THE STATUS, DISTRIBUTION AND ECOLOGY OF THE KLIPSPRINGER IN THE KRUGER NATIONAL PARK

by

Marius Kruger

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The chamois can't out-leap me (the blithe klipspringer sang),
For miracles of jumping I put over with a bang,
From height to height I bound, and as the eagles see me land
They marvel at my foothold where not one of them could stand.

❖

If you should fix a penny piece upon a church's spire,
And firmly place another on a steeple somewhat higher,
I'd spring from one to tother, bridging twenty feet or more,
And balance where I landed, and respond to your encore.

❖

When you talk of mountaineering, you really make me smile,
But if you are ambitious, come and watch me for a while,
And see me scale rock-faces, perpendicular –al –but-,
Though if you do, your appetite for climbing may go phut.

C.S. Stokes

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ABSTRACT

The status, distribution and ecology of klipspringer were studied in the Kruger National Park. For the status and distribution, the Kruger National Park south of the Olifants River was used as the study area. Data on the status and distribution were gathered from all the ranger sections in the study area with the use of a non-sampling method, namely a systematic search. The results showed that the klipspringer population in the Kruger National Park is secure with a patchy distribution consisting of 773 individuals in the study area and a sex ratio of one male per 1.1 female.

The ecology of the klipspringer was studied in a specific study area on the Nwatindlopfu spruit between Skukuza and Tshokwane where five klipspringer individuals were radio collared.

The aspects covered in the study on the ecology of klipspringer, were the activities associated with environmental and vegetation related variables as well as scent-marking. It was found that vegetation is the determining factor in the habitat selection of klipspringer in the Kruger National Park, in that it provides both shelter and food. The ideal klipspringer habitat can be described as an area that has limited access to other ungulates that can attract predators. The vegetation should consist of palatable plant species that could be utilized by klipspringer, and must also provide sufficient shelter against possible danger.

Klipspringer scent marks were surveyed in a specific klipspringer range in the Kruger National Park with the use of a strip transect method. Both the male and the female klipspringer scent-mark their ranges. A pair of pre-orbital glands below the eyes produces the scent. The secretion produced is a sticky milky substance that is deposited on a suitable twig. The results showed that klipspringer in the Kruger National Park scent-mark more frequently on the boundaries of their ranges and also more on the those sides where there is another resident klipspringer group.

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CHAPTER 1

INTRODUCTION

The klipspringer is a small antelope standing approximately 0.6 m at the shoulder. The males weigh approximately 10 kg with the female slightly heavier at approximately 13 kg (Skinner and Smithers, 1990). The klipspringer has the following classification (Skinner and Smithers, 1990):

Order	Artiodactyla
Family	Bovidae
Subfamily	Antilopinae
Tribe	Neotragini
Species	*Oreotragus oreotragus* (Zimmermann 1783)

The klipspringer has adapted well to live in rocky conditions and it is confined to rocky outcrops, koppies and mountains as a habitat. Although is distribution is patchy, this small antelope has one of the widest geographical distributions of all the antelope species found in Africa, occurring from the highlands of Ethiopia to the Western Cape Province of South Africa (Norton 1980). In spite of this wide distribution little attention has been given to these antelope by researchers in the past, resulting in little being known about them until recently. In the whole of Africa only five studies were conducted previously of which only two was in South Africa.

Previous studies done on klipspringer are those of Dunbar and Dunbar (1974, 1980) who studied social organization and ecology as well as pair-bond behaviour in Ethiopia. Cuneo (1965) studied breeding behaviour and behaviour of young klipspringer at Naples Zoo, Italy, Wilson and Child (1965) and Tilson(1980) reported on ecological aspects in Zambia and Namibia respectively, and Robinson, Bothma, Fairall, Harrison and Elder (1996) studied the chromosomal conservatism in southern African klipspringer. The study of Norton (1980) on habitat utilization and feeding behaviour of klipspringer in the Western Cape Province and the study of Scotcher (1980) on the distribution of klipspringer in Natal appears to be the only ecological research work that has been done in South Africa, with no studies previously done on klipspringer in the Kruger National

Park. Because little is known about klipspringer in the Kruger National Park the present study was initiated to provide some data for this small antelope in this large conservation area.

The objectives of the study were the following:

-To determine the status and distribution of klipspringer in the Kruger National Park south of the Olifants River.

-To determine and describe the habitat utilised by klipspringer in the Kruger National Park.

-To determine if a specific scent-marking pattern was followed by klipspringer in the Kruger National Park.

For the determination of the status and distribution of klipspringer, the Kruger National Park south of the Olifants River was chosen as the study area. With the help of section rangers in the Kruger National Park all koppies and rocky ridges in the study area were inspected for the presence of klipspringer.

After completion of the first part of the study a specific study area with three residential klipspringer groups was chosen for the remainder of the study on the ecology of the klipspringer. This study area was situated in the Central District of the Kruger National Park approximately 25 km northeast of Skukuza at 24°55'52''S latitude and 31°45'15''E longitude.

To be able to follow the klipspringer, five individuals from the three resident klipspringer groups were captured with the use of drop nets and radio-collared.

After the three groups were carefully studied, their ranges were determined in which vegetation surveys were then done and activities recorded.

Finally with the ranges being known, the scent-marking pattern of one resident klipspringer group was studied.

CHAPTER 2

STUDY AREA

The Kruger National Park is situated in the Lowveld of the Mpumalanga and Northern Provinces along the northeastern boundary of the Republic of South Africa. This park lies between 22°19' and 25°32' S latitude and 30°54' and 32°02' E longitude (Figure 1). It is approximately 350 km long from north to south, with a mean width of approximately 65 km from east to west. It covers a surface area of 1 948 528 ha. The Crocodile River in the South, the Levuvhu and Limpopo Rivers in the North and the Lebombo Mountains in the east form natural boundaries to the Kruger National Park. The park varies in altitude increasing from east to west from approximately 200 m above sea level on the plains in the east to approximately 900 m above sea level in the vicinity of Pretoriuskop in the southwest. It is drained by five perennial and numerous seasonal rivers that all flow from west to east. Except for a short distance along the Levuvhu River in the northwest, the Kruger National Park was fenced until recently. This prevented the movement of most of the larger herbivores. Portions of the fence on the western boundary between Phalaborwa and Skukuza were removed in the late 1990's. Because the neighbouring land is privately owned game reserves, the animals now have more space to move around in, although the fences of these reserves on their western borders still prevent further movement of the animals to the west.

Geology

A diverse assemblage of igneous, sedimentary and metamorphic rocks that covers a time-span of more than 3 000 million years occurs within the Kruger National Park (Figure 2). This diversity in parent materials has caused the development of a large variety of soils, plant communities and animal populations, which make the Kruger National Park ecologically unique (Venter, 1990) (Table1).

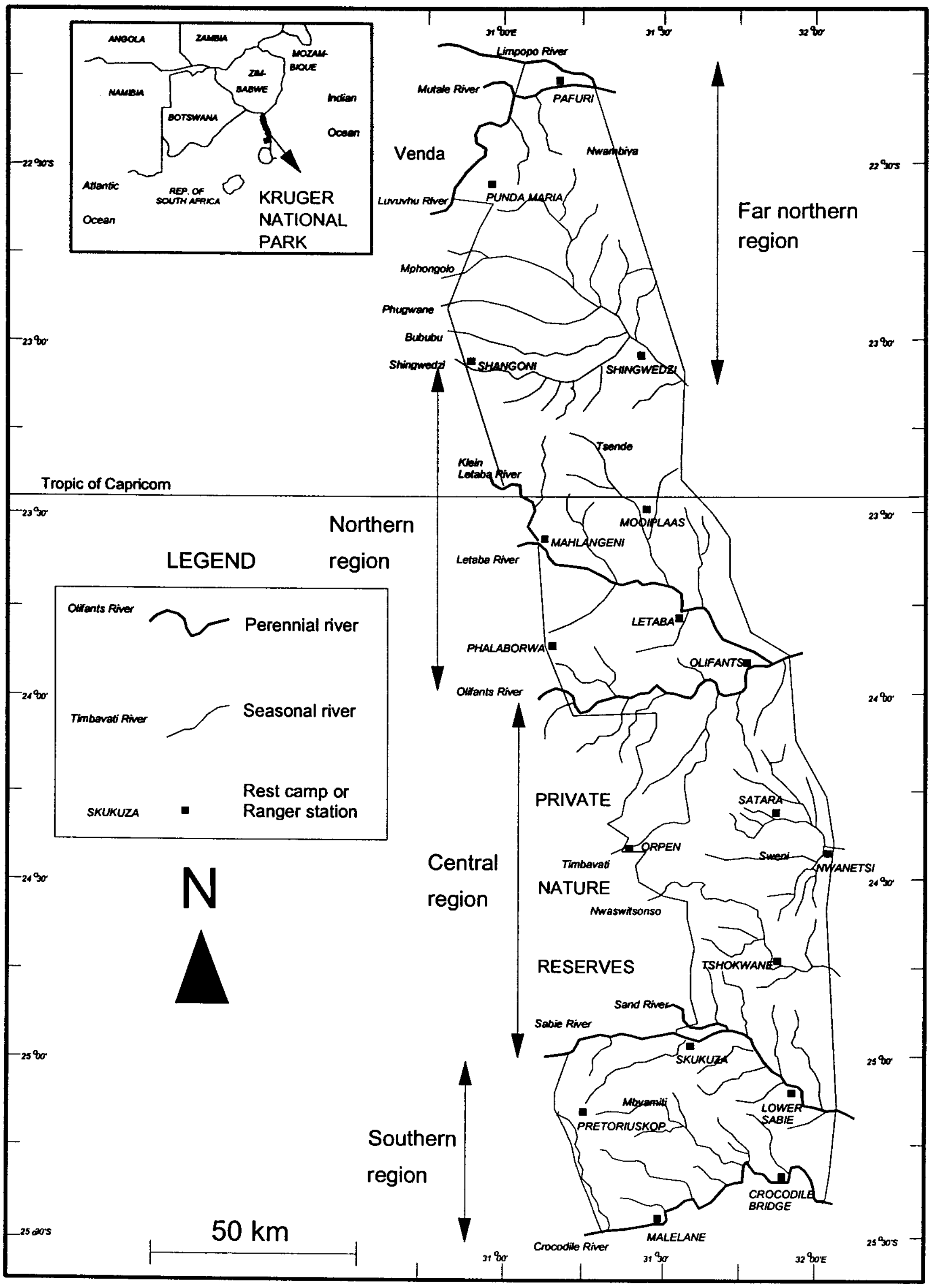

Figure 1. Locality of the Kruger National Park within South Africa and the division of the various management regions.

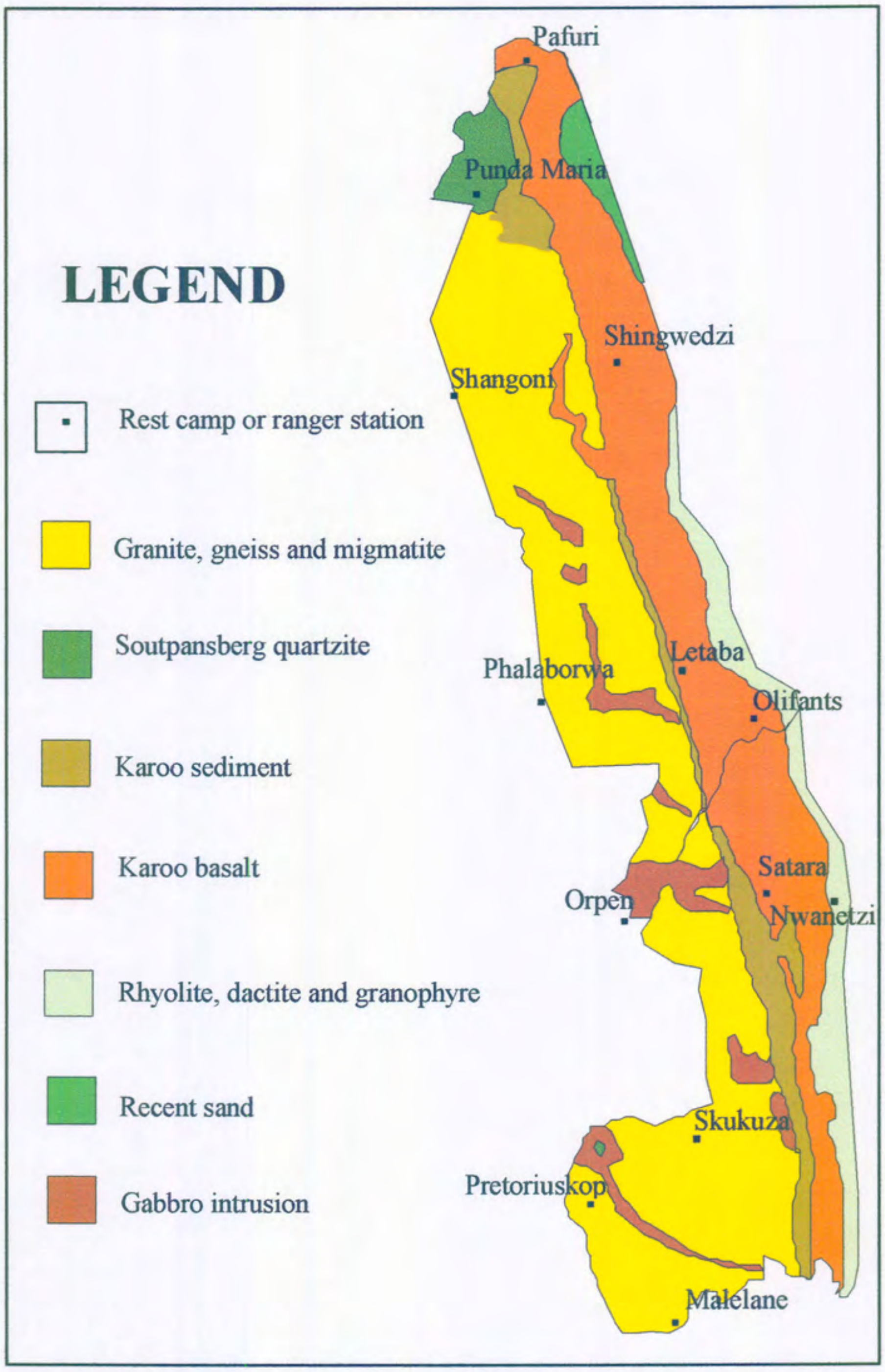

Figure 2. Simplified geological map of the Kruger National Park. Source: Bristow and Venter (1986).

Table 1. Summary of the stratigraphy of the major rock formations in the Kruger National Park, South Africa. Sources: SACS (1980), Schutte (1986), Barton, Bristow and Venter (1986) and Bristow and Venter (1986).

AGE IN MILLIONS OF YEARS	MAJOR UNITS	MAJOR SUB-UNITS	DOMINANT ROCK TYPES
<130	- Recent deposits	- Malvernia formation	- Alluvium, sand - Fossiliferous conglomerate and sandstone
<175		- Tshokwane granophyre	- Granophyre
~175		- Jozoni rhyolite formation	- Rhyolite, dacite
~190		- Sabie river basalt formation	- Olivine-poor basalt
~200	- Karoo sequence	- Letaba basalt formation	- Olivine-rich basalt
~200		- Mashikiri nephelinite formation	- Nepheline lava's
		- Clarens sandstone formation	- Fine-grained sandstone
~200-300		- Ecca group	- Shale, mudstone, grit, conglomerate, coal
~1000	- Timbavati gabbro		- Gabbro, quarts gabbro, olivine gabbro
		- Nzhelele formation	- Quartzite, sandstone, shale, basalt
~1800	- Soutpansberg group	- Wyllies poort quartzite formation	- Quartzite, sandstone
		- Fundudzi formation	- Sandstone, quartzite
		- Sibasa basalt formation	- Basalt
~2050		- Phalaborwa igneous complex	- Syenite
~2200		- Tsheri pegmatite	- Muscovite-bearing pegmatite
~2650		- Baderukwe granite	- Granodiorite, granite
~3200		- Nelspruit granite suite	- Granite, gneiss, migmatite
~3500	- Basement complex	- Orpen gneiss	- Gneiss
		- Makhutswi gneiss	- Gneiss, migmatite, amphibolite
>3500		- Goudplaats gneiss	- Gneiss, migmatite, amphibolite
		- Murchison sequence	- Amphibolite, schist
		- Barberton sequence	- Schist, amphibolite

Climate

According to Köppen's climate classification system the Lowveld falls in the Bsh climate zone which indicates an arid-steppe dry and hot climate (Schulze and McGee, 1978). Based on the life zone classification system the Kruger National Park has been subdivided into seven climatic regions by Schulze and McGee (1978) (Table 2).

Table 2. The climatic regions of the Kruger National Park according to the Life Zone Classification System of Schulze and McGee (1978).

SYMBOL	DESCRIPTION	AREA
5b	Tropical premontane arid thorn woodland	Pafuri
4a	Tropical premontane semi-arid very dry forest	Punda Maria
5a	Tropical semi-arid thorn woodland	Between Letaba and Punda Maria rest camps
5e	Subtropical semi-arid thorn woodland	Letaba and Olifants River valleys
4d	Subtropical semi-arid very dry forest	Southern Kruger National Park
3c	Tropical lower montane sub-humid dry forest	Pretoriuskop
3f	Tropical premontane sub-humid dry forest	Stolsnek/Malelane

The climatic conditions in the Kruger National Park vary from hot and humid during the summer months, to mild and predominantly dry during the winter months. The climate of the Lowveld is related to the regional climate of the subcontinent as a whole. It is influenced by anti-cyclonic systems that move over South Africa from west to east in a semi-rhythmical way (Venter 1990). The mean annual precipitation of the Kruger National Park decreases from the south to the north and from the west to the east, and ranges from 750 to 450 mm (Gertenbach 1978, 1980) (Figure 3). The rainy season normally starts in October and ends in April (Zimbatis and Biggs 1995).

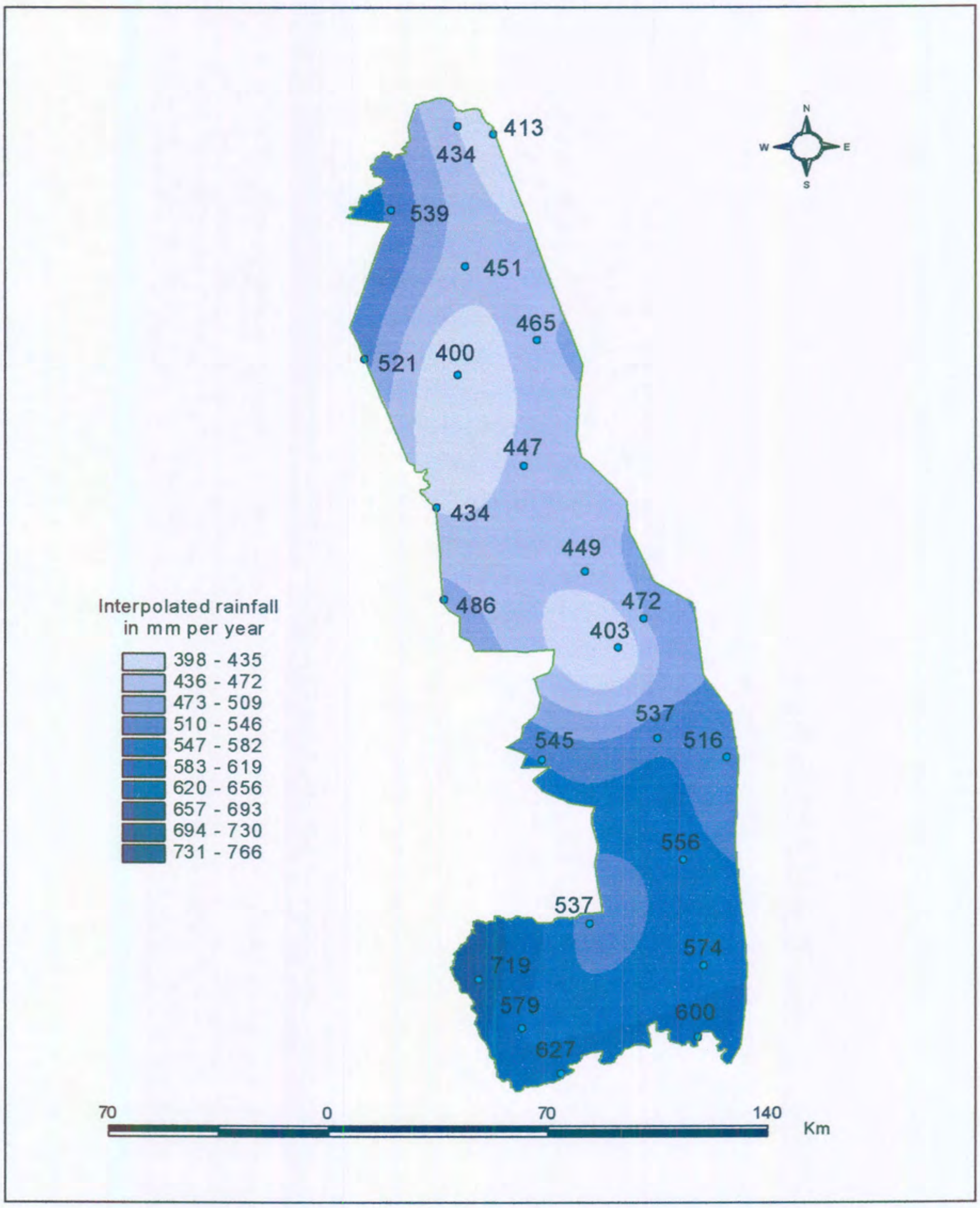

Figure 3. Interpolated annual rainfall of the Kruger National Park using the mean rainfall from 1960 to 1991. Source: Weather Bureau, Department of Environmental Affairs, Pretoria (1998).

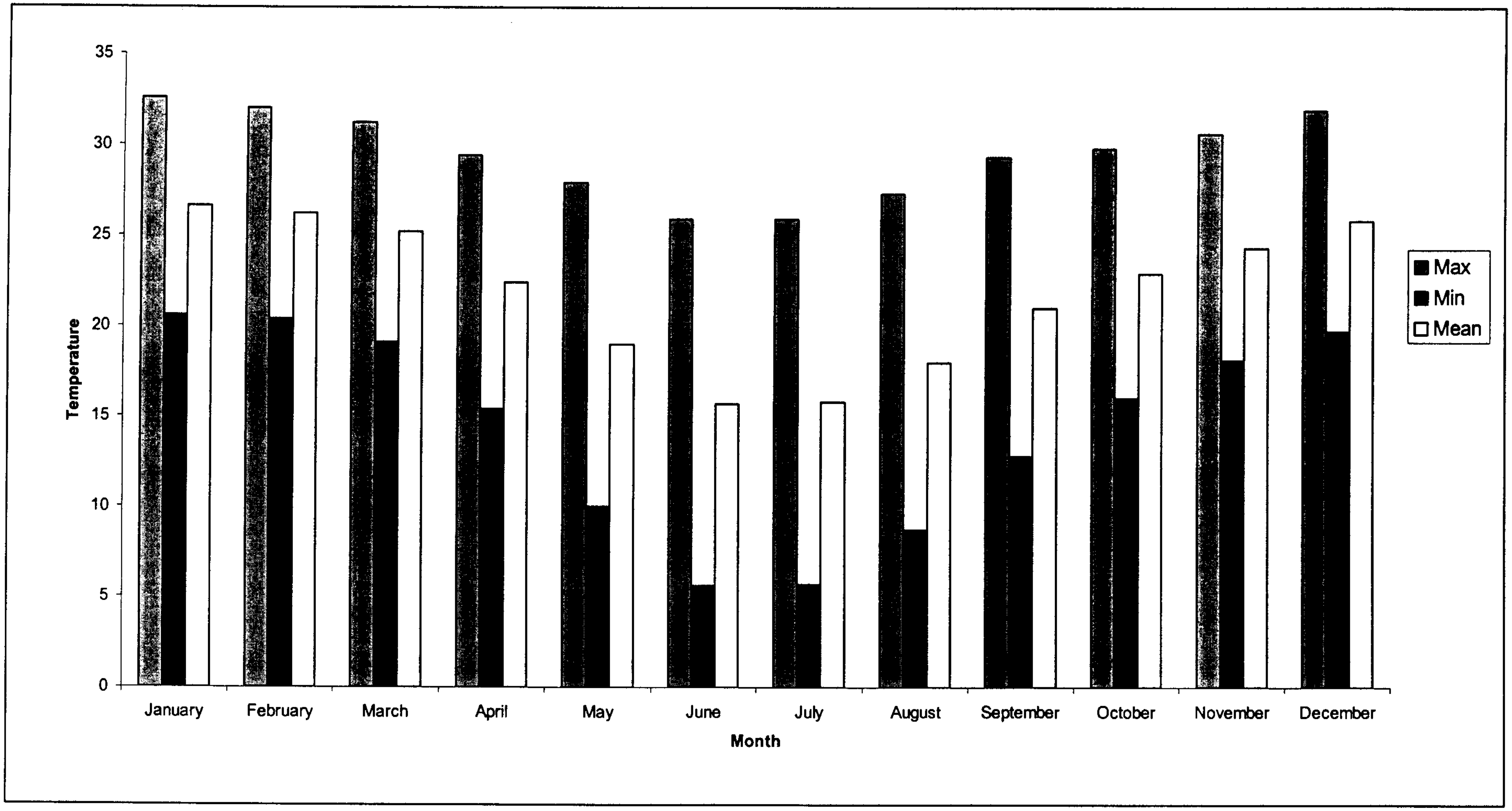

Figure 4. Monthly maximum, minimum and mean temperatures for Skukuza from 1960 to 1991. Source: Weather Bureau, Department of Environmental Affairs, Pretoria (1998).

Vegetation

The vegetation of the Kruger National Park consists of more than 1 950 different plant species. There is also a great variety of structural features, ranging from dense forest to shrubby grassland (Venter, 1990). Van der Schijff (1957), Van Rooyen (1978), Gertenbach (1978, 1983), Coetzee (1983) and Van Wyk (1984) have described the vegetation of the Kruger National Park in considerable detail. Van Wyk (1973) recognized 19 vegetation zones and Gertenbach (1983) identified 35 landscapes in the Kruger National Park, each of these consisting of several different plant communities. However, for the purpose of this study only a broad description of the vegetation will be given.

The area of the Kruger National Park underlain by granitoid rocks in the southwestern part south of the Timbavati river is characterized by quite dense woodland with the dominant tree species in the undulating area being *Combretum apiculatum*, *Combretum zeyheri*, *Combretum collinum* and *Terminalia sericea.* Along the footslopes where duplex soils are found, the dominant woody plant species are *Acacia nigrescens*, *Spirostachys africana*, *Dichrostachys cinerea*, and *Euclea divinorum.* In general the area has a good grass cover except on the shallow soils.

The northwestern part of the Kruger National Park, north of the Timbavati River on the granites mainly supports a *Colophospermum mopane* / *Combretum apiculatum* woodland. Apart from a small variation, the area is dominated by *Combretum apiculatum* on elevated areas and *Colophospermum mopane* on the depressions. Shallow soil in this area sometimes causes a poor grass cover and stunted forms of both above-mentioned species.

Thickets of *Acacia welwitschii*, *Albizia petersiana* and *Euclea divinorum* dominate the area underlain by Ecca sediments between the Olifants and Crocodile Rivers. The area south of the Olifants River is underlain by basalt. This area is dominated by *Acacia nigrescens*, *Sclerocarya birrea* and *Combretum imberbe* and by two important grass species namely *Themedra triandra* and *Panicum coloratum*. The area is an important grazing area in the Kruger National Park. The basaltic plains north of the Olifants River are characterized by multi-stemmed stunted mopane, with a lush grass cover in high rainfall areas.

The Lebombo Mountains along the eastern side of the Kruger National Park are basically rhyolitic with *Combretum apiculatum* and *Colophospermum mopane* the dominant tree species north of the Olifants River and *Combretum apiculatum* south of the river. This area hosts several plant species that are restricted to the Lebombo Mountains. The far northern areas of Punda Maria, Pafuri and Nwambiya consists of a number of plant communities. According to Van Rooyen (1978) and Gertenbach (1983) some of the more important communities there are:

- The *Colophospermum mopane* forest community
- The *Burkea africana/Pseudolachnostylis maprouneifolia* community
- The *Kirkia acuminata/Afzelia quanzensis/Combretum apiculatum* savanna community
- The *Androstachys johnsonii/Croton pseudopulchellus* woodland community
- The *Acacia albida/Ficus sycomorus* river forest community
- The *Baphia massaiensis/Goubourtia conjugata* thickets community

Specific study localities

The first part of the study concerned the status and distribution of the klipspringer in that part of the Kruger National Park south of the Olifants River. This area was described above. The more detailed ecology of klipspringer was studied in the Nwatindlopfu Spruit area, approximately 25 km north-east of Skukuza in the Central District of the Kruger National Park (Figure 5). This area was selected because it had more than 10 known resident groups of klipspringer in close proximity. This area can be described briefly as follows:

The Nwatindlopfu Spruit area

According to the landscape classification of the Kruger National Park by Gertenbach (1983), this area includes 2 landscapes. They are the thickets of the Sabie and Crocodile Rivers and the mixed *Combretum* species / *Terminalia sericea* woodland. The area is underlain by granite and gneiss, with numerous dolerite intrusions that are more than

10 m wide (Schutte 1986). The altitude of the landscape varies from 200 to 500 metres above sea level with gently sloping hills and valleys. Figure 4 shows the maximum, minimum and mean monthly temperatures for Skukuza, which is the closest first order weather station to the study area. These mean temperatures were calculated from 1960 to 1991.

Vegetation

The vegetation of this area can be described as mixed *Combretum* savanna woodland with dense thornbush thickets on the banks of the spruits and rivers (Pienaar 1963). The dominant woody species are *Acacia nigrescens, Combretum apiculatum, Grewia bicolor, Grewia flavescens, Sclerocarya birrea, Euclea divinorum, Spirostachys africana, Dichrostachys cinerea, Ziziphus mucronata, Lonchocarpus capassa, Strychnos madagascariensis, Cissus cornefolia, Ormocarpum trichocarpum* and *Dalbergia melanoxylon.* The herbaceous grass layer in the area is dominated by *Pogonarthria squarrosa, Perotis patens, Melinis repens, Digitaria eriantha, Panicum maximum, Aristida congesta, Schmidtia pappophoroides, Urochloa mosambicensis, Heteropogon contortus, Enneapogon cenchroides, Bothriochloa radicans and Themeda triandra.* The dominant forbs are *Waltheria indica, Evolvulus alsinoides, Heliotropium steudneri, Dyschoriste rogersii, Abutilon astro-africanum, Justicia flava, Sansevieria hyacinthoides, Rhynchosia totta, Cassia mimosoides, Commelina bengalensis* and *Hibiscus micranthus.*

Mammals

The largest population of impala *Aepyceros melampus* in the Kruger National Park most probably occurs in this area. Other mammals include the kudu *Tragelaphus strepsiceros*, common duiker *Sylvicapra grimmia*, steenbok *Raphicerus campestris*, bushbuck *Tragelaphus scriptus*, giraffe *Girraffa camelopardalis*, sable antelope *Hippotragus niger*, warthog *Phacochoerus aethiopicus*, elephant *Loxodonta africana*, white rhinoceros *Ceratotherium simum* and black rhinoceros *Diceros bicornis*. The predators that occur in the area are the lion *Panthera leo*, leopard *Panthera pardus*, cheetah *Acinonyx jubatus*, wild dog *Lycaon pictus* and spotted hyaena *Crocuta crocuta*.

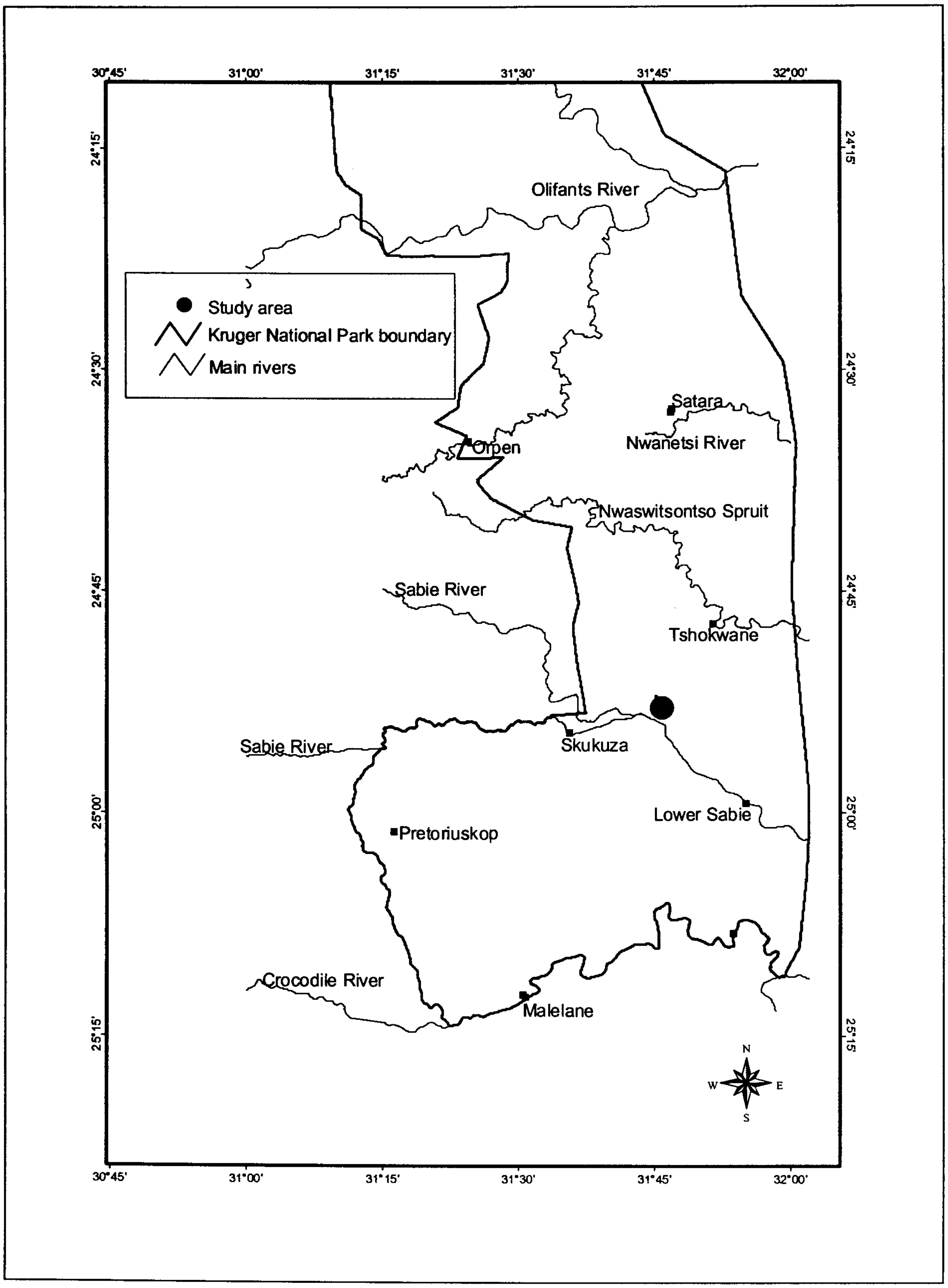

Figure 5. Map of the specific study locality in the Nwatindlopfu Spruit area in the Central District of the Kruger National Park from 1995 to 1997.

CHAPTER 3

STATUS AND DISTRIBUTION

Several factors influence the distribution of an animal species within a specific area, directly or indirectly. Examples include physical and climatic factors. Together these two factors have an indirect influence on animal distribution in that they affect the suitability of a habitat for a specific species. This is done through an influence on the vegetation. However, physical and climatic factors have a direct influence on the distribution, and the suitability of the habitat. For example, climatic factors can give rise to cold and wet, or warm and dry conditions, and physical factors to the presence of mountains or plains. These factors force the animal and plant species that are present in a specific area to adapt to certain ecological conditions or to move away or die. Other factors that also influence the distribution of such species are competition, the presence of predators, and the activities of man.

The klipspringer has adapted well to live in rocky conditions, and it is confined to rocky outcrops, koppies and mountains as a habitat. Although patchy and discontinuous in distribution, this small antelope has one of the widest geographical distributions of all the antelope species found in Africa, occurring from the highlands of Ethiopia to the Western Cape Province of South Africa (Norton 1980)(Figure 6). This distribution could give rise to possible phenotypic differences between the 11 recognized subspecies (Robinson *et al.* 1996).

Pienaar (1963) believed that klipspringer are widespread in the Kruger National Park where they appear to number several hundred. However, little is known about their true status and distribution. One objective of this study therefore was to determine the status and distribution of the klipspringer in the Kruger National Park. For the purpose of this study, the survey was confined to that part of the Kruger National Park south of the Olifants River.

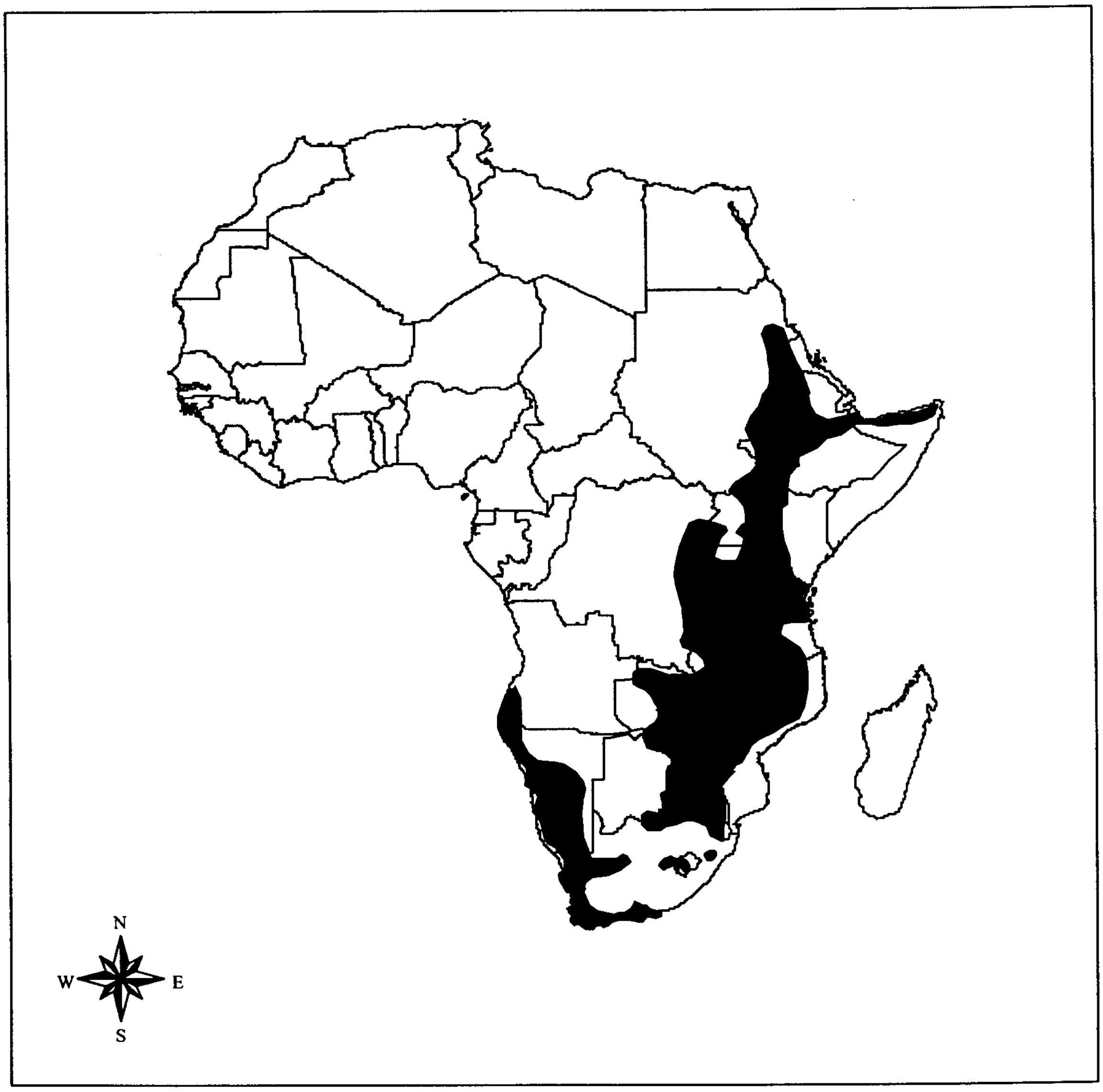

Figure 6. The pan-African distribution of klipspringer *Oreotragus oreotragus* based on Skinner and Smithers (1990).

Materials and methods

The objective in determining the status and distribution of klipspringer was to derive an absolute estimate of the number of klipspringer in the study area, and to see how the population is distributed. A non-sampling method was used. This was a systematic search in which the entire study area was covered and all animals seen were documented (Collinson 1985). Information about the status and distribution of klipspringer was gathered over the two-year period 1994 and 1995. This was done with the help of rangers, trails rangers and other field staff when on routine patrols, trails or fieldwork in the various sections of the park south of the Olifants River. Whenever klipspringer were sighted the exact locality and the number of animals that were seen were noted, and confirmed on a subsequent visit to the same locality. All the information gathered was then collected from the various sections, and these localities were then visited by the researcher for conformation of the data. These data were then plotted on an area map.

This method was chosen because of the following klipspringer characteristics:

- The territorial behaviour of klipspringer where a pair will occupy a specific area and also defend it against intrusion by other klipspringer (Dunbar and Dunbar 1980).
- The habitat selection of klipspringer where they are almost invariably confined to mountainous areas, koppies and rocky outcrops (Norton 1980).
- The low population density of klipspringer in the Kruger National Park. Moreover their distribution there is extremely clumped making it suitable to use the above method. (Caughley 1977).

Taking all the klipspringer characteristics into account it was clear that a non-sampling strategy was the best option. Sampling strategies are generally regarded to be inferior to a systematic search in a situation where a population is clumped. With a sampling strategy a considerable sampling effort is also required to obtain an estimate with a reasonable degree of accuracy (Caughley 1977).

The following important assumptions were made with the chosen non-sampling strategy (Seber 1973):

- That the entire study area was covered in the search.
- That all the individuals in the population were located.
- That no individuals were counted more than once.

Results and discussion

The klipspringer population in the Kruger National Park south of the Olifants River has a patchy distribution, with denser populations occurring in the mountainous area southwest between Berg en Dal and Pretoriuskop, to the east on the Lebombo Mountains, the north along the Olifants River, and in the northwest south of the Olifants River (Figure 7) (Table 3). No other data exist on the number of klipspringer previously found in the Kruger National Park so as to compare it with what was found in this study (Kruger[1] *pers. Comm.*). The total count for klipspringer in the Kruger National Park south of the Olifants River comprising an area of 914266 hectare was 773. The density of the population is therefore, one klipspringer per 1250 hectare. The patchy distribution can be explained in terms of the potential for klipspringer habitat, because some areas have mountainous areas or koppies where high numbers of klipspringer were found. The population has a sex ratio of one male per 1.1 female. Moreover 26% of the population consists of subadult animals.

A group size of two to three animals was most often observed. A group of three animals consisted of a male, a female and a subadult animal. When four animals were together, the group consisted of an adult male, an adult female, a juvenile and a yearling. Most young stayed with the parent group for 12 to 13 months after which they are chased off by both parents.

Most of the koppies or rocky outcrops that have suitable vegetation and provide food and cover are inhabited by one or more pairs of klipspringer. Some areas where there are

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[1] *Kruger, J.M: Private Bag X402 Skukuza, 1350. 2001*

hardly any rocks and appear to be marginal klipspringer habitat are also sometimes occupied by klipspringer, as was the case on the Nwatindlopfu Spruit (Chapter 5).

The status of the klipspringer in Africa is classified as at lower risk or conservation dependent in the IUCN red list of threatened species. A taxon is classified as at lower risk when it has been evaluated and does not satisfy the criteria for the categories of being extinct, extinct in the wild, critically endangered, endangered or vulnerable. When taxa are classified as conservation dependent, they are the focus of a continuing taxon-specific or habitat-specific conservation programme, targeted at the taxon in question. Cessation of such programmes would result in the taxon qualifying for one of the threatened categories within a period of five years (Hilton-Taylor, IUCN 2000).

A study done in the Drakensberg on the klipspringer population by Scotcher (1980) showed that the population there is stable, that there is no significant difference in numbers between months and years, and that concern about their decline there is unjustified.

In the Kruger National Park the survey on klipspringer will have to be repeated over a number of years to be able to determine the klipspringer's true conservation status is. The only real indication of its status, although not scientific, may be obtained from reports of past and present rangers which indicated where klipspringer were seen, as well as from the present study. From these reports and data the status of the klipspringer population in the Kruger National Park south of the Olifants River is probably secure.

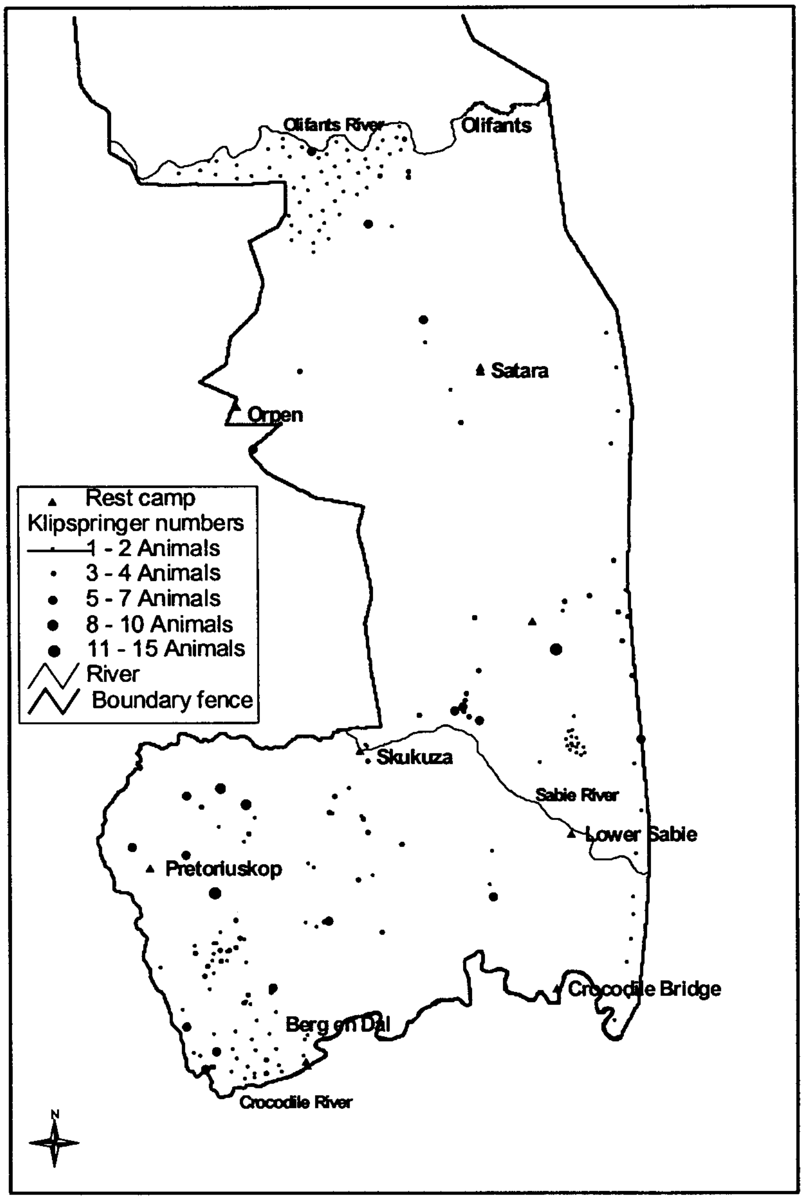

Figure 7. Klipspringer distribution south of the Olifants River in the Kruger National Park South Africa from 1994 - 1995

Table 3. The Status and distribution of klipspringer in the area south of the Olifants River in the Kruger National Park from 1994 to 1995.

RANGER SECTION	ADULT MALE	ADULT FEMALE	SUBADULT MALE	SUBADULT FEMALE	TOTAL
Crocodile bridge	9	10	3	3	**25**
Houtbosrand	76	82	8	6	**172**
Kingfisherspruit	2	4	2	2	**10**
Lower Sabie	18	16	5	3	**42**
Malelane	33	38	14	9	**94**
Nwanedzi	8	6	2	3	**19**
Olifants	28	23	4	6	**61**
Pretoriuskop	25	23	13	15	**76**
Satara	4	7	4	2	**17**
Skukuza	5	4	2	3	**14**
Stolsnek	40	56	30	27	**153**
Tshokwane	22	32	15	21	**90**
Total	**270**	**301**	**102**	**100**	**773**

CHAPTER 4

CAPTURE

The capture of wild animals is an event that takes place regularly in the Kruger National Park, be it to relocate animals, study various aspects of their physiology, collect specimens and samples, or to mark them. It has become an important tool in wildlife management and is highly specialized. For almost every animal species there is a unique capture technique that has been tested over the years. Such capture techniques are all designed in such a way as to minimize stress and to keep mortalities low. No previous attempt has been made to capture klipspringer in the Kruger National Park. However, some klipspringer were captured in the Augrabies National Park by using a helicopter and capture nets that were placed in the valleys where the animals moved around when flushed by the helicopter. Some klipspringer were also captured there with the use of a net gun which was shot over them from a helicopter (Grobler[1] *pers. comm*).

The capture of klipspringer for the current study took place in the Nwatindlopfu Spruit area. This area is in the Central District of the Kruger National Park approximately 25 km north-east of Skukuza. The main reason for capturing these animals was to fit them with radio collars. However, the opportunity was also used to collect blood samples for blood analyses, to collect ear clippings for genetic research, to take body measurements, to weigh the animals and to comb them for external parasites.

Materials and methods

The technique that was used here to capture klipspringer was a modification of the technique described by Pienaar and Van Niekerk (1963) to capture small antelope in general. A nylon drop net of approximately 200 m long by 2 m high, with a mesh size of 100 x 100 mm was set up downwind, in a half circle around a koppie. The net was tied to trees at the two ends and hooked to branches of suitable trees inbetween. Wooden spars were used to support the net where there were no trees. The net was set up in such a way that it dropped over the animal once the animal hit the net. Handlers were then positioned

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[1] *Grobler, D.G: P.O.Box 2485 Naboomspruit, 0560. 1995*

outside and at the ends of the net in sufficient cover so that the animals could not see them when approaching the net. The task of these handlers was to secure any animals that became entangled in the net until a veterinarian could attend to them (Grobler 1995).

Herding the animals into the nets was the last part of the capture operation. In doing so two different methods were compared. In the one, the drive was done with the aid of a helicopter. In the other it was done with some 20 handlers on foot in a pattern that completed the circle upwind from the ends of the net. These handlers clapped their hands while walking downwind towards the net (Figure 8)(Grobler 1995).

Once the animals were secured in the net they were immobilized by a veterinarian. The doses and drugs that were used for the immobilization of the klipspringer are as follows (Grobler 1995):

- 0.75 mg etorphine hydrochloride (M99) for narcosis and 3 mg diprenorphine hydrochloride (M5050) as narcotic antagonist for adult animals weighing 11 to 12 kg.
- 0.5 mg etorphine hydrochloride (M99) for narcosis and 1.5 mg diprenorphine hydrochloride (M5050) as narcotic antagonist for young animals weighing 5 to 7 kg.

Because klipspringer are such small antelope it is most important that these animals should only be handled once immobilized to avoid high stress levels and serious body injuries to themselves.

The following data were collected from the immobilized animals:

- Date of capture
- Sex
- Age in months
- Locality of capture
- Body weight (kg)
- Length of head (mm)
- Length of the body over the curves (mm)
- Length of the body in a straight line (mm)
- Length of the tail (mm)
- Length of the hind leg (mm)
- Length of the hind foot (mm)
- Rump width (mm)
- Shoulder height (mm)
- Elbow/brisket height (mm)
- Total height from head to the tip the hoof (mm)
- Girth (mm)

- Circumference of the higher neck (mm)
- Circumference of the lower neck (mm)
- Horns:total length(mm), circumference at base(mm) and distance between tips(mm)
- Length of the ear (mm)

Blood samples were also taken for analyses and a blood parasite count. Ear clippings were taken from two of the first animals that were captured for genetic research by Robinson, Bothma, Fairall, Harrison and Elder (1996) on chromosomal conservatism in South African klipspringer antelope. The animals were furthermore closely examined for the presence of ticks and other external parasites.

Finally radio collars with the following specifications were fitted to three adult male, two adult female and one seven-month-old male animal:

- Manufacturer:	Telonics: Telemetry and Electronics Consultants
- Model	MOD-125
- Expected operational life:	13 months
- Pulse width:	1.20 seconds
- Frequency range:	

Results and discussion

The helicopter was at first used as a means of herding the klipspringer into the nets. However, this method had limited success. In six attempts at different localities only one klipspringer was captured, for a 17 % success rate. This could be ascribed to two factors: the dense bushes that occurred in the vicinity of the koppies where the capture took place, and the deafening noise of the helicopter. The dense bushes made the locating and herding of klipspringer difficult. Furthermore, once the klipspringer had been flushed from the bushes the noise of the helicopter disorientated them to such an extent that they fled in all directions. Herding the animals back to the net proved equally difficult because the dense bushes prevented positioning of the helicopter in front of the klipspringer to stop the animals from running through underneath the helicopter. Furthermore, as soon as a klipspringer became exhausted, it hid in the bushes and did not flush again.

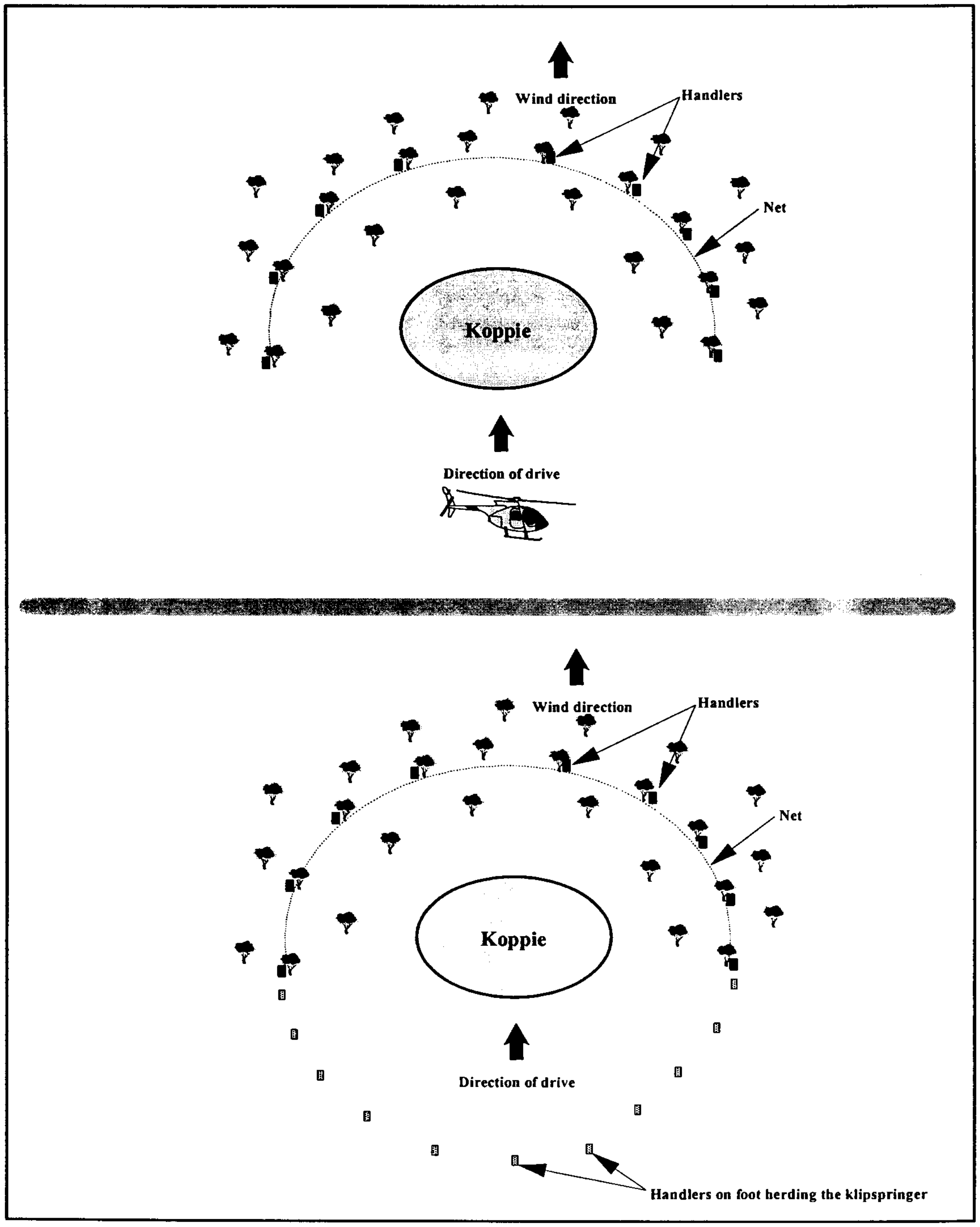

Figure 8. Two methods that were used to herd klipspringer into nets with a helicopter and with handlers on foot in the Kruger National Park.

Because of the limited success achieved with the capture of klipspringer by helicopter, it was decided to use handlers on foot on the ground to herd the animals instead of a helicopter. This method worked well because when the klipspringer were flushed they were persuaded by clapping the hands to run directly into the net. Fifteen klipspringer were captured in this way at a 100 % success rate, without any mortality and at low cost. Furthermore the animals were immobilized immediately after they had become entangled in the nets, causing little stress. After immobilization each animal was untangled from the net and placed in a shady place where the various measurements were taken (Table 4) and other procedures carried out.

Blood analyses

Table 5 shows the results of the analyses of the four blood parameters that were compared. They are the erythrocyte count, leukocyte count, haemoglobin level and packed cell volume or haematocrit. Blood samples from three klipspringer that were captured were also analysed against bovine normal blood values as a control, the international species information system (ISIS) African buffalo data values, and ISIS klipspringer data values. The ISIS system is widely used by zoological gardens and other institutions as a central database to gather and exchange data on captive animals.

The blood count for erythrocytes, which carries the haemoglobin through the body, is relatively similar in all the animals compared in the table, although that of klipspringer in the Kruger National Park is above the range found by Fowler (1978). This could be due to a difference in altitude between the study areas. Haemoglobin, which transports oxygen from the lungs to tissues in the body, seems to be higher in klipspringer than in bovines generally. This could be because the habitat that the klipspringer utilizes consists of rocky outcrops in which movement is more strenuous. Furthermore these habitats often occur at high altitudes. Both altitude and habitat can contribute to higher haemoglobin levels as a better means of transportation of oxygen in the body (Jain, 1986).

The leukocyte count of klipspringer from the Kruger National Park is lower than the range given by Fowler (1978). This could be due to the general health status of the animals in Fowler's study area, because with diseases the count will increase (Jain, 1986).

The haematocrit values for all the klipspringer of the Kruger National Park fall within the normal range. However the ISIS klipspringer data seem to be unrealistically high and unreliable. In general the haematological values for the animals in this part of the study show no real variation when compared with other species and indicates that these animals are in a healthy condition (Jain, 1986).

Genetic aspects

The genetic material collected from the klipspringer during the capture operation was used in a later study that has been reported on by Robinson *et al.* (1996). The aim of the above study was to ascertain whether geographically discrete populations of klipspringer differed detectably in chromosome structure. Robinson and Elder (1993) argued that mating between specimens characterized by different cytotypes could result in perinatal mortality or, at a later stage, in reduced fertility of offspring heterozygous for chromosomal rearrangements. The concern was therefore raised that the relocation of klipspringer from one area in South Africa to another could have a negative impact on the viability of the resident populations in the area.

The results from mitochondrial DNA data showed no meaningful differences between subpopulations of klipspringer in eastern and southern Africa. Robinson *et al.* (1996) stress that this removes the more obvious concerns governing moving klipspringer around, but that the apparent lack of regional cytotypes does not imply the absence of genetic differences between distant populations. Additional studies are needed to develop a successful translocation policy and any proposals to relocate klipspringer over extensive geographic distances should therefore be considered cautiously for the time being.

External parasites

All the klipspringer captured were closely examined for the presence of external parasites. Emphasis was placed on trying to locate the specific tick *Ixodes (Afrixodes) matopi*. This tick is attracted to twigs, which are scent-marked by the klipspringer with its pre-orbital glands (Rechav, Norval, Tannock and Colborne 1978). Little is known about the ecology of the African species of the genus *Ixodes* because it has specific host and habitat requirements and is seldom encountered by man or found on domestic animals (Colborne, Norval and Spickett 1981). The two studies mentioned here were both conducted in the Matobo National Park in Zimbabwe. Therefore it would be of value to establish whether this species also occurs in South Africa to determine its distribution in Southern Africa.

Ticks were only found on one young male animal that was captured. Only two species of tick were identified from all the animals captured. They were *Amlyomma hebraeum* (six nymphs and one adult male) and *Rhipicephalus evertsi evertsi* (two larvae, four nymphs and two adult males). Scent-marked twigs were also investigated but no ticks were found on them. This results does not mean that *Ixodes (Afrixodes) matopi* does not occur in the Kruger National Park, and more intensive research is needed to examine its presence or absence properly.

Table 4. Body measurements (mm) unless otherwise indicated and weight (kg) of klipspringer captured in the Nwatindlopfu Spruit area of the Kruger National Park.

CAPTURE DATE	18 FEBRUARY 1995	6 MARCH 1995	5 MAY 1995	5 MAY 1995	5 MAY 1995	5 MAY 1995	11 OCTOBER 1995	11 OCTOBER 1995	11 NOVEMBER 1996
Sex	Female	Male	Female	Male	Female	Male	Male	Male	Male
Age	Adult	Adult	Adult	Adult	7 months	Adult	Adult	Adult	13 months
Body weight(kg)	11.0	11.4	11.0	9.5	7.0	11.0	9.6	11.2	10.2
Length of head	91	200	170	160	145	150	164	175	185
Length of body over the curves	720	700	990	870	810	950	862	910	830
Length of body in a straight line	900	900	910	840	720	890	675	710	690
Length of tail	74	71	66	58	50	72	58	62	72
Length of hind leg	236	236	530	510	430	430	206	216	230
Length of hind foot	33	29	22	20	19	220	32	27	33
Rump width	130	135	115	110	90	125	134	138	145
Shoulder height	560	480	500	505	440	485	470	509	500
Elbow / brisket height	310	300	310	330	290	295	286	295	310
Total height (head to hoof)	700	560	-	-	-	-	720	710	670
Girth	575	520	-	-	440	520	490	505	476
Circumference of higher neck	200	190	190	200	170	210	194	195	210
Circumference of lower neck	260	285	260	280	240	290	225	264	285
Length of ear	94	92	85	105	95	100	92	95	100
Horns:									
-Total length	-	105	-	93	-	95	96	121	77
- Circumference of base	-	59	-	52	-	55	65	68	-
- Distance between tips	-	64	-	70	-	48	59	60	45

Table 5. Haematological values of three captured klipspringer for some parameters as compared with that of normal blood values for bovines, ISIS African buffalo data, ISIS klipspringer data and klipspringer values from the literature.

BLOOD SOURCE		ERYTHROCYTES (X 10^6 µL)	LEUKOCYTES (X 10^3 µL)	HAEMOGLOBIN (G/DL)	HAEMATOCRIT (%)
Bovines:	Mean	7.0	8.0	11.0	35.0
	Range	5.0 – 10.0	4.0 – 12.0	8.0 – 15.0	24.0 – 50.0
Mean ISIS African Buffalo data (n=30):		9.33	7.07	13.5	40.4
Impala:	Mean	20.25	10.1	13.5	40
Klipspringer:	Mean	6.99	10.00	12.0	40
	Range	5.5 – 8.0	9.0 – 11.0	10.0 – 14.0	30.0 – 50.0
Mean ISIS klipspringer data (n=3):		10.78	6.03	17.7	54.8
Klipspringer: Kruger National Park					
	Animal 1	10.08	7.3	15.8	47.5
	Animal 2	9.22	6.2	15.5	46.2
	Animal 3	9.62	6.4	15.0	47.0
	Mean	9.64	6.63	15.43	46.9

CHAPTER 5

HABITAT SELECTION AND UTILIZATION

Habitat selection in most terrestrial organisms is a complex process, and a wide constellation of factors act on an animal at any one time (Wecker 1962). These factors act in combination or singly. According to Boysen-Jensen (1949) species tend to persist in those parts of their environment that require the least expenditure of energy for maintenance, allowing surplus energy to be utilized for growth and reproduction.

Beament (1961) argues that animals select their environment through behavioural mechanisms and that these cause the animal to limit itself to a much narrower range than that in which it could survive. Allen (1977) takes it further and believes that this is the reason why some habitats, which appear to be physically identical, are occupied and others are not.

Klipspringer antelope are, without hardly any exception, confined to rocky outcrops, koppies and mountainous areas, where they are often seen browsing on the foot-slopes and resting in the shade on the mid-slopes and tops. These animals are anatomically adapted to live in rocky environments (Norton 1987).

Successful conservation of ecological communities requires sound knowledge of the habitat requirements of the species that comprise the communities. This will then allow for sound ecological management with limited erroneous decisions and practices being implemented (Cohen 1987). The aim of this chapter is therefore to determine the habitat selection of klipspringer and to describe its utilization by klipspringer.

Materials and methods

On-site cover analysis

This is a method to measure vegetative cover density or the obstruction of vision with the use of a density board as described by Wight (1938 In: De Vos and Mosby 1969) as modified by Cohen (1987). The density board is used to measure the horizontal density of the vegetative cover by recording the visual obstruction to the board by the vegetation or rocks occurring between the board and the observer. By recording the cover density at various height intervals, a density profile can be obtained and the horizontal cover components of the vegetation that is selected by animals can be quantified (Cohen 1987).

A density board 3.0 m high by 150 mm wide was constructed of pressed-wood. The board was divided into 20 equal units of 150 by 150 mm, and each unit was further subdivided into two equal triangles (Figure 9). The triangles in each unit were marked alternatively in red and yellow. Cohen (1987) stresses the fact that it is necessary to establish a standard distance from which the profile board should be read. This distance was determined in a trial, described by Cohen (1987), where vegetative cover readings were taken at the following 12 distances away from an observation point in the study area: 8, 9, 10, 11, 12, 13, 15, 20, 25, 30 and 35 m. The greatest variation was observed between 15 and 25 m away from the board. It was therefore decided to use a standard distance of 20 m from which observations were made.

The board is used in the following way: the observer stands on the exact spot where the klipspringer was sighted. The board is then placed upright at four points 20 m from the observer in all four major wind directions, facing the observer at all times. At each of these points a photograph of the board is taken at a height of 600 mm above ground level, this height being the standard shoulder height of a klipspringer (Smithers 1990). The board is then divided into units of 300 mm on the photograph (two blocks of 150 by 150 mm form a single unit). Therefore the board on each photograph consisted of 10 units (Figure 9). Each unit represents 10 % of the board's surface area. The cover is then read from the photograph for each unit as the percentage of the surface area of the board that is obscured. A total for the whole board is then calculated, also specifying what percentage of the obstruction is caused by vegetation, by rock or by any other inanimate objects such as termite mounds. This method gives an estimate of the cover and visibility that the klipspringer has in the four major wind directions from the sighting point. It is expected that this degree of visibility can be correlated with the observed activity of the animal at the time of the sighting, and that the cover characteristics of klipspringer habitat can then be determined. It was therefore necessary to record the activity of the animal at each sighting point.

Logistic regression models (Collett 1991) were used to assess the above interrelationships, and to determine which variables or combinations of variables significantly influence the activity of the animals. During animal sightings various environmental variables were also measured, and the activity of the animal was observed. The following variables were recorded:

Environmental variables:

- Landscape position
- Aspect
- Percentage cloud cover
- Wind direction
- Wind velocity
- Temperature
- Slope

Vegetation related variables:

- Percentage obstruction: This was measured from 300 to 3000 mm at 300 mm intervals and in all four major wind directions. As it was expected that the wind direction would not directly affect the activity of the animal, these percentages were added to obtain a total obstruction index for each height class.
- Percentage tree to shrub ratio
- Percentage herbaceous cover
- Percentage grass to forb ratio
- The height of the herbaceous layer
- Percentage obstruction caused by the vegetation
- Percentage obstruction caused by rocks or other inanimate objects

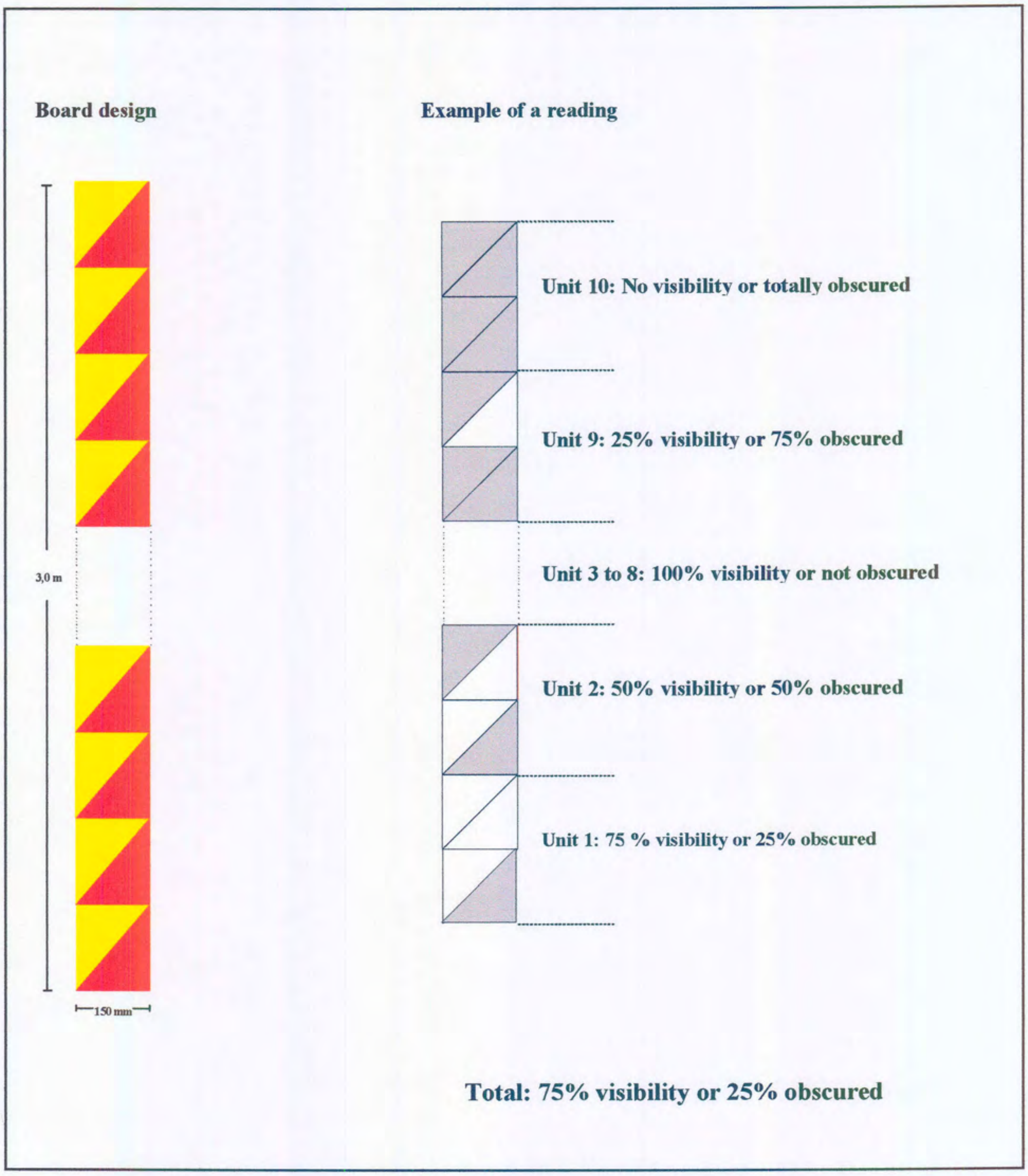

Figure 9. **Modified density board as used to quantify the vegetational structure of klipspringer habitat in the Kruger National Park, and the method of calculating the degree of visibility or obstruction (total visibility = $\sum$ 100(visibility of each unit / 1000).**

Animal activity

The following activities were recorded: fleeing, browsing, observing, hiding, resting, mating and grooming.

Factors affecting klipspringer activity: model fitting

The probability that certain variables affect the activity of a klipspringer was investigated by using logistic regression models, with activity being the binary response or dependent variable. Each activity was fitted separately with, a value of 1 indicating when the fitted activity took place and a value of 0 when an alternative activity took place. The variables fitted against each activity varied according to the activity because some of the activities were only recorded a few times and therefore could not be fitted to all the variables.

A subjective approach was also used to determine the most appropriate combination of explanatory variables to be used (Collett 1991). This was based on the underlying knowledge of the variables and by observing the changes in deviance when fitting the variables to determine whether they are significant or not. The activities that had the most data associated with them were fitted first in order to select explanatory variables subjectively. The degree of drop in deviance is a measure of the amount of variation that is accounted for by that variable. The larger the drop the more important a variable is. These drops where then evaluated against Chi-squared critical values for the appropriate degrees of freedom and significance (Collett 1991). The interactions were not fitted because it was expected that they would not be biologically meaningful. Each explanatory variable was first subtracted and then re-added to the model in order to obtain the deviance.

Woody vegetation structure and composition

After careful observation of the three groups of klipspringer that were fitted with radio collars in the present study, the range use of each group was established (Figure 10). It was then possible to do a vegetation survey in each range to quantify the habitat that the klipspringer occupied in the study area.

The method used in the woody vegetation survey was a modification of the quantitative description of woody plant communities technique as described by Smit (1989). Each survey was done in the form of transects stretching from the range boundary on the one side to the opposite boundary. The transects always stretched from north to south and east to west. These transects were dispersed over the whole range depending on the size of the range.

Two transects were done parallel to each other and then further subdivided into blocks to form plots (Figure 11). Woody vegetation data were analysed using the Biomass Estimates for Canopy Volume technique (BECVOL)(Smit 1996) as well as multivariate analysis (Ter Braak 1987).

Biomass Estimates for Canopy Volume (BECVOL)

BECVOL is a descriptive model that provides estimates of the actual leaf volume and leaf mass of individual trees from which Evapotranspiration Tree Equivalents (ETTE) and Browse Tree Equivalents (BTE) are derived (Smit 1996). In addition to total leaf dry mass per hectare, stratified estimates of leaf dry mass below 1.5, 2.0 and 5.0 m respectively are also calculated. The calculation of these evapotranspiration tree equivalents and browse tree equivalents is based on the relationship between the spatial volume of a tree and its true dry mass and true leaf volume (Smit 1996). The description of an *ideal* tree provides the basis for the calculation of the spatial volume of any tree, regardless of its shape or size (Figure 12). The spatial canopy volumes are calculated by using the following measurements:

- Total height of tree (A) in metres
- Height of tree at maximum canopy diameter (B) in metres
- Height of first leaves or potential leaf bearing stems (C) in metres
- Maximum canopy diameter (D) in metres
- Base diameter of the foliage at height C (E) in metres

For this analysis the three ranges namely Range 1, Range 2, and Range 3 were analysed separately. The three ranges had the following transect surface areas Range 1 : 1620 m^2, Range 2 : 3740 m^2 and Range 3 : 3680 m^2.

Multivariate Analysis (Canonical Ordination)

Canonical Ordination (CANOCO) is designed for data analysis in community ecology. It is a technique for relating the composition of species communities to their environment (Ter Braak, 1987). For the woody vegetation CANOCO was used in two ways in the present study. Firstly in an exploratory way which produced an ordination diagram of site, species and environmental variables, and secondly in a confirmative way which lead to statistical confirmation of the effects of particular environmental variables on community composition, taking the effect of other variables into account. First a Principal Components Analysis (PCA), which is a direct gradient analysis, was run to define the relationship between sites and species. In total 72 species and 226 sites were analysed. Indirect gradient analysis was then used to determine the effect of the environmental variables on the community composition. A Detrended Canonical Correspondence Analysis (DCCA) was then done to determine whether the data follow a linear or a unimodal distribution, and a Canonical Correspondence Analysis (CCA) was done to determine the effect of the environmental variables on the species data. The following environmental variables were included: percentage rock, rock size, aspect and slope.

Herbaceous vegetation composition

The dry-weight rank method was used to analyse the herbaceous vegetation composition ('t Mannetjie and Haydock, 1963). Plots of 1 by 1 m were placed at random within the larger plots that were used for the woody vegetation analysis, and all species present were recorded (Figure 11). Estimates were made of which species were the most abundant, second most abundant and third most abundant in terms of percentage dry weight. When no difference in rank could be observed the rank was allocated equally to the species. Once all the data were collected they were tabulated to give the proportion of quadrates in which each species occurred most abundantly, second most abundantly and third most abundantly. These proportions were then multiplied by the factors 70.19, 21.08 and 8.73 respectively and were then added to give the dry weight percentage of each species ('t Mannetjie and Haydock, 1963).

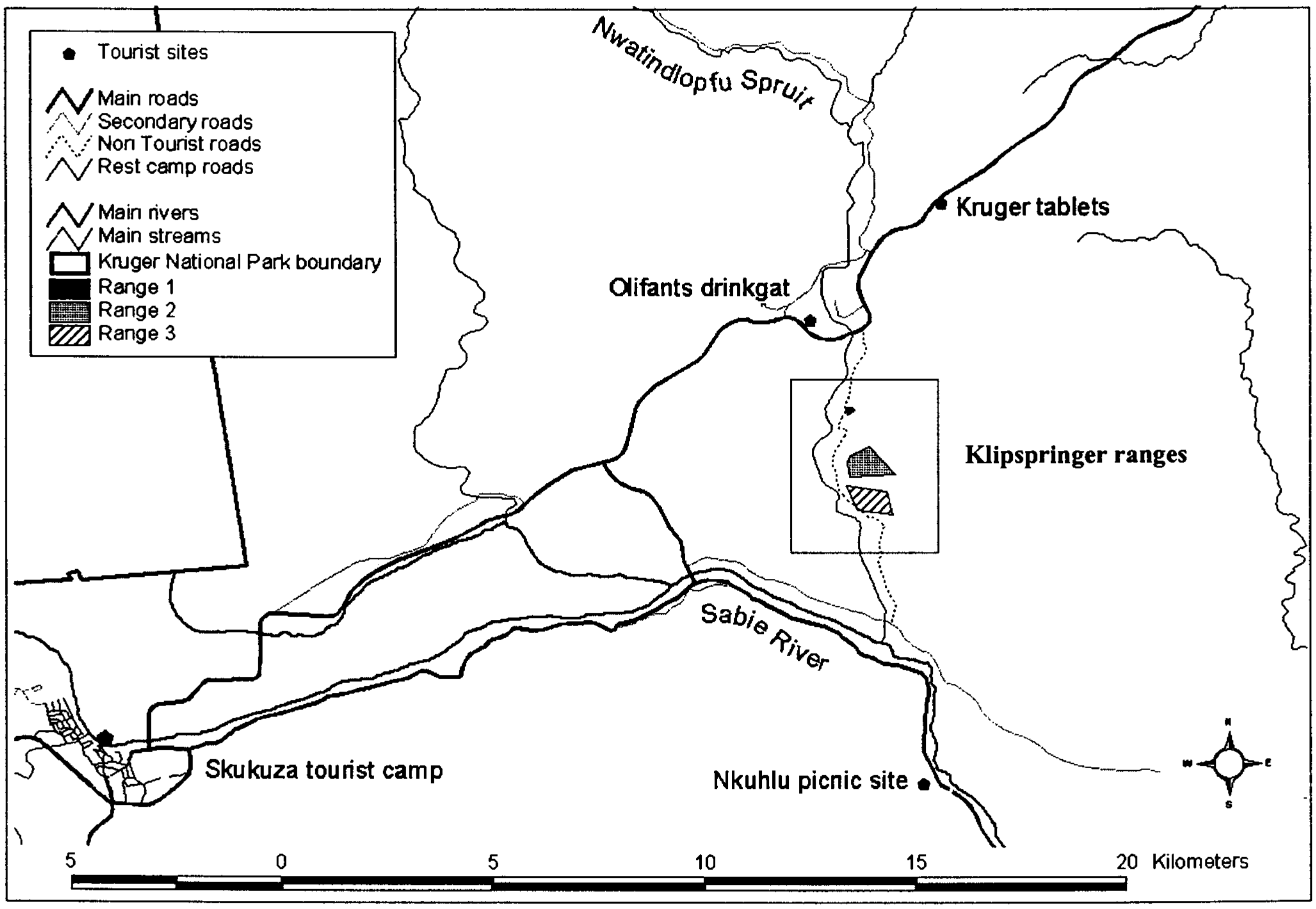

Figure 10. Location of the three klipspringer ranges used for intensive studies in the Central District of the Kruger National Park from 1995 to 1997.

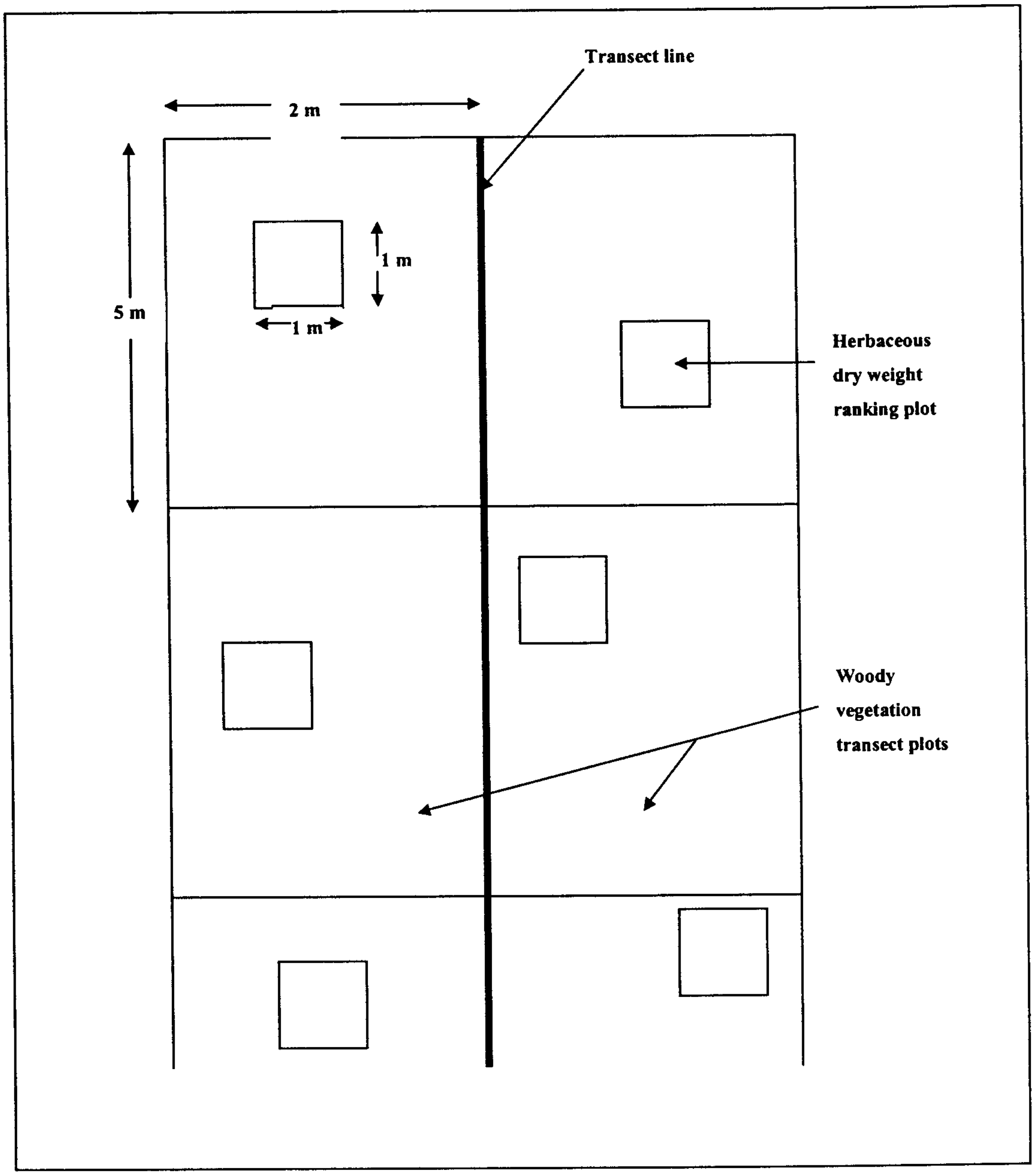

Figure 11. Transect layout and plot placements for the woody and herbaceous vegetation surveys respectively in the klipspringer habitat in the Central District of the Kruger National Park from 1995 to 1997.

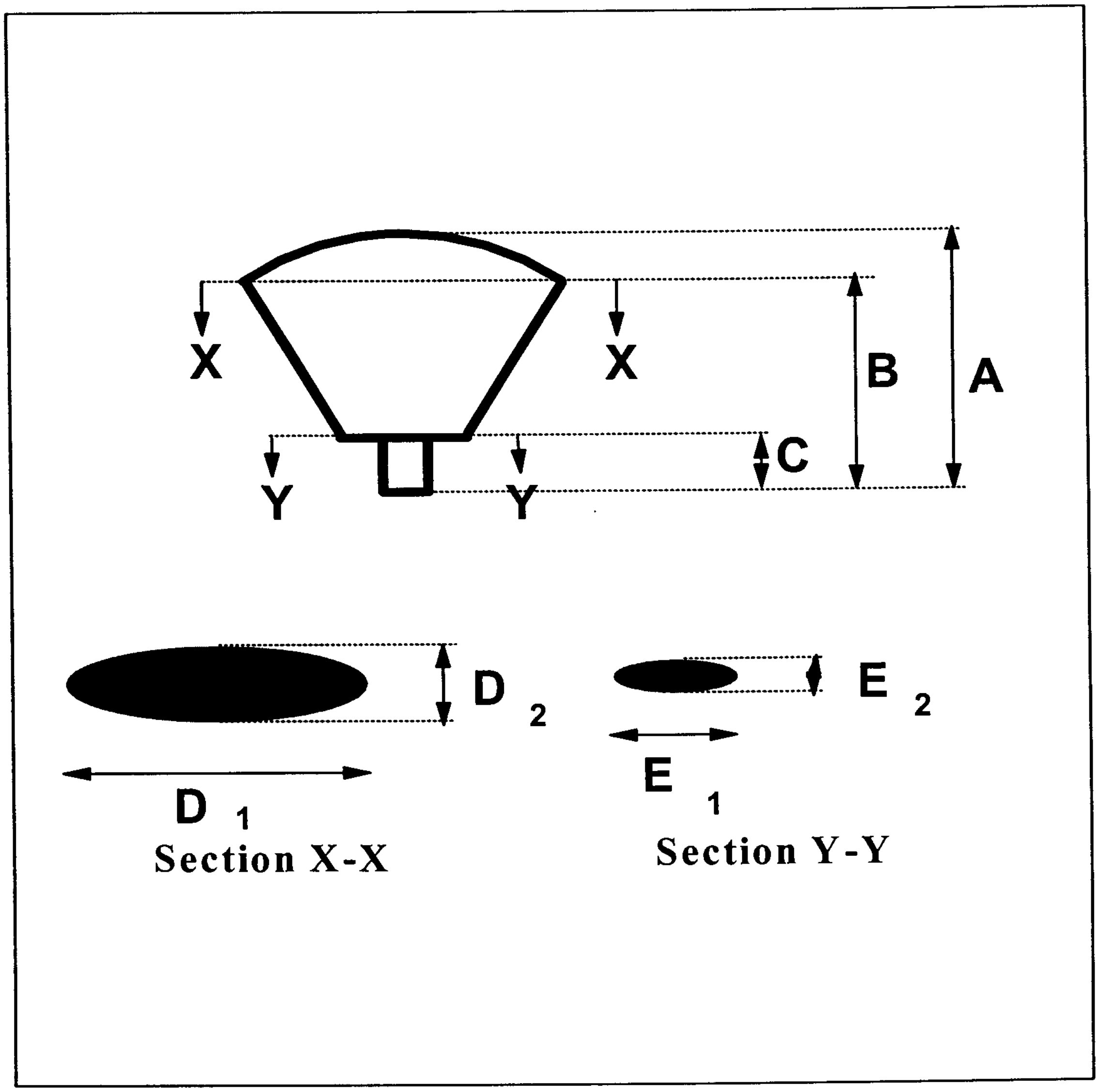

Figure 12. **Schematic illustration of an ideal tree, its measurements and structure as it was used to calculate the spatial volume of a tree where: A is the total height of tree in metres, B is the height of tree at maximum canopy diameter in metres, C is the height of first leaves or potential leaf bearing stems in metres, D is the maximum canopy diameter in metres and E is the base diameter of the foliage at height C in metres.**

Similarity index of the plant community

It was lastly necessary to determine if there was any similarity between the three ranges occupied by klipspringer concerning the vegetation. This was done separately for both the woody vegetation as well as the herbaceous vegetation. It is often difficult to establish a general acceptable degree of similarity in combining individual plant communities into an association. Similarity relations can, however, be expressed mathematically, and a set of arbitrary limits can then be set on a mathematical basis. These mathematical expressions of community similarity are referred to as indices of similarity (Mueller-Dombois and Ellenberg 1974).

The mathematical expression of Jaccard (1901, 1912, 1928) that is based on the presence-absence relationship between the number of species common to two areas and the total number of species was used to determine the similarity between the three ranges. This index is calculated with the use of the following equation (Index of Similarity of Jaccard = IS_J):

$$IS_J = \frac{c}{A + B - c} \times 100$$

Where c is number of species common to the two areas, A is the total number of species in area 1 and B is the total number of species in area 2.

Results and discussion

On-site cover analysis

Factors affecting klipspringer activity: model fitting

The change in deviance and corresponding number of degrees of freedom for each of the significant variables for the activities of resting, observing, hiding and fleeing are shown in Table 6. The data for the activities of browsing, mating and grooming were insufficient to be able to fit a model to it.

Resting

The individual variables that had the greatest predictive power by yielding the greatest drop in deviance were visibility at a height of 0.6 m and 1.2 m. Klipspringer rested in areas that had a visibility at 0.6 m of less than 50%, or in other words a cover value of more than 50% (Figure 13). Once the visibility increased above this they did not use these areas for resting. Klipspringer also rested in areas where the visibility at a height of 1.2 m was greater than 50% (Figure 14). The reason for this is that when klipspringer are resting they do not want to be too conspicuous but still want to be able to see out for possible danger, where one of the individuals in a group are resting on a higher point with good visibility while the other(s) are at a lower point between vegetation, rocks or other inanimate objects. The critical percentage cover and height for this activity is thus more than 50% cover at height 0.6 m and less than 50% cover at height 1.2 m.

Observing

The only significant variable was wind direction but it had a small deviance and this relationship was therefore regarded as a coincidence.

Hiding

The individual variables on their own that had the greatest predictive power by resulting in the greatest drop in deviance were visibility at a height of 1.5 m and 1.8 m. This activity occurred more often when the visibility at 1.5 m was greater than 50% (Figure 15). It declined once the visibility at a height of 1.8 m was greater than 50% (Figure 16).

Fleeing

The individual variables that had the greatest predictive power was herbaceous cover and visibility at a height of 0.6 m. Fleeing was more prevalent into areas where the herbaceous cover was greater than 60% (Figure 17) and where the visibility at a height of 0.6 m was greater than 50% (Figure 18). In such areas klipspringer tend to be more conspicuous and they therefore had a greater tendency to flee.

Table 6. Changes in deviance of the significant variables on removing them individually from the model for the different activities of klipspringer in the Kruger National Park from 1995 to 1997. A variable was considered significant when the change in deviance associated with it exceeded the chi-squared critical value at $P<0.05$ for the number of degrees of freedom that the variable conferred. The level of significance is listed in the probability column.

VARIABLE	DEGREES OF FREEDOM	CHANGE IN DEVIANCE	PROBABILITY
Resting			
Wind direction	10	32.208	<0.05
Visibility at a height of 0.6 m	1	9.779	<0.05
Visibility at a height of 0.9 m	1	4.843	<0.05
Visibility at a height of 1.2 m	1	9.983	<0.05
Visibility at a height of 2.1 m	1	4.255	<0.05
Visibility at a height of 2.4 m	1	4.563	<0.05
Percentage obstruction by vegetation	1	5.331	<0.05
Herbaceous cover	1	5.071	<0.05
Aspect	3	13.219	<0.05
Observing			
Wind direction	10	14.116	<0.05
Hiding			
Wind direction	10	39.5993	<0.05
Visibility at a height of 0.9 m	1	4.6760	<0.05
Visibility at a height of 1.5 m	1	6.1381	<0.05
Visibility at a height of 1.8 m	1	5.9041	<0.05
Herbaceous cover	1	5.1320	<0.05
Fleeing			
Visibility at a height of 0.6 m	1	7.5482	<0.05
Visibility at a height of 1.2 m	1	7.4954	<0.05
Visibility at a height of 1.8 m	1	4.8972	<0.05
Herbaceous cover	1	11.9548	<0.05
Aspect	3	11.9927	<0.05

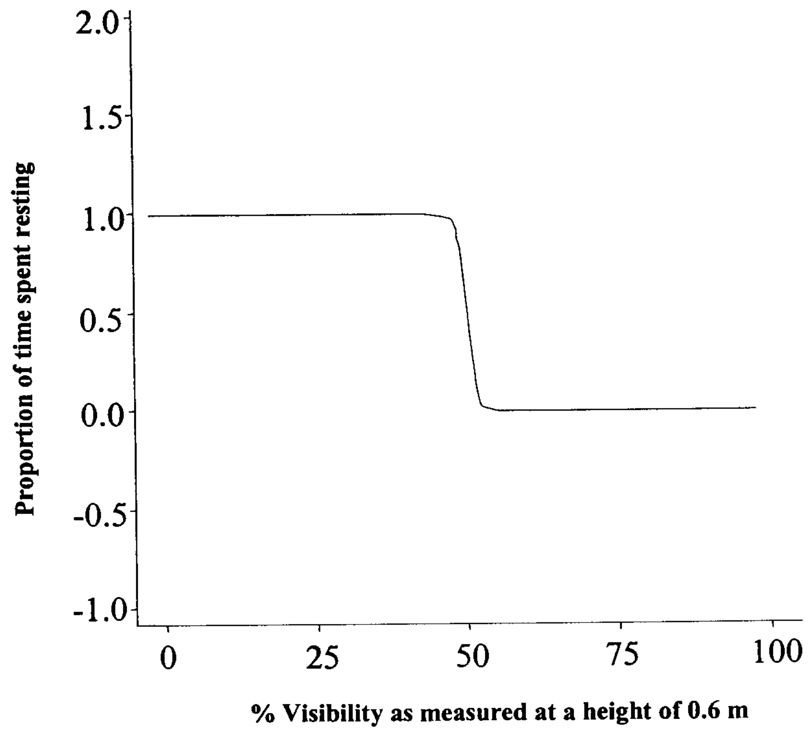

Figure 13. Predicted proportion of time that klipspringer spent resting with an increasing visibility as measured at a height of 0.6 m and as recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

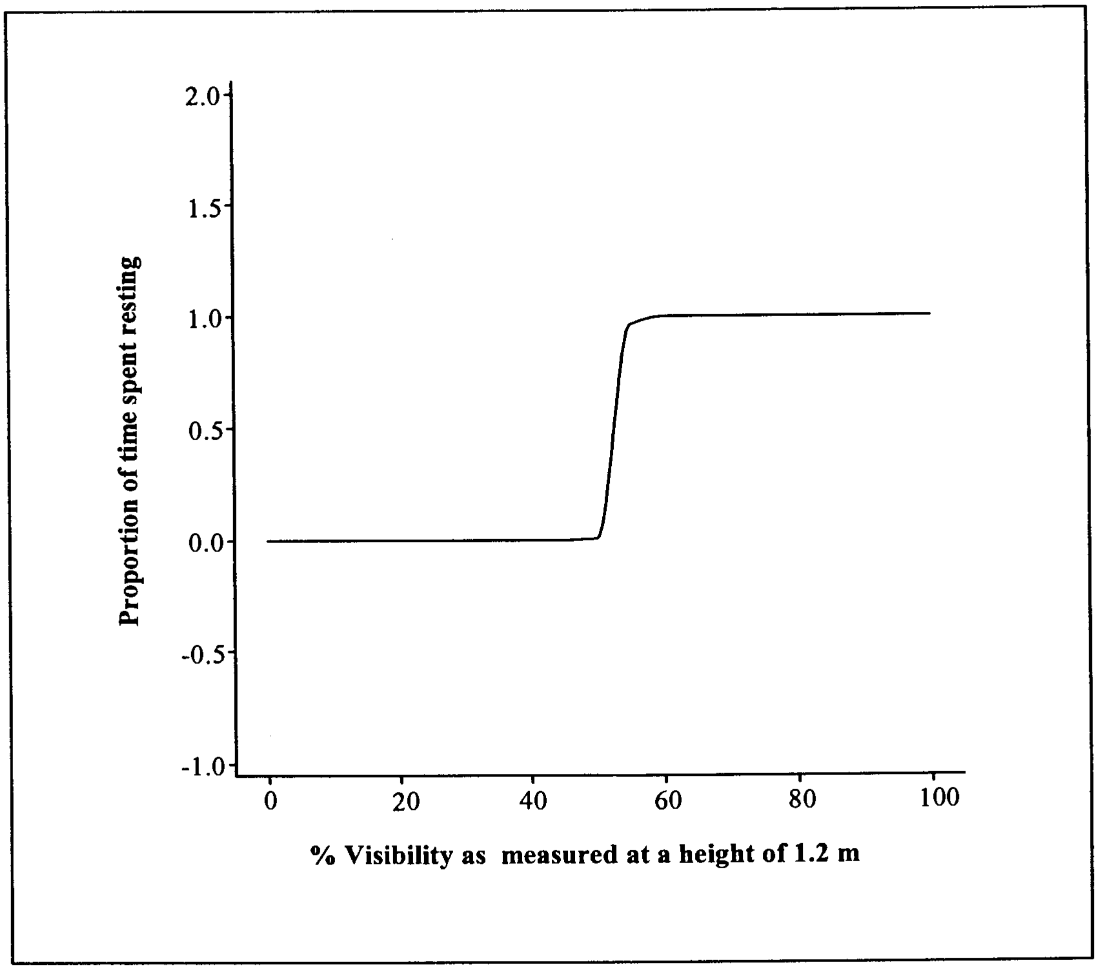

Figure 14. Predicted proportion of time that klipspringer spent resting with an increasing visibility as measured at a height of 1.2 m and as recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

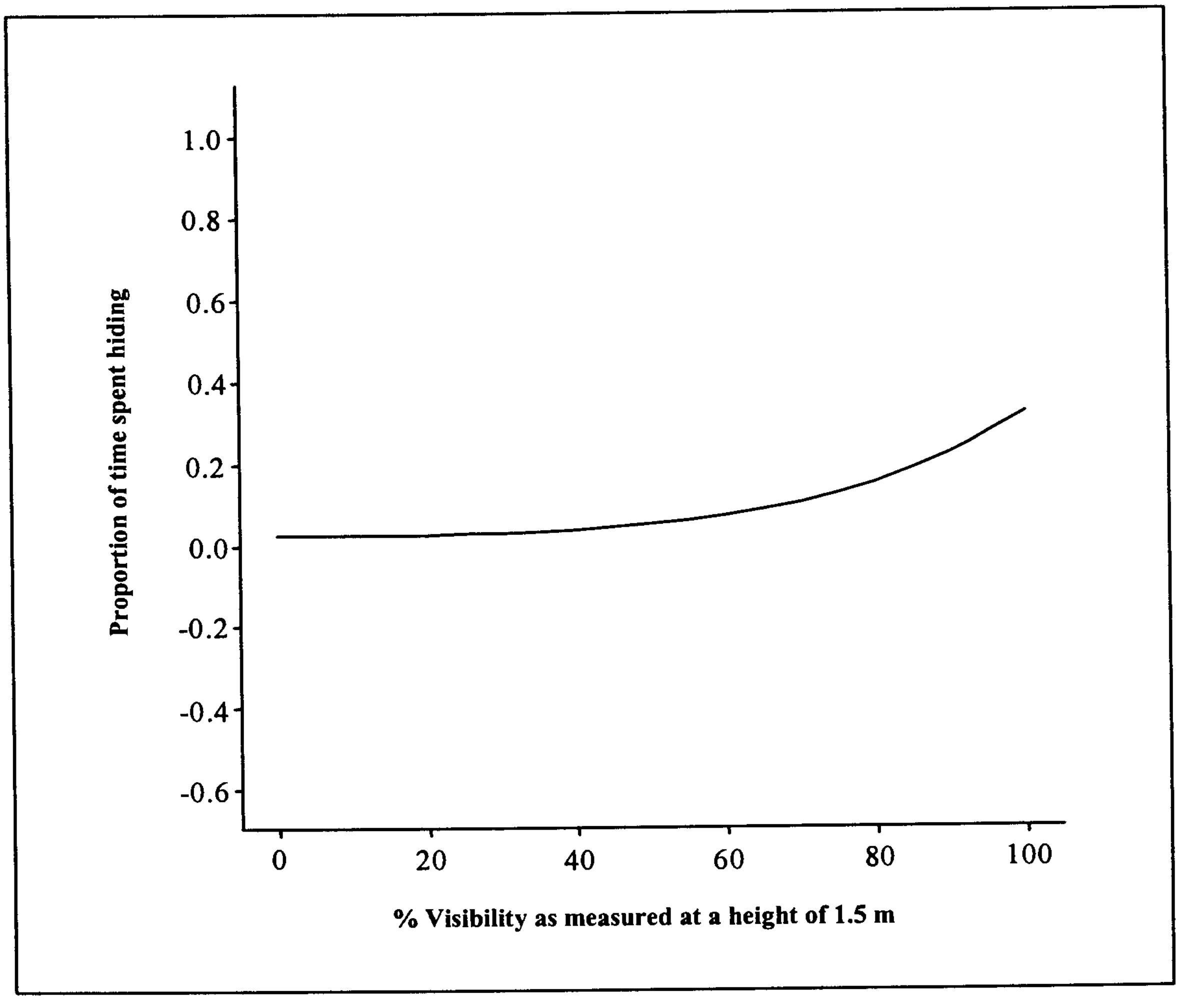

Figure 15. Predicted proportion of time that klipspringer spent hiding with an increasing visibility as measured at a height of 1.5 m and as recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

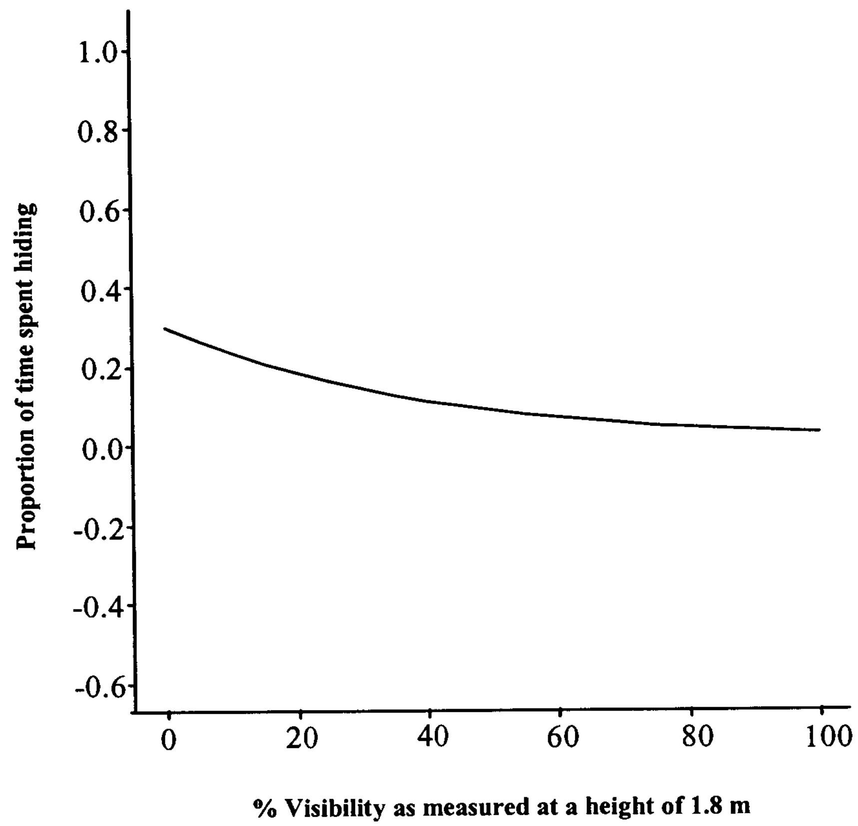

Figure 16. **Predicted proportion of time that klipspringer spent hiding with an increasing visibility as measured at a height of 1.8 m and as recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.**

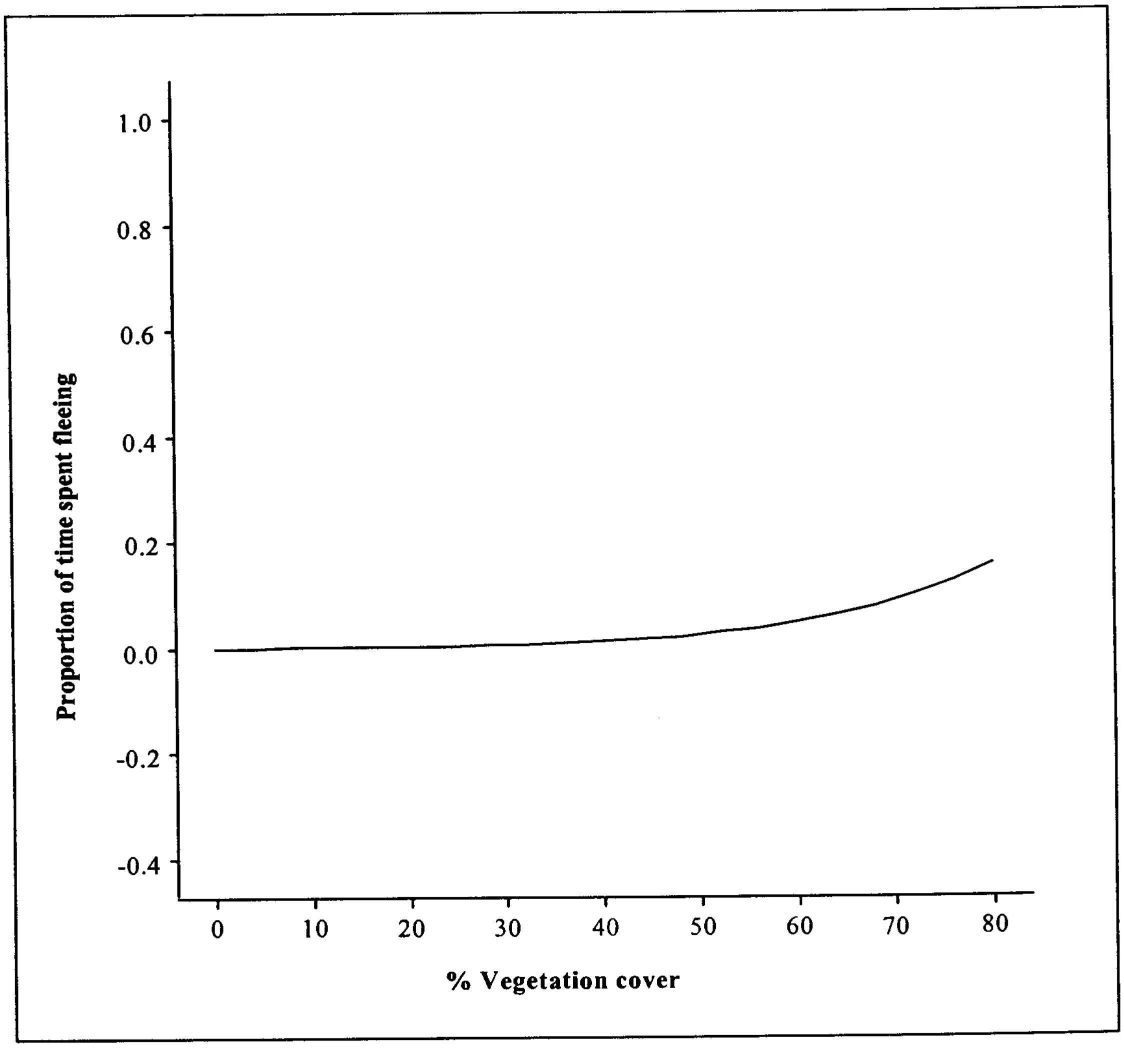

Figure 17. The predicted effect that the percentage vegetation cover has on the fleeing activity of klipspringer as observed in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

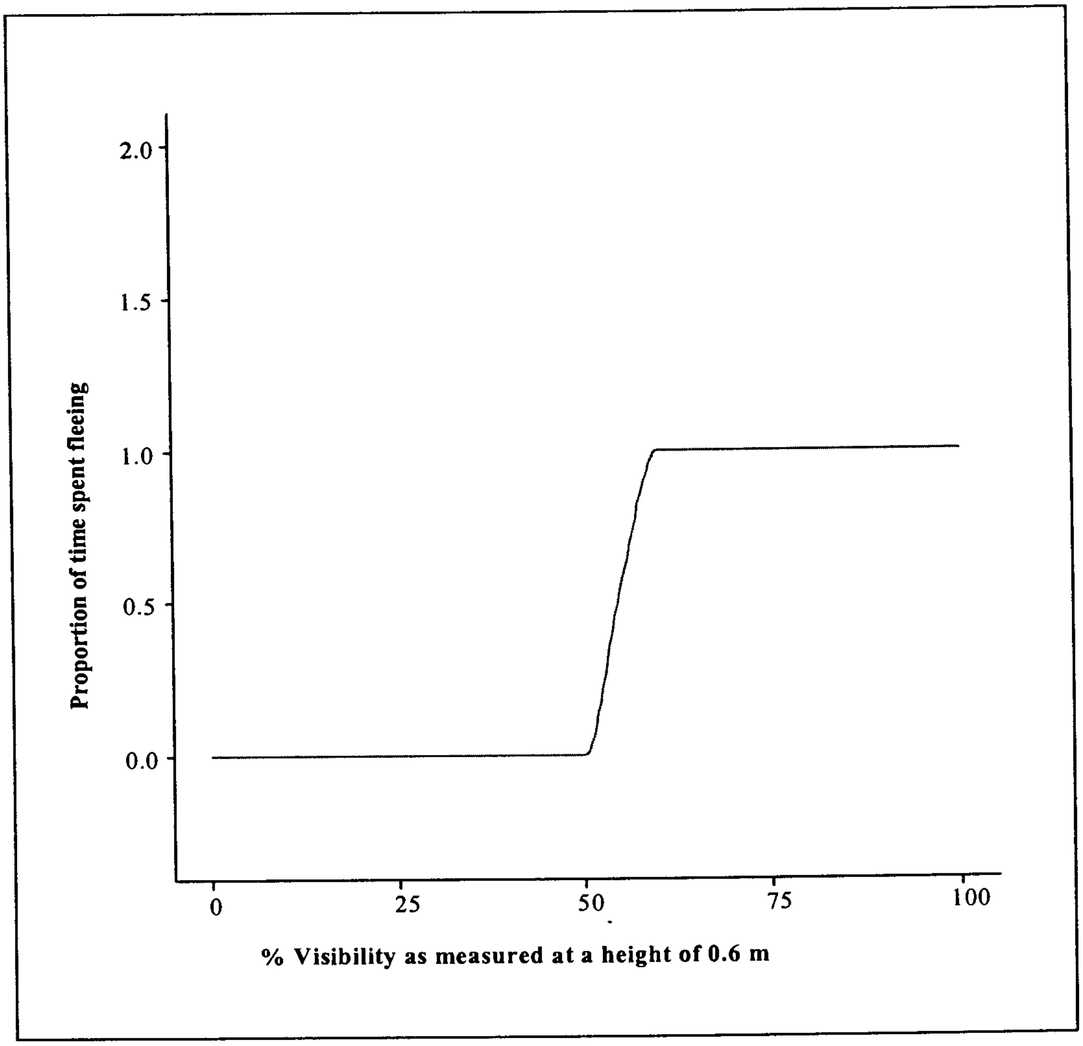

Figure 18. **Predicted proportion of time that klipspringer spent fleeing with an increasing visibility as measured at a height of 0.6 m and as recorded in the three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.**

Woody vegetation structure and composition

Biomass Estimates for Canopy Volume (BECVOL)

The three ranges were analysed separately. Table 7 illustrates the woody vegetation species present at each site. The woody vegetation density of Range 1 was 2 459 plants per hectare and it is dominated by the height class 0 - < 0.75 m (Table 8). The dominant species present are *Strychnos madagascariensis, Dichrostachys cinerea, Maytenus heteorphylla* and *Maytenus senegalensis.*

The woody vegetation density of Range 2 was 3 695 plants per hectare and it is also dominated by the height class 0 - < 0.75 m (Table 8). The dominant species present are *Strychnos madagascariensis, Dalbergia melanoxylon, Tricalysia junodii* and *Acacia nigrescens.*

The woody vegetation density of Range 3 was 3 139 plants per hectare and it is also dominated by the height class 0 - < 0.75 m (Table 8). The dominant species present are *Tricalysia junodii, Ochna pretoriensis, Protasparagus setaceus* and *Hippocratea longipetiolata.*

When running the BECVOL secondary calculations, the following species were omitted in the calculations because their contribution to the dry mass presentation was too small to be included. Range 1: *Ehretia rigida, Ficus abutilifolia, Ormocarpum trichocarpum, Rhynchosia totta* and *Ximenia caffra.* Range 2: *Euclea divinorum, Ochna natalitia, Ormocarpum trichocarpum, Solanum coccineum, Solanum incanum* and *Terminalia pruniodes.* Range 3: *Ehretia obtusifolia, Euclea divinorum, Fockea angustifolia, Pappea capensis, Solanum coccineum* and *Terminalia pruniodes.*

Table 9 gives a summary of the BECVOL secondary calculations for the different klipspringer ranges studied. Looking at the leaf dry mass per hectare it can be seen that Range 2 had the highest leaf production and tree equivalents per hectare which is a direct indication that this area has more dense vegetation than Ranges 1 and 3. Range 2 differs from Ranges 1 and 3 in that it is not a prominent koppie, but an almost flat area, with scattered rocks. This range is also utilized by other animals like the steenbok, duiker,

Table 7. Woody vegetation species present (X) in three klipspringer ranges studied to determine their woody vegetation structure and composition in the Central District of the Kruger National Park from 1995 to 1997.

SPECIES	RANGE 1	RANGE 2	RANGE 3
Acacia nigrescens	X	X	X
Acacia senegal	-	X	X
Acacia exuvialis	X	-	-
Adenium multiflorum	-	-	X
Albizia forbesii	X	-	X
Balanites maughamii	-	X	X
Cassia abbreviata	-	X	X
Cassia petersiana	X	-	X
Cissus cornifolia	X	X	X
Cissus rotundifolia	X	-	-
Combretum apiculatum	X	X	X
Combretum hereroense	X	X	X
Combretum mossambicense	X	X	X
Combretum zeyheri	X	X	X
Commiphora africana	-	X	X
Commiphora mollis	-	-	X
Commiphora neglecta	-	-	X
Dalbergia melanoxylon	X	X	X
Dichrostachys cinerea	X	X	X
Diospyros mespiliformis	X	X	X
Ehretia rigida	X	X	X
Erythrina humeana	-	X	-
Euclea divinorum	X	X	X
Euclea natalensis	X	-	-
Euphorbia cooperi	X	-	X
Ficus abutilifolia	X	-	X
Fockea angustifolia	-	-	X
Grewia bicolor	-	X	X
Grewia caffra	X	-	-
Grewia flavescens	X	X	X
Grewia hexamita	-	X	X
Grewia monticola	X	-	-
Hippocratea longipetiolata	X	X	X
Jatropha varifolia	X	-	X
Lannea schweinfurthii	X	X	X

Table 7 (continued)

Lonchocarpus capassa	X	-	-
Maerua parvifolia	X	X	X
Manilkara mochisia	-	X	-
Maytenus heterophylla	X	X	X
Maytenus senegalensis	X	-	-
Ochna natalitia	X	X	X
Ochna pretoriensis	-	X	X
Ormocarpum trichocarpum	X	X	-
Ozoroa engleri	-	X	-
Pappea capensis	X	-	X
Protasparagus setaceus	X	X	X
Protasparagus subulatus	X	X	X
Pterocarpus rotundifolius	-	X	-
Ptaeroxylon obliquum	-	-	X
Rhoicissus tridentata	X	X	X
Rhynchosia totta	X	X	-
Schotia brachypetala	X	X	-
Sclerocarya birrea	X	X	X
Securinega virosa	X	X	X
Solanum coccineum	-	X	X
Solanum incanum	-	X	-
Solanum panduriforme	-	X	-
Spirostachys africana	X	X	X
Sterculia rogersii	X	X	X
Strychnos madagascariensis	X	X	X
Tetradenia riparia	-	X	X
Terminalia pruniodes	-	X	X
Terminalia sericea	X	-	-
Tricalysia junodii	X	X	X
Turraea obtusifolia	X	-	X
Ximenia caffra	X	-	-
Ziziphus mucronata	X	X	X

Table 8. Density of woody vegetation at different height levels (m), expressed as a percentage of the total number of trees in the transects for each of three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

TREE HEIGHT	RANGE 1	RANGE 2	RANGE 3
0 - < 0.75	46	60	58
0.75 - < 1.50	25	19	22
1.50 - < 2.50	18	13	11
2.50 - < 3.50	6	3	4
3.50 - <5.50	3	3	3
≥5.50	2	2	2

Table 9. The secondary calculations from BECVOL, a descriptive model that provides estimates of the actual leaf volume and leaf mass of individual trees from which Evapotranspiration Tree Equivalents (ETTE) and Browse Tree Equivalents (BTE) are calculated, as used in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

CALCULATIONS	RANGE 1	RANGE 2	RANGE 3
Leaf volume in m^3 per ha	1229	1650	1221
Evapotranspiration Tree Equivalents per ha	2459	3303	2448
Leaf dry mass in kg per ha	546	735	537
Leaf dry mass in kg per ha below a browsing height of 1.5 m	109	124	167
Leaf dry mass in kg per ha below a browsing height of 2.0 m	182	184	178
Leaf dry mass in kg per ha below a browsing height of 5.0 m	428	535	437
Browse Tree Equivalents per ha	2184	1255	2163
Browse Tree Equivalents per ha below a browsing height of 1.5 m	434	555	498
Browse Tree Equivalents per ha below a browsing height of 2.0 m	729	857	724
Browse Tree Equivalents per ha below a browsing height of 5.0 m	1710	2287	1759
Canopied Subhabitat Index based on trees with a minimum height of 2.0 m	19.5	25.8	19.8
Canopied Subhabitat Index based on trees with a minimum height of 4.0 m	11.4	20.4	13.2

impala, kudu, and giraffe, whereas Ranges 1 and 3 are almost solely utilized by klipspringer.

Multivariate analysis (Canonical Ordination)

The data from three klipspringer ranges were analysed together. The results of the Principal Components Analysis (PCA) are illustrated in Table 10 and Figure 19. From Table 10 it is clear that the four axes account for 64.7% of the variation that is present in the species data. From Figure 19 it is clear that most of the woody vegetation is concentrated around the centre of the ordination diagram, with only a few plant species strongly influencing the axes. These species are *Dalbergia melanoxylon, Strychnos madagascariensis, Protasparagus setaceus* and *Ochna pretoriensis.* The angle formed when linking any two elements with the origin with a straight line gives a good indication of their relationship. When the angle that is formed in this manner is small, the elements are highly correlated with each other (Beardell, Joubert and Retief, 1984). The length of the arrow also indicates the power of this correlation. The longer the arrow the greater the degree of correlation. Because the angle formed by *Strychnos madagascariensis* and Axis 1 is small and the length of the arrow is long it indicates a strong correlation between Axis 1 and this plant species. This means that Axis 1 is strongly influenced by the presence of *Strychnos madagascariensis*. Similiarly Axis 2 is dominated by *Dalbergia melanoxylon, Ochna pretoriensis and Protasparagus setaceus.* Because *Dalbergia melanoxylon* and *Protasparagus setaceus* are on opposite sides of this axis they show a strong negative correlation with each other. This means that when the one occurs the other does not.

From the ordination diagram of the sites shown on Figure 20 it is clear that the site C35 found on the transect in Range 2 is closely associated with *Dalbergia melanoxylon*, sites Range 2 B19, Range 2 A11 and Range 2 A9 with *Strychnos madagascariensis* and sites Range 3 B33, Range 3 C19 and Range 3 B59 with *Protasparagus setaceus*. Range 1 appears to be centred around the middle of the ordination diagram. Even though Range 1 has a large proportion of *Strychnos madagascariensis* in comparison to that found in Range 2 it's contribution is small. Therefore the sites are not pulled out far along Axis 1.

Because the extent of sample scores obtained from the Detrended Canonical Correspondence Analysis (DCCA) was greater than 1.5 SD, a Canonical Correspondence Analysis (CCA) rather than a Redundancy Analysis (RDA) was performed on the data. This means that a unimodal model rather than a linear model fitted the data best. All the environmental variables as stated in the methods were included in this analysis because their inflation factors were all below 20, which suggested that there is no colinearity between variables. The environmental variables included in this ordination of vegetation data were sufficient and appropriate to explain the vegetation composition. Moreover the CCA ordination and first axis were both significant ($P < 0.005$). Although the first four axes of the CCA accounted for only a small amount of variation in the species data, 91.9% of variance in the species-environmental relationship was accounted for by it (Table 11).

The environmental variables of percentage rock and rock size had the most effect on the ordination. Even though the variable aspect and slope were not significant (Table 12) they were included because they are responsible for determining the variation at 11 and 8% respectively.

From Figure 21 it can be seen that the presence of *Tetradena riparia*, *Commiphora neglecta* and *Ochna natalitia* is clearly related to the percentage rock and the slope. *Fockea angustifolia*, *Grewia caffra*, *Acacia senegal* and *Ormocarpum trichocarpum* are all related to aspect. *Ozoroa engleri* and *Erythrina humaena* are related to position, and *Pterocarpus rotundifolius* to rock size. Most of the other woody plant species are grouped around the centre of the ordination. This means that they are equally affected by all the variables measured. Range 3 A25, Range 3 A23, Range 1 C13 and Range 3 C21 are closely related to percentage rock, Range 3 C3, C5, C17 and C19, Range 1 C5 and Range A14 are closely related to slope. Range 3 C1, Range 2 B43, B17 and Range 2 A49, A23 are closely related to aspect and Range 3 B37 is closely related to rock size (Figure 22).

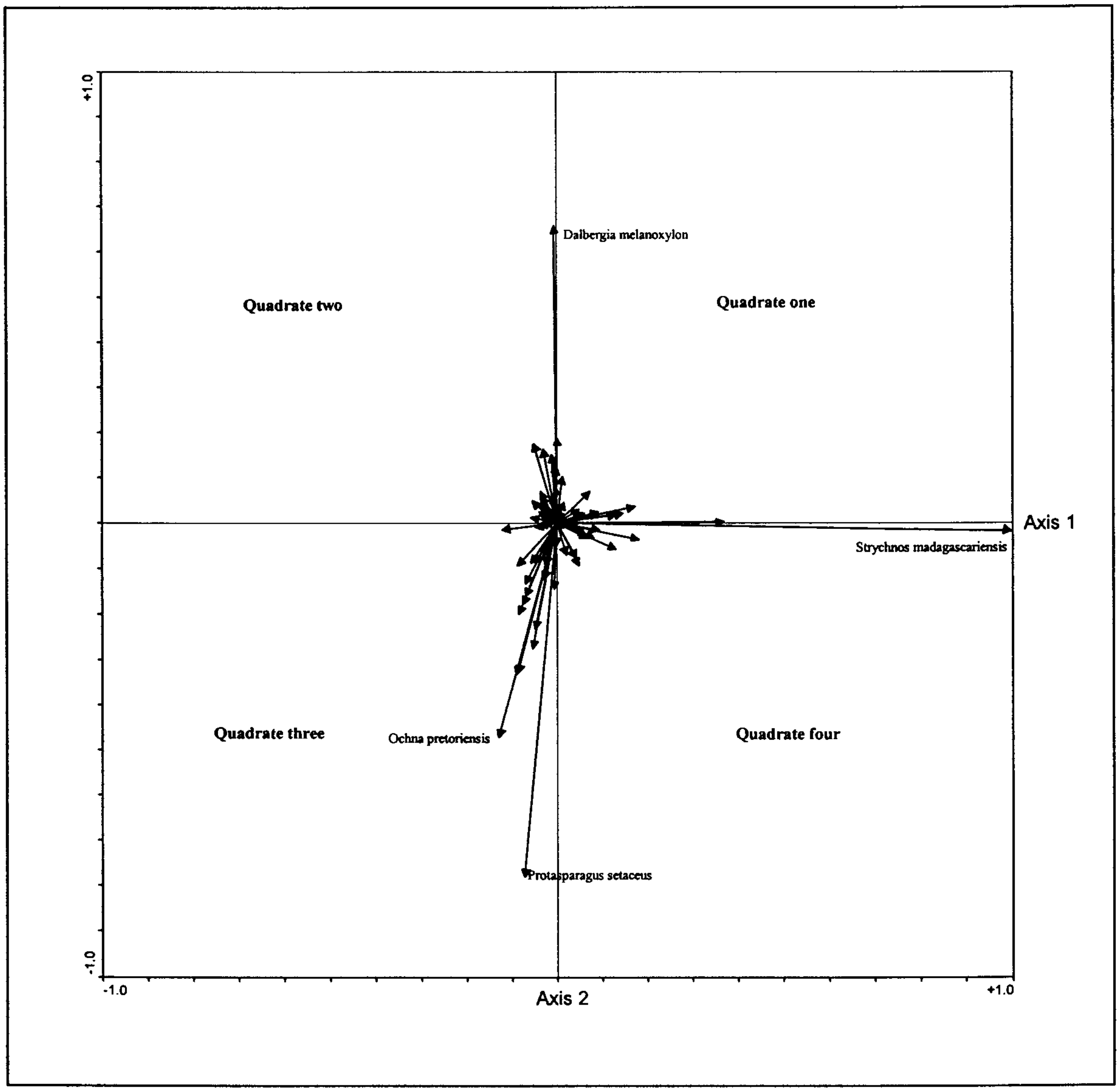

Figure 19. A plot of the first two axes of the Principal Components Analysis (PCA) of all the woody vegetation species data recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

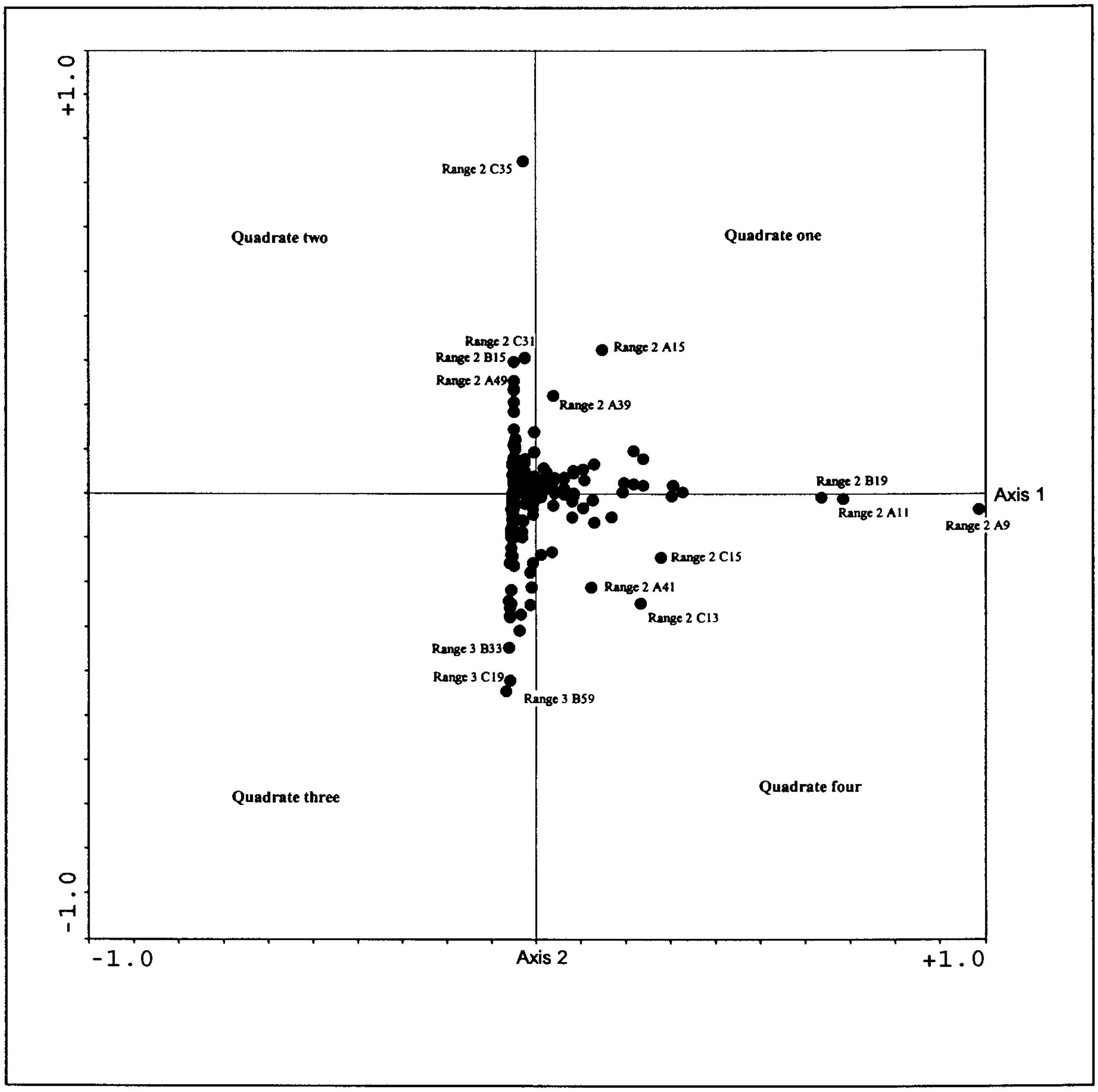

Figure 20. A plot of the first two axes of the Principal Components Analysis (PCA) of all the woody vegetation and site data recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

Table 10. Results of the Principal Components Analysis (PCA) performed on the woody vegetation data collected in three klipspringer ranges in the Central district of the Kruger National Park from 1995 to 1997.

	AXIS			
TYPE OF DATA	**1**	**2**	**3**	**4**
Eigenvalues	0.419	0.104	0.080	0.044
Cumulative percentage variance of species data	41.9	52.3	60.3	64.7

Table 11. Results of the partial Canonical Correspondence Analysis (CCA) performed on the woody vegetation and environmental data collected in three klipspringer ranges in the Central district of the Kruger National Park from 1995 to 1997.

	Axis			
TYPE OF DATA	**1**	**2**	**3**	**4**
Eigenvalues	.306	.129	.104	.074
Species-environment correlation's	.778	.585	.567	.512
Cumulative percentage variance				
Species data	2.5	3.5	4.4	5.0
Species-environment relation	45.8	65.2	80.8	91.9
Regression coefficients				
Percentage Rock	7.2796	7.9152	.7804	2.0926
Rock Size	7.5852	-7.0017	4.3477	-.8397
Position	-4.4414	-.3778	3.6343	-2.7094
Aspect	-3.7575	2.2426	6.6652	2.6022
Slope	1.1942	3.2152	-.737	-8.0713

Table 12. Results from the forward selection procedure and Monte Carlo permutation test performed on the environmental variables collected in the three klipspringer ranges in the Central district of the Kruger National Park from 1995 to 1997, showing the importance of each variable.

VARIABLE	VARIANCE N	LAMBDA 1	P	F
Marginal effects				
Percentage rock	1	0.24	-	-
Rock size	2	0.23	-	-
Aspect	4	0.15	-	-
Position	3	0.11	-	-
Slope	5	0.08	-	-
Conditional effects				
Percentage rock	1	0.24	0.005	4.42
Rock size	2	0.16	0.005	2.96
Aspect	4	0.11	0.005	2.20
Slope	5	0.08	0.115	1.49
Position	3	0.08	0.020	1.47

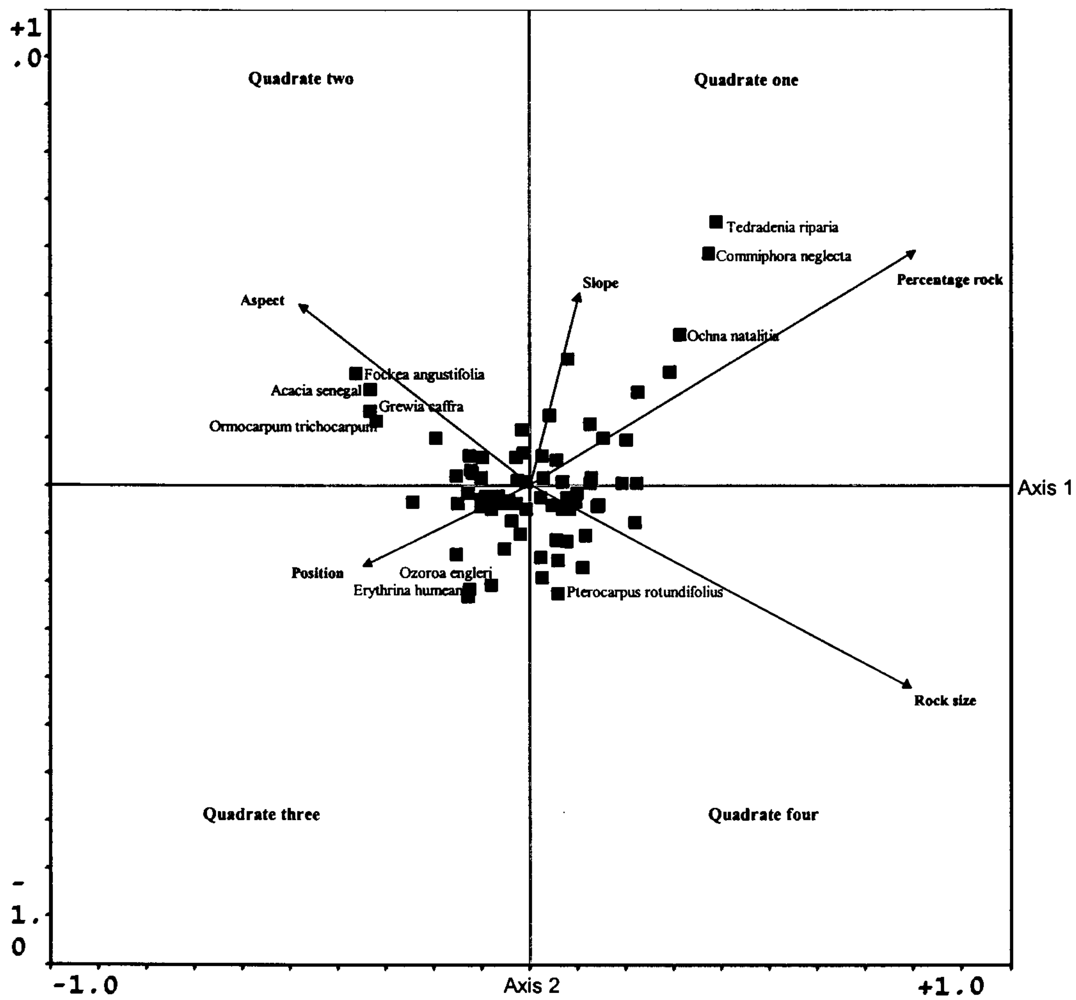

Figure 21. A plot of the first two axes of the Canonical Correspondence Analysis (CCA) of all the woody vegetation species and environmental data recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

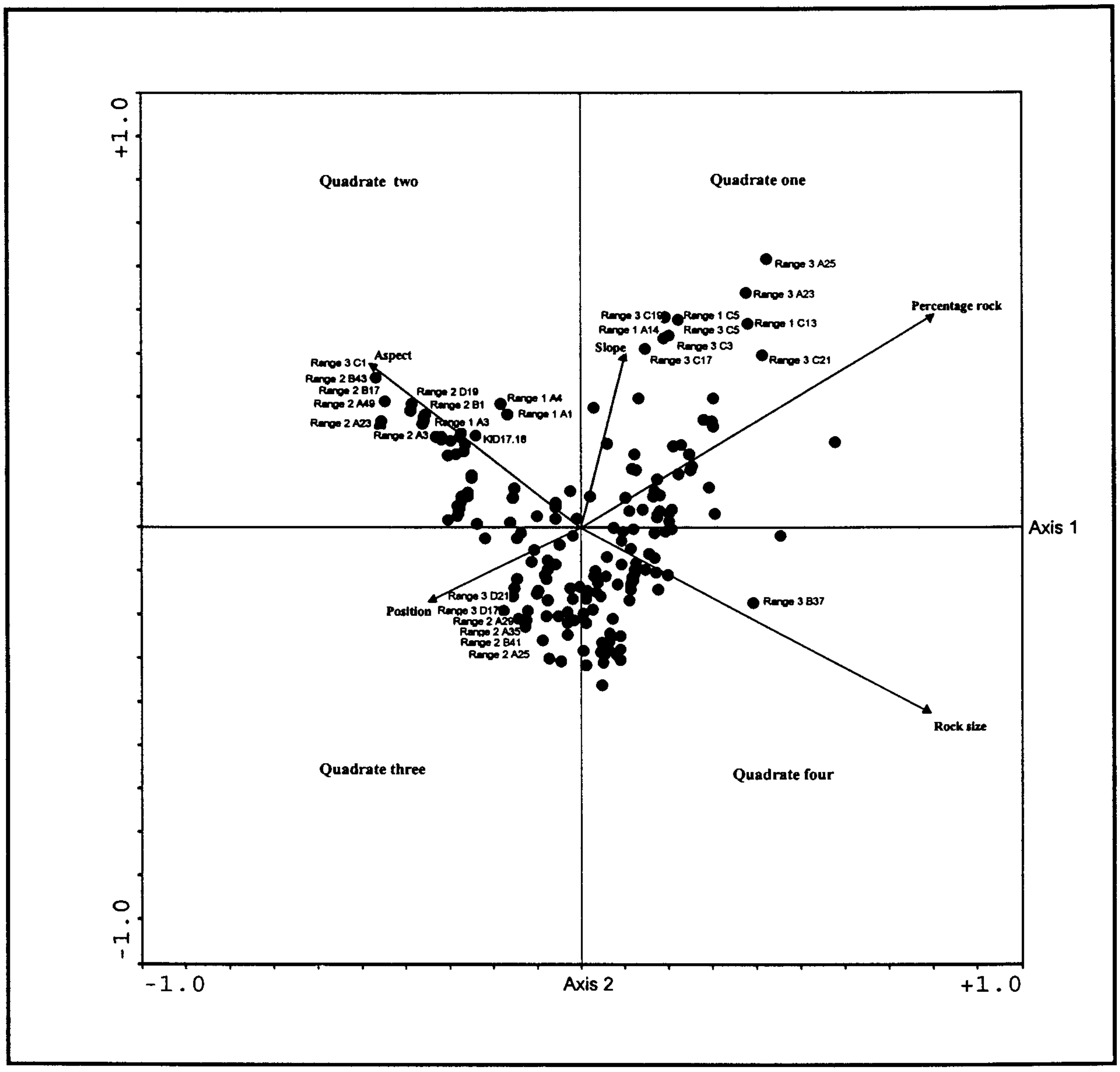

Figure 22. A plot of the first two axes of the Canonical Correspondence Analysis of all the woody vegetation site and environmental data recorded in three klipspringer ranges studied in the Central District of the Kruger National Park from 1995 to 1997.

Table 13. Dry weight percentages of the herbaceous vegetation species that make up 1% and more of the dry weight in three klipspringer ranges in the Central district of the Kruger National Park from 1995 to 1997.

	RANGE		
PLANT SPECIES	**1**	**2**	**3**
Aristida adscensionis	9.23	23.90	13.41
Aristida congesta	-	9.85	4.42
Acalypha indica	1.17	2.04	1.04
Aspilia mossambicensis	1.32	-	-
Aristida sciurus	5.22	-	-
Bothriochloa insculpta	2.66	-	-
Bothriochloa radicans	-	2.40	-
Digitaria eriantha	6.05	1.55	1.40
Dicoma tomentosa	-	-	2.09
Eragrostis biflora	7.25	-	1.20
Enneapogon cenchroides	-	3.89	6.57
Heteropogon contortus	3.13	9.28	5.87
Hibiscus engleri	-	-	1.10
Hyparrhenia hirta	2.70	-	-
Hibiscus micranthus	-	-	2.65
Kyphocarpa angustifolia	-	1.07	-
Melinis repens	-	-	1.60
Panicum maximum	44.90	22.68	39.70
Pogonarthria squarrosa	-	-	1.28
Rhynchosia totta	-	-	1.01
Schmidtia pappophoroides	1.29	-	-
Sorghum versicolor	-	1.91	-
Themeda triandra	1.15	4.65	-
Urochloa mosambicensis	5.28	9.06	1.80
Urochloa oligotricha	1.82	-	-

Looking at the lengths of the arrows and angles of the environmental variables related to the axes, Axis 1 is dominated by rock size and percentage rock and Axis 2 by slope and aspect. Range 1 is once again largely centred around the middle of the ordination diagram. Range 3 features prominently in quadrate one and is therefore correlated with percentage rock. Range 2 features prominently in quadrates two and three and is therefore correlated with aspect and position. Because percentage rock and rock size are positively correlated with each other and are also strongly correlated with Axis 1, it would appear that Axis 1 represents a gradient of rockiness. Quadrates one and four have more and bigger rocks than quadrates 2 and 3, indicating an increasing gradient from left to right along Axis 1. Slope is strongly correlated with Axis 2. This indicates a slope gradient with quadrate 1 having a steeper slope than quadrate 4 (Figure 22).

Herbaceous vegetation composition

Table 13 shows the dry weight percentages of the herbaceous vegetation species that make up 1% and more of the dry weight in three different klipspringer ranges. In Table 9 the secondary calculations from BECVOL are shown. This yields a canopied subhabitat index, which is defined as the canopy spread area of those trees in a transect under which *Panicum maximum* is most likely to occur (Smit 1989). It shows that Range 2 has the highest value. This should indicate that in Range 2 there is be a higher stand of *Panicum maximum*. However, this is not the case as seen in Table 13. The most likely explanation for this is that this area is probably overgrazed by the other animal species that also utilize the same area. Another indication of overgrazing is the species composition derived from the dry weight rankings of the herbaceous vegetation for the three ranges. The dry weight rankings are as follows:

Range 1: first *Panicum maximum* (44.90 %), second *Aristida adscensionis* (9.23%) and third *Eragrostis biflora* (7.25%). Range 2: first *Aristida adscensionis* (23.90%), second *Panicum maximum* (22.68%) and third *Heteropogon contortus* (9.28%). Range 3: first *Panicum maximum* (39.70%), second *Aristida adscensionis* (13.41%) and third *Enneapogon cenchriodes* (6.57%).

In Range 2 the increaser II and decreaser species are present in the same proportion. Increaser plant species are defined as species that dominate poor veld and increase with overgrazing, whereas decreaser species dominate in good veld, but decreases when veld is overgrazed (Van Oudtshoorn 1992). Ranges 1 and 3 on the other hand have a high decreaser to increaser species composition, the reason being limited access to Ranges 1 and 3. Only klipspringer can access this area due to its rocky nature, whereas Range 2 is also utilized by other animals that could have an impact on the vegetation composition.

Similarity index of the plant community

When the three klipspringer ranges are looked at subjectively, Ranges 1 and 3 seem to be similar because of their rockiness. Both these ranges are prominent koppies whereas Range 2 is almost flat with big and small rocks scattered over the whole range with big areas in between without any rocks. When deciding whether or not the three ranges can be considered similar, threshold values of more than 25 %, but less than 50 % are used as a guide. If the value is less than 25 % the ranges do not have a similar floristic composition, if on the other hand the value is more than 50 % the similarity is so great that differences should be looked for at a small scale (Mueller-Dombois *et al.* 1974).

Woody vegetation

Table 14 shows the similarity indices of the woody vegetation for the three klipspringer ranges. The similarity values between Ranges 1 and 2, Ranges 1 and 3 and Ranges 2 and 3 are 48.5, 45.7 and 52. 9 % respectively. This implies that the ranges are so similar with respect to the woody vegetation that the areas would have to be divided into much smaller subunits to be able to notice any differences between them (Mueller-Dombois *et al.* 1974).

Herbaceous vegetation

Table 14 shows the similarity indices of the herbaceous vegetation for the three klipspringer ranges. The similarity values between Ranges 1 and 2, Ranges 1 and 3 and Ranges 2 and 3 are 26.3, 28.5 and 27.0 % respectively. The ranges can also be regarded as similar with respect to the herbaceous vegetation, but the degree of similarity is less than that found in the woody vegetation.

Table 14. Calculations of Jaccard's index of similarity based on the plant species present in the three klipspringer ranges in the Central district of the Kruger National Park from 1995 to 1997.

	Range					
	1	**2**	**3**	**1 and 2**	**1 and 3**	**2 and 3**
Woody vegetation						
Number of species	48	50	54	-	-	-
Number of species common	-	-	-	32	32	36
Similarity index (%)	-	-	-	48.5	45.7	52.9
Herbaceous vegetation						
Number of species	41	60	67	-	-	-
Number of species common	-	-	-	21	24	27
Similarity index (%)	-	-	-	26.3	28.5	27.0

Conclusions

The activities of klipspringer appear to be correlated with certain clear environmental variables. Visibility as measured at different height levels is determined by both vegetation and rock. Visibility had the greatest influence on all the activities recorded. Visibility at a height of 0.6 m clearly influenced fleeing and resting. When the visibility was less than 50% the klipspringer rested in that area and once this increased above 50% the klipspringer avoided that specific area. When the visibility between 1.2 m and 1.8 m above the ground was greater than 50% the klipspringer either rested or hid in that area.

One of the three klipspringer ranges studied differed from the other two in that klipspringer occurred in an area that has no prominent koppie but is relatively flat and has fewer rocks than the other two. This range is also occupied by other ungulates that compete with the klipspringer for the same resources. However, this did not seem to disturb the klipspringer directly, but did so more indirectly because the other animals also attracted predators that on two occasions caught two klipspringer from one group. The other two ranges had prominent koppies in which the klipspringer were the only ungulate inhabitants. These two ranges provided escape cover and almost exclusive utilization by the klipspringer. When the vegetation of the three ranges was, however, compared it was found that they were similar in floristic composition and structure. Klipspringer occupied an area that at first glance seemed to be marginal habitat but the vegetation was suitable. Vegetation can therefore be a determining factor in the habitat selection of klipspringer.

The tendency observed in klipspringer to sometimes inhabit areas, which do not always provide the necessary security of rocks, gives the perception that there is a limit to the availability of klipspringer habitat in the Kruger National Park. The reason for this tendency being that all the available habitat is already occupied by other klipspringer. The proof is the fact that one young radio-collared male individual travelled in excess of 80 km in search of an unoccupied suitable habitat.

It would seem that klipspringer in the Kruger National Park can adapt well to less rocky areas as long as there is suitable vegetation. A woody vegetation density of between 2 500 and 3 700 plants per hectare with a dominated height class of < 0.75 m and a herbaceous cover of more than 60% seems to be ideal.

The ideal klipspringer habitat can therefore be described as an area that provides both shelter and sufficient visibility for the klipspringer to be able to see danger and hide from it when necessary. These areas should have limited access to other ungulates, which can attract predators. This attribute is normally provided in the form of rocks. Vegetation present should consist of palatable plant species that can be utilized by klipspringer, tall trees that provide shade, and shrubs and forbs that provide both shelter and serve as a source of food.

CHAPTER 6

SCENT-MARKING

Scent-marking behaviour has long been regarded as an important component of animal communication (Thiessen and Rice 1976). A number of hypotheses to explain why animals scent-mark have been put forward. These range from deterrence of intruders (Hediger 1949) to the establishment of a familiar smell within the range (Johnson 1973). A more recent hypothesis proposes that the scent advertises the identity of a range inhabitant to an intruder, enabling the latter to assess the holder's status, thus avoiding costly fights (Gosling 1982). Scent-marking is also considered to be associated with dominance in many animal species (Ralls 1971, Stoddard 1976, Brown and McDonald 1985, Kappeler 1990; and Somers, Rasa and Apps 1990).

Like other small antelope (Cohen and Gerneke 1976) both the male and female klipspringer scent-mark their ranges. This chemical communication functions as an unmistakable cue to ownership of a specific range. The scent is produced as a secretion by a pair of pre-orbital glands just below the eyes. The animal positions its head at a certain angle and rubs it against a suitable twig that normally points in an upward direction. A sticky, milky substance is secreted that has a sweet, aniseed-like scent.

The hypothesis for this preliminary study of scent-marking in the klipspringer in one study area in the Kruger National Park was that klipspringer would mark more frequently towards the boundaries of their territories, and also more frequently on those sides where there were resident neighbouring klipspringer in their proximity.

Materials and methods

Klipspringer scent marks were surveyed with the use of a strip transect method. The transects were placed out from the centre of the range of a specific klipspringer group in the Nwatindlopfu Spruit area that had neighbours on three sides (Figure 23). Each transect was 100 m wide and the survey was done from the centre to somewhat beyond the known boundary of the range of that group and in the four major wind directions. Each plant in the transect was inspected carefully for scent marks. When scent marks were found, the type of plant, the position of it in the transect and the number of marks present were recorded. Figure 23 shows the schematic illustration of the klipspringer range surveyed, and its position relative to the closest neighbours.

Data analysis

A two-fold approach was used to analyse the scent-marking data. The first approach was to investigate the spatial distribution of these marks so as to determine whether they were distributed at random or were clumped within the transects. The null hypothesis that was tested was that a klipspringer scent-marks randomly throughout its range. Should this be true, then the next approach was to use log-linear regression techniques in an effort to explain the pattern found.

Since the variable that was tested was the number of scent marks, normal linear regression methods of analysis were, however, not suitable because this linear method may lead to negative counts, and the variance will not be constant (Crawley 1996). Log-linear regression techniques or the Poisson distribution were therefore used to analyse the data. The Poisson distribution is used in cases where it is known how many times an event happened but where it is not known how many times an event did not happen. Here it meant how many times a klipspringer scent-marked its range (Crawley 1996).

Variables recorded

The following variables were recorded:

- The number of scent marks. These were counted in all four major wind directions from the centre of the range as described above.
- The distance between a scent mark and the nearest neighbouring klipspringer.
- The distance from the centre of the range to the nearest neighbouring klipspringer.
- The number of neighbouring klipspringer in all major wind directions.
- The compass direction from the centre of the range to where the scent mark was placed.

Because the hypotheses were not directional the direction of the scent mark was not included in the model for analysis. The direction was therefore only used for determining the number of the closest klipspringer.

Factors affecting scent-marking: model fitting

The full model that was fitted included the variables indicated above, except for the compass direction of the scent mark from the centre of the range. The only interaction variable that was included in the model fitting was the interaction between the distance between the various scent marks and neighbouring klipspringer and the number of neighbouring klipspringer. The other interaction terms were not fitted because no biological meaning could be ascribed to them. When the full model was fitted it was determined that the data were overdispersed. Therefore, a correction was made by changing the dispersion parameter. The variables were dropped one at a time from the analyses, starting with the interaction term. A variable was considered significant when the change in deviance associated with dropping that variable exceeded the chi-square critical value at $P < 0.05$ for the number of degrees of freedom that the variable conferred (Crawley 1996).

Results

Spatial distribution

Figure 24 shows the distribution of the scent marks as a three-dimensional map in which the third vertical dimension reflects the value of the quantitative data. The latter dimension represents the density of the scent marks. It is clear that the scent marks appear to be clumped in specific areas, mainly along the border of the range, with hardly any scent-marking occurring in the centre of the range. When this representative pattern was subjected to a nearest neighbour analysis (Krebbs 1989), and was compared with an expected random distribution, the index of aggregation (R) was 0.36128. This ratio indicates a deviation of the observed pattern from an expected random pattern. When the spatial pattern is random, then $R = 1$, and when clumping occurs then R approaches zero. Therefore it can be concluded that the scent marks where indeed clumped in specific areas of the range of klipspringer. To test the significance of the deviation from a random pattern, the Z statistic was calculated, where $Z = RA\text{-}RE/se$, RA = the mean distance to the nearest neighbour, RE = the expected distance to the nearest neighbour, and se = the standard error of the expected distance to nearest neighbour. This test yielded a Z value of 20.79144, which is greater than 1.96 ($p = 0.05$). Therefore the null hypothesis is rejected that the scent marks are randomly spaced in the study area (Krebbs 1989). Therefore, they are significantly spaced non-randomly.

Log-linear regression

The variable that had the most influence on the number of scent marks was the distance to the nearest neighbouring klipspringer, because it resulted in the greatest drop in deviance when it was dropped from the model, and the probability value associated with it was the smallest. The variable of the number of neighbouring klipspringer had the least effect on the number of scent marks because the drop in deviance was the smallest and the probability associated with it was the largest of the significant variables. The interaction between the distance between a scent mark and the nearest neighbouring klipspringer, and between the number of neighbouring klipspringer was, however, not significant ($p>0.05$)(Table 15).

The change in deviance and the corresponding degrees of freedom for each of the variables tested are shown in Table 15. The effect of distance to the nearest neighbouring klipspringer and the distance to a given scent mark are illustrated in Figures 25 and 26.

Discussion

It is clear that as the distance between the scent marks and the nearest neighbouring klipspringer increases, the number of scent marks decreases (Figure 25). Therefore the closer a klipspringer is to a neighbouring klipspringer the more frequently it will scent-mark. Also the further away that the scent marks are from the centre of the range, the more scent marks there are (Figure 26). Therefore, the frequency of scent-marking increases near the boundaries of a range. It is also clear that the number of neighbours that a klipspringer have will affect the frequency of scent-marking (Table 15). However the data are not conclusive because there were limited klipspringer concentrations. Nevertheless the data do indicate that all the variables except the interaction between the distance between a scent mark, the nearest neighbouring klipspringer and the number of neighbouring klipspringer have a significant effect on the frequency of scent-marking in klipspringer in the Kruger National Park.

Table 15. Poisson regression analyses of the effect of neighbouring klipspringer and the distance of scent marks from the centre of the range on the number of scent marks in klipspringer in the Kruger National Park. Star notation in the table represents the interaction between terms.

VARIABLE	DEGREES OF FREEDOM	DEVIANCE	PROBABILITY VALUE
Number of neighbouring klipspringer	1	-4.511	0.03370
Distance from centre of range to nearest neighbouring klipspringer	1	-8.884	0.0029
Distance between a scent-mark and nearest neighbouring klipspringer	1	-7.854	0.005
Distance between scent-mark and nearest neighbour * Number of neighbours	1	0.020	0.8875

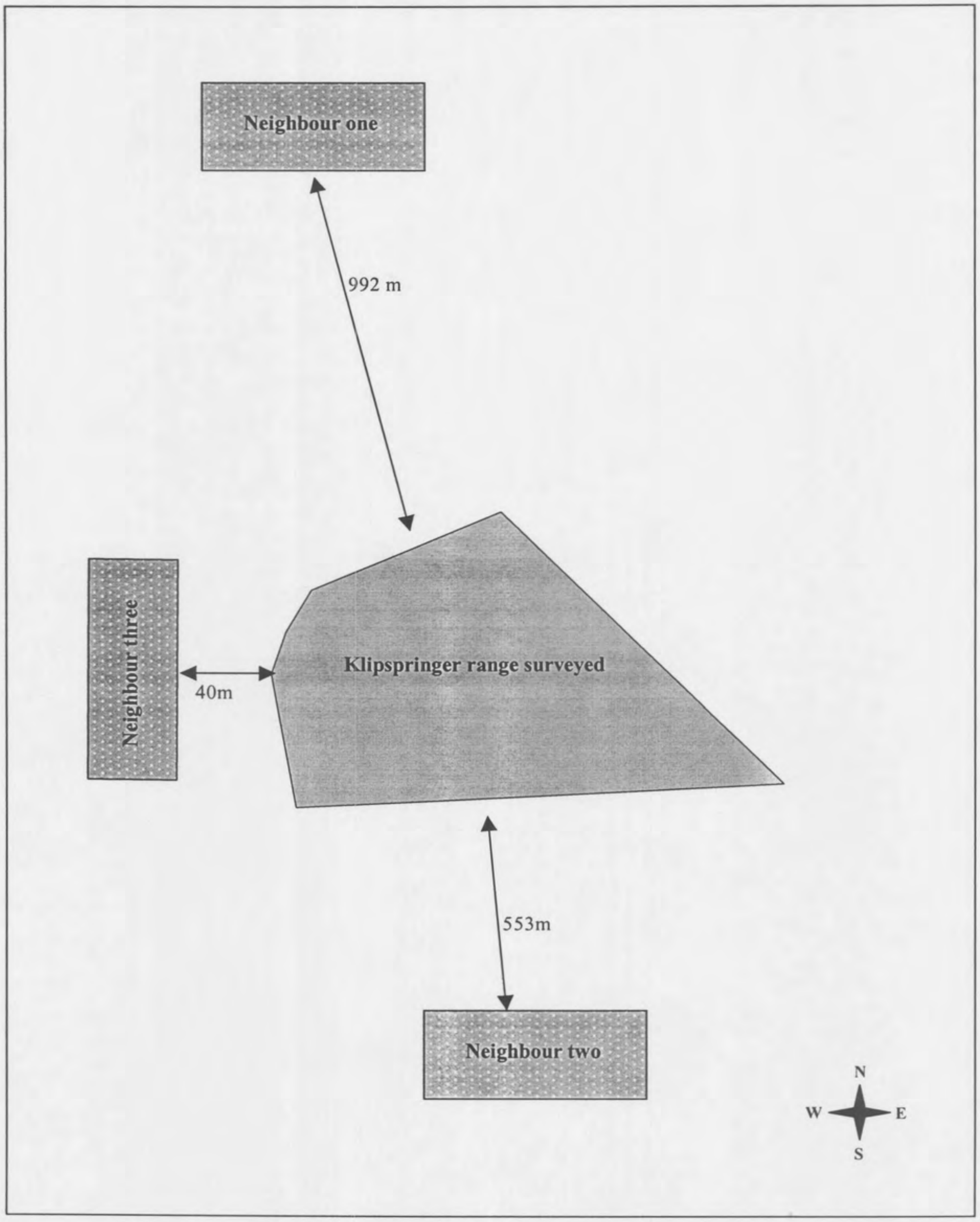

Figure 23. Schematic presentation of the klipspringer range that was surveyed for scent marks, also showing the proximity of the neighbours.

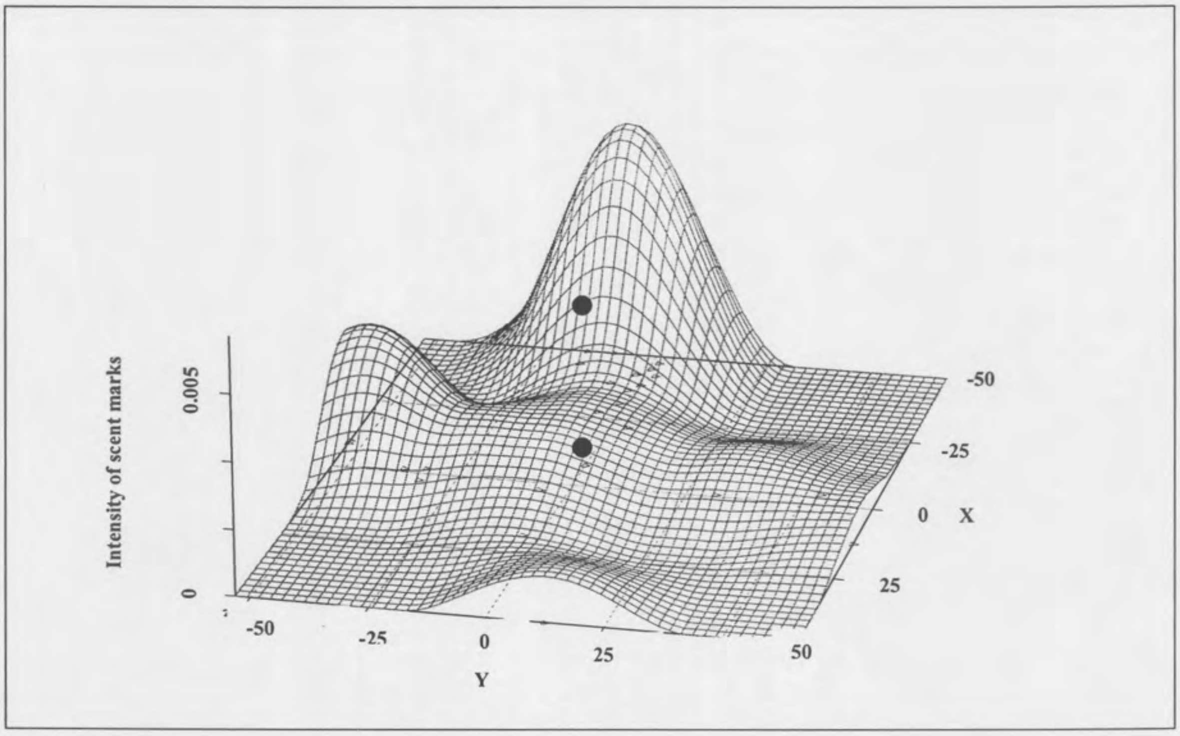

Figure 24. Three-dimensional presentation of klipspringer scent marks in the Kruger National Park to show the distribution of the scent marks. The black dot shows the centre of the range.

Conclusions

With the use of a nearest-neighbour mapping technique Roberts (1998) observed a similar scent-marking pattern in klipspringer in the Limpopo River Valley of Zimbabwe as was found here. In the study by Roberts (1998) the scent marks were placed in a rough ring just within the range boundaries of a resident group. The result of the current preliminary study on scent-marking in the klipspringer in the Kruger National Park, supports the hypothesis that klipspringer will scent-mark more frequently on the boundaries of their ranges, and also more on those sides of the range where there is another resident klipspringer group. Therefore scent-marking in klipspringer is used by them as a spacing behaviour.

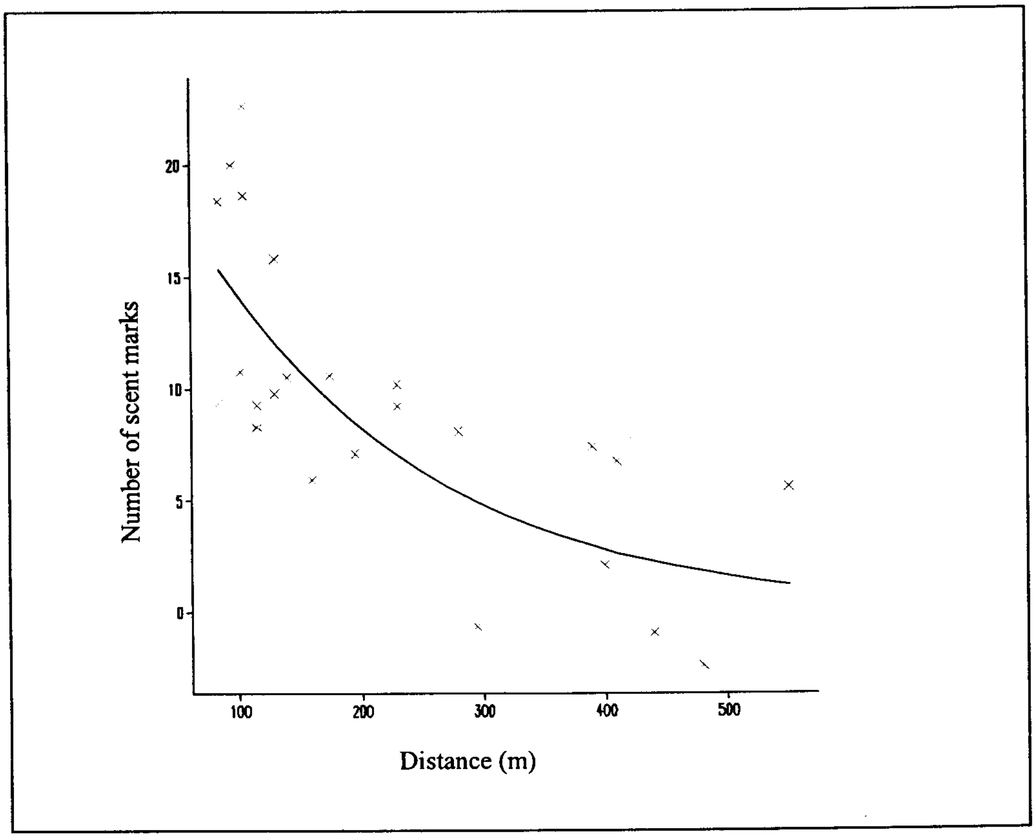

Figure 25. The effect of the distances (m) from the scent mark to the nearest neighbouring klipspringer on the number of scent marks produced by the klipspringer group studied in the Kruger National Park as obtained from log–linear regression techniques.

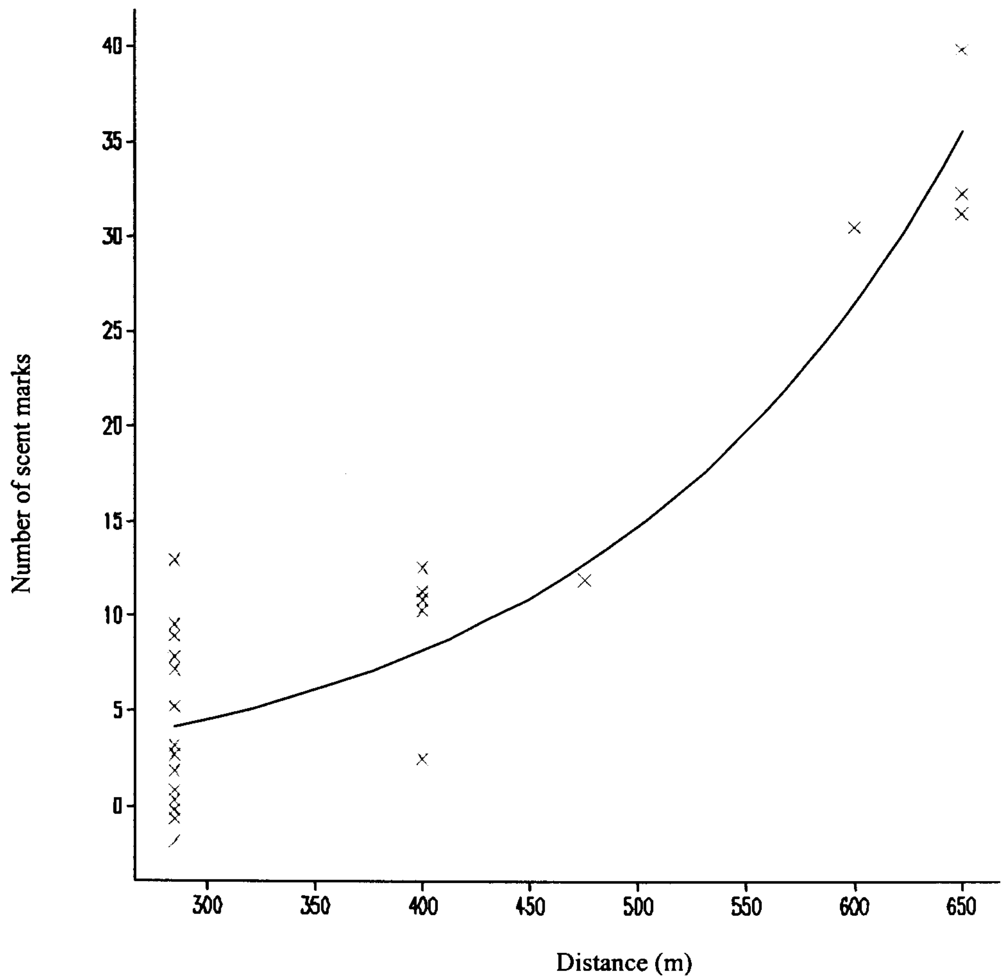

Figure 26. The effect of the distance from the centre of a range to the nearest neighbouring klipspringer on the number of scent marks in a klipspringer population in the Kruger National Park.

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THE STATUS, DISTRIBUTION AND ECOLOGY OF THE KLIPSPRINGER IN THE KRUGER NATIONAL PARK

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SUMMARY

The main purpose of the study on klipspringer was to obtain information on some aspects of its ecology as well as to get an indication of the status and distribution of klipspringer in the Kruger National Park south of the Olifants River.

The first part of the study was spent on a survey to determine the status and distribution of klipspringer in the area of the Kruger National Park south of the Olifants River, where the area were systematically searched for klipspringer. The results showed that klipspringer in the Kruger National Park have a patchy distribution, with denser populations occurring in the mountainous area southwest,

between Berg en Dal and Pretoriuskop, to the east on the Lebombo Mountains, the north along the Olifants River, and in the northwest south of the Olifants River. The number of klipspringer counted in the Kruger National Park south of the Olifants River were 773 with a sex ratio of one male per 1.1 female.

Most of the koppies or rocky outcrops that have suitable vegetation, providing food and shelter are inhabited by klipspringer. The status of klipspringer in South Africa is classified as lower risk or conservation dependant by the IUCN. The current management policy of the Kruger National Park does not include a specific monitoring programme for klipspringer. In order to obtain a better indication of the klipspringer's conservation status in the Kruger National Park a similar survey to the one used in this study will have to be repeated over the entire park. From ranger reports and the data from this study it would seem that the status of klipspringer in that area of the Kruger National Park south of the Olifants River is secure.

The ecology of klipspringer in the Kruger National Park was studied in a specific study area in the Nwatindlopfu Spruit area between Skukuza and Tshokwane, where five klipspringer individuals, in three groups, were radio-collared. The aspects of the ecology that were studied were habitat selection and utilization as well as scent-marking behaviour.

The result of the study on scent–marking behaviour in the klipspringer in the Kruger National Park showed that klipspringer scent mark more frequently on the boundaries of their ranges, and also more on those sides of the range where there is another resident klipspringer group.

The activities of klipspringer appear to be correlated with certain clear environmental variables. Visibility as measured at different height levels had the greatest influence on all the activities recorded. One of the klipspringer ranges studied differed from the other two in that klipspringer occupied an area that is relative flat with rocks, the other two ranges had prominent koppies in which the klipspringer were the only ungulate inhabitants. These koppies provided escape cover and almost exclusive utilization by the klipspringer. When the vegetation of the three ranges was compared it was found that their floristic composition and structure are similar. Klipspringer occurred in an area, which at first glance seemed to be marginal habitat but the vegetation was however suitable. Vegetation can therefore be described as the determining factor in the habitat selection of klipspringer. A woody vegetation density of between 2 500 and 3 700 plants per hectare with a dominated height class of < 0.75 m and herbaceous cover of more than 60% seems to be ideal.

The ideal klipspringer habitat can be described as an area that provides both shelter and sufficient visibility for the klipspringer. These areas should have limited access to other ungulates, which can attract predators. Vegetation present should consist of palatable plant species that the klipspringer can utilize, as well as plant species that provide shade, shelter and serve as a food source.

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