Status and distribution of cheetah outside formal conservation areas in the Thabazimbi district, Limpopo province

by

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ABSTRACT

The current status of the cheetah *Acinonyx jubatus* outside formal conservation areas in South Africa is undetermined. The largest part of the cheetah population in South Africa occurs on cattle and wildlife ranches. Conflict between cheetahs and landowners is common and cheetahs are often persecuted. Cheetah management and conservation efforts are hampered as little data are available on the free-roaming cheetah population. A questionnaire survey was done in the Thabazimbi district of the Limpopo province to collect data on the status and distribution of cheetahs in the district and on the ranching practices and attitudes of landowners. By using this method, a population estimate of 42 – 63 cheetahs was obtained. Camera trapping was done at a scent-marking post to investigate the marking behaviour of cheetahs. Seven different cheetahs were identified marking at one specific tree. Scat analyses were done to determine prey use of the cheetahs in the study area. The most common prey remains from the scats were of the grey duiker *Sylvicapra grimmia* and the impala *Aepyceros melampus.* VORTEX analyses were used to investigate the long-term viability of the cheetah population as well as the viability of sport hunting of cheetahs. The current Thabazimbi population is viable over 100 years without immigration, but after 200 years extinction probabilities become unacceptably high. Harvesting through sport hunting is only viable if staggered over several years. Several factors influencing the survival of the free-roaming cheetah population are also discussed.

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CONTENTS

CHAPTER 1

INTRODUCTION

The cheetah *Acinonyx jubatus* is currently globally classified as vulnerable with a high risk of extinction in the wild due to a population of 10 000 mature individuals or less (IUCN 2001). In South Africa the cheetah is classified in the Red Data Book as vulnerable due to persecution and illegal trade (Friedmann and Daly 2004). The persecution of carnivores by humans is the greatest threat to carnivore survival worldwide (Woodroffe and Ginsberg 1998). Trade in cheetahs is regulated under CITES Appendix I (species threatened with extinction) and such trade is limited to captive-bred cheetahs.

In South Africa the majority of the free-roaming cheetah population occurs outside conservation areas (Fig. 1). The population of the Kruger National Park is estimated at 175 individuals, with 65 individuals estimated for the Kgalagadi Transfrontier Park, 117 in smaller reserves and national parks and 300 free roaming individuals on ranch lands in the Limpopo and North West provinces (Friedmann and Daly 2004). Approximately 125 150 km^2 of land are suitable cheetah habitat in South Africa (Boitani, Corsi, De Biase, D'Inzillo Carranza, Ravagli, Reggiani, Sinibaldi and Trapanese 1999) of which approximately 55 654 km^2 is under formal conservation including the Kruger National Park and surrounding reserves, Pilanesberg National Park, Hluhluwe-Umfolozi Park, Phinda Resource Reserve and Kgalagadi Transfrontier Park (Friedmann and Daly 2004). Formal conservation areas account for 44.5% of the area that is suitable for cheetahs in South Africa.

Most of the land outside conservation areas where cheetahs occur is privately owned and is utilised for agricultural purposes. The trend in South Africa has been a change from cattle ranching to wildlife ranching (Van der Waal and Dekker 2000). This has meant that ranches have been surrounded by game-fencing and stocked with wildlife for the main purpose of hunting. There are few large carnivores on these ranches and with the exception of leopards *Panthera pardus* and brown hyaenas *Parahyaena brunnea*, cheetahs are the only large carnivores that occur on these ranches. The ranches are well stocked with wildlife species that are the natural prey for cheetahs.

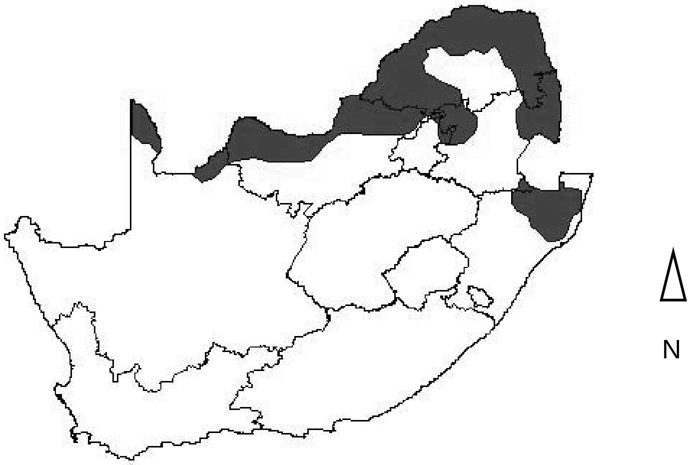

Figure 1: The distribution of cheetahs in South Africa (Friedmann and Daly 2004)

This means that cheetahs are now preying on wildlife that the landowner intended to have hunted in order to generate income from the ranch. A conflict situation has now arisen between the landowners and the cheetahs as they are both utilising the same wildlife resource.

Furthermore, outside of conservation areas, there are generally no lions *Panthera leo* and spotted hyaenas *Crocuta crocuta*. These predators are of the largest limiting factors to cheetah survival in areas where these three carnivores co-exist (Durant 1998). Wildlife ranches are perceived to be the ideal habitat for cheetahs, with little competition from other large carnivores and a high prey density. This emphasises the need for the conservation of cheetahs outside protected areas as a priority (McVittie 1979; Laurenson, Wielebnowski and Caro 1995; Purchase and Du Toit 2000).

Cheetahs are difficult to study as they use large ranges, are elusive and occur at low densities (McVittie 1979; Stander 1992; Gros 1998). The problem is further complicated on ranch lands where access to properties is limited, bush encroachment often occurs and cheetahs are persecuted. Research is therefore required to understand the behaviour of these cheetahs as well as to provide reliable information for the future management of these cats by conservation bodies.

The aim of this study was to shed light on some of the issues surrounding cheetahs that occur outside conservation areas. If future conservation efforts are to be successful then the interactions between people and predators need to be understood (Woodroffe 2000). In order to begin understanding the cheetah situation, it was necessary to define a study area on which to focus. It was decided to use the Thabazimbi district of the Limpopo province as numerous cheetah complaints had originated from this area.

The conservation of cheetahs outside of conservation areas should be a priority. Since many carnivores have large ranges, even populations inside conservation areas come in contact with humans (Woodroffe and Ginsberg 1998) and declines have been observed both inside and outside protected areas (Woodroffe 2000). In South Africa, the largest part of the cheetah population occurs outside protected areas (Friedmann and Daly 2004) and is thought to be continuous with the cheetah populations in Zimbabwe and Botswana. Additionally, during the latest updating of the Red Data Book of the Mammals of South Africa, the evaluation of the status of the cheetah was close to endangered due to the low number of breeding individuals as well as the threats facing the population (Friedmann and Daly 2004). Cheetahs occurring outside conservation areas therefore have to become a conservation priority to prevent this species from becoming endangered.

General information on the agricultural practices of the study area as well as the cheetah population in the area was necessary. This information was collected by using a questionnaire survey. Landowners were visited on their ranches and asked to complete a questionnaire containing questions on ranching practices, sightings of cheetahs and attitudes towards cheetahs. Cheetah scats were collected on ranches and analysed in the laboratory in order to quantify what cheetahs in the study area are preying on. The use of marking posts by cheetahs was investigated using camera traps. The software package VORTEX was used to model the viability of the cheetah population as well as to investigate the sustainability of sport hunting and a relocation programme on the cheetah population.

The following hypotheses were tested using key questions:

Hypothesis:

- Occurrence of free roaming cheetahs on privately owned cattle and wildlife ranches in the Thabazimbi district results in conflict with landowners.

Key questions:

- How frequently do ranchers sight cheetahs on their properties?
- What are the group sizes and composition of the sighted cheetahs?
- What is the attitude of the ranchers to cheetah occurrence on their ranches?
- Is it possible to obtain a population estimate from a questionnaire survey?

Hypothesis:

- Cheetahs prey on valuable sorts of wildlife that ranchers stock on their properties.

Key questions:

- Are scat analyses a feasible method for determining cheetah prey usage?
- What is the prey usage of cheetahs occurring in the study area?

Hypothesis:

- Cheetahs use scent marking posts on wildlife ranches in the study area.

Key questions:

- Can remote triggered camera traps be used to photograph cheetahs at scent marking posts?
- Can photographs obtained from remote triggered cameras be used to identify individual cheetahs?
- Do the same cheetahs repeatedly visit scent marking posts?
- How frequently do cheetahs visit scent marking posts?
- Is camera trapping a viable method of counting cheetahs?

Hypothesis:

- The cheetah population in the study area is viable in the long term and can support harvesting.

Key questions:

- What is the probability of survival of the cheetah population in the study area over time?
- What harvesting rates and scenarios are sustainable for the cheetah population without jeopardising the long term survival of the population?
- Can the cheetah population sustain current rates of removal through a relocation programme and illegal methods?
- Is trophy hunting of cheetahs a viable conservation tool?

CHAPTER 2

THE STUDY AREA

Location

The Thabazimbi district is situated in the southwestern part of the Limpopo province of South Africa (Fig. 1). The study area covers a surface area of approximately 695 000 ha, and is bordered on the west by Botswana, on the east by the Matlabas River and on the south and southeast by two mountain ranges, the Witfonteinrant Mountains and the Dwarsberge. The part of the district that is mountainous was not included in the study area because it is not cheetah habitat.

Land-use

Land in the Thabazimbi district is privately owned and dedicated to commercial agriculture mainly in the form of wildlife and cattle ranching. In the Limpopo province, the median size of wildlife ranches was found to be 1 150 ha (Van der Waal and Dekker 2000).

Vegetation

The Thabazimbi district lies in the Savanna Biome of South Africa but the main vegetation type in the district is Mixed Bushveld (Low and Rebelo 1996). On shallow soils, this vegetation type is dominated by the red bushwillow *Combretum apiculatum,* while the common hook-thorn *Acacia caffra*, sickle bush *Dichrostachys cinerea*, live-long *Lannea discolor*, marula *Sclerocarya birrea* and various *Grewia* species are also characteristic. The herbaceous layer is dominated by finger grass *Digitaria eriantha*, sand quick *Schmidtia pappophoroides*, wool grass *Anthephora pubescens*, silky bushman grass *Stipagrostis uniplumis* and a variety of *Aristida* and *Eragrostis* species. Where the soil is deeper and more sandy, the silver cluster-leaf tree *Terminalia sericea* becomes dominant in the woody plant layer, with the peeling plane *Ochna pulchra*, wild raisin *Grewia flava*, weeping wattle *Peltophorum africanum* and wild seringa *Burkea africana* also being characteristic. Broom love grass *Eragrostis pallens* and cat's tail *Perotis patens* are characteristic in the sparse grass sward.

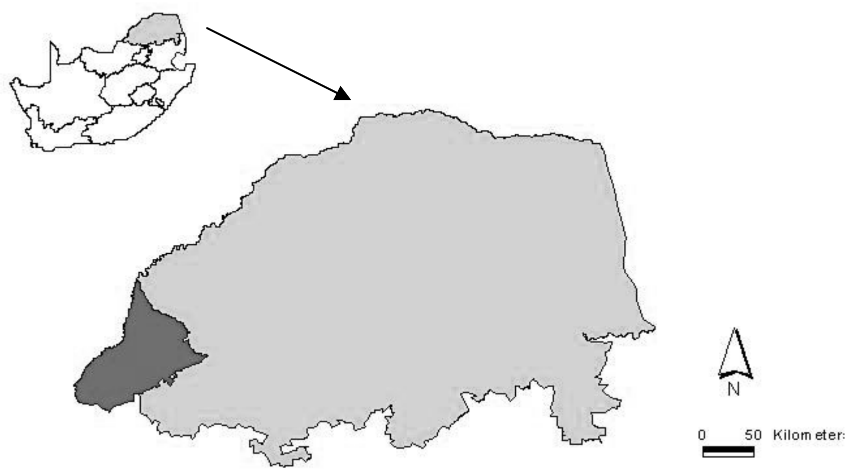

Figure 1: The Thabazimbi district (darkly shaded area) in the Limpopo province of South Africa.

Where the soil is more clayey, mostly along the rivers, Clay Thorn Bushveld occurs (Low and Rebelo 1996). This vegetation type is dominated by *Acacia* species like the umbrella thorn *Acacia tortilis*, scented thorn *Acacia nilotica*, sweet thorn *Acacia karroo*, knob thorn *Acacia nigrescens* and ankle or brak thorn *Acacia robusta.* Other woody species include the buffalo thorn *Ziziphus mucronata*, sicklebush and wild raisin. The dense grass sward is characterized by turf grass *Ischaemum afrum*, yellow turf grass *Sehima galpinii*, vlei bristle grass *Setaria incrassata* and white buffalo grass *Panicum coloratum*.

In the extreme north and along the eastern boundary of the study area, Sweet Bushveld (Low and Rebelo 1996) occurs. The vegetation structure there is short and shrubby with sandy areas dominated by trees such as the silver clusterleaf, yellow pomegranate *Rhigozum obovatum*, wild raisin and hairy umbrella thorn. The herbaceous layer is dominated by grasses such as broom grass, Kalahari sand quick, hairy love grass *Eragrostis trichophora* and various *Aristida* species. On the more arid and shallower soils the prominent woody plants are the common corkwood *Commiphora pyracanthoides*, wild raisin, shepherd's tree *Boscia albitrunca* and red bushwillow. Dense thickets of the blue thorn *Acacia erubescens*, black thorn *Acacia mellifera* and sicklebush are also found. The dominant grasses are guinea grass *Panicum maximum*, white buffalo grass and blue buffalo grass *Cenchrus ciliaris.*

Climate

The annual but mainly summer rainfall for the study area varies from 350 mm to 650 mm per year. The temperatures range from -8°C to 40°C with an annual mean of 21°C (Low and Rebelo 1996). However, climatological records for the Atherstone Collaborative Nature Reserve recorded a 14 year mean minimum temperature of 12.2°C and a mean maximum of 28.5°C. The lowest temperature recorded over a 14 year period was -6°C and the highest was 42.5°C. The mean annual rainfall recorded on Atherstone Collaborative Nature Reserve was 482.9 mm per year. The maximum annual rainfall recorded over a 14 year period was 986.2 mm and the minimum was 252.2 mm for a given year.

CHAPTER 3

METHODS

Because each chapter of this dissertation is prepared as a separate article, the methods and techniques used are described in detail in the relevant chapter. This chapter serves as a summary of all methods used in each chapter. All tree nomenclature follows Van Wyk and van Wyk (1998), grass nomenclature follows Van Oudtshoorn (1992) and mammal nomenclature follows Friedmann and Daly (2004).

For the purpose of this study, the following terminology will be used:

Free-roaming: any cheetahs that occur naturally in a geographic area, outside a properly enclosed protected area, which move freely, and have the legal status of “res nullius”

Wildlife ranching: the extensive production of free living wildlife that is managed on large fenced or unfenced private or communal grounds, for the main purpose of hunting or live sale.

Scent-marking post: any object that cheetahs use to scent mark on. These posts can be a natural object such as a tree or a man-made object such as a concrete block or dam wall. Such trees are also referred to by wildlife ranchers as play trees or newspaper trees.

THE QUESTIONNAIRE SURVEY

A questionnaire survey was done on the cheetahs in the Thabazimbi district to understand the cheetah population and the conflict situation that exists between cheetahs and ranchers better. A questionnaire survey is also a useful method for a better understanding of the ranching practices in the study area.

Ranchers were interviewed on their ranches by using a set questionnaire (Appendix I) that was compiled with the help of a statistician. The questionnaire was divided into two sections. The first section dealt with ranch details while the second one involved details on cheetahs. All cheetah sightings were recorded with date, location and cheetah group size.

Data obtained from the questionnaire were analysed statistically, frequency distributions were determined and relationships between appropriate variables were tested by using Chi-square tests. A population estimate of cheetahs in the Thabazimbi district was obtained by using the recognizable group size method (Gros 1998). The density of cheetahs in the study area was calculated and presented as the number of cheetahs per 100 km^2.

CAMERA-TRAPPING

A Trailmaster®[1] remote-triggered camera was installed at a tree that was known to be frequently scent-marked by cheetahs. The system consists of a 35 mm auto focus camera equipped with a flash. The camera is triggered by a TM-1500 infrared trail monitor. Agfa 100 ASA colour film was used in the camera. The photographs of cheetahs obtained were then used to identify individual cats by examining their unique spot patterns (Kelly 2001). The gender of the cheetahs in the photographs was also determined. The data were sorted and analysed to study the visitation patterns of all cheetahs to a specific tree.

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[1] Goodson and Associates Inc., 10614 Widmer, Lenexa, Kansas 66215, USA. www.trailmaster.com

SCAT ANALYSES

Cheetahs in the Thabazimbi district are elusive and the bush is too dense to make direct observations of cheetah behaviour from the ground possible. For this reason, scats were collected and analysed to determine prey-use by cheetahs in the Thabazimbi district. The cuticular pattern on the surface of a hair as well as the transverse cross section of the hair are species-specific. Hair ingested by an animal passes through the digestive system undamaged. These hairs can then be extracted from a scat and be examined to determine the identity of the prey item.

Scats were searched for and collected by walking on wildlife trails on ranches in the study area. Scats were also collected from known scent-marking posts. Each scat was placed in an individually marked paper bag and the name of the ranch was recorded along with the co-ordinates of the area where the scat was collected. The bag was stored in a cool, dry place.

In the laboratory the method of Keogh (1979) was adapted for prey identification. Hair was removed from the scats by washing the scats in warm water. Imprints of the cuticular pattern of the hair were made in gelatine and examined microscopically. Transverse cross sections of the hairs were made by imbedding the hairs in wax then sectioning them with a razor blade. These sections were then examined microscopically. The imprints and cross sections were then compared to reference samples to identify the species of animal that the hair originated from.

The prey-use of the cheetahs in the study was expressed as a frequency of occurrence in the collected scats. Prey-use was compared to similar studies of cheetahs in other areas in Africa.

VORTEX MODELLING

The viability of the Thabazimbi and South African free-roaming cheetah populations was investigated by using the computer-aided population extinction simulation model, VORTEX Version 9 for Windows (Miller and Lacy 1999).

All population parameters were obtained from the literature when they were not available from field observations (Chapter 7, Table 1). All parameters required for a population to be considered viable were decided before modelling started, and these parameters were obtained from literature and from a Conservation Breeding Specialist Group (CBSG) VORTEX Training Workshop.

All baseline models were run using 1000 iterations and were projected 100 years into the future. Harvesting models were projected for 50 years into the future and run at 100 iterations. Both the Thabazimbi and South African free-roaming populations were modelled both with and without harvesting. The effects of a relocation programme on the survival of cheetahs were modeled were the effects of the illegal, unregulated removal of cheetahs by ranchers. The viability and sustainability of a proposed sport-hunting quota was also modeled.

CHAPTER 4

A questionnaire survey to assess the status and distribution of the cheetah *Acinonyx jubatus* in the Thabazimbi district of the Limpopo province, South Africa

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ABSTRACT

A survey of free-roaming cheetahs *Acinonyx jubatus* was conducted in the Thabazimbi District of the Limpopo province, South Africa. Cheetahs were surveyed by using the interview method. A sample of 199 ranchers was interviewed, supplying information for 366 different ranches. Of these respondents, 39% had sighted cheetahs on their properties recently, and cheetah numbers were thought to be increasing by 72% of the ranchers that had sighted cheetahs on their property. Cheetahs were considered a liability by 71% of the respondents. A total of 240 cheetah sightings were recorded. Of these, 49% were of solitary cheetahs. The largest group reported consisted of eight cheetahs. A total of 20 sightings of females with cubs was recorded. An estimated population size of 42 to 63 individuals was obtained for the district at an estimated density of 0.6 to 0.9 cheetahs per 100 km². Cheetah conflict is discussed and the social aspect of this conflict is examined.

Key words: cheetah, questionnaire survey, attitudes, South Africa, wildlife ranching

1. Introduction

Over the past 20 years, there has been a shift from cattle to wildlife ranching in the Limpopo province of South Africa. This is reflected in the number of new exemption permits[1] issued annually by the provincial nature conservation authority. In 1983, only four new permits were issued and a peak of 207 permits was issued in 1991 (Van der Waal and Dekker 2000). This shift in land-use practice is due to the ecological and economic advantages of multi-species wildlife production systems in this semi-arid savanna area (Bothma 2002; Van der Waal and Dekker 2000). As a result of this change, most of the ranches have been surrounded with game fencing and are being stocked with wildlife for the main purpose of hunting. With the exception of the brown hyaena *Parahyaena brunnea* and the leopard *Panthera pardus*, no free-roaming large carnivores occur on these ranches. This is perceived by some authors to be an ideal situation for the cheetah *Acinonyx jubatus* (McVittie 1979; Laurenson, Wielebnowski and Caro 1995). In most of the Limpopo province, ranchers have been reporting more frequent cheetah sightings over the past decade. During an earlier survey, Myers (1975) recorded a sighting of cheetahs near the Brak River in the Zoutpansberg region of the Limpopo province (formerly Northern Transvaal) in 1966. From the 1966 cheetah sighting, until the survey of Myers was done in 1975, no further sightings were recorded. Today, cheetah sightings are not uncommon in the province. However, where people and predators co-exist, conflict is nearly always inevitable. To better understand the increased reports of conflict between ranchers and free-roaming cheetahs, it is necessary to quantify the abundance of cheetahs in this district.

[1] An exemption permit gives the landowner the right to utilise wildlife on the exempted ranch at his own discretion. Specific fencing and surface area requirements must be met before an exemption permit is issued. Permits must be renewed every three years.

It is hypothesized that cheetahs occur on cattle and wildlife ranches in the Thabazimbi district and that conflict between ranchers and cheetahs occurs. Furthermore, it is thought that landowners and laborers are a source of local knowledge that can be used for research purposes. Additionally, it is presumed that cheetahs occur in higher densities in the study area that in other similar habitats where lions *Panthera leo* and spotted hyaenas *Crocuta crocuta* occur.

2. Methods

2.1 Questionnaire survey

Cheetahs are notoriously difficulty to survey (McVittie 1979; Stander 1992; Gros 1998). Intensive field studies are time-consuming, expensive and not viable in an area where the land is privately owned and access is restricted. For these reasons, cheetahs were surveyed on the ranches in the Thabazimbi district by using the interview method. To avoid bias in the sample, an attempt was made to interview all the ranchers in the district. Ranchers were interviewed on their ranches by using a set questionnaire. The questionnaire was divided into two main sections, one relating to ranch details, the other to cheetah details. The date of the interview was also recorded.

The contact details of the landowner were recorded, as well as the ranch size and the main land-use practices. Ranchers were asked whether they had sighted cheetahs on their properties in the past two years. If they had sighted cheetahs, they were then asked for the following details of the sightings: frequency, date, place, group size and group composition. Their attitude towards cheetahs was also recorded. Ranchers were also questioned on the occurrence of other large carnivores on their properties. For all questions, it was stressed that “I do not know” was an acceptable answer.

The questionnaire data were captured and analysed statistically with SAS® (2002). Frequency distributions were determined and the relationships between appropriate variables were tested by using Chi-square tests.

The questionnaire method is advantageous in that it has been shown to be the most reliable indirect method of estimating large carnivore numbers, producing results representing 75 to 100% of reference densities (Gros, Kelly and Caro 1996). A further benefit of the method is that it is possible to cover large areas relatively easily and cheaply and is much more time efficient than an intensive field study. This technique has been used successfully on several types of cat including cheetahs in Kenya (Gros 1998) and Namibia (McVittie 1979) and tigers *Panthera tigris* in Thailand (Rabinowitz 1993). In an area like the present study district, where there is a high concentration of wildlife ranches with limited access and little tourism, the ranchers are the only people who have an intimate knowledge of the area. This knowledge is valuable and has been gathered over many years of working and living in the district. The questionnaire method pools this local knowledge that would otherwise take many years to obtain.

One of the main concerns with questionnaire methodology is sample bias. It was therefore necessary in the present study to obtain a random, representative sample of all the ranchers and ranches. To do this, a list of all the ranchers or ranches was required, but no such list existed. Using a map to select randomly select ranches was also not feasible because the maps that are available are not recent and the ranches have since been subdivided or amalgamated. Therefore it was decided to do a census of ranchers in the study district. In doing so, an attempt was made to interview all the ranchers in the district. This presented some problems in that not all the ranchers were available to be interviewed, even after repeated attempts, because some of them live elsewhere. Much time and resources were also wasted in interviewing ranchers in areas where cheetahs were unlikely to occur such as where intensive crop production occurred. However they were still reviewed so as to do a complete survey.

2.2 Population estimate

A population estimate of the cheetahs was made by using recognizable group sizes (Gros 1998). Cheetahs group sizes are relatively stable because mothers and their cubs stay together for several months, and male coalitions for many years (Caro 1994). All sightings were first sorted according to group size then they were listed according to date and then by location (Knight 1999). All sightings of a similar group size, composition and location were considered to represent the same group. The sum of the sizes of all the groups then gave the estimated population size.

2.3 Cheetah density

Cheetah density was calculated by dividing the lowest estimated number of cheetahs by the size of the study area (km^2). The size of the study area was obtained from the Geographic Information System software package ArcView[2]. Densities were calculated as the total number of cheetahs per 100 km^2.

3. Results

All available ranchers in the Thabazimbi district were surveyed from August 2000 until March 2001. Information for 366 different ranches was obtained by interviewing 199 ranchers (Fig. 1). Nearly all the interviews were carried out on the ranches in Afrikaans. Of these respondents, 39% had sighted cheetahs on their properties (Fig. 2), 57% had not, and 4% were unsure of cheetah presence.

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[2] ArcView® GIS Version 3.1 for Windows® Copyright 1992-1998 Environmental Systems Research Institute Inc., CA, USA.

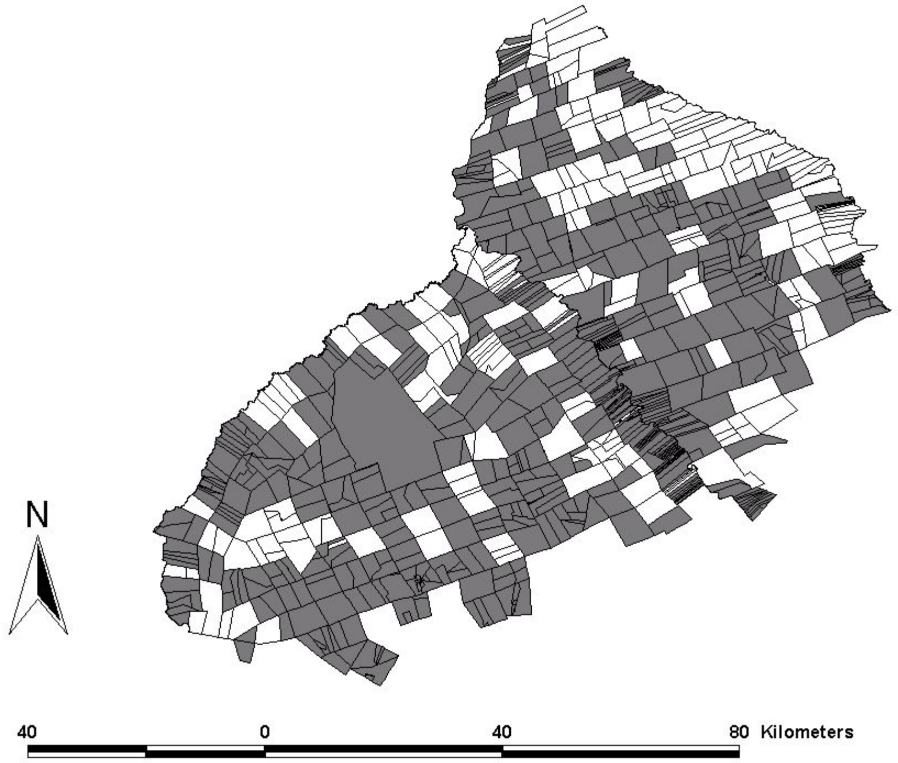


Figure 1: The Thabazimbi district in the Limpopo province of South Africa showing ranch boundaries. Shaded ranches denote ranches surveyed during the questionnaire study from August 2000 until March 2001.

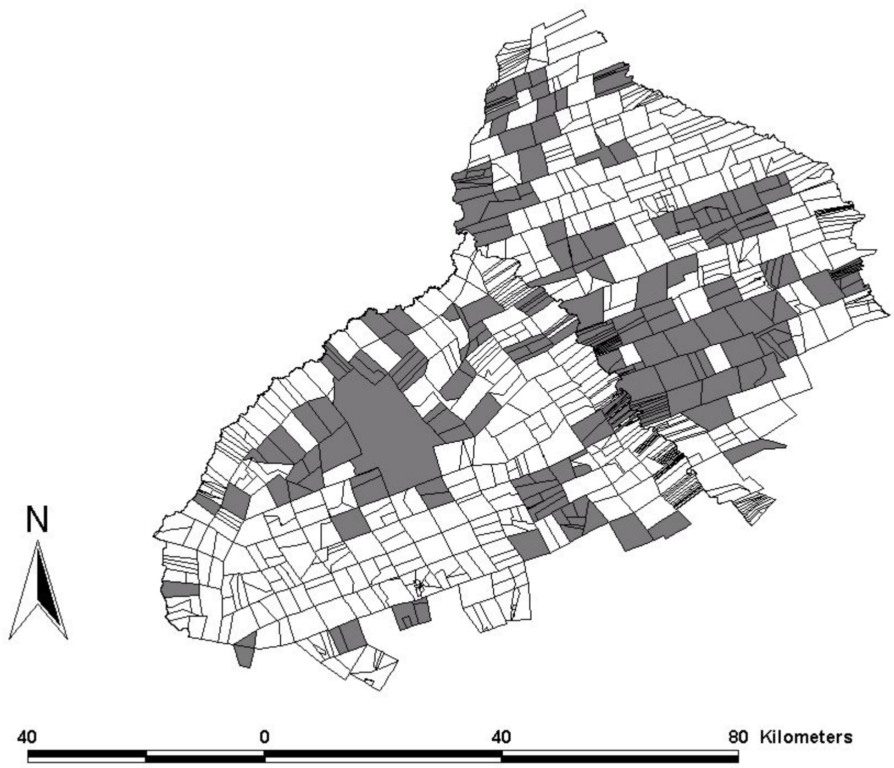


Figure 2: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported cheetah presence on their ranches.

Of the ranchers who reported having cheetahs on their properties, 2% reported seeing cheetahs on a daily basis, 14% weekly, 13% monthly and 71% less frequently than monthly (Fig. 3). In all 240 cheetah sightings were recorded. The seasonal sighting distribution was: 40% in winter, 24% in spring, 20% in summer and 16% in autumn (Fig. 4).

Of the 240 recorded sightings, 49% were of single animals, 18% of the sightings were of a group of two, 13% of a group of three, 10% of a group of four, 5% of a group of five, 4% of a group of six and 1% a group of eight (Fig. 5). The frequency of sightings of groups of adults as obtained from this survey was compared graphically with frequencies that were found in two other surveys that also used the interview method (Fig. 6). Gros (1998) conducted a survey in Kenya that included both protected and non-protected areas, and McVittie (1979) surveyed cattle and wildlife ranches in Namibia. It appears that single cheetahs were reported most in all the studies that were done to date, with a decrease in the frequency of sightings with an increase in cheetah group size (Figs. 7, 8, 9, 10, 11, 12, 13).

In all, 20 sightings of females with cubs were reported. Of these, 50% were of a female with two cubs, and 20% of a female with three cubs. A female with a single cub and a female with four cubs were each reported in 15% of the sightings. For the purpose of mapping, these sighting were lumped into a single group comprising all sightings of females and cubs (Fig. 14).

When asked about their perception of cheetah numbers over the past five years, 72% of the ranchers who had sighted cheetahs on their property thought that the cheetah numbers were increasing, 5% perceived that they were decreasing, 3% that they were stable, and 20% were unsure of any trends (Fig. 15).

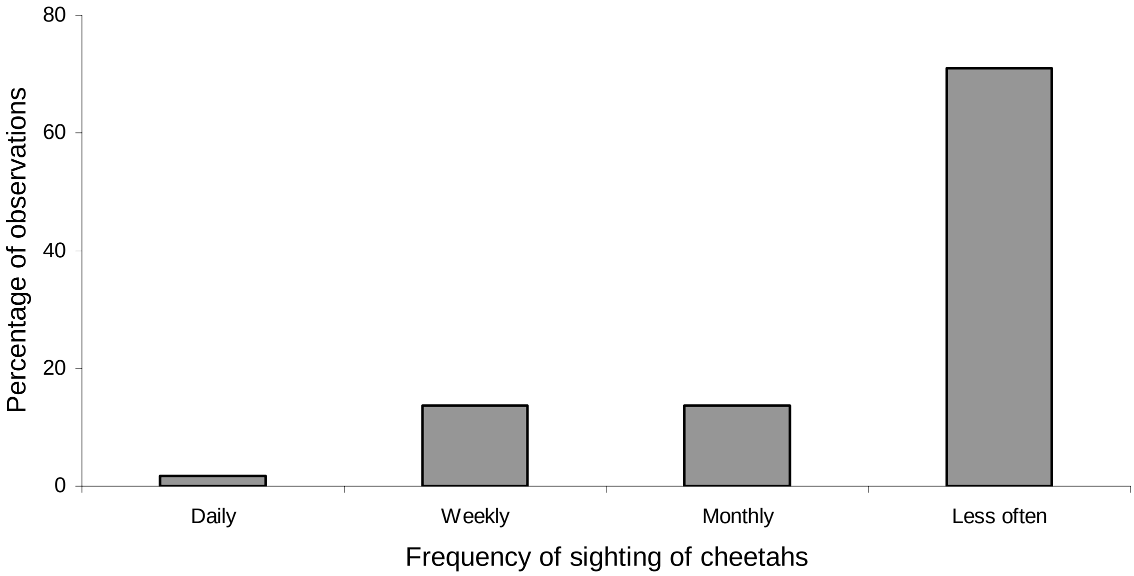


Figure 3: The frequency of sighting of cheetahs on ranches where cheetah sightings have been reported in the Thabazimbi district of the Limpopo province during a questionnaire survey done from August 2000 until March 2001.

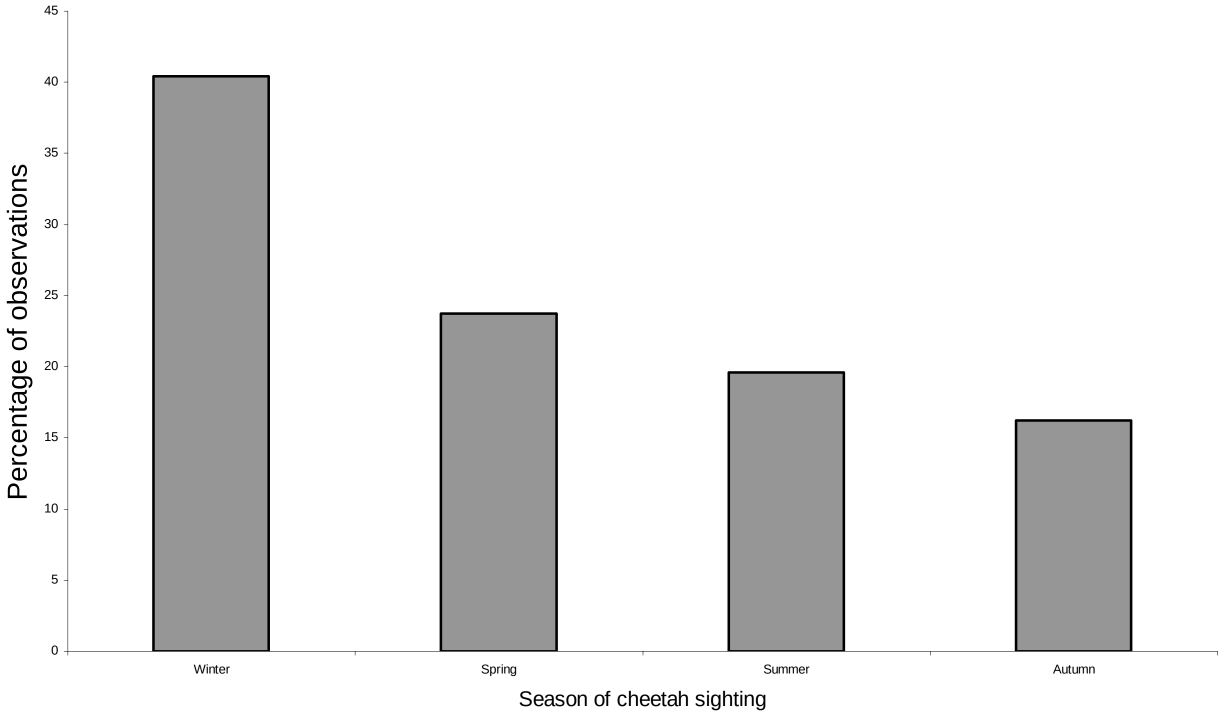


Figure 4: The seasonal sighting distribution of cheetahs on ranches where cheetahs have been reported in the Thabazimbi district of the Limpopo province during a questionnaire survey done from August 2000 until March 2001.

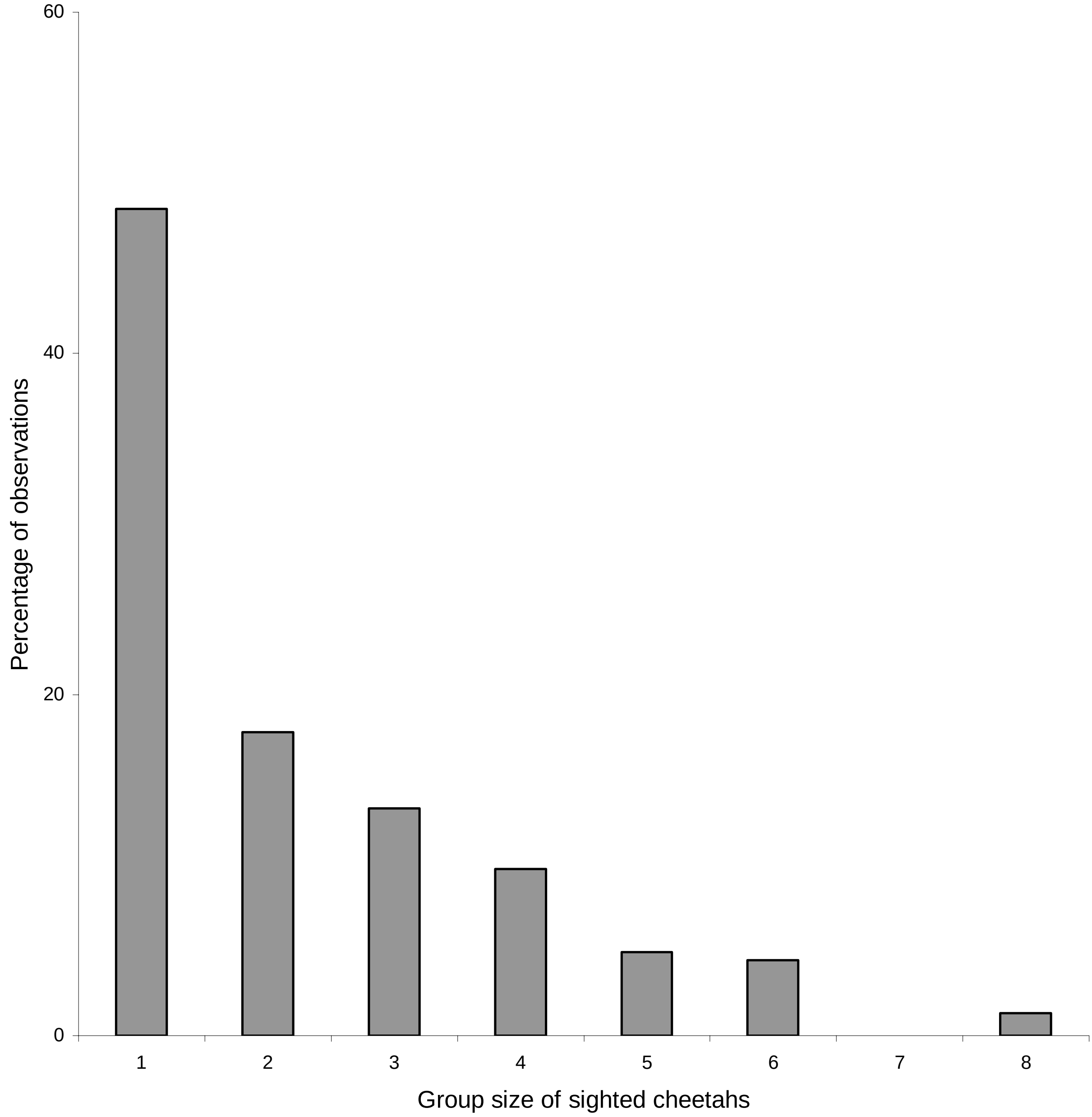


Figure 5: The group size in which cheetahs were sighted in the Thabazimbi district of the Limpopo province during a questionnaire survey done from August 2000 until March 2001.

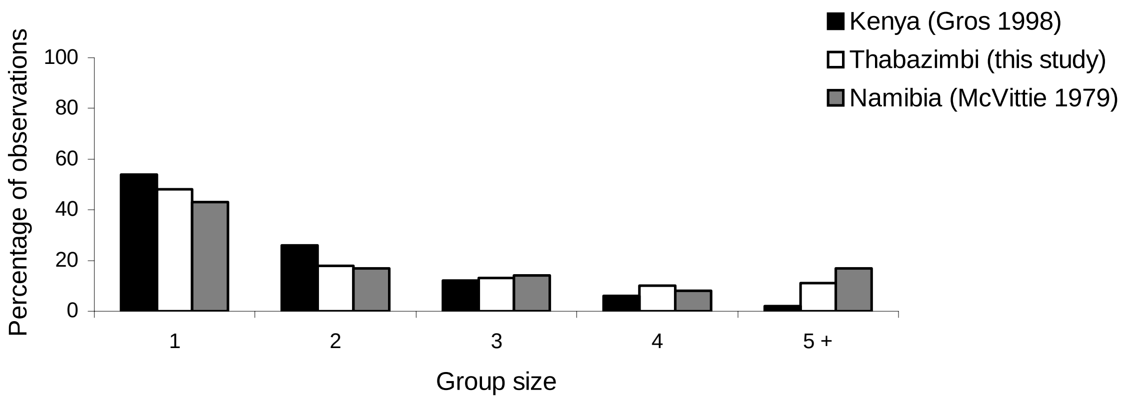


Figure 6: A comparison of cheetah group sizes that were reported in three different surveys in Kenya, Namibia and the Thabazimbi district, South Africa showing a decrease in frequency of sightings with an increase in cheetah group size.

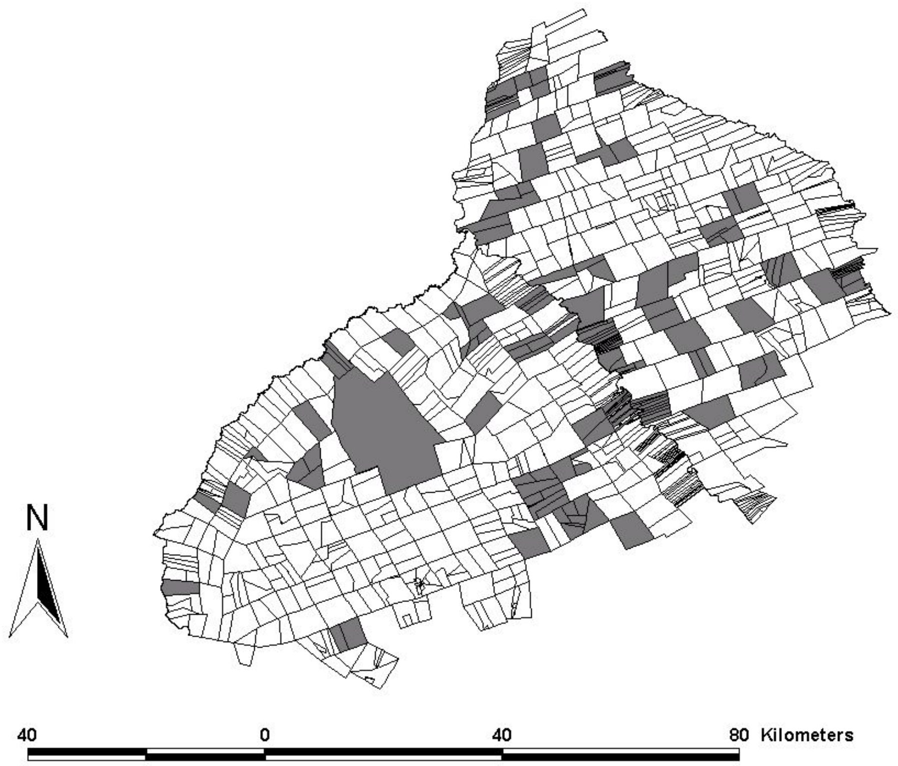


Figure 7: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey. done from August 2000 until March 2001, reported sighting single cheetahs on their property.

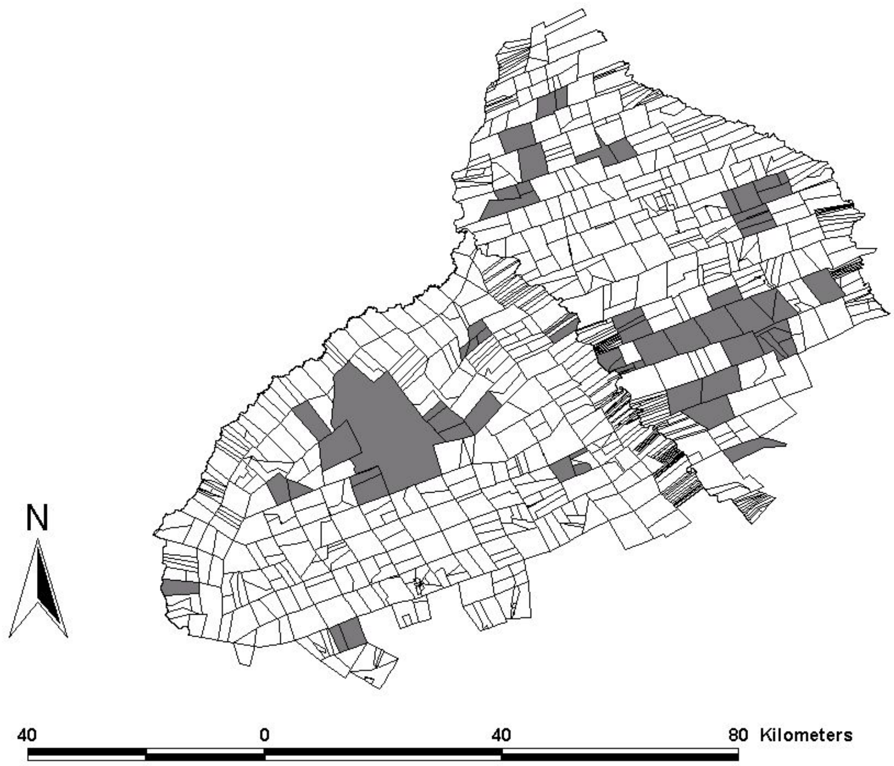


Figure 8: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of two cheetahs on their property.

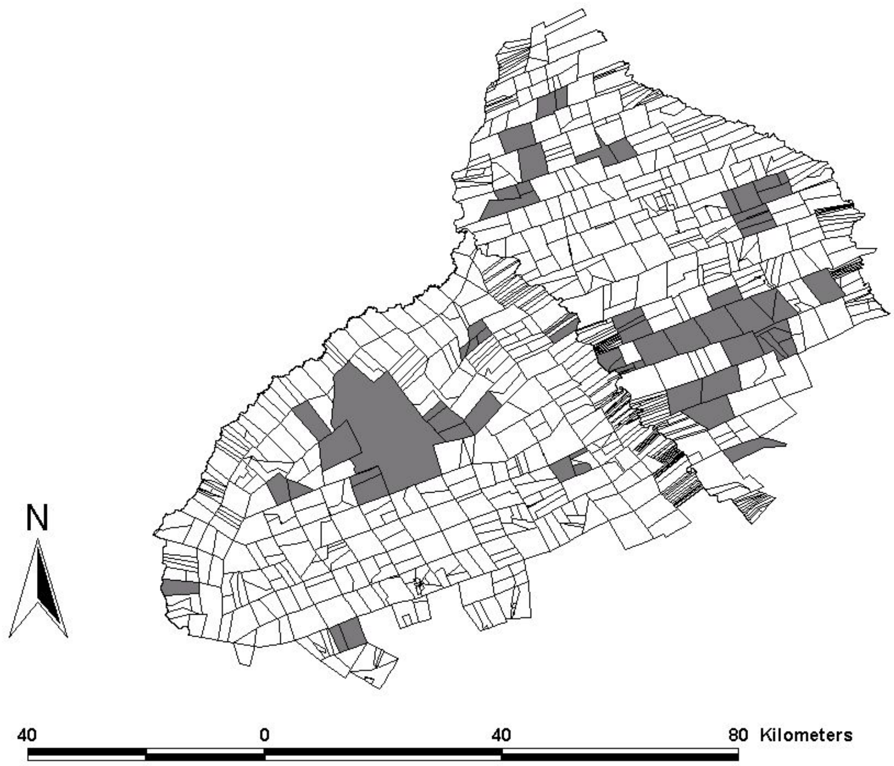


Figure 8: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of two cheetahs on their property.

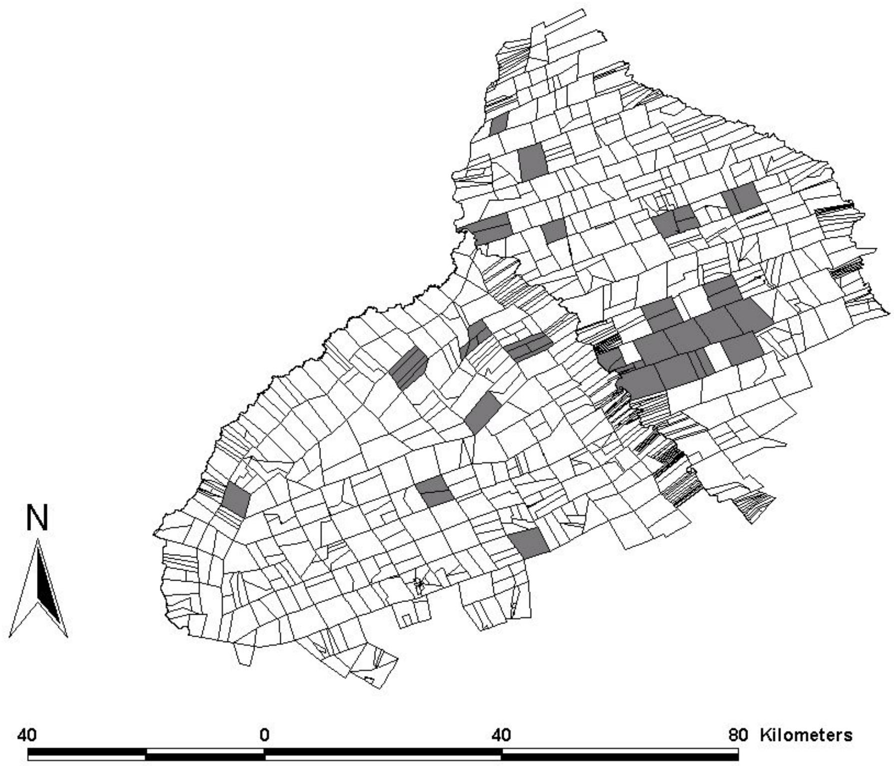


Figure 9: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of three cheetahs on their property.

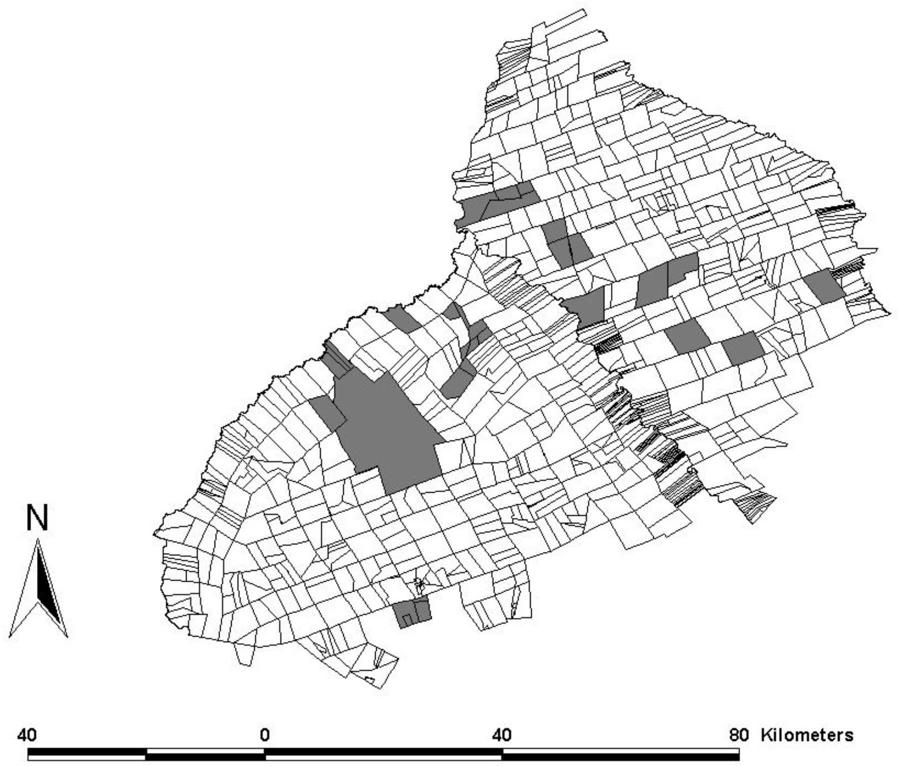


Figure 10: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of four cheetahs on their property.

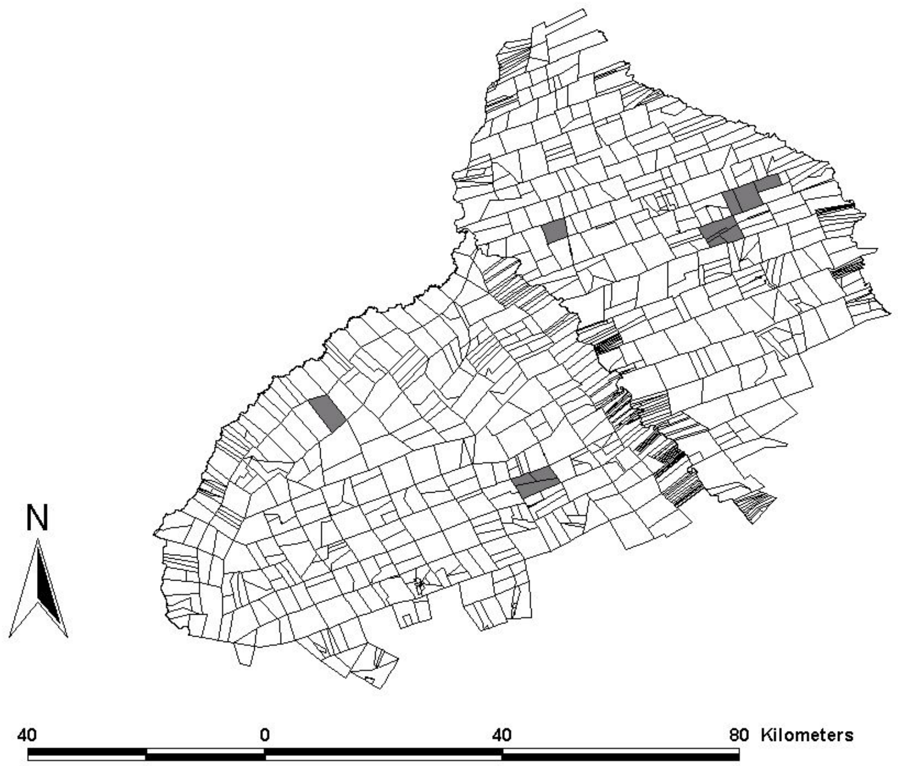


Figure 11: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of five cheetahs on their property.

Figure 12: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of six cheetahs on their property.

Figure 13: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting a group of eight cheetahs on their property.

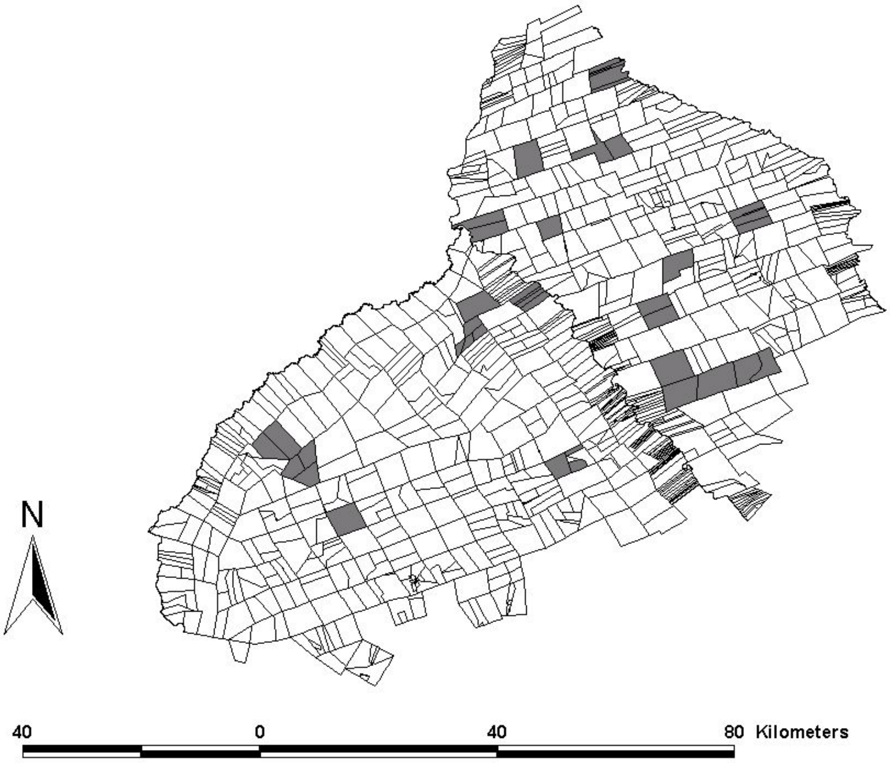


Figure 14: The Thabazimbi district of the Limpopo province showing ranch boundaries. Shaded areas denote ranches where respondents to the questionnaire survey, done from August 2000 until March 2001, reported sighting female cheetahs with cubs on their property.

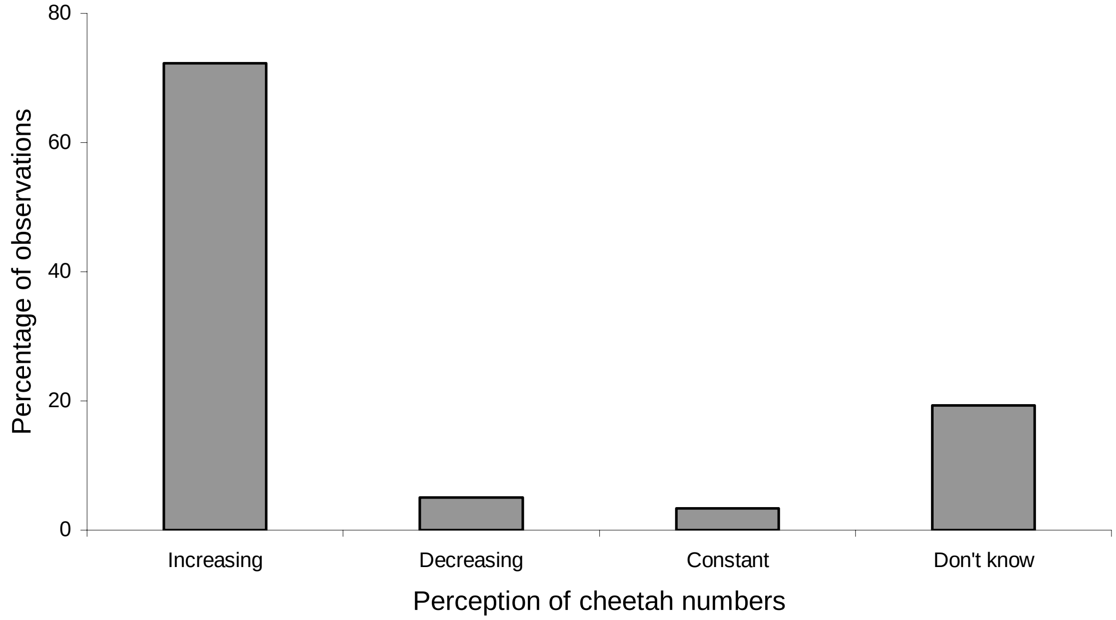
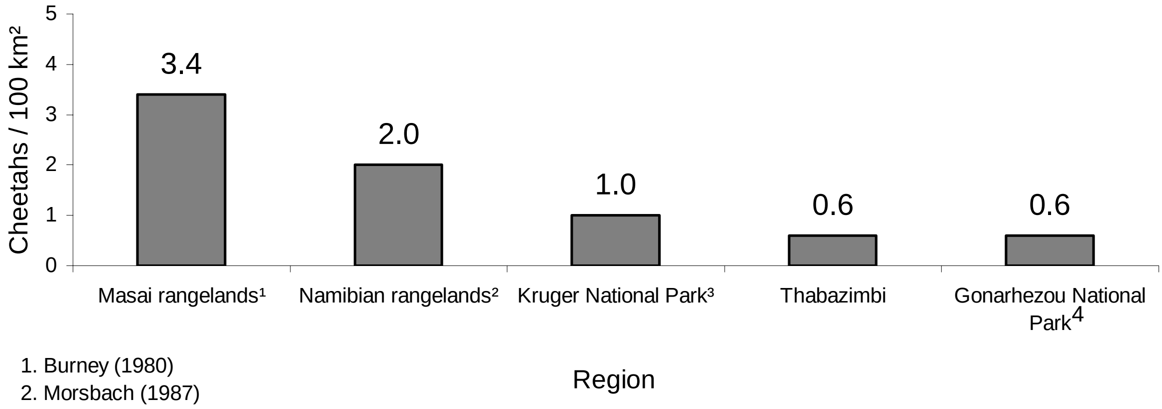


Figure 15: The perceived trends in cheetah numbers over past five years as reported by ranchers who have sighted cheetahs on their ranches in the Thabazimbi district of the Limpopo province during a questionnaire survey done from August 2000 until March 2001.

Of all the ranchers who had cheetahs on their properties, 29% felt that cheetahs were an asset to them, while 71% considered cheetahs to be a liability. In analysing these results the chi-square testing was treated cautiously as many cells have insufficient counts. There was no significant relationship between the frequency of actual sightings and the perception of cheetah numbers (χ^2=2.7254 P=0.2560 df=2) and 75% of the cells have expected counts of less than 5. There is also no significant relationship between the frequency of sighting, and attitudes of ranchers towards cheetahs (χ^2=1.3732 P=0.2413 df=2). The attitude of the ranchers towards cheetahs and their perception of cheetah numbers, however, did appear to be related (χ^2=26.4192 P=0.0001 df=2) although 33% of the cells had low frequencies.

Multivariate analyses showed a statistically significant relationship (χ^2=44.2875 P<0.0001) between ranch type and cheetah presence. There was a tendency for wildlife ranchers or mixed cattle and wildlife ranches to have more cheetah sightings than any of the other ranch types in the study district. There were no significant correlations between any of the other variables in the data set.

The recognizable group size method (Gros 1998) yielded a population estimate of between 42 and 63 cheetahs in the study area at an estimated density of 0.6 to 0.9 cheetahs per 100 km^2. This density is comparable to cheetah densities that were calculated in other natural range areas (Fig. 16) where lions and spotted hyaenas also occur. However, the density of cheetahs in Namibian and Kenyan rangelands is higher.



1. Burney (1980)
2. Morsbach (1987)
3. Mills (1998)
4. In: Gros *et al.* (1996)

Figure 16: A comparison of cheetah densities in different regions in Africa.

4. Discussion

4.1 Questionnaire survey

A major deficiency of the questionnaire survey method is that its accuracy relies on human memory and honesty. Most of the reported sightings in the present study were not accurate to the day, but only to the month. Some were only accurate to the season or a specific time of the year, such as early in the hunting season. Careful questioning and cross-checking were required to ensure acceptable data integrity. It was also necessary to ensure that the respondents were reporting on cheetahs, as there is often confusion with the Afrikaans common names for the cheetah and the leopard. Much confusion also exists in identifying the difference between a cheetah spoor and a brown hyaena spoor. If there was any doubt regarding the type of predator being reported, the respondent was questioned on the physical and behavioural characteristics of the animal. It is possible that group size also played a role in the recollection of the sighting. A rancher was more likely to remember seeing a larger group of cheetahs than an individual animal. Moreover, a large group will be sighted more easily, biasing the sightings in favour of groups over individual animals (McVittie 1979).

4.2 Frequency of sightings

The frequency and season of cheetah sightings are probably linked to the movement of the ranchers on their properties. Most of the ranches are used primarily for hunting. This means that much of the human activity occurs during the hunting season, from late autumn until early spring (approximately from May to August). For the most part, there is little human activity in the field during the hot summer months and early autumn. Cheetah sightings similarly taper off steadily from a maximum of 40% in winter to a minimum of 16% in the autumn. Winter is the dry season in the study area, and the bush is not as dense then as it is in the summer. This could make sightings in the winter easier than in the summer. However, bush encroachment is common and the vegetation is dense in most of the district. Therefore, it is doubtful that the dry season would make a significant difference to ease of visibility. The availability of water also is not a factor as the ranchers provide water for wildlife in the form of artificial waterholes that are maintained throughout the year. Because of the relatively small size of the ranches (mean size: 18 km^2), the prey is sedentary and probably has no influence on cheetah movements.

The frequency of cheetah sightings is probably influenced by the human activity patterns on the ranches. Cheetahs were sighted less frequently than once per month by 71% of the respondents who reported having seen cheetahs on their ranches. Most of the respondents sighted cheetahs twice a year. The frequency and season of sighting of cheetahs in this study could therefore be affected by human activity patterns on the ranches. It is probable that the cheetah population remained stable, but that the sightings had a seasonal bias because of human behaviour.

4.3 Group size

The most frequently sighted cheetahs in the present survey were single animals. A group of eight cheetahs was reported twice during the survey. The frequency of cheetah group sizes reported decreases with increasing group size. In both Namibia and the Thabazimbi district, a higher frequency of occurrence of groups of four or more cheetahs was reported than in the Kenya survey. This supports the results of Gros (1998) in Kenya where the group sizes of adult cheetahs tend to be larger outside protected areas than inside protected areas. This may be a result of decreased interspecific carnivore competition allowing for larger group formation of cheetahs (Eaton 1978).

In the present survey in the Thabazimbi district, only 20 sightings of females and cubs were recorded. Therefore care must be taken when interpreting these data. Observations involving cubs are problematic in that ageing of the cubs for the untrained eye is difficult and there is also the possibility that not all the cubs in a group were seen. For these reasons, the data on cheetah cubs have not been analysed or interpreted in detail and when mapping these sightings, but they were lumped as a single group of females with cubs (Fig. 14). This was done to investigate areas of possible female presence.

4.4 Attitude towards cheetahs

The large proportion (72%) of respondents who considered cheetahs to be a liability on their wildlife ranches is the main obstacle to the conservation of free-roaming cheetahs in South Africa. Most ranchers are intolerant of large carnivores on their properties. Because most of the ranches are used for hunting, even the loss of one antelope to cheetah predation is considered to be an economic loss for the rancher. In general, the ranchers feel that cheetahs are pests and that they have no value, either economic or aesthetic.

In South Africa, it is illegal to hunt cheetahs unless a permit is issued to hunt it as a so-called problem animal. These permits are difficult and time consuming to obtain, and most ranchers feel that it is easier to shoot the cheetahs on sight regardless of the legal implications. There is a general attitude among the ranchers that if the cheetahs had some economic value, such as in the form of legal hunting, then they would be more willing to tolerate the presence of cheetahs on their ranches. At present, the only form of economic gain that can be legally acquired from cheetahs is the compensation-relocation programme of the National Cheetah Conservation

Forum of South Africa[3]. In this programme, problem cheetahs are captured, the rancher is compensated and the cheetah is relocated to a ranch where a cheetah presence is acceptable. This is all done under strict monitoring.

Nevertheless, the above programme only offers a short-term solution to the problem. The only long-term solution for the survival of cheetahs outside formal conservation areas is a total shift in the attitude of the ranchers. This attitude cannot be changed by ecological and biological studies alone, and the sociology and socio-economic aspects of the specific conflict must also be examined and understood (Kranz 2000; Liu 2001). Many factors influence the conflict between large predators and humans, and Ahearn, Smith, Joshi and Ding (2001) found that in Nepal, the more cattle that were killed by tigers close to a village during a given time interval, the more the villagers were motivated to attempt to poison the tigers. However, when management strategies were changed and the villagers started to guard their livestock increasingly, tiger predation on domestic stock decreased and a significant decrease in the number of tiger poisoning mortalities was recorded.

Kranz (2000) investigated the human dimensions of otter *Lutra lutra* depredation on fish farms in central Europe. Factors such as the possibility of fish loss to other predators, the economic situation of the farmer, the size of the farm, the attitudes and emotions of the farmer, and the conservation and compensation policies of the country involved all had an influence on the attitudes of the farmers towards damage caused by otters. In the Thabazimbi district, the significant relationship between the attitude of the ranchers towards cheetahs and their perception of cheetah numbers shows that this perception and attitude could be linked, but that neither are influenced by the frequency of the cheetah sightings.

[3] D. Cilliers, National Cheetah Conservation Forum, P.O. Box 52071, Dorandia, 0188, South Africa

Moreover, the conflict potential between cheetahs and landowners is possibly increased because cheetahs are perceived to have little economic value to the rancher. In many cases, ranchers feel that the legislation protects cheetahs, which effectively prevents the ranchers from protecting their wildlife against what they consider to be a problem animal. Many ranchers do not have any incentive to tolerate cheetahs on their ranches. Economic conditions are difficult for ranchers in South Africa more so because: the agricultural sector was deregulated in the early 1990s and lost its political power base in Parliament after the transition to a full democracy in 1994, new labour laws have also increased the cost of ranch labour, agricultural subsidies have effectively ceased, stock theft has increased dramatically over the past two decades and a general decrease in ecological capacity of ranches due to bush encroachment is evident (Anon 2002). These factors add to the economic stress of the ranchers, which in turn makes them less tolerant of losses by cheetah predation. Some of the small-scale ranchers also tend to get emotionally attached to antelope that they can recognise as specific individuals. When cheetahs kill these animals, the rancher then is usually more motivated to try and exterminate the cheetah.

A growing trend in ranching areas within close proximity of a major city is weekend ranching. Businessmen who live in the city keep a wildlife ranch for their own relaxation and enjoyment over weekends and holidays. These ranches are not a primary source of income for the rancher. In such cases the rancher is less likely to persecute cheetahs and enjoys the possibility of a cheetah sighting on his ranch.

The above are some of the factors that have to be taken into consideration along with ecological factors when attempting to resolve the long-standing conflict between ranchers and cheetahs, and in compiling a management plan for the long-term survival of viable free-roaming cheetah populations. If ecological, demographic, socio-economic and behavioural factors are not integrated in the formation of a conservation strategy or management plan, success will clearly not be achieved (Liu 2001).

4.5 Cheetah occurrence

The data showed that cheetah occurrence reports may be linked to ranch type. Cheetahs appear to occur more frequently on wildlife or mixed wildlife and cattle ranches, than on any other ranch type in the district. This is probably largely due to the availability of prey and suitable habitat on these ranches. On ranches where intensive crop production occurs, the prey base is low and a constant movement of humans and vehicles occurs. These factors impact negatively on cheetah occurrence.

4.6 Population estimate

The recognizable group size method is an easy, convenient way of obtaining an approximate population estimate for cheetahs from a questionnaire survey. However, the method probably underestimates cheetah numbers, as it does not allow for more than one group of the same composition to occur in the study area, or for counting single cheetahs. For this reason, there is a wide range in the population estimate. The low number of 42 cheetahs was obtained without taking single individuals or group size duplication into account. After sorting the sighting data according to date and location, it became apparent that there may be more than one group of two adults in the district, and that some of the sightings including cubs were probably also of different groups. Two sightings of a female with two cubs were recorded over a two-year period. It was assumed that this was not the same group because the cubs of the first sighting would have been mature before the second sighting. Dates and locations of sightings of single animals were plotted on a map and examined. This showed that there was more than one single cheetah in the district. Consequently, the estimated population is a maximum of 63 cheetahs.

The questionnaire method was not ideal for obtaining accurate cheetah numbers, but was particularly appropriate for presence-absence type data and for obtaining-base line information in ranching areas.

4.7 Cheetah density

When calculating the cheetah density, it was decided to be conservative by using the estimated population low. Because cheetahs are suspected to fare better in areas with no other large carnivores (McVittie 1979; Laurenson, Wielebnowski and Caro 1995), it would be expected that cheetahs would occur at higher densities in ranching areas, like the Thabazimbi district, where there are few other large carnivores and relatively high prey concentrations. When cheetah density in the Thabazimbi district was compared with those obtained from other studies on rangeland in Namibia and Kenya, the density for Thabazimbi district was low. This could be a function of the possible underestimate in population size from the recognizable group size method. However, when the estimated maximum population size was used, a density of 0.9 cheetahs per 100 km^2 was obtained. This density was still notably less than that obtained on rangelands in Namibia and Kenya. The maximum density of cheetahs in the Thabazimbi district appeared to be similar to the estimated density in the Kruger National Park. However, lions and spotted hyaenas also occur in the Kruger National Park. Therefore, it would have been expected that the density of cheetahs in that park would be lower than in the Thabazimbi district.

A possible explanation for the above discrepancy was that in the present study a relatively high level of cheetah persecution by humans occurred. This persecution could replace the role of other large predators in the ecosystem, suppressing cheetah density in the process. Additionally, it has been shown that cheetahs are more inclined to have smaller litter sizes in areas of high conflict between ranchers and cheetahs (Gros 1998), which could perhaps also account for the lower than expected density of cheetahs in the study area.

To obtain a possible population estimate for the whole of South Africa, the calculated cheetah density of 0.6 – 0.9 cheetahs per km^2 was extrapolated for the entire known current cheetah range of 125 153.2 km^2 in South Africa (Boitani *et al*. 1999). This translates into an estimated population of 750 – 1126 cheetahs occurring in South Africa assuming that cheetahs occur at an even density throughout their entire possible range. This estimate is higher than the estimate of 422 – 872 obtained by Friedmann and Daly (2004), however, the numbers in Friedmann and Daly (2004) are based on broad estimates by field workers and additionally, the lowest estimated number of cheetahs was utilized in accordance with the precautionary principle.

5. Conclusions

The questionnaire method was an ideal method for obtaining data on carnivores from ranching areas. Large areas could be covered relatively quickly and cost-effectively and the method drew on the pooled knowledge that many individuals have obtained over long periods of time. It was an ideal method for collecting presence-absence type of data as well as data on land-use and attitudes of ranchers in the study area. The method was useful as an initial survey of an unknown area and to obtain approximate population numbers, but the population estimates that were obtained were not statistically reliable. This method should be followed up with intensive field studies in order to fully investigate the status of cheetahs in a specific area.

The cheetahs that occur on rangeland in the Thabazimbi district of South Africa did not seem to fare notably better than their counterparts inside conservation areas. However, it is important to promote conservation of cheetah populations outside formal conservation areas. These populations on ranch lands are not isolated from the cheetah populations in Botswana and Zimbabwe. This is genetically vital because many of the cheetah populations in conservation areas in South Africa are isolated. Without active management, inbreeding could become a problem. Additionally, more land in South Africa is under commercial wildlife ranching and private ownership than what is protected in National Parks and other conservation areas (Van der Waal and Dekker 2000). Wildlife and cattle ranches provide valuable habitat for predators like the cheetah that require large tracts of land for survival. Nevertheless, the survival of large carnivores on private land depends almost entirely on the attitude and tolerances of the landowners. For improved cheetah conservation in the Thabazimbi district, a change in attitude is necessary, as is a change in ranching practices to reduce prey losses due to predation by cheetahs. The landowners also have to learn to understand the role of cheetahs in the ecosystem better. However, conflict cannot be resolved simply by ecological studies. The human dimension has to be addressed too by combining sociology and socio-economics with ecological aspects to formulate a successful strategy to manage the conflict between landowners and cheetahs (Kranz 2000).

Acknowledgements

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CHAPTER 5

USING CAMERA-TRAPPING TO INVESTIGATE THE USE OF A TREE AS A SCENT-MARKING POST BY CHEETAHS IN THE THABAZIMBI DISTRICT

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ABSTRACT

The use of a specific tree as a scent-marking post by cheetahs *Acinonyx jubatus* was studied on a wildlife ranch in the Thabazimbi district of the Limpopo province. A remote-triggered camera was set up at a marula tree *Sclerocarya birrea* subsp. *caffra*, which was known to be scent-marked frequently by cheetahs. In all, 87 camera-days produced 43 photographs of various animals including African elephants *Loxodonta africana*, African civets *Civettictis civetta,* aardvarks *Orycteropus afer,* white rhinoceroses *Ceratotherim simum,* brown hyaenas *Parahyaena brunnea* and cheetahs. Twenty-three photographs of cheetahs were taken on 13 different occasions. The photographs were used to determine the gender of the cheetahs and to identify individuals by using their spot patterns. Seven different cheetahs were identified, all of which were adult males. Of the 13 cheetah visitations, 10 happened at night, two at dawn or dusk and one during daylight. Territorial marking included defecation on and under the tree, urine-spraying and clawing of the tree. The viability of obtaining a population estimate by using the capture-recapture method based on photographs taken at scent-marking trees is investigated. The management implications of the study are discussed.

Key: Words: *Acinonyx jubatus*, cheetah, scent-marking, camera-trapping, spot patterns

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INTRODUCTION

Free-roaming cheetahs *Acinonyx jubatus* occur on many wildlife ranches in the Limpopo province, Northern Cape Province and North West Province of South Africa. Most of these wildlife ranches in the Limpopo province are enclosed by game-proof fencing, have a mean size of approximately 1800 ha and are kept for the main purpose of hunting (Wilson, Van der Linde, Bothma & Verdoorn *in prep*.). This results in conflict between cheetahs and the wildlife ranchers and the consequent persecution of cheetahs. Little is known about the population status, distribution and behavioural ecology of the cheetahs occurring on these ranches.

Female cheetahs have large ranges with loosely defined boundaries that they do not defend actively (Bothma & Walker 1999). In the marula-knobthorn savanna of the Kruger National Park, the range of a female varies from 151 to 169 km² in size (Mills 1998). Females usually do not scent-mark, but they will do so frequently when they are in oestrus to make their presence known to males (Labuschagne 1979). Therefore, when a female cheetah scent-marks, it serves a reproductive and not a social behavioural function. The ranges of female cheetahs also overlap considerably (Caro 1994).

The range of a resident male cheetah is usually smaller than or equal in size to that of a female. This is unique among the felids (Mills 1998). Non-territorial or nomadic males have larger ranges, and are usually in a poorer physical condition than their territorial counterparts (Caro 1994). Considerable overlap may occur in the territories of males (Labuschagne 1979; Mills 1998) and territorial males scent-mark their territories regularly to keep intruders away (Bothma & Walker 1999).

Cheetahs use both urine and faeces as scent marks. Scent marks have a pungent odour and are believed to deter intruders for about 24 hours (Bothma & Walker

1999). Cheetahs will mark on anything that is conspicuous in the landscape. Scent-marked objects include trees, shrubs, termite mounds and even man-made structures (Eaton 1970).

Large trees with at least one sloping horizontal branch are preferred for scent-marking (Labuschagne 1979). Such a scent-marking tree was identified on a privately owned wildlife ranch in the present study. Cheetahs will climb into such a tree to urinate and defecate on the branch. They will also claw the bark of the trunk. Trees are frequently scent-marked, and different males will often visit the same tree repeatedly. When re-entering an area, males will visit and mark the same tree regularly, even following the same path that was used by other males to reach the tree (Eaton 1970; Labuschagne 1979). Scent-marking is a spatial separation mechanism that prevents possible conflict that may result from a meeting of conspecifics, or interference when hunting (Eaton 1970).

Cheetahs are also elusive, shy and notoriously difficult to count. These problems are compounded in a region like the Thabazimbi district where much of the land is privately owned with restricted access, the bush is thick and the cheetahs are often persecuted making them extremely cautious. In such cases, camera-trapping is a useful, non-intrusive method for studying many facets of wildlife ecology (Cutler & Swann 1999) and has been used successfully in the past to investigate the densities of bobcats *Lynx rufus* (Diefenbach *et al.* 1994), tigers *Panthera tigris* (Karanth 1995; Karanth & Nichols 1998; Carbone *et al*. 2001) and several other large mammal species (Jacobson *et al.* 1997).

In the present study, a camera-trap was placed at the cheetah scent-marking tree that was identified above so as to investigate the use of the tree for scent-marking, and to serve as a pilot study to investigate the possibility of using this technique to survey the cheetah population. Camera-trapping has been used successfully to estimate the density of tigers by applying mark-recapture models (Karanth & Nichols 1998). It would be particularly useful if this technique could be adapted for surveying cheetahs. Therefore the effectiveness of camera-trapping at a cheetah scent station was investigated here with the aim of applying this technique to cheetah density studies. The hypothesis tested was that photographs of cheetahs obtained from camera trapping can be used to identify individual cheetahs using their spot patterns with the aim of developing a capture-recapture study design in order to obtain population densities for cheetahs.

METHODS

The scent-marking tree was selected because it was used frequently by cheetahs, and a camera location was necessary that would ensure photographing of cheetahs. The specific tree that was chosen was a large, marula tree *Sclerocarya birrea* subsp. *caffra* that was situated on the verge of a service road on a wildlife ranch. The tree has a low long sloping horizontal branch that cheetahs use to climb onto and scent-mark. An attempt was also made to photograph cheetahs at a live bait station, but this proved to be unsuccessful.

A Trailmaster®[1] remote-triggered camera (Kucera & Barrett 1993) was installed at the tree. The system consisted of an auto focus, 35 mm camera that was equipped with a flash. The camera is triggered by a TM-1500 infra-red trail monitor. Colour photographs were taken by using 100 ASA Agfa colour film. The unit recorded the date and time of any visitation and could be set to switch off and on at selected times. The interval between the photographs could be set to prevent the whole film from being used by a single animal moving around in the infra-red beam.

[1] Goodson and Associates Inc. 10614 Widmer, Lenexa, Kansas 66215, USA. www.trailmaster.com

The sender and receiver were set up in such a way that the infra-red beam was parallel to the horizontal branch on to which the cheetahs climbed. Originally the camera was positioned to face the tree. After the first photographs were developed, it was decided to move the camera so that it was facing away from the tree to photograph any approaching cheetahs. This meant that photographs were obtained of the side of the cheetah from a frontal angle as opposed to one from the back. This positioning made the individual recognition of cheetahs easier. A velvet raisin bush *Grewia flava* that was growing below the horizontal branch of the marking tree was pruned in such a way that access to the tree was only possible from one side. This prevented the cheetahs from approaching the tree from the opposite side, and avoiding being photographed.

For the present study, the camera delay was set on a 20-second interval and the camera was kept on for 24 hours per day. All the other settings were kept on the default mode. The equipment was mounted on custom-made brackets, and all the wires were buried shallowly under the ground, and were fixed securely to the mounting post of the camera. The sender and receiver were fixed at a height of approximately 0.5 m above the ground level. All tall grasses and any branches that could interrupt the infra-red beam were mowed or removed. During camera installation and reading of the event data, contact with the tree and its direct surroundings was minimized. The equipment was checked as frequently as possible for malfunctioning, battery life and the replacement of exposed film.

The spot pattern of each cheetah is unique and can be used to identify individuals (Caro 1994; Kelly 2001). This technique was used here to identify individual cheetahs from the photographs. Identification was done manually by eye, even though software is available for computer-aided matching of cheetahs (Kelly 2001), this is only viable when large numbers of photographs are obtained. For a small sample size, as in this study, manual matching proved to be more effective. Three or four recognizable spot pattern areas were identified on the flanks or legs of each cheetah in a specific photograph. These patterns were then compared with the spot patterns of any cheetahs appearing in the other photographs. Scats were collected from the tree for genetic and prey selection studies.

RESULTS

In all, 87 camera-days and 43 photographs were obtained in three sampling periods, one of 48 days duration from November to December 2000, one of 22 days in February and March 2001 and one of 17 days in June 2001. A sample of 43 photographs of various animals was obtained (Table 1). Of the photographs, 23 were of cheetahs representing 13 different visitation events. This happened because some of the cheetahs were photographed more than once per visitation as they moved around to break the infra-red beam repeatedly. Ten of the 13 cheetah visitations took place at night, two occurred at dawn or dusk and only one in daylight. The visitations mostly occurred from 01:00 to 04:00 (Table 2).

Seven different cheetahs were identified individually by using their spot patterns. These cheetahs consisted of lone adult males and a coalition of two males. The minimum interval between re-visitations by a specific cheetah was 16 hours, and the maximum was 22 days (mean=6.0 days; SD=6.50 days). With the exception of the members of the one coalition, two different cheetahs never visited the tree in the same 24-hour period.

In the first sampling period, Cheetah A was photographed on three consecutive occasions and on the first visitation two photographs, one of each side were obtained as the cheetah moved around inside the infra-red beam (Figs. 1 & 2). Nine days

Table. 1: Details of visitations by all animals to the scent-marking tree on a private wildlife ranch in the Thabazimbi district from November 2000 until June 2001.

Photo ID	Date (dd/mm/yyyy)	Animal	Activity	Comments
1	14/11/2000	Africa civit	Sniffing ground	None
2	14/11/2000	Cheetah	Sniffing ground	None
3	19/11/2000	Aardvark	Walking away	None
4	23/11/2000	Cheetah	Looking over shoulder at camera	None
5	23/11/2000	Cheetah	Spray urinating against tree	None
6	24/11/2000	Cheetah	Approaching tree	None
7	02/12/2000	Cheetah coalition	Approaching tree	After rain
8	02/12/2000	Cheetah coalition	Both sniffing tree	After rain
9	02/12/2000	Cheetah	Rubbing cheek on *Grewia* branch	Member of coalition
10	04/12/2000	Cheetah	Approaching looking at camera	None
11	04/12/2000	Cheetah	Sniffing tree	None
12	04/12/2000	Cheetah	Sniffing ground	None
13	05/12/2000	Brown hyaena	Looking at camera	None
14	05/12/2000	Warthog	Walking past	None
15	06/12/2000	Cheetah	Sniffing ground	None
16	28/12/2000	Cheetah	Head low	Just eaten, stomach swollen and cut on flank and lip
17-19	31/12/2000	White rhinoceros	Breaking receiver	None
20	18/02/2001	Africa civet	Walking away	None
21	21/02/2001	Cheetah	Spray urinating on sender	After rain
22	21/02/2001	African civet	Running away	After rain
23-24	25/02/2001	White rhinoceros	Breaking receiver	None
25-27	11/03/2001	African elephant	Breaking receiver and camera	None
28	05/06/2001	Cheetah coalition	Approaching tree	None
29	05/06/2001	Cheetah coalition	One cheetah in tree other approaching	None
30	05/06/2001	Cheetah	Jumping off tree	None

Photo ID	Date (dd/mm/yyyy)	Animal	Activity	Comments
31	07/06/2001	Cheetah	Walking away	None
32	10/06/2001	Cheetah	Sniffing tree	None
33	11/06/2001	Brown hyaena	Sniffing receiver	Scat visible on tree branch
34	12/06/2001	Cheetah	Approaching looking at camera	Scat visible on tree branch
35	12/06/2001	Cheetah	Sniffing tree	Scat visible on tree branch
36	12/06/2001	Cheetah	Front feet on branch	Scat visible on tree branch
37	12/06/2001	Cheetah	Leaving	Scat visible on tree branch
38	12/06/2001	Brown hyaena	Sniffing ground	Scat visible on tree branch
39	12/06/2001	African civet	Paste marking on sender post	Scat visible on tree branch
40	15/06/2001	Brown hyaena	Looking at camera	Scat visible on tree branch
41	19/06/2001	Bat	Flying	Scat visible on tree branch
42	21/06/2001	Cheetah	Sniffing branch	Scat visible on tree branch
43	21/06/2001	African civet	Rubbing face on ground	Scat no longer on tree branch

Table. 2: Details of cheetah visitations to the scent-marking tree on a private wildlife ranch in the Thabazimbi district from November 2000 until June 2001. Cheetah identification, date, time and interval between cheetah visitations are represented.

Sample period	Date (dd/mm/yyyy)	Time	Interval between visits (days)	Cheetah ID
1	14/11/2000	01:05	N/A	A
1	23/11/2000	04:15	9	A
1	24/11/2000	20:03	0.6	A
1	02/12/200	19:00	8	A+G
1	04/12/2000	03:39	2	C
1	06/12/2000	02:28	2	B
2	21/02/2001	-	N/A	D
3	05/06/2001	-	N/A	A+G
3	07/06/2001	-	2	G
3	10/06/2001	-	3	A
3	12/06/2001	-	2	E
3	21/06/2001	-	9	F

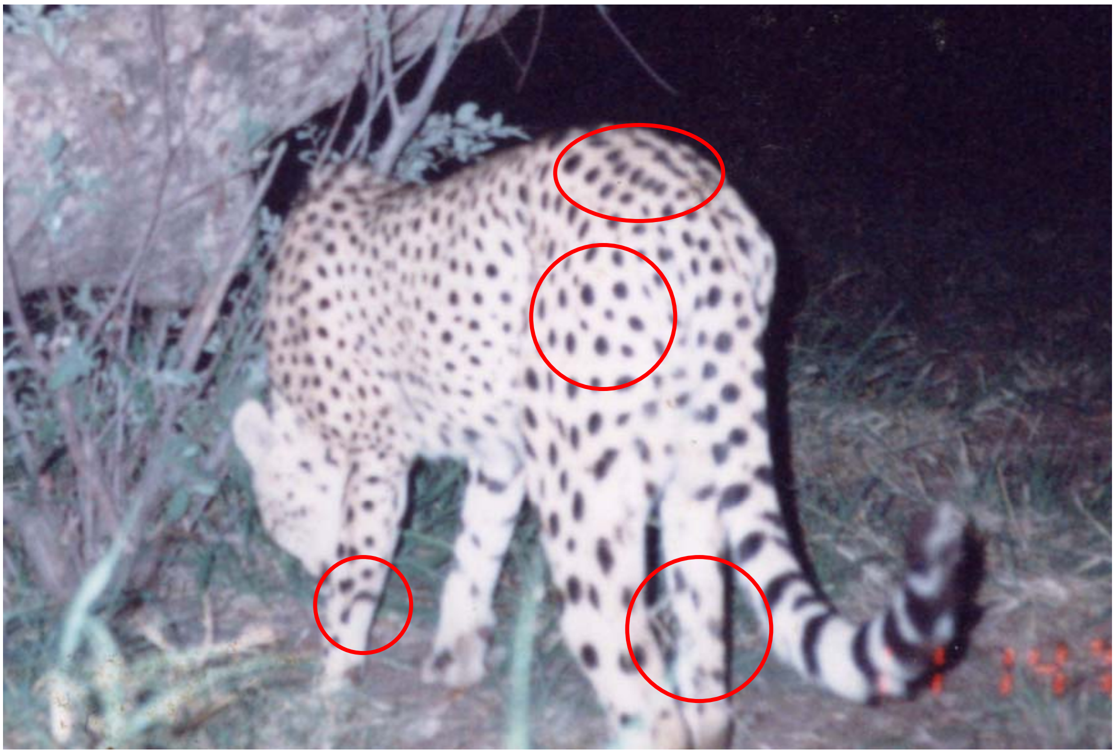

Fig. 1: Cheetah A photographed at 01:05 on 14/11/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

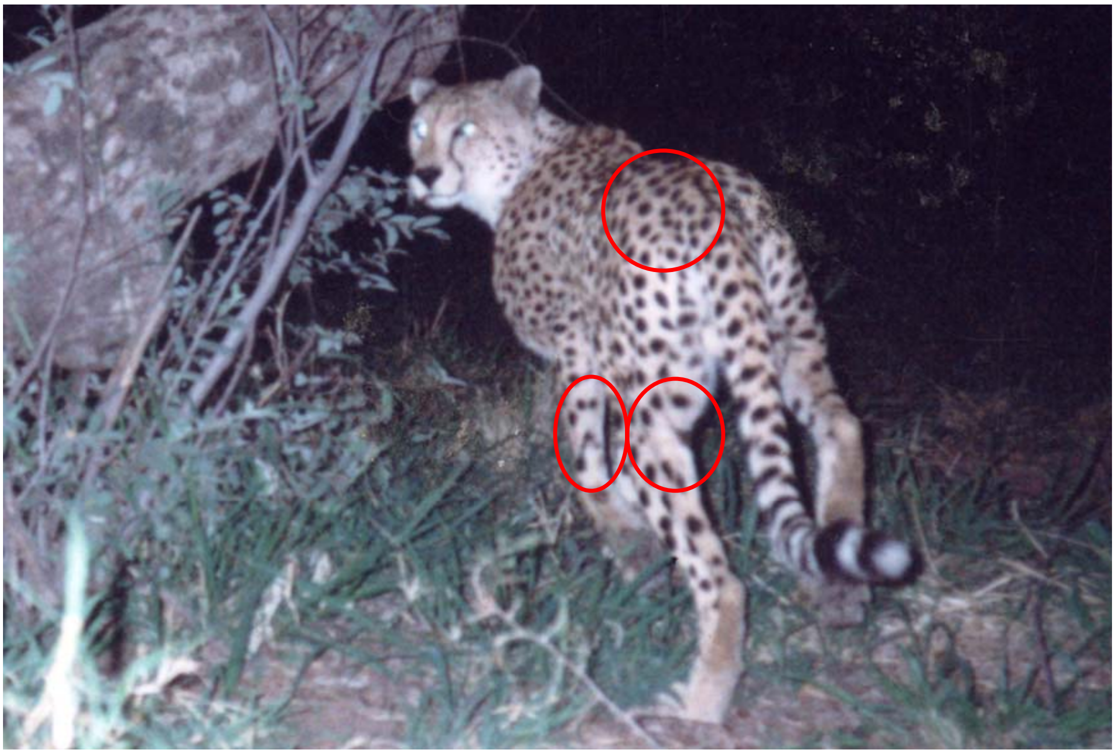

Fig. 2: Left side of cheetah A photographed at 04:14 on 23/11/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

later he was photographed again (Fig. 3), and then another photograph was obtained 16 hours later (Fig. 4). Cheetah A was again photographed eight days later in a coalition with another male, Cheetah G (Fig. 5).

Two days later Cheetah C was photographed (Fig. 6), followed by Cheetah B two more days later (Fig. 7). The next visitation by a cheetah occurred 22 days later, and it was identified as cheetah B (Fig. 8). The second sampling period only produced one photograph of a cheetah, which was identified as Cheetah D (Fig. 9). The third sampling period started with a photograph of the coalition between Cheetahs A and G (Fig. 10 & 10a). Two days later, Cheetah G was photographed alone (Fig. 11). Three days after that, cheetah A was photographed alone (Fig. 12). Cheetah E was then photographed two days later (Fig. 13), and nine days after that Cheetah F was photographed (Fig. 14). The cheetahs were photographed when approaching or leaving the tree, sniffing at the tree, jumping on and off the branch, and on one occasion when urinating against the tree.

Other animals that were photographed at the tree included: the African civet *Civettictis civetta*, aardvark *Orycteropus afer*, brown hyaena *Parahyaena brunnea*, warthog *Phacochoerus africanus*, white rhinoceros *Ceratotherium simum*, African elephant *Loxodonta africana* and a slit-faced bat of the genus *Nycteris*.[2]

DISCUSSION

It was originally intended to have one continual sampling period, not three shorter ones. However, this was impossible for several reasons. Firstly, the equipment was damaged and broken several times by elephants and a white rhinoceros. The camera activating wire was also chewed through once, possibly by rodents. Access

[2] T. Kearney, Collection Manager: Dry Vertebrates, Transvaal Museum, P.O. Box 413, Pretoria, 0001, South Africa.

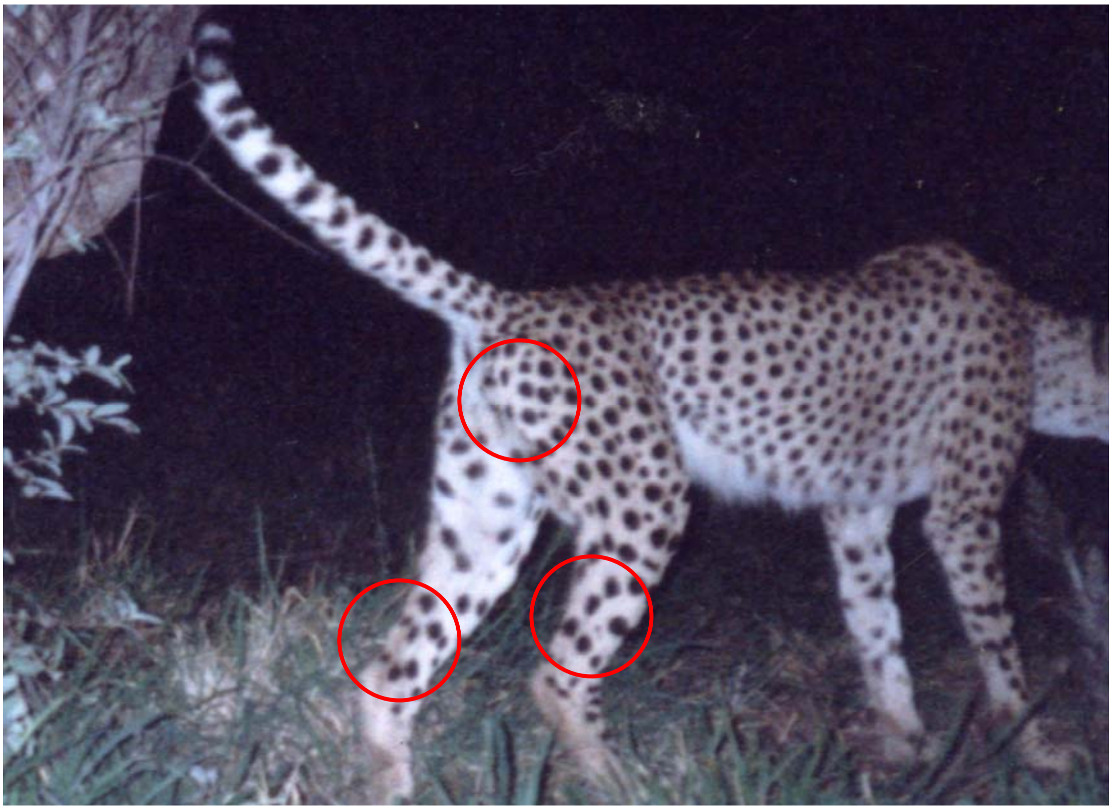

Fig. 3: Right side cheetah A photographed at 04:15 on 23/11/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

Fig. 4: Left side of cheetah A photographed at 20:03 on 24/11/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

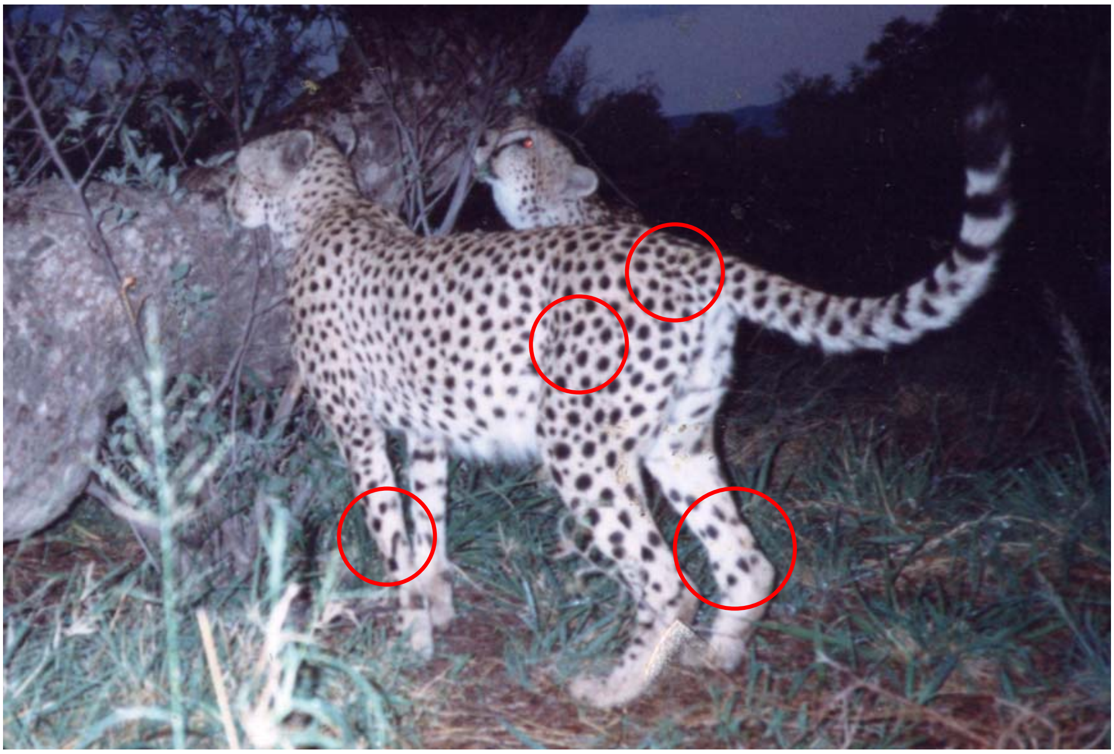

Fig. 5: Cheetah A (front) with cheetah G photographed at 19:00 on 02/12/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

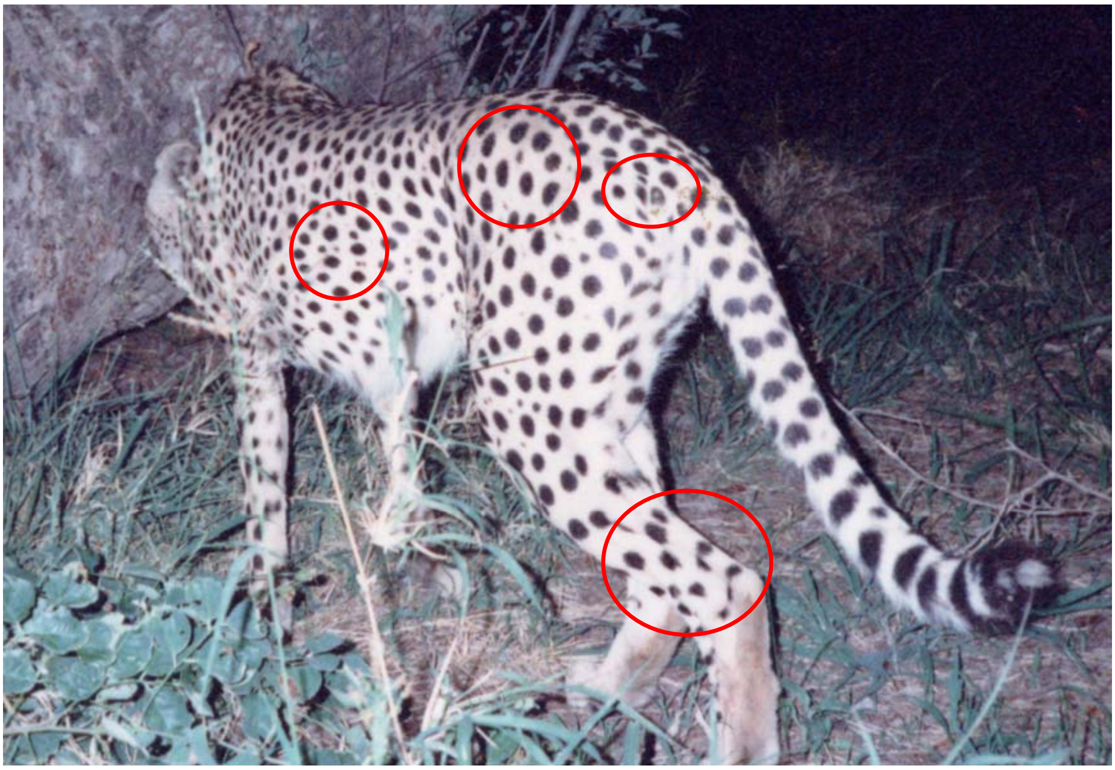

Fig. 6: Cheetah C photographed at 03:39 on 04/12/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

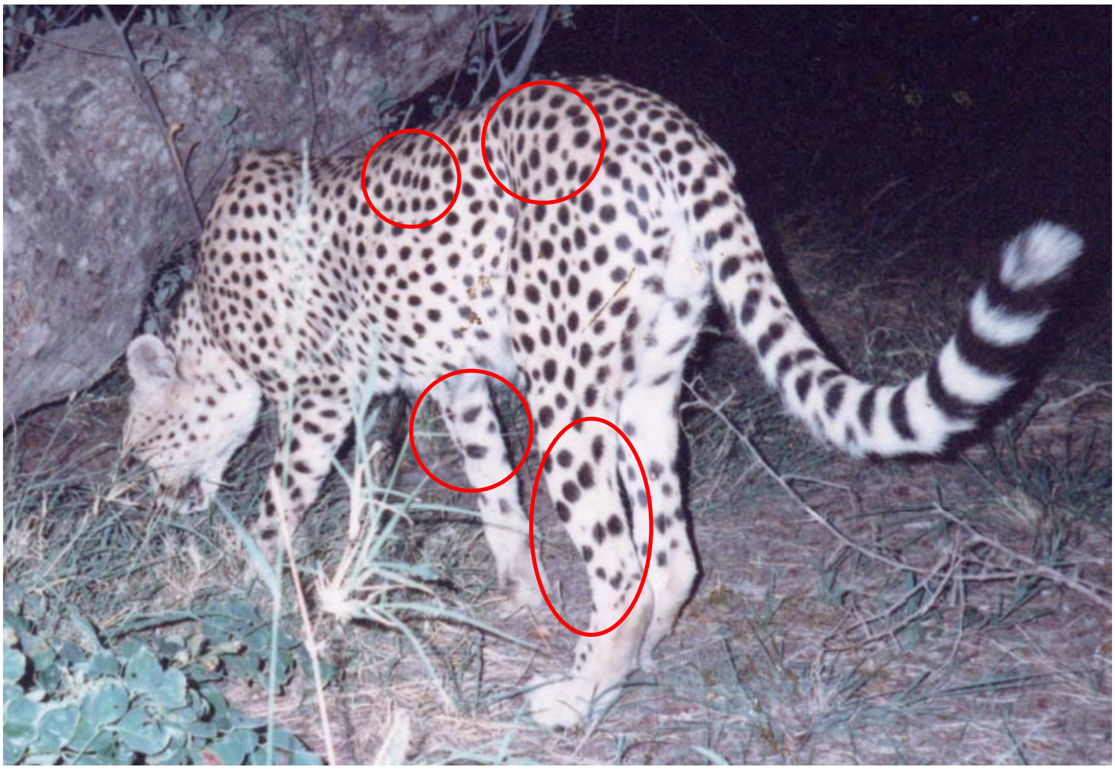

Fig. 7: Cheetah B photographed at 02:28 on 06/12/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

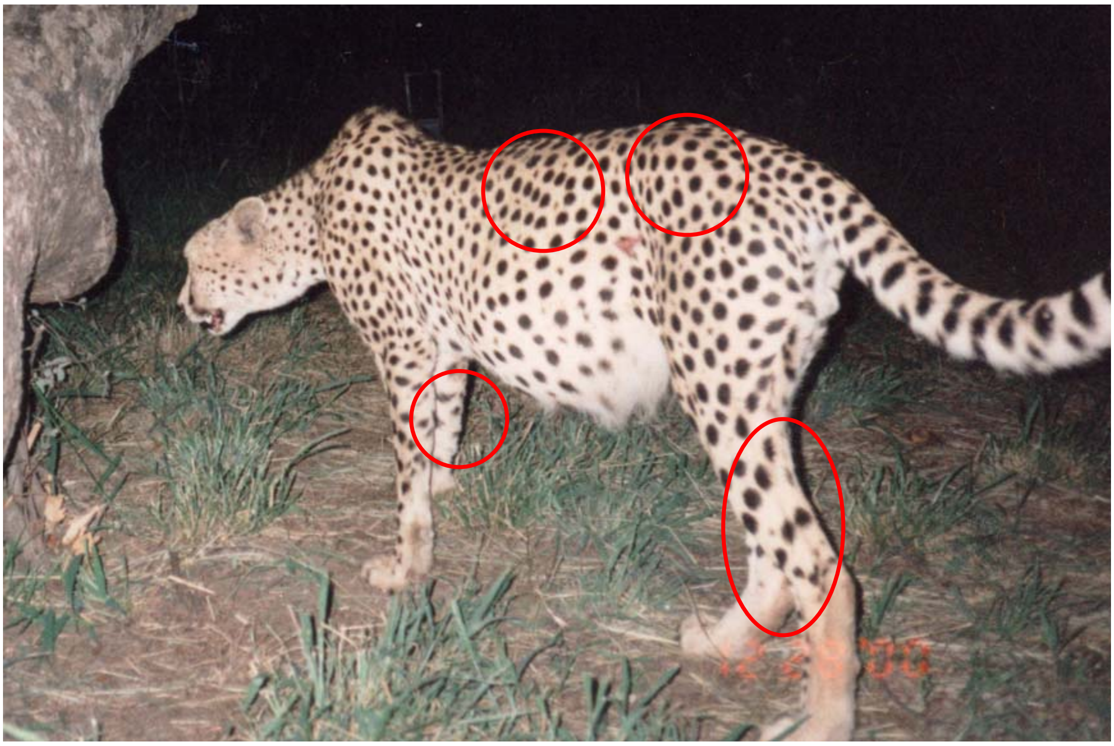

Fig. 8: Cheetah B photographed at 01:55 on 28/12/2000 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification. Note the swollen belly and cut on flank.

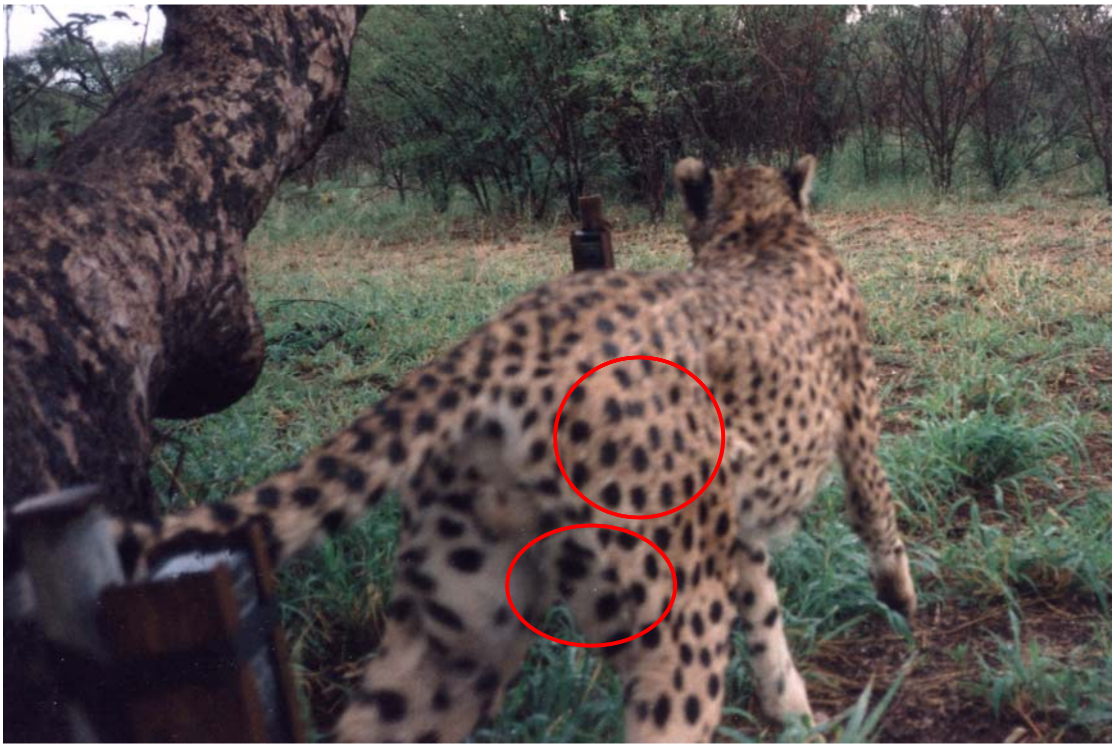

Fig. 9: Cheetah D photographed on 21/02/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

Fig. 10: Cheetah A (front) with Cheetah G photographed on 05/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

Fig. 10a: Cheetah G cut from Fig. 10 photographed on 05/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

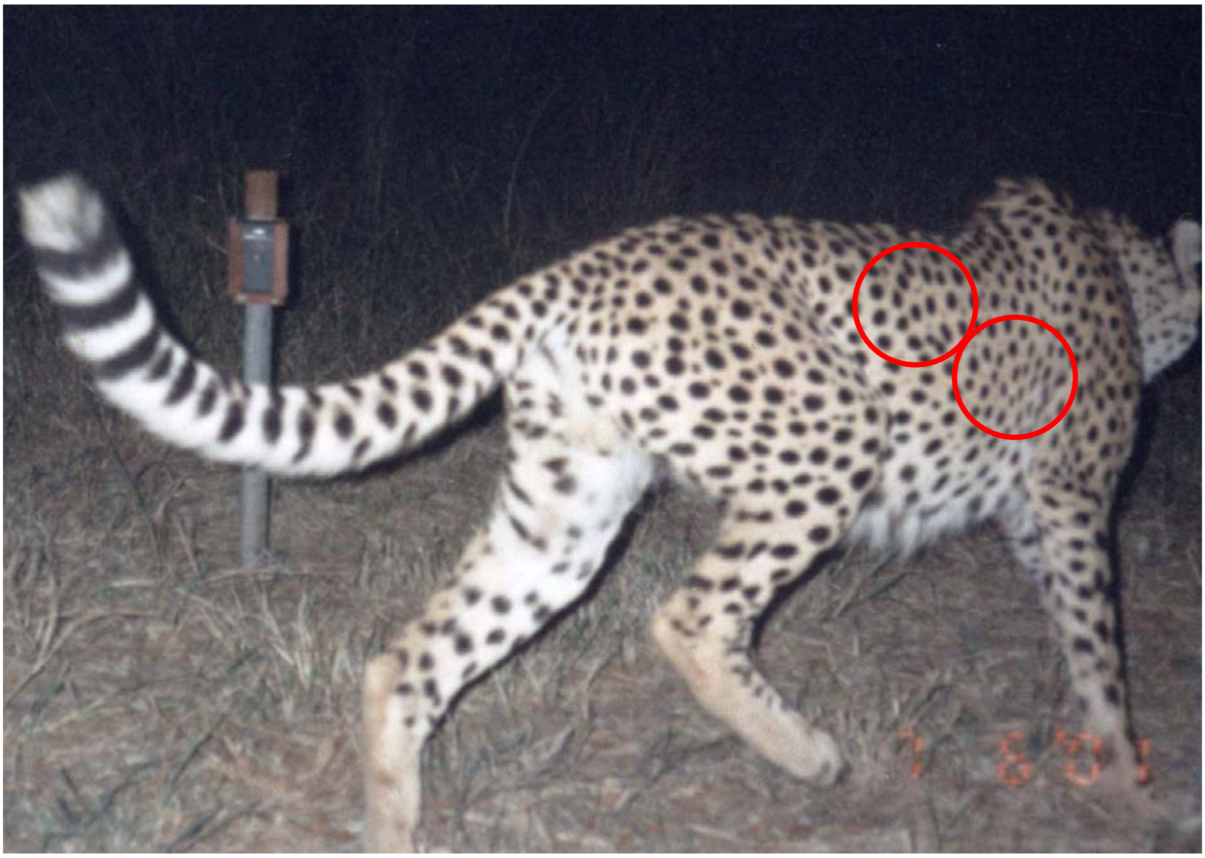

Figure 11: Cheetah G photographed on 07/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

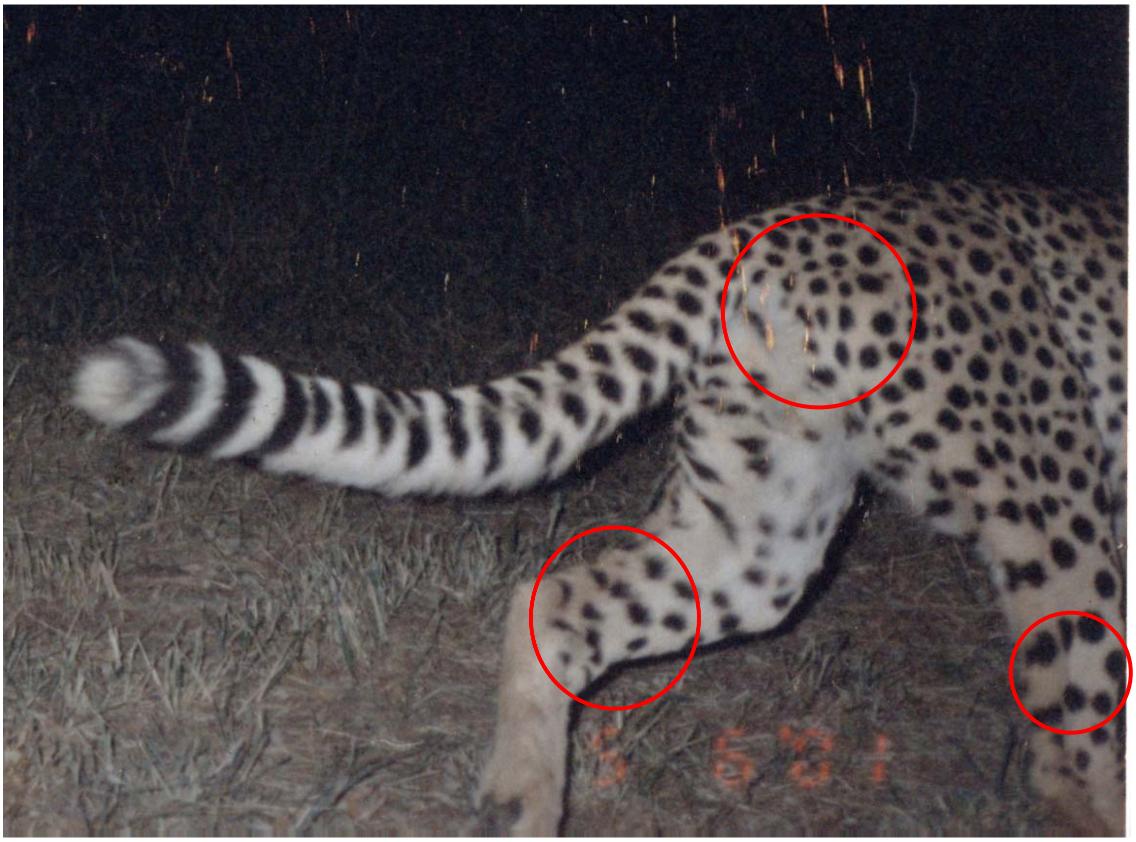

Fig. 12: Cheetah A photographed on 05/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification.

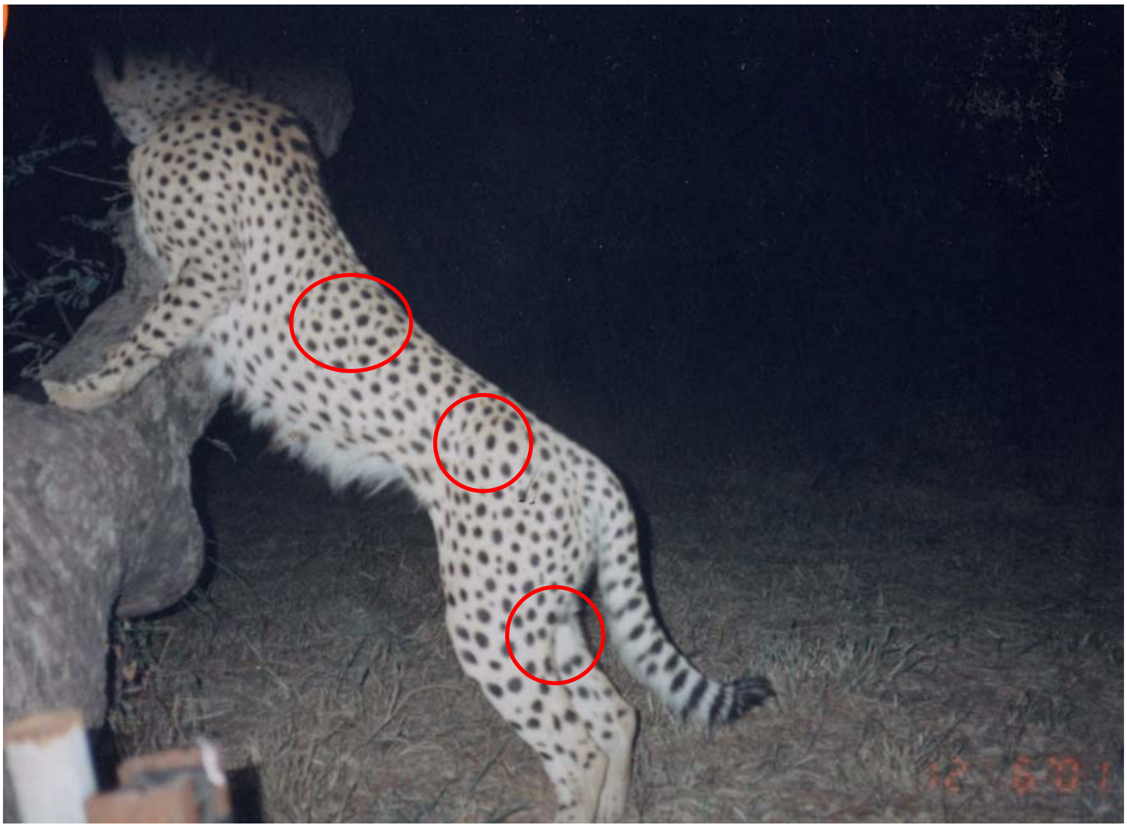

Fig. 13: Cheetah E photographed on 12/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification. Note the scat on the tree next to the left foot of the cheetah.

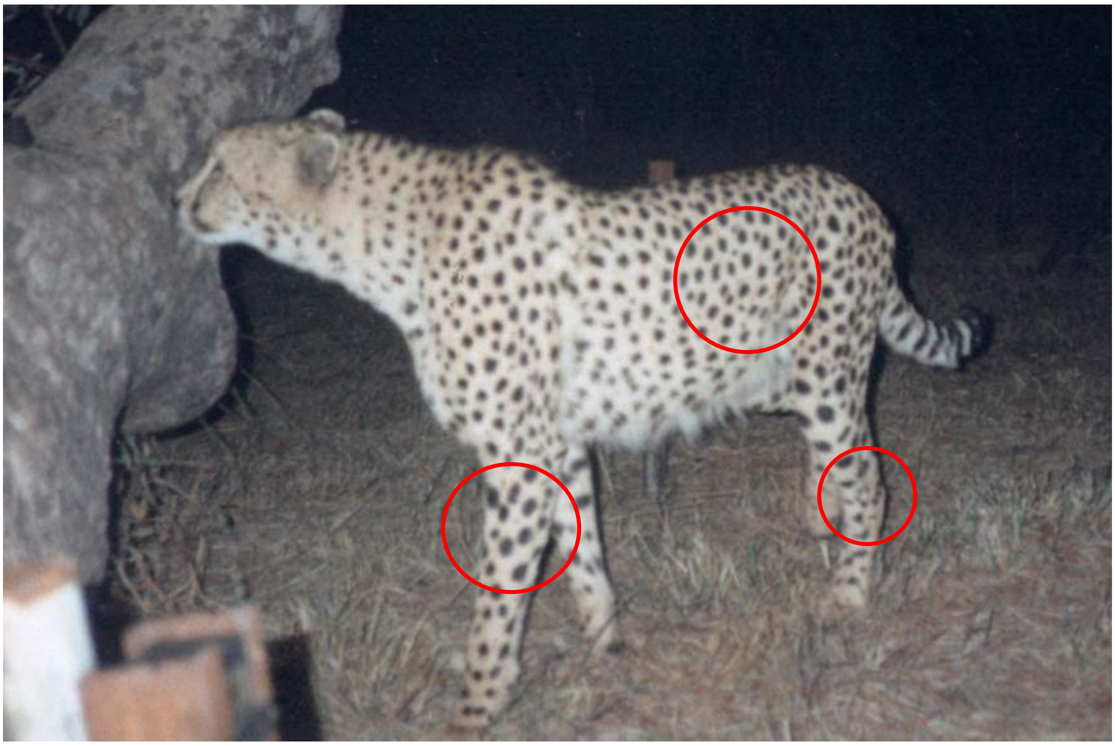

Fig. 14: Cheetah F photographed on 21/06/2001 using an infra-red triggered camera at the scent-marking tree on a private wildlife ranch in the Thabazimbi district of the Limpopo province. Red circles show spot patterns that were used for identification. Note the scat on the tree at the top left edge of the photograph.

to the tree and equipment was also limited because the tree was situated on a private road on a private wildlife ranch. This meant that the battery life of the sender and receiver and camera film could not be checked as regularly as was desirable.

Setting up the camera was difficult at first, but it became easier with practice and experience as was found by Kucera & Barrett (1995) and Rice (1995). Also problematic was the fact that there were no other trees that were large enough or conveniently placed enough for attachment of the sender and receiver. This was solved by welding metal droppers together to make ladder-like brackets. However, these brackets were damaged several times by a white rhinoceros that returned repeatedly, flattening the bracket and sender with its horn, then defaecating on the equipment and scraping its hind legs over it. New, sturdier brackets were then made by using steel water pipes. Steel boxes were also welded to house the sender and receiver. Appropriate holes were drilled in the housing to allow access to the relevant controls and for transmitting and receiving the infra-red beam. These housings were then bolted onto the water piping, and the pipes were hammered about 0.5 m into the ground.

The same white rhinoceros, however, again damaged the modified equipment. As a last resort, fresh rhinoceros dung was collected from a midden, that the rhinoceros was suspected of using. This dung was rubbed over the brackets and housings. No further problems were encountered with the rhinoceros but this may have been purely co-incidental.

The majority of the photographs were taken at night. This was surprising because cheetahs are normally regarded as being diurnal to avoid other large predators that are mainly nocturnal (Estes 1997; Sunquist & Sunquist 2002). Perhaps the cheetahs are more nocturnal in the study district because of the absence of other large carnivores there. Cheetahs were also persecuted in most parts of the study area, and human activity on the ranches is highest during the daylight hours. This nocturnal behaviour could therefore be a mechanism that is used by the cheetahs to avoid human disturbance. Black-backed jackals *Canis mesomelas* have been shown to be more nocturnal in areas where they are persecuted in an attempt to avoid human movements (Skinner & Smithers 1990; Kaunda 1998; Kaunda 2000).

Using spot patterns to identify individual cheetahs has proved to be a simple and effective technique. The photographs were of good quality both in dark and light conditions. The flash seemed to have little effect on the behaviour of the cheetahs. On several occasions, multiple photographs were obtained per visitation, indicating that the cheetahs were not scared off by the flash.

For individual identification, it was necessary to find different recognizable sections on the same cheetah. Because the cheetahs were not always standing at the same angle to the camera, a specific pattern of spots might have been obscured in a particular photograph, making identification impossible if only one region of the body was used for identification. The use of several groups of spot pattern on the body proved to be a useful technique to confirm the identity of a cheetah. Whenever three regions of the body have the same spot pattern on a cheetah that appears in two different photographs, then they were identified as being the same individual.

In instances where more than one photograph was obtained per visitation, it was often possible to get photographs of both sides of the same cheetah (Fig. 4 and Fig. 5). This eased the later identification of the cheetah when the cheetah approached from a different angle or direction. It also made sexing easier. Identification can be simplified by placing two linked cameras at the same tree or site in such a way as to obtain photographs of both sides of the cheetah at the same time (Karanth & Nichols 2002).

Of the seven different cheetahs that visited the tree in the present study, only the members of one coalition and Cheetah B visited the tree repeatedly. Cheetah B visited the tree twice in 22 days, with no other cheetah visits in between. The coalition was composed of Cheetahs A and G. Cheetah A visited the tree three times alone before being photographed with cheetah G. The next photograph of either cheetah showed them in a coalition. Two days later, Cheetah G was photographed alone, and three days later, Cheetah A was photographed alone. This is unusual because male collations are normally stable and the members were normally found within close proximity of one another (Caro 1994). Four photographs were obtained of the coalition, two at each visitation. In these four photographs, both members were always close to each other and both appeared together in the same photograph three times. In one of the photographs, they were standing shoulder to shoulder (Fig. 7). For these reasons it is unlikely that one of the members was not included in a photograph at a visitation. In the Serengeti ecosystem, male cheetah coalitions seldom split up and only do so when searching for females in oestrus (Caro 1994). It was not possible to determine the presence or not of an oestrus female in the present study. However, if no such female was involved, then the male coalitions in the study area may not be as stable as in totally natural systems such as the Serengeti.

Apart from the two-male coalition and Cheetah B, no other cheetahs were recorded to re-visit the tree. Cheetahs C, D, E and F all visited the tree only once during the study period. This means that the re-capture rate could be too low to allow the reliable use of the capture-recapture technique for population estimation. The low recapture rate can also perhaps be an indication that only the males from the coalition, and perhaps Cheetah B, are resident territorial males. All the other cheetahs visiting the tree could have been nomadic. Two male cheetahs were seen in the study area where they were hunting several kilometers from the tree during the time that the camera was operational. It was impossible to determine if they were the same males as in the photographs, but it does seem likely. Consequently, it may indicate that they were resident in the area. The low recapture rate could perhaps be solved by using a higher camera density and longer sampling periods (Jacobson *et al.* 1997).

All the cheetahs that were photographed at the tree were males. This is probably related to the territorial behaviour of the males. The absence of such territorial behaviour in the females places some limitations on using camera-trapping at scent posts for obtaining population estimates of cheetahs. Territorial males who will return to the tree repeatedly can be surveyed, but the females, cubs and immature males will be omitted from the survey. This problem can be overcome if the male to female ratio in a given area were known. The density of the males can then be determined with the cameras, and the sex ratio data can be used to extrapolate a population estimate for the females. Consequently, an overall population estimate and density can be obtained.

The possibility of using several camera traps over a large study area and placed in areas where cheetah presence has been confirmed should also be tested to attempt to include the females in such surveys (Karanth & Nichols 2002). Such areas would include roads where spoor are frequently observed as well as marking posts. This would allow for the inclusion of females in the population estimate.

Surveying carnivores is essential for obtaining base-line data for management plans. Camera-trapping is a relatively cheap method of collecting such data. Once the equipment is purchased, the running cost per trap was approximately R100.00 per month for batteries and film. If enough scent-marking trees can be identified and fitted with cameras over a large area, then it would be possible to obtain an indication of the movement patterns of individual animals too.

MANAGEMENT IMPLICATIONS

Many ranchers consider cheetahs to be problem animals on wildlife ranches. Consequently, they trap the cheetahs at scent-marking trees (McVittie 1979; Marker 2002; Cilliers, *pers com*.[3]). In South Africa, ranch owners can be compensated for these cheetahs, which are then relocated to areas where they will not be persecuted. Trapping cheetahs at such trees is relatively easy and successful, but will result in only mature males being caught. This could create a skewed sex ratio in the remaining population, with a heavy bias towards females and immature males. The true effect of this skewness is unknown, but it is quite possible that it may decrease productivity and the survival rate of cheetahs on privately owned land.

CONCLUSIONS

One of the major hurdles in developing a management plan for large wild cats is obtaining reliable population estimates. This is difficult and nearly impossible to do in some areas. Camera-trapping is a feasible method for doing this with cheetahs. However, a technique has to be developed that will overcome the strong current bias towards recording only males by trapping at scent posts. It is also necessary to understand and be fully familiar with the functioning of the camera before trying to use it in the field. This will prevent malfunctions and the loss of valuable data. The trapping and the removal of problem cheetahs at scent posts should be done with care until its effects on cheetah populations are better understood.

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CHAPTER 6

SCAT ANALYSES TO DETERMINE PREY USE OF CHEETAHS IN THE THABAZIMBI DISTRICT

To be submitted to: South African Journal of Wildlife Research

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ABSTRACT

A sample of 38 scats of the cheetah *Acinonyx jubatus* was collected on wildlife ranches in the Thabazimbi district of the Limpopo province to determine prey use. Transverse sections and cuticular imprints of prey hairs that were found in the scats were analysed microscopically, and were compared with specially prepared reference samples and published hair keys. Six different prey species were identified, with only one prey species present in each scat. The most common prey was the grey duiker *Sylvicapra grimmia*, which occurred in 50.0% of the scats, followed by the impala *Aepyceros melampus* in 23.7% of the scats. The least frequent prey found was the kudu *Tragelaphus strepsiceros* and the roan antelope *Hippotragus equinus* each present in one (2.6%) scat only. No remains of domestic livestock were found in any of the scats.

Key words: *Acinonyx jubatus*, cheetah, scat analysis, prey, hair keys

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INTRODUCTION

Over the past 20 years, there has been a shift from cattle to wildlife ranching in the Limpopo province of South Africa. These wildlife ranches are maintained for the main purpose of hunting, and this means that even the loss of one antelope can represent an economic loss to a rancher. Much confusion exists among the ranchers as to which types of prey are being utilised by cheetahs *Acinonyx jubatus* that occur naturally on these ranches. Consequently cheetahs are routinely blamed for massive losses to antelope populations. This conflict is further exacerbated by the perceived losses to cheetah predation in intensive free-range breeding systems of rare, valuable wildlife such as the roan antelope *Hippotragus equinus* and sable antelope *Hippotragus niger*. In order to investigate these claims, a study of the diet of this cheetah population was undertaken.

The elusive nature of the cheetahs because of persecution by humans, combined with the dense bush in the study area made direct observations of cheetah behaviour impossible. It was therefore decided to use scat analyses to investigate the prey-use of the cheetahs. When a predator ingests a prey animal, a certain quantity of hair is ingested too, passing through the digestive system undamaged (Keogh 1979). All hairs have cuticular patterns on the surface. These patterns are species-specific and can be examined microscopically to determine their origin. Hairs can therefore be extracted from scats and be identified to determine what prey was eaten by a particular cheetah.

METHODS

Scats were collected on seven wildlife ranches in the study area. The landowners were first asked where cheetahs had been sighted most recently, or are seen frequently on their properties. Wildlife trails in these areas were then walked on foot to search for and collect scats. A scent-marking tree was identified and scats were collected on and around them. The date and the latitude and longitude co-ordinates, obtained by using a global positioning system (GPS), of each scat were noted. The scat was then placed in a brown paper bag marked with a unique number for identification and stored in a cool, dry place.

In the laboratory, the hair was first separated from the rest of the scat material by washing the scat in water. This was done by sewing the scat into a numbered cotton envelope, which was then washed individually by hand in a bath of warm water before being rinsed under the tap until the water ran clear. The envelope was then hung to dry overnight in a drying oven at 70°C.

The hairs were then removed from each of the envelopes, washed in absolute alcohol, rinsed in distilled water and were allowed to dry on a paper towel in an adapted method of Keogh (1979). Clean, distilled water, alcohol and petri-dishes were used for each scat to avoid cross-contamination of scat contents.

The hair cuticular patterns were examined by using hair imprints made in gelatine as described by Keogh (1979). Granular gelatine was dissolved in cold, distilled water until saturated. The solution was then heated on a hot plate and 10% by volume of eosin blue was added. A thin layer of the gelatine solution was spread onto a glass slide by using a glass rod. A selection of the washed hairs from the scats was placed on the slide individually. Each hair was placed on the slide in such a way that it did not overlap with other hairs, and care was taken to ensure that the hairs were flat on the slide. Care was also taken to ensure that both the root and the tip of the hair were placed in the gelatine layer. The slides were left to air-dry overnight. The hairs were then removed carefully from the slide by using a dissection needle and tweezers.

Transverse sections of the hairs were also required for identification and were made by adapting the plastic tubing method of Douglas (1989). Drinking straws were cut in half transversely, and one end was sealed by folding it over and wrapping adhesive tape around the folded end. Paraffin wax was melted in a beaker on a hot plate until the wax was liquid and clear. A bundle of the prey hair from the scat was wet in water to improve handling. The bundle was removed from the water, all excess water was squeezed off, and the bundle was folded over longitudinally as many times as possible. Care was taken to try to keep the hairs lined up with each other. A prepared straw was then filled to approximately a third with hot wax. The hair bundle was then pushed into the straw with a dissection needle until the bundle was totally immersed in the wax. The straw was then filled to about three-quarters with more liquid wax. The hair bundle inside the straw was then squeezed with the fingers to remove any air bubbles that were trapped between the hairs. The straw was then placed in a glass bottle to keep it upright. The bottle with the straw was put in a drying oven at 75°C for approximately three hours to allow complete infiltration of the wax around the hair bundle. The straws were checked regularly, and were squeezed when necessary to remove any further air bubbles. After removing the straws from the drying oven, the wax was allowed to cool and set either at room temperature or in a refrigerator.

The wax containing the hair bundle was next removed from the inside of the straw by cutting the straw open longitudinally with a sharp razor blade. Transverse sections of the hairs were then made by cutting thin sections of the waxed hair bundle with the razor blade. No sectioning stand was found to be necessary. The cut sections were then fixed with a mounting medium onto the slides. Transverse sections and cuticular patterns were made with hair samples from all possible cheetah prey that occurred in the study area in advance to serve as a reference collection.

The transverse sections and the hair scale pattern imprints from each scat were examined under a light microscope. These were then compared with the reference samples and published hair keys (Dreyer 1966; Keogh 1979; Perrin & Campbell 1980; Keogh 1983; Buys & Keogh 1984) to identify the type of prey involved. For scats for which the identity of the predator was uncertain, the hair from the scat was searched thoroughly for the presence of cheetah hair from grooming to confirm that the scat did belong to a cheetah. If no cheetah hairs could be found in the scat, the sample was discarded.

The frequency of occurrence of prey in the scats was recorded (Stuart & Hickman 1991). Cheetahs do not normally scavenge food (Kingdon 1977; Bertram 1979; Caro 1994). Therefore it was assumed that the cheetahs killed all the prey items that were found in their scats.

RESULTS

In all, 62 scats were collected, of which 38 were identified as cheetah scats, representing six different prey species. The most frequently occurring prey was the grey duiker *Silvicapra grimmia*, which was present in 50.0% (n=19) of the scats, followed by the impala *Aepyceros melampus*, (23.7% n=9) of the scats. Springbok *Antidorcas marsupialis* occurred in 15.8% (n=6) of the scats and warthog *Phacochoerus africanus* in 5.3% (n=2) of the scats. The least abundant prey were the roan antelope *Hippotragus equinus* and the kudu *Tragelaphus strepsiceros* which each occurred in 2.6% (n=1) of the scats.

Only one prey species was found per scat. With the exception of a small piece of bone that was found in two of the scats, the only prey remains present in the scats were hairs. No small mammal remains, insects or vegetation were found in any of the scats.

DISCUSSION

Collecting cheetah scats on wildlife ranches by walking wildlife trails was time-consuming and did not result in the discovery of many scats. It took approximately nine hours to find a single scat. It was also impossible to determine without doubt in the field that the scats that were collected were cheetah scats. This had to be confirmed in the laboratory. Due to the nature of the study area, it was impossible to track cheetahs to collect scats. Collecting scats on and around scent-marking trees was quick and easy, once such a tree had been identified. This method, however, does bias the sample in favour of male cheetahs because only males visited these scent-marking posts in the study area (Wilson, Bothma & Verdoorn *in press*.).

Finding cheetah scats in the large study area was further complicated by the low density of 0.6 to 0.9 cheetahs per 100 km² (Wilson *et al. in press*.), resulting in a low density of scats. For these reasons, it was not possible to collect a large sample of scats. In future studies, the use of scat sniffing dogs will be investigated.

Identification of the prey based on the hair cuticular imprints alone was impossible; but the use of transverse sections of the hair simplified the process. It was not viable to identify hairs by only using hair keys and published material. Making a reference collection of all the possible prey items for comparative purposes was essential. The straw method for making transverse sections proved to be quick and easy. Sectioning hair bundles in wax with a razor blade was easier and less time-consuming than using a microtome.

Because the aim of the study was to investigate prey-use by the cheetahs in the Thabazimbi district, no attempt was made to quantify the proportional representation of prey in the scats as Stuart & Hickman (1991) did. Prey presence in the scat was merely recorded as a frequency of occurrence in all the samples.

Predators ingest their own hairs during grooming. If predator hairs can be found in a scat, then the identity of the predator can be determined. This was, however, not always possible. The micro-structure of cheetah hair is similar to that of the leopard *Panthera pardus*, which could lead to confusion. In addition, no predator hair could be found in some of the scats. The scats of leopards and cheetahs are also similar in appearance, which further complicated their positive identification. This meant that 24 scats had to be excluded from the study because of an unconfirmed identity.

Cheetahs are able to use a wide variety of prey, but they most commonly prey on the most abundant medium-sized antelope that are present in an area (Mills 1998) weighing around 30 kg (Bothma & Walker 1999). From this sample of scats, it appears that the cheetahs in the study area appeared to select for the grey duiker, which is also an important secondary prey for cheetahs in the Kruger National Park (Mills 1998). The largest prey in the present study were the roan antelope and kudu. It is likely that these larger prey found were young animals that were killed by coalitions of males as found in the Kruger National Park (Mills 1998). Roan antelope have also been recorded as prey that are utilised in low frequencies by cheetahs in East Africa (Graham 1966) and the Kruger National Park (Pienaar 1969). One reliable sighting confirmed a coalition of three males killing a mature female kudu in the Thabazimbi district. Kudu remains occurred in only one (2.6%) of the cheetah scats examined in the present study. This was comparable to what was found in the Marula-knobthorn habitat of the Kruger National Park where kudus comprised 4.9% of the cheetah kills (Mills 1998). The 5.3% frequency of occurrence of warthogs as prey in the Thabazimbi study is also similar to results from the Kruger National Park where warthogs were consumed in 3.3% of all the recorded hunts (Mills 1998). During the Thabazimbi study, one warthog kill was found. This warthog was an immature animal, and a female cheetah with three young cubs had made the kill. The Thabazimbi district is not a natural distribution area for springbok or roan antelope (Skinner & Smithers 1990), but these antelope are stocked on wildlife ranches for the purpose of hunting and live sales. Nevertheless, they still form part of the diet of the cheetah.

No small rodent remains were found in the scats that were available in the present study. In the Matusadona National Park in Zimbabwe, cheetahs also did not prey on rodents (Purchase & Du Toit 2000). In East Africa, rodents formed a mere 0.6% of the prey in the diet of the cheetahs (Graham 1966) and in the Serengeti, rodents comprised 0.2% of the prey in the diet (Frame 1986; Caro 1994). During feeding trials of captive cheetahs, it was discovered that cheetahs refused to feed on the laboratory rat *Rattus norvegicus* and the multimammate mouse *Mastomys natalensis* (Hiscocks & Bowland 1989). Clearly, cheetahs do not prefer rodents as prey.

In the study area, many ranches stock blesbok *Damaliscus pygargus phillipsi*, which are exotic to the area, for the purpose of hunting. The ranchers report that blesbok are heavily preyed upon by cheetahs. This is not supported by the analysis of the cheetah scats. The preferred prey of the cheetahs in the Thabazimbi district appears to be the grey duiker, which is not commonly sought by hunters. This means that losses of duikers to cheetah predation do not have the same economic impact on the rancher, as would an impala or blesbok. All the prey recorded in this study have been found in other cheetah studies, confirming their general occurrence as cheetah prey.

CONCLUSIONS

The preferred prey of cheetahs in the study area is the grey duiker, which is a smaller primary prey than what is found for cheetahs in other study areas. Cheetahs do not seem to prey heavily on blesbok and other antelope as believed by the ranchers. Further investigations have to be done to clarify the real reasons for the perceived decline in impala and blesbok numbers on wildlife ranches, that do not seem to be attributable to cheetahs as has been generally supposed. Nevertheless, cheetah predation on wildlife ranches is a cause of heavy conflict with the ranchers, whether justified or not. The present study could be a first step in developing a better understanding of and managing this conflict. The long-term survival of cheetahs outside formal conservation areas is almost solely dependent on the attitudes of the landowners. Until a scientifically sound management strategy is implemented that benefits both the rancher and the cheetah, and until misconceptions about cheetahs and their prey can be cleared up by unambiguous facts, the persecution of the cheetahs by ranchers will continue.

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CHAPTER 7

USING VORTEX MODELLING TO INVESTIGATE THE VIABILITY AND HARVESTING VIABILITY OF THE SOUTH AFRICAN FREE-ROAMING CHEETAH POPULATION

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ABSTRACT

The viability of the population of cheetahs *Acinonyx jubatus* (Schreber, 1775) in the Thabazimbi district, and that of the free-roaming cheetah population outside formal conservation areas in South Africa, are modelled by using the VORTEX Version 9 software program for Windows. The effect of the reported persecution by landowners is modelled, as is the viability of an ongoing relocation programme. The sustainability of long-term harvesting of cheetahs in the form of sport hunting is also investigated. Input data for the model were obtained from the literature and field studies. The current Thabazimbi population is not viable over a period of 200 years

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(r=0.03; PE=0.05; H=49) without immigration. Harvesting of this population is not sustainable over 50 years unless the harvesting is staggered over time. The current South African population is viable over 100 years (r=0.077; PE=0; H=97) without any harvesting. The current reported rate of persecution of problem cheetahs is not sustainable over 50 years (r=-0.047; PE=1; H=0). The relocation programme appears to be sustainable at the current rate over 50 years (r=0.062; PE=0; H=99). Harvesting of the cheetah population must be handled with care until more reliable data are available on the range size and immigration rates of cheetahs outside formal conservation areas.

Key words: *Acinonyx jubatus*, cheetah, Vortex, modelling, population viability, sustainable utilisation.

INTRODUCTION

Most of the wild cheetahs *Acinonyx jubatus* in South Africa occur outside formal conservation areas on privately owned land. Such land is usually used for commercial wildlife or cattle production. The wildlife ranches have been fenced with game fencing and stocked with various types of wildlife, for the main purpose of sport hunting. This may appear to be the ideal habitat for cheetah survival because cheetahs are believed to fare better outside formal conservation areas, away from the pressures of other large carnivores (Kelly & Durant, 2000). However, where people and predators co-exist and both utilise the same prey resource, conflict is nearly always inevitable.

In South Africa there is a strong tradition of wildlife utilisation based on the commercial value of wildlife. The sole purpose of wildlife ranches is therefore economic gain and not conservation. Consequently, the loss of antelope to predators is mostly unacceptable to the landowner. The cheetah is protected by legislation in South Africa, and although some provinces are able to issue permits for the hunting of free-roaming cheetahs, this is at present not being done. No CITES quota for the export of cheetah products has been granted to South Africa. Due to this hands-off approach to aid the conservation of the cheetah, many of the ranchers have a negative attitude towards the occurrence of cheetahs on their properties. One of the main reasons is that the ranchers feel that the cheetahs are costing them money and that they do not get any financial gain from the presence of cheetahs. There is currently a strong lobby among landowners and some conservation officials for a quota for the hunting of cheetahs. It is, however, not known what effect such hunting will have on the cheetah population, nor if it can be done sustainably.

As an interim and temporary solution to this conflict, the National Cheetah Conservation Forum[1] was formed. This is a liaison forum consisting of anyone who has a stake in cheetah conservation. It includes ranchers, conservation officials, ecologists, academics and captive breeders. The main focus of this forum has been the implementation and management of a compensation-relocation programme. A landowner who is experiencing damage from cheetah predation can capture the cheetah and receive a cash compensation for the cheetah. The cheetah is then radio-collared and released into a conservation area with minimum fencing specifications. This scheme has been successful, and 60 cheetahs were relocated between 2000 and 2004. This is, however, not believed to be a long-term solution to the sustainable survival of free-roaming cheetahs on South African ranches. The effects of these relocations on the free-roaming cheetah population in South Africa are also of concern.

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In the present study, the viability of the cheetah population in the Thabazimbi district of the Limpopo province, as well as that of the whole cheetah population outside formal conservation areas in South Africa was modelled by using VORTEX Version 9 for Windows (Miller & Lacy, 1999). The effects of the National Cheetah Conservation Forum's relocation programme were incorporated into the model, as well as the reported rate of killing of cheetahs by landowners. Several scenarios are generated artificially to investigate the possibility of developing a sustainable harvesting programme for free-roaming cheetahs. Population viability analyses have proved to be an accurate, valid tool for the management and categorisation of endangered species (Brook *et al.*, 2000).

METHODS

The computer-aided population extinction simulation model, VORTEX Version 9 for Windows, was used to predict the viability of the Thabazimbi and South African free-roaming cheetah populations. VORTEX is an individual-based modelling system that models the stochastic simulation of the extinction process (Miller & Lacy, 1999). In doing so, it is important to decide which parameters are required for a population to be considered viable before the modelling starts. For the purpose of this study, it was considered that a population with an extinction probability of 5% or less would be viable (Schaffer, 1981), and that its genetic diversity should be greater than 95%, with a population growth rate of 10% (Lacy, 2002). As also recommended by Lacy (2002), the number of lethal alleles with equivalent cumulative effects was set at two as for cats generally, while the age distribution was considered to be stable, while the standard deviation in ecological capacity due to environmental variance was zero because no data are available on this.

It is also important to measure survival over a specific period (Schaffer, 1981). When modelling the Thabazimbi and South African population without harvesting, the model was set to run 1000 iterations that were projected 100 years into the future. When modelling of the harvesting rates, the model was set to run 100 iterations over a projected period of 50 years. Extinction was defined as reaching the point where only one sex remains. For the purpose of this study, the Thabazimbi population was considered to be one population because no data were available on the movements and range use of individual cheetahs in the area, nor on the extent of immigration and emigration. The same assumption was made for the South African population, because again no data are available on the movements of cheetahs into and out of Botswana, Namibia and Zimbabwe.

Catastrophes were not considered in any of the simulations. The main catastrophes that could affect cheetahs are drought and disease. In the study area, drought would probably not have had a severe direct effect on the cheetah population because wildlife ranchers provide water for their wildlife at artificial watering points. Wild herbivore populations are also fed supplementary food during the dry season and this will sustain the prey base. Disease was not considered to be a substantial threat.

The demographic variables that were used for the modelling of the cheetah population appear in Table 1. No data were available on the demographic parameters of the cheetah population outside formal conservation areas in South Africa. Therefore, these population parameters were adopted from habitats that were as similar as possible to that of the study area.

The age of first reproduction for males and females was set at three years (Bothma & Walker, 1999). In the Serengeti, the mean age of first reproduction of females is 2.4 years (Kelly *et al.*, 1998). In the Kruger National Park, the age of first reproduction for females is approximately 2.6 years (Broomhall, 2001) and in Namibia it was

Table 1: Demographic population parameters with the data source that were used for VORTEX modelling of the cheetah population in South Africa

Population parameter	Value assigned	Source
Catastrophes	None	Not applicable
Number of lethal alleles	3.14	Miller & Lacey (1999)
Age at first reproduction	3 years: both sexes	Van Dyk *pers comm*.*
		Berry *et al.* (1997)
Maximum progeny per year	6	Broomhall (2001)
Percentage males	50	Caro (1994)
		Miller & Lacey (1999)
Percentage age specific mortality:		
0-1 year	50	Broomhall (2001)
>1-2 years	15	Broomhall (2001)
>2-3 years	15	Broomhall (2001)
>3 years	20	Not applicable
Percentage males in breeding pool	100	Caro (1994)
Initial population size:		
Thabazimbi district	42 to 63 individuals	Wilson *et al. in prep.*
South Africa	750 individuals	Wilson *et al. in prep.*

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estimated to be about three years (Berry *et al.*, 1997). For the purpose of this study, it was decided to err on the conservative side by using an age at first reproduction of three years. Males are physiologically able to reproduce at a younger age, but social factors probably keep breeding restricted to the older males (Berry *et al.*, 1997). Captive female cheetahs are also more successful breeders when they are older than three years of age and male fertility is only reliable after this age. The maximum age of reproduction was set at 10 years. The maximum breeding age of captive cheetahs is also approximately 10 years (Van Dyk *pers comm*. [2]). Because cheetahs are polygynous, the effect of reproductive age on the demographic outcome of the model used is not considered to be significant, unless the population is small (Berry *et al.*, 1997)

The maximum number of young per year as used in the model was six (Broomhall, 2001). This value was obtained from studies in the woodland savanna of the Kruger National Park. This is a habitat type that is close to that of the Thabazimbi district. The sex ratio of cubs at birth was set at parity, which is standard for most mammals (Lacy, 2002). This ratio was confirmed in a cheetah study in the Serengeti where it was found that the sex ratio of cheetah cubs in the lair was at parity (Caro, 1994). Cheetah breeding was assumed to be density-independent because no evidence exists to show that the percentage of breeding females is a function of population density (Purchase, 1998; Kelly & Durant, 2000).

Age-specific annual mortality rates were derived from data presented for the woodland savanna (Broomhall, 2001), and were: from 0-1 year of age: 50% mortality; from >1-2 years of age: 15% mortality; from >2-3 years of age: 15% mortality and >3 years of age: 20% mortality. These mortality rates were assumed to hold for both

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males and females. All the males were considered to be in the breeding pool, with both the resident and nomadic males breeding naturally, and all the members of coalitions taking part in mating (Caro, 1994)

An initial population size of 42 to 63 individuals was assumed, based on a count that was done in the Thabazimbi district (Wilson *et al. in prep*.). Simulations were therefore run by using the population high of 63 and a low of 42 individuals. These figures did not account for immigration and emigration, and it was assumed that the population was stable both in size and age structure. Sensitivity analyses were run for all the parameters used.

The ecological capacity of the study area for cheetahs was estimated at 70 individuals. Therefore it was assumed that the current population was just below the ecological capacity. This assumption was further substantiated because the current cheetah density for the study area was comparable to that found elsewhere in Africa (Wilson *et al. in prep*.). Simulations were run at a higher ecological capacity, but this strongly influenced the predicted population size. For the harvesting and population viability models for the whole of South Africa, an estimated population size of 750 individuals was used (Wilson *et al. in prep*.). Population estimates for the South African cheetah population are approximately 557 cheetahs and numbers range from a low of 400 cheetahs to a high of 850 cheetahs (Friedmann & Daly, 2004)

The viability of the removal of cheetahs from the Thabazimbi district and national populations was also modelled. Three different types of harvesting of cheetahs were considered:

- Removal and relocation of ‘problem’ cheetahs by the National Cheetah Conservation Forum. These data were obtained from the database of the organisation. These scenarios are referred to as ‘NCCF’ in the models.

- The illegal removal of cheetahs by landowners by shooting, other lethal methods or by live capture and trade on the black market. These data were extrapolated from information received from ranchers, conservation officials and field workers. These scenarios are referred to as 'suspected annual harvest' in the models.

- Sustainable utilisation of cheetahs in the form of hunting. Several scenarios were created to test the viability of such a programme. These scenarios are referred to as 'utilise' in the models.

Simulations were run that included and excluded harvesting of the population. Possible harvesting was an important factor to consider in the study area and for South Africa as a whole because cheetahs were often shot as problem animals or were captured and traded on the black market. Moreover, a strong lobby amongst the landowners is currently pressing for a CITES quota to allow the regulated hunting of cheetahs. Several simulations were run at varying harvesting rates. To test for the viability of sustainable trophy hunting, only male cheetahs should have been considered in the harvesting simulations. However, because of the lack of sexual dimorphism in cheetahs, it is doubtful whether only male animals will be harvested should hunting ever be done. Some persecution of cheetahs by landowners will probably always occur, and therefore females were included in each simulation for harvesting. No cubs or subadults were included in the hunting model. No supplementation of the population was considered because this was not an option in view of the conflict that exists between the cheetahs and the landowners in the study area.

RESULTS

The simulation results for the Thabazimbi district cheetah population in the absence of harvesting pressure appear in Table 2. The high probability of extinction and expected low mean heterozygosity after 200 years showed that the population was not viable over this time span (Fig. 1). However, the viability of the population improved when it was projected over a 100-year time span (Fig. 2). When harvesting was incorporated into the model (Table 3), it appeared that the population was not able to sustain continual long-term harvesting. The few animals that were removed by the National Cheetah Conservation Forum did not seem to have a significant effect on the long-term viability of the population. It appeared that a long-term utilisation programme that is done over a period of 50 years with a five-year interval between the harvests is sustainable, with an acceptable probability of extinction and loss of genetic diversity (Fig. 3).

The national free-roaming population of cheetahs was viable over 100 years when modelled without harvesting (Table 4), even when the National Cheetah Conservation Forum take-off was included (Fig. 4). The only modelled utilisation scenario that produced an acceptable probability of extinction was one that allowed for the utilisation of 10 females and 50 males per year (Fig. 5). The only other utilisation scenario that would be sustainable is one that staggered the harvests with an interval of several years between harvests. The current suspected annual harvest from removal of problem animals was not sustainable over a 50-year period.

DISCUSSION

It is important to remember that because of the assumptions that have had to be made, and the random nature of natural events, VORTEX analyses cannot provide exact answers, and any results obtained must be interpreted conservatively (Novellie, Millar & Lloyd, 1996), and must be updated as new baseline data emerge.

Table 2: VORTEX analyses projections for periods of 100 and 200 years ahead when using baseline demographic data as listed in Table 1 for the Thabazimbi district cheetah population at an ecological capacity of 70 cheetahs for the district. Underlined values fall outside predetermined acceptable limits.

Initial size	Estimate level	Period	Iterations	r	SD(r)	PE	N	H
42	Low	100	1000	0.046	0.108	0.01	57	71
42	Low	200	1000	0.029	0.115	<u>0.17</u>	42	<u>48</u>
63	High	100	1000	0.048	0.107	0.01	57	71
63	High	200	1000	0.03	0.115	<u>0.15</u>	43	<u>49</u>

r = mean stochastic growth rate

PE = probability of extinction

SD(r) = standard deviation of r

H = mean heterozygosity of the population

N = mean number of cheetahs in extant population

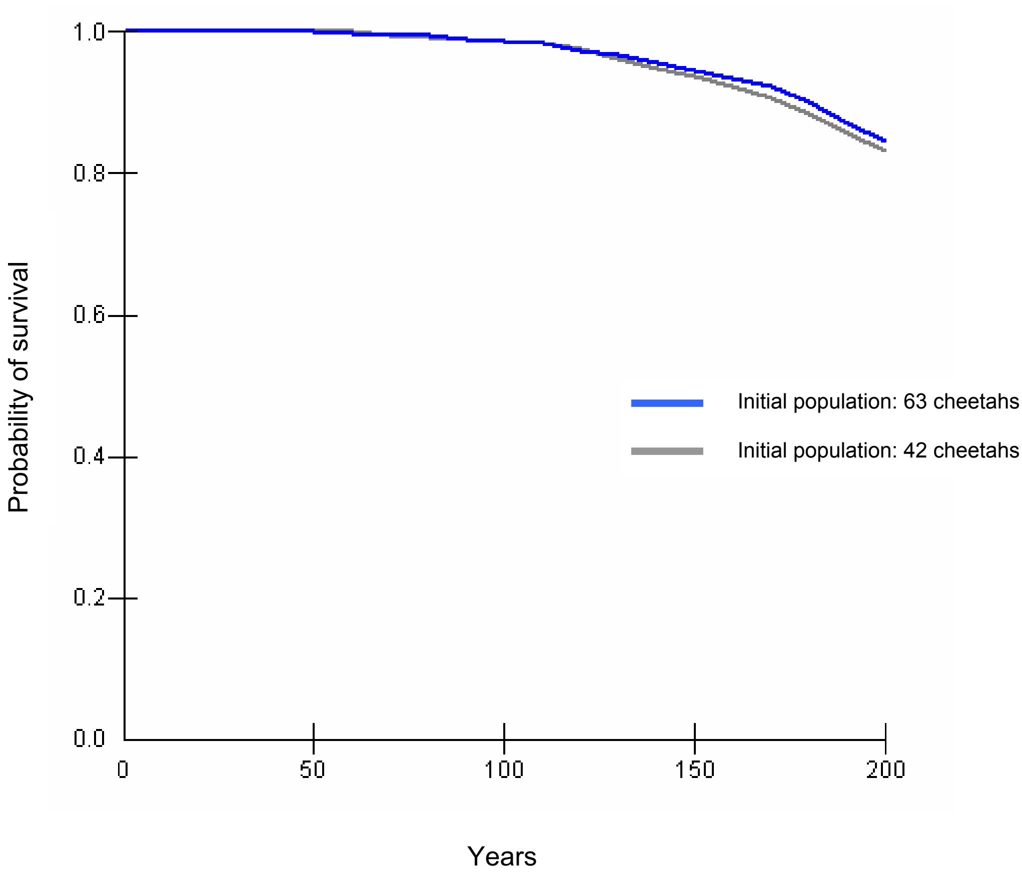

Figure 1: Probability of survival of the Thabazimbi cheetah population over a period of 200 years when no harvesting is done and an ecological capacity of 70 cheetahs is modelled for initial population sizes of 42 and 63 cheetahs. A probability of survival of 0.0 implies that there is no statistical chance of the modelled cheetah population surviving, while a probability of survival on 1.0 implies that there is no statistical chance of the modelled cheetah population becoming extinct.

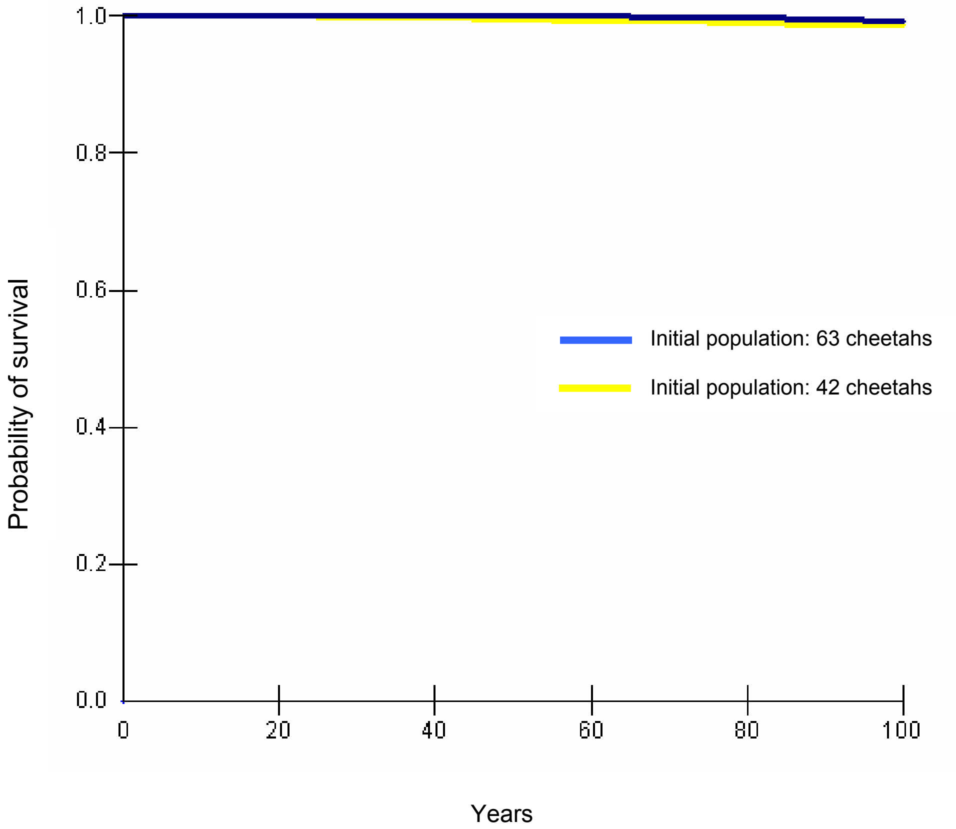

Figure 2: Probability of survival of the Thabazimbi cheetah population over a period of 100 years when no harvesting is done and an ecological capacity of 70 cheetahs is modelled for initial population sizes of 42 and 63 cheetahs. A probability of survival of 0.0 implies that there is no statistical chance of the modelled cheetah population surviving, while a probability of survival on 1.0 implies that there is no statistical chance of the modelled cheetah population becoming extinct.

Table 3: The impact of various population harvesting scenarios of cheetahs as based on VORTEX analyses when using baseline demographic data as displayed in Table 1 for the Thabazimbi district cheetah population, using a population high of 63 cheetahs, an ecological capacity of 70 cheetahs with harvesting being done every year for 50 years. Underlined values fall outside predetermined acceptable limits.

Harvesting details	Years	Iterations	r	SD(r)	PE	N	H
NCCF:							
1♂ and 1 sub ♂ per year	50	1000	0.054	0.114	0.03	61	83
Suspected annual harvest:							
2♀♀ and 5 ♂♂ per year	50	1000	<u>-0.069</u>	0.21	<u>0.99</u>	33	<u>76</u>
NCCF and suspected annual							
harvest combined	50	1000	<u>-0.11</u>	0.234	<u>1</u>	<u>0</u>	<u>0</u>
Utilisation:							
2♀♀ and 5♂♂ every 5 years	50	1000	0.044	0.123	0.02	59	83

r = mean stochastic growth rate

PE = probability of extinction

SD(r) = standard deviation of r

H = mean heterozygosity of the population

N = mean number of cheetahs in extant population

NCCF = annual live removal of problem cheetahs by the National Cheetah Conservation Forum

Suspected annual harvest = illegal removal of cheetahs by landowners either by shooting, other lethal methods or live capture and trade on the black market

Utilisation = sustainable utilisation of cheetahs in the form of hunting

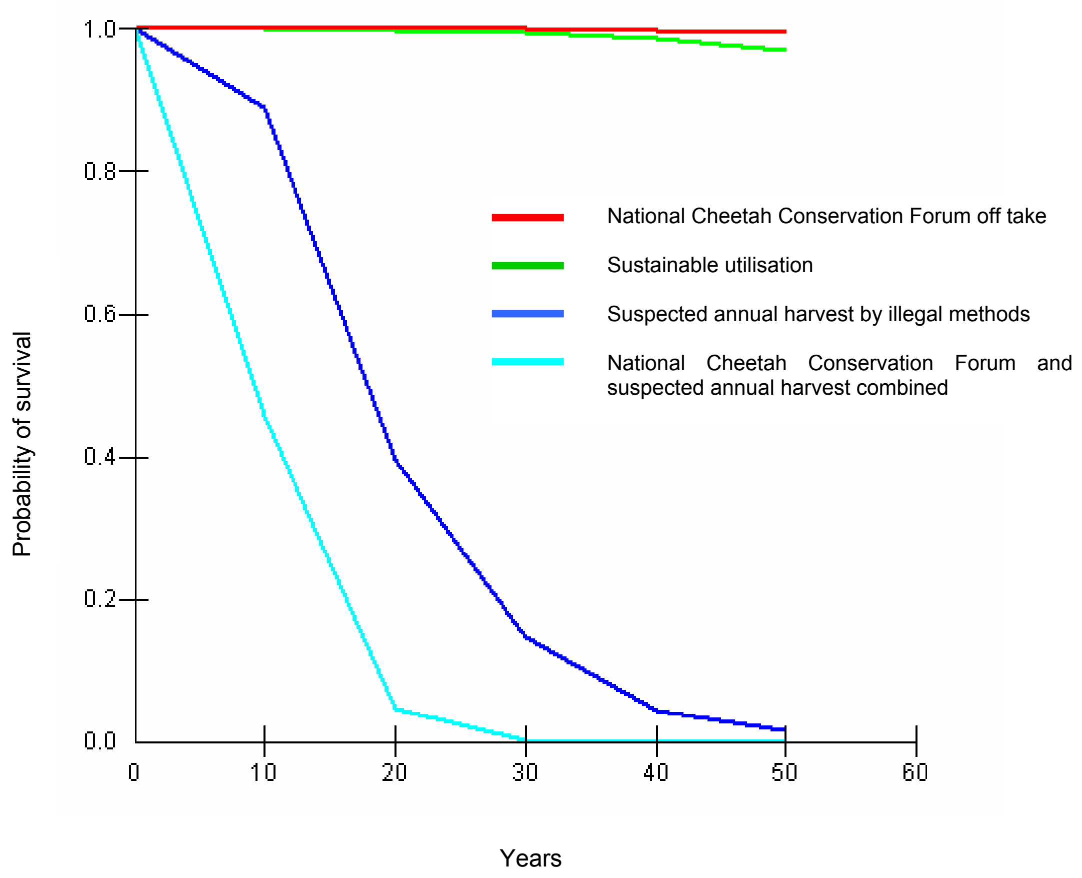

Figure 3: The probability of survival of the Thabazimbi cheetah population over a period of 50 years when no harvesting is done and an ecological capacity of 70 cheetahs is modelled for initial population size of 63 cheetahs. The National Cheetah Conservation Forum off take of problem cheetahs was set at one adult and one subadult male per year. The suspected annual harvest was the estimated number of cheetahs that were estimated to be removed annually by landowners by shooting or other illegal methods. This was set at two females and five males. The combined off take models the cumulative effect of both types of removal. A sustainable utilisation model of two females and 5 males was modelled. A probability of survival of 0.0 implies that there is no statistical chance of the modelled cheetah population surviving, while a probability of survival on 1.0 implies that there is no statistical chance of the modelled cheetah population becoming extinct.

Table 4: The impact of various population harvesting scenarios of cheetahs as based on VORTEX analyses by using baseline demographic data as listed in Table 1 for the South African free-roaming cheetah population, based on a population of 750 cheetahs with an ecological capacity of 800 cheetahs. Underlined values fall outside predetermined acceptable limits.

Harvesting details	Years	Iterations	r	SD(r)	PE	N	H
Baseline data (no harvest)	100	100	0.077	0.057	0	776	97
NCCF:							
1♀cub; 2sub♀♀; 3♀♀; 4sub♂♂; 6♂♂	50	100	0.062	0.059	0	762	99
Suspected annual harvest:							
12♀♀ and 88♂♂	50	100	-0.047	0.252	1	0	0
NCCF and suspected annual harvest	50	100	-0.098	0.24	1	0	0
Utilise: 10♀♀ and 50♂♂	50	100	0.045	0.064	0	722	98
Utilise: 10♀♀ and 55♂♂	50	100	0.042	0.077	0.08	730	98
Utilise: 10♀♀ and 60♂♂	50	100	0.042	0.083	0.08	709	98

r = mean stochastic growth rate

PE = probability of extinction

SD(r) = standard deviation of r

H = mean heterozygosity of the population

N = mean number of cheetahs in extant populations

NCCF = annual live take off of problem cheetahs by the National Cheetah Conservation Forum

Suspected annual harvest = illegal removal of cheetahs by landowners either by shooting, other lethal methods or live capture and trade on the black market

Utilisation = Sustainable utilisation of cheetahs in the form of hunting

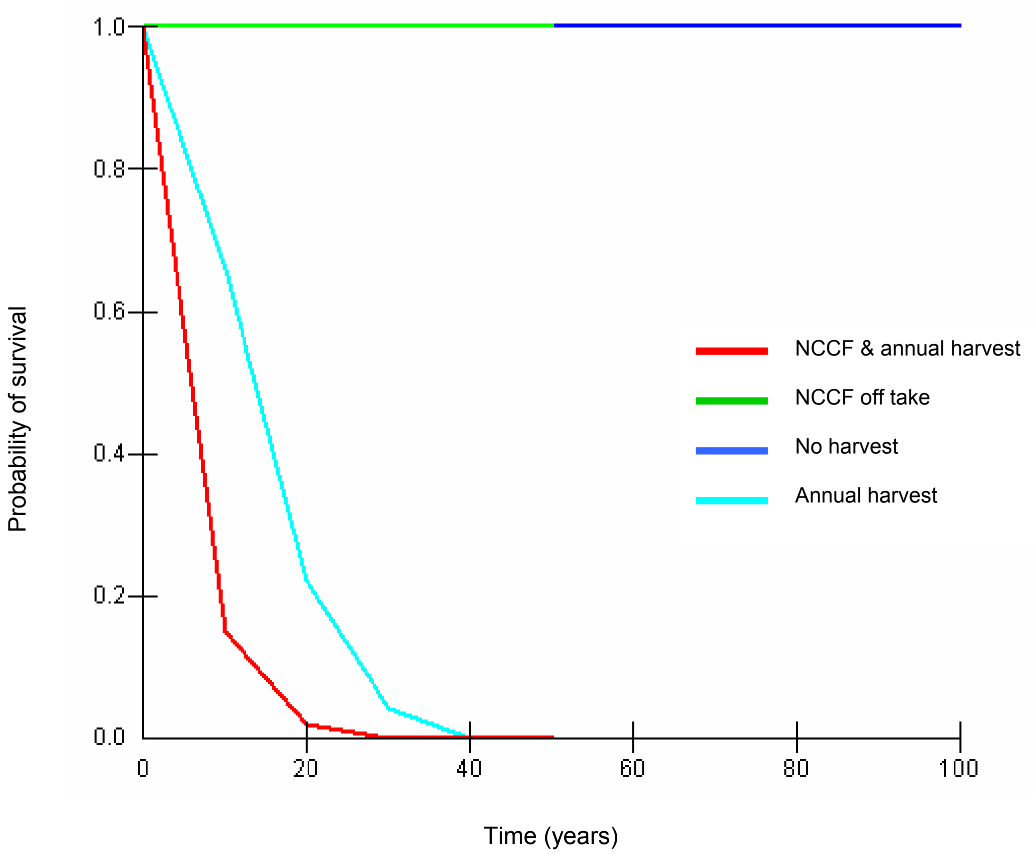

Figure 4: Probability of survival of the South African free roaming cheetah population over a period of 100 years under various annual harvesting scenarios, as well as without harvesting, with an initial population size of 750 cheetahs and an ecological capacity of 800 cheetahs. The NCCF off take of problem cheetahs is set at one female cub, two sub adult females, three adult females, four sub adult males and six adult males per year. The suspected annual harvest is the estimated number of cheetahs removed annually by landowners which set at 12 females and 88 males and the combined off take models the cumulative effect of both types of removal.

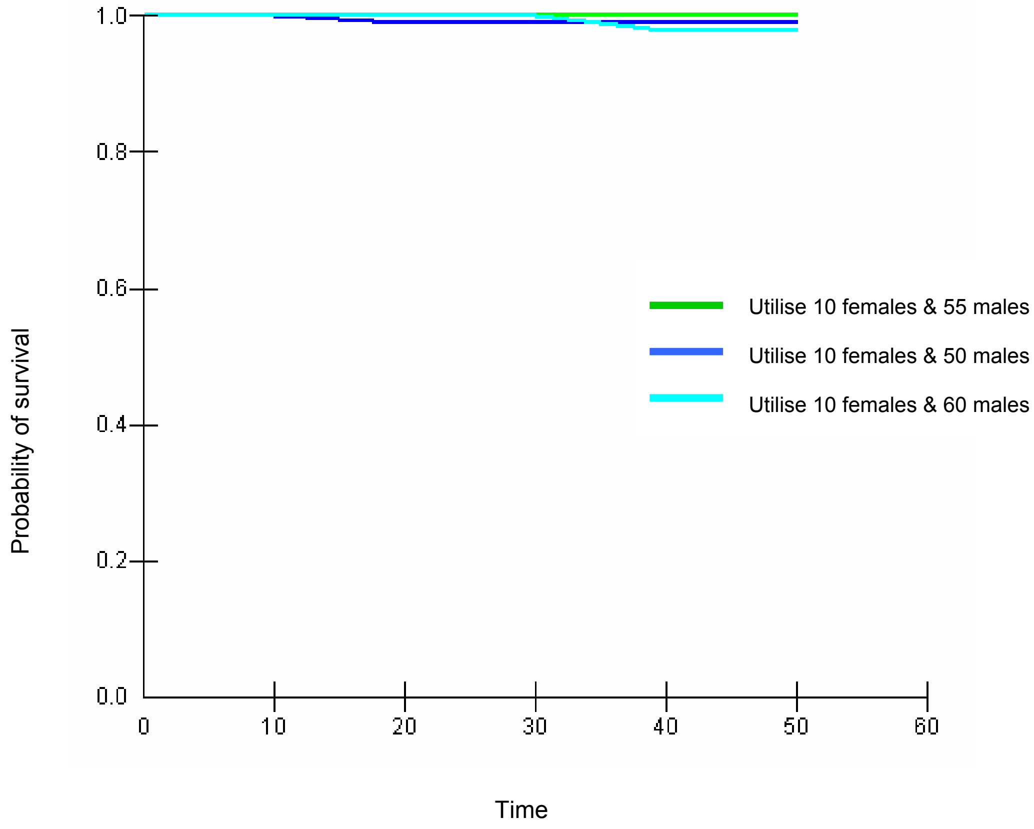

Figure 5: Probability of survival of the South African free roaming cheetah population over a period of 100 years under various annual harvesting scenarios, as well as without harvesting, with an initial population size of 750 cheetahs and an ecological capacity of 800 cheetahs.

When modelling by using the baseline demographic data of the Thabazimbi district cheetah population with an estimated population low of 42 and a high of 63 cheetahs, it appeared that the population would persist over a period of 100 years. This scenario changed, however, when the model was projected over 200 years. Over such a long period, the probability of extinction became unacceptably high, and the mean heterozygosity too low for both a high and low population scenario. This suggested that the current cheetah population would not be sustainable over 200 years. When utilisation was incorporated into the model, it became clear that the population would not be able to sustain any long-term harvesting at all unless the interval between the harvests was at least five years as it was done in the current model. The few cheetahs that were being removed by the National Cheetah Conservation Forum as problem animals during the study did not seem to be excessive, and did not have any long-term effect on the viability of the population in such a model.

The results of the harvesting models that were developed here must be treated and interpreted with care, even though the data for the numbers of cheetahs that are killed or removed by the ranchers as problem animals were obtained from reliable sources during field studies in the district. These reports claimed that 19 males and seven females were killed over a period of three years from 1999 to 2001. This level of persecution is not sustainable according to the model that was used here. However, it is possible that the number of persecuted animals had been inflated. It was also assumed that the Thabazimbi district population is a closed population with no immigration or emigration. This is most likely not the case because there is nothing preventing cheetahs from moving to and from the neighbouring Lephalale (formerly Ellisras) district and Botswana. It is also possible that the Thabazimbi district population could be a population sink that is being fed by immigration from neighbouring cheetah populations. Sink populations may be quite large, but will eventually disappear without a regular source of immigration (Pulliam, 1988).

The results of the harvesting models that were developed for the South African population must also be interpreted cautiously. The current suspected rate of harvesting seems to be devastating the cheetah population. This may be the case, but the probability of immigration of cheetahs from neighbouring countries must not be ignored as this may increase the rate of survival. Moreover, there is also the possibility of inflated harvesting rates being reported by the landowners. Harvesting of the cheetah population must be approached with care because survival of adult cheetahs is the factor that most strongly influences cheetah population survival (Crookes, Sanjayan & Doak, 1998; Kelly & Durant, 2000). This implies that management plans and conservation models for the free-roaming cheetah population of South Africa will have to be directed at improving the survival of adult cheetahs (Crookes *et al.*, 1998)

Many of the required demographic factors for modelling the cheetah population outside formal conservation areas in South Africa effectively were still lacking at the time of this study. For this reason, data were obtained from the literature. In doing so, it was attempted to use records from as similar as possible habitat types to that of the study area. Nevertheless, there is considerable variation among the population parameters of cheetahs in different literature sources, even within a given study area. For this reason, all the variables that were used were interpreted in the context of the study area and the relevant field observations. This also means that the necessary caution must be exercised when interpreting the results of any models that are based on these variables.

CONCLUSIONS

VORTEX Version 9 for Windows was a user-friendly tool in this conservation planning study. Modelling generally allows for lateral thinking on management problems (Starfield & Bleloch, 1991) and directs the focus to the dynamics of the population being modelled (Norton, 1994). The free-roaming cheetah population outside formal conservation areas in South Africa was sustainable only if the current conflict between cheetahs and landowners could be resolved and the level of cheetah persecution could be minimised. Sustainable sport hunting of the South African free-roaming cheetah population could be an important management option, but it should not be implemented on a large scale until more reliable data are available on the on dynamics of the cheetah population, and on the persecution rates of cheetahs outside formal conservation areas. It is also necessary to focus any conservation initiatives for the free-roaming cheetah population on improving the survival of adult cheetahs.

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CHAPTER 8

MANAGEMENT RECOMMENDATIONS

INTRODUCTION

The largest part of the South African cheetah *Acinonyx jubatus* population occurs free roaming on livestock and wildlife ranches in the Limpopo, North West and Northern Cape provinces (Friedmann and Daly 2004). Cheetahs have a low competitive ability when compared to lions *Panthera leo* and spotted hyaenas *Crocuta crocuta* (Durant 1998) thus the survival of cheetahs is believed to rely strongly on their conservation on ranch lands where other large predators are absent (Kelly and Durant 2000). This means that the survival of cheetahs outside conservation areas in South Africa is dependent on the attitudes and management practices of the landowners on whose land the cheetahs occur.

CONFLICT BETWEEN RANCHERS AND CHEETAHS

Perceptions of landowners

In the Thabazimbi district, 71% of the respondents in the questionnaire survey considered cheetahs to be a liability to them. Such negative attitudes towards large predators by ranchers are not unique to this study and ranchers have consistently expressed the most negative attitudes towards large predators in several other studies involving various predators (Kellert, Black, Rush and Bath 1996; Ericsson and Heberlein 2003). Unless such attitudes change, the survival of cheetahs on ranch lands cannot be ensured.

Perceptions of the landowner are often stronger than reality and can strongly influence their attitude to predation which can result in severe emotional, financial and political consequences (Mech 1981). During the questionnaire survey, it became apparent that conflict arose as a result of perceptions based on ignorance, incorrect ranch management and lack of information on the behaviour and status of cheetahs on ranch lands. Changing of attitudes is a long-term process and, in the case of the landowners in the Thabazimbi district, will require intensive extension work and education. Additionally, the sociology and socio-economic aspects of the specific conflict need to be addressed (Kranz 2000; Liu 2001). This means that the unique environment of the wildlife ranch needs to be taken into consideration; every antelope represents a financial input or gain to the landowner while the cheetah has no economic value. The negative attitude of wildlife ranchers towards large predators is normally motivated by a fear of economic loss (Kellert 1985; Marker 2002). Additionally, the historical perceptions of predators by the ranching community also need to be taken into consideration.

CONFLICT RESOLUTION

Education of landowners, managers and labourers

The perceptions of the ranchers towards the cheetahs need to be addressed by educational programmes. However, the rancher should ensure that all individuals involved in wildlife ranching are also informed including managers, labourers, hunters, professional hunters and field guides. Ranchers need to understand the biology of the various predators that occur on the ranches: leopards *Panthera pardus*, cheetahs, brown hyaenas *Parahyaena brunnea*, black-backed jackals *Canis mesomelas* and caracals *Caracal caracal*, be able to identify their tracks and killing methods and understand their roles in a healthy ecosystem. Additionally ranchers need to know the legal aspects involved in predator control.

Management practices

Ecologically sound management practices need to be understood and practiced by the landowners. The ecological management of wildlife ranches generally lacks quantitative monitoring and scientific basis (Van der Waal and Dekker 2000). A good example of this as noted in the questionnaire survey is the numbers of wildlife on the ranches. The rancher often blames carnivores for the loss of wildlife because it is thought that the wildlife numbers have decreased because the rancher sees fewer of a certain animal on the property. Additionally, on small ranches, the genetic diversity of the wildlife is seldom a management goal. In a survey of wildlife ranches in the Limpopo province, it was found that rainfall and wildlife population birth and mortality rates were regularly monitored, while animal and veld condition were rarely scientifically monitored and that genetic diversity was largely ignored (Van der Waal and Dekker 2000). Without correct management practices, wildlife cannot produce at an optimum rate, resulting in frustration of the landowner and possible conflict with carnivores.

Removal of damage causing cheetahs

The only legal method of removing cheetahs is through the compensation-relocation scheme of the National Cheetah Conservation Forum[1]. This scheme compensates the landowner for live-caught cheetahs, which are then relocated to areas where they are desired, monitored, cannot escape and are managed as part of a greater metapopulation. This scheme has made great strides in wining the cooperation of the landowners, but does not present a long-term, sustainable solution to cheetah conservation. The current rate of removal of cheetahs by this scheme is at present sustainable over 50 years ($r = 0.062$; $PE = 0$; $H = 99$) without detriment to the survival

[1] D. Cilliers. Manager: National Cheetah Conservation Forum, P.O. Box 52701, Dorandia 0188, South Africa.

of the free roaming population. However, the number of cheetahs trapped every year is unpredictable and fluctuates greatly making management of removals and understanding the threats to cheetah survival as a result of such removals difficult to quantify (Marker 2002). Additionally, in Namibia it was found that significantly more male cheetahs were captured on wildlife ranches (Marker 2002) a trend that appears to be developing in South Africa too.

Problems may be created rather than prevented by indiscriminate removal of cheetahs; removing part of a social group could result in the rest of the group not hunting efficiently, or by creating a vacuum that could be filled by younger, less experienced cheetahs that are dispersing (Marker 2002). Additionally, adult survival appears to be the main factor influencing cheetah population survival (Crookes, Sanjayan and Doak 1998; Kelly and Durant 2000). It is thus important to remove only the specific individual identified to be truly damage causing and to limit the indiscriminate removal of adult cheetahs.

It is a common practice for ranchers to set cheetah capture cages at marking trees and posts. During the camera trapping study at a marking tree on a wildlife ranch in Thabazimbi, seven different cheetahs visited the tree during 87 camera-days. These cheetahs were all adult males and five of the seven cheetahs photographed did not return to the marking post during the study period. This implies that not all cheetahs using the marking post are resident and may be transient. Thus the removal of these cheetahs can have negative consequences for the survival of the cheetah population and will not effectively solve any problems experienced due to cheetah predation.

Trophy hunting of cheetahs

Trophy hunting of cheetahs is often considered as a conservation tool to ensure cheetah survival on ranch lands by attaching an economic value to the cheetah. However, trophy hunting is not to be seen as the ideal solution to the conflict. Hunting cheetahs ethically and within a quota system is complicated by difficulties in determining age and sex of cheetahs from a distance, not being able to lure cheetahs to bait and their large range use habits. The cheetahs in the study area were very elusive and only two brief sightings were made by the researcher during the study. Cheetahs are effectively hunted using dogs in Namibia (Flack 2004), but this practice raises ethical issues. Trophy hunting of cheetahs as a conservation tool must be considered provided it is possible to regulate the practice sufficiently in order to ensure sustainability and prevent inadvertent promotion of the practice of 'canned shooting'.

RESEARCH REQUIREMENTS

Further research on the habits of cheetahs on ranch lands needs to be done in order to obtain correct information to be fed back to the landowners. Range use studies are vital in order to understand what area cheetahs are using in ranching areas. This will give further clarity on the extent of the impact that cheetahs have on a single wildlife ranch. It is probable that the cheetahs are using large ranges as found in other study areas (Broomhall *et al.* 2003; Purchase and Du Toit 2000; Caro 1994), thus when landowners report sighting cheetahs on ranches distant to each other, it is possible that they are in fact observing the same cheetahs, giving the impression of inflated cheetah numbers.

An attempt needs to be made to obtain accurate numbers of cheetahs. Camera trapping appears to hold a lot of promise for this purpose and a pilot study needs to be conducted to assess the feasibility of using this method for cheetahs. This needs to then be carried out on an ongoing basis in order to monitor trends in the population. Once sufficient data have been collected in this manner, then accurate VORTEX analyses can be done to investigate long term survival of the cheetah population as well as the viability of sustainable utilisation of the cheetah population.

CONCLUSIONS

The survival of cheetahs on ranch lands is important for the conservation of cheetahs as a whole. However, conflict issues need to be resolved to prevent removal of cheetahs and ensure their survival. A multi-faceted approach to conflict needs to be applied involving: education of landowners and their staff; research on cheetah numbers, movement and behaviour on ranch lands; socio-economic studies of the wildlife ranching industry and improved ranch management. More knowledge on cheetahs alone will not be sufficient to overcome perceptions that result from direct negative experiences (Ericsson and Heberlein 2003).

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APPENDIX I. Questionnaire used to survey occurrence of cheetahs on wildlife ranches in the Thabazimbi district of the Limpopo province.

QUESTIONNAIRE ON OCCURRENCE OF CHEETAH

This questionnaire forms part of a preliminary survey to determine the status and distribution of cheetahs outside formal conservation areas in the Northern Province of South Africa. The information obtained from this study will, amongst others, allow for more accurate CITES classification, and hence also allocation of quotas for hunting and trade.

The study is being carried out by Kelly Wilson as an MSc study through the Centre for Wildlife Management at the University of Pretoria under the supervision of Prof. J du P Bothma.

Please fill in the questionnaire as accurately as possible and return it to:
Kelly Wilson
Centre for Wildlife Management
University of Pretoria
Pretoria
0002

Or fax it to (012) 362-2034
An electronic copy of the questionnaire is available, at e-mail: s9931389@lcdv.up.ac.za
If you have any questions please call Kelly Wilson at (012) 420-2338 or 082-477-4470 or e-mail the above address.

A. Respondent number

1. Name of landowner

2. Name and position of person filling in questionnaire

3. Name of contact person

4. Contact numbers

	Code	Number
Work:		
Home:		
Cell:		
Fax		
E-mail		

5. Postal Address

6. Physical address of farm

7. Name of farm

8. Name and number of farm as on map

9. Co-ordinates of farm

Latitude:	
Longitude:	

10. Type of farm (mark **all** that apply)

Beef	**1**
Crops	**2**
Dairy	**3**
Game	**4**
Horticulture	**5**
Poultry	**6**
Sheep	**7**
Other: (please specify)	**?**

11. To what extent is the farm enclosed or surrounded by game fences?

Totally	**1**
Partially	**2**
Not at all	**3**

12. What size is your farm? (Hectares)

13. Are there **cheetahs** on your **neighbours** farms?

Yes	**1**
No	**2**
I do not know	**3**

If yes, supply contact details.

14. Are there **cheetahs** on **your** farm?

Yes	**1**
No	**2**
I do not know	**3**

If you answered no to question **14** above, you need not continue with the rest of the questionnaire. Nevertheless, your response and return of this questionnaire is still important to the overall study. **Thank you for your time and contribution.**

15. How many cheetahs have you seen on your farm?

Sighting details		*Group details*	
Year/Month	*Day (If Applicable)*	*Number of individuals*	*Composition*
Nov-1999	17th	3	3 males
Oct-99	?	5	1 female, 4 cubs

Sighting details		Group details	
Year/Month	Day (If Applicable)	Number of individuals	Composition

16. How often do you see **cheetahs** on your property?

Daily	**1**
Weekly	**2**
Monthly	**3**
Less often	**4**

17. What is your perception of **cheetah** numbers in the area over the past 2 years?

Increasing	**1**
Decreasing	**2**
Remaining constant	**3**
I do not know	**4**

18. Which of the following large carnivores also occur on the farm:

Lion	**1**
Brown hyaena	**2**
Spotted hyaena	**3**
Leopard	**4**

19. Do you have any photographs of cheetahs taken on your farm over the past 15 years?

Yes	**1**
No	**2**

20. Would you be willing to donate or lend the photographs for the purpose of this survey?

Donate	**1**
Lend	**2**

21. Do you regard **cheetahs** on your property as an asset or liability?

Asset	**1**
Liability	**2**

22. Why? (give the **main** reason only)

23. Would you be willing to participate in and have cheetah photographed and studied in more detail on your property as part of this study?

Yes	**1**
No	**2**

24. Does your farm have exemption from the Provincial Nature Conservation Ordinance? If yes, please supply number.

Yes	**1**	Number
No	**2**	

Thank you very much for your contribution.

APPENDIX II: Summary of results from all scenarios modelled during VORTEX analyses using baseline demographic data as listed in Chapter 7 Table 1 for the various South African free-roaming cheetah populations

Population details	Yrs	Iterations	r	SD(r)	PE	N	H
Thabazimbi population: Ecological capacity=70 Population size=42	100	1000	0.047	0.108	0.01	58	71
Thabazimbi population: Ecological capacity=70 Population size=42	200	1000	0.029	0.115	0.17	42	48
Thabazimbi population: Ecological capacity=70 Population size=63	100	1000	0.048	0.106	0.01	57	71
Thabazimbi population: Ecological capacity=70 Population size=63	200	1000	0.030	0.115	0.15	43	49
Thabazimbi population: Ecological capacity=70 Population size=70	100	1000	0.047	0.106	0.01	57	72
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 1♀, 1♂ and 5 subadults	50	100	0.046	0.106	0.01	57	71
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 2♂♂ and 5 subadults	50	100	0.048	0.106	0.01	58	71
Thabazimbi population: Ecological capacity=70 Population size=42 Harvest 2♂♂ and 5 subadults	50	100	0.046	0.107	0.01	57	71
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 2♀♀ and 5 subadults	50	100	0.043	0.107	0.01	57	71
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 10♂♂ and 5 subadults	50	100	0.026	0.138	0.65	56	68
Thabazimbi population: Ecological capacity=70 Population size=42 Harvest 10♂♂ and 5 subadults	50	100	-0.112	0.207	0.99	60	71
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 6♂♂, 2♀♀,5 subadults and 4 cubs	50	100	0.033	0.126	0.09	56	68
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 5♂♂ and 5 subadults	50	100	0.047	0.108	0.01	57	71

Population details	Yrs	Iterations	r	SD(r)	PE	N	H
Thabazimbi population: Ecological capacity=70 Population size=42 Harvest 5♂♂ and 5 subadults	50	100	0.038	0.120	0.14	55	68
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 7♂♂ and 5 subadults	50	100	0.043	0.114	0.05	56	70
Thabazimbi population: Ecological capacity=70 Population size=42 Harvest 7♂♂ and 5 subadults	50	100	0.019	0.146	0.68	55	65
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 6♂♂ and 5 subadults	50	100	0.045	0.110	0.01	56	70
Thabazimbi population: Ecological capacity=70 Population size=42 Harvest 6♂♂ and 5 subadults	50	100	0.032	0.129	0.384	54	68
Thabazimbi population: Ecological capacity=70 Population size=68 Harvest 8♂♂ and 5 subadults	50	100	0.041	0.119	0.14	57	69
Total SA population Baseline data (no harvest) Ecological capacity=800 Population size=75	100	100	0.077	0.057	0	776	97
Total SA population: Ecological capacity=800 Population size=750 NCCF removal: 1♀cub, 2♀♀subadults,3♀♀,♂♂subadults and 6♂♂	50	100	0.062	0.059	0	762	99
Total SA population: Ecological capacity=800 Population size=750 Suspected annual harvest: 12♀♀ and 88♂♂	50	100	-0.047	0.252	1	0	0
Total SA population: Ecological capacity=800 Population size=750 NCCF removal and suspected annual harvest	50	100	-0.098	0.24	1	0	0
Total SA population: Ecological capacity=800 Population size=750 NCCF removal and suspected annual harvest of 10♀♀ and 20♂♂	50	50	0.034	0.063	0	713	98
Total SA population: Ecological capacity=800 Population size=750 NCCF removal and suspected annual harvest of 20♀♀ and 40♂♂	50	50	-0.002	0.092	0.28	572	98

Population details	Yrs	Iterations	r	SD(r)	PE	N	H
Total SA population: Ecological capacity=800 Population size=750 NCCF removal and suspected annual harvest of 15♀♀ and 30♂♂	50	50	0.028	0.064	0	692	98
Total SA population: Ecological capacity=800 Population size=750 NCCF removal and suspected annual harvest of 10♀♀ and 80♂♂	50	50	-0.017	0.223	0.96	390	97
Total SA population: Ecological capacity=800 Population size=750 Utilise: 10♀♀ and 50♂♂	50	100	0.045	0.064	0	722	98
Total SA population: Ecological capacity=800 Population size=750 Utilise: 10♀♀ and 55♂♂	50	100	0.042	0.077	0.08	730	98
Total SA population: Ecological capacity=800 Population size=750 Utilise: 10♀♀ and 60♂♂	50	100	0.042	0.083	0.08	709	98

Yrs = number of years the model was projected over
Iterations = number of times the model was run during a simulation
r = mean stochastic growth rate
PE = probability of extinction
SD(r) = standard deviation of r
H = mean heterozygosity of the population
N = mean number of cheetahs in extant populations
NCCF = annual live take off of problem cheetahs by the National Cheetah Conservation Forum
Suspected annual harvest = illegal removal of cheetahs by landowners either by shooting, other lethal methods or live capture and trade on the black market
Utilisation = Sustainable utilisation of cheetahs in the form of hunting