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WILDLIFE DENSITY, DISTRIBUTION AND ABUNDANCE WITH EMPHASIS ON CHEETAH PREY IN MACHAKOS AND MAKUENI DISTRICTS, KENYA

BY

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DEDICATION

This thesis is dedicated to my parents

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ABREVIATIONS AND ACRONYMS

AEZ	Agro Ecological Zone
AMK	Aimi ma Kilungu Ranch
BG	Bare Ground
BRN	Burnt
GIS	Geographical Information System
GPS	Global Positioning System
KE	Kapiti Plains Estate
KMR	Kima Ranch
KUR	Kiu Ranch
KWS	Kenya Wildlife Service
LCCS	Land Cover Classification System
MHG	Medium Height Grass
MOST	Ministry of Science and Technology
MR	Malili Ranch
MWF	Machakos Wildlife Forum
NNP	Nairobi National Park
PA	Protected Area
PCP	Preferred Cheetah Prey
PLG	Ploughed
PSD	Partially Sub-divided
SCP	Sometimes Cheetah Prey
SD	Sub-divided
SG	Short Grass
SNCP	Seldom or Never Cheetah Prey
SS	Stanley and Son Ltd.
TG	Tall Grass
UC	Under Crop
USD	Unsubdivided

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ABSTRACT

More than half of Kenya's wildlife is found outside protected areas. However, its continued existence in these areas is threatened by changes in land-use patterns. The present study investigated wildlife density, distribution, abundance, and factors influencing settlements in ranches that have been partially sub-divided, completely sub-divided and the ones that have not undergone any sub-division in Machakos and Makueni districts, Kenya. Data on density and abundance by day and night was collected over a six month period in two seasons by means of transect counts, covering a distance of 1182 kilometers and analysed using DISTANCE software programme. Data on settlements was obtained by digitizing survey plans for four farms in ArcView 3.2 programme revealing 5456 smallholder plots of land ranging from 2 to 30 acres. Distribution of wildlife species was also obtained by means of the same programme. In total, 32 wild animal species were recorded in the study area, out of which eight were categorised as preferred cheetah prey. The results show that settlements in the sub-divided parts of the study area are influenced by the availability of water and transport infrastructure. Wildlife density was lowest in the partially sub-divided ranches and highest in the unsubdivided ones. Although density varied significantly between day and night, there was no seasonal variation. The total sub-division of two ranches and continued settlements will have an effect on the wildlife as farming and settlement take place. It is suggested that monitoring of wildlife and settlement patterns be continued and strategies developed to encourage wildlife conservation.

Key words: Abundance, conservation, density, protected area, seasonal variation, settlements, wildlife.

1. INTRODUCTION

Charles Darwin puzzled over the abundance of animals supported in extensive savannas (grasslands with sparse tree cover) when recounting his voyage on the HMS Beagle: "….there can be no doubt of its being sterile country…..covered by poor and scanty vegetation. Now if we look to the animals inhabiting these wide plains, we will find their numbers extra ordinarily great and their bulk immense…..it is truly surprising how such a number of animals can find support in a country producing so little food" (Darwin, 1909-1914, Reid *et al.*, 2008a). These lands support three percent of the world's population; but they keep 35% of the world's sheep, 23% of goats and 16% of cattle and water buffalo (Reid *et al.*, 2008a).

Grazing lands which include savannas, grasslands, prairies, steppe and shrub lands cover 61.2 million km^2 or 45% of the earths surface (excluding Antarctica) (Asner *et al.*, 2004; Reid *et al.*, 2008a). More than half of these lands, (60%) are dry and relatively warm (Reid *et al.*, 2008a) and are inhabited by both commercial and subsistence herders. Despite their aridity, they can be deceptively productive (Reid *et al.*, 2008a).

In Kenya, these 'grazing lands' or rangelands, habour different wildlife species, which are resources generating income for the government, jobs for local people as well as providing conservation benefits to those living in the developed countries (Kinyua *et al.*, 2000). Latest figures indicate that 65% of all wildlife in Kenya is found outside of National Parks (PA) and Reserves (Western *et al.*, 2006). In Kenya, protected areas occupy only about 8% of the country's total land area (Kinyua *et al.*, 2000). The lands outside of PA's are a key to the future of wildlife in Kenya and play an integral part in wildlife protection and conservation (KWS, 1990; Kinyua *et al.*, 2000). However, they are increasingly facing many changes in land-use that are threatening the continued existence of wildlife as fragmentation continues to alter habitats of biodiversity (de Fries *et al.*, 2004).

In Australia, fragmentation of rangelands has been a relatively recent phenomenon (Strokes *et al.*, 2008), whereas in Mongolia, political changes in the 20th century have changed the size and boundaries of administrative units, which in turn have altered access to resources and restricted seasonal movement of livestock (Ojima and Chuluun, 2008). Range management is concerned with the synthesis and use of information relating to the structure and function of the rangeland ecosystem, to provide information concerning what is physically and biologically possible and the application of economics to ranch management decisions, where the ranch is viewed as a business. In addition to profit, the objectives of ranch management aims to achieve an equilibrium between animal numbers, on the one hand, and ranch forage and water resources, on the other, coupled with maintenance or improvement of range condition (Pratt and Gwynne, 1977 as cited in van Kooten *et al.*, 1997). Fragmentation of rangelands, especially in the Machakos and Makueni districts of Kenya, has been driven by two major factors: human population growth and socio-economic factors (Olang and Njoka, 1988). From the 1930's-1980's, the human population of Machakos District grew five fold (Behnke, 2008). Whereas historical land-use policies and priorities have been identified as critical drivers of fragmentation in Maasailand in Kenya (BurnSilver *et al.*, 2008). Within this context of management, the wildlife management policy that involved the economic exploitation of wildlife on private land translated into multiple-use approach to resource allocation between wildlife and livestock (van Kooten *et al.*, 1997).

The Kenyan government effected a ban on wildlife hunting in 1977 to control poaching which meant that ranch owners could not shoot wildlife and were therefore left to bear the costs associated with harbouring wild animals but its ownership remained with the government (Kinyua *et al.*, 2000). With no way to control herbivore populations, this policy turned an otherwise abundant resource into a nuisance and a threat to life and livelihood (Kinyua *et al.*, 2000). Under pressure from landowners to allow for utilization of wildlife on private property, the government in 1990 instituted a policy to allow ranch owners to harvest certain species of wildlife on an experimental framework based on quotas allocated by Kenya Wildlife Service (KWS) in what was referred to as game cropping (Anonymous, 2003). Cropping allowed ranchers to benefit from the wildlife on their land although with certain restrictions (Kinyua *et al.*, 2000). Poaching in the ranches is said to have intensified when the moratorium on game cropping was effected in 2003 (Personal Communication). Poaching is considered a major threat to African wildlife outside of parks (Caro, 1999, Rondeau and Bulte, 2007). Desnaring activities carried out in the ranches only increased fence vandalism as the poachers would cut fence lines to make new snares, thus making desnaring activities more expensive to the farm owner than not removing them (Personal Communication).

The British colonial settlers established commercial ranches, mainly in Machakos, Nakuru and Laikipia districts of Kenya (Olang and Njoka, 1988). After independence, most of the colonial settlers offered their ranches for sale to local Kenyans. The sale prices for those ranches were so high that the local people could not raise the required money at that time. Loans were made available by the government for 80% of the sale price. People who wanted to buy the ranches pooled their resources together as a cooperative and by 1964, local people in Machakos had formed 55 Cooperative Societies (Olang and Njoka, 1988). When shareholders bought the ranches, most of them thought that the benefits coming from the ranch would be immediate and substantial. Others became members just to see the colonialists go, while still others thought they would graze their own livestock side by side with those of the society (Olang and Njoka, 1988).

For some time, the high quality standard of livestock was maintained and a number of the ranches supplied the local farmers with improved bulls and the Kenya Meat Commission continued to get high-grade steers for slaughter (Olang and Njoka, 1988). Due to their tenure system, AMK and MR came under intense pressure to sub-divide from the shareholders, because they were not getting returns for their investment (Personal Communication). These economic factors forced the members to push for sub-division of the ranches so that each member can own his/her own piece of the land (Wayumba and Mwenda, 2006). Owning a piece of land comes with a title deed for that piece of land and for a long time, the title deed has been used as an economic instrument to access credit facility from the mainstream banking sector in Kenya (Anonymous, 2003).

With a burgeoning human population and a need for more land for crop production, rangelands are facing intense pressures. In East Africa, 23% of grasslands are now under crop production (Reid *et al.*, 2008b) and cooperative ranches in Machakos and Makueni districts, Kenya, that were not performing well due to mismanagement came under pressure to sub-divide (Personal Communication). With this kind of human population growth the increasing subsistence demands of the population often lead to sub-division of large ranches and invariably leads to a reduction in the size of wildlife dispersal areas (Wayumba and Mwenda, 2006).

The sub-division of ranches entails the demarcation of the land into smallholder plots of different acreage (Olang and Njoka, 1988) from two acres to 30 acres per shareholder based on the number of shareholders (Personal Communication). After the sub-division and allocation of the plots to the shareholders, they are free to use it. Usually, people occupying the land put up fences for demarcation purposes. As predicted by Gardner *et al.* (1987), the ease of movement of animals through a connected landscape is rapidly lost when 30-50% of the landscape is converted to uses incompatible with animal movement (Reid *et al.*, 2008b). Some of the severest changes suffered by species are associated with farmlands (Gaston *et al.*, 2000) and agriculture is noted as a principal threat to African wildlife (Rondeau and Bulte, 2007). In Kajiado district, Kenya, Mwangi and Warinda (1999) observed that new landowners with a farming tradition put up more fences to protect their crops from wildlife. These land-use practices can change the structure and functioning of savanna ecosystems (Higgins *et al.*, 1999). Coughenour (2008) also noted that many, if not most, of the expansive and spatially heterogeneous habitats that large herbivore species evolved in, have been increasingly compressed, sub-divided, fragmented and homogenized, disrupting the movement of wildlife species.

Apart from livestock, these ranches harbour small to large carnivores like the cheetah (*Acynonyx jubatus* Schreber 1776) a globally endangered large carnivore (IUCN, 2002). It has been noted that an increase in human density in newly sub-divided ranches ultimately leads to a disappearance of the large carnivores (Ogada *et al*., 2003), which are especially sensitive to the growth of human population (Woodroffe, 2000). In Namibia, studies have shown that majority of the cheetah live outside of protected areas where species such as lion and spotted hyaena have largely been eliminated or controlled (Marker *et al.*, 2003). The conservation of large carnivores like the cheetah, with their typically large home ranges (Kelly *et al.*, 1998; Bissett and Bernard, 2007) requires large tracts of suitable habitat and these will often compete with other forms of land-use (Bissett and Bernard, 2007). Breuer (2005) observed that fragmentation of rangelands had influenced distribution and availability of prey for predators in the ecosystem. A loss of this prey may lead to conflicts with livestock farmers and therefore, the wild prey base available to the cheetah is critical in the issue of human - cheetah conflicts and their continued persistence in farmlands (Marker *et al.*, 2003).

As the number of extinct and threatened species in a given area is positively related to the number of humans in that area (Mc Kinley, 2001), it is difficult to ascertain the status of wildlife in the entire Machakos Wildlife Forum (MWF), as two reports on the status of wildlife in the ranches were conflicting. According to Western *et al.* (2006), wildlife numbers in the entire study area declined significantly during 1991-2002; while Parker (2003) states that, overall number of large mammals did not decline during that period. It is in this context, that the present study seeks to provide information on the status of wild animals in six ranches cutting across the two districts (Machakos and Makueni).

2. Objectives of the study

2.1 General objective

The general objective of this study is to evaluate the density, distribution and abundance of various wild animal species, especially those considered as important prey species for the cheetah and to determine factors influencing settlement patterns in the sub-divided ranches.

2.2 Specific objectives

The specific objectives of the study are:

- To determine the distribution of wild animals in the study area.
- To determine the density and abundance of wild animals in the study area
- To determine the density, distribution and abundance of preferred cheetah prey wild animal species in the study area.
- To evaluate factors that influence settlements in the newly sub-divided ranches.
- To suggest measures for conservation and maintenance of the ecosystem integrity in the study area with its cheetah population.

3 DESCRIPTION OF THE STUDY AREA

3.1 Location

The present study area forms part of the eastern boundary of the greater Athi-Kapiti plains ecosystem, which is principally located on the northern end of Kajiado district with the northern tip of the ecosystem falling inside the Nairobi National Park (NNP) (Reid *et al*, 2008b). The study area lies between latitude 10° 35´ and 10° 54´ south and longitude 37° 10´ and 37° 18´ east (Anonymous, 1997; Norconsult, 2003) and covers an area of approximately 380 square kilometers (Fig. 1).

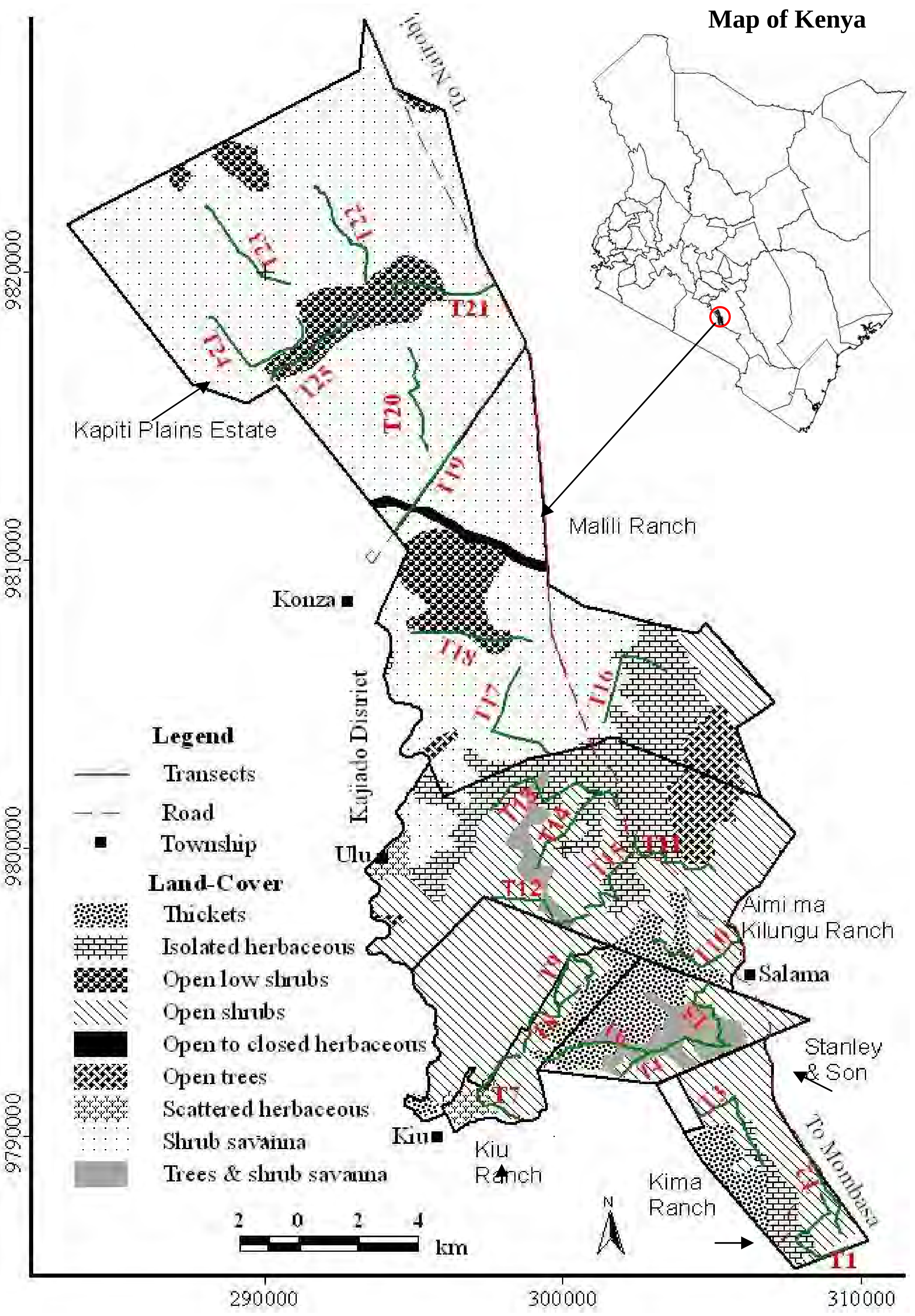


Figure 1. Map of study area showing vegetation types and transect. Outline of Kenya is given INSET.

Aimi ma Kilungu (AMK), Kiu ranch (KUR), Stanley & Son Ltd (SS) and Kima Ranch (KMR) are located in Kilome Division of Makueni District. One farm, Kapiti Plains Estate (KE) is located in Central Division of Machakos District and Malili ranch (MR) straddles both Districts. MR and AMK were completely sub-divided (SD) in 2006, which means that the entire farm has been demarcated into small plots and allocated to shareholders for their own use. Whereas KUR and KMR are partly sub-divided (PSD), the sub-division occurred more than five years ago, and some of the plot owners have taken possession of their allocated plots while the rest of the plots remain accessible to wild animals. Partial sub-division in the present context means that part of the ranch has been demarcated into smaller plots and allocated to the farm shareholders for their own use while the remaining portion is maintained as a cooperative ranch with a management team to run it. SS and KE are not sub-divided and are subsequently referred to as unsubdivided (USD) (Table 1).

Table 1. Farms in the study area and their land-uses.

Name	**Category**	**Approximate Acreage**	**Land-use type**
Kima Ranch	PSD	5,500	Dairy, Sheep and Goats
Stanley & Son Ltd.	USD	5,000	Dairy, Beef, Camels and Semen production
Kiu Ranch	PSD	3,000	Dairy (<100cows) Partially settled
Aimi ma Kilungu	SD	19,000	Partially settled
Malili Ranch	SD	22,500	Partially settled
Kapiti Plains Estate	USD	33,000	Beef , Sheep, Livestock Research

(Settled plots, wherever it appears in this thesis means that the plot has been converted to a different land-use, permanent or semi permanent building erected on the plot or it has been fenced, thus excluding its use by wild animals).

The two districts are bordered by Kajiado district to the west, Kitui district to the east and Taita Taveta borders Makueni to the south. Forests in Machakos and Makueni Districts are limited and are only found on the hilly masses in the high potential parts of the Districts (Anonymous, 1997; Norconsult, 2003).For example, Kilungu forest on the western part of Makueni, Mbooni and Mua hill forests on the western part of Machakos district.

3.2 Economic activities

The Akamba community, who practice mixed farming, primarily inhabit this area. The crops grown in this area include different varieties of fruits like mango, pawpaw, oranges and avocado. Staple crops include maize, beans, cowpeas, millet and sorghum.

3.3 Soils and Climate

There are three major soil types in the study area. These are; vertisols, acrisols and cambisols. These types of soils are developed on quartz – feldspar gneisses. (Anonymous, 1997; Norconsult, 2003).

Agro-Ecological Zones (AEZs) give an indication of the land-use potential, which is dependent on sound farming practices and improved seed and regiment planting programs based on rainfall probabilities. The study area falls under Agro-Ecological Zone V, which is classified as semi-arid with an annual rainfall of 450- 900 mm, falling in two seasons. Long rains occur in March/April continuing to the end of May, and the short rains in October/November continuing to the end of December (Anonymous, 1997; Norconsult, 2003). The study area is generally hot and dry; experiencing high temperatures during the day and low temperatures during the night with temperatures ranging from 20.2° C to 24.6° C with an average of 22.1° C. Extreme heat is more pronounced during the dry season (January – February) and (August – October) (Anonymous, 1997; Norconsult, 2003).

3.4 Habitat

The northern portion of the study area is predominantly shrub savannah with the major grass type in the area being *Thameda triadra*, a tufted perennial with a height of 50-150 cm that is valuable for grazers (Kinyua *et al.*, 2000). Other habitat types include closed to open woody vegetation (thickets), open low shrubs, open shrubs and trees and shrub savannah (FAO, 2000). Some common trees in the study area include *Balanities aegyptiaca, Croton megalocapus* various *Acacia* sp. including *Acacia drepanolobium.*

3.5 Biodiversity

Various wildlife species are found in the study area including herbivores like zebra (*Equus burchelli*), eland (*Taurotragus oryx*), giraffe (*Giraffa camelopardalis*), cokes hartebeest (*Alcelaphus buselaphus*), and grant's gazelle (*Gazella granti*). Carnivores include the endangered cheetah (*Acynonyx jubatus*), spotted hyaena (*Crocuta crocuta*) and black backed jackal (*Canis mesomelas*). Primates include yellow baboon (*Papio cynocephalus*) and vervet monkey (*Cercopithecus pygerrythrus*). There are also game birds such as ostrich (*Struthio camelus massaicus*) and guinea fowls (*Numida meleagris*) in the area (Kinyua *et al.*, 2000).

4 MATERIALS AND METHODS

4.1 Materials

Major tools used during the survey include a hand held global positioning system (GPS), Leopold range finder, a four by four wheel land-rover vehicle, hand held compass, spot light, digital camera and clip board.

4.2 Methods

4.2.1 Preliminary survey

A preliminary survey of the roads in the study area was conducted in August 2007 and the roads to be used for transects were identified. Permission to conduct the study was sought from the farm owners, farm managers and the Ministry of Science and Technology (MOST), Kenya. Permission was granted by three farms: KMR, KUR, KE, and MOST in September 2007. Permission was not required for two farms: AMK and MR as they have been sub-divided. One farm, SS granted its permission in November 2007 and was therefore surveyed only for five out of the six months intended for the study. Permission was sought and granted by the Kenya Pipeline Company for use of the pipeline road, which cuts across five of the six farms. This was especially necessary for the night counts as this road is prohibited to use after six o'clock in the evening and as the road was part of some of the transects.

4.2.2 Sampling design

Three transects each were set in KMR (T1, T2 and T3), SS (T4, T5 and T6) and KUR (T7, T8 and T9) ranches, respectively, taking into consideration the relatively smaller size of theses farms while at the same time making sure that the representative vegetation types were surveyed. Only one vegetation type was omitted from the survey due to inaccessibility limitations. Six transects each were set in AMK (T10-T15) and KE (T20-T25), respectively, and four transects in MR (T16-T19). Thus a total of 25 transects measuring 101.7 kilometers long and a uniform width of 400 meters were established based on logistics, accessibility and vegetation type to ensure for a comprehensive survey during both the wet and dry seasons (Table 2). Transect 19 was counted on one side because it lied on the main Konza road which forms part of the boundary with KE (Fig. 1) and the length was subsequently halved to indicate two kilometers instead of four kilometers for the purpose of estimating density and abundance using Distance software Program. Counts of animals began in October 2007 and ended in March 2008.The counts were carried out approximately 21 days apart and took 10 day to complete. The morning count began at 6.30 a.m and lasted approximately two and a half hours while the night count bagan at 9.00 p.m and lasted approximately three and a half hours. Apart from the January 2008 count where field survey was interrupted for a week due to political instability in Kenya, the other counts were conducted on time. A four by four Land-rover vehicle with two roof hutches was used for the survey apart from two morning and two night surveys where a Toyota double cabin pick-up truck was used due to the unavailability of the Land Rover. Both vehicles offered similar elevation levels. A minimum of three people were involved in the surveys: a driver, a spotter and a recorder. In total, 294 transect counts covering

1182.6 kilometers were conducted in six months. A total of 20.38 km^2 (5.38 % of the total area) was sampled during the present study period.

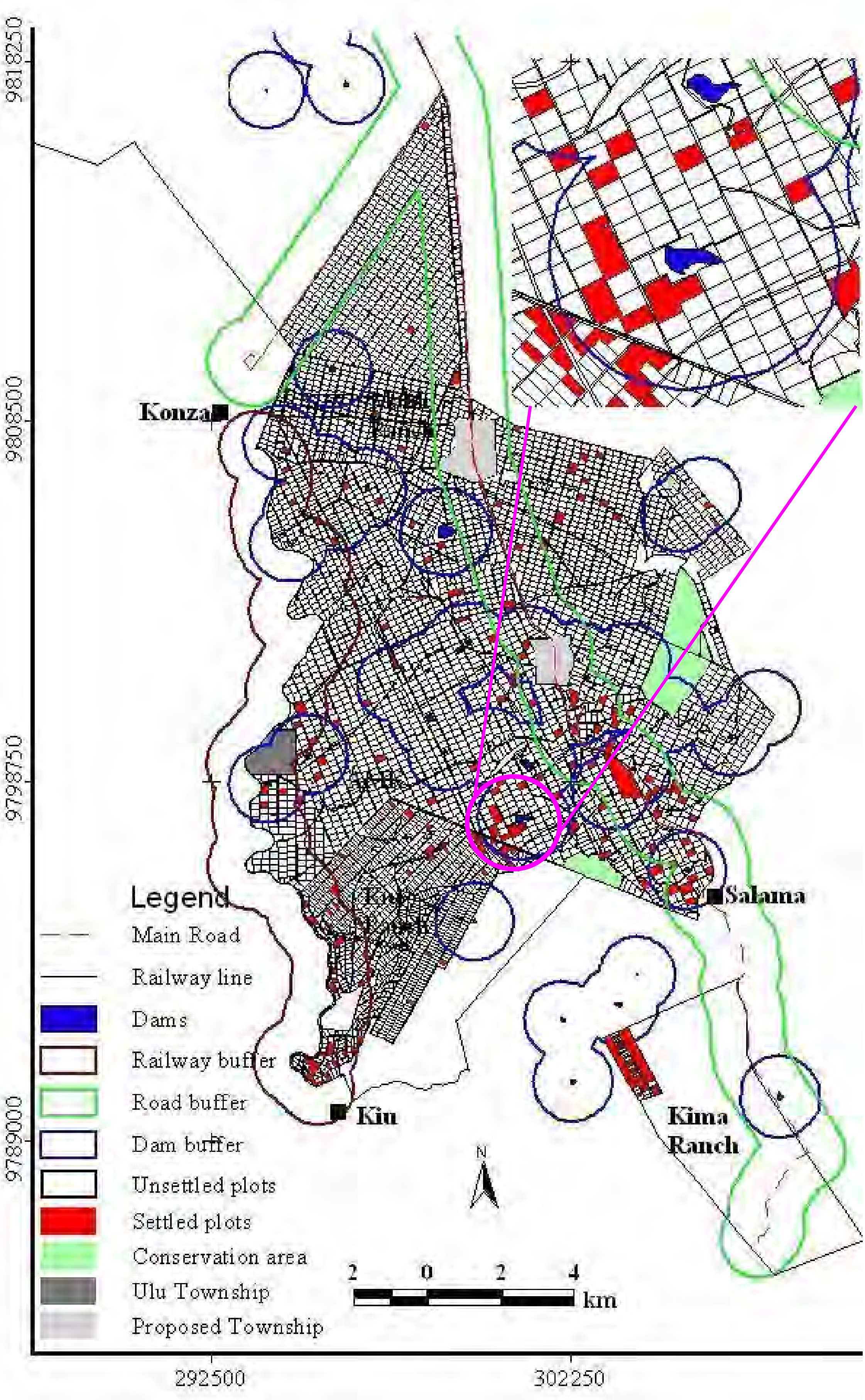
Table 2. Number, length and width of survey transects.

Transect	Length (km)	Width (m)	Transect	Length (km)	Width (m)
T1	4.5	400	T14	4.5	400
T2	3.4	400	T15	4.2	400
T3	4.4	400	T16	3.9	400
T4	4.2	400	T17	4.7	400
T5	3.4	400	T18	4.1	400
T6	3.9	400	T19	2	400
T7	4	400	T20	4	400
T8	3.9	400	T21	4	400
T9	3.8	400	T22	4.1	400
T10	4.6	400	T23	4.2	400
T11	3.8	400	T24	5	400
T12	3.8	400	T25	4.1	400
T13	5.2	400			

4.2.3 Data collection

4.2.3.1 Settlement patterns and farm categories

Survey plans for the sub-divided and partially sub-divided ranches, were obtained from the farm managers and used for the generation of base map for the ranches. Data on plots that had been settled was obtained during the survey period by recording the GPS coordinates of all plots cultivated or fenced. The buffer tool, in ArcView 3.2 X-Tools extensions was used to create a one-kilometer buffer around dams, railway line and the main road to determine the influence of these factors, if any on new settlement of plots (Fig. 2).



Map of the partly sub-divided and sub-divided ranches showing the sub-divisions and buffer boundaries. INSET is a zoomed in Portion showing property boundaries.

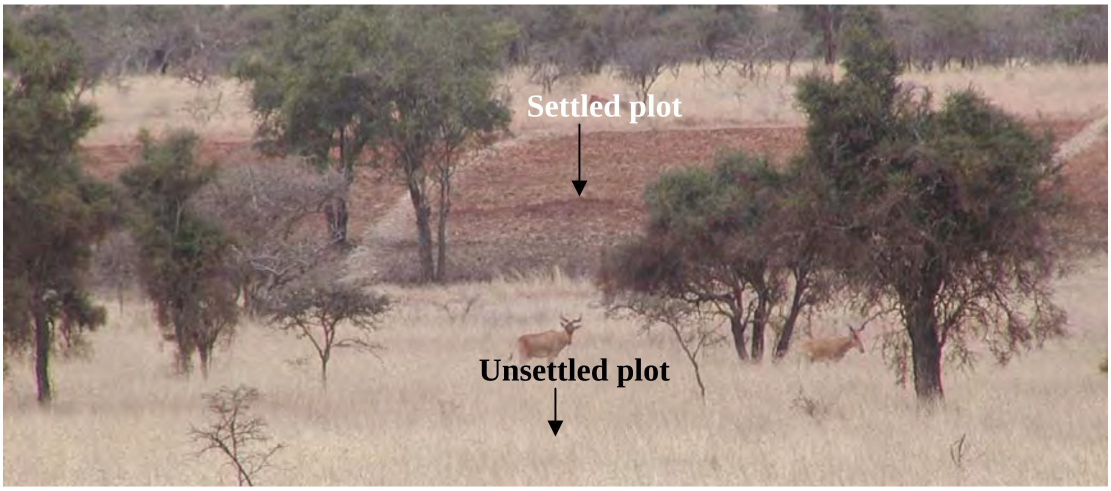


Plate 1. Settled and unsettled plots in Aimi ma Kilungu Ranch after sub-division (Photo: Mary Wykstra, February 2008).

Farms were categorized based on the level of sub-division that has occurred in them as follows: KMR and KUR as partially sub-divided (PSD), AMK and MR as sub-divided (SD) and SS and KE as Unsubdivided (USD). (Size of each of the farms have been indicated as approximate because the maps in this thesis cannot be used as an authority on property boundaries).

4.2.3.2 Density, distribution and abundance data

Data was collected from October 2007 to March 2008 for both seasons dry (October, February, and March) and wet (November, December, and January), during morning (beginning 6:30 am) and night (beginning 21:00 pm). The vehicle was driven at an average speed of 15km/h and when an animal of interest was sighted, the vehicle was stopped, species was identified and geographic location was obtained using a hand held global positioning system (GPS). For the night count, a spot light was swept from side to side up to a 90-degree angle from the car to spot eye glare from an animal's eyes. The animals of interest ranged from small herbivores like cape hare and springhare to large mammals like giraffe. The number, sex and age of the observed species, whenever possible were noted. Perpendicular distance from point of observation to the animal/s was measured with a range finder, the bearing from point of observation was also obtained using a hand-held compass and the general vegetation type recorded (see Appendix 1). Observed wildlife species were divided into three categories based on their size, weight and their morphological ability to inflict injury to a cheetah (Hayward *et al*., 2006). Based on their results, wildlife species in the study area were classified as: Preferred cheetah prey species: the species in this category ranged in weight from 4 kg for Cape hare to 40 kg for Grant's gazelle. Sometimes cheetah prey (SCP) ranged from 1.8 kg for Guinea fowls to 200 kg for Zebra and seldom or never cheetah prey (SNCP) varied from small cats like the African wild cat to Cape buffalo weighing 450 kg (Mizutani, 1999). Out of the 32 wild animal species recorded, eight were categorised as preferred cheetah prey (Table 3). Wildlife recorded in the study area was also classified as Order Carnivora, Primates, Artiodactyla, Tubulidentata, Lagomorpha, Rodentia and Class Aves.

Table 3. Cheetah prey categories in the study area.

Prey category		
PCP	**SCP**	**SNCP**
Cape hare	Guinea fowl	Aardvark
Dikdik	Cokes hartebeest	African wild cat
Duiker	Lesser kudu	Baboon
Grant's gazelle	Ostrich	Bat eared fox
Impalla	Spring hare	Buffalo
Reedbuck	Vervet monkey	Civet cat
Steinbuck	Warthog	Eland
Thomson's gazelle	Wildebeest	Giraffe
	Y.N.S. Fowl	Jackal
	Zebra	Porcupine
		Serval cat
		Spotted hyaena
		Striped hyaena
		Waterbuck

(PCP = preferred cheetah prey, SCP = sometimes cheetah prey, SNCP= seldom or never cheetah prey, Y.N. S. Fowl = yellow necked spurfowl).

4.2.3.3 Vegetation types

For the purpose of this study, vegetation types in the study area were classified following the standard Land Cover Classification System (FAO, 2000) (Table 4).

Table 4. Vegetation type classification in the study area.

LCCS definition	**LCCS code**	**Area (km^2)**
Shrub savannah	RL-2	178.8
Open shrubs (45-40% crown cover)	FR-7	92.2
Open trees (65-40% crown cover)	FR-3	10.3
Closed to open woody vegetation (thicket)	FR-5	19.7
Open low shrubs (65-40% crown cover)	FR-8	23.6
Trees and shrub savannah	RL-3	9.81
Open to closed herbaceous	RL-5	2.15
Isolated herbaceous	AG-1C	38
Scattered herbaceous	AG-1B	4
Total Area (km^2)		**378.56**

4.2.3.4 Vegetation structure

Vegetation structure was defined as burnt area (Plate 2), ploughed (Plate 3), cropped (Plate 4), bare ground, tall grass (grass more than one and a half feet high), medium height grass (grass with a height of six inches to one feet) and short grass (grass with a height of six inches and below) (Plate 5).

Plate 2. Burnt area in Aimi ma Kilungu Ranch.

(Photo: Cosmas M. Wambua, October 2007).

Plate 3. Ploughed plot in Aimi ma Kilungu Ranch

(Photo: Cosmas M. Wambua, October 2007).

Plate 4. Land under crop in Malili Ranch.

(Photo: Cosmas M. Wambua, January 2008).

Plate 5. Short grass on a previously burnt area in Malili Ranch.

(Photo: Cosmas M. Wambua, January 2008).

4.2.4 Data Analysis

4.2.4.1 GIS analysis

Survey plans for the sub-divided and partially sub-divided farms were digitized on a digitizing table to come up with a base map for the farms. As this map was geo-referenced, the data on plots that had been fenced or converted to crop production were overlaid on the map and the respective plots identified in ArcView 3.2 (ESRI, 1996). Also, as every transect had a corresponding start and end GPS coordinate reading, these coordinates were overlaid on the land-cover map and their exact locations were mapped out in ArcView 3.2 (ESRI, 1996).

In addition, since all data points also had corresponding GPS coordinates, they were overlaid on the land-cover map to map out the distribution of wild animals observed during the study period. in the study area. As boundaries for all the farms involved in this study were available, the total area covered by each vegetation category was calculated using ArcViews' X-Tools extension.

The transects were overlaid on the land-cover image and their length per vegetation category in each farm was calculated. Transects cutting across similar vegetation types were summed to come up with the total length in the individual vegetation types. The sum was then divided by the total transect length for the study area to compute the percentage coverage per vegetation type. The total percentage of vegetation type sampled was obtained by multiplying total transect length that went through each vegetation type with the transect width. The area was then divided by the area of that vegetation type and multiplied by 100 to come up with the percentage of coverage.

4.2.4.3 Statistical analysis

The program DISTANCE (Version 5.0, Thomas *et al*., 2006) was used to estimate density and abundance of wild animals recorded in the study area. Distance sampling theory (Buckland *et al*., 1993) includes two main approaches to estimate density: line-transects and point-transects (Mizutani, 1999). For line-transect, Distance requires the data to include transect number, cluster size, area of the study area, radial distance and angle or perpendicular distance, and distance from the point of observation. Density and abundance for all wild animals recorded was calculated using sightings (encounters) only. The density was calculated for individual wildlife species in each vegetation type they were encountered. Truncation distances used for density and abundance calculations for individual species varied depending on the vegetation type they were encountered. The uniform key function with simple polynomial adjustments was used for all density and abundance analysis.

Apart from density and abundance, the other tests were done in SPSS 11.5. Pearson Chi-square was used to test the association between the explanatory variables. The explanatory variables were: Farm Categories (SD, PSD and USD), Season (Wet and Dry), Transects (T1-T25), Vegetation type (RL-2 = Shrub savanna**,** FR-7= Open shrubs, FR-3 = Open trees, FR-5 = Thickets, FR-8 = Open low shrubs, RL-3 = Trees and shrubs savanna, RL-5 = Open to closed herbaceous, AG-1C = Isolated herbaceous, AG-1B = Scattered herbaceous), prey categories (PCP, SCP and SNCP), Time of the day (Day and Night) and Vegetation structure (Short grass, medium height grass, tall grass, bare ground, burnt, ploughed and cropped).

Simpson's index of diversity (D) was calculated to evaluate the differences in species diversity between different vegetation types by the following formula.

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = the total number of individuals of a particular

Species

N = the total number of individuals of all species

5. RESULTS

5.1 Settlement patterns

Aimi ma Kilungu Ranch was sub-divided into 1577 plots, each measuring approximately 10 acres. Of these, 178 (11.3%) plots had been settled by March 2008. Out of the settled plots, 23 (12.9%) were outside the dam, railway or main road buffer. Approximately 14 (7.9%) were inside the railway buffer while, 107 (60.1%) were within the one kilometer buffer for dams and 34 (19.1%) were within the main road buffer. In total, 155 (87.1%) of all settled plots in AMK were within the one kilometer buffer of dam, main road and railway line. Malili Ranch was sub-divided into 2579 plots measuring approximately 7.7 acres each. Out of these, 98 (3.8%) were settled. Of the settled plots, 27 (27.5%) were outside the dam, railway or main road buffer. Plots inside the railway line buffer comprised (1111.2%) while 38 (38.8%) were within the dam buffer and 22 (20.4%) were within the main road buffer. Settled plots falling inside the three buffers comprised 72.4% of all settled plots. The sub-divided portion of Kiu Ranch had 1200 plots of which 204 (17%) were settled. Of the settled plots, 112 (54.9%) were within the railway line buffer, 14 (6.9%) were within the dam buffer while 78 (38.2%) were outside the three buffers. The sub-divided portion of Kima Ranch had a total of 200 plots and due to its location, the buffers could not be executed However, 130 (65%) plots were settled on. Out of 5,456 plots in the study area, only 518 (9.5%) were settled on by March 2008 (Fig. 3).

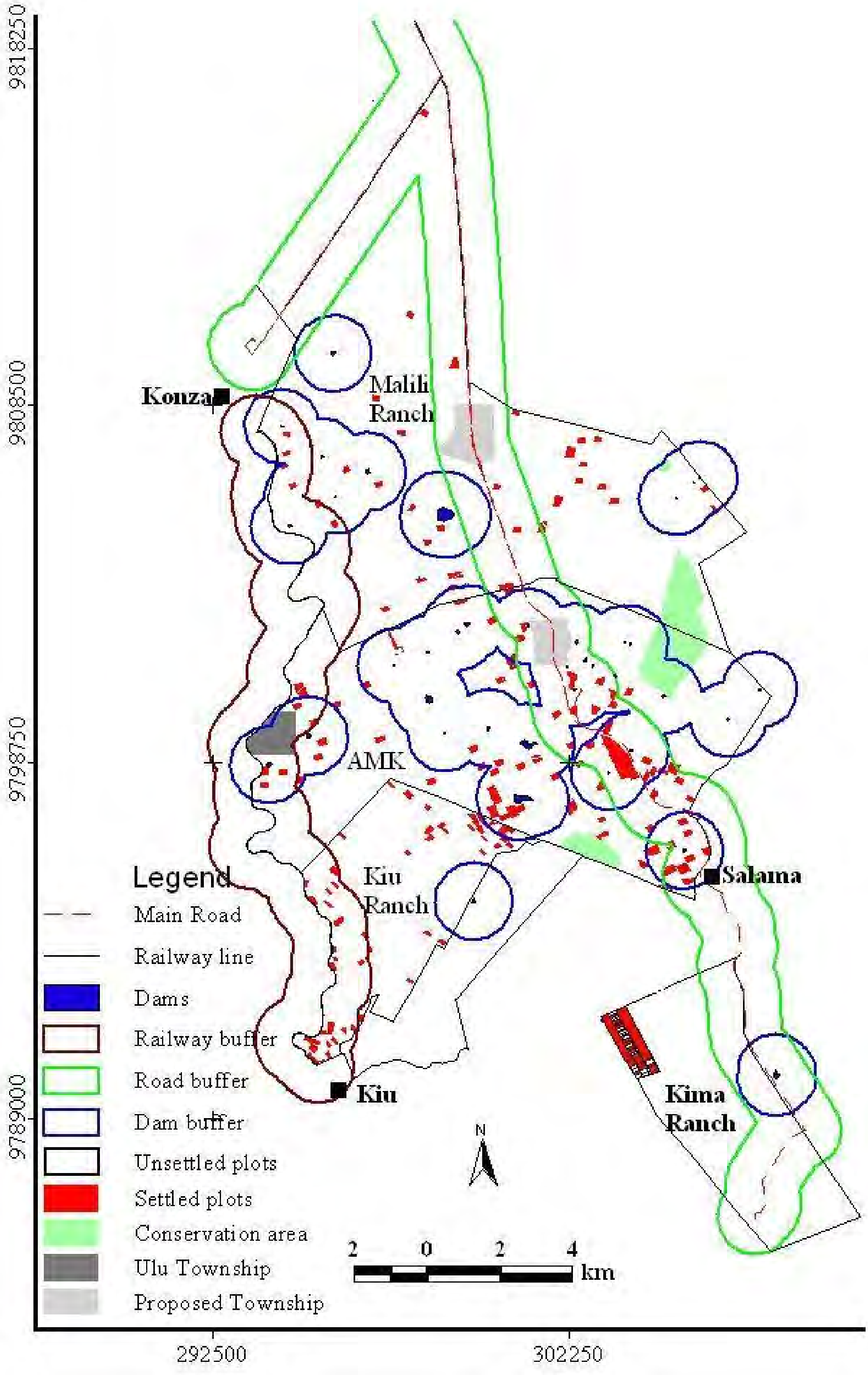


Figure 3. Map showing locations of settled plots in four farms in the study area in relation to the buffer zoning.

5.2 Species composition

A total of 7,960 individual wild animals were recorded during the study period of which 6,930 were wild mammal species and 1,030 were game birds. Seven of the mammalian species were members of the Order Carnivora including Families: Canidae (Bat-eared and Black backed jackal), Felidae (African wild cat and Serval cat), Viverridae (Civet cat), and Hyaenidae (Spotted and Striped hyaena). Among Order Artiodactyla, 15 species were recorded representing 46.9% of all wildlife species encountered. These include Families Giraffidae (Giraffe), Suidae (Warthog) and Bovidae (Cape buffalo, Dikdik, Duiker, Eland, Grant's gazelle, Impalla, Coke's hartebeest, Lesser kudu, Reedbuck, Steinbuck, Thomson's gazelle, Waterbuck and Wildebeest). In Order Perissodactyla, one species of Family Equidae (Zebra) was recorded. Two Families were recorded in Order Rodentia, Hystricidae (Porcupine)and Pedetidae (Spring hare). Among Order Primates, Family Cercopithecidae, two species were recorded (Baboon and Vervet monkey). One member of Order Tubulidentata was recorded (Aardvark) and one member of Order Lagomorpha (Cape hare) was encountered. Three species belonging to Class Aves, were also recorded (Guinea fowl, Ostrich and Yellow necked spurfowl) (Table 5).

Table 5. Species of wild animals observed in the study area.

Category	No. of Species	Proportion (%)
Artiodactyla (Order)	15	46.9
Aves (Class)	3	9.4
Carnivora (Order)	7	21.9
Lagomorpha (Order)	1	3.1
Perissodactyla (Order)	1	3.1
Primates (Order)	2	6.2
Rodentia (Order)	2	6.2
Tubulidentata (Order)	1	3.1
Total	**32**	**100**

The most abundant preferred cheetah prey species was Thomson's gazelle, with 546 (29.88%) individuals recorded while the least abundant preferred cheetah prey species was Reedbuck, with 39 (2.13%) individuals observed (Table 6).

Table 6. Total number and relative abundance of preferred cheetah prey species recorded in the study area.

Species	**Number recorded**	**Relative abundance (%)**
Cape hare	262	14.34
Dikdik	75	4.11
Duiker	134	7.33
Grant's gazelle	244	13.36
Impala	408	22.33
Reedbuck	39	2.13
Steinbuck	119	6.51
Thomson's gazelle	546	29.88
Total	**1827**	**100**

Out of the total observations, 341, 395 were of PCP, 299, 360 were of SCP, and 59 and 53 were of SNCP during the dry and wet seasons, respectively. The difference was however not statistically significant ($\chi 2 = 2.05$ *df* = 2, *P*= .35). However, significant seasonal differences existed amongst species in the PCP ($\chi 2 = 18.99$ *df* = 7, *P*= 0.008) and SCP categories ($\chi 2 = 24.12$ *df* = 9, *P*=.004). Species in the SNCP category showed a marginally significant difference between the seasons ($\chi 2 = 23.09$ *df* = 13, *P*=.04). Among PCP species, Impalla had the highest seasonal difference of 28 (62.2%) encounters for the wet and 17 (37.8%) for dry season. Thomson's gazelle recorded higher dry season encounters 62 (58%) than the wet season 45 (42.1%) (Table 7).

Table 7. Seasonal encounters of preferred cheetah prey species in the study area.

PCP Species	Dry	Wet	Total
Cape hare	84 (38.3)	135 (61.7)	**219**
Dikdik	23 (43.4)	30 (56.6)	**53**
Duiker	57 (48.3)	61 (51.7)	**118**
Grant's gazelle	39 (55.7)	31 (44.3)	**70**
Impalla	17 (37.8)	28 (62.2)	**45**
Reedbuck	7 (30.4)	16 (69.6)	**23**
Steinbuck	52 (51.5)	49 (48.5)	**101**
Thomson's gazelle	62 (57.9)	45 (42.1)	**107**
Total	**341**	**395**	**736**

Figures in parentheses indicate percentage of encounters

The highest number of observations was 395 during the wet season for PCP and the lowest was 53 observations for SNCP during the wet season (Fig. 4).

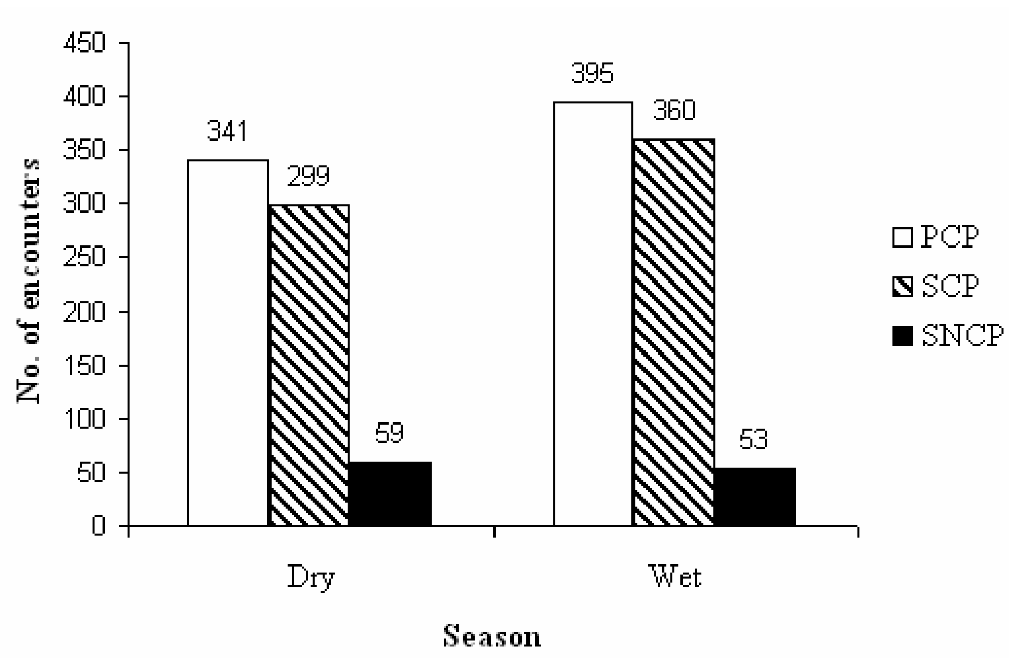


Figure 4. Number of encounters for prey categories between dry and wet seasons (PCP=preferred cheetah prey, SCP=sometimes cheetah prey, SNCP=seldom or never cheetah prey).

Although the number of encounters for SCP category were higher in the wet season than the dry season, the total numbers for the same category were higher in the dry season than the wet season (Fig. 5, Appendix 4).

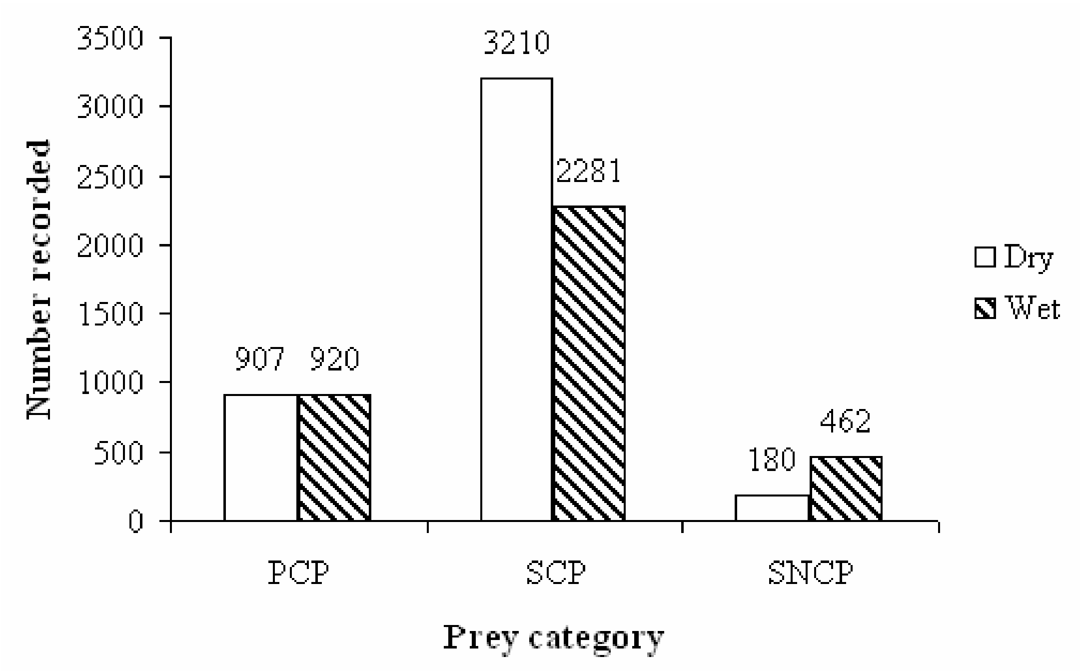


Figure 5. Total number of wild animals within prey categories recorded seasonally (PCP=Preferred cheetah prey, SCP= sometimes cheetah prey, SNCP= seldom or never cheetah prey).

PCP category recorded the highest night encounters of 575 while SCP category had the highest day encounter rates of 352. Amongst prey categories, the difference between day and night was statistically significant ($\chi 2 = 149.64$ df = 2, P<.0001) (Fig 6).

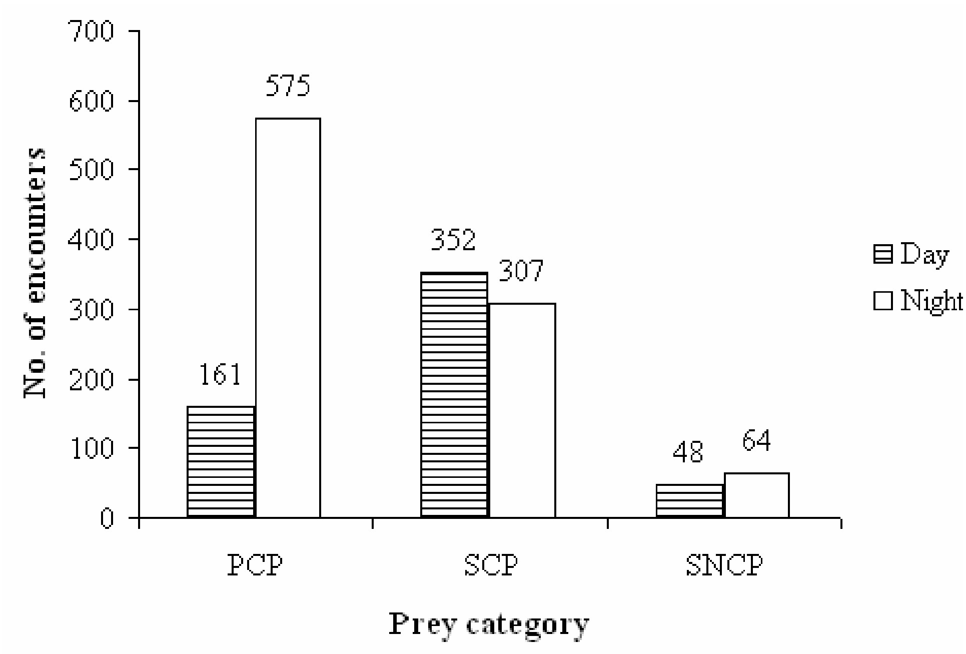


Figure 6. Prey category encounters between day and night.

(PCP=preferred cheetah prey, SCP=sometimes cheetah prey, SNCP=seldom or never cheetah prey).

In addition, there was a statistically significant difference amongst preferred cheetah prey species ($\chi 2 = 159.50$ *df* = 7, *P*<.0001) with cape hare, duiker and steinbuck recording the highest difference with dominant night encounter of 217 (99%), 100 (84.7%) and 82 (81.2%) respectively (Table 8).

Table 8. Day and night encounters of preferred cheetah prey species in the study area.

PCP Species	**Day**	**Night**
Cape hare	2 (1)	217 (99)
Dikdik	7 (13.2)	46 (86.8)
Duiker	18 (15.3)	100 (84.7)
Grant's gazelle	40 (57.1)	30 (42.9)
Impalla	21(46.7)	24 (53.3)
Reedbuck	8 (34.8)	15 (65.2)
Steinbuck	19 (18.8)	82 (81.2)
Thomson's gazelle	46 (43)	61 (57)
Total	**161**	**575**

Figures in parentheses indicate percentage of encounters.

5.3 Farm categories

Prey category encounters between farm categories showed high significant difference ($\chi 2 = 85.36$ *df* = 4, *P*<0.001) with the highest number of encounters (416) being recorded in the unsubdivided farm category for SCP while the lowest (13) were in the partially sub-divided category for SNCP (Fig. 7).

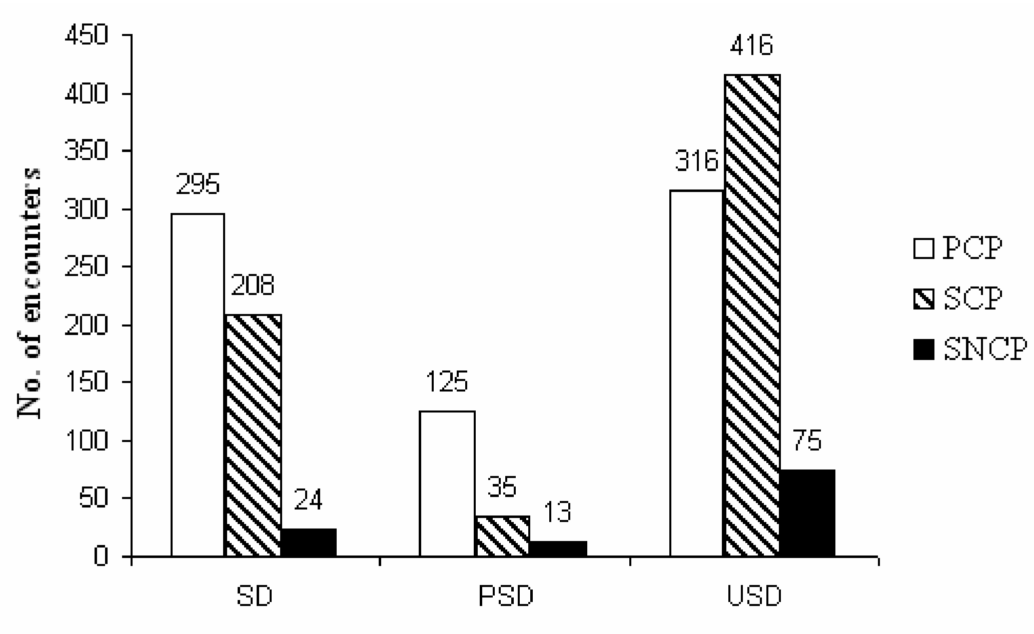


Figure 7. Prey category encounters between farm categories.

(PCP=preferred cheetah prey, SCP=sometimes cheetah prey, SNCP=seldom or never cheetah prey, SD=sub-divided, PSD= partially sub-divided, USD= unsubdivided).

The association between all wild animal encounters and farm category with time of the day was also highly significant ($\chi 2 = 66.70$ df = 2, P<0.001) with the unsubdivided ranches recording highest encounters during both day and night (Fig. 8).

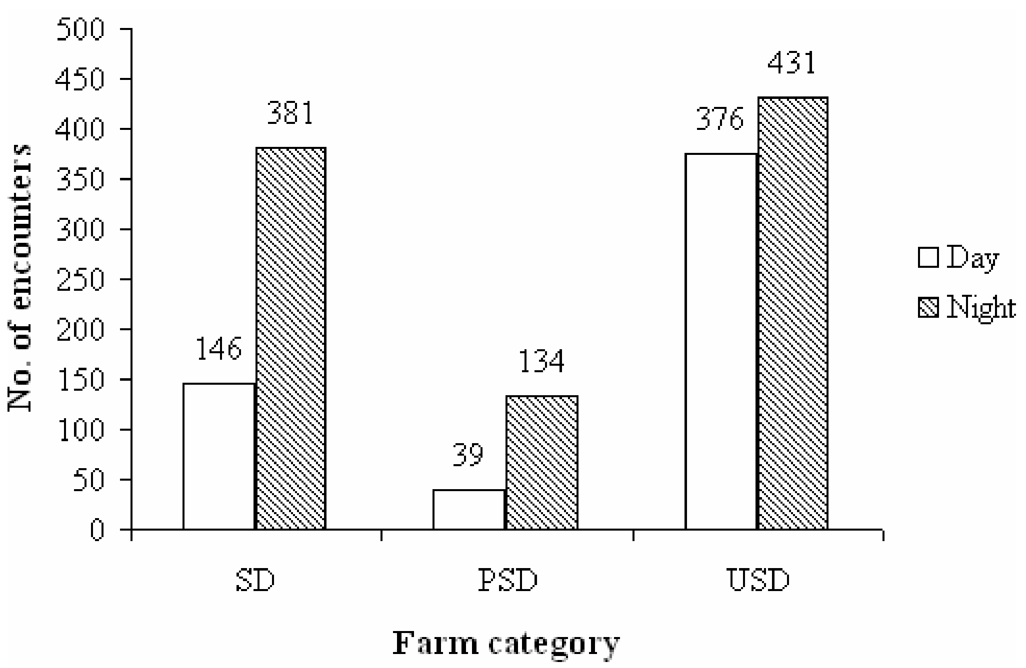


Figure 8. Wild animals encounters between day and night amongst farm categories (SD=sub-divided, PSD= partially sub-divided, USD= unsubdivided).

Seasonal differences in encounters of all wild animals between farm categories were not statistically significant

($\chi 2 = .34$ *df* = 2, *P*= 0.84) (Fig. 9)

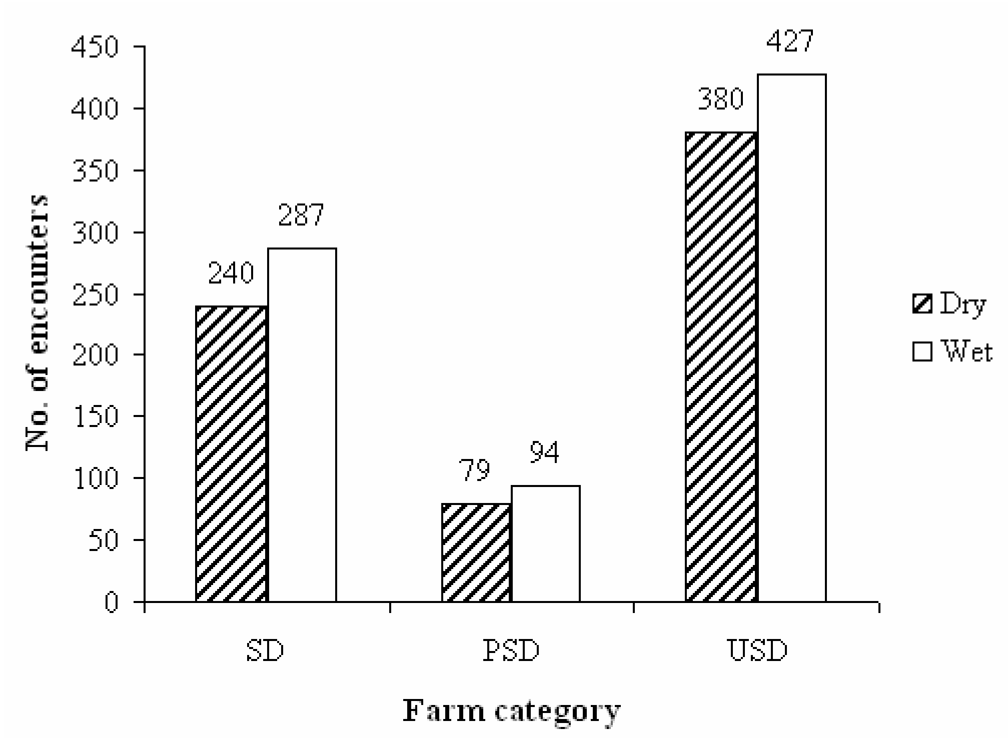


Figure 9. Seasonal encounters of observed wild animals between farm categories in the study area (SD=sub-divided, PSD= partially sub-divided, USD= unsubdivided).

All wildlife encounters between the farm categories showed a highly significant difference ($\chi 2 = 464.82$ *df = 62,* $P<.0001$) with the USD farm category recording the highest number of encounter 807 (53.8%) and the PSD recording the lowest 173 (11.5%) (Table 9).

Table 9. Wild animal species encountered in the farm categories

Animal Species	SD	PSD	USD	Total
Aardvark	1	1	2	4
African wild cat	0	0	2	2
Baboon	0	1	0	1
Bat eared fox	3	1	1	5
Buffalo	1	0	0	1
Cape hare	80	63	76	219
Civet cat	0	0	2	2
Dikdik	21	14	18	53
Duiker	38	35	45	118
Eland	2	0	13	15
Giraffe	1	0	34	35
Grant's gazelle	27	0	43	70
Guinea fowl	7	17	50	74
Impalla	6	1	38	45
Jackal	5	3	13	21
Kongoni	116	0	121	237
Lesser kudu	1	1	1	3
Ostrich	1	0	19	20
Porcupine	5	0	0	5
Reedbuck	6	1	16	23
Serval cat	1	5	2	8
Spotted hyaena	4	1	1	6
Spring hare	48	4	97	149
Steinbuck	61	11	29	101
Striped hyaena	1	0	0	1
Thomson's gazelle	56	0	51	107
Vervet monkey	0	1	8	9
Warthog	1	0	50	51
Waterbuck	0	1	5	6
Wildebeeste	11	0	12	23
Yellow necked spurfowl	11	12	20	43
Zebra	12	0	38	50
Total	**527**	**173**	**807**	**1507**

5.4 Vegetation types and distribution of wild animals

Shrub savanna (RL-2), covered the largest area in the study area (178 km^2) while the smallest (2.15 km^2) was under open to closed herbaceous vegetation (RL-5). Tree and shrub savanna (RL-3) had the highest percentage of area sampled (19.98% km^2) while the open trees vegetation type (FR-3) was not sampled at all due to inaccessibility (Table 10).

Table 10. Area sampled per vegetation type. (Figures in parentheses are percentages of area covered by each vegetation type).

Vegetation type	**Area in (km^2)**	**Sampled (km^2)**
Open trees (65-40% crown cover)	10.3 (2.7)	0
Closed to open woody vegetation (thicket)	19.7 (5.2)	0.91 (4.62)
Open shrubs (45-40% crown cover)	92.2 (24.4)	6.42 (6.96)
Open low shrubs (65-40% crown cover)	23.6 (6.2)	1.7 (7.2)
Shrub savannah	178.8 (47.2)	5.91 (3.31)
Trees and shrub savannah	9.81 (2.6)	1.96 (19.98)
Open to closed herbaceous	2.15 (0.6)	0.06 (2.8)
Scattered herbaceous	4 (1.1)	0.32 (8)
Isolated herbaceous	38 (10)	3.1 (8.16)
Total (km^2)	**378.56**	**20.38 (5.38)**

Shrub savanna vegetation type had the largest proportion of encounters for all wild animals observed 712 (47%) while scattered herbaceous and open to closed herbaceous vegetation types recorded 1% each of all wild animal encounters respectively (Fig. 10).

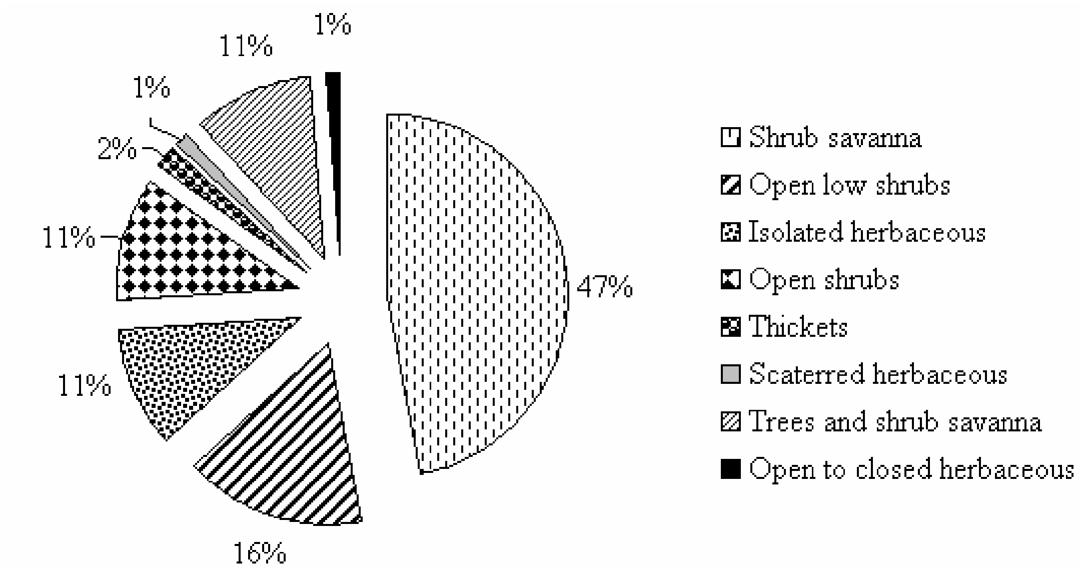


Figure 10. Proportions of wildlife encounters in different vegetation types.

The difference in prey category and vegetation type association was highly significant ($\chi 2 = 206.54$ *df* =14, *P*<0.001). PCP category recorded the highest number of encounters in the scattered herbaceous vegetation type (85.5%) and the lowest in open to closed herbaceous vegetation type (16.7%) (Table 11)

Table 11. Encounters of prey category in different vegetation types (Figures in parentheses are percentages of prey category observed in different vegetation types).

Vegetation Type	**Prey Category**			
	PCP	**SCP**	**SNCP**	**Total**
Shrub savannah	266 (37.4)	404 (56.7)	42 (5.9)	712 (47.2)
Open low shrubs	131 (55)	66 (27.7)	41 (22.3)	238 (15.8)
Isolated herbaceous	115 (70.5)	39 (24)	9 (5.5)	163 (10.8)
Open shrubs	129 (75.4)	33 (19.3)	9 (5.3)	171 (11.3)
Thickets	17 (60.7)	9 (32.1)	2 (7.2)	28 (1.9)
Scattered herbaceous	12 (85.5)	1 (7.1)	1 (7.4)	14 (0.9)
Tree & shrub savanna	64 (37.8)	97 (57.4)	8 (4.8)	169 (11.2)
Open to closed herbaceous	2 (16.7)	10 (83.3)	0	12 (0.8)

PCP=preferred cheetah prey, SCP=sometimes cheetah prey, SNCP=seldom or never cheetah prey.

However, the open low shrubs vegetation type had the highest wild animal diversity and the open to closed herbaceous vegetation type had the lowest wild animal diversity (Table 12).

Table 12. Simpson's index of diversity of wild animals between vegetation types.

	Vegetation types (Habitat)							
	FR-8	**FR-5**	**FR-7**	**AG-1B**	**AG-1C**	**RL-2**	**RL-3**	**RL-5**
1-D	0.86	0.86	0.85	0.84	0.83	0.76	0.61	0.4

FR-8= open low shrubs (65-40% crown cover), FR-5= closed to open woody vegetation (thicket), FR-7= open shrubs (45-40% crown cover), AG-1B= scattered herbaceous, AG-1C= isolated herbaceous, RL-2= Shrub savannah, RL-3= trees and shrubs savannah, RL-5= open to closed herbaceous. 1-D denotes Simpson's Index of Diversity.

The association between PCP species and vegetation types (Fig.11) in the study area was highly significant ($\chi 2 = 409.58$ *df* = 49, *P*<0.001) with shrub savanna recording 266 (36.1%) of all PCP encounters while open to closed herbaceous recorded 2 (0.3%) of all PCP encounters. Among the PCP species, Grant's gazelle was encountered the most in shrub savanna vegetation type 62 (88.6%) while duiker was relatively evenly distributed between open low shrub, isolated and open shrub vegetation type 25 (21.2%), 27 (22.9%) and 37 (31.3%) respectively (Table 13, Fig. 12, see Fig.11).

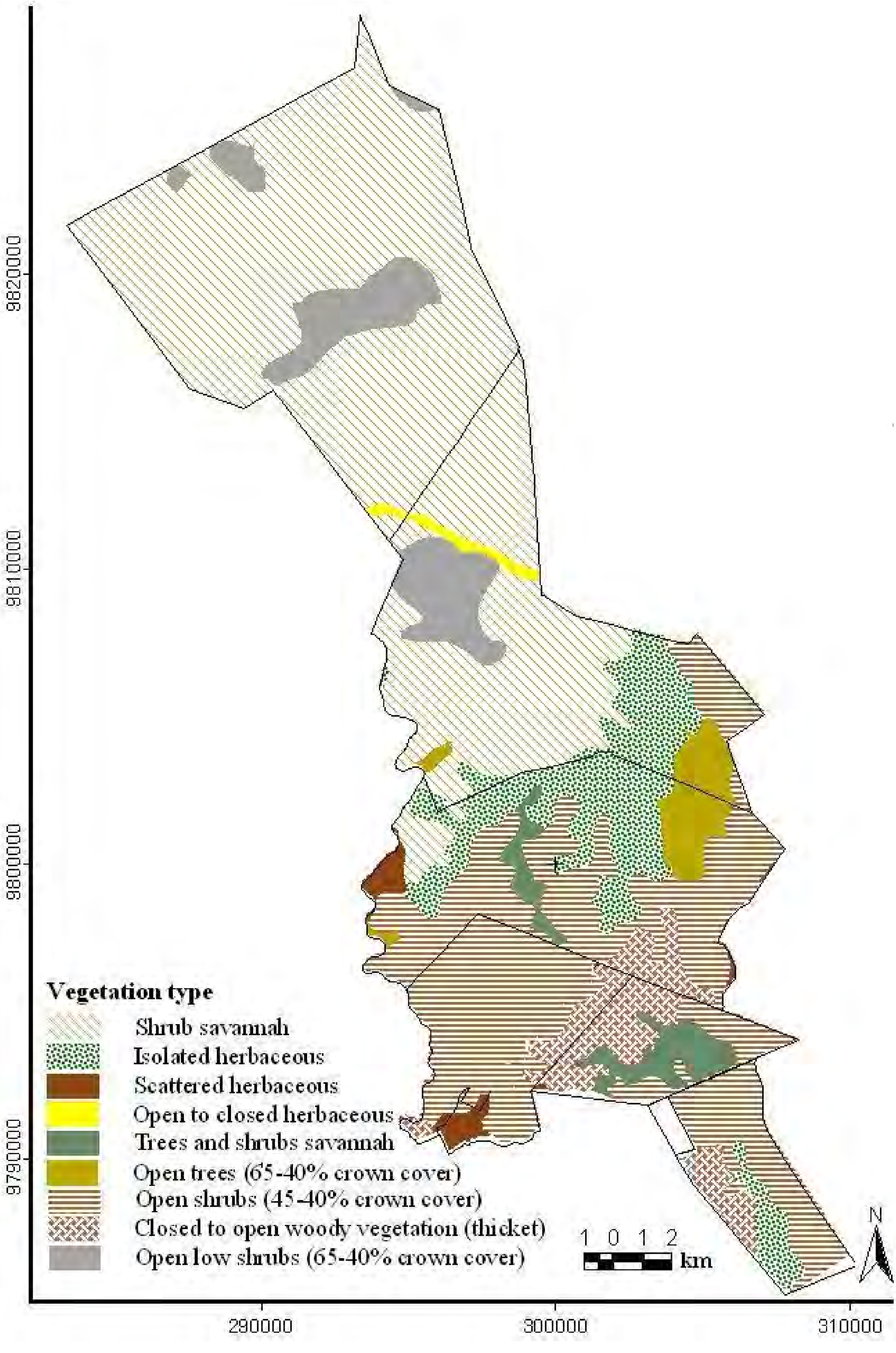


Figure 11. Map of vegetation types in the study area.

Table 13. Distribution of Preferred cheetah prey species in vegetation types (Figure in parentheses denote percentage of encounters).

	PCP							
Veg. Type	CH	DD	DK	GG	IM	RB	SB	TG
RL-2	67(30.6)	2(3.7)	14(11.8)	62(88.6)	8(17.8)	0	32(31.7)	81(75.7)
FR-8	24(10.9)	4(7.6)	25(21.2)	7(10)	25(55.5)	14(60.9)	12(11.9)	20(18.7)
AG-1C	43(19.6)	12(22.6)	27(22.9)	0	4(8.9)	1(4.3)	24(23.8)	4(3.7)
FR-7	54(24.6)	20(37.7)	37(31.3)	0	0	1(4.3)	1716.8)	0
FR-5	2(1)	5(9.4)	2(1.7)	0	0	4(17.4)	3(2.9)	1(0.9)
AG-1B	5(2.3)	2(3.8)	2(1.7)	0	0	1(4.3)	2(1.9	0
RL-3	24(10.9)	8(15.1)	11(9.3)	0	8(17.8)	2(8.7)	11(10.9)	0
RL-5	0	0	0	1(1.4)	0	0	0	1(0.9)
Total	219	53	118	70	45	23	101	107

Veg. Type= Vegetation type, RL-2= Shrub savannah, FR-8= open low shrubs (65-40% crown cover), AG-1C= isolated herbaceous, FR-7= open shrubs (45-40% crown cover), FR-5= closed to open woody vegetation (thicket), AG-1B= scattered herbaceous, RL-3= trees and shrubs savannah, RL-5= open to closed herbaceous, CH= cape hare, DD= dikidik, DK= duiker, GG= Grant's gazelle, IM= impalla, RB= reedbuck, SB= steinbuck, TG= Thomson's gazelle.

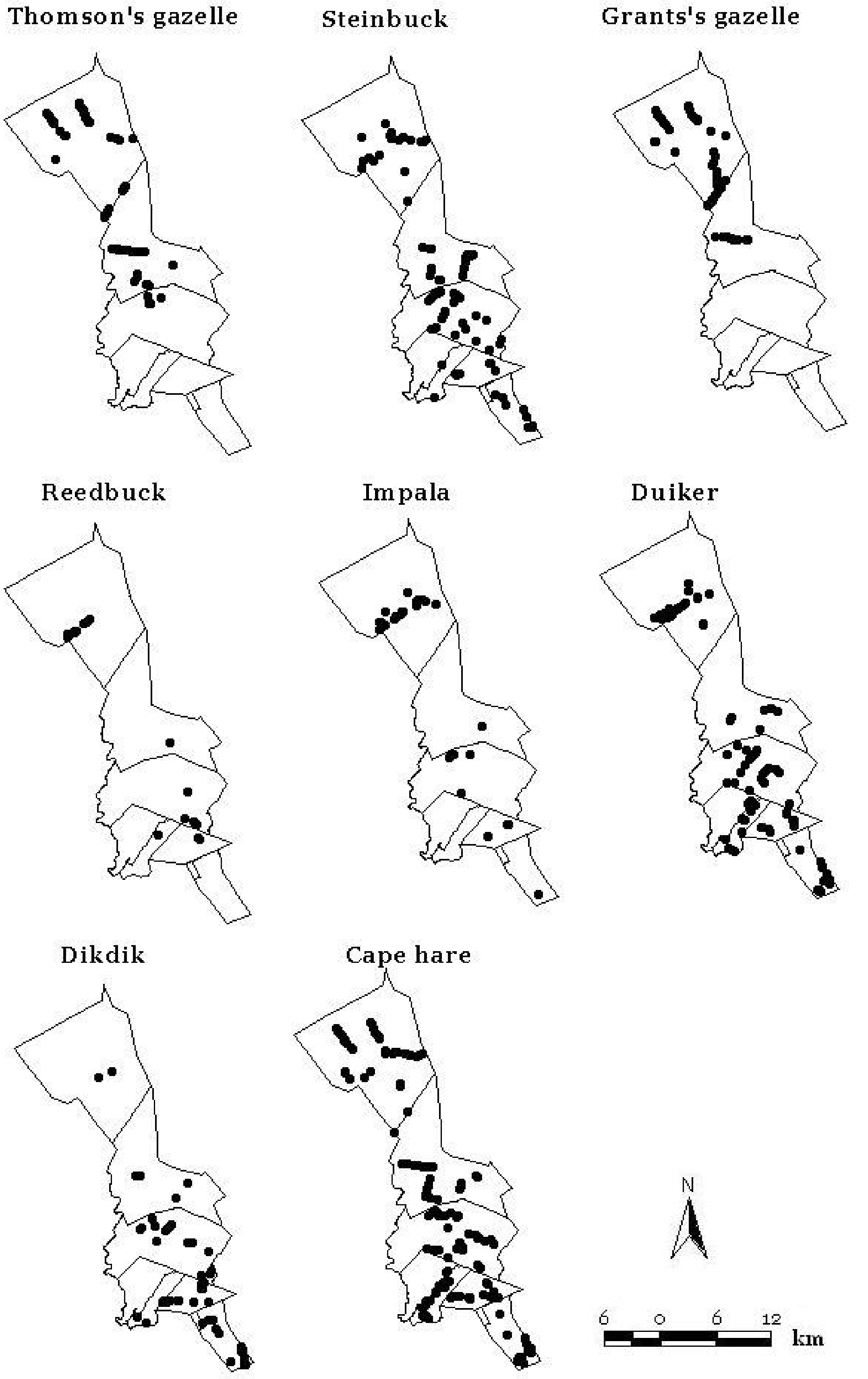


Figure 12. Distribution of preferred cheetah prey species in the study area as observed during the study period. (Refer to Figure 11. for names of vegetation types). types).

There was a significant difference in encounters between all wildlife species recorded in specific vegetation type in the study area ($\chi 2 = 1305.36$ *df* = 217, *P*<0.001). Among game birds, ostrich was restricted in the shrub savanna vegetation type (N = 20) (Fig. 12, see Fig.11).

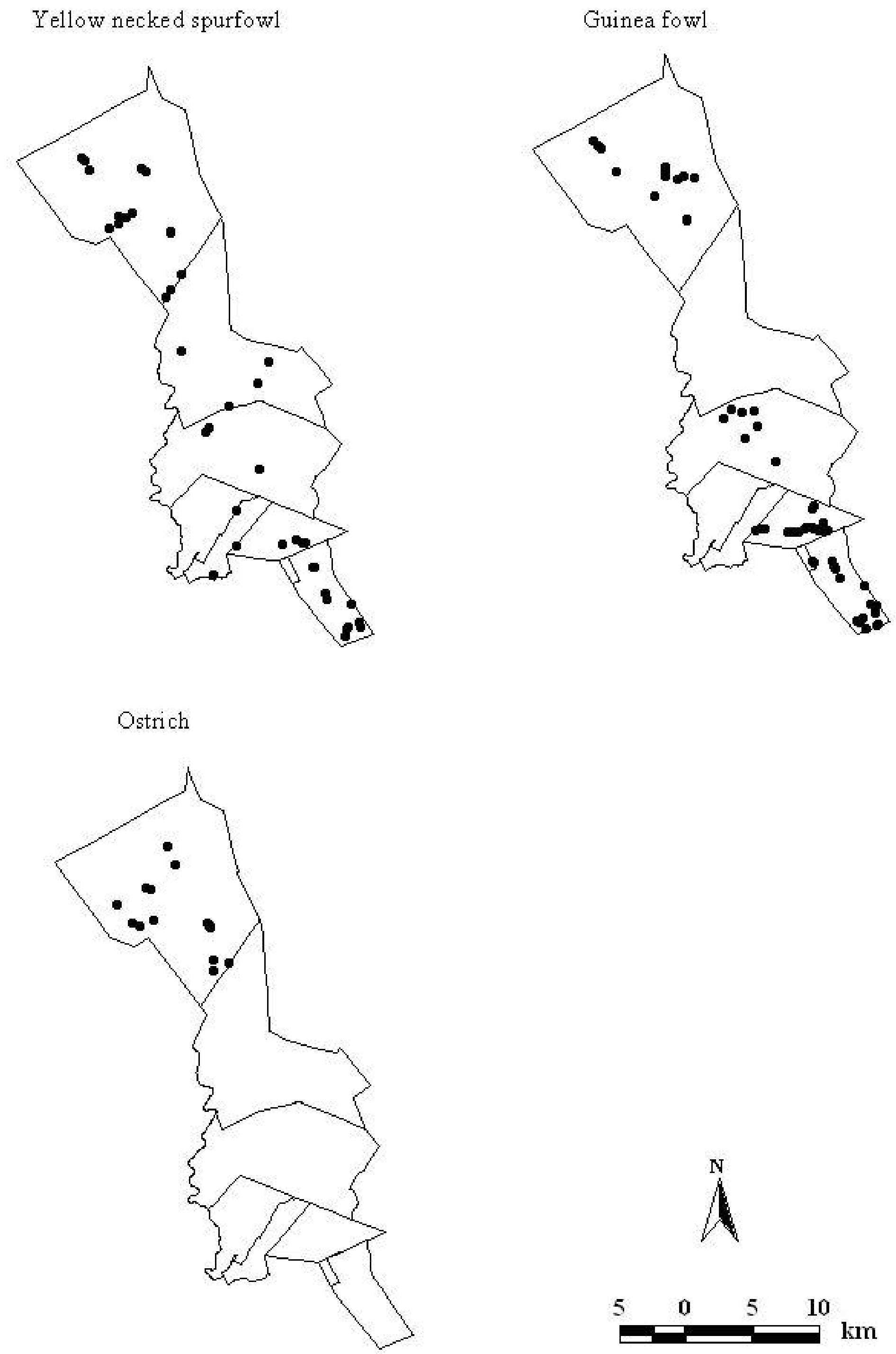


Figure 13. Distribution of game birds in the study area as observed during the study period. (Refer to Figure 11. for names of vegetation types).

Among carnivores, the African wild cat was exclusively encountered in the open low shrub vegetation type (N= 2) (Fig.14, see Fig.11)

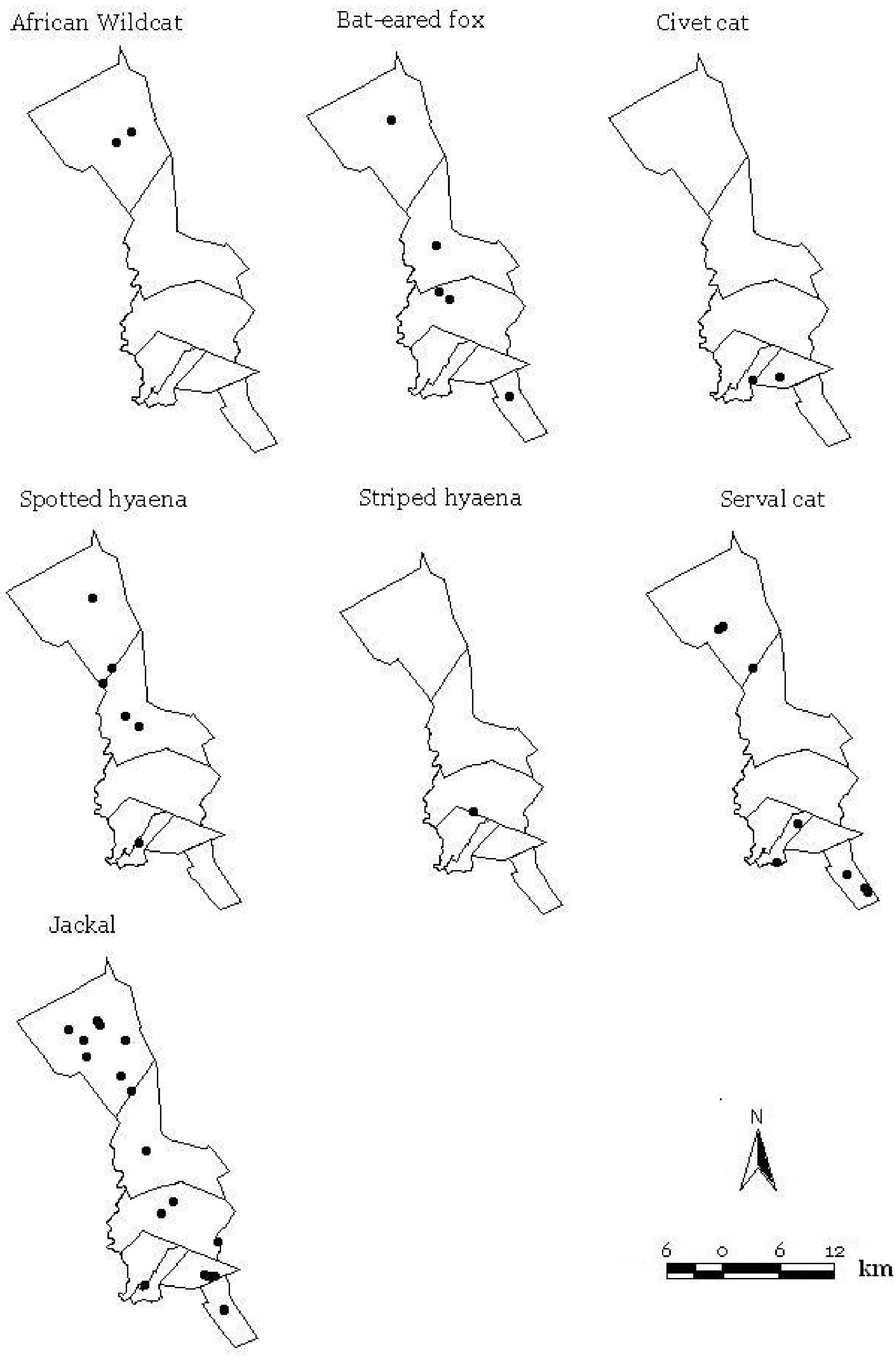


Figure 14. Distribution of wild carnivores in the study area as observed during the study period. (Refer to Figure 11. for names of vegetation types).

While among large herbivores, zebra recorded the highest number of encounters in the shrub savanna vegetation type (88%, n = 44) (Fig. 15, see Fig. 11).

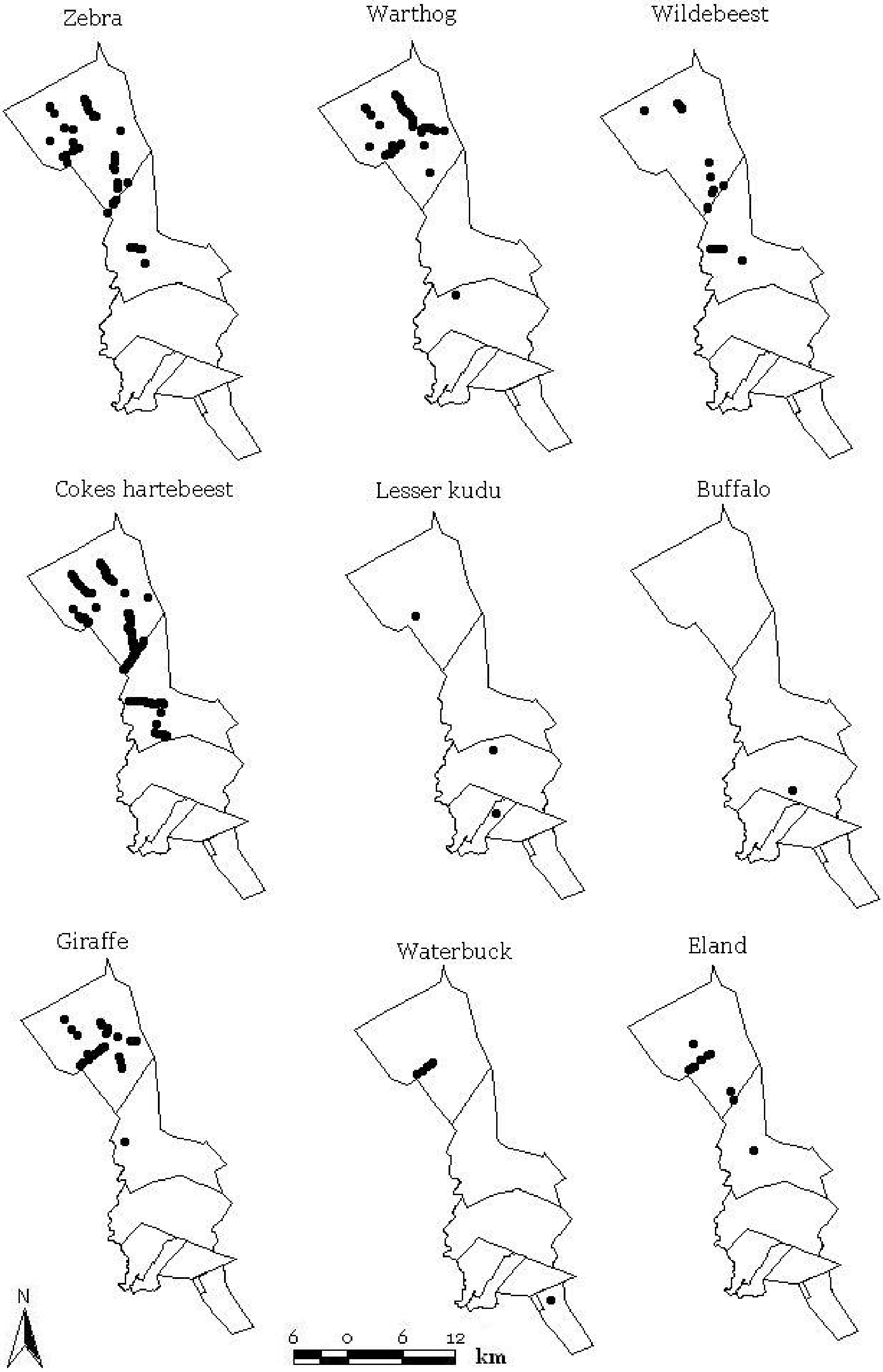


Figure 15. Distribution of other wild herbivores as observed during the study period. (Refer to Figure 11. for names of vegetation types).

5.5 Vegetation structure

Encounters of observed wild animals in different vegetation structures was highly significant ($\chi 2 = 664.12$ *df* = 186, *P*<0.001) with the highest number of encounters 817 (54%) being recorded in short grass, and the lowest 12 (0.8%) in areas under crop. Preferred cheetah prey accounted for 11 (91.7%) of all sightings on the areas under crop. The highest number of encounters for PCP was in the short grass, while no species belonging to SCP category was encountered in the ploughed or areas under crop. SNCP were not encountered on the burnt and ploughed areas (Table 14).

Table 14. Encounters of wild prey categories in various vegetation structures. (Figures in parentheses indicate percentage of prey category observed in various vegetation structures).

Vegetation structure	**PCP**	**SCP**	**SNCP**	**Total**
Tall grass	37(48)	31(40)	9(12)	77
Medium height grass	225(45)	217(43)	60(12)	502
Short grass	385(47)	393(48)	39(5)	817
bare ground	29(64)	13(29)	3(7)	45
Burnt	39(95)	2(5)	0	41
Ploughed	10(77)	3(23)	0	13
Under crop	11(92)	0	1(8)	12
Total	**736**	**659**	**112**	**1507**

PCP=preferred cheetah prey, SCP=sometimes cheetah prey, SNCP=seldom or never cheetah prey.

The difference in encounters amongst preferred cheetah prey species was highly significant ($\chi 2 = 309.75$ df = 42, P<0.001) between vegetation structures. Of all cape hare encounters, 158 (72.2%) were on short grass while duiker was encountered the most in medium height grass 73 (62%) (Table 15).

Table. 15. Preferred cheetah prey species encounters in different vegetation structure. (Figures in parentheses indicate percentage of encounters)

PCP	TG	MHG	SG	BG	BRN	PLG	UC
Cape hare	3(1.4)	22(10)	158(72.1)	26(11.9)	7(3.2)	1(0.5)	2(0.9)
Dikdik	5(9.4)	14(26.4)	26(49)	1(1.9)	6(11.3)	1(1.9)	0
Duiker	10(8.5)	73(61.9)	24(20.3)	2(1.7)	3(2.5)	4(3.4)	2(1.7)
G. Gazelle	6(8.5)	24(34.3)	34(48.6)	0	6(8.5)	0	0
Impalla	5(11.1)	26(57.8)	12(26.7)	0	1(2.2)	0	1(2.2)
Reedbuck	0	19(82.6)	2(8.7)	0	0	0	2(8.7)
Steinbuck	6(5.9)	37(36.6)	39(38.6)	0	12(11.9)	4(4)	3(3)
T. Gazelle	2(1.9)	10(9.3)	90(84.1)	0	4(3.7)	0	1(0.9)
Total	37	225	385	29	39	10	11

PCP= preferred cheetah prey, TG= tall grass, MHG= medium height grass, SG= short grass, BG= bare ground, BRN= burnt , PLG= ploughed, UC= under crop.

5.6 Transect counts

There was a statistically significant difference in wildlife encounters between transects across seasons ($\chi 2 = 54.70$ df = 24, P<0.001). Significant differences also existed in wildlife encounters amongst transects during day and night ($\chi 2 = 120.74$ df = 24, P<0.001) (Table 16).

Table 16. Wildlife encounters across seasons between day and night in the study area.

Transect	Dry	Wet	Total	Day	Night	Total
T1	26	31	57	14	43	57
T2	17	14	31	8	23	31
T3	13	14	27	11	16	27
T4	23	60	83	31	52	83
T5	21	28	49	10	39	49
T6	18	31	49	9	40	49
T7	12	16	28	4	24	28
T8	8	11	19	1	18	19
T9	3	8	11	1	10	11
T10	5	11	16	3	13	16
T11	5	25	30	0	30	30
T12	7	9	16	0	16	16
T13	17	40	57	19	38	57
T14	9	15	24	3	21	24
T15	6	16	22	2	20	22
T16	28	16	44	11	33	44
T17	32	30	62	12	50	62
T18	96	65	161	54	107	161
T19	35	60	95	42	53	95
T20	67	57	124	78	46	124
T21	40	38	78	33	45	78
T22	91	91	182	81	101	182
T23	45	47	92	50	42	92
T24	22	24	46	17	29	46
T25	53	51	104	67	37	104
Total	699	808	1507	561	946	1507

Transect T18 had the highest number of encounters during the dry season 96 (13.7%) and night 107 (11.3%) while transect T22 showed consistent encounters for both dry and wet seasons 13% and 11.3% (n = 91), respectively. Preferred cheetah prey species and transect association showed a statistically significant difference ($\chi 2 = 950.76$ df = 168, P<0.001). Cape hare was encountered in all transects, while Steinbuck was encountered in 23 transects (Table17).

Table 17. Encounters of preferred cheetah prey species between transects.

Transect	Cape hare	Dikdik	Duiker	Grant's gazelle	Impalla	Reedbuck	Steinbuck	Thomson's gazelle
T1	24	4	9	0	1	0	1	0
T2	6	3	10	0	0	0	4	0
T3	2	5	1	0	0	0	4	0
T4	8	2	1	0	0	0	1	0
T5	9	5	3	0	1	0	5	0
T6	5	9	5	0	5	2	1	0
T7	16	2	6	0	0	0	1	0
T8	11	0	4	0	0	1	1	0
T9	4	0	5	0	0	0	0	0
T10	2	3	1	0	0	4	5	0
T11	10	3	3	0	0	1	3	0
T12	8	0	3	0	1	0	3	0
T13	12	4	4	0	4	0	16	4
T14	2	3	9	0	0	0	5	0
T15	6	1	8	0	0	0	3	0
T16	6	5	8	0	1	1	16	1
T17	12	0	2	0	0	0	6	8
T18	20	2	0	12	0	0	3	30
T19	2	0	0	15	0	0	1	13
T20	3	0	2	11	0	0	2	0
T21	15	1	3	2	16	0	8	5
T22	12	0	2	18	1	0	7	34
T23	18	0	0	9	0	0	0	11
T24	4	0	7	3	3	0	2	1
T25	2	1	22	0	12	14	3	0
Total	219	53	118	70	45	23	101	107

5.7 Wild animal density and abundance in the study area

There was a significant difference in the density amongst the prey categories ($\chi 2 = 246.10$ *df* = 2, *P*<0.001) with PCP category having the highest mean density (4.47 ± 3.71 animals/km^2) and the SNCP category having the lowest mean density (0.45 ± 0.24). Amongst PCP species, the difference was also statistically significant ($\chi 2 = 523.99$ *df* = 7, *P*<0.001) with Cape hare having the highest mean density of (9.08 ± 3.13 animals/km^2) while reedbuck had the lowest mean density (0.78 ± 0.34 animals/km^2). Density amongst all wild animals recorded in the study area was statistically significant ($\chi 2 = 1049.64$ *df* = 31, *P*<0.001). Cape hare and Cokes hartebeest had the highest densities in the study area (9.08 ± 3.13 animals/km^2 and 6.27 ± 2.25 animals/km^2) respectively. Although Cape hare had a higher density than Coke's hartebeest, it was encountered fewer times than the Cokes hartebeest. Cokes hartebeest was the most abundant species in the study area based on total numbers accounting for 2721 (34.4%) of all recorded wild animals. Buffalo, baboon and striped hyaena were recorded once during the study period (Table 18).

Table 18.Density and abundance of wild animal species recorded in the study area.

Animal species	**Mean ± SD**	**No. of Encounters**	**Relative abundance (%)**
Aardvark	0.20 ± 0.09	4	0.27
African wild cat	0.49 ± 0.00	2	0.13
Baboon	0.25 ± *	1	0.07
Bat eared fox	0.20 ± 0.05	5	0.33
Buffalo	0.41 ± *	1	0.07
Cape hare	9.08 ± 3.13	219	14.53
Civet cat	0.98 ± 0.00	2	0.13
Dikdik	1.48 ± 1.05	53	3.51
Duiker	3.14 ± 1.32	118	7.83
Eland	0.26 ± 0.06	15	1
Giraffe	0.71 ± 0.06	35	2.32
Grant's gazelle	2.01 ± 0.53	70	4.65
Guinea fowl	1.85 ± 0.93	74	4.91
Impalla	1.25 ± 0.78	45	3
Jackal	0.47 ± 0.17	21	1.4
Cokes hartebeest	6.27 ± 2.25	237	15.72
Lesser kudu	0.26 ± 0.15	3	0.2
Ostrich	0.70 ± 0.00	20	1.33
Porcupine	0.26 ± 0.07	5	0.33
Reedbuck	0.78 ± 0.34	23	1.53
Serval cat	0.27 ± 0.10	8	0.53
Spotted hyaena	0.15 ± 0.02	6	0.4
Spring hare	4.82 ± 1.97	149	9.9
Steinbuck	1.63 ± 0.60	101	6.7
Striped hyaena	0.49 ± *	1	0.07
Thomson's gazelle	4.41 ± 1.59	107	7.05
Vervet monkey	0.69 ± 0.09	9	0.6
Warthog	1.81 ± 0.20	51	3.4
Waterbuck	0.23 ± 0.01	6	0.4
Wildebeeste	0.61 ± 0.20	23	1.53
Y.N.S. Fowl	1.36 ± 0.40	43	2.85
Zebra	0.99 ± 0.27	50	3.31
Total	3.93 ± 3.34	1507	100

(***** Denotes Standard Deviation could not be calculated due to low numbers).

The association between farm categories and the time of day revealed a statistically significant difference in density ($\chi 2 = 66.70$ df = 2, P<0.001). Although mean density for farm categories almost doubled in the unsubdivided and sub-divided categories, it more than tripled in the partially sub-divided farm category (Fig. 16).

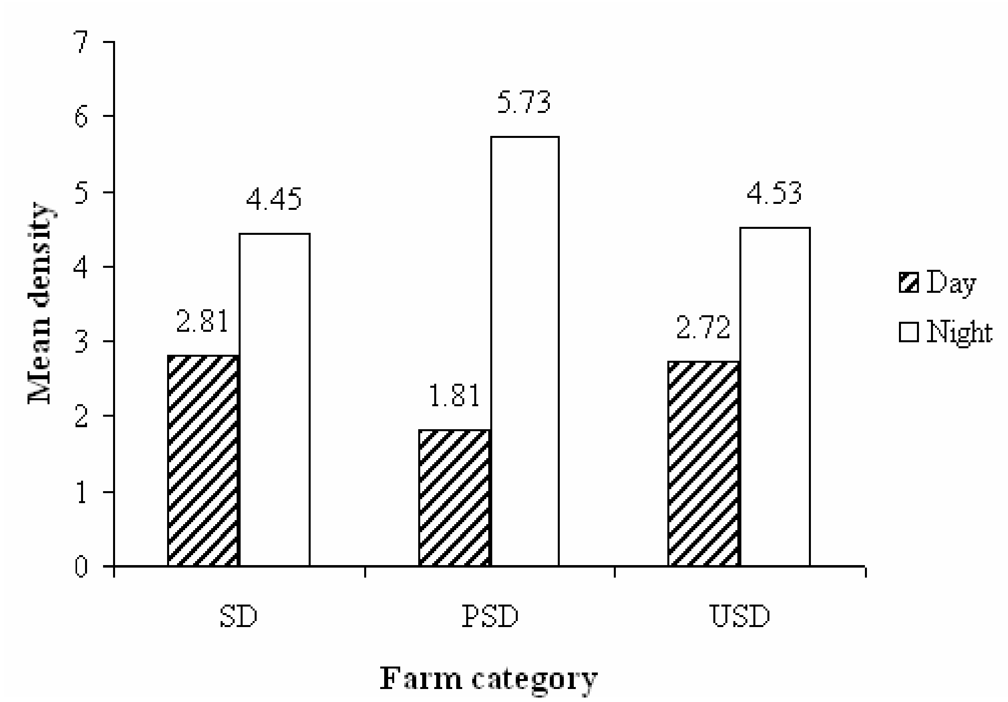


Figure 16. Density of wild animals in the farm categories during day and night.

A comparison of mean log density of wild animals between farm categories revealed significant differences (Tukey HSD P<0.0001) all farm categories. USD had a mean density of 9.55 animals/km^2 and 11.13 animals/km^2 for dry and wet seasons, respectively. SD farms had a mean density of 6.87 animals/km^2 and 9.12 animals/km^2 for dry and wet seasons, respectively, while PSD farms had a mean density of 4.84 animals/km^2 and 4.32 animals/km^2 for dry and wet season respectively (Table 19).

Table 19. Seasonal density and abundance of wild animal prey categories among farm categories in the study area.

Prey category	Farm category	Season	Density	95% (CI)	Abundance	95% (CI)
PCP	USD	DRY	18.14	9.22-35.75	6902	3506-13586
		WET	20.6	11.16-38.04	7840	4246-14474
SCP	USD	DRY	7.34	3.23-16.68	2792	1228-6346
		WET	9.86	4.76-20.42	3752	1812-7769
SNCP	USD	DRY	3.18	1.35-7.51	1210	512-2856
		WET	1.94	0.87-4.34	739	331-1650
Mean			10.18	5.1-20.46	3872	1939-7780
PCP	SD	DRY	14.78	6.98-31.31	5623	2655-11912
		WET	22.10	12.11-40.35	8411	4607-15353
SCP	SD	DRY	5.23	1.58-17.33	1989	600-6594
		WET	4.04	1.20-13.65	1539	456-5192
SNCP	SD	DRY	0.6	0.22-1.64	228	83-624
		WET	1.23	0.31-4.78	466	119-1819
Mean			7.99	3.73-18.14	3042	1420-6915
PCP	PSD	DRY	13.64	5.67-32.80	5190	2158-12480
		WET	11.85	5.32-26.35	4507	2026-10028
SCP	PSD	DRY	0.2	0.51-0.74	74	20-282
		WET	0.2	0.30-1.24	74	12-472
SNCP	PSD	DRY	0.68	0.21-2.15	258	81-821
		WET	0.91	0.27-3.05	347	104-1159
Mean			4.43	2.05-10.72	1741	733-4207

6. DISCUSSION

6.1 Settlement patterns

Establishment of individual holdings in rangelands happens first in areas that are closer to urban centres or that contain key resources that are essential for successful crop cultivation (Reid et al, 2008b). This view is exemplified in this study as settlement on the sub-divided farms was highly influenced by the availability of water and transport infrastructure. These settlements around water points and other related human activities are known to have a negative effect on distribution of wildlife (de Leeuw *et al.,* 2001).

6.2 Species compositions

Results of the present study indicate that there is no seasonal variation in number of encounters for wildlife species. However, there were significant differences amongst the various species of each prey category. These differences may have been brought about by a breeding stint, where normally solitary animals, are likely to be seen in pairs or, a birthing period. Cokes hartebeest were observed with young calves towards the end of the dry season and this might explain why the numbers differed with sightings for SCP category. However, wildlife has also been noted to migrate in to the northern part of the study area during the dry season (Olang and Njoka, 1988). Although no cheetah were recorded in this study, three male cheetah were encountered on a night count in KE outside the transect parameters. Apart from hyaena and jackal, the other carnivore species recorded are not considered as competitors for the cheetah.

6.3 Farm categories

As reported by Viio (2003) based on studies in the Kalahari, species richness differed between land-use areas. In the present study, the PSD farms had lower diversity indices for both dry and wet seasons. However, the encounters for wildlife quadrupled during the night in PSD farms suggesting that most animals in the partially sub-divided farms became active at night even when they are not necessarily nocturnal as levels of human activity go down after dusk. For example, using jackal sightings, 40% and 60% were recorded in the SD farms between day and night respectively. On the other hand, 42% and 58% were recorded between day and night respectively in the USD farms and 100% recorded during the night in the PSD farms (See Appendix 5). It is clear from the results of this study that, although Jackal is not exclusively nocturnal, they are only recorded at night in the farm category with high levels of disturbance during the day. Caro (1999) observed that human disturbance played a role in reduced mammal density in unprotected areas in a study in Katavi, Tanzania. On the other hand, the inclusion of time of day-specific species in the various prey categories could explain the day/night difference. However, since the PCP category was not the only one with time-specific species. The three times increase in mean density cannot merely be explained by this factor. Due to high activity levels in the PSD farms, wildlife species seek cover during the day and only come out at night when the levels of activities subside. Encounters for some wildlife species that were recorded in all the farm categories also show variations between day and night. More duiker and dikdik were recorded in the unsubdivided ranches during daytime compared to the partially sub-divided and sub-divided ranches (see Appendix 5). Although vegetation type differences between the farms may influence the species composition in the farm categories, the encounter rates should not be very different within ideal conditions. How this variation in encounters and by extension density, between day and night affects cheetah in the study area is a factor for additional study as other studies have shown that cheetah can hunt successfully in thicket vegetation and sometimes in darkness (Bissett and Banard, 2007). The results from this study indicate that in farms where sub-division occurred more then five years ago (PSD), density of wildlife is lower than in the other two categories. This does not mean that sub-division is the only factor that can be attributed to the low density. As Reid *et al*. (2008) noted, the overall decline in wildlife (72%) in the entire Athi-Kapiti plains ecosystem was far higher than the proportion of land fenced (14%) as fencing restricts wild animal movement. This fact, however, does not contradict other studies, which have shown that sub-division results in a reduction of herbivore density (BurnSilver *et al.*, 2008).

6.4 Vegetation types and distribution of wild animals

The results from this study indicate that although vegetation type (habitat type) use differed amongst species, it did not differ across season. Habitat selection by species based on their densities supports that species were recorded the most in preferred habitats. Smaller herbivore species like dikdik, duiker, and steinbuck were mostly recorded in single numbers, which is not different from the observations of Bergstrom and Skarpe (1999) in the Kalahari. In their study, Khan and Ghaleb (2003) observed that cheetahs prefer to hunt single animals. These species also showed a bias towards habitats with cover (Appendix 6), and as Khan and Ghaleb (2003) also noted, most wildlife animals especially small-sized prey species, remain concentrated near regions where they get maximum protection from predator species, usually in thick vegetation cover.

There was an uneven distribution of wildlife species in the study area with some species being restricted to certain vegetation types. This preference for certain vegetation types was highly pronounced for ostrich, which was recorded only in the shrub savanna vegetation type. Other species like the cape hare were distributed more evenly, occurring in all vegetation types sampled, although in varying frequencies. Some larger herbivores like zebra, cokes hartebeest and wildebeest also showed restricted ranges preferring the shrub savanna vegetation type. Nunez *et al.* (2000) suggested that the selection of prey species would depend upon regions where predators occupy.

6.5 Vegetation structure

There was variation in the usage of vegetation structure by different species of wild animals. The short grass areas recorded more wild animal encounters. Cape hares were predominantly recorded in short grass areas, while duikers were largely recorded in the medium height grass areas. This would suggest that vegetation type is not the only factor that influenced distribution of wild animals in the study area, but each species of wild animal has a specific adaptation to any or most of the habitat types.

6.6 Transect counts

Wild animal encounters in transects revealed some spatial variability with some species being recorded in some transects and not others. Transect T18, T19, T20 and T22 in the savanna shrub recorded higher densities of cokes hartebeest, whereas transects T2, T14, T15 and T16 which were located in open shrubs had higher densities of duiker. Ostrich were recorded only in transects lying on the shrub savanna suggesting that the species has a positive affinity towards that vegetation type.

6.7 Wild animal density and abundance in the study area

In their study on prey selection by cheetah, Hayward *et al*. (2006) reported that cheetah will take the most abundant species within a range of 23-56 kg but they will also take prey of similar, although, slightly smaller dimensions. Cape hare and cokes hartebeest had the highest densities and they were the most abundant prey species in the study area. Based on the distribution of preferred cheetah prey species in the study area, duiker, cape hare and steinbuck would hypothetically form the bulk of the cheetah diet in the southern section of the study area and Thomson’s gazelle the major cheetah prey in the northern part of the study area.

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The present study provides information on the density, distribution and abundance of wild animals in the study area. It is expected that the information gathered will help in further studies on different aspects of wildlife on farmland areas especially the prey base that supports various carnivore species.

Because a big portion of the study area has now sub-divided, the rate of settlement suggests that it is going to take a while before the area can become inaccessible to wildlife. However, the farming tradition of the local people makes habitat loss a major problem as the new settlers clear the land for agriculture and put up fences to protect their crops, thus restricting the movement of wild animals. In the Zambezi Valley of Zimbabwe, studies by Fritz *et al*. (2003) showed that wildlife was less likely to use sections of the river bordered by agriculture and that the negative effect of agriculture on density and diversity of wildlife using the area was greatly enhanced when a threshold was reached.

The complete sub-division of AMK and MR ranches will have a negative effect on wildlife, considering that parcels of land near dams are attracting the highest rates of settlements. This will eventually close off access to water for the wildlife. In addition, cases of human - wildlife conflict are likely to occur in the new farms considering that some wild animals were recorded on areas under crop. The loss of MR and AMK ranches to wildlife will put more pressure on the two ranches that are not sub-divided as animals move to safer areas.

Based on the results of this study, the sub-division of MR and AMK will have a profound negative effect on the density and diversity of the entire regions wildlife since these two ranches habour a substantial number of wildlife in their varied vegetation types.

7.2 Recommendations

Based on the results of this study, and previous works, the following recommendations are suggested.

- Continued study to monitor wildlife in the study area and focus on prey selection of the various predators, especially the cheetah, in this mosaic of changing land-use of smallholder farms and big ranches.

- Development of appropriate strategies where wildlife can offer landowners tangible benefits that can compete with the urge to farm the land.

- Small mammals, especially rodents have been neglected in studies on rangelands, as a result of which their contribution to the functions of the savanna ecosystem is little understood. It is recommended that a study on small mammals in the study area be carried out to document their ecological significance.

- Improved dissemination of results of studies to members of the public to make them aware of the findings, and incorporate them to find out solutions, rather than viewing them as the problem for wildlife conservation.

- Consideration should be given to scientific results and recommendations in implementing policy decisions on land-use and sub-division to ensure maximum benefit is derived from the land taking into consideration ecological zones to preserve sensitive ecosystems.

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Appendix 2. Length and percentage covered by each transect in different vegetation types in all the farms.

Farm	LCCS code	Length (Km)	%of total length						
				T1	T2	T3			
KMR	AG-1C	2.89	23.5	1.2	0.0	1.69			
	FR-7	9.41	76.5	3.3	3.4	2.71			
				T4	T5	T6			
SS	FR-7	1.95	17	0.74	1.24	0.0			
	FR-5	1.5	13.3	0.0	0.0	1.5			
	RL-3	8.02	69.7	3.46	2.16	2.4			
				T7	T8	T9			
KUR	FR-7	9.86	84	2.4	3.66	3.8			
	FR-5	0.24	2.4	0.0	0.24	0.0			
	AG-1B	1.6	13.6	1.6	0.0	0.0			
				T10	T11	T12	T13	T14	T15
AMK	AG-1C	10.4	39.8	0.0	2.06	0.0	3.84	2.18	2.32
	FR-7	11.1	42.5	1.77	1.74	2.77	0.96	1.99	1.88
	FR-5	2.83	10.8	2.83	0.0	0.0	0.0	0.0	0.0
	RL-3	1.76	6.7	0.0	0.0	1.03	0.4	0.33	0.0
				T16	T17	T18	T19		
MR	RL-2	10.49	71.4	1.7	4.7	2.39	1.7		
	FR-8	1.71	11.6	0.0	0.0	1.71	0.0		
	AG-1C	2.2	15	2.2	0.0	0.0	0.0		
	RL-5	0.3	2	0.0	0.0	0.0	0.3		
				T20	T21	T22	T23	T24	T25
KE	RL-2	19.06	75	4.0	1.6	4.1	4.2	5.0	0.16
	FR-8	6.34	25	0.0	2.4	0.0	0.0	0.0	3.94

Appendix 3. Common name, scientific name, suitability as cheetah prey and order of all wildlife species recorded in the study area.

Common Name	**Scientific name**	**Prey Category**	**Order**
Aardvark	*Orycteropus afer*	SNCP	Tubulidentata
African wild cat	*Felis silvestris*	SNCP	Carnivora
Baboon	*Papio cynocephalus*	SNCP	Primates
Bat-eared fox	*Otocyon megalotis*	SNCP	Carnivora
Buffalo	*Syncerus caffer*	SNCP	Artiodactyla
Cape hare	*Lepus capensis*	PCP	Lagomorpha
Civet cat	*Viverra civetta*	SNCP	Carnivora
Dikdik	*Madoqua kirkii*	PCP	Artiodactyla
Duiker	*Sylvicapra grimmia*	PCP	Artiodactyla
Eland	*Taurotragus oryx*	SNCP	Artiodactyla
Giraffe	*Giraffa camelopardalis*	SNCP	Artiodactyla
Grant’s gazelle	*Gazella granti*	PCP	Artiodactyla
Guinea fowls	*Numida meleagris*	SCP	Aves
Impala	*Aepyceros melampus*	PCP	Artiodactyla
Jackal	*Canis mesomelas*	SNCP	Carnivora
Cokes hartebeest	*Alcelaphus buselaphus*	SCP	Artiodactyla
Lesser Kudu	*Tragelaphus imberbis*	SCP	Artiodactyla
Ostrich	*Struthio camelus massaicus*	SCP	Aves
Porcupine	*Hystrix cristata*	SNCP	Rodentia
Reedbuck	*Redunca redunca*	PCP	Artiodactyla
Serval cat	*Felis serval*	SNCP	Carnivora
Spotted hyaena	*Crocuta crocuta*	SNCP	Carnivora
Spring hare	*Pedetes capensis*	SCP	Rodentia
Steinbuck	*Raphicerus campestris*	PCP	Artiodactyla
Striped hyaena	*Hyaena hyaena*	SNCP	Carnivora
Thomson’s gazelle	*Gazella thomsoni*	PCP	Artiodactyla
Vervet monkey	*Cercopithecus aethiops*	SCP	Primates

Continued.

Continued

Warthog	*Phacochoeru aethiopicus*	SCP	Artiodactyla
Waterbuck	*Kobus ellipsiprymnus*	SCP	Artiodactyla
Wildebeest	*Connochaetes taurinus*	SCP	Artiodactyla
Yellow necked spurfowl	*Francolinus leucoscepus*	SCP	Aves
Zebra	*Equus burchelli*	SCP	Perissodactyla

Appendix 4. Seasonal wildlife encounters between farm categories

	SD		PSD		USD		**Total Encounters**	
Wildlife	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Aardvark	0	1	1	0	0	2	**1**	**3**
African wild cat	0	0	0	0	2	0	**2**	**0**
Baboon	0	0	0	1	0	0	**0**	**1**
Bat-eared fox	2	1	0	1	1	0	**3**	**2**
Buffalo	1	0	0	0	0	0	**1**	**0**
Cape hare	26	54	24	39	34	42	**84**	**135**
Civet cat	0	0	0	0	1	1	**1**	**1**
Dikdik	5	16	11	3	7	11	**23**	**30**
Duiker	19	19	16	19	22	23	**57**	**61**
Eland	2	0	0	0	8	5	**10**	**5**
Giraffe	1	0	0	0	22	12	**23**	**12**
G. Gazelle	14	13	0	0	25	18	**39**	**31**
Guinea fowl	1	6	5	12	15	35	**21**	**53**
Impala	2	4	1	0	14	24	**17**	**28**
Jackal	1	4	1	2	6	7	**8**	**13**
Cokes hartebeest	64	52	0	0	63	58	**127**	**110**
Lesser kudu	0	1	1	0	1	0	**2**	**1**
Ostrich	0	1	0	0	9	10	**9**	**11**
Porcupine	0	5	0	0	0	0	**0**	**5**
Reedbuck	3	3	0	1	4	12	**7**	**16**
Serval cat	0	1	1	4	0	2	**1**	**7**
Spotted hyaena	2	2	1	0	1	0	**4**	**2**

Continued

Spring hare	16	32	2	2	35	62	**53**	**96**
Steinbuck	25	36	8	3	19	10	**52**	**49**
Striped hyaena	1	0	0	0	0	0	**1**	**0**
Thomson's gazelle	34	22	0	0	28	23	**62**	**45**
Vervet monkey	0	0	1	0	3	5	**4**	**5**
Warthog	1	0	0	0	24	26	**25**	**26**
Waterbuck	0	0	1	0	3	2	**4**	**2**
Wildebeest	8	3	0	0	6	6	**14**	**9**
Y. N. Spurfowl	5	6	5	7	11	9	**21**	**22**
Zebra	7	5	0	0	16	22	**23**	**27**
Total	**240**	**287**	**79**	**94**	**380**	**427**	**699**	**808**

Apendix 5. Wildlife encounters between day and night in different farm categories

Wildlife	SD		PSD		USD		Total Encounters	
	Day	Night	Day	Night	Day	Night	Day	Night
Aardvark	0	1	0	1	0	2	**0**	**4**
African wild cat	0	0	0	0	0	2	**0**	**2**
Baboon	0	0	1	0	0	0	**1**	**0**
Bat-eared fox	0	3	0	1	0	1	**0**	**5**
Buffalo	0	1	0	0	0	0	**0**	**1**
Cape hare	1	79	1	62	0	76	**2**	**217**
Civet cat	0	0	0	0	0	2	**0**	**2**
Dikdik	3	18	1	13	3	15	**7**	**46**
Duiker	3	35	3	32	12	33	**18**	**100**
Eland	1	1	0	0	11	2	**12**	**3**
Giraffe	1	0	0	0	23	11	**24**	**11**
Grant’s gazelle	16	11	0	0	24	19	**40**	**30**
Guinea fowl	7	0	17	0	49	1	**73**	**1**
Impala	2	4	1	0	18	20	**21**	**24**
Jackal	2	3	0	3	4	9	**6**	**15**
Cokes hartebeest	50	66	0	0	66	55	**116**	**121**
Lesser kudu	0	1	1	0	1	0	**2**	**1**
Ostrich	1	0	0	0	15	4	**16**	**4**
Porcupine	0	5	0	0	0	0	**0**	**5**
Reedbuck	1	5	0	1	7	9	**8**	**15**
Serval cat	0	1	0	5	0	2	**0**	**8**

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Spotted hyaena	1	3	0	1	0	1	**1**	**5**
Spring hare	0	48	0	4	0	97	**0**	**149**
Steinbuck	14	47	1	10	4	25	**19**	**82**
Striped hyaena	0	1	0	0	0	0	**0**	**1**
Thomson's gazelle	19	37	0	0	27	24	**46**	**61**
Vervet monkey	0	0	1	0	7	1	**8**	**1**
Warthog	1	0	0	0	49	1	**50**	**1**
Waterbuck	0	0	0	1	4	1	**4**	**2**
Wildebeest	7	4	0	0	9	3	**16**	**7**
Yellow necked S.F	10	1	12	0	20	0	**42**	**1**
Zebra	6	6	0	0	23	15	**29**	**21**
Total	**146**	**381**	**39**	**134**	**376**	**431**	**561**	**946**

Appendix 6. Seasonal total numbers recorded between day and night.

Species	Dry	Wet	Day	Night	Total
Aardvark	1	3	0	4	4
African wild cat	2	0	0	2	2
Baboon	0	1	1	0	1
Bat-eared fox	2	7	0	9	9
Buffalo	12	0	0	12	12
Cape hare	97	165	2	260	262
Civet cat	2	1	0	2	3
Dikdik	36	39	12	63	75
Duiker	67	67	19	115	134
Eland	47	310	349	8	357
Guinea fowl	321	543	852	12	864
Giraffe	89	91	119	61	180
Grant’s gazelle	143	101	149	95	244
Impala	201	207	209	199	408
Jackal	12	27	9	30	39
Cokes hartebeest	1834	886	1592	1128	2720
Lesser Kudu	5	3	5	3	8
Ostrich	28	27	44	11	55
Porcupine	0	6	0	6	6
Reedbuck	14	25	14	25	39
Serval cat	1	7	0	8	8
Spotted hyaena	6	5	1	10	11
Spring hare	112	187	0	299	299

Continued.

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Species	Dry	Wet	Day	Night	Total
Steinbuck	61	58	22	97	119
Striped hyaena	1	0	0	1	1
Thomson's gazelle	288	258	223	323	546
Vervet monkey	44	30	61	13	74
Warthog	85	99	184	4	184
Waterbuck	5	4	7	2	9
Wildebeest	88	86	113	61	174
Yellow necked spurfowl	67	44	110	1	111
Zebra	626	376	661	341	1002

DECLARATION

I, the undersigned declare that this thesis is my original work, has not been presented for a degree in any other University and that all sources of materials used for the thesis have been duly acknowledged.

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