary

Little published information on the carnivore assemblage of the Matobo Hills World Heritage Site (MHWHS) in Zimbabwe is available and no known systematic survey of carnivores in that ecosystem has previously been undertaken. This survey aimed to develop a contemporary inventory of carnivores present in the Matobo Hills, investigate species' distributions in relation to land use and habitat, record recent human-carnivore conflict and attitudes towards carnivores, and make recommendations to the MHWHS steering committee for management and conservation of this important group of mammals.

The survey was carried out primarily in the latter half of 2013, using a combination of infra-red triggered camera traps (47 sites sampled; 1524 trap days) and structured interviews (76 reliable respondents) across a 65 km E-W transect spanning the bulk of the northern section of the MHWHS. In addition, data spanning the period 1900 to 2014 were acquired from the Bulawayo Natural History Museum, the literature, anecdotal records and other research projects. These historical data were used to provide a baseline of species presence and, where possible, an indication of historical abundance, in the Matobo Hills.

Historical data recorded a total of 25 species of wild carnivore in the Matobo Hills, although three species - lion (*Panthera leo*), cheetah (*Acinonyx jubatus*) and African wild dog (*Lycaon pictus*) were considered to be transitory. In the current survey, with the exception of lion, all species previously recorded were detected through interviews and / or camera trap photographs.

Insufficient data were available to test for habitat associations for all but eight species. Tree density was significantly positively associated with slender mongoose (*Herpestes sanguineus*) presence, but no other habitat variables were significant for any species. The odds that carnivores were reported by residents of the Matobo Hills was higher for species that were disliked, suggesting that records from questionnaire surveys may be biased towards conspicuous species that are perceived to be problematic. The degree of habitat specialisation of species was extracted as a significant determinant of detection by camera traps.

Similar species richness was recorded for human-modified land uses (communal and resettlement areas) and areas of low human density (extensive livestock rangelands and wildlife areas), but species assemblages differed slightly. For example, civet (*Civettictis civetta*), honey badger (*Mellivora capensis*), Cape clawless otter (*Aonyx capensis*) and water mongoose (*Atilax paludinosus*) were only recorded in areas of low human density, whilst Selous' and Meller's mongoose were not recorded in livestock or wildlife areas in this study. The most widespread species, in terms of distribution across land uses and relative abundance, were genets (*Genetta* spp.), slender mongoose and black-backed jackal (*Canis mesomelas*).

Thirty-four of 67 livestock owners reported livestock losses in the year preceding the survey. The vast majority of losses were of poultry, with the primary culprits being slender mongoose and African wild cat (*Felis silvestris cafra*), but civet, genets and other diurnal mongooses were also identified as poultry raiders. Leopard (*Panthera pardus*) and spotted hyaena were responsible for goat, cattle and donkey depredation. Jackals (*Canis* spp.) and cheetah also took goats. Attitudes towards carnivores were significantly more positive for people that did not own livestock or who had alternative sources of income, indicating that the threshold of tolerance is linked to economic factors.

Residents of the Matobo Hills believed most carnivore species to be increasing or stable, although a proportion of respondents suggested a decline in five species – black-backed jackal, African wild dog, slender mongoose, white-tailed mongoose (*Ichneumon albicauda*) and leopard – and the status of civet, cheetah, caracal (*Caracal caracal*) and Selous' mongoose (*Paracynictis selousi*) were unknown. Reasons given for perceived increasing populations in human environments included predators leaving protected areas that had depauperate wild prey populations, non-utilisation of carnivores by people, and high carnivore reproductive rates. Offtake of carnivores was not formally investigated in this study, but some respondents reported removal of individuals through retaliation following livestock losses (primarily African wild cat),

trapping for unspecified reasons (caracal) and accidental bycatch in traps set for hyraxes (genets, small mongooses).

Few respondents provided information on Indigenous Knowledge Systems (IKS) and traditional beliefs concerning carnivores. Recorded uses were of spotted cats (leopard, cheetah), civet and genet skins for traditional ceremonies and use by the elite members of society; carnivore skins for blankets and karosses; and hyaena parts (particularly the tail) used by thieves and witches for nefarious activities. Use of the totem system, in which animals that are a family's totem are actively or passively protected by that family, was not strongly evident.

Whilst there was little indication of severe declines in any carnivore species, there appeared to be a trend of increasing conflict with predators, particularly spotted hyaena. There is need to provide additional information to people in the Matobo Hills about the roles and values of carnivores in ecosystem functioning and revenue earning for the country. In addition, effective, inexpensive and culturally-acceptable livestock management practices should be implemented to reduce livestock depredation. This is particularly important in resettled areas where nocturnal kraaling of livestock is not commonly practised, and leopard and hyaena populations appear to be on the increase. Finally, it is recommended that IKS and belief systems concerning carnivores be formally documented, as there are indications of attrition of traditional ecosystem management practices.

Photo 2: Banded mongoose (*Mungos mungo*) fossicking for insects.

2   Introduction

Successful biodiversity conservation is contingent on the availability of adequate data concerning species richness, abundance and distributions, and understanding how ecosystem components interact. Mesocarnivores, that is, the smaller members (<20 kg) of the order Carnivora, are a diverse but little-understood group in Africa. However, they are vital components of natural and agrarian ecosystems worldwide, carrying out critical ecosystem services (Anderson & Katz, 1993; Dickman, 2005; Zhou *et al.*, 2008).

In spite of their ecological value, mesocarnivores are poorly known in Zimbabwe. This is due, in part, to the difficulties involved in detecting or censusing them – particularly the small and nocturnal species. Detailed work was carried out by Smithers prior to the 1980s in Mashonaland Province (Smithers & Wilson, 1979) and Botswana (Smithers, 1971), but relatively few data for southern Zimbabwe and the Matobo Hills in particular are available. Unpublished reports and draft book chapters indicated a total of 24 species present in the Matobo Hills (F.P.D. Cotterill, unpubl. data) based on anecdotal records, the literature, Museum records and personal observations (F.P.D. Cotterill, *in litt.*, 8 May 2013).

The Matobo Hills are a UNESCO World Heritage Site (cultural landscape) with multiple land use systems and a human habitation history exceeding 40,000 years. Approximately 40% of the area is subsistence agro-pastoralist land, where food insecurity is high (c. 20% - Zimbabwe Vulnerability Assessment Committee, 2010). Sustainable conservation – a requirement for retaining World Heritage status – is therefore reliant on a suitable management plan, which must be based on accurate biodiversity and environmental data. However, the paucity of knowledge concerning most carnivores hampers holistic management implementation. Carnivores fulfil important ecological roles, but outside of protected areas can come into conflict with humans through depredation of livestock and the spread of zoonoses (Gillingham & Lee, 1999; Campbell, 2000; Treves & Karanth, 2003; Lindsey, du Toit & Mills, 2004, 2005; Dickman, 2005; Woodroffe & Frank, 2005; Woodroffe *et al.*, 2007; Romañach, Lindsey & Woodroffe, 2007; De Luca & Mpunga, 2013; Siemer *et al.*, 2014). Conversely, benefits they provide include control of pests such as rodents in granaries and avian pests of cereal crops (Dickman, 2005). Further, carnivores such as leopard (*Panthera pardus*) generate important eco- and consumptive tourism revenue (Grant, 2012).

This study was initiated to gather baseline data on the carnivore guild of the Matobo Hills, with particular emphasis on the smaller species (mesocarnivores). The aims were to: (i) record which species are present in the area and compare this with historical data, (ii) where possible, identify habitat- and / or land use associations of species, (iii) record indigenous beliefs concerning carnivores, (iv) record levels of human-carnivore conflict, and (v) make conservation recommendations within the aims of the World Heritage Site management plan, based on the data collected. Data were collected via semi-structured interviews with residents and property owners in the Matobo Hills, with independent corroboration using infrared-triggered camera traps.

In recent years, the use of infrared-triggered camera traps has grown phenomenally across the globe (Barea-Azcón *et al.*, 2007; Tobler *et al.*, 2008; Kays *et al.*, 2010; Pettorelli *et al.*, 2010; Bird & Mateke, 2013). This non-invasive method enables large areas to be sampled with relatively little manpower (Silveira, Jacomo & Diniz-Filho, 2003; Gompper *et al.*, 2006; Barea-Azcón *et al.*, 2007; Lyra-Jorge *et al.*, 2008), and generates verifiable data. Although initial equipment costs are relatively high, cost-effectiveness in the long term is good (Silveira *et al.*, 2003). With suitable experimental design for the research question (Mackenzie & Royle, 2005; Bailey, MacKenzie & Nichols, 2013), it is a highly effective way to generate species inventories, determine distributions, occupancy and relative abundance and to obtain demographic data (Silveira *et al.*, 2003; Rovero, Tobler & Sanderson, 2010; Ancrenaz *et al.*, 2012). A drawback to camera traps is that detectability of species varies with habitat, body size and behaviour (Gompper *et al.*, 2006; Harmsen *et al.*, 2010), with the result that smaller, fast-moving species in dense habitats may be under-represented.   Another frequently used method for carnivore research involves questionnaire surveys. They have the advantage of being relatively inexpensive (Gros, 1996, 1998; Gros, Kelly & Caro, 1996; Foley *et al.*, 2004) and enable the collection of a large quantity of ancillary data such as tolerance levels and perceived trends (Gros, 1997; Anadón, Giménez &

Ballestar, 2010; Williams, 2011). However a disadvantage is that quantification is subjective and the expertise and memory of respondents is highly variable, which makes calibration of reliability difficult (but see Anadón *et al.*, 2010). Thus, the use of multiple methods allows cross-validation and compensates for biases due to variable detectability across species and methods (Silveira *et al.*, 2003; Zielinski *et al.*, 2006; Elliott, 2007; Pettorelli *et al.*, 2010).

3   Methods
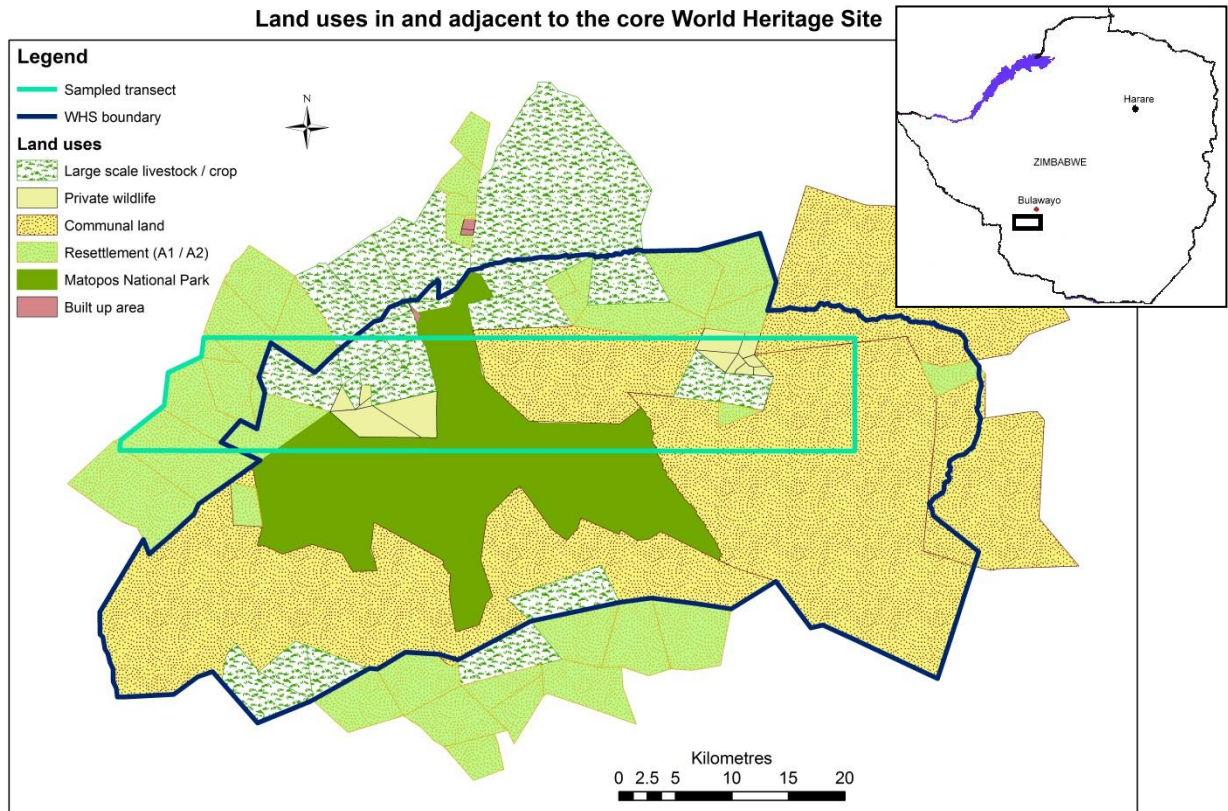
Figure 1: Map of the study area, showing main land uses and the sampled transect. Inset: Map of Zimbabwe showing the position (black rectangle) of study area.

3.1   Study site

The study was conducted in approximately 23% of the Matobo Hills area (total area 3100 km²) in semi-arid southern Zimbabwe (Fig. 1). The bulk of the Matobo Hills were proclaimed a UNESCO World Heritage Site (Cultural Landscape) in 2003. The area is characterised by large granite outcrops (dwalas and kopjes in local parlance) interspersed with vegetated valleys. Valley floors comprise open to medium-density deciduous woodland, seasonal wetlands (vleis or dambos) dominated by tall grasses, and croplands and livestock rangelands in inhabited areas. Land use types comprise subsistence farming (crop) areas with rock outcrops and livestock rangelands interspersed (c. 35% of area), a National Park protected area (c. 17% of area) and extensive cattle ranching or wildlife farming / hunting areas (hereafter referred to as commercial ranches, c. 48% of area) (Fig. 1). A number of commercial cattle ranches, particularly in the west of the Matobo Hills, were converted to A1-model resettlement between 2000 and 2013. The A1 resettlement model is similar to communal areas; i.e. families are provided with a small plot (typically several hectares in size) for their homesteads and cropping, and communal rangelands for livestock are established close to villages.

3.2   Development of a historic species inventory

Historical data – both in terms of species presence and locality – were obtained from the Bulawayo Natural History Museum, previous (known) surveys or studies, and the literature.

Natural History Museum, Bulawayo

Records of carnivores between 20°S and 21°S and 27.5°E and 29°E were obtained from accession and collection cards held at the Museum. All relevant data were recorded, including species, locality, date of collection, age / sex of the specimen and collector's name, but excluding measurements (Appendix 1). The majority of cards gave localities at QDS (quarter degree square) resolution, but where possible, finer-scale coordinates were estimated from property names or site descriptions. For those records without detailed coordinates (often from roadkill submitted by civilians), best guess coordinates were derived from site descriptions.
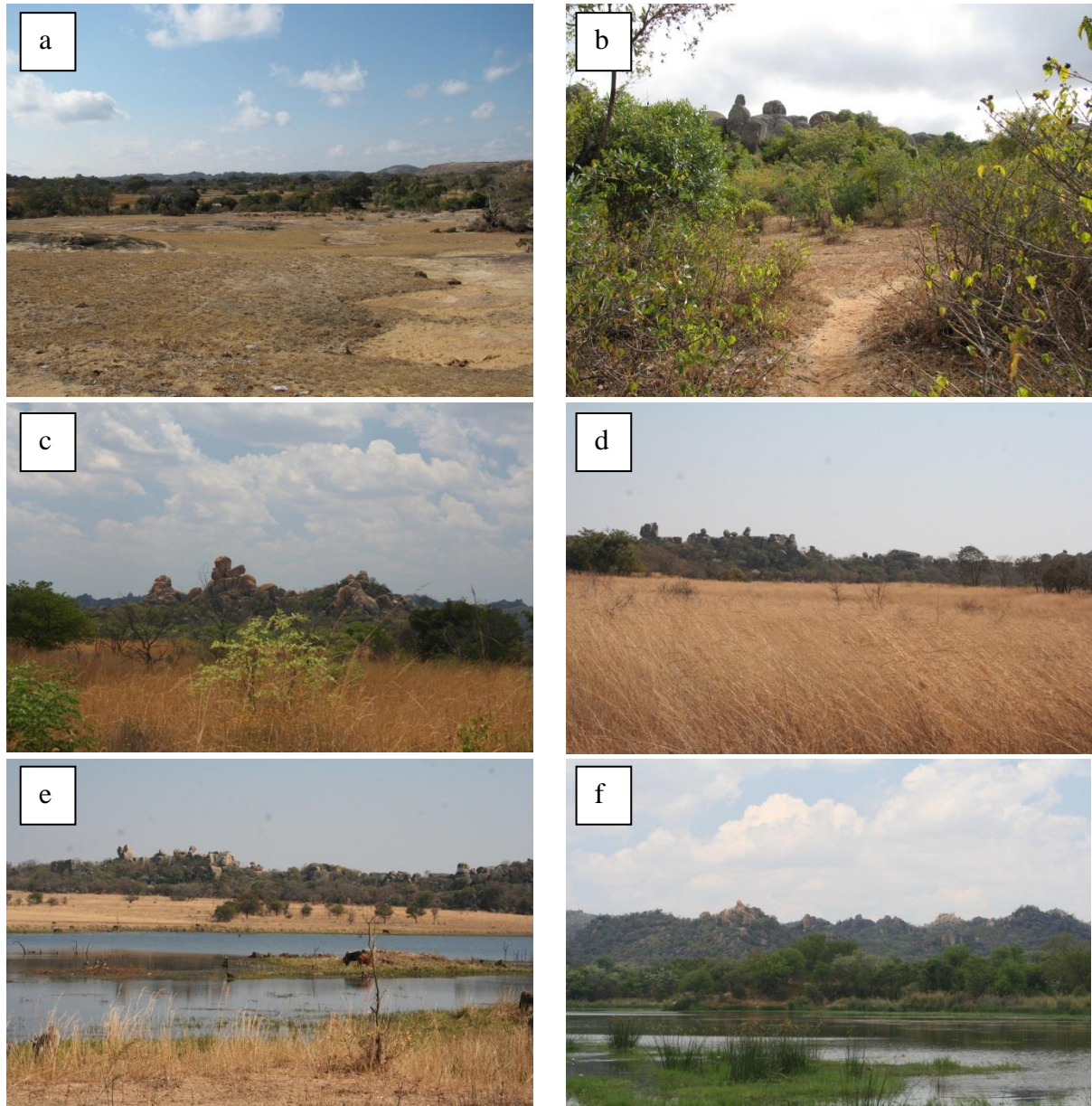
Photo 3: Typical habitats in the Matobo Hills: (a) heavily utilised communal rangeland, (b) communal rangeland / thicket dominated by *L. camara* and unpalatable shrubs, (c) open woodland / grassland in a protected (wildlife) area, (d) grassland in A1 resettlement, (e) dam utilised by livestock in A1 resettlement, and (f) dam in protected (wildlife) area.

3.3   *Data from other projects*

Locality data for carnivores were provided from a 2010 leopard camera-trap study carried out in a 200 km^2 area of Mangwe District (T. Grant, *in litt.*), centred on 20.86 °S 28.07 °E. Cameras were set up at approximately 20 km intervals, usually at sites baited for leopard (Grant, 2012).

Data were also derived from a joint DWT / Parks and Wildlife Management Authority rhino monitoring project in the Matopos National Park. This project utilised up to 24 cameras per deployment at a total of 77 sites monitored between July 2011 and July 2014.

Although data from both the Marula and Matopos National Park camera trap surveys were relatively recent, differences in deployment heights, camera settings (e.g. trigger delays, images per trigger event), camera spacing and camera type probably impacted on detection probability, so data were not pooled with those of the current study for statistical analysis.

3.4 This study

3.4.1 Camera trap survey:

Sampling was carried out along a 65 km x 10 km band at a latitude of 20.5°S, running from the western boundary of the World Heritage Site in the west to 3 km East of the Mtshabezi River in the East (Fig. 1). This band was subdivided into 5 km by 5 km grid blocks. Using a stratified sampling system to ensure proportional representation of all major land-uses within the Matobo Hills area, two sample sites per grid block were selected using Google Earth imagery (Google Inc., 2013), and their localities uploaded to a handheld Garmin ETrex GPS device (Garmin Ltd, 2000-2004).

Where possible, sites were located at least 2 km apart to reduce the probability of double-counting individual carnivores. *A priori* assessment of land use categories from maps, Google Earth imagery (Google Inc., 2013) and information from local officials and residents indicated the following proportional representation of each land use in the sample: 62% of sites in inhabited areas (communal lands and A1-model resettled farms), 26% in wildlife areas (National Park and private wildlife / photographic tourism) and 12% on commercial livestock farms. This proportional representation was achieved (Chi-square test; $X^2 = 0.56$, $p > 0.1$).

The bulk of sampling was carried out in the dry season (June to October) when undergrowth was reduced, ambient temperatures were relatively low and the probability of detection of small species was high; however, some sites were sampled later due to logistical challenges. Up to fourteen cameras were deployed per month, with a total of 50 sites sampled but three of these did not generate data due to damage to or theft of cameras. At

Photo 4: Camera traps were positioned close to the ground to detect small carnivores, and placed in protective metal boxes.

each sample point, a single Bushnell TrophyCam ® digital camera trap (with infrared flash to prevent trap shyness) was used. Cameras were set up along established wildlife or livestock trails, at an angle of between 0° and 90° to the trail and a height of 20 to 40 cm above ground level to improve the probability of detection of small, fast-moving animals. Trap sites were not baited, but one camera was set up near a baited live trap. Cameras were set to their highest resolution (8 MP), with two images taken per trigger event and a 30-second interval between sensor triggers. According to the manufacturer, trigger speed was in the region of 0.3 s (Bushnell Outdoor Products, Kansas).

At each site, a rapid habitat assessment was carried out in front of, behind and at right angles to the camera position. Variables recorded were: (i) habitat type (woodland/ grassland / bare

ground), (ii) tree density (nil, low, medium, high – based on a reference diagram produced in-house) and dominant tree species, (iii) herbaceous layer development (absent, height classes), (iv) substrate type (sand, rock, clay, water) and (v) visibility distance, measured by determining the proportion of a black-and-white checkerboard held 50 cm above ground visible at 10 m from the camera.

Cameras were left in place for a mean of 30 days; operational days ranged from 10 to 59 days per site.   At the end of each site's sampling period, images on digital memory cards were downloaded, animals photographed were identified, and images were catalogued in a custom Microsoft Access database. Multiple photographs of a single species taken within 30 minutes of each other were recorded as a single event, unless obviously different individuals or groups were photographed.

3.4.2   Questionnaire survey

Using the same transect strip as for the camera trap survey, up to five local residents were interviewed per 25 km² grid block, with fewer interviews carried out in low human density areas (e.g. commercial farms, National Park, livestock rangelands and very hilly terrain). Selection of respondents was at random from the subgroup meeting the following criteria: (i) minimum age of 15 years, (ii) activities that required movement away from the homestead in a variety of directions (e.g. herders, firewood collectors and wildlife rangers), (iii) a linear distance of at least 500 m from other interview sites (except for wildlife / livestock areas where households were clustered), and (iv) willingness to participate. Respondents were interviewed by a trained student interviewer fluent in isiNdebele (the native language of people living in the Matobo area). A structured questionnaire (Appendix 2) was used as a guide, but questions were open-ended.   All respondents were advised that "I do not know" was an acceptable answer to any question and they were not forced to answer any questions. Interviews were typically 20 to 30 minutes in duration.
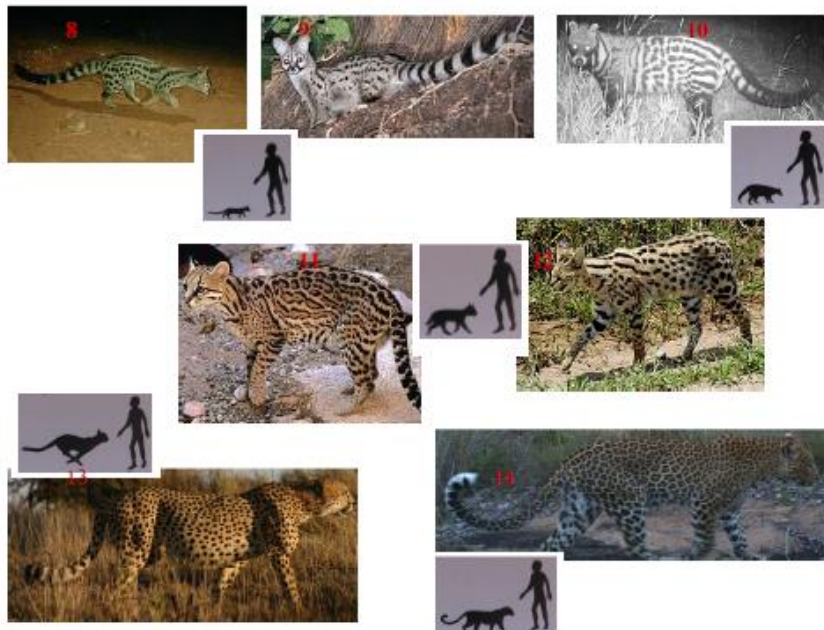
Figure 2: Example of a photo montage (spotted cats and viverrids). Scales relative to a human figure (Stuart & Stuart, 2007) were included. Extralimital species (e.g. #11, ocelot) were included on each montage to determine respondents' abilities to discriminate among species.

After explaining the purpose of the study, the interviewer obtained basic information from the respondent (e.g. age, occupation, number of years resident in the area) before showing him / her photo montages of carnivores (Fig. 2) and asking him / her to point out carnivore species seen in the area. To verify identification, the respondent was asked to describe the appearance of the animal, its activity period, the habitat/s it was seen in (from a photo montage of habitats), diet and behaviour. Additional questions asked – for all species seen if the respondent had only seen a few, or for a subset of species if many had been seen – related to attitudes towards the carnivore,

sighting frequency and locality information for most recent sightings, traditional beliefs associated with the species and perceived levels of conflict.

Data reliability was assessed based on a three-point ordinal scale for four criteria (i) ability to identify and name carnivores, (ii) consistency of answers, (iii) knowledge about basic biology of a subset of species (so that obvious misidentifications could be excluded), and (iv) willingness to participate. Data from respondents scoring an aggregate of less than 67% were reviewed, and where necessary, omitted from further analysis.

Throughout the survey, any sightings or sign of carnivores were recorded using a Garmin ETrex (Garmin Ltd, 2000-2007) GPS receiver.

3.5   Analysis of data:

3.5.1   Occupancy and species richness:
Species inventories were compiled from combined questionnaire and camera trap data for each land use type individually, as well as for all land uses combined.

Naïve occupancy was calculated from camera trap data, as the proportion of sites at which each species was detected. *Modelled occupancy:* since detection probabilities were likely to vary with species and site characteristics (i.e. non-detection did not necessarily reflect true absence), occupancy was modelled using *Presence* (Hines, J.E., 2006). At each site, the number of trap days was truncated at 28, and data were collapsed into four 7-day periods (replicate counts). Detection of each species was coded (0 = not detected; 1 = detected) for each time period at each site. The simplest model was used: "Single Season" analysis, with "1 group, constant P".

Species richness based on camera trap data was estimated for all land uses combined; for inhabited areas (communal and resettlement) and for uninhabited areas (wildlife and extensive cattle farms) using EstimateS (Colwell, R.K., 2006). The Jackknife1 estimator, which calculates expected species richness based on samples, was used. Independent sites were used for calculations.

3.5.2   Predictors of habitat use:
Species incidence (presence / absence) was coded for each camera trap station. Five explanatory variables were derived, either from local site measured variables or calculated *post hoc.* These were (i) sward height (cm); (ii) visibility % at 50 cm above ground and 10 m distance; (iii) vegetation density index; (iv) distance from protected area boundary (km); (v) anthropogenic index, calculated as household density x livestock density (km^{-2}). Data for (v) were obtained from another survey (Sagonda & Pegg, 2015). For species detected at a minimum of four sites, generalised linear models (GLMs) were run in R (R Core Team, 2014). The full model contained all five explanatory variables as main effects. Thereafter, the *step* function was used to find the best model. Model fit was tested using the Hosmer-Lemeshow test.

4   Results

4.1   Species inventories and species richness

4.1.1   Historical data: 1900 to 1999
Museum accession cards contributed 112 records of 21 species of carnivore between latitudes 20° S and 21° S and longitudes 27.5° E and 29° E spanning the period 1900 to 1999; there were no more recent records available (Table 1; Appendix 1). In addition, F. Cotterill, a previous curator of mammalogy at the Bulawayo Natural History Museum, included aardwolf, spotted hyaena and wild dog in a list for a book on Matopos (Fitzpatrick and Cotterill, in prep.); these additions were based on historical sightings, anecdotal and literature records, and personal observations (F.P.D. Cotterill, 8 May 2013, *in litt.*). Wilson (1969) also reported a transient lion (*Panthera leo*) in 1968. These historical data, totalling 25 species, formed the basis for comparison with recent data.

Table 1: List of species obtained from the literature and Bulawayo Natural History Museum accession cards. Scientific names follow the IUCN Red List (www.iucnredlist.org) nomenclature as at July 2015.

Common name	Scientific name	No. records (Museum)	Notes from the literature
FAMILY CANIDAE			
Black-backed jackal	*Canis mesomelas*	2	Western limit of range (Cotterill, in prep.)
Side-striped jackal	*Canis adustus*	1	
African wild dog	*Lycaon pictus*	0	Transient (Cotterill, in prep.)
FAMILY VIVERRIDAE			
African civet	*Civettictis civetta*	1	
Rusty-spotted genet	*Genetta maculata*	16	
Common (small-spotted) genet	*Genetta genetta*	15	
FAMILY MUSTELIDAE			
Cape clawless otter	*Aonyx capensis*	5	
Honey badger	*Mellivora capensis*	2	
Striped polecat	*Ictonyx striatus*	4	
FAMILY HERPESTIDAE			
Dwarf mongoose		1	
Banded mongoose	*Mungos mungo*	1	
Slender mongoose	*Herpestes sanguineus*	19	Common (Cotterill, in prep.)
Selous' mongoose	*Paracynictis selousi*	8	
Meller's mongoose	*Rhynchogale melleri*	4	Widespread but rarely seen (Cotterill, in prep.)
White-tailed mongoose	*Ichneumon albicauda*	4	
Water (marsh) mongoose	*Atilax paludinosus*	0	Widespread and common, based on spoor along rivers (Cotterill, in prep.)
FAMILY PROTELIDAE			
Aardwolf	*Proteles cristata*	0	
FAMILY HYAENIDAE			
Brown hyaena	*Parahyaena brunnea*	3	Locally extinct by 1968 (Wilson, 1969); Present – found in west (Cotterill, in prep.)
Spotted hyaena	*Crocuta crocuta*	0	Transient (Wilson, 1969) Uncommon, transient (west and north) (Cotterill, in prep.)
FAMILY FELIDAE			
African wild cat	*Felis silvestris cafra*	4	Resident; regularly hybridises with domestic cat (Cotterill, in prep.)
Serval	*Leptailurus serval*	13	Uncommon (Cotterill, in prep.)
Caracal	*Caracal caracal*	2	Uncommon (Cotterill, in prep.)
Leopard	*Panthera pardus*	10	Uncommon (Wilson, 1969);

Common name	Scientific name	No. records (Museum)	Notes from the literature
Cheetah	*Acinonyx jubatus*	1	Abundant in National Park (Smith, 1977) Abundance: National Park > commercial farms > communal land (Cotterill, in prep.) Not known in National Park, but sporadic accounts in the west and south (Wilson, 1969) Not uncommon in west (Cotterill, in prep.)
Lion	*Panthera leo*	0	Transient – 1 record 1968

4.1.2 Data from other studies

Both the Mangwe District leopard study (Grant, 2012) and the Matopos National Park rhino camera trap study (DWT, unpubl. data) were designed to detect species other than small carnivores, so smaller species were probably under-represented. Grant (2012) had baits set at the top of inclined branches, and did not detect smaller, non-arboreal species. Despite this, ten species of carnivore were photographed in the Mangwe study (Table 2) and 20 were recorded in Matopos National Park (Table 2). In both surveys, genets were combined for naïve occupancy calculations, due to the difficulties involved in differentiating between genet species; however, at least two species were recorded.

Table 2: Naïve occupancy (# sites at which a species was recorded / # sites sampled) and relative abundance index (RAI = # events/ # trap days*100) of carnivores from the Marula study (Grant, 2012) and the DWT / PWMA project (DWT, unpubl. data). Trap days = cumulative number of days over which cameras were active; events were separated by 30 minutes.

Common name	Marula (T. Grant) 20 sites; 800 trap days; baited; 2010		Matopos National Park (DWT) 77 sites; 11154 trap days; not baited; 2011-2014	
	Occupancy	RAI	Occupancy	RAI
FAMILY CANIDAE				
Black-backed jackal	0.05	0.38	0.04	0.04
Side-striped jackal	Not detected	-	0.04	0.04
African wild dog	Not detected	-	0.01	0.01
FAMILY VIVERRIDAE				
African civet	0.35	5.13	0.43	1.30
Rusty-spotted genet Common genet	0.85*	75.38*	0.34*	0.74*
FAMILY MUSTELIDAE				
Cape clawless otter	Not detected	-	0.01	0.01
Honey badger	0.50	19.38	0.27	0.39
Striped polecat	Not detected	-	Not detected	-
FAMILY HERPESTIDAE				
Dwarf mongoose	Not detected	-	Not detected	-
Banded mongoose	Not detected	-	0.10	0.24
Slender mongoose	0.15	0.88	0.04	0.12
Selous' mongoose	Not detected	-	0.04	0.05
Meller's mongoose	Not detected	-	0.10	0.35
White-tailed mongoose	Not detected	-	0.17	0.32

Common name	Marula (T. Grant) 20 sites; 800 trap days; baited; 2010		Matopos National Park (DWT) 77 sites; 11154 trap days; not baited; 2011-2014	
Water (marsh) mongoose	Not detected	-	0.01	0.01
FAMILY HYAENIDAE				
Aardwolf	Not detected	-	Not detected	-
Brown hyaena	0.80	7.00	0.56	2.23
Spotted hyaena	0.40	1.88	0.05	0.04
FAMILY FELIDAE				
African wild cat	Not detected	-	0.09	0.15
Serval	0.05	0.13	0.27	0.48
Caracal	0.05	0.13	0.17	0.20
Leopard	0.80	25.13	0.52	1.68
Cheetah	Not detected	-	0.04	0.03
Lion	Not detected	-	Not detected	-
Total species	10 (11)		20 (21)	

* Genets were combined, due to the difficulty of differentiating species from black and white camera trap images.

4.1.3 Current survey

From combined questionnaire and camera trap data, all species previously recorded in the Matobo Hills, apart from lion, were detected during the survey. The number of species recorded in areas of high (communal / resettlement) and low (livestock / wildlife) human activity from pooled data was 24 and 22, respectively. However, the species richness in inhabited areas may have been biased upwards due to respondents recording species in their land use that were seen in different land uses, e.g. during travel between villages.

In a total of 1524 trap days (defined as the cumulative 24-hour periods for which cameras were functional) across 47 sites, 20 species of carnivore, including domestic dogs (*Canis familiaris*) and domestic cats (*Felis catus*), were identified across all land uses. Estimated total species richness based on the "Jackknife1" estimator of EstimateS (Colwell, R.K., 2006) was 23.9 (Fig. 3). Similar results were obtained when using either trap days or number of sampled sites. A clear asymptote was not reached for livestock and wildlife areas (18.8 species), indicating that sample effort should be increased in those land uses (Fig. 3).

Questionnaires generated a species list of 22 species from 76 reliable respondents (Table 3). Ten of these respondents had not seen any carnivores. African civet was not reported by anyone living in settled areas (communal lands and resettlement) and Meller's and water mongoose were not reported. Only two extralimital species were recorded – ocelot (*Leopardus pardalis*, mistaken for leopard) and spotted-necked otter (*Hydrictis maculicollis*), which may have been confused with water mongoose as the respondent identified two dark-coloured water-associated small carnivores. In one other case, a respondent pointed to a wild dog, but named and described it as a jackal. Cases of misidentification or misnaming were omitted from further analysis.

Ad hoc sightings of carnivores during fieldwork comprised one sighting of a pack of dwarf mongoose on a commercial livestock ranch, one record of leopard spoor on the Gulati Communal Land / Matopos National Park boundary, and two sightings of slender mongoose in the Ravenwood Resettlement area in the west and in the Gulati Communal Land. All three slender mongoose sightings were in areas heavily infested with *Lantana camara*.

To determine which factors affected detection of carnivores by inhabitants of the Hills, stepwise regression of detection odds [ln(detection/(1-detection))] was run against five factors: median body mass, activity period (nocturnal, diurnal, crepuscular), dietary and habitat specialisation (1 = generalist; 2 = semi-specialised; 3 = highly specialised) and attitude (proportion of respondents

who reported a species that "disliked" it). Only attitude (dislike) was significant, with greater odds of detection with increased levels of dislike ($F_{1,19} = 7.781$, $p = 0.012$).

Using the same factors as above, stepwise regression of naïve occupancy at camera sites was calculated. Habitat specialisation was identified as a significant predictor ($F_{1,15} = 6.078$, $p = 0.027$).
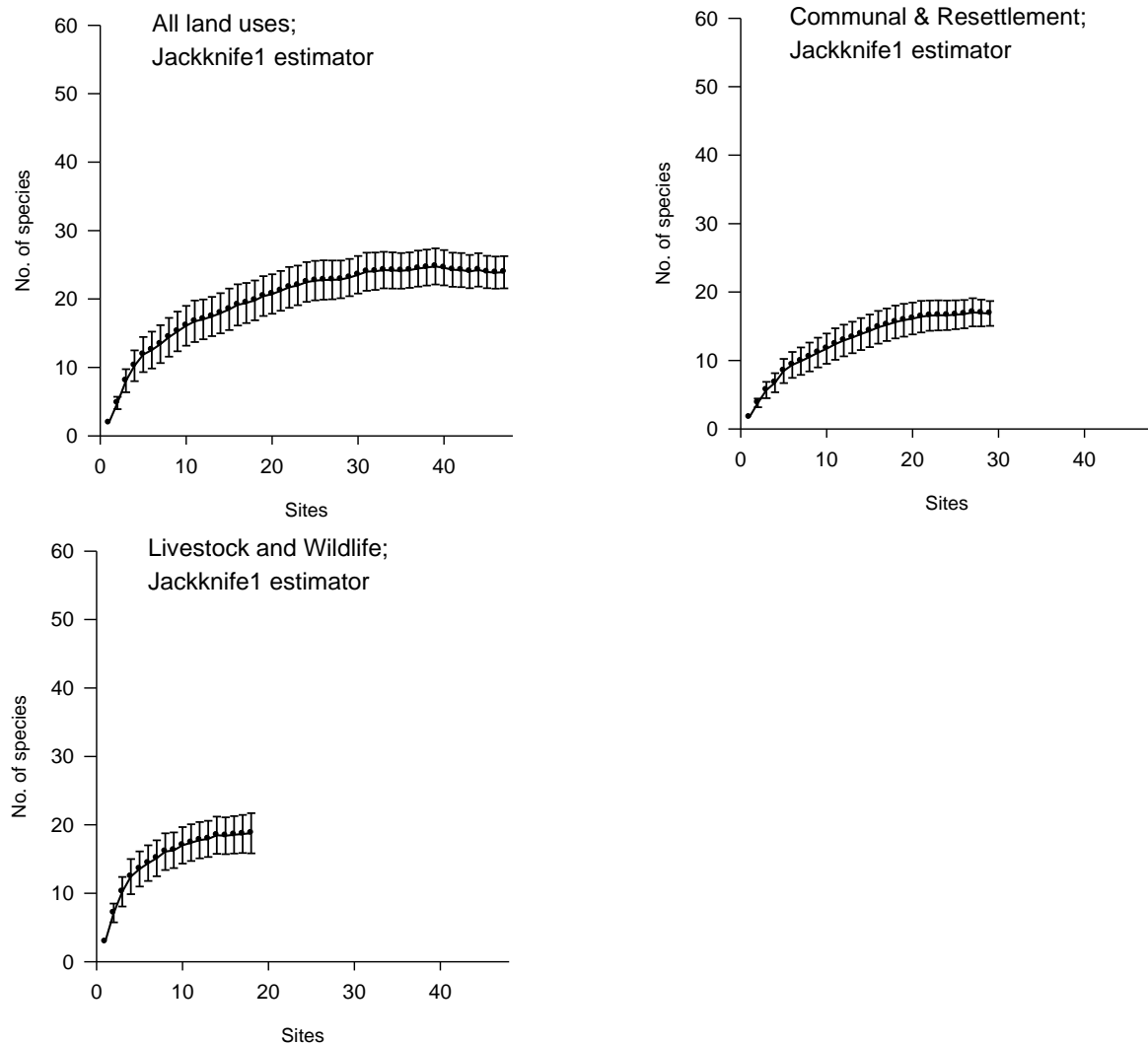
Figure 3: Predicted species richness against number of samples (sampled sites) using the Jackknife1 estimator ± 1 S.D. (Colwell, R.K., 2006) for (top left) all land uses combined, (top right) inhabited areas [resettlement and communal areas] and (bottom left) uninhabited areas [extensive livestock rangelands and wildlife areas].

4.2 Occupancy, abundance and habitat selection

4.2.1 Distributions of carnivores

Insufficient data were available to model current distributions of carnivores in the Matobo Hills. However, some preliminary trends were apparent from mapped sighting data (questionnaire and camera trap data combined). Sighting data from interviews were mapped according to respondents' estimates of distance and direction from the interview site and / or description of sites or place names.

Canids (Fig. 4)
Black-backed jackal was ubiquitous and commonly encountered across the study site, whilst side-striped jackal appeared to be more common in the wetter east. In the west, side-striped

jackal was found close to permanent water. African wild dog was only recorded via interviews, and was only reported in the east. This species was rarely encountered by people living in the Matobo Hills and reported group sizes were small (<4), suggesting that animals sighted were dispersing groups moving through the area rather than resident packs.

Table 3: Percentage of interviewed respondents, arranged by land use, who reported sightings of carnivores.

English Name	Communal (N = 44)	Resettlement (N = 17)	Livestock (N = 5)	Wildlife (N = 10)	Pooled land use (N = 76)
FAMILY CANIDAE					
Black-backed jackal	56.8	64.7	80.0	70.0	61.8
Side-striped jackal	18.2	5.9	40.0	40.0	19.7
African wild dog	6.8	0.0	0.0	0.0	3.9
FAMILY VIVERRIDAE					
Common genet	9.1	0.0	0.0	30.0	9.2
Rusty-spotted genet	9.1	17.6	20.0	20.0	13.2
Civet	0.0	0.0	20.0	40.0	6.6
FAMILY MUSTELIDAE					
Clawless otter	0.0	5.9	0.0	10.0	2.6
Striped polecat	18.2	17.6	40.0	20.0	19.7
Honey badger	11.4	5.9	20.0	10.0	10.5
FAMILY HERPESTIDAE					
Banded mongoose	6.8	0.0	40.0	20.0	9.2
Dwarf mongoose	6.8	5.9	20.0	10.0	7.9
Selous' mongoose	0.0	5.9	0.0	0.0	1.3
Slender mongoose	25.0	17.6	0.0	30.0	22.4
White-tailed mongoose	4.5	11.8	0.0	0.0	5.3
FAMILY HYAENIDAE					
Aardwolf	2.3	5.9	20.0	10.0	5.3
Brown hyaena	2.3	5.9	40.0	30.0	9.2
Spotted hyaena	18.2	47.1	40.0	30.0	27.6
FAMILY FELIDAE					
African wild cat	22.7	23.5	20.0	10.0	21.1
Caracal	2.3	11.8	20.0	20.0	7.9
Cheetah	9.1	5.9	20.0	20.0	10.5
Leopard	36.4	41.2	60.0	70.0	43.4
Serval	4.5	0.0	40.0	0.0	5.3
Nil species seen	15.9	17.6	0.0	0.0	13.2

Mustelids (Fig. 4)
All three expected species were recorded by at least one sampling method, but striped polecat was not photographed. Honey badger was relatively widespread but appeared to be more common in less populated areas. Cape clawless otter was rarely reported, but is a habitat specialist. Records from this study indicated its presence in medium and large permanent water bodies.

Viverrids (Fig. 4)
Genets were widespread and frequently photographed, although reported to be present by less than one-fifth of interviewees. Both historical species were identified via questionnaires, but camera trap data were inconclusive with overlap of characters used to differentiate rusty-spotted from common genet (Gaubert, Taylor & Veron, 2005). African civet was reported via interviews

and detected on camera. Civet appeared to be associated with areas of low human density, such as livestock rangelands and wildlife areas.

Herpestids (Fig. 4)
Slender mongoose was the most widespread species recorded in the study, and was generally associated with areas with good cover (e.g. *Lantana* thickets and dense woodland). White-tailed mongoose was more frequently detected in the west of the study area (protected areas, livestock farms and resettled areas), with only one record in the communal areas in the east. Whether this is a reflection of rainfall, habitat or human density is unknown. The two gregarious species – banded and dwarf mongooses – were recorded patchily across the study zone. Insufficient data for Selous', Meller's and water mongooses were obtained to comment on their distributions.

Hyaenids (Fig. 4)
Although aardwolf was reported by several respondents, only one photograph was obtained of this species, in a resettlement area in the west of the transect. Spotted hyaena was reported across the transect although no photographs were obtained, and brown hyaena was photographed in livestock, resettlement and wildlife areas.

Felids (Fig. 4)
Despite being reported widely by interviewees, leopard was only photographed at two sites in low human density areas. Caracal was not photographed, and was only reported by five respondents. Serval was recorded in grassland habitats, primarily in or near protected areas, whilst wild cat was fairly widely distributed, reported by a fifth of respondents (Table 3) and photographed in human-inhabited and wildlife areas.

Domestic carnivores (Fig. 4)
Interviewed people were not asked about the distribution of domestic carnivores (cats and dogs), since these were present at most homesteads apart from wildlife areas and the Matopos National Park. By law, domestic dogs are supposed to be limited to people's homesteads in communal and resettlement areas. However, dogs were recorded at a large number of camera stations both close to and distant from homesteads. Dogs were also detected in commercial farm rangelands and in wildlife areas. Only one photograph of a domestic cat was obtained.

4.2.2   Naïve and modelled occupancy
Naïve occupancy, which is the proportion of sampled sites at which each species was recorded, was lower than modelled occupancy except for species detected only once at a single site (Table 4). Significant differences between naïve and modelled occupancy (Wilcoxon signed rank test, p < 0.001) indicated non-detection of carnivores by camera traps. The greatest discrepancies were for domestic dogs, genets and white-tailed mongoose, which were potentially missed at 7, 6 and 21 sites, respectively.

4.2.3   Abundance
To obtain a measure of abundance, the estimated sighting frequency (SF), calculated as the number of sightings per month, were calculated from interview data. Due to the limited number of responses (range 1 to 18 per species), data were not subdivided by land use. Camera trap data were used to calculate relative abundance indices (RAI), that is, the number of photographic events per species divided by the trap days, for each land use. This index provides a measure of sighting frequency, not of population size, as the same individual/s may have been photographed more than once.

Unsurprisingly, domestic dog attained the highest RAI of any species, primarily in communal and resettlement areas where dogs tend to roam freely (Table 5). Domestic cat was photographed infrequently and only in inhabited land uses (Table 5). Genets and Meller's, Selous' and slender mongooses were encountered regularly in inhabited areas as indicated by SF and RAI estimates (Fig. 5; Table 5). Genets appeared to be equally common across all land uses, as were white-tailed mongoose in less populated areas (Table 5). Diurnal carnivores and common genet were encountered frequently by people (Fig. 5), with slender mongoose commonly recorded on camera
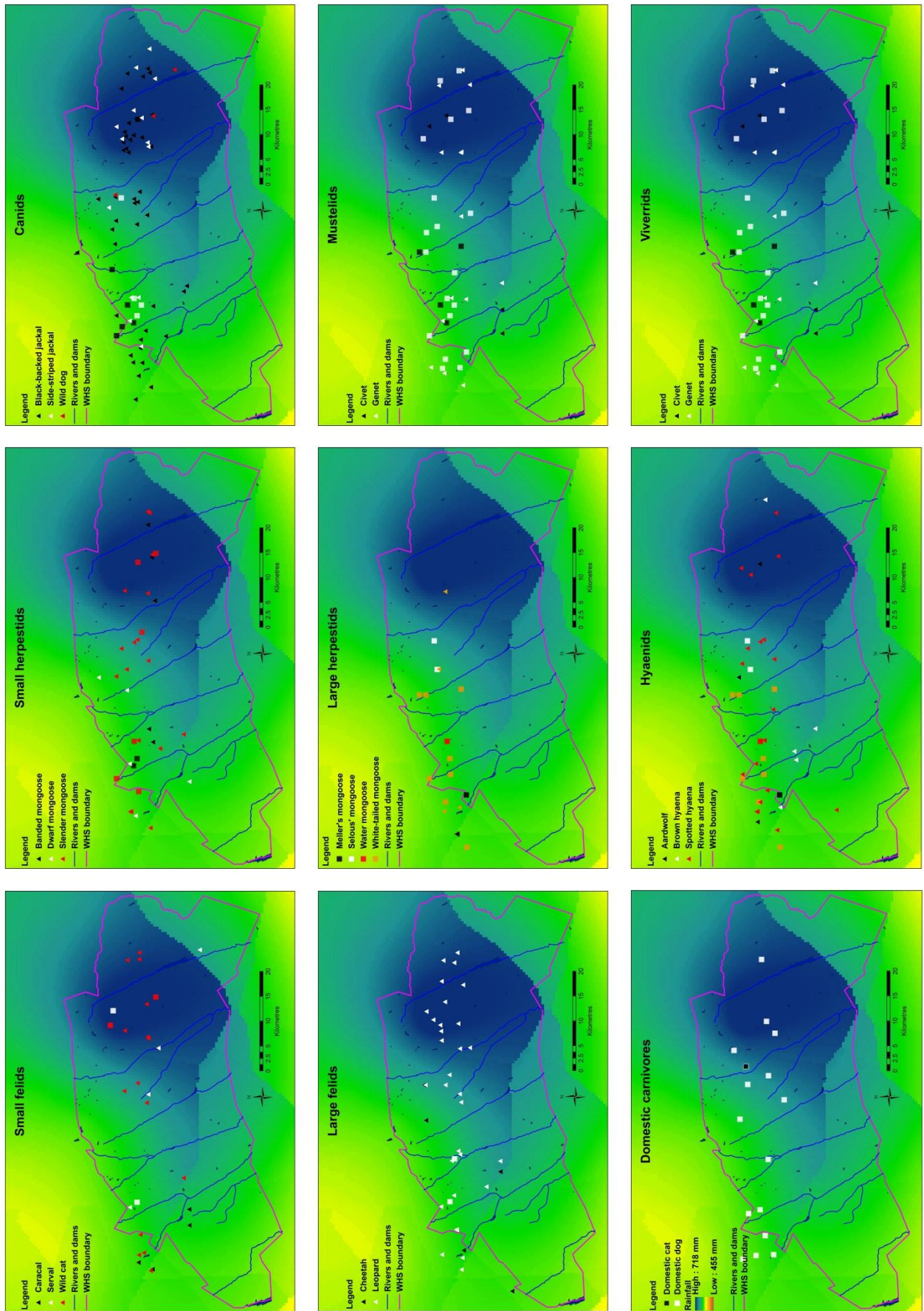
Figure 4: Distribution maps of carnivores from camera traps (squares) and interviews (triangles) overlaid on a rainfall surface derived from 10-year means at multiple sites. Key to rainfall: see domestic carnivore map.

traps in communal areas (Table 5). Brown hyaena, serval and leopard were photographed exclusively in commercial livestock and wildlife areas (Table 5) and encountered less than once every two months by people (Fig. 5). Low RAIs for water mongoose and Cape clawless otter were partly a result of low sampling rate in suitable habitat (Table 5). The remainder of species were found across a number of land uses, but tended to have higher abundance indices in areas with lower human densities, particularly livestock ranches (Table 5). Of interest is that the SF for side-striped jackal was higher than for the black-backed jackal (Fig. 5) and RAI for this species was higher in communal and wildlife areas (Table 5).

Table 4: Naïve and modelled occupancy for species detected by camera traps in the current survey.

Species	Naïve occupancy	Modelled occupancy
Canids		
Black-backed jackal	0.128	0.140 ± 0.055
Side-striped jackal	0.085	0.120 ± 0.069
Domestic dog	0.340	0.479 ± 0.125
Mustelids		
Cape clawless otter	0.021	n/a
Honey badger	0.064	0.070 ± 0.04
Viverrids		
African civet	0.192	0.225 ± 0.072
Genet (species combined)	0.468	0.592 ± 0.109
Herpestids		
Banded mongoose	0.042	0.047 ± 0.033
Meller's mongoose	0.021	n/a
Selous' mongoose	0.044	n/a
Slender mongoose	0.128	0.159 ± 0.067
Water (marsh) mongoose	0.0213	n/a
White-tailed mongoose	0.170	0.613 ± 0.541
Hyaenids		
Aardwolf	0.021	n/a
Brown hyaena	0.106	0.138 ± 0.066
Felids		
African wild cat	0.043	n/a
Domestic cat	0.043	n/a
Leopard	0.043	n/a
Serval	0.043	0.060 ± 0.050

4.2.4 Habitat associations

Eight species were detected at a minimum of five camera sites, enabling GLM analysis of habitat associations. The full model (see methods) was not retained for any species. Visibility, anthropogenic index or vegetation density index were retained in most models. Slender mongoose presence was significantly positively affected by high woody vegetation density (GLM, $z = 2.676$, d.f. = 46, $p = 0.007$); no other factors were significant for any species.

Table 5: Relative abundance indices (mean ± S.E.) from camera traps for carnivores in each land use. Highest RAI for each species is shown in boldface. NR = species not recorded during the camera trap survey.

Species	Communal	Resettlement	Livestock	Wildlife
Black-backed jackal	0.002 ± 0.002	0.030 ± 0.027	**0.074 ± 0.056**	0.005 ± 0.003
Side-striped jackal	0.006 ± 0.006	NR	**0.022 ± 0.022**	0.010 ± 0.008
African wild dog	NR	NR	NR	NR
Domestic dog	0.041 ± 0.021	**0.242 ± 0.206**	0.007 ± 0.007	0.005 ± 0.003
Cape clawless otter	NR	NR	NR	0.002 ± 0.002
Honey badger	NR	NR	**0.033 ± 0.033**	0.006 ± 0.004
Striped polecat	NR	NR	NR	NR
Civet	NR	NR	**0.102 ± 0.082**	0.041 ± 0.020

Species	Communal	Resettlement	Livestock	Wildlife
Genet (combined spp.)	0.031 ± 0.015	0.037 ± 0.015	0.037 ± 0.022	**0.038 ± 0.017**
Banded mongoose	NR	NR	**0.036 ± 0.022**	NR
Dwarf mongoose	NR	NR	NR	NR
Meller's mongoose	NR	**0.003 ± 0.003**	NR	NR
Selous' mongoose	0.006 ± 0.004	**0.008 ± 0.004**	NR	NR
Slender mongoose	**0.018 ± 0.011**	0.007 ± 0.005	NR	0.009 ± 0.009
Water mongoose	NR	0 ± 0	NR	**0.005 ± 0.005**
White-tailed mongoose	NR	**0.011 ± 0.005**	0.011 ± 0.011	0.010 ± 0.006
Aardwolf	NR	**0.002 ± 0.002**	NR	NR
Brown hyaena	NR	0.005 ± 0.004	**0.087 ± 0.087**	0.0222 ± 0.020
Spotted hyaena	NR	NR	NR	NR
African wild cat	0.002 ± 0.002	NR	NR	**0.003 ± 0.003**
Caracal	NR	NR	NR	NR
Cheetah	NR	NR	NR	NR
Leopard	NR	NR	**0.011 ± 0.011**	0.002 ± 0.002
Serval	NR	NR	**0.011 ± 0.011**	0.008 ± 0.008
Domestic cat	**0.002 ± 0.002**	**0.002 ± 0.002**	NR	NR
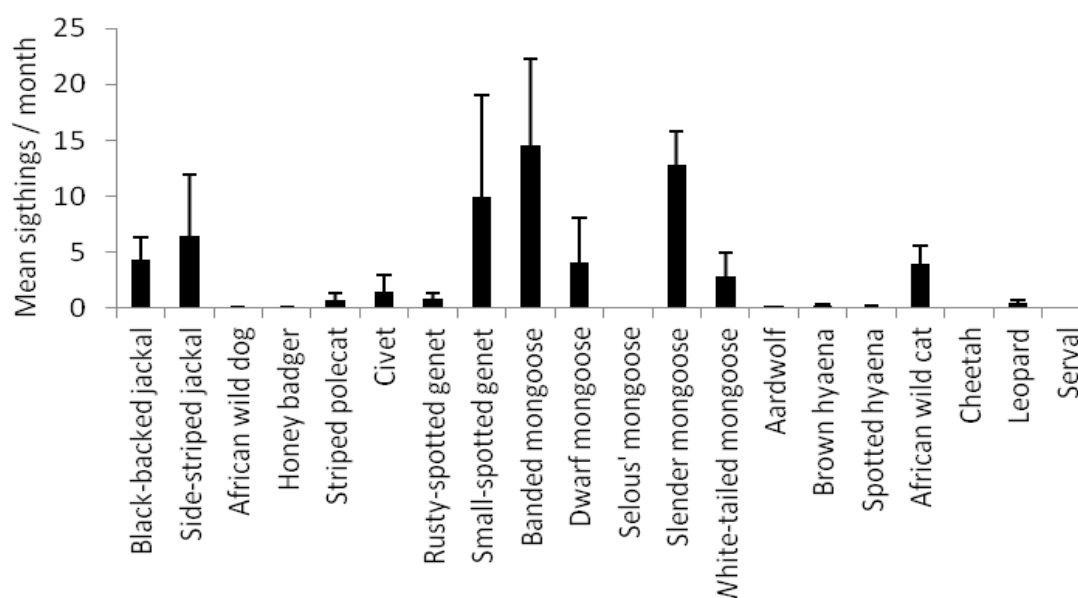
Figure 5: Sighting frequency (SF) of carnivores per month (mean ± SE) based on interview data from Matobo Hill residents.

4.3 Conflict and attitudes

4.3.1 Livestock losses and conflict between 2012 and 2013

Sixty-seven of the 76 people interviewed were farmers or managed livestock. Of these, 34 reported livestock losses to predators in the year preceding the survey. The vast majority of losses were poultry (chickens), but 25 goats, 22 cattle and two donkeys were also taken by predators (Fig. 6). Jackals, leopard, spotted and brown hyaena were identified as predators of larger livestock, with leopard being the most common culprit.

Of the cattle taken, nine were on a commercial cattle farm and most were calves; after calving camps were introduced, no more calves were lost. A village headman lost six cattle to leopard. The other six affected farmers lost one or two cattle each.

Eight farmers lost a total of 25 goats, with losses per farmer ranging from one to six animals. Leopard and both species of jackal were the identified predators. Only two donkeys were reportedly taken by predators (one each to leopard and spotted hyaena).

African wild cat, slender mongoose and genets were the principal predators of poultry (Fig. 6). Most chickens were free-ranging by day in communal areas, making them easy prey for diurnal slender mongooses. Nocturnal raids of chicken coops by civets and genets were also reported.
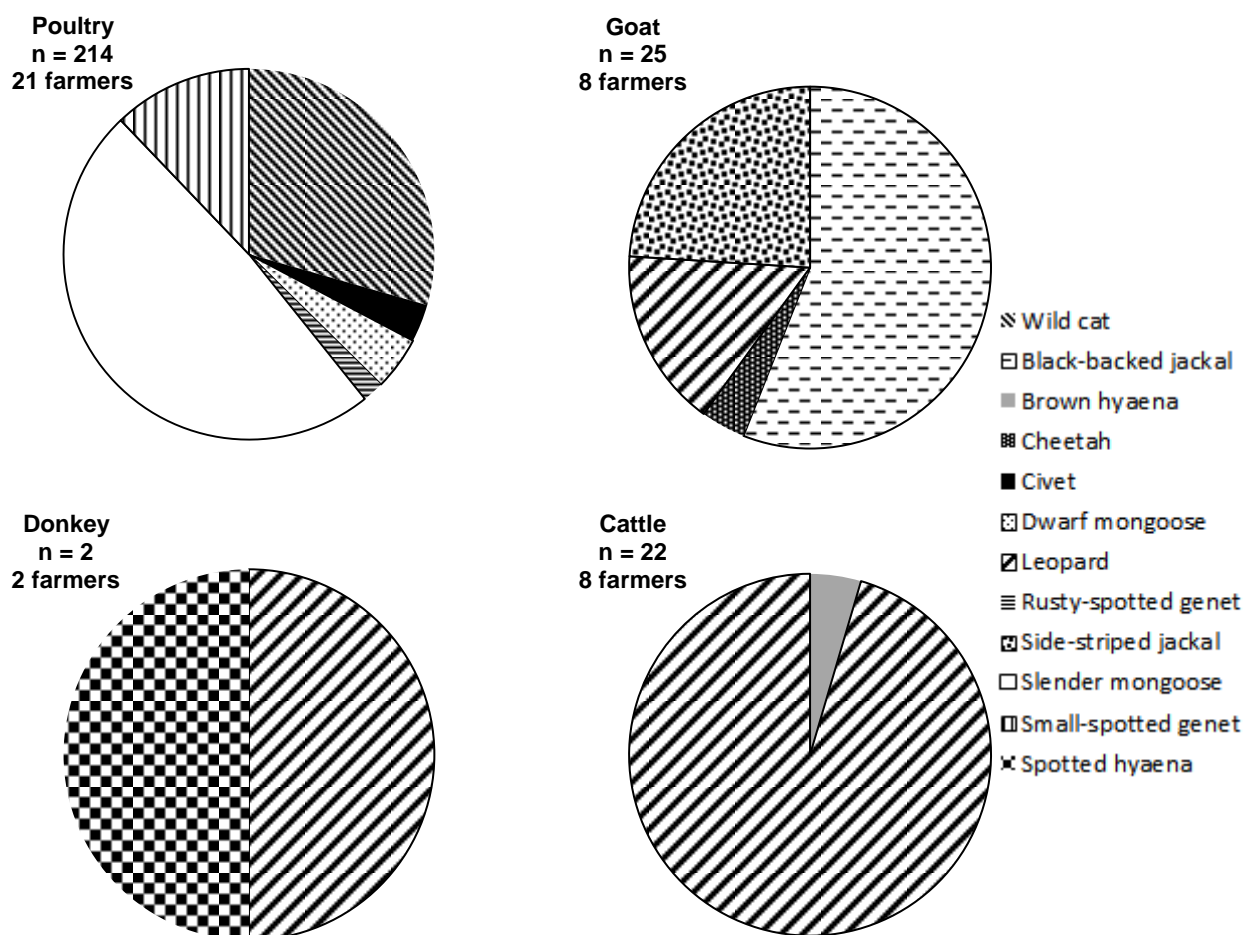
Figure 6: Livestock losses experienced by respondents between June 2012 and June 2013.

Respondents did not provide an opinion on whether they considered species seen as "problem animals" for 117 of 247 predator records. Four species – Selous' mongoose, serval, caracal and Cape clawless otter – were not regarded as problem animals by any respondents. The remainder of species was listed as problem animals by between 25% and 100% of respondents who answered the question (Fig. 7). Most species were regarded as problematic because they prey on livestock. However, striped polecat and aardwolf were also associated with crop damage (digging for invertebrates in fields), and one respondent reported that a villager was attacked by a honey badger when climbing a kopje. One person stated that he considered banded mongooses to be beneficial as they kill snakes.

4.3.2 Traditional beliefs, totems and uses of carnivores

Few people provided information on indigenous knowledge or beliefs associated with carnivores. The cats, civets and genets are held as totems by some families (surname "Sibanda"), but people interviewed did not identify any other totem carnivores in the study area.

Skins of spotted cats, particularly cheetah and leopard, were reported to be used in traditional ceremonies and worn by elite members of society, such as chiefs and spirit mediums.

Traditionally, skins of honey badgers, genets, jackals and wild cats are used to make blankets, clothing and hats.

Hyaenas were associated with witchcraft, with a commonly held belief that the tail of a hyaena can be used by thieves and witches to induce a deep sleep in residents of households, enabling the thief to go undetected. One person also held that possession of a hyaena tail makes thieves "invisible" to the police.

Another common belief was that genets evert their anal glands to attract chickens. When chickens approach, the genet seizes its head with its anus before biting the bird's neck to kill it.
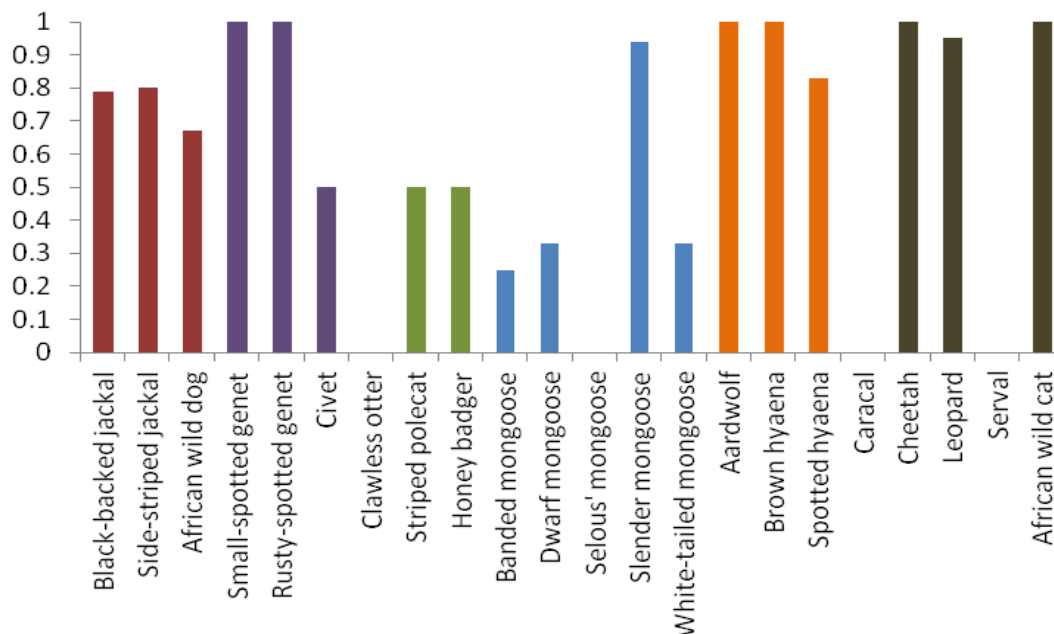
Figure 7: Proportion of respondents who regarded each carnivore as a "problem animal". Data were restricted to those who answered the question.

4.3.3 Perceived trends in carnivore populations

Only four species – black-backed jackal, African wild dog, slender mongoose and leopard – were regarded by any respondents to be decreasing in the area (Fig. 8). Respondents did not know what civet or Selous' mongoose population trends were, and none of the people who reported caracal offered an opinion (Fig. 8). With the exception of white-tailed mongoose and African wild dog, carnivore populations were believed to be stable or increasing.
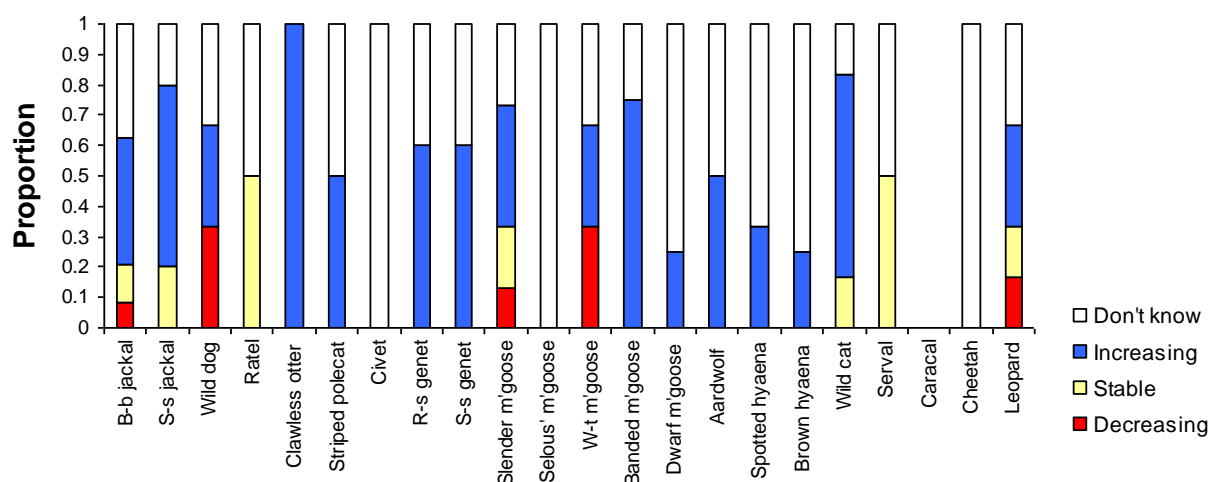
Figure 8: Perceived trends in abundance of species recorded by respondents.

When asked for an opinion for the reasons for observed trends, increases were attributed to a large prey base, not being hunted / persecuted, and carnivores leaving depauperate protected

areas in search of food. Hunting and human population pressure were given as explanations for decreasing trends. A few respondents gave examples of human activities that negatively impact on carnivores. These included retaliatory killing of stock killers (wild cat) and accidental bycatch in traps set for hyraxes (genets, slender and dwarf mongooses).

5 Discussion

Despite being of short duration, this survey generated useful information about the small and large carnivores in the northern Matobo Hills region. No species that had not been previously recorded were detected, but differences in abundance and distribution compared with the literature were apparent. Interestingly, relative abundance indices for nine of the 17 recorded wild carnivores were highest on commercial livestock farms, not wildlife areas as may be expected. This may be a result of relatively low prey populations in the National Park along with increased insect populations associated with livestock activity.

5.1 Species present and notes on their distribution

The literature generated few reports of mesocarnivores in the Matobo Hills, making it difficult to compare distributions or abundances with results from the current survey. Cotterill (in prep.) described serval and caracal as "uncommon" and Meller's mongoose as widespread and common but rarely detected.

Despite being reported by almost 8% of respondents across all land uses, caracal certainly seems to be uncommon in Matobo when considering Museum and camera trap records. The high reporting rate may reflect the ease of identification of this species, which is unlikely to be confused with other carnivores. Serval is closely linked with grassland habitats near permanent water, making its apparent rarity possibly a reflection of habitat availability. In the National Park, serval was photographed at more than one-quarter of sampled sites, and the RAI was the fifth highest for any carnivore. This strong apparent habitat association explains the scarcity of this cat in human-modified environments.

Meller's mongoose was not reported by any interviewees and was only detected once during the survey; however, this species was not infrequently detected in the National Park (RAI 0.35%) although it was found at relatively few sites (eight of 77). Kingdon (2015) reports that Meller's mongoose is uncommon in regions with high fire frequency, such as may be found in some areas of the Matobo Hills. Selous' mongoose was infrequently detected by camera or reported during interviews, indicating that it is a relatively uncommon species. Although white-tailed forms can be mistaken for white-tailed mongoose, the size and stance differ substantially, enabling the species to be distinguished from camera trap photographs (pers. obs.). Meller's and Selous' mongooses are small, nocturnal and unlikely to impact negatively on humans due to their primarily insectivorous diet (Kingdon, 2015), so are probably overlooked.

White-tailed mongoose was not reported by many interviewees, but was widespread (except in the wetter east) and found in most habitats. Identical naïve occupancy rates were estimated from the ongoing DWT survey and the current survey (0.17), although modelled occupancy estimated a much higher incidence (0.61) of this species. Estes (1991) suggested that white-tailed mongoose and aardwolf densities are inversely correlated, possibly due to competition for dens. If this relationship holds, it may explain the low incidence of aardwolf in what would otherwise seem suitable habitat with appropriate termite prey (Kingdon, 2015). The higher apparent incidence of aardwolf in livestock areas was probably a result of heavily-utilised rangelands having an abundance of harvester termite (*Hodotermes* and *Trinervitermes*) colonies on which aardwolf rely.

African civet was infrequently reported by interviewees but appeared to be common in the Matobo Hills – although restricted to wildlife areas and livestock rangelands. This omnivorous species may be expected to be widespread; it is possible that its rarity in inhabited areas is linked to harassment by domestic dogs and / or persecution by people. The other relatively large mesocarnivore – the honey badger – showed a similar distribution to the civet, although it was less frequently detected on camera traps.
Museum records were biased towards synanthropic species, such as slender mongoose and genets. Slender mongoose, a diurnal species, was the most frequently reported herpestid. This

species is strongly linked with habitats with dense cover (Estes, 1991), particularly dense woodland and even *Lantana camara* thickets (pers. obs.), which are a feature of many degraded rangelands. Its penchant for taking poultry made it relatively unpopular.

Genets were reported less frequently than might be expected by inhabitants of the Matobo Hills, considering that they were detected across the full extent of the transect and were frequently photographed both during this survey and in other studies (e.g. Grant, 2012; DWT camera survey, unpubl. data). Genets have been implicated in poultry depredation, making the low reporting rate surprising. Interestingly, common genet was reported to be seen more frequently than rusty-spotted genet, in contrast with the apparent abundance of these species from camera trap records.

a.

b.

c.

Figure 9: Variability in genet morphology and pelage. (a) Pale-centred, large spots; tail bands approximately equal width, dark tail tip, pale feet (visible in subsequent photos in sequence) make this most probably *G. maculata*; (b) Small, solid, linearly arranged spots, "confused" annulation at base of tail, wider white:dark mid-tail bands and pale tail tip suggest *G. felina*; (c) Paler ground colour, solid, linearly arranged spots, dark feet and tail bands entire suggest *G. genetta*, but wide pale tail bands indicate *G. felina* and black tail tip suggests *G. maculata.*

The taxonomy of genets is currently unclear (Gaubert *et al.*, 2005), with three putative species potentially present in the Matobo Hills (Kingdon, 2015; Gaubert et al. 2005 do not include G. felina in Zimbabwe) and two species (*G. maculata [=tigrina]* and *G. genetta*) recorded historically (Cotterill, in prep.). According to Gaubert *et al.* (2005) and Kingdon (2015), *G. felina* has a light grey coat, a prominent dorsal crest, highly contrasting facial markings, very dark feet and pale tail bands (mid-tail) twice the width of the dark bands. *Genetta genetta* has a short dorsal crest, a strongly tapered tail with pale and dark bands (mid-tail) of equal width and a light tail tip, linearly-arranged dark brown spots on a sandy background and dark hindfeet (Gaubert et al., 2005; Kingdon, 2015). Rusty-spotted genet (*G. maculata*) is described as having short fur, no dorsal crest, bright feet and a dark tail tip, and pale tail bands (mid-tail) 50-75% of the width of the dark bands (Gaubert *et al.*, 2005).

Differentiating genet species in the field is frequently problematic (Fischer, Tagand & Hausser, 2013), particularly from monochrome photographs when animals are moving and coat details become blurred. Based on non-solid spots (paler centres), pale feet, dark tail tip and poorly-defined crest, rusty-spotted genet was unambiguously identified in the survey (Fig. 9a) although the relative width of the mid-tail bands in most individuals was at odds with Gaubert *et al.* (2005). This species was larger and looked more robust than the other species and was more frequently identifiable from photographs. At least one other species was photographed, based on the coat having solid, more linearly arranged spots and individuals having dark feet. However, variation in

tail-band width, ground colour and tail-tip colour (Fig. 9b and c) made it difficult to determine how many additional species (one or two) were present. For the purposes of this report, two species in total were reported, with the identity of the second being given as *G. genetta* since Zimbabwe is out of *G. felina*'s range according to Gaubert *et al.* (2005).

The two species of gregarious mongoose (dwarf and banded) were reported by relatively few people, although they were frequently encountered. Dwarf mongoose was not detected by any camera-trap survey (although it was seen once during fieldwork). Fischer *et al.* (2013) suggested that dwarf mongoose is too small to be detected by camera-traps. However, in this study, small animals such as elephant shrews (*Elephantulus* spp.) and passerine birds were photographed so poor camera sensitivity was an unlikely reason. Camera placement in relation to pack home ranges was a more likely factor: both dwarf and banded mongooses use disused termitaria as refuges and rarely wander far from safety and both species have small home ranges (<1.5 km^2) (Kingdon, 2015).

Both black-backed and side-striped jackals were recorded from camera traps and interviews. The latter species was less frequently reported by people and had a lower overall RAI than black-backed jackal, indicating that it is less common. However, it was more commonly encountered than the black-backed jackal in communal and wildlife areas. The Matobo Hills are towards the western limit of the side-striped jackal's range (Estes, 1991). Although this mesic-associated species was more frequently encountered in the drier west, on closer examination this correlated with lower human densities and most sightings were close to permanent water. The arid-adapted and conspicuous black-backed jackal, which is more vocal (Kingdon, 2015) and exhibits more diurnal behaviour (Estes, 1991) than *C. adustus* was reported across the sampled zone and was relatively frequently encountered, particularly in livestock rangelands.

Given the sampling methods, it is not surprising that water mongoose and Cape clawless otter were not well represented in the survey. Both are primarily nocturnal and very habitat specific, being restricted to areas near permanent water or along drainage lines, making them less likely to be detected by people. All photographs obtained from camera trapping, in this study and the ongoing DWT monitoring study, were within 50 m of permanent water. Cotterill (in prep.) indicated that water mongoose was common in suitable habitat in the National Park. Similarly, whilst striped polecat was reported by one-fifth of interviewees, this fast-moving species was never unequivocally photographed. This was probably a result of relatively long camera latency (i.e. time from detection to image capture) in the cameras used. Use of scent lures helps with detection of fast-moving species (White, 2013) and may be of use to better understand the distribution of small carnivores.

More information on larger carnivores has been published. Wilson (1969) stated that spotted hyaena "no longer exist in the Matopos National Park and it is doubtful if any are left anywhere in the hills". He commented that there had been an incident of four sheep killed by hyaena in 1968, with the animal originating in the Gwanda area. Similarly, Cotterill (in prep.) indicated that it is a transient species. There are indications that spotted hyaena is recolonizing the northern Matobo Hills. A reasonable percentage of people interviewed reported seeing or hearing them, DWT received reports of sightings from several sources from the beginning of 2013, and photographs of spotted hyaena were obtained from mid-2013 in the National Park (DWT, unpubl. data). It is likely that this population originated in the Shashe area to the south of the Hills, with several individuals becoming resident in and around the National Park. Regular photographs (with subadult animals) at the same sites in the National Park suggest that the animals are now resident.

Brown hyaena was similarly believed by Wilson (1969) to be locally extinct in the Matopos National Park and its surrounds and Smith (1977) commented on the absence of "traditional scavengers such as hyaena and jackals" in a study conducted between 1971 and 1974. The last record of brown hyaena had been of an animal trapped by a National Parks ranger in 1960 (Wilson 1969). However, the Matopos National Park survey, the Marula leopard study and this study all recorded brown hyaena. In fact, between 2011 and 2014, it was the most frequently detected carnivore in the National Park (Table 2). This species, in particular, seems to have undergone range expansion in recent decades (Wiesel, 2015), despite being persecuted.

An oft-quoted statistic is that leopard densities in the Matopos Hills are the highest in the world (e.g. Expert Africa, 2015). This dates back to work published by Smith (1977) where estimated numbers in the prime Nswatugi / Maleme / Whovi habitats were extrapolated across the whole Park. In contrast, Wilson (1969) stated that leopard was not as common as first believed: in fifteen months, 15 dung piles were encountered and only four leopards were seen in 48 observation nights. Grant (2012) estimated leopard densities in the south-western Matobo Hills at 4.7 – 5.1 leopards / 100 km^2, intermediate between arid and mesic habitats. In the current survey, leopard was detected at only two sites (on commercial farmland and a private wildlife area), and spoor was recorded at a camera site on the boundary of the National Park. This species was reported by a large number of people interviewed, but its SF was low (< once / month).

Two species, cheetah and African wild dog, are probably transitory in the Matobo Hills. Cotterill (in prep.) indicated that cheetah is not uncommon in the west of the Hills, but Wilson (1969) stated that there were no records in the National Park and only sporadic reports from Figtree and near Kezi. One animal was also reported near the Matopos Research Station just to the north of the Matobo Hills proper. From interviews, cheetah was reported by eight people across all land uses. Although not photographed during this survey, cheetah was detected twice in the National Park in 2011 and 2012 (Table 2), and a reliable source reported a cheetah in the National Park at -20.531° S 28.535° E on 21 July 2013 (W. Dally, *in litt.*). African wild dog was reported by three people in the eastern Matobo Hills, with one person stating that he saw a few individuals, on average, twice a year. A group of three dogs was photographed in the western section of Matopos National Park in November 2012 (DWT, unpubl. data); this was probably a dispersing group (R. Groom, pers. comm.). Given the prey densities and anthropogenic influences in the Matobo Hills, African wild dog is unlikely to be resident.

Only one record of free-ranging lion (*Panthera leo*) relating to the Matobo Hills was found in the literature: Wilson (1969) reported a lion that was sighted in the National Park that came from the south and later disappeared towards Plumtree.

5.2   Habitat associations of carnivores

Insufficient records were available to robustly test all species associations with land use and / or habitat variables. However, indications were that most carnivore species were more abundant in less (human) populated areas. Exceptions included insectivorous nocturnal mongooses, genets and slender mongoose. The latter two are tolerant of humans and also recorded in suburban areas (Kingdon, 2015). Slender mongoose did, however, show a strong preference for habitats with good cover as has been reported previously in the literature (Estes, 1991).

5.3   Relationships with humans

Approximately half of the livestock owners interviewed during this survey had lost animals to predators. In spite of this, tolerance levels were relatively good, and several respondents commented on the beneficial aspects of carnivore presence. As may be expected, few respondents who reported having lost livestock to predators "liked" the carnivores responsible. Those who were neutral towards or liked the predators were either employees (and therefore the livestock were not their own) or had other forms of income. This suggests a tolerance threshold related to socio-economic factors, as previously reported in Kenya (Romañach *et al.*, 2007).

Records of brown hyaena taking large stock were probably a case of mistaken identity. This species will scavenge at carcasses, but is not known to take large prey anywhere in its range (Estes, 1991). It is likely that obvious hyaena attacks (ripped hindquarters, ears and so on) were by spotted hyaenas, with brown hyaenas being more conspicuous at the carcasses after the fact.

Information on abundance trends were biased: respondents were more likely to give an opinion on abundance if they disliked the species (69% answer rate) than if they liked it (48% answer rate). Additionally, 78% of answers for species that were disliked indicated increasing populations, compared with 62% for liked/neutral response species. For these reasons, use of questionnaires to gauge population trends and levels of conflict may be problematic and data should be viewed cautiously as conflict species may be over-reported.

Acquiring accurate quantitative information on predator offtake (e.g. retaliatory killings) is difficult, given that wildlife in communal and resettlement areas belong to the State and killing animals without a permit is a criminal offence. Some insights were obtained through questionnaires; for example, African wild cat was readily persecuted for preying on poultry and small mongooses and genets were bycatch in traps set for hyraxes (Procaviidae; a source of food and skins). One respondent reported that someone he knew had trapped a caracal on the eastern boundary of the National Park for reasons unknown. Since skins (particularly of spotted cats, civets and genets) are used in traditional ceremonies and some carnivore parts (e.g. hyaena tails) are used in traditional healing and magic, it is probable that there is unrecorded offtake of carnivores in the Matobo Hills. A current study in South Africa indicates that the Matobo region is a major source of leopard pelts for ceremonies in the Shembe church (G. Balme, *in litt.*, 25 March 2015).

Another potential threat to carnivores, particularly smaller or non-aggressive species, is domestic dogs (Butler & du Toit, 2002; Butler, du Toit & Bingham, 2004). One respondent commented that his dogs frequently fought with a striped polecat that traversed his property. The large number of unrestrained dogs, as indicated by dogs photographed on camera traps across the transect and particularly in the western resettlement areas, would suggest that such conflicts would not be uncommon. Interactions between wild and domestic carnivores also pose risks for transmission of diseases such as rabies, distemper and parvovirus, which can devastate both domestic animal and wildlife populations (Kat *et al.*, 1995; Murray *et al.*, 1999; Courtin *et al.*, 2000; Loveridge & Macdonald, 2001; Butler *et al.*, 2004, 2004) as well as putting humans at risk (rabies).

Very little information on the traditional uses and beliefs associated with carnivores was acquired during this study, partly due to time limits on interviews and partly because respondents frequently claimed ignorance of specific details. Apart from the use of hyaena parts for magical purposes (invisibility and non-detection), the only recorded use of carnivores (or their parts) were for clothing, blankets and ceremonial apparel. In fact, many respondents cited non-hunting or limited uses of carnivores as a reason for population increases. In contrast, further north in Africa, carnivores are frequently used in traditional medicine and are eaten by some ethnic groups (Bahaa-el-din *et al.*, 2013; De Luca & Mpunga, 2013).

Traditional conservation practices in the Matobo Hills, such as taboos and totems, were effective historically. Traditional leaders oversaw offtake of wildlife and no-hunting areas were respected. People would not eat or harm their totem animal or plant; in this way, reservoir populations (especially of harvested organisms) would be established. Recent surveys indicate a loss of indigenous knowledge and erosion of belief in the traditional methods of conservation (Sithole, 2009). Only one totem was reported during the survey, linked to the surname "Sibanda" and referring to cats and spotted carnivores such as civet and genet. Although not recorded during interviews in this study, people with the Ndebele surname "Gayana" hold canids and hyaenids sacred (S. Ndlovu, pers. comm.). It was not determined what proportion of people still adhered to the tenets of the totem system.

5.4 Recommendations for carnivore conservation in the Matobo Hills

An encouraging outcome of this survey was that all species known to occur in the Matobo Hills in the past century are still present. Few historic data on abundances were found in the literature; most data were anecdotal (but see Smith, 1977; and Grant, 2012). Whilst this study did not acquire sufficient data to provide robust abundance estimates, repeatable measures of relative abundance (camera traps) and sighting frequency (questionnaire data) were compiled and may be used as a baseline for future surveys.

Indications were that carnivores were more prevalent in areas with lower human densities and medium to high livestock densities. There may be concern that conflict, particularly with large carnivores such as leopard and spotted hyaena, may increase particularly in the vicinity of wildlife areas. A number of residents of the Matobo Hills commented that predators move out of protected areas to hunt in community areas because wild prey densities have declined. A multi-pronged approach to wildlife conservation and human livelihood strengthening is therefore recommended, encompassing education about the role of carnivores in the ecosystem, the value of carnivores, legal aspects of wildlife utilisation in Zimbabwe and livestock management systems to reduce livestock losses.

Conflict, particularly with spotted hyaena, was on the rise in 2013, with subsistence farmers looking to the local authorities to eradicate the species. Given the importance of carnivores in the ecosystem, the proximity to the Matopos National Park (an important ecotourist destination) and potential revenue derived from safari hunting, the eradication or removal of carnivores should be avoided. A better, more sustainable approach would be to implement and / or strengthen existing non-lethal anti-predator approaches to livestock management. From observations during the fieldwork period and informal conversations with residents of the Hills during fieldwork and subsequently, livestock management is suboptimal. Livestock kraals were observed to be porous (a visual barrier is preferable), and one village headman stated that few people in resettlement areas protected their livestock at night. Tolerant coexistence is possible, provided that suitable, culturally-acceptable and affordable methods to protect livestock are adopted. Provision of knowledge (for example, through education and pilot projects) is key to achieving this.

6 Conclusion

All expected species of large and small carnivores in the Matobo Hills were recorded during this survey. Some species that were regarded as locally extinct or transient in the 1960s and 1970s, such as spotted and brown hyaena, were found to be resident in the northern Matobo Hills. Habitat and wildlife conservation are critical for the maintenance of high carnivore species richness, and mechanisms to assist people to conserve wildlife whilst strengthening their own livelihoods should be implemented.

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8 Appendices

8.1 Appendix 1: Museum accession records for carnivores found between the latitudes 20 and 21 °S and longitudes 27.5 and 29 °E. Names on accession cards are retained.

Scientific name	Sex	Locality	Map grid	Latitude	Longitude	Date	Collector / Donor
Canis adustus	F	Nr Bambata Matobo		20.5	28.41	07-Jan-94	Pat Fox
Canis mesomelas	M	6 mi W Figtree	2028 A4	20.36	28.31	23-Apr-64	Mr Evans
Canis mesomelas	M	Plumtree Road		20.3	28.4	01-Feb-98	J Ndlovu
Aonyx capensis	-	Maleme Dam		20.55	28.5	01-Jan-60	I Thompson
Aonyx capensis	F	Matopos National Park		20.55	28.5	16-Jan-60	I Thompson
Aonyx capensis	M	Maleme Dam		20.55	28.5	16-Jan-60	I Thompson
Aonyx capensis	M	Maleme Dam		20.55	28.5	16-Jan-60	I Thompson
Aonyx capensis	M	Mzingwane Dam		20.43	28.91	28-Jun-60	SPCA
Ictonyx striatus	F	3 mi from Marula		20.46	28.08	19-Feb-74	PJ Wright
Ictonyx striatus	M	15 mi from Byo on Matopos Road	2028 A4	20.26	28.53	25-Sep-74	P Wright
Ictonyx striatus	U	Whovi Wilderness area		20.55	28.4	29-Feb-92	AJ Gardiner
Ictonyx striatus	M	Matopos Road				29-Mar-96	
Mellivora capensis	F	Bulawayo	2028 B1	20.16	28.63	24-Aug-64	Mr Oldham
Mellivora capensis	F	Gladstone farm, Matopos	2028 A4	20.45	28.48	02-Jun-74	SS Ball
Civettictis civetta	-	Maleme area		20.55	28.5	mid 1972	
Genetta genetta	F	Mamba Mine, Byo	2028 B1			27-Mar-52	
Genetta genetta	F	Brickfields Byo	2028 B1			21-Oct-52	R Smithers
Genetta genetta	M	Khumalo Byo	2028 B1	20.15	28.61	24-Nov-52	K McCosh
Genetta genetta	F	Cyrene Mission	2028 A4	20.31	28.4	09-Dec-52	
Genetta genetta	M	Balla balla	2029 A3	20.43	29.03	26-Sep-57	
Genetta genetta	M	Bulawayo	2028 B1			03-Mar-58	M Hammond
Genetta genetta	M	6 mi W Figtree	2028 A4	20.36	28.21	04-May-60	W Evans
Genetta genetta	M	Figtree District	2028 A4	20.36	28.31	19-Jun-63	W Evans
Genetta genetta	M	W Evans' Farm, Figtree	2028 A4	20.36	28.31	04-Aug-65	W Evans
Genetta genetta	F	W Evans' Farm, Figtree	2028 A4	20.36	28.31	14-Aug-65	W Evans
Genetta genetta	F	Entrance gate east MNP	2028 C2	20.41	28.51	06-Jun-67	
Genetta genetta	F	Essexvale Ranch		20.25	28.06	25-Jan-68	SW Goussard

Scientific name	Sex	Locality	Map grid	Latitude	Longitude	Date	Collector / Donor
Genetta genetta	M	Quiet Waters Essexvale	2028 D2	20.2	29	07-May-68	B Longden
Genetta genetta	F	Gumtree	2028 B1	20.21	28.71	05-Sep-78	Albert
Genetta genetta	F	1 km SW Byo		20.23	28.56	17-Apr-79	
Genetta tigrina	M	Matopos Hills				27-Aug-51	
Genetta tigrina	M	9 mi Essexvale Road S of Byo	2028 B1	20.2	28.71	29-Nov-55	S Smith
Genetta tigrina	M	9 mi Essexvale Road S of Byo	2028 B1	20.2	28.71	22-Sep-56	S Smith
Genetta tigrina	F	9 mi Essexvale Road S of Byo	2028 B1	20.2	28.71	01-Oct-56	S Smith
Genetta tigrina	M	Figtree	2028 A4	20.36	28.31	20-Jul-64	B Evans
Genetta tigrina	M	W Evans' Farm, Figtree	2028 A4	20.36	28.31	03-Feb-66	W Evans
Genetta tigrina	M	Toghwana Dam	2028 D1	20.53	28.6	27-Aug-67	VJ Wilson
Genetta tigrina	F	Essexvale Ranch	2028 B4	20.25	28.06	25-Jan-68	SW Goussard
Genetta tigrina	M	White waters	2028 C2	20.56	28.45	29-Jan-68	VJ Wilson
Genetta tigrina	F	Game Park Matobo	2028 C2	20.55	28.4	30-Jan-68	VJ Wilson & C Gray
Genetta tigrina	F	Game Park Matobo	2028 C2	20.55	28.4	30-Jan-68	VJ Wilson & C Gray
Genetta tigrina	M	Matopos Rd, 10 km from Byo	2028 b1	20.25	28.5	02-Apr-68	CTH Fisher
Genetta tigrina	F	UNK	2027 C1			29-Sep-68	
Genetta tigrina	M	Gumtree 10 mi out on old Essexvale Rd	2028 B1	20.21	28.71	01-Jul-76	B Bretter
Genetta tigrina	F	Maleme Rest Camp	2028 D1	20.36	28.5	12-Jan-77	
Genetta tigrina	M	Worringham Nr Esigodini		20.23	28.75	18-Jan-84	SA Lambe
Helogale parvula	F	MNP Game Park	2028 C2	20.55	28.4	07-Jun-67	VJ Wilson / C Coffin-Grey
Herpestes sanguineus	M	Bulawayo	2028 B1			18-May-51	
Herpestes sanguineus	M	Steelworks	2028 B1			30-Apr-59	
Herpestes sanguineus	M	10 mi Essexvale Road	2028 B2	20.21	28.71	26-Oct-66	PR Brettler
Herpestes sanguineus	F	Gumtree	2028 B2	20.21	28.71	29-May-67	PR Brettler
Herpestes sanguineus	M	Gumtree	2028 B2	20.21	28.71	29-May-67	PR Brettler
Herpestes sanguineus	F	Figtree	2028 A4	20.36	28.31	01-Jun-67	B Evans
Herpestes sanguineus	F	10 mi Essexvale Road	2028 B2	20.21	28.71	27-Aug-73	VJ Wilson
Herpestes sanguineus	M	2 km from entrance Gate, MNP	2028 B3	20.4	28.5	30-Aug-79	CJ Lightfoot
Herpestes sanguineus	F	Matopos Cyrene Rd	2028 A4	20.33	28.41	15-Jun-81	JWA Stead
Herpestes sanguineus	M	Willow Park	2028 B4	20.36	28.68	25-Sep-86	A Kumirai
Herpestes sanguineus	M	Falcon College Streambed	2028 A4	20.2	29	16-Oct-86	A Kumirai
Herpestes sanguineus	M	Falcon College Streambed	2028 A4	20.2	29	17-Oct-86	A Kumirai
Herpestes sanguineus	F	Falcon College Streambed	2028 A4	20.2	29	22-Oct-86	A Kumirai

Scientific name	Sex	Locality	Map grid	Latitude	Longitude	Date	Collector / Donor
Herpestes sanguineus	M	Umhlonyane, Matopos	2028 B3	20.37	28.68	28-Nov-86	A Kumirai
Herpestes sanguineus	F	Umhlonyane, Matopos	2028 B3	20.37	28.68	02-Dec-86	A Kumirai
Herpestes sanguineus	F	Umhlonyane, Matopos	2028 B3	20.37	28.68	11-Dec-86	A Kumirai
Herpestes sanguineus	M	Umhlonyane, Matopos	2028 B4	20.37	28.68	18-Dec-86	A Kumirai
Herpestes sanguineus	F	Umhlonyane, Matopos	2028 B3	20.37	28.68	07-Jun-88	A Kumirai
Herpestes sanguineus	F	Bulawayo	2028 B1			17-Jul-07	
Ichneumia albicauda	F	MNP	2028 C2	20.55	28.4	10-Feb-60	
Ichneumia albicauda	M	Maleme Dam	2028 D1	20.36	28.5	15-Feb-61	
Ichneumia albicauda	M	Matopos N Park	2028 B3	20.46	28.66	01-Apr-62	
Ichneumia albicauda	M	Bonanza Store on Kezi Rd	2028 A4	20.46	28.41	29-Apr-81	National Parks
Mungos mungo	F	2 km S Tshabalala		20.26	28.55	01-Aug-99	B Magwizi
Paracynictis selousi	?	6 mi W Figtree District	2028 a4	20.36	28.26	20-Apr-65	Evans
Paracynictis selousi	M	Evans Farm Figtree	2028 A4	20.36	28.31	17-Aug-65	Evans
Paracynictis selousi	M	15 mi peg W Byo on Figtree Rd	2028 A4	20.25	28.46	08-Sep-65	P Hepburn
Paracynictis selousi	M	Figtree Norton Farms	2028 A4	20.36	28.31	06-Jun-67	Bowker Evans
Paracynictis selousi	F	TTL on way to Toghwana / Mtsheleli Dams	2028 D1	20.56	28.61	30-Aug-67	VJ Wilson
Paracynictis selousi	F	matopos	2028 D1	20.5	28.6	14-Dec-67	C Fisher
Paracynictis selousi	M	Matopos	2028 C2	20.4	28.45	12-Dec-68	T Osborne
Paracynictis selousi	F	Matopo Hills	2028 B3	20.45	28.75	02-Jan-69	C Fisher
Rhynchogale melleri	M	MOTH Shrine	2028 D1	20.45	28.51	28-Oct-58	D Benbow
Rhynchogale melleri	F	Main entrance G Park Matopos	2028 C2	20.56	28.45	30-Jan-68	VJ Wilson & C Gray
Rhynchogale melleri	F	Matopos Ft Usher Rd	2028 C2	20.4	28.55	10-Feb-68	C Fisher
Rhynchogale melleri	M	Matopos	2028 B3	20.45	28.75	12-Dec-68	T Osborne
Hyaena brunnea	F	Gladys farm, Matopos		20.46	28.43		TW Everett
Hyaena brunnea	-	Marula	2028 A3	20.46	28.08		
Hyaena brunnea	M	Matopos National Park	2028 C2	20.55	28.4	26-Aug-60	
Acinonyx jubatus	U	N side Mpopoma Dam (VISUAL SIGHTING)		20.53	28.36	27-Feb-92	AJ Gardiner & EB Miller
Felis caracal	F	Longridge Store, 200 m from Falcon College		20.2	28.95	01-Apr-77	Dr Rockingham-Gill
Felis caracal	F	Between res stn and Matopos Dam		20.36	28.51	21-Nov-93	H Erwee
Felis lybica	?	Bulawayo	2028 B1	20.15	28.58		WB Bucknell
Felis lybica	F	Cyrene Mission		20.33	28.41	09-Jan-53	
Felis lybica	?	Legion Mine 15 m S	2128 B3	21.33	28.5	01-Jul-54	E Evans
Felis lybica	F	21 km N Kezi		20.71	28.48	01-Mar-98	FW Cotterill

Scientific name	Sex	Locality	Map grid	Latitude	Longitude	Date	Collector / Donor
Felis serval	?	Essexvale	2028 B4	20.28	28.93	01-Jun-49	
Felis serval	F	Cyrene Mission		20.33	28.63	07-Aug-49	Paterson
Felis serval	M	Essexvale Rd	2028 B1			17-May-55	S Smith
Felis serval	M	Main entrance G Park Matopos		20.56	28.45	30-Jan-68	VJ Wilson
Felis serval	M	Matopo Hills				30-Jan-68	
Felis serval	F	Game Park Matobo		20.55	28.4	08-Nov-68	VJ Wilson
Felis serval	F	Matopos N Park		20.55	28.4	26-Jun-72	
Felis serval	F	Matopos N Park		20.55	28.4	07-Jun-73	
Felis serval	F	Matopos	2028 B4	20.45	28.76	07-Jun-73	VJ Wilson
Felis serval	F	4 mi byo side of Essexvale	2028 B4	20.26	28.88	19-Feb-74	
Felis serval	F	Tshabalala opp.	2028 B1	20.25	28.55	28-Mar-81	T Harris
Felis serval	-	Byo-19 Old Gwanda Rd				02-Feb-94	
Felis serval	M	Matseumhlope Byo				08-Jun-99	EW Carew
Panthera pardus	F	Matopos	2028 C2	20.55	28.5	1965	
Panthera pardus	-	Maleme Area (Matopos National Park)	2028 D1	20.55	28.5	1938	
Panthera pardus	F	Matopos		20.55	28.4	1960	
Panthera pardus	M	Matopos	2028 C2	20.55	28.4		
Panthera pardus	-	Matopos		20.58	28.3	01-Sep-60	
Panthera pardus	-	Maleme area	2028 D2	20.55	28.5	01-Sep-60	
Panthera pardus	M	Matopos National Park	2028 D1	20.55	28.5	06-Jan-65	S. Coffin Grey
Panthera pardus	M	Lucydale Farm, Leopard Kopje, Matopos	2028 A4	20.4	28.4	03-Jan-71	JH Grobler
Panthera pardus	M	Matopos Game Park	2028 C2	20.55	28.4	01-May-77	H Grobler
Panthera pardus	-	Matopos National Park		20.55	28.4	01-Jun-89	Mr Erwee

8.2 Appendix 2: Questionnaire questions

Respondent unique identifier:
Village name:
Interview locstat:
Respondent's age: **15-20 | 21-25 | 26-30 | 31-35 | 36+ |**
Respondent's occupation:
Number of years resident in the area:
Estimated radius of activity from homestead:

1. Which of these animals have you seen in this area [from photo montages of predators]
    a. In the past year?
    b. In the past five years?
2. Where was your most recent sighting?
    a. Distance and direction from interview site
    b. Habitat [identified from photo montage of habitats]
3. Please give a brief description of the species you have seen
    a. What it looks like
    b. Time of day that it is active
    c. Is it solitary or social?
    d. What does it eat?
    e. How does it kill / eat its prey?
4. How often do you see this species?
5. Over the past five years, do you think that this species' population has increased, decreased or stayed stable? What are the reasons for the trend?
6. What activities do you carry out that you think may affect the abundance, distribution or behaviour of this carnivore?
7. What is your attitude towards this species? [like / dislike/ neutral]
8. Do you consider this animal to be a "problem animal"? If yes, why?
9. Have you lost any livestock to predators? If yes:
    a. How many losses of each type of livestock have you had in past year? [Livestock: cattle, donkey, goat, sheep, poultry, rabbit, other]
    b. Which predators were responsible?
10. Are you aware of any traditional beliefs associated with this animal? What are they?
11. Is this animal a totem animal? Do you know of anyone in this area that has this animal as a totem?