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THE ECOLOGY OF THE LEOPARD (<u>PANTHERA</u> <u>PARDUS</u>) IN THE WATERBERG

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THE ECOLOGY OF THE LEOPARD (*PANTHERA PARDUS*) IN THE WATERBERG.

by

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THE ECOLOGY OF THE LEOPARD (*PANTHERA PARDUS*) IN THE WATERBERG.

by

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ABSTRACT

Although the opportunistic feeding habits of leopards were evident in this study, scat analysis showed that ungulates were by far the predominant food, with impala being the most frequent item. The fact that cattle calves were only taken up to ± 100 days old, emphasize the relevance of a proper stock management program to prevent stock losses. In addition, where such measures were impractical, tempory fisical barriers such as electric fencing showed potential for application.

Modification on different capture techniques were investigated not only to capture leopards for radio collaring but also for the elimination of problem leopards.

The effective home range size of a resident male and female leopard in the Naboomspruit area were calculated at 303 km^2 and 157 km^2 respectively. A density of one leopard per 53 km^2 are suggested for the Naboomspruit study area. Both leopards were predominantly nocturnal with some crepuscular activity. Translocation experiments revealed different results. The conducting of translocations in farming areas, where problem leopards are involved are however not suggested.

Leopard density and distribution patterns showed that numbers are relative safe, and that populations are currently to a large extent linked, which makes natural gene flow a possibility. Although suitable areas for leopards thus exist, these may not be available as homogenous units in the future, due to increasing human pressure.

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CHAPTER 1: INTRODUCTION

PERSPECTIVE

Within the cat group as a whole, the leopard is in many respects the archetypal felid, and stands at the opposite end of the spectrum from the cheetah, Acinonyx jubatus (Kleiman & Eisenburg 1973). The leopard is the largest of the spotted cats in Africa. Skinner & Smithers (1990) give the average mass of male leopards and that of females from Zimbabwe as 59,7 kg and 31,5 kg repectively. While for leopards in the Cape Province, Stuart (1981) gives an average weight of 30,9 kg for males and 21,2 kg for females.

In the Waterberg twelve leopards weighed an average of 58,8 kg (range 52,8 - 64,1 ; n=6), for males and 34,9 kg (range 29,2 - 41,0 ; n=6) for females (Table 1).

The leopard is the most widely distributed of all the world's cats (Weigel 1975), due to a wide habitat tolerance. While they generally associate with areas of rocky koppies, rocky hills, mountain ranges and forests, they also occur in suitable habitat in deserts, living along the fringes or penetrating watercourses (Skinner & Smithers 1990). They therefore range over most of Africa and much of Asia (except for the Arctic Tundra area), as far to the north and east as Manchuria and Korea (Hamilton 1981). They can exist in zones with as little as 50 mm rainfall (Monod 1965), obtaining moisture from their prey. The only habitat in sub-Saharan Africa with which the leopard is unable to cope, is unvegetated sand dunes.

At the other extreme, they can exist satisfactorily in the alpine zone of the East African mountains (Brown 1971). They are found from sea level to over 5000 m (Mt Kilimanjaro) and they occur in areas of mean annual rainfall of over 2000 mm (West Africa). Cover to lie in safely during daylight hours, and from which to hunt, is an important requirement. In areas of intense development, providing there is adjacent cover provided by rocky hills or forest, they manage to persist even in the face of intense control.

Because of it's secretive, solitary and largely nocturnal habits, it has been one of the last mammals to yield to scientific study. Until the spoor tracking study of Smith (1977) in Zimbabwe and the radio-tracking studies of collared leopards in Tsavo and Meru National Parks (Hamilton 1981) and the Serengeti National Park, Tanzania (Bertrum 1978), almost all recorded information on leopard ecology appeared in popular and semi-popular literature, most of which Turnbull-Kemp (1967) has summarised. In recent years Norton & Lawson (1985) and Norton & Henley (1987) published data on leopard movements (Cape Province), while le Roux & Skinner (1989), reported on aspects of their ecology in the Transvaal Lowveld. Bothma & le Riche (1984;1986), also contributed data from the southern Kalahari.

Recognizing man's influence, on leopard mortality and thereby on the social organization of a solitary carnivore, as well as the impact of these carnivores on the assets of man, is extremely important in any conservation plan. Research on unexploited long standing populations in different habitat types is essential to establish the intrinsic "norms" for a given species. Knowing the "norms", provides a tremendous advantage in recognizing what is going on in exploited populations (Hornocker & Bailey 1986).

In highly evolved intelligent species such as cats, we can expect different behaviour from different populations, as behaviour is wholly dependant on extrinsic and intrinsic factors. Rather than emphasizing "conflicting" data from different populations and regions, we should recognize the flexibility inherent in the species and it's ability to adapt.

PRIMARY OBJECTIVES

The prime objectives of the present study were to examine the following aspects of leopard ecology in the Waterberg.

a. Leopard space utilization and activity patterns.

b. The leopard's diet relative to prey abundance, together with related aspects such as capture and feeding behaviour, especially pertaining to domestic livestock.

c. Different aspects of leopard translocations, particularly the relevance thereof in a leopard conservation strategy.

d. A conservation strategy for leopards in farming areas of the Transvaal with special reference to stock protecting measures.

TABLE. I

Overall measurements (mm) and mass (kg) of leopards captured in the Waterberg (1985 - 1988).

	MALES			FEMALE		
	X	n	Range	X	n	Range
TL	2175	5	2070 - 2220	1852	6	1840 - 1870
HB	1378	5	1300 - 1420	1158	6	1130 - 1200
T	798	5	740 - 850	695	6	640 - 740
Hfs/u	254	5	240 - 265	229	6	210 - 250
Ear	70	5	62 - 74	62	6	58 - 70
Neck	500	5	490 - 510	379	6	360 - 400
Canines:						
Upper	34	5	30 - 36	29	6	24 - 30
Lower	29	5	28 - 30	23	6	20 - 25
Mass	58,8	6	52,8 - 64,1	34,9	6	29,2 - 41,0

DESCRIPTION OF STUDY AREAS

Location

Melk River :

This area is located in the Waterberg mountain range of the north west Transvaal, R.S.A, and comprised private cattle and/or game farms. Some cropfarming occurs along the banks of the Palala river. The game farm Sliedrecht (23° 58'S, 28° 15'E) formed the centre of the study area which is approximately 50 km south west of Melk River and 50 km north west of Vaalwater (Fig. 1).

Naboomspruit :

Also located in the Waterberg mountain range, but more in the central northern Transvaal, this area is also comprised of private cattle and/or game farms with some cropfarming especially in the Sterk River Settlement area. The Doorndraai Dam Nature Reserve (TPA) formed the centre of the study area (24° 20'S, 28° 45'E). This reserve lies 45 km south west of Potgietersrus and 50 km north west of Naboomspruit (Fig.2).

Topography and Geology

Melk River :

The area is situated at the north eastern periphery of the Waterberg plateau. This region forms a highland area with an altitude between 1100 m in the north west and almost 2100 m in the south west.

Figure 1 : Topographical map of the Melk River study area (Scale 1 : 250 000).

The main escarpment stretches from Warmbaths, extending northwards forming a rugged territory, the centre of which is called the Palala plateau. The plateau surface declines gradually to the west where a well defined scarp overlooks the peneplain of the Upper Limpopo Valley. The south escarpment ends at the Sandrivierberg (Wellington 1955).

Quartzilic sandstones are common in the region and occur in thick beds which are often pebbly or gritty. Both the sandstones and conglomerates have a red colour which is doubtless in great part due to the amount of felsitic and other ingenous debris present in the original sediments as well as to oxidizing conditions during or after deposition. Coarse conglomerates, with occasional breccias mark out the base, though occurring higher up as well and many range from 33 to 130 m in thickness (Du Toit 1954).

Several perennial rivers have their source within the undulating hills that comprise the Waterberg plateau. Five drainage systems have been classified for the Waterberg group (Anon 1984). The Sand river to the north and the Crocodile river to the south are the most important. The Palala river that runs within two km north of the study area is classified amongst the five main drainage systems of the region. The main stream in the area is the Blockland spruit that drains into the Palala river.

Naboomspruit :

The Sterk river runs through the study area into the Doorndraai Dam. This dam with a surface consisting of 600 ha provides irrigation water to the nearby Sterk River Settlement.

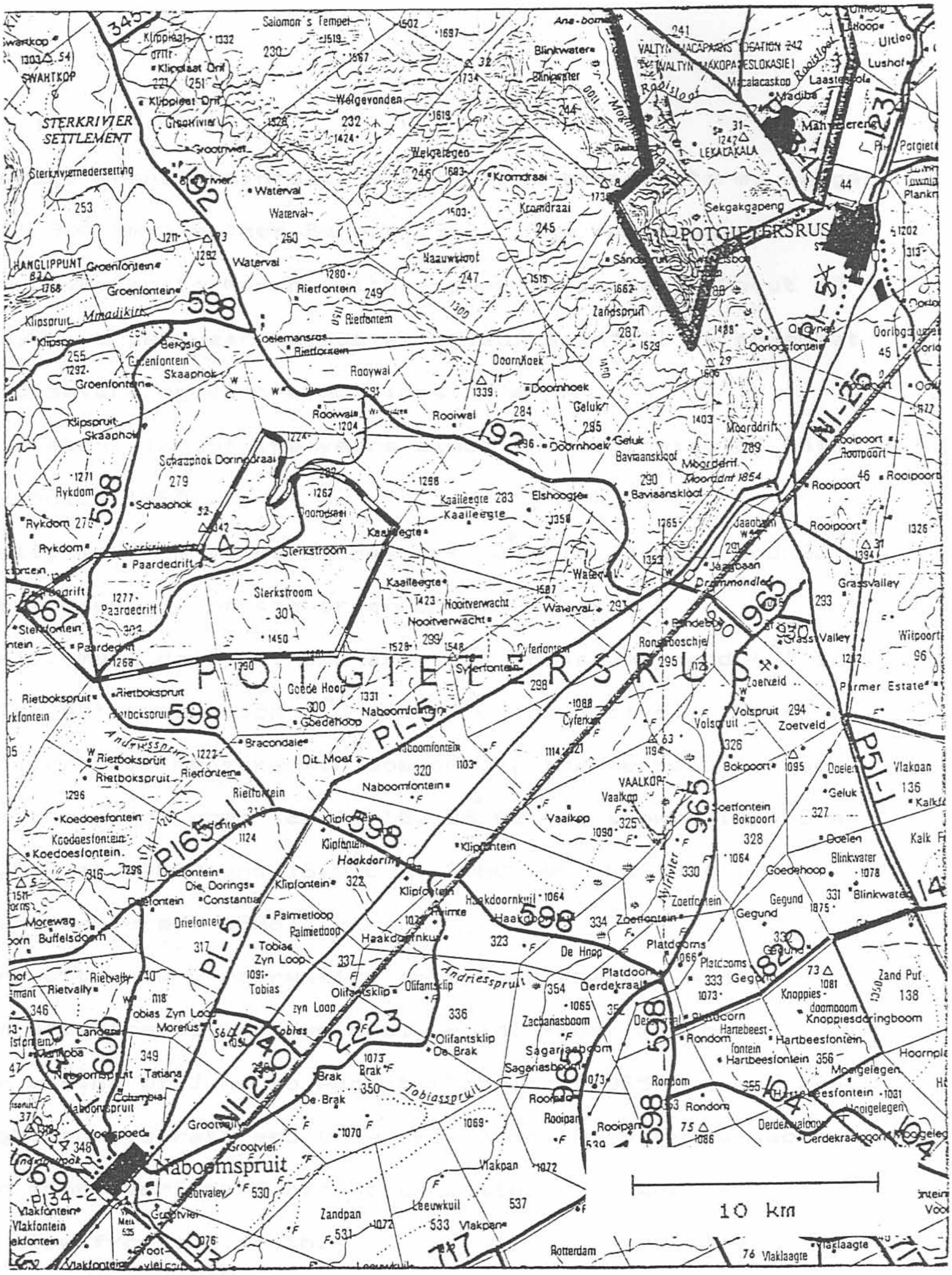

Figure 2 : Topographical map of the Naboomspruit study area (Scale 1 : 250 000).

Climate

Melk River :

The average annual rainfall, mainly from thunderstorms ranges from 630 to 900 mm (Weather Bureau 1986). The rainy season lasts from about November to March, with a peak in January. About 50 to 80 rainy days per year may be expected. Rainfall is somewhat erratic and severe drought conditions have occurred in about 12% of the years since the beginning of this century (Schulze 1965).

Mean daily maximum temperatures are 32 °C in January and 22 °C in July. Extremes are of the order of 42 °C and 32 °C respectively. Mean daily minima are 18 °C in January and 4 °C in July, whilst extremes reach 8 °C and -7 °C respectively. Mean annual temperatures measured in Goedehoop, the nearest weather station to the study area (24° 14 'S, 28° 02 'E) showed 14,4 °C at 08h00, 25,0 °C at 14h00 and 16,0 °C at 20h00 on the 1974-1982 period (Weather Bureau 1986).

Days are often very oppressive in summer whereas winter nights can occasionally be decidedly cold. Frost may occur during the months of June to August (Schultze 1965). Winds are mainly light to moderate and blow from a north easterly sector except for short periods during thunderstorms or weather changes when they blow from the south.

Naboomspruit :

The average annual rainfall from 1976 - 1990 is given as 570 mm (Odendaal. pers comm)*. The rainy season lasts from about

November to March, with a peak in January. Mean daily maximum temperatures are given at 30,8 °C in January and 18,0 °C in July for Doorndraai Dam Nature Reserve. Mean daily minima temperatures are 17,0 °C in January and 3,4 °C in July whilst extremes reaching 39,0 °C in summer (January) and -3 °C in winter (July).

Vegetation

Melk River and Naboomspruit :

The Sour Bushveld is typical of the Waterberg area and is recognised at community level (Acocks 1975). The vegetation conforms to moist savanna, although some of the more abundant floristic components relate the region to the arid savanna and include *Acacia* spp., *Commiphora* spp. and *Aristida* spp. (Huntley 1982). Generally however, the availability of water, which is the main determinant of the distribution of moist and arid savanna biomes, classifies a region that receives more than 650 mm annual rainfall as a moist savanna (Huntley 1982).

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Classifying an area as sourveld indicates that the nutritive value of grass deteriorates rapidly as it lignifies. The vegetation is comprised of a catena of tall closed non spinescent mesophyllous deciduous woodland and open drainage-line grasslands. The herbaceous productivity is usually high and dominated by tall perennial mesophytic grass species (Huntley 1984).

CHAPTER 2 : THE LIVE CAPTURING OF FREE RANGING LEOPARDS.

INTRODUCTION

The live capturing of elusive free ranging carnivores has over the years proved to be very time consuming and the effort in most cases enormous. Such capture operations are therefore mostly conducted for the purpose of research projects, the removing of problem animals from livestock depredation areas and for harvesting furbearers.

Failure to capture problem animals promptly and effectively without damaging non-target animals, is the most crucial component of problem animal management (Beasom 1974). Many research projects have also been terminated due to problems associated with the capture of study animals.

Numerous techniques have been employed for different carnivores in diverse habitat types and conditions. These ranged from direct darting of spotted hyaenas (Crocuta crocuta) from vehicles (Henschel 1986) and coyotes (Canis latrans) from helicopters (Baer, Severson & Linhart 1978) to capturing leopards in box traps (Norton & Lawson 1985). Steel-jawed traps (gintraps) have been successfully used for the live capturing of many canids, e.g. wolves, Canis lupus (Kolenosky & Johnston 1967), dingos Canis familiaris dingo (Green 1976) and black-backed jackals, Canis mesomelas (Rowe-Rowe & Green 1981). Englund (1982) captured red foxes (Vulpes vulpes) successfully with plastic foot snares.

On occasion trained tamed animals have been used to chase target animals into trees or holes. Tigers (Panthera tigris) have been chased into trees with the aid of Asiatic elephants (Elephas maximus) and darted. Trained dogs were used for mountain lions, Felis concolor missoulensis, (Hornocker 1970). In many instances adaptations and modifications of these techniques are necessary to realise the objectives in different situations.

Leopards have been captured live using boxtraps in Kenya, Tsavo National Park (Hamilton 1981), and in the Lowveld, Kruger National Park (Hornocker & Baily 1986). In areas outside conservation areas the situation is somewhat different. Due to persecution, leopards are much more wary and elusive, and success with conventional boxtraps is rare (Norton & Lawson 1985). This is also the scenario in the Waterberg, where capturing of especially problem leopards with boxtraps is virtually impossible.

OBJECTIVES

The objective of this chapter is to present information on successful capture techniques developed for the capturing of leopards in the Waterberg. This information is not only relevant for future research projects, whereby live capturing of individuals is essential but also crucial for the fast and effective ellimination of problem leopards.

METHODS

With advice received from numerous expert farmers and TPA Officials, together with extensive efforts launched in the Waterberg, specific technique modifications for specific situations were developed and tested.

The following techniques were involved:

Box or Cage traps

(i) Single door walk-in box trap
(ii) Double door walk-in box trap

Steel jawed traps :

(i) Jump trap
(ii) Horizontal double coil spring steel trap.

Single door walk-in box trap :

This trap was made from a metal frame measuring 2,0m x 0,9m x 0,9m and covered with 6mm iron rods to form a mesh of 80mm x 80mm. The sliding door was activated by a 1,5mm steel cable, fastened by means of a pulley system to the bait. An alternative approach was to use an 800mm x 300mm footplate in front of the bait which triggered the pulley system as soon as the animal stepped on the plate.

Box traps were hidden in relative dense bush under a low canopy, accessible by a 4x4 vehicle. The cage was only partially covered with dry branches and the floor completely covered with soil and grass to give a natural surface appearance. The cage was camouflaged and placed in such a manner that the bait could not be clawed and triggered by a leopard from the sides or back of the cage.

Bait used, ranged from dead domestic chickens, guinea fowl (Numida meleagris), parts of zebra and donkey carcasses and newly born cattle calves (that died from natural causes), to whole carcasses of baboons, impala and even fresh barbel (Clarias gariepinus). Leopard kills used as bait on the spot included cattle calves, impala carcasses, duiker etc.

The closing of trap doors was monitored from a distance by using a transmitter with an on and off switch. A closed door activated the signal and was received with an LA 12 receiver (A.V.M. Instrument Co, California, USA).

Double door walk-in box trap :

Two approaches were used in the double door concept.

The first type was provided by the Problem Animal Unit of the Division of Nature and Environmental Conservation (TPA) (Fig. 3). This cage system consisted of two separate compartments (1,5m x 0,8m x 0,9m) each, with a trapdoor on either side. The framework was covered with 2mm welded mesh (20mm x 40mm).

Live bait (tethered goats) was placed in a pen concealed with thorn branches. A total of six goats were used in rotation, each remaining in the box trap for 24 h. They were fed lucerne and given water twice a day. After each feeding session all lucerne and water were removed. This enclosure's only opening was linked through the cage system. Bait was therefore only visible through the tunnel of the cage system.

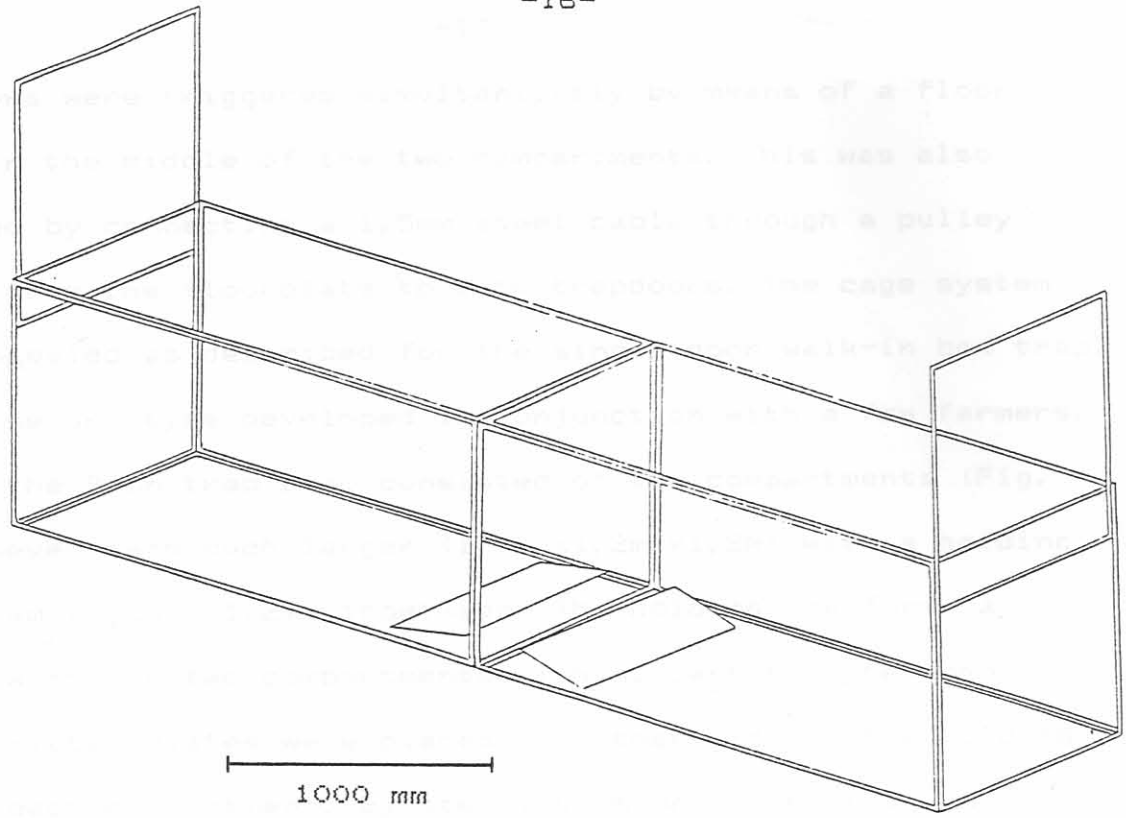

Figure 3 : The TPA Double Door Walk-in Box Trap.

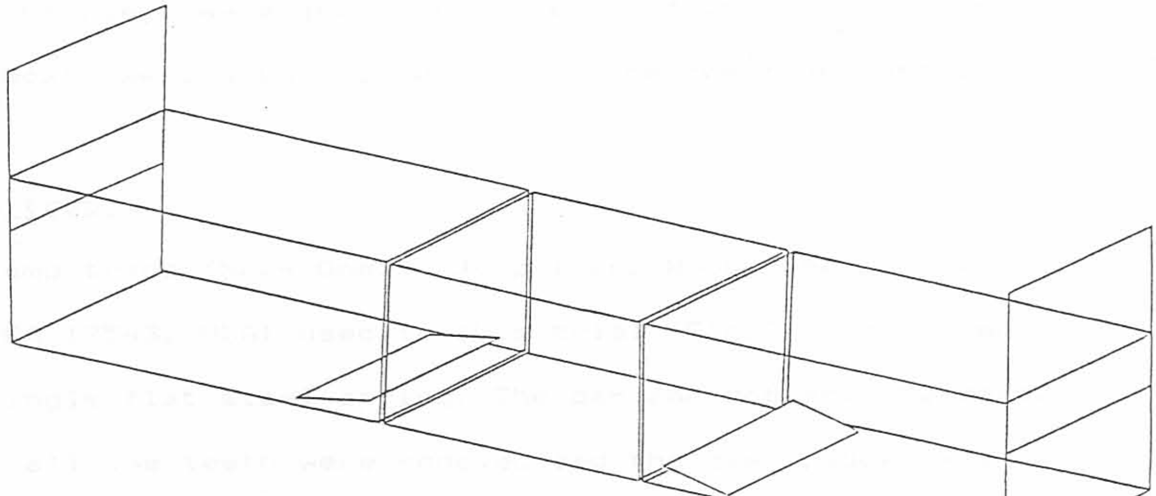

Figure 4 : The Boon Double Door Walk-in Box Trap.

Trapdoors were triggered simultaniously by means of a floor plate in the middle of the two compartments. This was also achieved by connecting a 1,5mm steel cable through a pulley system from the floorplate to both trapdoors. The cage system was concealed as described for the single door walk-in box trap.

The second type developed in conjunction with a few farmers, namely the Boon trap also consisted of two compartments (Fig. 4), however each much larger (1,7m x1,2m x1,2m) with a holding box (1,4m x1,2m x 1,2m) inbetween. The holding box forms a tunnel with the two compartments with no partition between them. Floor trigger plates were placed on either side of the holding box in each compartment. By stepping on only one of the plates, both trapdoors are triggered by means of a cable pulley system.

To facilitate handling in rough terrain, the cage consisted of different frames which could be bolted together at the setting location. The heaviest frame weighed 36,8 kg and the total cage 420 kg. A young domestic goat was held in the holding "box" (area) and tied with a 0,5 meter rope around his neck so that his hindlegs were just out of reach of the two trigger plates. Goats were also rotated as for the previous method.

The_Jump_trap_:

The Jump traps (No.4 Oneida Jump Trap, Woodstream Corp. Lititz, PA 17543, USA) used in this trial (Fig.5) are closed with a single flat steel spring. The pan and dog are standard. At first all the teeth were removed and the jaws padded with two layers of rubber tubing. However due to the two individuals escaping, the rubber tubing was removed and teeth replaced. The

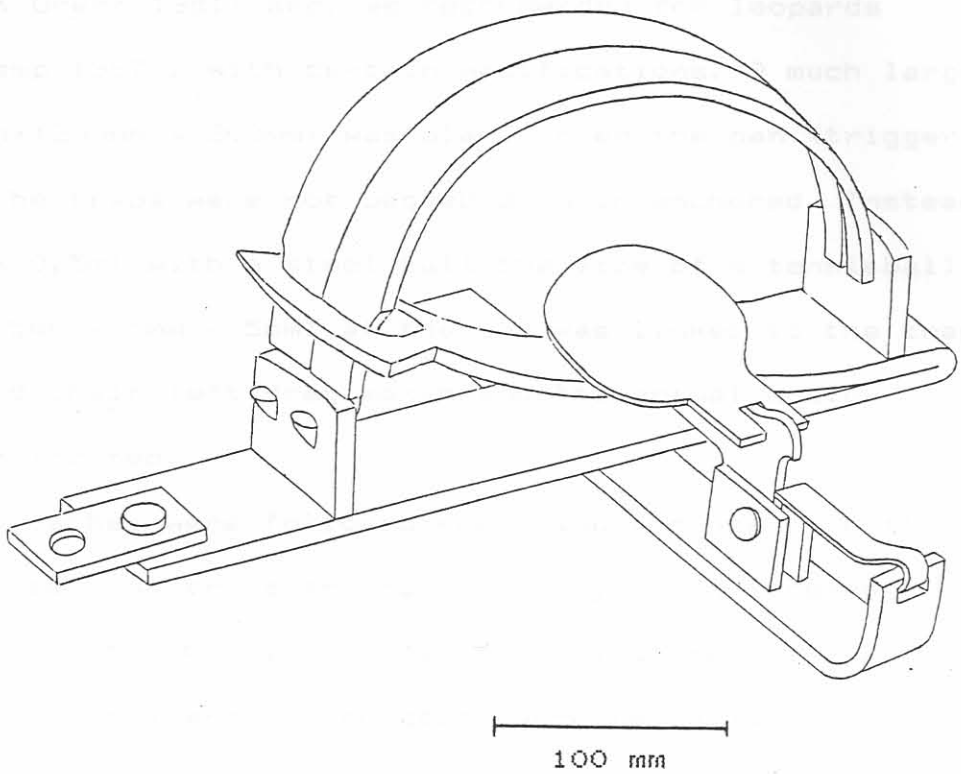

Figure 5 : The No 4 Oneida Jump Trap.

strategy of siting and setting of traps was based on the philosophy used for the capture of black backed jackals (Rowe-Rowe & Green 1981) and, as recommended for leopards (Turnbull-Kemp 1967), with certain modifications. A much larger cotton cloth (200mm x 200mm) was placed over the pan (trigger plate) and the traps were not pegged down or anchored. Instead a chain (6mm x 0,5m) with a steel ball the size of a tennisball with knobs (5mm x 5mm x 5mm) at the end was linked to the trap. This ball and chain left drag marks and the animal could therefore be located.

Three approaches were followed regarding the use of bait. The first was to set two traps around a freshly found leopard kill. In addition, due to the difficulty of finding fresh leopard kills, two radio collared young goats were released in the veld and located every morning to find out if they fell prey to a leopard.

The second approach was to put out a fresh carcass or parts there-of and set two traps around it. The best strategy was to use a relatively large carcass e.g. impala or larger, fastened down, and only set the traps once a leopard was known to feed on the carcass. In the third approach developed by M. Keith (pers.comm.) a live goat was fastened against a tree and 6 - 8

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jump traps circled just out of reach, around the goat. Goats were also fed and rotated as described for the double door walk-in box traps.

The horizontal dubble coil spring steel trap :

This trap (Jonker Enterprizes, Linton Grange, Port Elizabeth, RSA) with certain modifications (Fig. 6) was used due to shortcomings experienced with the different box traps and jump trap.

The disadvantages of box traps compared to steel traps are being dealt with in the discussion. The shortcomings of the jump trap were related to the speed of jaw closure and holding ability. The actual siting and setting criteria were used as for jump traps. Traps were also not anchored but connected to a chain and steel ball.

Darts were developed based on the van Rooyen dartgun concept in the Kruger National Park (Fig.7) and mounted on the trap jaws. Three dart covers were mounted on the jaws of each trap. Two on the one jaw and the other in the middle of the other jaw. A 0,8 ml removable dart was placed in each dart cover. Each dart (Fig.7) consisted of a screw-on perforated needle (10mm x 2mm) with a rubber plunger. A little spring provided the pressure in the dart-body. Due to a volume limitation of 0,8 ml for each dart a drug with a high concentration in small volume had to be used. The drug also had to be stable as the traps were sometimes buried for up to five days. A dosage of 500 mg phencyclidine hydrochloride (Syclan, Centaur Labs (Pty) Ltd, Johannesburg, RSA) (0,5 ml) was used in each dart.

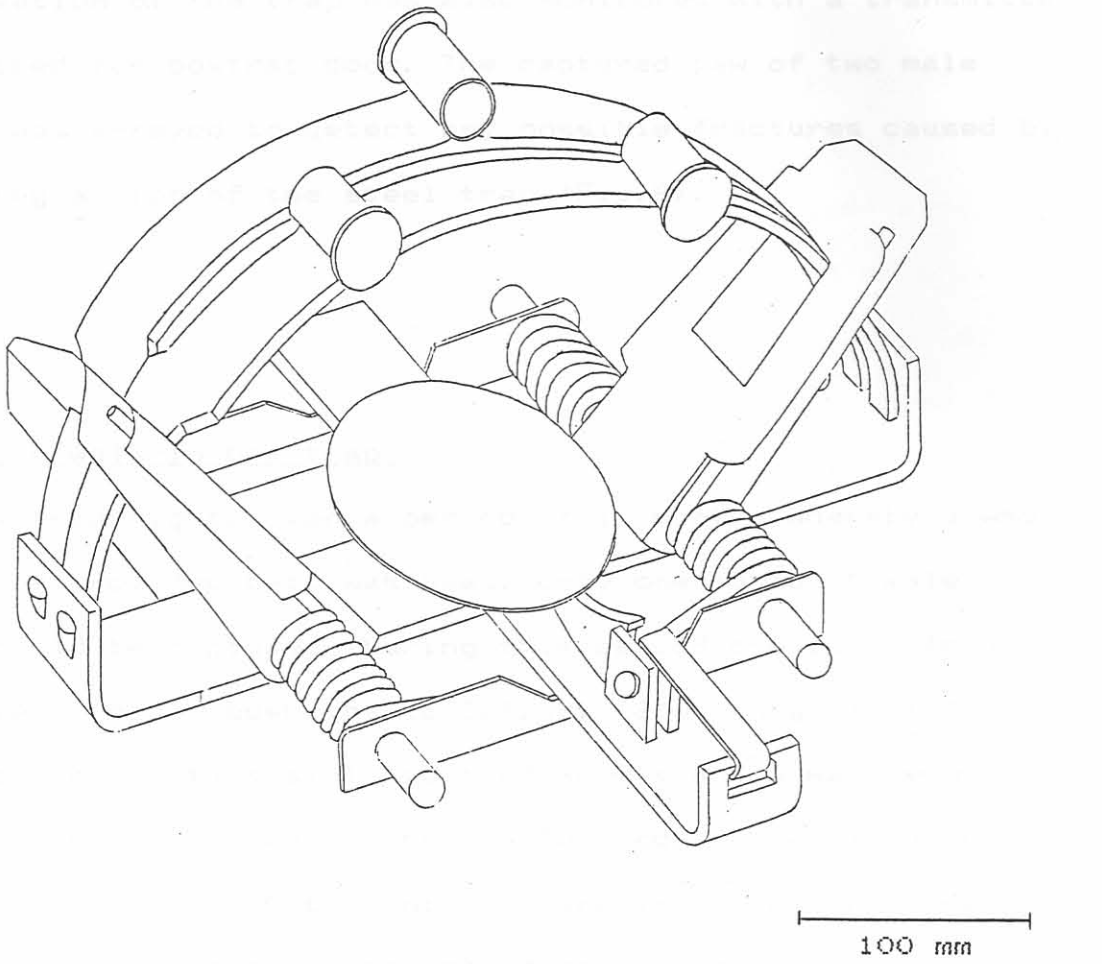


Figure 6 : The Horizontal Dubble Coil Spring Steel Trap.

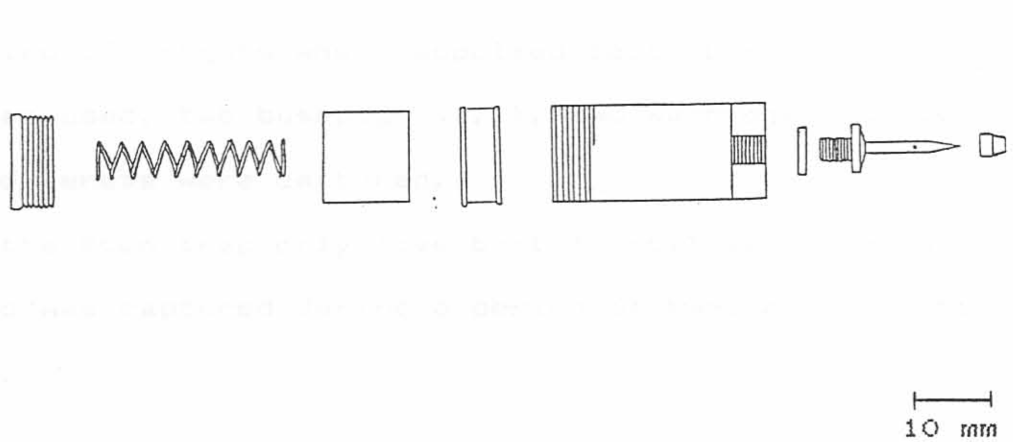


Figure 7 : Dart for mounting on the Coil Spring Steel Trap.

The activation of the trap was also monitored with a transmitter as described for boxtrap door. The captured paw of two male leopards was x-rayed to detect any possible fractures caused by the closing action of the steel trap (Fig.8).

RESULTS

Single door walk-in box trap

In 954 trap nights over a period of 11 months whereby a whole spectrum of provided bait was used, only one subadult male leopard could be captured. During this period one adult female brown hyaena, eight bushpigs (2,2,1,3), 12 warthogs (4,1,1,6), four porcupines, eight small spotted genets and a watermongoose were captured. In six cases where a leopard's own kill was used as bait, and whereby 36 trap nights were involved, only one genet, a bushpig and a warthog could be trapped.

Double door walk-in box trap

The cage systems of the Problem Animal Unit were used in 264 trap nights over a period of eight months. Live goats were used as bait in 72 trap nights over a period of four months. One young male caracal and two porcupines (1,1) were trapped. In the remaining 192 nights where supplied bait (parts of zebra, donkey etc) was used, two bushpigs (1,1), two warthogs and five small spotted genets were captured.

In the Boon trap only live bait (goats) was used. A male leopard was captured during a period of twelve consecutive trap nights.

The Jump trap

Jump traps were used on four occasions at freshly found leopard kills. Nine trap nights were involved. In three instances leopards were actually captured, but escaped after dragging the trap with ball and chain for 10, 20 and 80 m respectively. One brown hyaena female was trapped on the left frontpaw in the third instance and was darted. The leopard did not return to the setting site in the last instance.

Where supplied bait was used in 93 trap nights, a whole spectrum of non target animals were trapped. These included one male brown hyaena, three bushpigs, eight small spotted genets, a male civet and three ratels (two males and one female). Two sheep carcasses were also put out against a tree without setting the traps. Traps were only put out when a leopard in one case and a brown hyaena in the other case came in to feed. This happened during night three and four respectively. A female leopard approached the carcass again the following night, and was captured. In the case of the brown hyaena only triggered traps were found at the trap site the next morning.

In the third method whereby six jump traps were placed in a circle around a tethered goat, a brown hyaena and a leopard were captured, but both escaped. Twenty one trap nights were involved.

Horizontal double coil-spring steel trap

Two traps were used on four occasions (12 trap nights). A female leopard was captured at an impala carcass, which she killed the previous night. She came in the following morning at

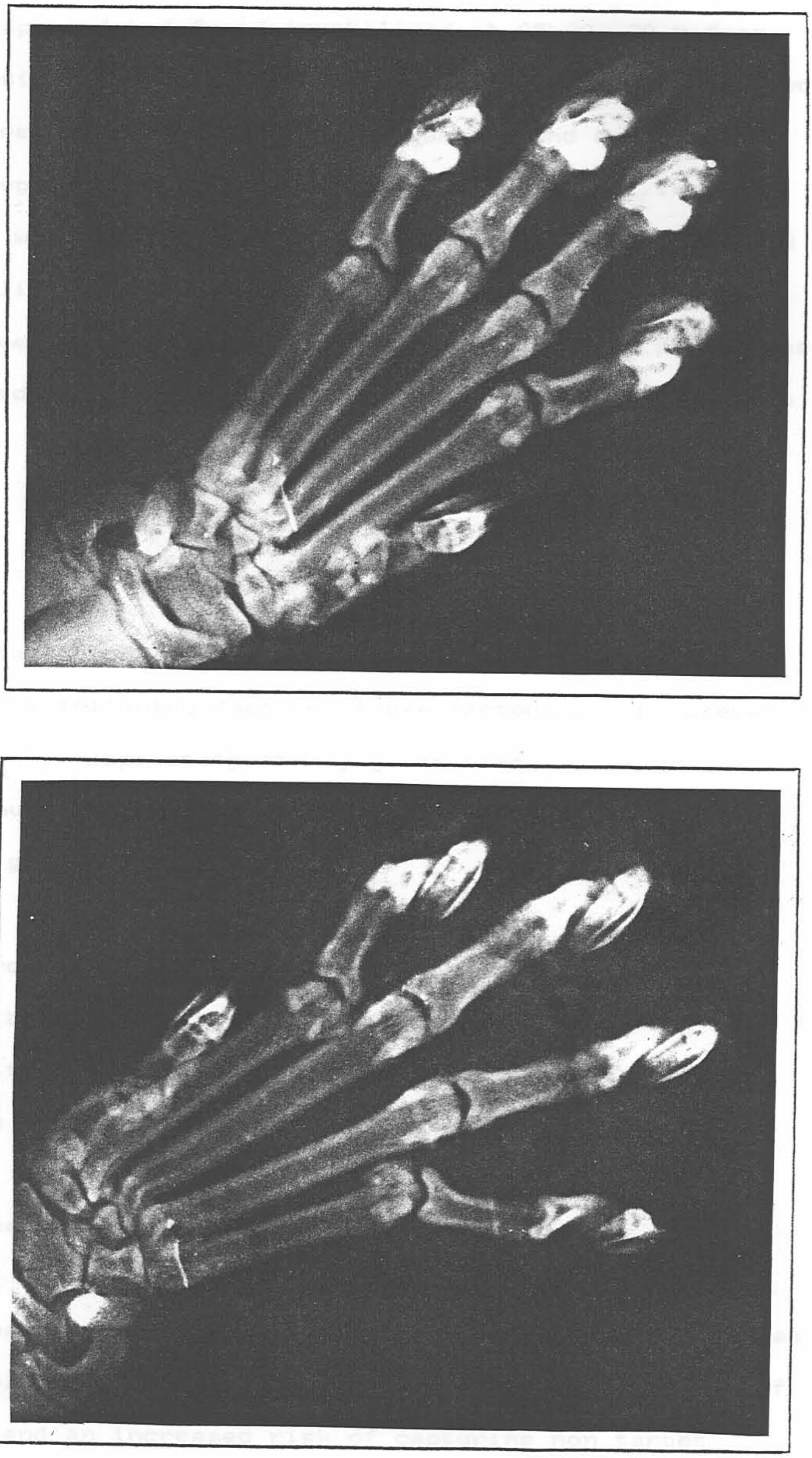


Figure 8 : Normal left paw (top) and steel trapped right paw (bottom) of a female leopard.

04h10, was captured and found immobilized at 05h20, 20 m from the capture site. On occasion a cattle calf carcass was fastened against a tree. A female brown hyaena came in and consumed the right hind leg on the first night. Two traps were set the next morning. She was captured that night at 20h15 on her return and found immobilized 32 m from the capture site at 21h05. Both individuals were captured by the right front paw. The paw of the leopard showed local swelling, but x-rays revealed no fractures (Fig.8).

DISCUSSION

The live capturing of leopards in the Waterberg is mainly hampered by the following factors. These factors may be present in combination or separately at any given time.

a. The continuous exposure to human persecution in areas of cattle or game farming.

   The leopard's inherent sense of shyness and alertness is increased by the fact that they are constantly exposed to capturing techniques. This is especially so where capture techniques failed and animals escaped.

b. Large leopard home range sizes.

   This increases the time interval of leopards revisiting areas within their home ranges. This leads to the decomposition of dead bait and an increased risk of capturing non target carnivorous species.

c. Interference of other carnivore species.

This leads to the occupation of the trap and subsequently to the spoiling (destruction) of the capture site or the inside of box traps. In many instances months of preparation are waisted and traps must eventually be moved to other areas.

d. Leopard's dietary condition :

Hunger can be an important motivating factor for a leopard to approach bait. This may be relevant in a situation of food abundance and availability but especially so when food is not readily available.

e. Aggression of captured animals.

Some techniques e.g. gintraps etc. may be effective in catching a leopard. This however may lead to serious injuries to the captured animal and also pose a threat to humans approaching the enfuriated animal.

The presence and subsequent implications of these factors on the success rate of different capture techniques have given rise to certain adaptations to conventional methods. The impact of the above mentioned factors were manifested in two basic components of the techniques used, namely trap and bait type. The aggression of a snare or gin-trapped leopard (pers.

observ.) and the frequent injuries sustained by humans, in the process (Turnbull-Kemp 1967), made the initial usage of box traps an obvious choice.

Walk-in box traps have been used all over the leopard range with variable success by researchers (Hamilton 1981; Norton and Lawson 1985) and many farmers (Esterhuizen & Norton 1985). Two scenarios are to be dealt with before the secondary factors that influence box trap success are considered. First, where provided bait and secondly where the leopard's own kill is used. It was evident that leopards ignored provided dead bait in freshly set box traps in the Melk River study area. This was irrespective of the bait type or the way in which traps were set (including trees). In 608 trap nights no leopard even attempted to go for the bait. Instead many non target animals were captured. According to tracks, on four occasions leopards (three individuals) did show interest while the traps were set and unoccupied.

In ten cases where a leopard's own fresh kill was used as bait and whereby 45 trap nights were involved only one young adult male leopard could be captured. In the other nine cases the leopards (four individuals) ignored their kill (in the cage) and didn't even attempt to enter the cage. Tracks indicated that they did however investigate the trap.

The fact that only genet was captured showed that interference by other carnivore species was not an important influencing factor. Where the leopard's own kill is used, the effect of two factors namely large home range size and interference by other carnivores are mainly absent. Furthermore in this scenario, the leopard has made a kill and is therefore expected to be hungry and motivated to feed (Leyhausen 1979). In the process inherent shyness and alertness may play a less important role.

Another factor that could have had a negative impact on the animal's motivation to face a foreign structure in combination with the visual and olfactory disturbance, was the relative abundance and availability of prey items in the Melk River study area at the time. A wary animal suspecting danger will make another kill rather than risk possible danger .

However, over a period of three years just outside the study area three leopards were captured in box traps using old dry skin and bone pieces as bait. The leopards captured were all subadults (two males and one female), probably inexperienced and hungry. They were captured in cages that were placed in position, not interfered with and set year after year. The cage is thereby covered naturally with vegetation and with the absence of any foreign smells.

From the results obtained in the Waterberg and the opinion of farmers it seems that the visual disturbance of box traps was one of the important factors hampering success in a situation where leopards are constantly persecuted. This is further aggravated by over-camouflaging the cage e.g. using excess amounts of fresh (wet) broken branches. Although leopards apparently don't to have a strong sense of smell (Turnbull-Kemp 1967), olfactory disturbances like oil on the doorframes, human urine and deodorants must have a deterrent effect.

A recommended approach regarding the capturing of experienced leopards in box traps with provided dead bait in a situation, where there is abundant prey, is to first reduce the impact of visual disturbance. Traps should be placed on the setting site, only partly covered with a few dry branches to break the symmetry and left alone for months before the actual baiting and setting. This will give the target animals time to get used to the structure. The floor is especially important in that it must simulate the area just outside the cage, including growing grasses and shrubs.

For bait it is recommended that a small to medium sized antelope (e.g. duiker or impala) be shot in the vicinity of the prepared cage. Without touching it with bare hands the rumen should be opened. The whole antelope is then dragged to the cage along a route known to be used by leopards. At the cage the bait is pulled through the door to the other end with a long stick without entering the cage. The bait is connected to the trigger system from the outside.

Two factors however still have a crucial impact on the success of this approach. Due to the large home range sizes of leopards in areas of the Waterberg, it may take days before a leopard enters a specific area. During this time the interference from other carnivorous species is a main threat. Bait also decomposes, especially so in the summer months with much insect activity. This means that a hungry leopard must " by accident " be hunting in the vicinity of the cage at the right moment. This approach is only recommended for long term studies where the time period is not a critical factor.

The major shortcoming of this method is thus the interference by non target animals. The only way to reduce this problem in the Waterberg situation was to change to live bait, together with relevant changes regarding the cage structure.

This led to the application of the double door walk in box trap with a live domestic goat as bait. The goat's role was not only to reduce trap interference but also to lure leopards more efficiently by bleating.

The same principles regarding visual disturbance were relevant and traps were therefore also put out in advance before baiting and setting commenced. In 72 trap nights over a period of four months only one young male caracal could be trapped. On eight occasions leopard spoor (four individuals) were found around the set traps while a goat was in the kraal (pen).

It was thought that the narrow tunnel effect caused by the cage system (three meters) contributed to the animal's suspicion in a live bait situation. The enlargement of the cage, together with the moving of the bait (goat) to the centre of the system, with two entrances, had the necessary effect. This Boon trap is however still to be utilized more extensively, due to the small sample size, before a definite conclusion can be drawn.

While the designing of this alternative approach regarding a cage system was in progress, the application of gin traps was also tested.

Gin traps are one of the most commonly used techniques for the capturing of leopards, especially problem leopards that are to be destroyed (Turnbull-Kemp 1967; Esterhuizen & Norton 1985). This method is also regarded in the Waterberg by most farmers as the only method to capture "elusive" leopards that are causing damage to stock.

The main advantages of gin traps is their total invisibility and the absence of physical disturbance caused by setting. By using the right procedures (clean traps, cloves and floor canvas) the detection of smell by elusive leopards is prevented (Rowe-Rowe & Green 1981 for black backed jackal). Gin traps are furthermore mobile and easy to carry to far and remote mountainous terrain. The strategy was to use this successful concept as a basis and make certain alterations to meet the objective, namely capturing an animal alive, radiocollaring and releasing the animal unharmed.

The eight jumptraps were used in three approaches (e.g. trap circle, provided dead bait and leopards own kill). In all cases leopards came in for the bait. Shortcomings of the traps per se however lead to the escaping of all the individuals. First the pans (Fig.5) were much to big and had to be reduced to a diameter of 40 mm. Larger pans resulted in light holds and the subsequent escape of the individual.

A further problem experienced with the jump trap was the speed of closing in comparison with the double coil spring steel trap. The slower jaw action of the jump trap increased the possibility that an animal is captured by the tip of the toe. The better holding ability due to the closing of two springs from either side in the double coil spring steel trap, also prevented escaping.

Gintraps are not fastened with a chain to a tree or a pen as this causes major injuries to the struggling animal's paw. The

exact location of the animal can therefore not be ascertained immediately. This can only be achieved by following the spoor mark left by the iron ball connected to the trap. Nevertheless no matter what precautions are taken, the possibility of a light hold is always there. A sudden charge towards an approaching person in such cases can lead to the animal being freed. Such an aggravated animal will almost without exception attack.
This signifies a major threat to the person nearing the animal. The captured leopard will also not necessarily leave the capture site in the opposite direction of the approacher. The possibility that the chain of the gintrap can get stuck between branches and roots is also not to be ignored. This may lead to injury of the captured animal's paw.

By immobilizing the animal on the closing impact of the trap, the above mentioned possibilities are eliminated. The only limiting factor was the 1 ml capacity of the syringes mounted on the gintrap. The drug also had to be stable for up to five days, as traps are left underground until the leopard returns. Short induction times (0-10 min) and relatively long immobilization times (2-10 h) were important. Phencyclide hydrochloride was the only available drug at the time with these characteristics.

The unpredictability concerning the return time of the leopard to his bait also influences the success of the immobilization. If the drug is administered at 18h00 and the capture site only visited the next morning at 06h00 the effect of the drug would probably have worn off. It was therefore necessary that the actual trigger time had to be monitored. This was accomplished by the buried transmitter trigger device.

CHAPTER 3: SPACE UTILIZATION AND ACTIVITY PATTERNS

INTRODUCTION

An individual's relationship to space reflects it's relationship to resources and other ecological factors. Uneven use of land by an individual and the relative way conspecifics use it, can provide an indication of the importance, distribution, richness and accessibility of an important resource such as food (Henshel 1986).

An individual's range must however satisfy all of it's energetic needs (Gittleman & Harvey 1982). The utilization of other resources, such as mates, water, shelter / hiding sites, depending on the demand for them, may also elicit special behavioural patterns. Depending on the quality and distribution of resources, certain behavioural patterns such as the establishing of territories in fixed areas at a given time, where resident individuals or groups dominate and limit access to resident conspicifics (Kaufmann 1983) may develop. In addition, certain ecological factors such as man-inflicted mortality may influence space utilization patterns in specific areas and of altering the internal characteristics of a population, by removing tenured individuals, creating behavioural instability, and keeping the social organization in a perpetual state of flux (Hornocker & Bailey 1986).

Although radio tracking studies in different regions of the world have revealed information on aspects of leopard spatial utilization (Bertram 1978; Muckenhirn & Eisenburg 1973; Smith

1977; Norton & Lawson 1984; le Roux & Skinner 1989), only the study of Hamilton (1976) and to a lesser extend Hornocker & Bailey (1986) can be regarded as representative in terms of information gained on the association between conspicifics in a specific area which facilitate the interpretation of the social organization of the population.

Hamilton (1976) described the existence of stable recognisable home ranges for leopards in Kenya, which the occupants cover frequently, thoroughly, and more or less evenly, although they do occasionally leave on forays from time to time. These leopards revealed a mosaic arrangement of polygonal male home ranges, which overlap relatively little, while showing that female home ranges do not appear to fit in with the male mosaic but are probably superimposed in a separate overlapping mosaic of female ranges. He confirmed that the leopard is basically solitary, except when females have dependant young. Associates between sexes are not only brief but also infrequent.

OBJECTIVES

By assuming the above mentioned scenario as the intrinsic "norm" of the social system of the species, radio tracking of leopards in the Naboomspruit study area was conducted to gain information on the following aspects of leopard space use and activity.

a. Extent of movement which includes total and seasonal home range sizes as well as mean distances travelled in a diel tracking period.

b. Occupancy of range relative to the distribution of cattle- and game farms.

c. Estimated leopard density.

d. Diel and seasonal patterns of activity.

METHODS

Radio-telemetry

A male and female leopard were captured as described in Chapter 2, immobilized with Ketamine hydrochloride, Parke Davis, Pty Ltd, RSA; 10 mg/kg and Syclan, Contour Labs Pty Ltd, RSA; 10 mg/kg respectively. The male was darted in the cage with a Vario I dartgun (Telinject R.S.A. Randburg) while the female was captured in the modified steeltrap with mounted darts as described in Chapter 2.

After being weighed and measured (Table 1) the study animals were fitted with radio collars manufactured by the Telonics Telemetry- Electronics Consultants, Mesa Arizona, USA. The complete collars weighed approximately 250 grams and contained 4 B transmitters (150.800 - 150.900 MHz) powered by one Telonics type B - 3H hermetic lithium cell with a theoretical operational life of 15 months. Each collar also contained a S6B motion sensor - inverse mode with a fast pulse rate when active and a reduction in pulse rate after cessation of movement. An LA 12 receiver (AVM Instrument Company, California, USA) was used.

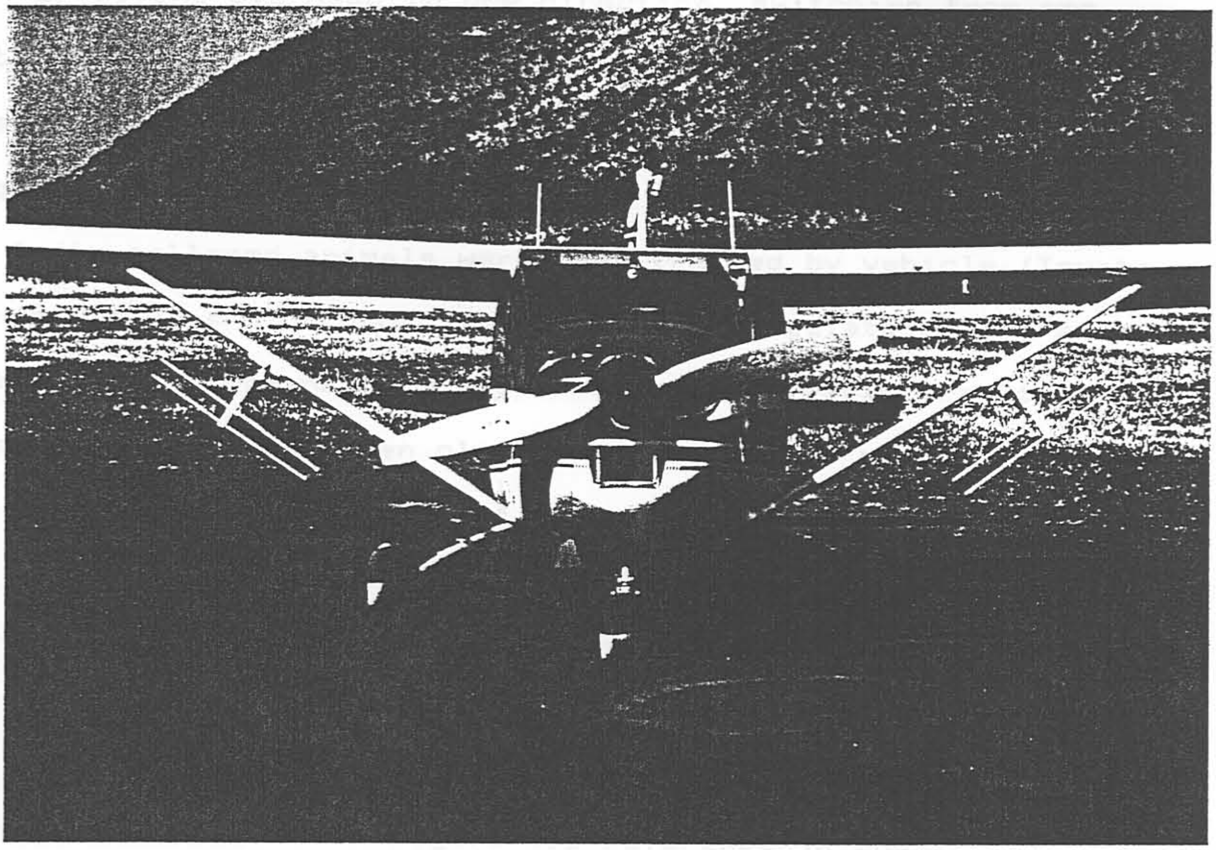


Figure 9 : A Cessna 185 with yagi antennas attached to the wing struts.

Due to the large home ranges of the study animals and broken terrain, initial location had to be done from the air (Cessna 185) with two 2 - element yagi ($\frac{1}{4}$wave) antennas (CSIR, NEERI, Pretoria, RSA) mounted on the two wing struts (Fig 9). This was based and modified on the methods developed by Inglis (1981) and Whitehouse (1977). The study animals were pin-pointed from the air by flying overhead in one direction, switching from one antenna to the other by means of a switchbox (operated from inside the aircraft). This was checked with another fix at right angles.

Radio-collared animals were then tracked by vehicle (Toyota Landcruiser) and on foot, by means of triangulation with a 4-element yagi antenna from two or more known radio tracking stations, which had been plotted on a 1:50 000 map.

At each point a bearing of antenna direction was taken with a prismatic compass about 8 m from the vehicle. The true bearings were plotted on a 1:50 000 map overlaid by a 1 km x 1 km grid. The point at which two or more lines intersected, represented the leopards plotted position. This was also expressed to the nearest 125 m as a six figure map reference (X and Y coordinates) for computer analyses.

Both study animals were tracked for periods varying from four days to 14 days on a continuous 24 h (diel) basis. Tracking was carried out from November 1986 to July 1987 in the case of Leopard A and from March to September 1987 for leopard B, 759 and 322 radio plots were ascertained respectively. In the male (Leopard A) winter (April - Sept), 451 plots and summer periods (October to March), 308 plots were distinguished.

Extent of movement

Home range sizes (including seasonal) were calculated using the minimum area method (Mohr 1947), which measures the area of convex polygon linking the outermost radio-tracking plots. Areas were calculated on the flat plane of a 1:50 000 map, and no allowance was made for the increased area of mountain slopes.

The home range (area covered by normal activities) was separated from the "observed range" (all points included) as described by Hamilton (1981) by excluding plots that were considered to present "forays", away from the main home range.

Observation - area curves (Odum & Kuenzler 1955) indicated for each leopard whether the number of plots was adequate to describe the total area used. Mean distances travelled (MDT) in a diel tracking period from 12h00 to 12h00 were calculated to assess the rate of movement around the home range. This was taken as the total straight line distance between successive points during a diel tracking period.

Occupancy of home range

The intensity of habitat use was measured in terms of the number of locations recorded in each grid for each leopard. This was analysed by the computer programme, ARC/INFO TIN MODULE, (GIS Lab, University of Pretoria), and demonstrated three dimensionally by plotting the frequencies per block (grid).

Peaks represent high values i.e. highly utilized space in the territory. As study animals were basically nocturnal or crepusculer lying up sites (resting sites) at 12h00 were also plotted for each individual. The different farming activities on each farm is shown as G = Game, S = Stock or M = Mixed.

Activity patterns

Activity patterns were presented as the number of nights active vs the time of the day (hour interval), and compared seasonally. This was done by the continuous monitoring of the study leopards throughout 24 h - periods on a minute basis.

The total number of minutes active in a specific hour interval was classified under the following three categories: Active, i.e. - active for more than 40 min of that hour interval; Intermediate, i.e. active between 20 and 40 min and inactive, i.e. active for less than 20 min of the interval. The intermediate category was not used in the calculations of the data. A total of 52, 24 h periods were observed. The male was monitored for 52 complete 24 h periods while the female's data were obtained from 23 complete 24 h-periods.

RESULTS

Extent of movement

Sufficient data were obtained to calculate the "home ranges" for both leopards. The observation curves for both leopards seemed to level off after 300 radio plots (female) and 675 radio plots (male). (Fig. 10). The first 300 radio plots of the male leopard were obtained during the summer period. After the first 225 radio plots of this period, the graph levelled off but started to increase again in the winter after a total of 375 radio plots. As no forays occurred, the "observed range" sizes

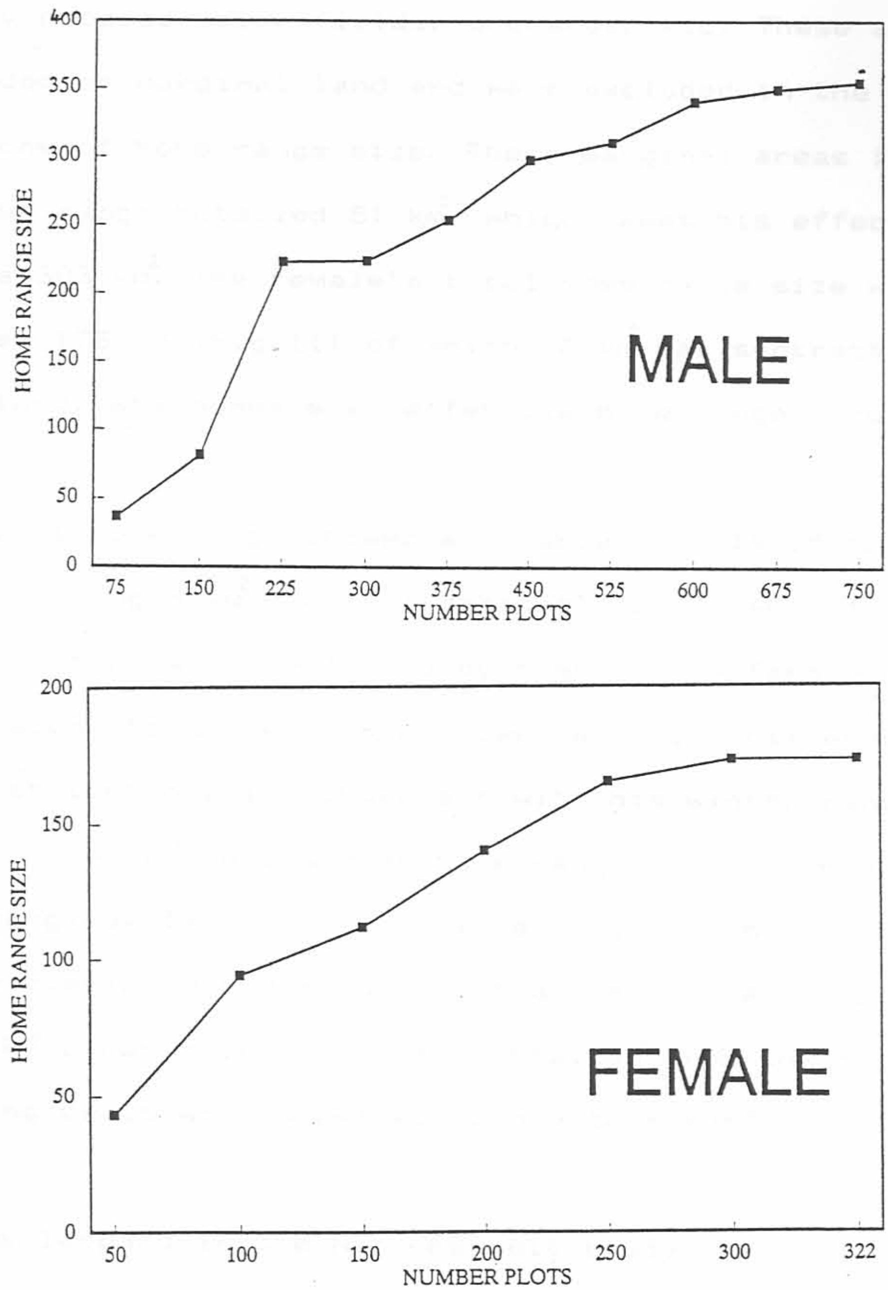


Figure 10 : "Observation - area curves" (Odum & Kuenzler 1955) for the male and female leopard in the Naboomspruit study area.

were taken as representative for the "home range" sizes.

The total home range size of the male leopard was calculated to be 354 km^2 (Fig. 11). However, while covering his range he frequently crossed maize fields, orchards, etc. These areas were all regarded as marginal land and were excluded in the calculations of home range size. These marginal areas in the male's home range totalled 51 km^2, which makes his effective home range size 303 km^2. The female's total home range size was measured at 173 km^2 (Fig. 11) of which 16 km^2 was subtracted as marginal land, which means an effective home range size of 157 km^2.

The male's home range showed an overlap of 91% of that of the female (excluding 8 km^2 marginal habitat), while 46% of the male's home range was overlapped by that of the female (Fig. 11). The male leopard's summer range showed a slight difference in spatial distribution, in comparison with his winter range (Fig. 12). Winter (247 km^2) and summer home range sizes (206 km^2) which excludes marginal land, did not differ significantly. The percentage overlap between the two seasons was calculated to be 43 % (133 km^2). Radio tracking data obtained from the female wasn't being dealt with seasonally, due to insufficient summer data.

The male leopard in the Naboomspruit study area moved a mean distance of 8,6 km per diel tracking period (SD = 5,1), (n = 52). The greatest distance was measured at 21,5 km and the minimum 0,6 km. The female averaged a distance of 6,1 km per diel tracking period (SD = 4,3), (n = 23), with a maximum of 12,2 km and a minimum of 0,2 km. Average seasonal distances of

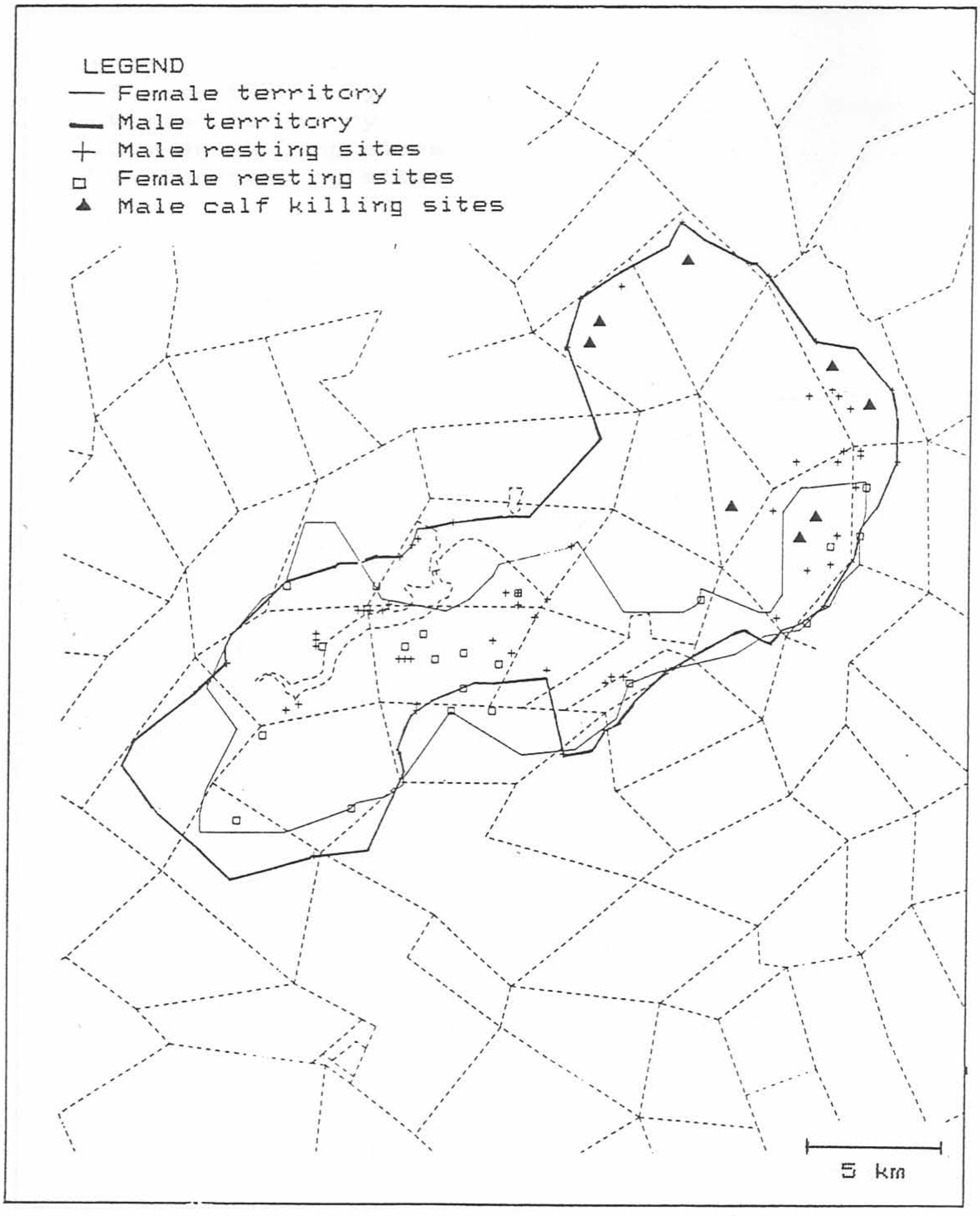


Figure 11 : Spatial distribution of the male and female leopard territories, with 12h00 resting sites and male cattle calf killing sites in the Naboomspruit study area.

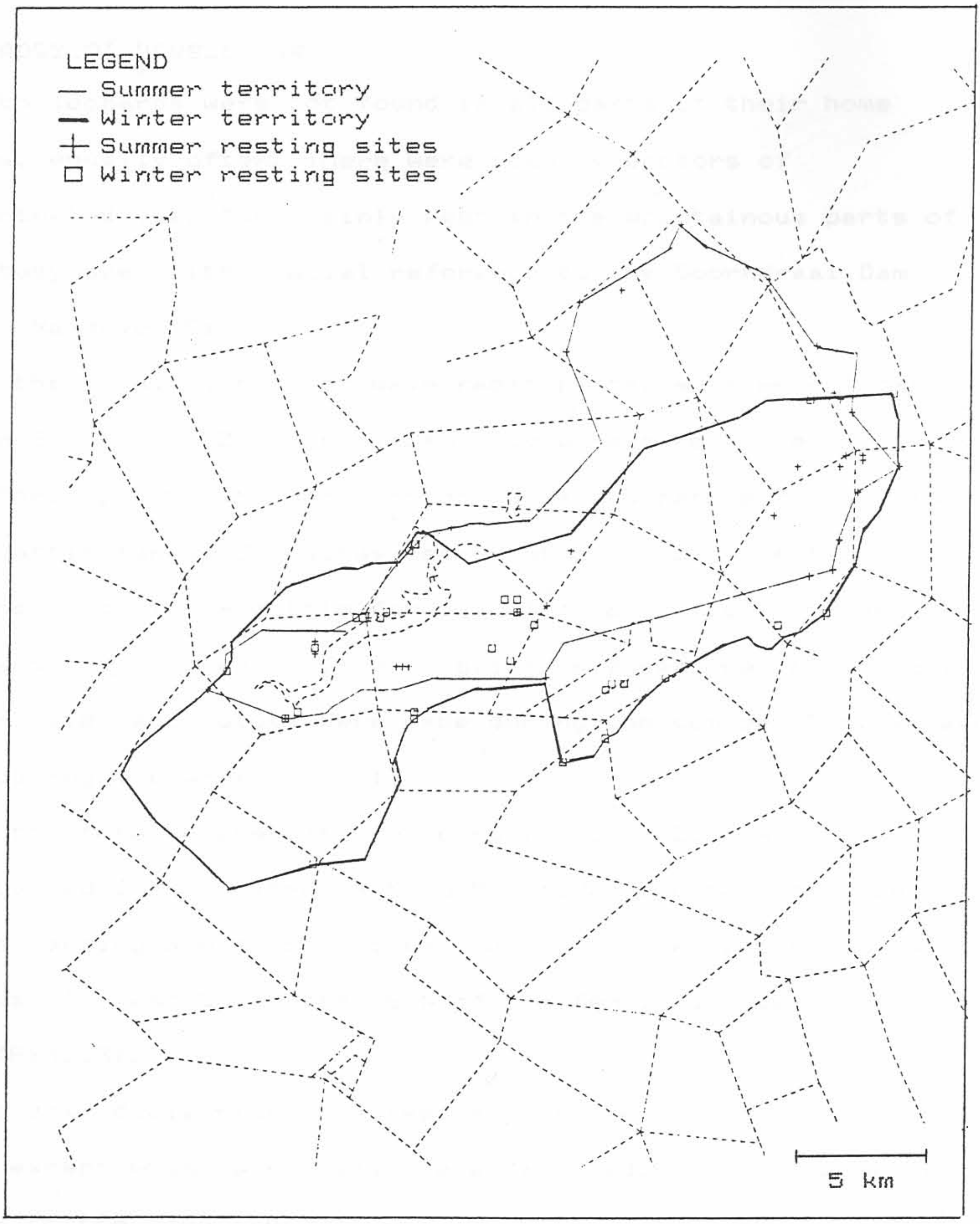


Figure 12 : Spatial distribution of the male leopard's summer and winter territories with 12h00 resting sites.

the male were calculated at 8,9 km during the summer (SD = 5,2), (n = 32) and 8,05 km during the winter (SD = 3,9), (n = 20).

Occupancy of home range

Both leopards were not found in all parts of their home ranges, equally often. There were usually sectors of concentrated use. They mainly kept in the mountainous parts of the study area with special reference to the Doorndraai Dam Nature Reserve (Fig. 13).

Of the total numbers of male radio plots, 49 % were located within G - sites (Doorndraai Dam Nature Reserve and exclusively game farms), 3 % within M - sites (Game and cattle farms) and 48 % on cattle farms. G - sites represented 25 %, M - sites 10 % and the remaining - cattle farming 65 % (S - sites) of the male's total home range size.(Fig.13) On a seasonal basis 52 % of G - site radio plots were made during the summer (Fig.14) and 48 % during the winter(Fig.14).

Of the total number of female radio plots 39 % were ascertained in G - sites, 4 % in M - sites and the remainder in cattle farming areas (S - sites). G - sites represented 53 %, M - sites 21 % and S - sites 26 % of the female's total home range size (Fig.13).

The same daily resting sites was not used during consecutive days, except when large kills were involved. They did however, return to the same tree or rock in the course of time and seemed to have favourite resting places, just as they preferred certain game trails and vehicle tracks as travel routes. Resting sites were exclusively on the ridges of mountains which permitted a

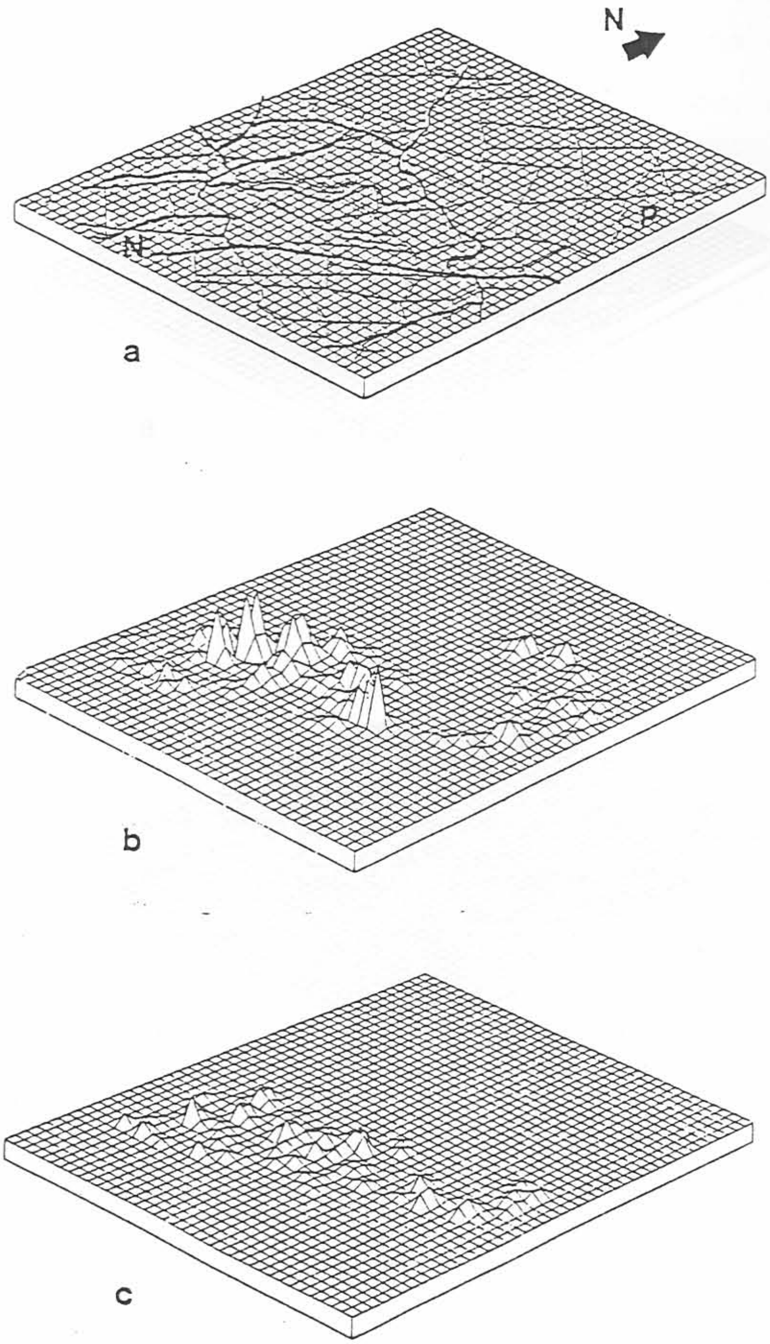
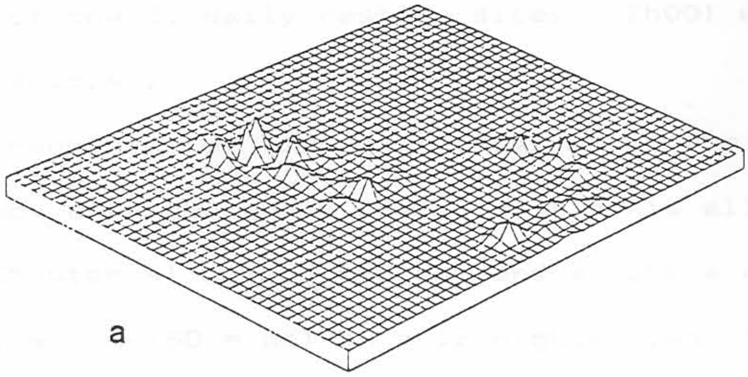


Figure 13 : Three - dimensional, ARC / INFO TIN MODULE - generated map representation of (a) Naboomspruit study are (b) male leopard space use (c) female leopard space use ; based on the number of plots in each grid (N = Naboomspruit ; P = Potgietersrus).



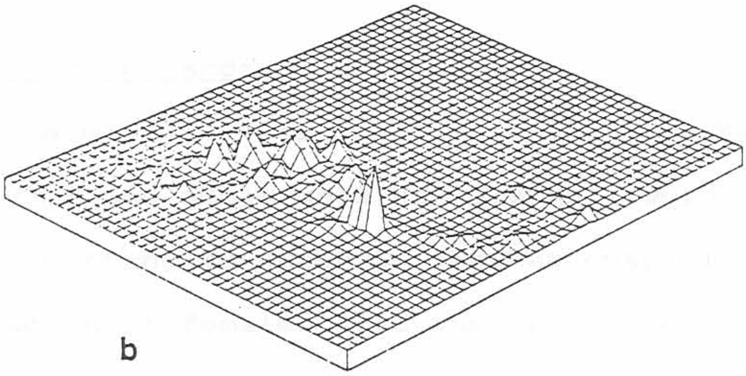


Figure 14 : Three - dimensional, ARC / INFO TIN MODULE - generated map representation of (a) male leopard summer space use (b) male leopard winter space use, based on the number of plots in each grid.

good view of the surrounding area (Fig.11 & 12).

Of the 77 male daily resting sites (12h00), 34 % were recorded in the Doorndraai Dam Nature Reserve. In the case of the female 38 % of the 21 daily resting sites (12h00) were made in this Reserve (Fig.4).

During the consumption of five cattle calves in the Naboomspruit study area the radio collared male hid all carcasses (see Chapter 4) during the day and sought a resting place on average 425 m (SD = 85) (N = 12 nights) away from the carcasses. With each carcass he returned to the same daytime resting site, except for the last night of consumption after which he left the area.

Estimated density of leopards

If one assumes a male overlap of 30 % in the home range of 303 km^2, a density of one adult male per 303 km^2 - 90,9 km^2 = 212 km^2 is relevant. According to spoor in the Naboomspruit study area, at least two adult females used the male's home range. This means, one adult leopard per 70 km^2. The number of subadults can only be a subject for speculation. One subadult was seen during the study period as well as the spoor of two cubs. If one only considers the one subadult, the leopard density for the Naboomspruit study area represents one leopard per 53 km^2.

Activity patterns

Both individuals were predominantly nocturnal with some crepuscular activity (Fig 15). The female (n = 23) was active in 10 nights between 17h00 and 18h00, with a sharp peak between

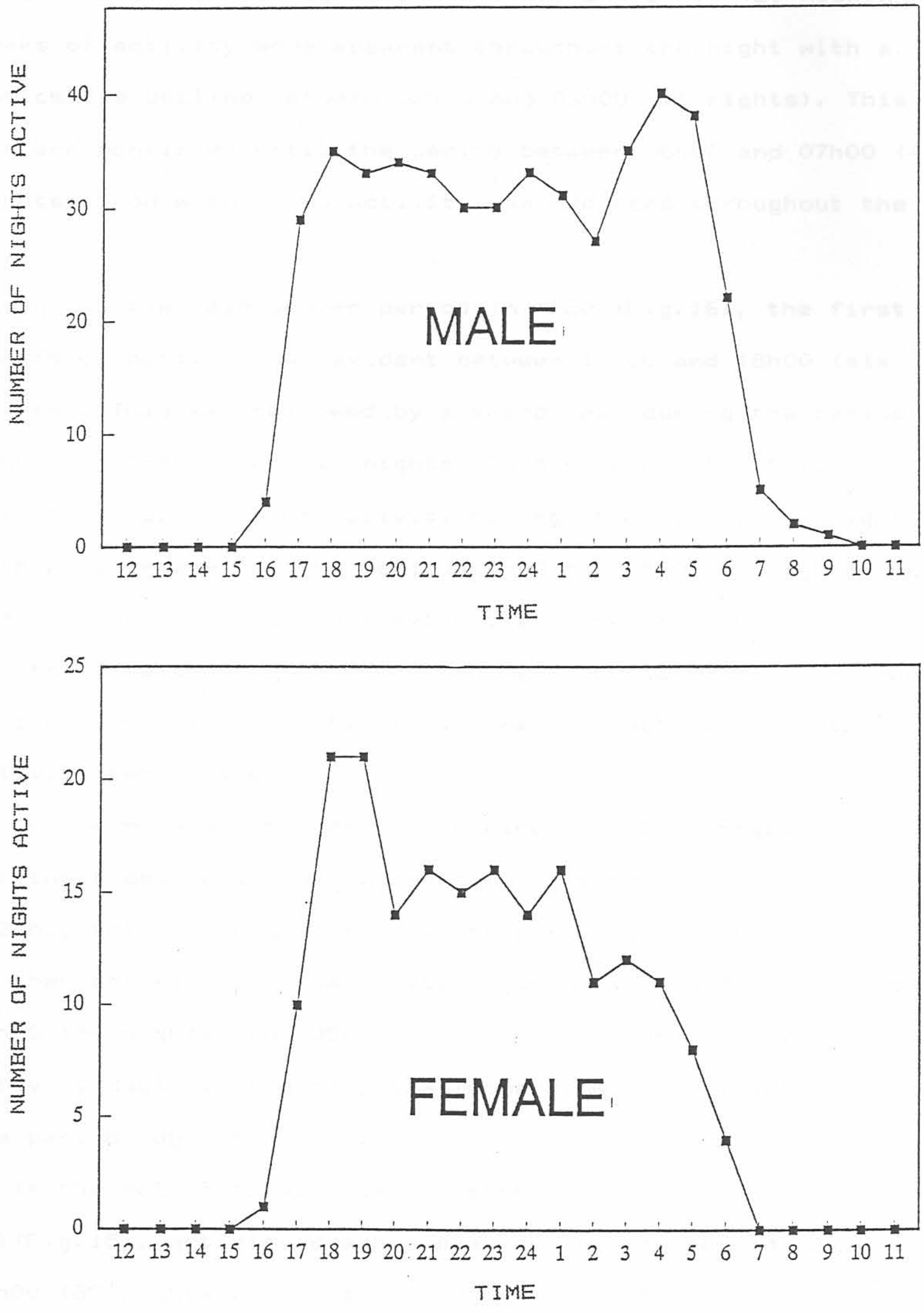


Figure 15 : Diel activity patterns of the male and female leopard in the Naboomspruit study area.

18h00 and 19h00 (21 nights), and 19h00 and 20h00 (21 nights). Peaks of activity were apparent throughout the night with a noticeable decline between 02h00 and 03h00 (11 nights). This pattern continued until the period between 06h00 and 07h00 (4 nights) from when on no activity was recorded throughout the day.

During the male summer period (n = 20)(Fig.16), the first period of activity was evident between 17h00 and 18h00 (six nights). This was followed by a sharp peak during the period 18h00 and 19h00 where 15 nights (75 % showed activity). Infrequent patterns of activity during the rest of the night with an increase for the period 24h00 to 01h00 (17 nights) were recorded. Another peak was evident at 04h00 to 05h00 (16 nights). The periods 07h00 to 08h00, 08h00 to 09h00, and 09h00 to 10h00 only showed activity in one day each, after which activity terminated.

In the male winter activity period (n = 32) (Fig.16), a prominent peak was also apparent for the period 17h00 to 18h00 (23 nights). Although activity was recorded throughout the night another definite peak was evident during the periods 04h00 to 05h00 (24 nights) and 05h00 to 06h00 (23 nights) from where activity declined sharply, the leopard becoming inactive during the period 08h00 to 09h00.

In the male's total activity pattern scenario (n = 52)(Fig.15), activity reach a peak during the period 18h00 to 19h00 (35 nights). This slightly levelled off for a short period between 02h00 to 03h00 (27 nights). A last peak during the period 04h00 to 05h00 (40 nights) was apparent. Low activity

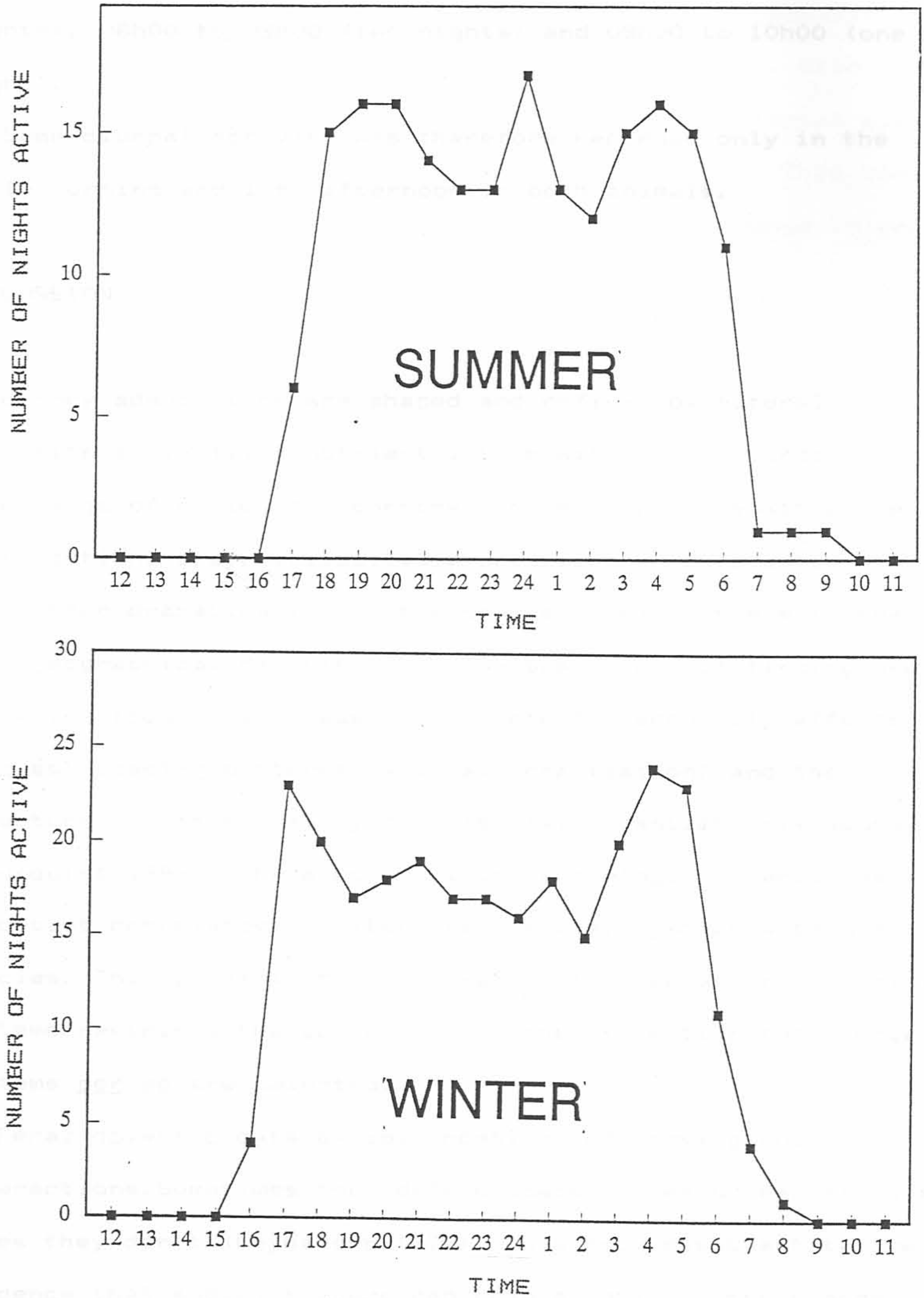


Figure 16 : Diel summer and winter activity patterns of the male leopard in the Naboomspruit study area.

patterns were monitored for the periods 07h00 to 08h00 (five nights), 08h00 to 09h00 (two nights) and 09h00 to 10h00 (one night).

Some diurnal activity was therefore recorded only in the early morning and late afternoon in both animals.

DISCUSSION

Predatory adaptations are shaped and refined by natural selection to maximize nutrient intake within the bounds of a wide range of ecological constraints (e.g. prey density, prey distribution, prey availability, predation or persecution) that may differ dramatically for the same species at the extremes of it's geographical distribution. The basic task of finding and gathering food under these constraints fundamentally affects a species' spacing patterns (spacial organization) and the structure of its social systems (social organization)(Sunquist & Sunquist 1989). These constraints or ecological variables are important correlates of alternative social systems within a species. This possibility of intraspecific variation in social systems restricts the generality of the assumption that social systems *per se* are selected.

Feral domestic cats exhibit complex and varying social interactions. Sometimes they defend space or resources, at other times they don't (Leyhausen 1979). This provides quantitative evidence that social systems can have adaptive consequences (Lott 1984) and are not fixed through natural selection. A drastic decline in the bobcat (*Lynx rufus*) food supply, namely blacktailed jackrabbits (Lepus californicus) led to the complete break down of the territorial system of the bobcat population and the resident adults scattered in all directions. With the recovery of the rabbit population the bobcat territorial system started to operate again (Hornocker & Bailey 1986). This however can be regarded as a sudden and extreme case of change in prey demography.

The degree to which a territorial system can be achieved and maintained in practice depends on the cost in energy expenditure to the male or female in attempting to exclude possible competitors of the same sex. Because home range size varies depending on for example, prey availability, resident animals may be incapable of defending a territory adequately to exclude possible competitors. This accounts for most of the cases where overlap exists in the home ranges of like sexed adults. Overlap thus occurs when the cost of excluding the neighbour is either too great or, if the home range is large enough, impossible.

Spotted hyaenas on the Serengeti, get most of their food by scavenging the remains of small, migratory prey. The hyaenas usually are nomadic, living in small, loosely organized social groups. Hyaenas in the Ngorongoro crater get most of their food by killing large bodied sedentary prey. The hyaenas are organized in large cohesive social groups which defend territories year round. The interpretation of this intraspecific variation in social system, is that the food base in the Serengeti is usually too scanty and unpredictable to support large groups of hyaenas or provide the energy required to defend territories. In contrast, most of the food in the crater is only available to groups large enough to kill it. Moreover, it is predictable and relatively abundant, making territorial defence seem both possible and functional.

Another ecological factor apart from prey population characteristics that may alter a predator's social system, is the continuous elimination of individual adults in that system through human activity or other mortality agents. This mortality has the capability of altering the internal characteristics of a population by removing tenured individuals creating social instability, and keeping the social organization in a dynamic state (Hornocker, Messick & Melquist 1983).

Burt (1943) defined home range as the area that an animal learns thoroughly through habitual patrols. The traditional but controversial definition of territory is an exclusive area maintained through overt defence or advertisement (indirect defence)(Noble, 1939). Although this definition of territory needs a better description for large mammals (Grimbeek 1984), it is used here as a basis in the discussion of the social organization of leopards.

In all studies so far conducted on the socio-ecology of leopards, a male arrangement of territories with relatively little overlap and a separate overlapping mosaic of female territories has been described (Hamilton 1981, Hornocker & Bailey 1986, Norton & Henley 1987).

Although Hornocker (1969) indicated that solitary predators that depend on their own physical well-being to survive, cannot afford injury through aggresive agonistic behaviour, a number of cases of fighting between leopards have been described in defending their territories (Turnbull-Kemp 1967, Hamilton 1981, le Roux & Skinner 1989, pers. observ.)

In addition, indirect means of territory defence may also be present. These include visual, olfactory and auditory (vocal) markings. (Hamilton 1976 ; Bothma & le Riche 1984, this study).

The flexibility of the social systems of solitary felids is becoming more and more apparent as detailed information on this aspect becomes available. Due to the wide distribution of these animals it is reasonable to assume that, along with adaptability, a highly flexible social system has evolved. Striking evidence for such flexibility was obtained in mountain lion and bobcat research (Hornocker & Bailey 1986).

In leopards this phenomenon may also be present as more detailed studies in divergent habitat types become available. Some indications of alternative social systems are present but, as detailed investigation is lacking, this cannot be ascertained. Two scenarios where the manifestation of alternative social systems are possible are to be examined, at this stage.

In ecosystems where the distribution and availability of food necessitates large areas of utilization, the economic cost of defending a territory must be measured against the benefits. Detailed information on the social organization of leopard populations, where home range sizes are in excess of 400 km^2, e.a. Stellenbosch area in the Cape Province, southern Kalahari and the Judean Desert of southern Israel, would possibly reveal interesting data on the exclusivity of home ranges.

Secondly, in the relatively high density leopard population in the Kruger National Park (one leopard per 6 km^2) territorial exclusivity by conspicifics was not complete. According to Hornocker & Bailey (1986) this was probably because of the limited habitat available in the southern Kruger National Park. Leopards were largely confined to the Park and nearby private game reserves. Those straying into intensively farmed and grazed areas on the west and south of the Park were probably quickly exterminated.

Most available leopard habitat adjacent to the study area was probably already occupied by resident leopards. Some young leopards didn't disperse from the natal area but remained in the population as non breeding "floaters".

Although some fighting did occur, the effect on the population was minimal. None of the mortality in adults (18% annually) was attributed directly or indirectly to fighting among conspicifics (Hornocker & Bailey 1986).

In a third well studied intermediate scenario where leopard densities are lower such as Kenya, one leopard per 13 km^2 (Hamilton 1976) and Tanzania, one leopard per 29 km^2 (Bertram 1978) and possibly the Waterberg, one leopard per 53 km^2 (present study) and where enough surrounding habitat was available, the maintenance of exclusive territories was evident. However, whenever males made forays into the territories of others, they changed their behaviour outside their own home ranges and tended to withdraw sharply after encountering a resident male.

However Hamilton (1981) is of the opinion that bloody fighting among Kenyan male leopards is more common than has hitherto been believed and that it may even be a significant cause of mortality.

Home range sizes (territories) of leopards so far described in the literature varied from 8 km^2 in the Chitawan National Park, Nepal (Seidensticker 1976) to > 400 km^2 in the southern Kalahari (Bothma & le Riche 1984). However different interpretations exist on exactly what constitutes a home range and the effect of the number of radio plots ascertained (Norton & Lawson 1985). Although not exactly comparable it provides an indication of trends in different regions. In the Naboomspruit study area, the male and female's home ranges can be regarded as representative for the specific period, as both individuals observed area curves (Fig.2, Fig.3) levelled of by the time radio tracking terminated.

The spacing pattern in a population of solitary carnivores is the result of the behaviour chosen by the individual animal in an attempt to survive and maximize reproductive success. It is believed that female spacing patterns are determined by the availability of food, whereas male spatial organization, at least during the mating season, is determined by the distribution of females (Sandell 1989).

Because a non-cooperative (solitary) species such as the leopard female rears young by themselves, their reproductive success is closely correlated with the amount of energy they can allocate to reproduction. In turn, this amount mainly depends on the food resources available during the rearing period. Thus for females, food is the most important resource, and females should adopt behaviour which maximizes their chances of securing food resources for reproduction and survival. One can therefore predict that female home range size is correlated with food availability during the critical period of the year (Sandell 1989).

The spatial distribution of the Waterberg (Naboomspruit) female leopard followed the superimposed mosaic arrangement over male territories as described by Hamilton (1981) for Kenyan leopards. As 46% of the males territory has been overlapped by the female, this means that another female (or females) is expected to be present in the northern sector of the males territory (Fig.11). This seemed to be the case as female spoor (different from the radio collared female) were detected in that area. Another male and female's spoor were also encountered on two and three occasions respectively on the south western boundary of the radio collared male's and female's territories. The infrequent presence of these individuals is probably related to the size and spatial distribution of their territories as suboptimal habitat (such as irrigation farming) exists in a south western and north western direction.

According to Sundell (1989) solitary male spatial organization is influenced by two resources, namely food outside the mating season and receptive females during the mating period. It follows that during a substantial part of the year male and female spacing patterns are determined by different factors, and range size in males should be a function not only of food requirements but also of female distribution. Since food ranges are minimized whereas mating ranges are expected to be maximized, it follows that male ranges should be larger than predicted by energy requirements.

The interpretation of the spatial distribution of the Naboomspruit radio-collared male leopard in the absence of data on the female(s) reproductive status is however incomplete. Leopards (radio-collared male and female) were known to associate for brief periods (two to three hours) in more or less the same area on four occasions. All of whom were in the Doorndraai Dam Nature Reserve.

The expanding of the male's territory in a northerly direction during the summer period can definitely be attributed to the presence of cattle calves on these farms during the calving season, where he took five individuals (Fig 11). The male's winter movements in the south of his territory can be related to the presence of "winter" cattle calves on the farms. No cattle losses were however recorded in this area during the time, as calves were kraaled every night.

Although Doorndraai Dam Nature Reserve constituted only 20% of the male's total home range size, almost 50% of the total number of radio plots were recorded in the reserve for both winter and summer periods. With the exception of the northern expansion (summer) and southern expansion (winter)as mentioned, the territory of the male was therefore relatively stable over the 11 month period (Fig.12). In the case of the female the Doorndraai Dam Nature Reserve contributed almost 40% of her total territory size in which 53% of the radio-plots were recorded. It seems therefore that the female used her territory more evenly when compared to the male.

It is apparent from Figure 11 that both leopards concentrated in rocky mountainous areas which, on the one hand, are not only relatively remote from human activities but also facilitates hunting efficiency. All felids rely extensively on physical features in their environment, using almost any type of cover to get as close as possible to prey before making the final attack. (Sunquist & Sunquist 1989). Bothma & le Riche (1989) also recorded optimal positioning in the leopard whereby potential prey were selected from a high vantage point. Thus confirming the concept that cover and sight play an important role in hunting by cats (Kruuk 1986).

Bush density, grass height, ungulate numbers and biomass were uneven over the study area. The mountainous parts are typical sour bushveld with open savannas in the less rocky parts and dense, mixed bushveld in the rugged parts with a high diversity of micro habitats (Acocks 1975).

These mountainous areas supported a whole spectrum of potential prey species especially in the Doorndraai Dam Nature Reserve, where the highest prey numbers and biomass (excluding cattle) were recorded. Open savannas in and surrounding these mountainous ranges in the Reserve, supported small and large ungulates. A high density of small mammals including smaller antelope occurred outside the Reserve. (See Chapter 4) The circadian activity of especially antelope is relevant during the cold winter months, when they seek refuge in the denser mountainous bush away from the water (Doorndraai Dam).

Resting sites were also always on the ridges of mountains to enable proper viewing of the surrounding area. It was thus impossible to approach a leopard without being noticed. No selecting for resting sites in the Doorndraai Dam Nature Reserve was evident.

The male leopard in the present study without exception returned to the same daily resting places when large prey was captured.

According to Bothma & le Riche (1984) leopards in the southern Kalahari seldom spend two successive nights in the same part of their range. During the hot hours of the day they lay in the shade of a suitable bush or tree or take refuge in the cool underground in an aardvark or porcupine burrow.

Leopards in Kenya (Hamilton 1981) also rested in a different place each day, except when they had large kills or small cubs. They did, however sometimes return to the same tree or rock in the course of time and seemed to have some favoured resting places as been found in the Naboomspruit study area. The leopards in the Cedarberg also appeared to rest in different places each day. There was no clustering of radio plots that would have suggested the use of favourite resting sites (Norton & Henley 1987).

Leopards frequently show maximum activity at night, with activity declining to a minimum at midday (Sunquist 1981). These patterns can however be vastly affected by the amount of human interference. In the southern Kalahari where no human interference exists, leopards rest frequently soon after the onset of their nightly movements, and again when they approach the end of such movements (Bothma & le Riche 1984). Radio collared leopards in Kenya also moved mostly at night and rested during the hotter hours of the day (10h00 to 17h00)(Hamilton 1981). However, in agreement with Bertram (1978) they sometimes move at any time of day and Hamilton (1981) recorded leopards hunting on two occasions at 09h30 and 15h00 on hot days. Kenya leopards showed a sharp increase in activity between 18h00 and 19h00, with a more or less continuous movement throughout the night.

In the Cape Province leopard activity patterns did not support the popular belief that leopards are mostly nocturnal. Norton & Henley's (1987) results show that the leopards were most active during the day, with peaks in the late morning and late afternoon. Leopards were also usually inactive for most of the early morning from midnight till after sunrise. During the day they were recorded as active under a variety of conditions, and were not apparently by high temperatures. (Norton & Henley 1987)

In the Waterberg, leopards showed almost exclusively nocturnal activity patterns with early evening (18h00 to 19h00) and morning (04h00 to 05h00) peaks (Fig.15). However the later peak in the male is based more on directional movement (travelling). This seems to be patrolling related (territory maintenance or female interactions) and/or to optimize positioning, i.e. to move out of a potential high human activity zone to a more isolated zone. This activity was especially evident when no large kills had been made the previous night or early morning. Early evening and through the night activity peaks, in both sexes, seemed to be more hunting related, although the above-mentioned functions should also be expected to be relevant.

In the female the morning peak (04h00 to 05h00) was less prominent, as her territory didn't expand frequently into human activity zones. The smaller size of her territory also facilitated territorial maintenance.

A possible explanation of winter movement inhibition could be the low winter temperatures (as low as -6 °C) experienced in this time interval during the study period. This temperature impact could also be reflected in the movement patterns of larger ungulate prey species, thereby making them more available in the denser rough terrain to leopards.

The incidence of large kills also has an inverse effect on activity, as a leopard would spend most of the night at the carcass feeding at intervals. Rain showers per se did not seem to have an influence on activity. The radio collared male in the Naboomspruit study area travelled extensively on two occasions during heavy thunderstorms.

The straight line distance between resting sites of leopards on consecutive days (the daily distance) varied in Kenya from leopard to leopard more or less in direct proportion to the size of the animal's home range. The smallest distance recorded was a subadult male (0,9 km). That of an adult female was calculated to be 2,0 km, while those of five adult males varied from 2,3 to 4,2 km, with a mean distance for all five males of 2,9 km. Maximum daily distances recorded varied from 4,9 for the adult female to 8,4 for the adult male.

The mean daily distances of the study leopards in the Cederberg (Cape Province) were very similar to those found in Kenya, where it varied from 2,3 to 4,2 km (Norton & Henley

1987). In the Stellenbosch area female daily distances of 11,2 km, and daily male distances of 6,7 km were recorded (Norton & Lawson 1985).

In the Waterberg mean distances travelled in a diel tracking period give more detailed information in that different points throughout a night were linked and not only the daily resting sites. Waterberg figures are thus not actually comparable and are expected to be higher. The 8,6 km daily mean distance travelled by the Waterberg male is however much lower than the 14,3 km mean distance recorded by Bothma & le Riche (1984) in the southern Kalahari. A maximum of 33,0 km was travelled by this male in comparison with the maximum of 21,5 km recorded in the Waterberg. Females with cubs moved a mean distance of 13,4 km during a 24 hour period in the southern Kalahari, whilst the female in the Waterberg only covered an overall distance of 6,1 km. These higher distances in the southern Kalahari seemed to correlate with the higher "territories" 400 km^2 in comparison with the 150 km^2 (female) and 300 km^2 (male) in the Waterberg.

The two Waterberg leopards not only showed a tendency to patrol the edges of their territories, but their movements within the territories showed they did cross rapidly backwards and forwards within the area. In the Melk River study area tree-scratching was very common. Only three tree species were utilized namely the water pear (<u>Syzygium guineense</u>), the water berry (<u>Syzygium cordatum</u>) and to a lesser extent (once) the common white pear (<u>Dombeya rotundifolia</u>). High frequencies were encountered for the first two species especially along watercourses, which probably represented areas of high utilization. In the southern Kalahari tree scratching also occurred frequently, in contrast with the view of Turnbull-Kemp (1976), that tree-scratching is rare in African leopards or Hamilton (1976) who never observed tree scratching in Kenyan leopards.

According to Ewer (1973) tree scratching does not only have a definite communicatory function, but also serves to neat the claws. The selecting of specific tree species for this neating process indicates that the composition of the bark and/or the woody part of these trees facilitate this function.

Scent marking in the Waterberg followed the same pattern as found by Bothma & le Riche (1984) in the southern Kalahari, Schaller (1972) in the Serengeti and Hamilton (1976) in Kenya, including the fact that faeces does not seem to be used in any special manner. There is also no evidence yet that leopards in the Waterberg (present study) and the southern Kalahari (Bothma & le Riche 1984) use specific trees as scent posts, as leopards do in Sri Lanka (Eisenberg 1970).

Urine-scraping was also relatively common along roads in the Waterberg. In the southern Kalahari these frequent scrapes seem to be associated with squirts of small quantities of uriene on low shrubs or grass tufts (Bothma & le Riche 1984) and agrees with the observations of Eisenberg & Lockhart (1972). Although no data could be ascertained in the Waterberg, both sexes of leopards in the Kalahari scent-mark (Bothma & le Riche 1984).

This phenomenon of scentmarking was extended in that leopards in the Waterberg often rolled in the lavender bush Lippia rehmannii and fever tea bush Lippia javanica which presents a strong aromatic smell when bruised. The leaves and stems of these bushes also possess coarse hair on which leopard hair sticks. It is believed that this is not only functional in marking a territory but the leopard most probably also carried the laventel like smell with him, that would disguise his smell while hunting. This phenomenon was also observed by Bothma & le Riche (1984) who described the frequently rolling in places where other wildlife have urinated or defecated.

The calling of leopards is described by Turnbull-Kemp (1967) as a harsh rasping sound. This rasping is repeated more than fifteen times in unbroken succession. The Waterberg radio-collared male called on six occasions, whereby the rasping sound was repeated for seven to nine times. This happened between 21h00 and 22h00 in all cases, while he was active in the Doorndraai Dam Nature Reserve. Smith (1977) found that vocalisations in the Motobos National Park, Zimbabwe were most common between 21h00 and 24h00 and again between 04h00 and 05h00. Although these callings are possibly primarily territory - maintenance related it can also function as territory independant spacing mechanisms as found with territorial wolf packs (Harrington & Mech 1983). It's role as a communication measure per se is therefore relevant, for example during the mating season.

A knowledge of the density as well as the intrinsic regulatory mechanisms of a population is of critical importance where management decisions are to be made. This is even more so where the population is in direct competition with man on the one side, but also may be exploited through trophy hunting. In the high leopard population of the Kruger National Park, one leopard per 6 km^2 (Bailey pers. comm., in Hamilton 1981), the population appear to be regulated by food supply, but the number of breeding adults was regulated by social behaviour.

Due to the lack in exclusivety in home ranges (Hornocker & Bailey 1986; le Roux & Skinner 1989), it seems that conspicifics do tolerate each other as long as the "intruder" shows submissive behaviour.

Scars and wounds indicated there was some fighting among adults. but it's effect on the population was minimal as tenured animals remained in the same areas. Further, none of the mortality in adults (18% annually) was attributed directly or indirectly to fighting among conspicifics (Hornocker & Bailey 1986). In this population 18% of the adults, 32% of the subadults and 50% of the cubs-of-the-year died annually; 64% attributed to starvation and 36% to predation or man. In spite of this turnover the population remained constant.

The leopard population in the Naboomspruit area is much lower (one leopard per 53 km^2) but the intensity of territorial maintenance and exclusivety of occupancy seem to be much higher, as described for Kenya leopards (one leopard per 13 km^2) (Hamilton 1981). A high turnover of adult leopards prevails in certain Waterberg areas.

Mortality factors present in the Kruger National Park also differ vastly from those operating in the Waterberg. In the

Kruger National Park cubs and subadults are particularly vulnerable to predators such as lions and spotted hyaenas while this factor is absent in the Waterberg. Hunting pressure here, is directed more at young and older adults. This population also appear to be controlled by food but social behaviour and hunting pressure plays a greater role in comparison with the southern Kruger Park population.

It is traditionally believed that most stock-raiding is done by either old or immature leopards (transient). Esterhuizen & Norton (1985) showed that most leopards that kill livestock in the Cape Province are prime adult leopards. Twelve leopards that were captured during the study period in different areas of the Waterberg after they had allegedly killed stock, consisted of five adult males, four young males, three adult females and one young female. None of the individuals were old or in bad condition as being found in the Cape Province. Stock preventing measures are therefore to be aimed at the population as a whole.

CHAPTER 4 : DIET OF LEOPARDS IN TWO AREAS OF THE WATERBERG.

INTRODUCTION

Because of their predation on livestock and the subsequent additional economic burden placed on farmers, the habits of leopards are receiving more attention. Not only are stock losses of many thousands of rands occurring annually on cattle ranches, but the fast growing game-ranching industry is becoming increasingly concerned about the presence of these predators.

Leopards are known to be preying on a wide spectrum of animals including birds, fish, reptiles, small mammals and larger herbivores of more than twice their own body mass, as well as carrion (Turnbull-Kemp 1967 ; Grobler & Wilson 1972 ; Schaller 1972 ; Hamilton 1976 ; Bothma & le Riche 1984 and Norton, Lawson & Avery 1986). This ability to use virtually any potential prey animal they may encounter, results in frequent incidents of stock raiding in farming areas.

Because of their secretive nature, much qualitative information is still lacking regarding prey preference, particularly in stock farming regions.

In general, a correlation can be drawn between ecological factors such as prey size, distribution and density, and the social systems of felids. These factors influence the social interactions and movement patterns of individuals, and hence shape the overall social organisation of the population (Sunquist 1981).

It is furthermore important to gain more knowledge about methods of capture as well as feeding behaviour of leopards to enable effective protection measures for livestock to be adopted as part of a conservation strategy for leopards.

OBJECTIVES

The objectives of the investigation were :

a. To examine the diet (prey items) of leopards in two areas of the Waterberg (Naboomspruit, Melk River), relative to prey abundance.

b. To investigate prey capture and feeding behaviour of leopards, especially pertaining to domestic livestock.

c. To determine prey item utilization in terms of quantitative consumption during a night feeding session and the utilization of carcasses over a period of time.

METHODS

Prey_abundance

The number of large ungulates () steenbok) were obtained from non-sampling methods provided by game farmers. This was based on systematic search (total) counts and known group counts (Collinson 1985).

In the case of the Doorndraai Dam Nature Reserve (TPA), census data were provided by the Transvaal Division of Nature and Environmental Conservation. This information was also based on systematic search counts and known group counts

(Coetzee pers comm)*. Own observations and verified opinions of farmers were used in the case of small mammals. Small mammals are given only as common or rare.

Prey_items

Leopard scats (n=76) were collected (June 1985-June 1987) in both study areas, along farm roads and in areas frequently used by leopards. Each sample was kept separate in a paper bag, later transferred to a small nylon bag and washed in a commercial clothes washer (Defy Automaid, Defy Corporation Limited, Johannesburg R.S.A.) untill all soluble material was removed. The contents of each bag were emptied onto a glass tray and food items identified.

Leopard and brown hyaena faeces were distinguished using general morphology (e.a. segment length, colour) and especially associated tracks and scrapes. Leopard scats with their typical cat-like "segmented" appearance were considered as doubtfull when less than 20 mm in diameter. This was necessary due to the presence of caracals in the study area. Most food items in scats, and remains at den sites were identified using cross-sections of hairs that were compared to

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photographic reference material.

This photographic reference collection was compiled by collecting reference material (hairs) from various parts (flanks, mane, belly and rump) of mammal skins collected in the veld, stored at the Transvaal Museum and made available by a taxidermist (N van Rooyen, Taxidermist, Rosslynn, Pretoria). In addition, other reference collections from photographs were made available for comparison (J.D. Skinner, H. Keogh and J. du P. Bothma).

The identification of ungulates, carnivores, primates, lagomorphs and other larger rodents (>1kg) were to species level, whereas smaller rodents, reptiles, birds, insects and plants were only identified as such. When no hairs were present in a scat the origin was recorded as unknown. Additional information was obtained from investigations of 40 leopard kills of which 19 were cattle calves.

Prey capture and feeding behaviour

Information regarding cattle predation behaviour was collected by visiting farms where cattle losses occured (n=19). Capture site in relation to nearest human activity, calf age, calf sex, method of killing and method of feeding were recorded. Investigations of 22 ungulate carcasses (excluding cattle calves) revealed futher information regarding prey age, sex, food concealment behaviour, method of killing and feeding behaviour.

Food consumption

The quantity of meat consumed by a male leopard weighing, 60,5 kg during each of 12 feeding nights of 12 hours where three cattle calves were the prey was measured. Six nights were recorded during winter (June) and six in summer (December). All four legs and the head of a carcass were separately fastened to a tree trunk, thus preventing the leopard tearing parts off a carcass and dragging it away.

RESULTS

Prey abundance

The mammal fauna (>1kg) in the Melk River area consisted of 24 species of ungulate, 18 carnivore species (including cat *Felis catus* and dog *Canis familiaris*), two species of primates, two of lagomorphs, one tubulidentate, one pholidate, three rodent species and one hyracoid (Table 2). Livestock occurring in these areas were cattle, donkeys, sheep and goats, these and to a lesser extent all other vertebrates in the area, were regarded as potential food items for the brown hyaena. The mammal fauna (>1kg) in the Naboomspruit study area consisted of 19 ungulate species, 18 species of carnivores (including domestic cat and dog), one hyracoid, two primates, two lagomorphs, one tubulidentate, one pholidate and three rodent species (Table 2).

Table 2: Species and abundance of the mammalian fauna (>1kg) in the Melk River (1985-1986) and Naboomspruit (1986-1987) study areas.

Species	Abundance	
Ungulates	Naboomspruit	Melk River
Ceratotherium simum	0	12
Giraffa camelopardalis	6	0
Taurotragus oryx	0	70
Equus burchelli	55	200
Equus zebra hartmannae	0	10
Hippotragus equinus	37	28
Kobus ellipsiprymnus	57	200
Hippotragus niger	29	6
Connochaetes taurinus	100	80
Alcelaphus buselaphus	8	195
Tragelaphus strepsiceros	200+	400+
Tragelaphus angasi	0	10
Damaliscus lunatus	118	0
Oryx gazella	0	82
Tragelaphus scriptus	50+	80+
Redunca arundinum	50+	40+
Redunca fulvorufula	100+	200+
Aepyceros melampus	500	1300
Damaliscus dorcas phillipsi	20	55
Sylvicapra grimmia	C	C
Raphicerus campestris	C	C
Oreotragus oreotragus	100+	200+
Phacochoerus aethiopicus	C	C
Potamochoerus porcus	C	C
Bos spp. (cattle)	C	C
Equus asinus (donkey)	C	R
Ovis aries (sheep)	C	R
Capra hircus (domestic goat)	C	R
OTHER		
Procavia capensis	C	R
Papio ursinus	C	C
Cercopithecus aethiops	C	C
Canis familiaris	C	R
Felis catus	C	R
Felis serval	R	R
Felis caracal	C	C
Proteles cristatus	R	R
Aonyx capensis	R	R
Lutra maculicollis	R	R
Canis mesomelas	C	C
Genetta genetta	C	C
Genetta tigrina	C	C
Atilax paludinosus	C	C
Panthera pardus	R	C
Hyaena brunnea	C	C
Mellivora capensis	R	C

Ichneumia albicauda	R	R
Civettictis civetta	R	R
Mungos mungo	C	C
Ictonyx striatus	R	R
Orycteropus afer	C	C
Lepus saxatilis	C	C
Pronolagus randensis	C	C
Hystrix africaeaustralis	C	C
Thryonomus swinderianus	C	C
Manis temminckii	R	R
Pedetes capensis	C	C

Table 3: Leopard diet in two areas of the Waterberg as determined by scat analysis (% of occurrence). Carcass observations are in parenthesis.

SPECIES	MELK RIVER SCATS (n=39)		NABOOMSPRUIT SCATS (n=37)		TOTAL	
UNGULATES	N	%	N	%	N	%
CATEGORY I (> 60 Kg)						
Bos spp.	1(8)	2,5	2(11)	5,4	3(19)	3,9
Equus burchelli	2(1)	5,1	0(0)	0	2(1)	2,6
Hippotragus equinus	0(1)	0	0(0)	0	0(1)	0
Tragelaphus strepsiceros	2(0)	5,1	3(0)	8,1	5	6,5
Connochaetes taurinus	0(0)	0	2(0)	5,4	2	2,6
Alcelaphus buselaphus	1(0)	2,5	0(0)	0	1	1,3
CATEGORY II (< 60 Kg)						
Damaliscus lunatus	1(2)	2,5	0(0)	0	1(2)	1,3
Tragelaphus scriptus	2(1)	5,1	1(1)	2,7	3(2)	3,9
Aepyceros melampus	13(6)	33,3	7(2)	18,9	20(8)	26,3
Redunca fulvorufula	1(1)	2,5	1(0)	2,7	2(1)	2,6
Potamochoerus porcus	1(0)	2,5	1(0)	2,7	2	2,6
Potamochoerus aethiopicus	2(0)	5,1	2(0)	5,4	4	5,2
Capra hircus	1(2)	2,5	0(0)	0	1(2)	1,3
Oreotragus oreotragus	2(2)	5,1	1(0)	2,7	3(2)	3,9
Raphicerus campestris	0(0)	0	2(1)	5,4	2(1)	2,6
Sylvicapra grimmia	1(1)	2,5	3(1)	8,1	4(2)	5,2

	N	%	N	%	N	%
UNGULATE TOTAL:	30(25)	76,3	25(16)	67,5	55(41)	72,3
OTHER :						
	N	%	N	%	N	%
Papio ursinus	0(1)	0	0(0)	0	0(1)	0
Panthera pardus	0(0)	0	1(0)	2,7	1	2,6
Canis mesomelas	1(0)	2,5	1(0)	2,7	2	2,6
Galerella sanguinea	2(0)	5,1	1(1)	2,7	3(1)	3,9
Pronolagus randensis	1(0)	2,5	1(1)	2,7	2(1)	2,6
Lepus saxatilis	2(0)	5,1	3(0)	8,1	5	6,5
Procavia capensis	3(0)	7,6	0(0)	0	3	3,9
Tryonomus swinderianus	1(1)	2,1	2(0)	5,4	3(1)	3,9
Otomys spp.	0(0)	0	1(0)	2,7	1	1,3
Mice Spp.	1(0)	2,5	2(0)	5,4	3	3,9
Birds	0(0)	0	1(0)	2,7	1	1,3
Unknown	2(0)	5,1	2(0)	5,4	4	5,2
TOTAL:	13(2)	35,8	15(2)	40,5	28(4)	36,8

Scat analysis

The percentage of scats (total occurrence) containing identifiable food items for the two areas is presented in Table 3.

The opportunistic feeding habits of leopards were also apparent in this study. Apart from ungulates, a range of other prey from baboons to small rodents and birds were preyed upon.

Melk River study area :

Ungulate hair was found in 76,3 % of the scats collected in this area. Impala were by far the best represented, at 33,3 % . Burchell's zebra, kudu, warthog and klipspringer hairs were each recorded in two scats, while red hartebeest, blesbok, mountain reedbuck, bushpig, duiker and domestic goat remains were present in one scat each. Cattle hair was present in one scat.

Carcasses found included a yearling roan antelope calf, a newly born zebra foal, six impala carcasses (one subadult male, five adult females), two subadult female blesbok, one adult female bushbuck, an adult male mountain reedbuck, an adult male duiker, two adult klipspringer (sexes unknown) and two domestic goats. In addition, corpses of eight cattle calves were confirmed to have been killed by leopards.

Ages of the calves differed from newly born to 103 days old, with an average age of 22 days. Sexes were evenly represented.

Mammals other than ungulates featured in 35,8 % of the scats collected in the Melk River area. Three scats contained rock dassie hair, two scats scrub hare while slender mongoose remains were found in two scats.

A black backed jackal, Jameson's rock rabbit, cane rat and rodent were recorded once. Two scats were discarded in that the contents could not be ascertained. Carcasses of a subadult baboon (sex unknown) and a cane rat were found.

Naboomspruit study area :

In this area, 67,5 % of the scats contained the hair of an ungulate, of which impala contributed 18,9 %, kudu and duiker both 8,1%, while blue wildebeest, warthog, steenbok and cattle were each found in two scats. Bushbuck, mountain reedbuck, bushpig and klipspringer were found once.

Investigations in this study area revealed the presence of the carcasses of two impala (adult male and female), female bushbuck, adult steenbok (sex unknown) and a duiker male. Leopards took 11 cattle calves over a period of 11 months (September 1986- July 1987). The ages of the calves varied from new-born to 90 days old, with an average of 21 days (n = 11) (SD = 10). Five individuals were bull-calves while four were heifers.

Mammals other than ungulates featured in 40,5 % of the scats. Scrub hare remains were found in three scats, while cane rat and rodent hair (species unknown) occurred in two scats each. Black backed jackal, Jameson's red rock rabbit, slender mongoose and vlei rat only occurred once. Only one scat contained the feathers of an unknown bird. Remains of a Jameson's rock rabbit and a slender mongoose were also found.

Table 4 : Percentage occurrence (n=76) of different prey groups represented in leopard scats in the Melk River and Naboomspruit study areas.

GROUP	SCATS (N=76)	% OCCURRENCE
UNGULATES :		
Category I (> 60Kg)	13	17,1%
Category II (< 60Kg)	42	55,2%
UNGULATE TOTAL:	55	72,3%
Hyracoids	3	3,9%
Rodents	7	9,2%
Lagomorphs	7	9,2%
Birds	1	1,3%
Carnivores	6	7,9%

Prey capture and feeding behaviour

Capture locality :

In the 19 cases of where calves were taken only one was killed in a kraal in the presence of other cattle. This happened on the farm Rooikoppies, district Brits, in August 1985, only one kilometer from human activity. Three calves were taken in open veld close to farmhouses (<800m) in different localities in the Waterberg, while the remainder (n=15) were taken in mountainous veld (rocky areas) far (>2 km) from human disturbance. All 19 calves were in the company of cows, or at least in their near vicinity. Antelope carcasses (21) were found far from human activity.

Method of killing :

All ten of the calves killed, where the throat and neck were not already consumed, showed teeth marks occurring as haemorrhaging under the skin. In cattle calves younger than five weeks (n=7) all were by bites through the nape of the neck. In ages between six and 12 weeks (n = 3), one was strangled (nine weeks old), and the other two were possibly suffocated (10 - 11 weeks old). Claw marks were also present on the shoulder blades of both the latter calves.

In the Melk River area, four antelopes (a roan antelope calf, three adult female impala) were killed by suffocation. Both domestic goats were killed by their necks being fractured. In an impala (adult female) and steenbok (sex unknown) examined in the Naboomspruit area, teeth marks were found in their neck and throat regions.

Drag distance :

Following killing, drag distances (cattle calves) showed considerable variation, varying from 20m to 1005m with an average of 220m (n = 10). No differences between season or correlation between prey weight and drag distances were apparent. Second night drag distances varied from 0 - 350 m (n = 8). First night (capture night) drag distances of two impala females measured 416 and 1115 m.

An adult blesbok female was dragged 426 m after capture. Due to advanced consumption and rainy weather it could not be ascertained whether the blesbok was killed the previous night or two nights before. Drag marks of a klipspringer carcass was tracked for 725 m but the carcass could not be located.

Method of feeding :

In ten kills investigated after the first night of feeding (killing night), radio-collared male A started by opening the belly in five cases, consuming the abdomen and eating away the end of the ribs. No discarded paunches were found and it was assumed that they were eaten entirely. All these calves were younger than five weeks.

In three of the five cases the intestines (liver and heart) were partly consumed. The first night feeding patterns of the same leopard in the remaining five cases, consisted in four cases of eating the hindlegs between the thighs, and in the remaining case eating the brisket. In another eight cases where different leopards were involved (different regions in the Waterberg and therefore presumed to be different individuals), five cattle calf carcasses were initially consumed by opening up the belly and eating the entrails. In the remaining three instances, initial consumption started between the thighs (n = 2) and in the chest region (n = 1).

In the case of adult impala, bushbuck, klipspringer and goat carcasses found in the Melk River area, no heads, vertebrae, femurs, tibia or hooves were consumed. In younger antelope (subadult impala male, roan calf) and a zebra foal however, only hooves, femurs and parts of the vertebrae were found. No carcasses of cattle calves were monitored up to the end of consumption in this area. In the Naboomspruit area however, the radio-collared male on one occasion consumed a whole cattle calf (two months old). Only the molars and hooves were left. Hair plucking was recorded in two carcasses of cattle calves and two carcasses of impala taken in the Melk River area but only on a cattle calf in the Naboomspruit area.

Hiding behaviour :

In only one instance was prey (zebra foal) hoisted into a tree (Burkea africana). In another five cases, the carcasses were only dragged away. The leopard did however, return the following night to feed. In thirty five cases carcasses were taken into dense scrub cover. Of these, six were covered with leaves and twigs.

Consumption :

The first calf that was weighed following successive feeding nights was killed on 2 December 1986, on the farm Baviaanspoort (Naboomspruit study area). During the first night only the abomasum and parts of the intestine were eaten. The calf weighed 45,5 kg at that stage. During the second and third nights 10,1 kg and 8,2 kg were consumed respectively, followed by 9,5 kg on the fourth night. Unfortunately, the remainder of the carcass was removed by the leopard on the fifth night and the remnants could not be found. An average of 9,2 kg was therefore consumed per night. This radio-collared leopard moved out of the area during the sixth night. The second calf was killed by the same leopard during the night of 12 December 1986, also on the farm Baviaanspoort. During the night of capture approximately one kg of meat was consumed from the groin area. When fastened against a tree the calf weighed 39,2 kg. During the second and third nights the leopard consumed 10,8 and 9,3 kg of meat respectively. The fourth night a further 8,6 kg was removed. The leopard did not, however, return again and the remains (head, tibia and hooves) were consumed by black backed jackals. An average of 9,6 kg of meat was therefore consumed during this period per feeding night. On the evening of 3 June 1987, another calf was taken by the same individual on the farm Cyferfontein.

When discovered the next morning, approximately two kg had been eaten from the breast region. The second night 6,8 kg was consumed, followed by 5,6 kg, 6,0 kg and 5,1 kg of meat on successive nights. During the sixth and seventh nights 4,8 and 4,2 kg meat was eaten. The remains (head and left tibia) were loosened and carried away by the leopard on night eight. The leopard left the area during night nine. An average of 5,4 kg meat was consumed during this period per feeding night.

DISCUSSION

Methods used in the past to determine prey species utilized by leopards differ from indirect observations (Bothma & le Riche 1984) in the southern Kalahari, to direct observations in Kenya (Hamilton 1976), in the Serengeti (Bertram 1980), and in the Transvaal Lowveld (le Roux & Skinner 1989). Although some of these studies were supplemented by means of scat analysis in determining diet, most studies have had to rely solely on information gained by scat analysis (Grobler & Wilson 1972 in Zimbabwe; Smith 1977 in Zimbabwe; and Norton et al. 1986 in the Cape Province).

Due to their stealthy habits, Waterberg leopards could only be studied indirectly primarily through scat analysis and tracing kills in identifying prey items. Prey availability rather than mere prey biomass are important to a predator.

In a prey abundance scenario, the food available to a leopard is influenced by prey size, physical condition, habitat type, social structure and aggression and mortality agents (Kruuk 1986). Prey size as a function of prey availability has been documented in studies all over the leopard's range.

In the Waterberg the majority of scats contained the remains of ungulates (72,3%). Those weighing less than 60 kg (Category II), contributed 55,2%. It is however most likely that sub-adults of species weighing more than 60 kg were involved, or that mortality agents of some kind were present in the case of adult individuals. Unfortunately hair identification does not reveal information regarding age of prey but in observations on carcasses (kills), where adults weigh >60 kg, both kills were juveniles.

Bothma & le Riche (1984) also found a clear preference for medium sized mammals in the southern Kalahari in both male and female leopards. Prey larger than adult springbok was caught infrequently. This agrees with observations on leopard diet in Tanzania (Kruuk & Turner 1967), Zimbabwe (Grobler & Wilson 1972; Smith 1977), the Transvaal Lowveld (le Roux & Skinner 1989) and the Cape Province (Norton et al. 1986). It also supports the suggestion by Seidensticker (1976) that prey size is important in prey selection by leopards. In natural and relatively stable ecosystems, felids, in common with many other carnivores have little effect on the numbers of individuals in prey populations (Sinclair 1979, Hornocker 1970). However there can be effects of predation on the age-composition of prey populations or their physical condition.

Cougars did not select for age amongst mule deer Odocoileus hemionus, but amongst elk they preferred young animals (Hornocker 1970). Feral cats and European wildcats also select young rabbits, and rabbits suffering from myxomatosis (Corbett 1979; Liberg 1981).

Prey size as a function of prey availability in the leopard is also of great importance in a cattle protecting strategy (see Chapter 6), as only calves up to four months are vulnerable to leopard predation. Habitat type can also have an important effect on the availability of certain prey species to felids (Kruuk 1986).

The evidence that hunting success is highly dependant upon the amount of available cover (Schaller 1972 ; Hornocker 1970 ; Corbett 1979) supports the assumption that the number of places where prey can be successfully stalked by predators is limited (Kruuk 1986). In the southern Kalahari Bothma & le Riche (1989), furthermore, recorded optimal positioning in the leopard whereby potential prey were selected from a high vantage point. Thus confirming the concept that cover and sight play an important role in hunting by cats (Eltringham 1979 ; Kruuk 1986).

Certain features can however further assist the predator. In the Waterberg all game ranches are game fenced. The amount of available prey in the territory of each leopard is therefore constant over the seasons. These farms are furthermore stocked with various game species, which are forced to use sub-optimal dense and rocky mountain veld during certain periods of the year. This favours the hunting techniques e.g. stalking and ambushing used by leopard.

Especially plains and open savanna species like blesbok, impala, Burchell's zebra and red hartebeest would be vulnerable to leopard predation under such conditions.

Although the abundance of impala in the two study areas could account for the high percentage of impala remains (33%) in leopard scats, the rocky habitat definitely favoured the hunting techniques of leopards. Only one scat contained the remains of a blesbok. This could be due to the relatively low number of blesbok in the study area. However on two farms Klipfontein and Lady Grey, blesbok populations showed a growth rate of 6,0 and 8,0 % respectively. The role of predation couldn't be excluded. In two African National Parks, Nairobi and Kruger, predation by lions caused a serious decline in wildebeest populations, after man had interfered by putting in fences and by changing the grass burning regime (Rudnai 1974 ; Smuts 1978). In both cases wildebeest were forced to graze in longer grass, and were therefore more vulnerable to lion predation than previously. Gibb, Ward & Ward (1978) described the almost complete extinction of a (fenced) rabbit population by feral cats in New Zeeland. Although baboons were common in the study area no scats contained baboon remains. Only one carcass, killed by a leopard was found. It has been suggested that baboons are able to avoid predation by leopards, probably due to their co-operative mobbing behaviour (Pienaar 1969). This view is also shared by Hamilton (1981) in Kenya and Norton <u>et al</u>. (1986) in the Cape Province. Hamilton (1981) is of the opinion that leopards do take baboons, particularly the young when they get the opportunity, and therefore apparently have some effect on their populations. He however believes the effect to be exaggerated.

Leopards may nevertheless have an important effect on selection of resting places, and therefore movements of baboon troops (Smithers 1983). Some leopards are known to specialize in hunting baboons, as in Kenya (Simons 1966). This is probably for the very good reason that little other food is available for leopards, as capture is not without risk. The formidable canine teeth of baboons are capable of inflicting real damage on a predator.

Over the period February 1985 to December 1987 one leopard was known to have been killed in the Waterberg by baboons. The leopard was torn to pieces at the Police Training Terrain at Rankins Pass (25° 15'S 30° 30'E) in December 1986.

There are also idiosyncrasies, the origin of which is quite obscure. Estes (1967) noted an individual leopard addicted to killing black backed jackals. Bothma & le Riche (1984) also reported on the development of individual taste in a southern Kalahari leopard. A male leopard killed six times in 12 days, four of the kills being porcupines ambushed as they emerged from their burrows.

Bothma & le Riche (1989) furthermore presented data which imply that the varied reaction of leopards to their prey may be related to past experiences. Gemsbok, probably the most aggressive prey of leopards in the southern Kalahari and known to have killed lions, spotted hyaenas and leopards (Eloff 1973) are approached carefully. Leopards respond by elaborate stalking and even optimal positioning, especially when hunting a gemsbok calf attended by a cow. This varied hunting approach to different prey types thus supports the concept that leopards exhibit individual variation in hunting technique as suggested by Leyhausen (1979) for cats in general and by Schaller (1972) for lions. This variation may be based on differences between the sexes, or related to social rank.

Many game ranches in the Waterberg are also overstocked with game. Leopards may be more selective among relatively large prey (unavailable) in cases where these prey categories suffer from limiting factors such as hunger and disease. The manifestation of disease in such stressful situations is well known (Lightfoot & Norval 1981).

As an important scavenger (Turnbull-Kemp 1967 ; Hamilton 1981) leopards are favoured when mortality agents (e.g. diseases etc.) are present, which make large unavailable prey available. As scavengers they will feed on animals such as elephants (Hamilton 1981), and litter around deserted camps (Turnbull-Kemp 1967).

In the Melk River study area, on the farm Sliedrecht, leopards attacked wounded animals on two occasions. In both cases the impala was wounded but efforts to find him were abandoned at dusk. These animals were located the next day, killed (teeth marks around throat) and partially consumed by a leopard. Turnbull-Kemp (1967) even noted the fact that leopards have been attracted by shots, knowing these to mean potential food, in Kenya.

Indeed, leopards will eat almost any animal available, and this adaptability is perhaps the species greatest strengh apart from it's secretive habits. Moreover because leopards have such a catholic diet they are less seriously affected than other large predators by the decline or dissappearance of populations of any one, or several of their prey species (Hamilton 1981). This opportunistic feeding habit has brought them into direct conflict with cattle farmers and even nowadays into conflict with game farmers.

Over a large portion of their range leopards' natural prey has been reduced to such low levels that they have to utilize alternative prey such as cattle calves. However the fact that cattle calves are an easy prey also eleviates their preference, even in the presence of an abundance of other prey species.

In formulating a cattle calf protection strategy which is one of the crucial components in conserving leopards, information regarding stock capture (such as capture locality, calf size, killing method) and subsequent feeding behaviour (which includes carcass handling) is of the utmost importance. The fact that only one calf out of 19 was killed in a kraal near human activity, shows that the natural tendency of leopards is to avoid such areas of activity.

Leopards in the Waterberg furthermore also selected calves up to three months old. Although calves up to five months have been killed, this seldom happens and can be regarded as very infrequent. This information regarding capture locality and prey age forms an important part in a proposed cattle calf protection strategy (Chapter 6).

This must however be seen against the background of the presence of possible problem leopards. A problem leopard as defined in Chapter 6 as being a troublesome stock-raider who makes a habit of stock-killing and will go to extremes to predate on cattle calves, in the presence of calf protection measures (such as kraals etc.). These leopards can't be accommodated in a calf protection strategy (CPS) and should be destroyed as effectively and quickly as possible. It is hence crucial to react promptly and effectively in eliminating such individuals, without affecting other components of the ecosystem. An appropriate knowledge of the capture and feeding behaviour of a leopard is thus of great importance to first, identify the species involved in the killing, and to subsequently take the necessary action.

In general leopard without exception kill their prey by either strangulation or a bite through the nape of the neck (Turnbull-Kemp 1967 ; own observations). In the Waterberg cattle calves younger than five weeks (n = 7) were killed by means of bites through the nape of the neck. Calves between six and twelve weeks old were strangled (n = 5). These are consistant with the findings of Eltringham (1979) and Bothma & le Riche (1984) who described the predominant killing method to be a throat and neck or head bite.

Black backed jackals may also strangle their prey. Roberts (1986) described the use of distance between upper canines to distinguish between black backed jackals and other predators (dogs) of sheep in Natal. An average of 26 mm was found between puncture holes as caused by the upper canines of black backed jackals (Roberts 1986). Puncture holes caused by Waterberg leopards varied from 38 to 48 mm apart with an average of 44 mm (n = 4).

In contrast to leopards and black backed jackals, brown hyaenas do not go for the throat but rather kill by bites across the rump or on the head and neck. It must however be stressed that brown hyaenas and black backed jackals seldom are involved in cattle calf predation in the Waterberg.

During the three year study period only one calf was believes to have been killed by a brown hyaena. One kill whereby a black backed jackal was involved has been recorded.

The killing method of leopards furthermore enables the possible use of a toxic or lithium chloride (Stream 1976) collar on cattle calves as has been used against coyotes on sheep (Mc Bride 1974). This however needs further investigation before application to the leopard.

In cases where the interpretation of killing methods is not possible due to advanced consumption or putrefaction, the predator involved can fairly easy be identified on feeding methods and/or clues such as spoor and scratch marks. This information can however not ascertain the killer, but merely the feeder. The brown hyaena, unlike the leopard, is a very untidy feeder, and will consume a carcass to the full, including the femur and the head. Black backed jackals also have quite a sistematic way of consuming a carcass (Roberts 1986).

In 24 known kills inspected in the southern Kalahari, hair was licked or plucked away from the body of the prey in five before eating (Bothma & le Riche 1984). This observation agrees with Schaller (1972) and Smith (1977). Hamilton (1976) however found no incidence of hair plucking in Tsavo leopards. In 40 kills inspected in the Waterberg the hair of two impala and three cattle calves were plucked or removed by licking while feeding.

Leopard kills are normally not left in the open like those of black backed jackals and brown hyaenas but are concealed in thick cover or sometimes hoisted into trees. Only five carcasses were left unconcealed under trees in the Waterberg. The rest (n = 35), with the exception of one, were concealed in thick ground cover.

Six of these concealed carcasses were also partly covered with brush or plant litter as found by Smith (1977) in Zimbabwe. In the southern Kalahari Bothma & le Riche (1984), found no evidence of such attempts.

Hoisting of prey items by leopards occurs throughout its range. In Chitawan National Park (Seidensticker 1976) leopards pulled about half of their kills into trees. In the Londolozi Game Reserve, le Roux & Skinner (1989) found 76 % of carcasses being hoisted into trees. As scavengers are fairly low in density in the Kalahari, and as leopards usually kill medium-sized prey which are consumed quickly, they are not bothered by scavengers to the same extent as they would be in more humid areas. Only 17 % of kills (n = 24) were stored in trees (Bothma & le Riche 1984).

In the Waterberg only 2,4 % of the kills (n = 1) were found in trees. Hoisting of carcasses was also found to be uncommon in the Matobo Hills National Park, Zimbabwe (Smith 1977). This as in the Waterberg, supports the conclusion that leopards rarely store kills in an area devoid of large scavengers.

Due to the absence of large predators such as spotted hyaena and lions in the Waterberg (apart from brown hyaenas) leopards did not seem to experience competition from scavengers (Brain 1981). Although no evidence of interactions between leopards and brown hyaenas were found, it is believed that leopards are dominant over brown hyaenas (Mills 1981).

In carrying or dragging the kill to a place of concealment or security, considerable distances are sometimes covered. In the open interior habitat of the southern Kalahari, the mean distance of 410 m (males) and 742 m (females) which leopards dragged or carried prey to suitable cover (Bothma & le Riche 1984) were greater than the average of 120 m (wet season), 260 m (dry season) and 1600 (maximum) reported by Smith (1977) for Zimbabwe leopards.

The capture night dragging distances in the Waterberg varied between 20 m and 1115 m with a mean distance of 650 m. A female leopard dragged a cattle calf 916 m and an impala female 1115 m to two waiting cubs. Second night dragging distances in Waterberg leopards varied from 0 to 350 m with a mean distance of 98 m. Cattle calves were without exception dragged to a vantage point or into thick cover. It seems that the presence of cubs and of human activity in an area, influences dragging distances in the absence of lions and traditional scavengers such as spotted hyaenas.

According to Turnbull-Kemp (1967) the maximum intake of food at any time by leopards is seldom appreciably greater than 20 % of it's body weight in 24h. In Tsavo, Hamilton (1981) measured the daily food intake of leopards of known weight, feeding on baits of known weight. The amount of meat consumed ranged from 2,0 kg to 9,5 kg per leopard per night, with a mean weight of 6,3 kg. Expressed as percentages of the body weights of individual leopards, the amounts eaten on one night represented 4 - 24 % of body weight with a mean of 16 %. Thirteen (62 %) of the meals represented 13 - 17 % of body weight and four (19 %) exceeded 20 % of body weight.

Bothma & le Riche's (1984) data in the southern Kalahari revealed an average daily consumption of some 3,5 kg of meat per day for a male leopard and 4,9 kg per day for females with cubs. Days on which no prey were caught were however included.

In the Waterberg a 60,5 kg radio-collared male consumed an average of 9,4 kg / 12 h (n = 6) during the summer (wet season) and an average of 5,4 kg / 12 h (n = 6) during the winter (dry season). Expressed as a percentage of body weight the amount eaten in one night represented 15,5 % of body weight in the wet season and 8,9 % in the dry season (winter).

A small sample size is involved, and the leopard could possibly have consumed other prey prior to the third calf killed (winter sample) which could have depressed his appetite, so this apparent difference should be treated with caution.

On the other hand, very low night temperatures were experienced (-3°C) at the time when carcass three (winter period) was consumed. These low temperatures delay putrefaction and hence prolong the period of meat availability. This is clearly reflected in the long period spent at the carcass (eight nights). Carcass consumption in the summer months, when insect activity is prominent and putrefaction is much more rapid, did not last longer than four nights (n = 3). This may have influenced rate of consumption. Human disturbance played no role during these periods of carcass consumption.

CHAPTER 5 : LEOPARD TRANSLOCATIONS

INTRODUCTION

Translocation of mammalian species has received increasing attention over the last few decades. First because the natural areas where these predators occur are shrinking and they therefore come into direct or indirect conflict with human interests. Removing such problem carnivores is often the only choice. Secondly, many populations were and are being depleted due to different human actions. Therefore, in an attempt to re-establish viable populations, individuals are being introduced from elsewhere.

The objectives of these various research or management actions are represented by the following approaches :

1) Captive breeding and re-establishing a species in areas within it's historic range, where it has been exterminated (Henshaw & Stephenson 1974; Carley 1981; Pettifer 1980; Van Aarde & Skinner 1986). This is especially relevant in the case of endangered or rare species.

2) Locally abundant species captured in the wild have been moved to areas where they were exterminated or to stimulate existing non viable populations (Penzhorn 1971).

3) Wildlife biologists are frequently requested to resolve conflicts between e.g predators and man. Translocating such

individuals away from the area of conflict has been conducted to determine the feasibility of re-establishing these species elsewhere, where no conflict would exist (Craighead 1976; Miller & Ballard 1982; Meagher & Phillips 1983; Skinner & Van Aarde 1987).

Studies have also been carried out to investigate primarily from an academic point of view, which mechanisms are involved in orientation during homing behaviour, following a successful relocation. In all these cases animals were not enclosed and could disperse as they wished (Griffo 1961; Murie 1963; Robinson & Falls 1965; Sheppe 1965; Mackintosh 1973; Cooke & Terman 1977).

Although predators have been and are being translocated on a regular basis all over the world as a management and conservation strategy, there is relatively little information available on the fate of these carnivores after release. Hamilton (1981), mentioned that almost without exception, failures were described, with few accounts of success. The lack of well monitored post release movements is evident. Only studies on wolves (Mech 1970; Weise, Robinson, Hook & Mech 1975; Fritts, Paul & Mech 1984), brown bears, <u>Ursus arctos</u> (Harger 1970; Alt, Matula, Alt & Lindzey 1977; Mc Arthur 1981; Miller & Ballard 1982), and to a lesser extent on brown hyaenas (Skinner & Van Aarde 1987), can be considered as representative findings. In the Felidae only studies on relocation of leopards (Hamilton 1981), captive bred cheetahs (Pettifer 1980) and servals (Van

Aarde & Skinner 1986) have been published.

In many parts of their range in the Transvaal, leopards come into conflict with human interests by taking domestic livestock and wild ungulates. Large numbers are being caught in the process and speculation still occurs as what to do with these animals, other than to kill them.

OBJECTIVES

With this background it was decided to investigate different aspects of leopard translocations, namely :

a. Post release movement patterns.

b. Minimum distances and other factors involved in preventing homing behaviour.

c. Which factors negatively influence the possibility that a leopard may settle in a released area.

d. To speculate about possible mechanisms of orientation involved in homing behaviour.

e. The feasability of translocating leopards to areas where they were partly or totally exterminated due to reasons which don't prevail any more.

METHODS

All five translocated leopards in the present study were culprits or suspected culprits involved in stock losses, and were provided by the Problem Animal Unit of the Transvaal Division of Nature and Environmental Conservation. They were either caught by farmers and handed over to the Problem Unit, or captured by the Unit itself using fall-door traps.

During immobilization (8 mg/kg Ketamine hydrochloride, Parke Davis, Pty Ltd R.S.A) leopards were fitted with radio-collars (Leopard A - CSIR Pretoria, RSA; Leopard B - Telonics, Arizona USA; Leopard C - AVM Instrument Company California, USA; Leopard D - Potchefstroom University RSA; Leopard E - Potchefstroom University RSA), and directly transferred by road to the release site. All leopards were allowed to recover fully before release. Full recovery was considered when the animal could make a charge from the rear of the cage, without losing his balance.

Transportation cages were tightly covered with canvas and no additional drug dosages were administered during transport. In two cases leopards were kept for three (Leopard B) and four days (Leopard C) respectively, at the Problem Animal Unit prior to their release. This was necessary as they had to be drugged to move them to another cage for transfer purposes to the Unit at De Wagensdrift, while radio-collars were prepared. It was not ethical to administer a second dosage within three days to fit a radio-collar.

A lot of consideration was given to the sites for release. First the distances from capture sites to release sites were carefully selected. Thought was also given to the status quo of the release site leopard population as well as the prey situation. Translocated leopards were released by raising the drop door of the cage (still on the vehicle), by means of a pulley operated from the safety of the vehicle.

Released leopards were continuously monitored for the first five to seven days by vehicle, after which they were followed on a weekly basis from a fixed wing aircraft (Cessna 185). Radio tracking by vehicle only was impractical because of the unpredictability of their movements, large overnight distances sometimes traversed by released leopards, as well as lack of access roads. Movements were plotted on a 1:50 000 map, by means of trangulation and the aid of topographic features.

RESULTS

Leopard A

This female was caught by a farmer on the farm Doornfontein (Koedoeskop) (24° 51'S, 27° 33'E) in November 1984. Due to legal complications, the Chief Directorate of Nature and Environmental Conservation confiscated the animal. After the investigation, which lasted several months, permission was given to fit it with a radio-collar. She was released on the farm Kwarriehoek (24° 45 'S, 27° 53'E), 60km east of her capture site on July 6 1985.

The first night she walked 300m (Fig.17), where she remained inactive until the following night when she covered an additional 500m. Night three was spent on the same spot. During night four she moved from the farm Kwarriehoek and was tracked six km further, moving in a westerly direction (4).

In the early morning of night five she found refuge in the Elandsberg, another 4,1 km away (5). The next few days she couldn't be tracked. Her signal was however again received two weeks later on 24 July (A). This time against the northern aspect of the Boshoffsberge, 19,6 km in a straight line from point 5. On 11 August she was again detected on the southern

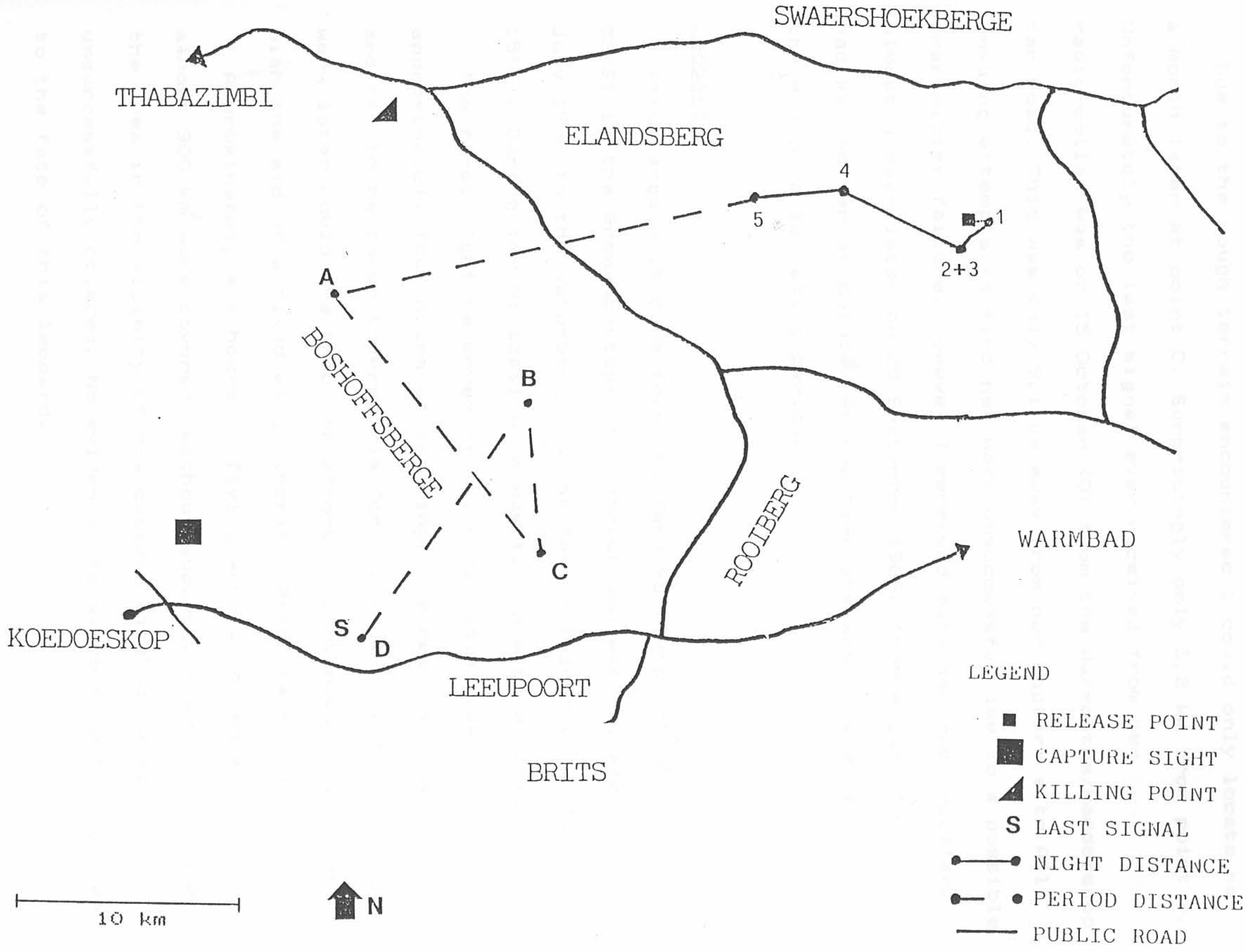

Figure 17 : Post release movements of translocated leopard A.

aspect of the same mountain range (B), 15 km from the previous locality.

Due to the rough terrain encountered I could only locate her a month later at point C. Surprisingly only 6,2 km from point B. Unfortunately the last signal ever received from her radio-collar was on 15 October (D) from the Warmbaths/Koedoeskop tar road. This was only 9,1 km away from her capture site. All ensuing attempts to find her were unsuccessful due to a possible transmitter failure. However I received back her radio-collar, almost a year later on 25 September 1986, from a game farmer who had killed her at point ▲. At the time she was apparently near the end of a lactating period.

Leopard B

This large male came from the farm Spitskop (25°46'S, 28°52'E) in the Bronkhorstspruit district and was released on 9 July 1986 in the Waterberg, on the farm Sliedrecht (23°58'S, 28°15'E). During immobilization he was fitted with a radio-collar.

The first night he moved off at remarkable speed. After approximately four hours of tracking, the receiver gave problems and had to be taken to Pretoria for repair the next day. Only a week later could the tracking effort be continued. This time with the aid of a fixed wing aircraft (Beechcraft Z10).

Approximately six hours of flying were involved whereby almost 900 km^2 were covered, without success. Four months later the area in the vicinity of his capture site was also unsuccessfully covered. No evidence has since come to light as to the fate of this leopard.

Leopard C

Also captured at Spitskop (25°46'S, 28°52'E), on 13 April 1987, the female leopard was released on the farm Baviaanskloof (24°15'S, 28°55'E) near Potgietersrus the following day (Fig. 18), after being fitted with a radio-collar. This was 165 km from her previous territory. The first night she took up residence 1,1 km higher up the mountain (1). Here she remained inactive intil the following night, after which she moved 22 km into a smaller ravine (2). During night three she did not show any directional movement and remained in the same small ravine (3).

The first directional movement took place on the fourth night when she covered 4,1 km (4). The fifth and sixth nights she moved 1,8 (5) and 7,8 km respectively. However she suddenly changed direction during night seven and headed back in the direction of point of release. Seven km later she became inactive at locality (7).

On 1 May 1987 she was found inactive 7,4 km (A) from her previous monitored locality (7). Ten days later her signal was received from the Doorndraai Dam Nature Reserve, 3,5 km further (B). A week later (17 May 1987), it seemed as if she had settled in the area because she was only 3,6 km (C) from point B. However another week later she moved 21,1 km (D) and on her way crossed the busy N1 Highway to the north. On 30 April 1987 she was located 3,6 km further (E), and on the fourth and sixth of May another 8,1 km (F) and 1 km (G) respectively in the direction of Zebedela.

The last signal to be received from her radio-collar was on

16 June 1987 (H), 12,3 km in the direction of her released site. After almost nine weeks she was therefore approximately 15 km from her initial site of release.

During this period she covered a minimum straight line distance of 81,1 km. Despite five hours of flying whereby vast areas were covered (3000 km^2), no signal could be detected. Her dissappearance could have resulted from a possible transmitter failure or that she had been caught by a farmer and the radio-collar destroyed.

Leopard D

Leopard D was a young male that was trapped on the farm Doornkloof (Assen) (24°08'S, 27°25'E) on 20 July 1987, radio-collared and released in the Doorndraai Dam Nature Reserve (24°17'S, 28°46'E) three days later, 143 km from Doornkloof (straight line distance). The first night he walked 1,4 km into mountain cover, where he remained inactive until the following day (1) (Fig.19).

Although locally active he only moved approximately 50 m the next two nights. During night four, five and six he covered 2,0 km, 3,1 km and 1,0 km respectively (3,4,5). On 8 August 1987 his signal was received on the opposite side of the Doorndraai Dam (Point A), 6,5 km in a line walking around the dam.

Ten days later on 18 August he still wandered in the same vicinity (B), only 1,2 km from the previous site (A). On 20 August we found him still (C) within the boundaries of the Reserve, 2,8 km from point B. On 9 September the first signs of possible settlement in the area were evident. He only moved 3,1

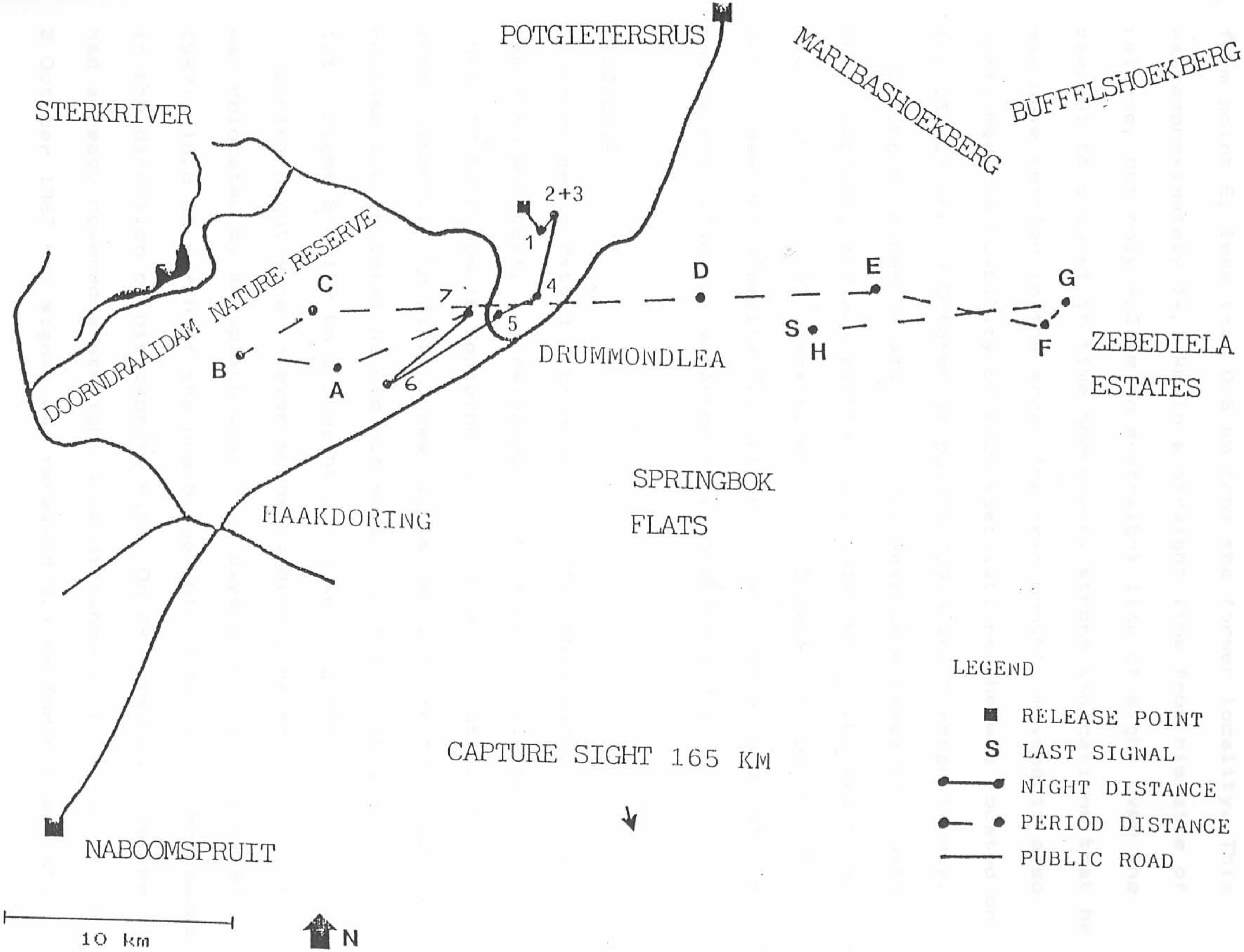

Figure 18 : Post release movements of translocated leopard C.

km (D) in the direction of point A.

Exactly two months after release a strong signal was received from point E, less than 0,8 km from the former locality. This was approximately 14,1 km in a straight line from his site of release, but only 4,2 km in a straight line of sight over the dam. At this point in time there were strong indications that he may have settled in the area. The next month's movements also confirmed the viability of such speculations. He was located on 10, 15, 24 and 29 October at points F,G,H and I respectively.

During November he also used the Reserve extensively, with one exception, and was plotted at localities J,K,L, and M on days 4,15,20 and 29 respectively. On 15 December however, his well preserved appetite for cattle calves counted against him and he was killed by a farmer at point ▲ (Fig. 19).

Leopard E

After being fitted with a radio-collar this male, caught on the farm Witpoort, was released on the farm Kwarriehoek (24° 45'S, 27° 53'E) on 16 September 1987, 60 km in a straight line from Witpoort. The first three nights he spent on the koppie of release and in total he did not move more than 3 km (night 1 - 1,5 ; night 2 - 1,2 km and night 3 - 1 km)(Fig 20).

During night 4 he however suddenly dissappeared. His signal was relocated by aeroplane only four days later (24 September 1987), 18,8 km north of the Hoekberge (A). A day later he headed in the direction of his capture site. On 28 September 1987 he had already covered a straight line distance of 15,4 km (B). On 2 October 1987 his signal was received 9,4 km further and still

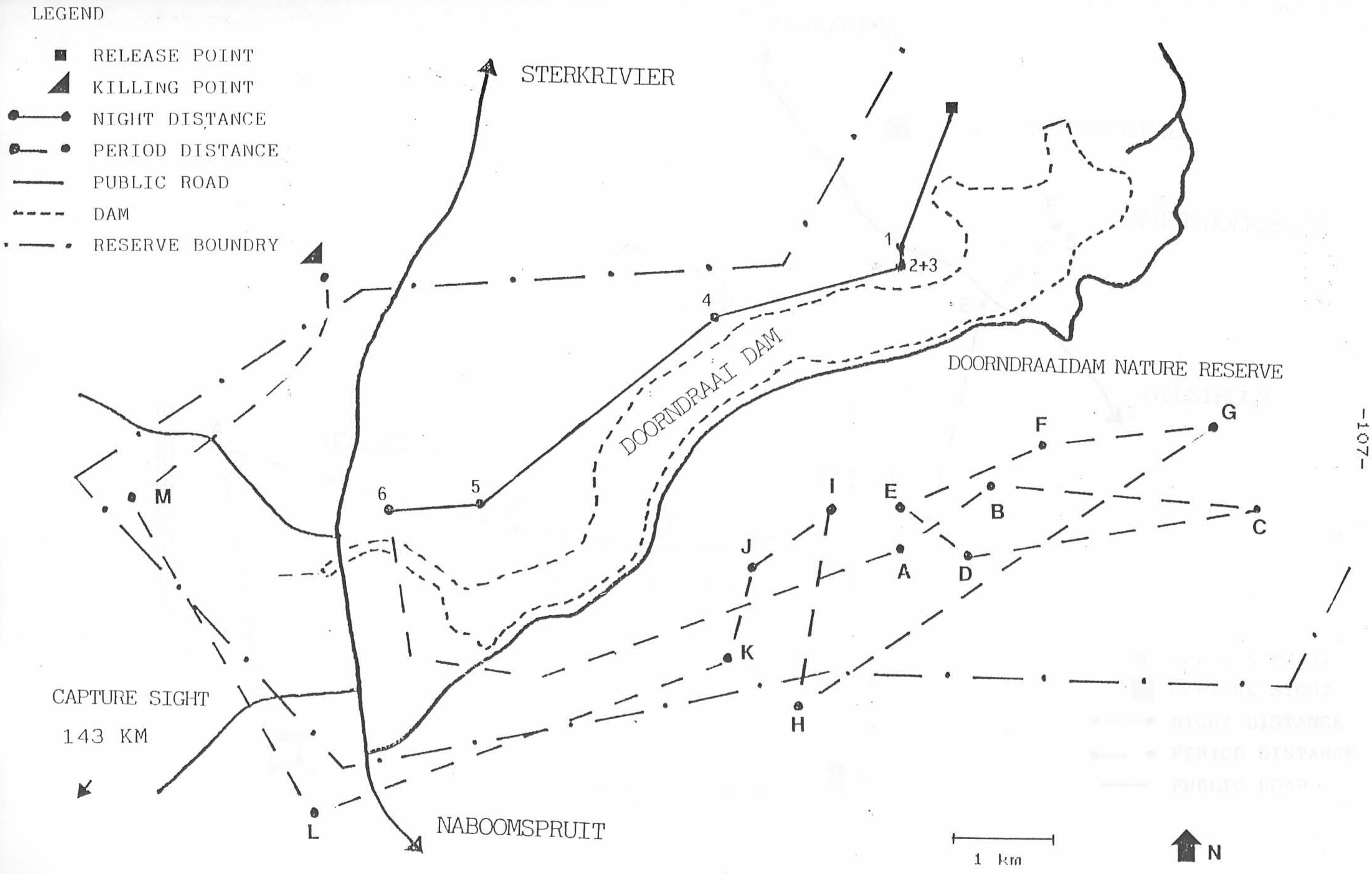

Figure 19 : Post release movements of translocated leopard D.

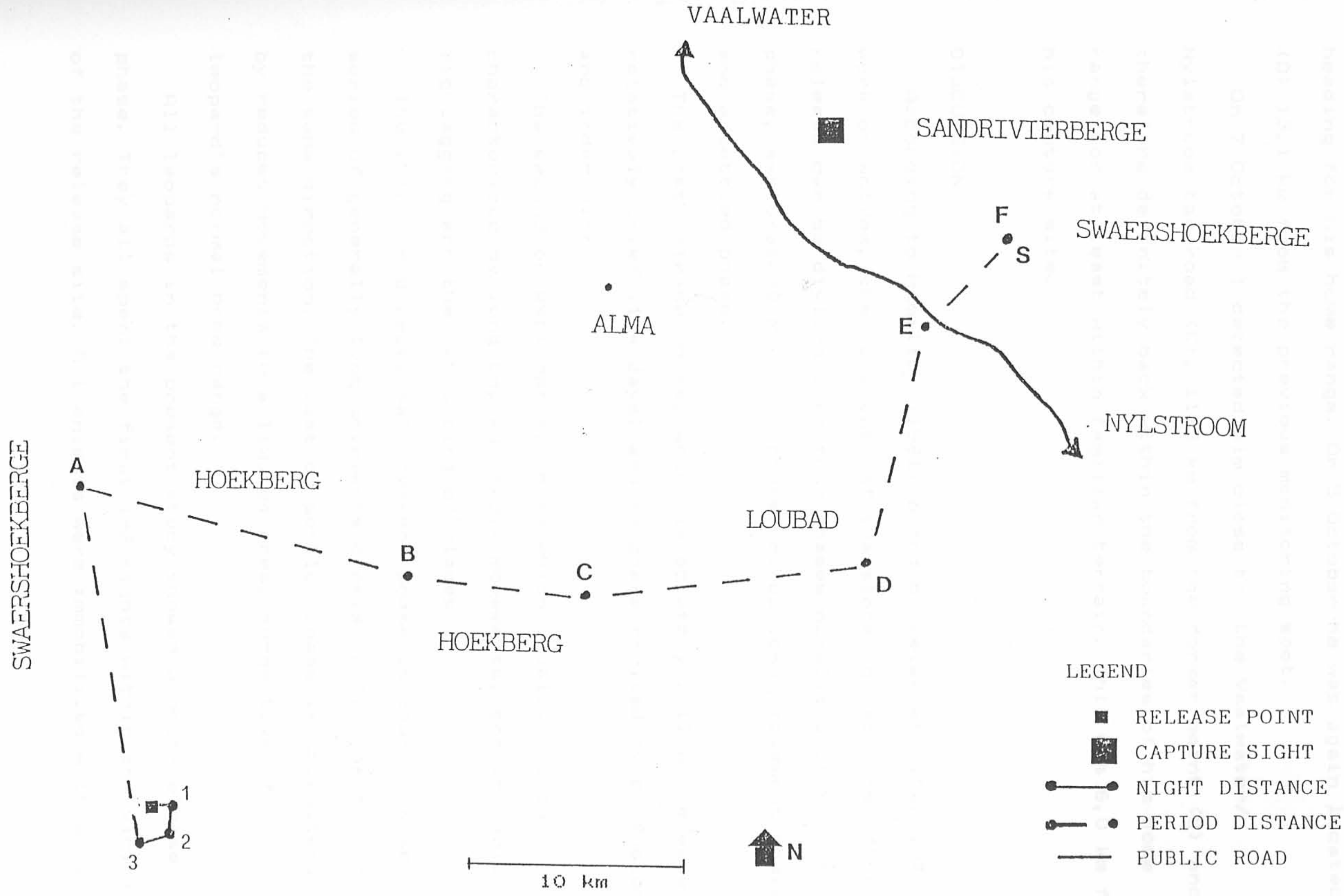

Figure 20 : Post release movements of translocated leopard E.

heading for his home range. On 5 October he was again located (D) 13,1 km from the previous monitoring spot.

On 7 October I detected him close to the Vaalwater/ Nylstroom tar road (E), 11,3 km from the former point (D) and therefore definitely back within the boundaries of his home range, or at least within familiar terrain. This was 6,0 km from his capture site.

DISCUSSION

According to Hamilton (1981) based on Weise _et_ _al_'s. (1975) work on wolves, the movements of translocated leopards after release can be divided into four phases namely: post release phase, exploratory movement phase, directional movement phase and a settled phase.

The post-release phase, which immediately follows release, is relatively brief (1-4 days) and is characterised by confusion and indecision.

The second or exploratory phase which usually follows is characterised by long unpredictable movements, considerable zig-zagging and the revisiting of places.

The third or directional movement phase is characterised by a series of generally long movements consistantly made in about the same direction. The last or settled phase is characterised by reduced movements to a limited area, suggestive of a leopard's normal home range.

All leopards in the present study showed a post-release phase. They all spent the first 1-3 nights within the vicinity of the release site. All animals were immobilized with a single dose of ketamine hydrochloride for the fitting of radio-collars and relevant measurements to be taken. During transfer no drugs were administered and the animals had recovered completely on arrival at release sites.

Drug inducement was therefore not suspected as influencing this relatively inactive phase, but it was probably an orientation reaction towards a strange environment. My findings however did not show an exploratory phase succeeding the first phase. A directional phase was subsequently evident and lasted for different periods depending on circumstances (distance from capture site, motivation to home seeking, etc). Leopard A which was released 60 km in a direct line from her capture site started directly after the post-release phase to home in on her former locality by means of this directional phase, until she reached her destination.

Leopard C who was released 165 km from her capture site showed a directional phase of only three nights averaging 4,5 km straight line distance per night, after which she started zig-zagging and revisiting places.

Leopard D, a young male, was released 143 km from his capture site but did not show a strong motivation to walk back. He also showed a directional phase from night three until five weeks later, averaging 1,8 km per night.

Leopard E also showed directional movement after the initial post-release phase, which was followed through until he reached familiar terrain.

Leopard C which was released far from her capture site however showed a third phase namely an exploratory phase, when she started to zig-zag after night seven. This was followed again by a directional phase and shortly after another exploratory phase. The large home range sizes (300+ km) of free living leopards in the Waterberg (Chapter 3), as well as the long distances travelled each night (up to 20 km a night), made it difficult to determine whether an individual was in the exploratory or settled phase. The fact that Leopard D did settle in his released area after almost five months, gave me the opportunity to analyse his movement patterns.

Individual C on the other hand seemed motivated and in an attempt to find her way back, followed the exploratory phase up with more directional movement phases.

Pronunciations made regarding factors that could prevent or hamper animals in a homing attempt, or negatively influence them settling in an area, are in many cases derived from their general behaviour patterns and/or extrapolated from other species behaviour and/or human interpretation. It is however still of great importance to consider all such factors if representative information is lacking. Studies on white-footed mice, Peromyscus leucopus noveboracensis (Cook &Terman 1977), European woodmice, Apodemus sp. (Bovet 1982), wolves (Fritts et al. 1984) and black bears, Ursus americanus (Mc Arthur 1981), however, specifically addressed factors relevant to homing behaviour.

Homing limiting factors:

Cook & Terman (1977) showed that in the white-footed mouse, homing performance was inversely distance dependant. There also did not seem to be a linear relatioship between the two factors.

A threshold effect may however be involved after increasing distance to a limit. Furrer (1973) found in the mice Peromyscus maniculatus that there was a gradual decline in homing success with increasing displacement distance, beyond which the homing percentage declined sharply.

Homing success was also found to be inversely related to distance in black bears (Mc Arthur 1981), brown bears (Miller & Ballard 1982) and wolves (Fritts et al. 1984). From a management point of view, defining a threshold distance is very relevant.

Findings in one region for a specific species can however not be extrapolated to another ecological region, without conducting an independant study.

Threshold distances were suggested to be greater than 258 km for brown bears in Alaska (Miller & Ballard 1982). It is suggested by Hamilton (1981), that a translocated leopard should not be released less than 100 km from the place of capture. The greater the distance the better.

Both leopards A and E walked back (homed) from a straight line distance of 60 km. The large homerange sizes of leopards in the Waterberg (> 300 km^2 in a resident radio-collared male) mean exposure to larger familiar habitat. Although the fate of leopards B and C is not known, where 336 km and 165 km straight line homing distances were involved, it is feasible to suggest that translocation distances greater than 150 km should be allowed in the Transvaal.

Furthermore, other factors like topographic barriers etc. are also expected to influence homing performance negatively. Topographic barriers had an effect in brown bears (Miller &

Ballard 1982), whereby a wide and braided river prevented homing. Mountains and lakes also influenced homing behaviour in wolves (Fritts et al. 1984).

Interestingly, Mc Arthur (1981), found the number of ridges and elevation gain, between the trapping and release sites were highly correlated with the success of translocating black bears. Differences in the importance of distance and elevation gain between males and females and between experienced bears were also identified. The influences of the above mentioned features in the present study could only be made applicable on leopard D. She had not homed, or surely settled at the time when I received her last signal. Although these influences could be ruled out, it seemed more likely that human settlement played a limiting role in her initial homing performance.

The town Naboomspruit and the adjacent Springbok flats are situated to the south of her release site, with small farms surrounding it. To the west she encountered Leboa with a lot of activity at the Zebediela Estates and townships (Mokerong). Although these could be regarded as obstacles which hampered her initial movements, at this stage there is no certainty that they prevented her reaching her destination, as she could only be monitored for two months.

In other studies, differences between adult and subadult individuals concerning homing success have also been described. Due to more erratic initial direction and movements, than those of adults, Fritts et al. (1984), suggested that subadults (inexperienced animals) showed less developed orientation ability.

This could also be linked to a lack of motivation to return to his capture site (Rogers 1977). Leopard D, a young male, although released more than 140 km from his captured site, did not even consider homing in on his former range, despite a lack of other limiting factors like topographic features and human activity. An absence in motivation was therefore a strong possibility.

Settling limiting factors :

The importance of motivation as a factor in increasing homing success also received attention. Because a homerange not only satisfies an animal's physical needs, but also constitutes an area within which it can move with assurance, allowing it to efficiently use the resource there, translocated animals are highly motivated to return to their home ranges (Beeman & Pelton 1976).

The importance of an animal's social structure in this motivation process has also been described. Rogers (1977) observed a difference in motivation between black bear males and females, due to a difference in territoriality. Females defended a territory whereas male black bears defend only the personal space surrounding them as they travel through their home ranges. Because females returned more frequently, it follows that they are more highly motivated to return.

Leopard studies so far, however, showed that both males and females are territorial (Hamilton 1981; Bertram 1980.

The presence or absence of conspecifics in the capture area and/or release site may also play an important role as a motivation in homing behaviour.

If we first consider the presence of mates in the captive area, certain types of social structures, especially pair bonds (black backed jackal), but also others like matriarchal societies (lions) etc, will increase motivation to walk back depending on social status. A temporary bond between solitary species can also play a significant role.

The night when leopard E, an adult male, was captured, smaller leopard spoor were found in the vicinity of the trap. As the leopard is a solitary species, this may have been a female in oestrus which was temporarily associating with him. The movements this leopard showed after release in new habitat were of a highly motivated individual. He was back in familiar territory within 18 days, during which period he covered a straight line walking distance over rough mountains of almost 72 km.

The presence of conspecifics in the released area could have the reverse effect. Hamilton (1976) argued that the home ranges of resident adult leopard males formed a tight mosaic with little overlap, and that detected intrusions by other males were seldom tolerated by the occupants, which sometimes fought fiercely.

As translocated male leopards are strangers to any males resident in the released area, encounters will be hostile, resulting in avoidance. According to Hamilton (1981) such avoidance behaviour is unlikely to render translocation successful in any release area already occupied by a dense population of resident males.

Strange translocated females are more likely to be accepted by resident males. However in view of the intolerance that female felids normally show towards each other, and particularly towards strangers, it is improbable that a translocated female leopard can readily settle in the released area unless there is room for her. According to Hamilton (1981), settlement of translocated leopards in the release area will succeed only if there are vacancies for leopards of the required sex or sexes.

Hamilton (1981) also used the situation in Meru National Park, Kenya as an example. According to his records this Park once had a substantial leopard population, which was heavily depleted by poaching. In theory. therefore, Meru should have had plenty of vacancies for translocated leopards of both sexes. The majority of translocated leopards however, failed to integrate after release. Hamilton (1981) believed the answer lies in the nature of the species. The leopard appears to him to be a species that does adapt well following translocation, bearing in mind that the area of release was human selected.

In the present study it was planned to relocate leopard A in an area with a low leopard density, a plentiful number of potential prey species and a habitat that should have satisfied her physical needs, yet this also did not succeed. Although the straight line distance from her release site to her former home range was apparently inadequate, other factors must have influenced her as well.

For example, in this case human activity like continuous game drives involving guests etc. had a negative influence, due to her inherent fear of humans, as she was captured in an area where leopards were not tolerated. The sanctuary area into which she was released was apparently too small and did not have enough secluded places.

Orientation mechanisms :

Many hypotheses have been proposed regarding orientation mechanisms in mammals. Studies in homing behaviour of the grey wolf led to the belief that their movements are in response to visual, olfactory and auditory cues, with the latter probably being the most important (Henshaw & Stephenson 1974).

They argued that the wolf seems driven to return to familiar territory, using the strongest acquired exogenous cues. It must however be mentioned that these wolves were hand reared and thereafter released into the wild. They would thus maintain their affinity for human habitation and could locate centres of human activity over long distances.

Studies on white-footed mice (Cooke & Terman 1977), suggest that something other than vision, possibly olfaction, may have been utilized for orientation on familiar terrain, while vision may have been used on an unfamiliar area. Visual cues such as landmarks were subsuquently found to be important in house mice, Mus musculus (MacKintosh 1973).

Henshaw & Stephenson (1974) also mentioned an inherent or calculated sense of orientation. Especially the latter aspect with reference to indices of time and direction. These were available in sun-arc, celestial and photoperiodic cues in combination with circadian biological rhythms.

Erickson & Petrides (1964) found that black bears released in unfamiliar surroundings evidently wander at random until they either find a familiar area or can establish new home ranges. In familiar terrain they utilize directed movements to reach their destination. However, Miller & Ballard (1982) found that brown bears homing was not dependent on random movements, until familiar terrain was encountered. Like polar bears (Ursus martimins) they seemed to navigate, without physical reference points to maintain their position.

It therefore seems that a variety of mechanisms are involved in the homing behaviour of terrestrial mammals, and no definite mechanisms are apparent. In leopards, one can at this stage only mention possible inherent or calculated senses of determining direction. However, it seems most likely that they do use auditory, visual and olfactory cues, as primary, or even secondary navigatory mechanisms, where an inherent sense of direction is relevant.

The fact that only two individuals homed in, over relatively short distances, makes speculation regarding the mechanisms involved more difficult. If one assumes the absence of an inherent sense of direction, as well as any visual, olfactory and auditory cues in a leopard that was released further than 150 km from his territory, he was left with one option, and that was to wander at random until he either found familiar indicators (cues) or terrain or a new acceptable vacant territory. These indicators could be visual like prominent mountain shapes (for example Hangklip in the Naboomspruit area), post office towers with red lights (Potgietersrus area) or even the lights of towns. All these cues are visible at night from a high point over vast distances.

Auditory cues also may assist in direction finding. Here, sounds familiar to the animal like locomotives, large trucks on the highway and even regular aeroplane flights (in the vicinity of an airport), could aid in the orientation of a leopard.

Olfactory indicators are most likely to play a role in the final stages of homing behaviour. Individual recognition through the scent marks of conspicific neighbours may be an important mechanism in direction orientation in the leopard, especially where leopards roam over vast areas and have overlapping home ranges.

Feasibility of translocations:

The initial capturing of an individual is in most cases due to socio-economic reasons. In other words the impact this predator had on the stock-farmer and his subsequent preventative action. This resulted in removing the animal (translocation) or killing it. Due to the rare status of the leopard in South Africa, a long term conservation strategy for the species should also be taken into consideration in any decision making effort. Consideration should be given to stimulating or restocking populations in suitable habitats that have been depleted for reasons that do not exist anymore.

Contrary to the belief of Hamilton (1981), I am of the opinion that, apart from problem leopards, leopards could be considered for such a conservation strategy objective in the Transvaal. Depleted populations could be stimulated and vacant territories occupied wherever the potential for this exists. In the case of problem leopards (as defined in Chapter 2) they must however be killed immediately. The priority is therefore to solve the 'problem' rather than transferring such leopards, thereby prejudicing the longterm conservation strategy for the species.

Hamilton's (1981) situation dealt almost exclusively with problem leopards. In Kenya cattle farming procedures differ markedly from those practised in South Africa. In the Transvaal leopards almost exclusively (exception the Lowveld) inhabit mountainous areas, and only pose a threat to cattle calves (up to three months old) during calving periods.

Usually most farmers thus have the option when to use mountain grazing and when to protect vulnerable calves (anti-predator stock management). Not all of them unfortunately apply strict measures.

In Kenya, however, due to the wide distribution of natural areas, leopards are expected to be present at any time in most cattle farming areas. The fact that goats are also extensively utilized as stock by local farmers or herdsmen makes them vulnerable throughout the year. Natural prey species of the leopard are also being depleted in some of these regions. In Kenya problem leopards were transferred to National Parks and if a leopard moves out of this human selected area of release, the problem of stock raiding is only transferred. The value of a translocation is therefore questioned.

In evaluating the feasibility of translocations in the Transvaal, it is important to examine the different criteria being used to enable possible justification or dissaproval of the action. The two objectives of a translocation to be fulfilled before it can be considered a success are therefore first, a socio-economic commitment (forms part of responsive management) towards the landowner and secondly to assist with the conservation of the species, namely a conservation commitment.

Socio-economic factors such as the attitude of the people in control of the initial area concerned should be taken into consideration, in that their 'problem' must be solved. Translocation actions could be considered a success even though individuals had moved out of the area of release and settled elsewhere in the vicinity. As long as they could complement or strengthen a leopard population without being problem leopards.

A leopard captured on bait that has most likely been killed by him, can be considered as the culprit, but not necessarily as a problem leopard. Leopards may occasionally prey upon a calf when it is available without becoming a problem leopard. It all depends on the circumstances whereby the cattle calf was taken, for instance the locality of killing site (was it near human activity etc), precautionary measures taken (were cattle kraaled or protected), as well as recent frequency of stock killing incidences in the area.

If relevant stock protecting measures, as proposed (Chapter 6) were applied, could the incident be avoided? A first incident in three or more years, due to poor stock management, does not mean that a death sentence should be imposed on a captured leopard. The same applied to a leopard that was captured with bait, provided it was not killed by the leopard, after a series of stock losses. Many innocent leopards have been killed in this way, just for the culprit to return again.

To remove (translocate or kill) the captured leopard would be the only option (responsive management) in any situation where a leopard has been caught, as few farmers would allow a leopard captured on their property just to be released again in the same area. The whole occurrence must be used to enlighten the farmer that a potential threat exists to his livestock and that he should impose precautionary measures (preventative management).

This was the case with leopard A. This subadult female was captured using donkey meat. After she was removed from the farm, the farmer still had problems with a leopard killing calves near the farmhouse. This only ceased three months later when an adult male was killed. As mentioned in Results, Leopard A returned to her former locality after release but did not cause problems. When she was again captured on another farm, 12 months later, after she had killed a blesbok, she was in the final stage of lactation. This translocation was therefore from a conservation point of view, successful in that a litter was probably raised.

The human factor relevant in deciding where to locate an individual or set home range boundaries is often subject to bias and will in many instances not satisfy the needs of the animal. Subtle settling limiting factors could be overlooked.

Translocations where the transferred individual moves out of the selected area and settles in another area of his choice can be seen as making a positive contribution towards the future of the species. The condition that no problem animals should be involved, still prevails. Even when an animal returns to his former habitat, the whole action should not be considered as a failure, unless the individual starts causing damage. The translocation per se would however be seen as unsuccessful in such a case, even if it does not cause problems. A translocation action would therefore be considered unsuccessful when the initial status of the leopard is incorrectly evaluated i.e. when a problem leopard is relocated. Moreover, from a public opinion point of view, care should be taken to ensure that individuals do not home in on their original territory.

Leopard D's translocation per se could be considered as a proven success. The whole translocation action however is questionable due to the domestic calf that he apparently killed in the new area. However, the farmer concerned was also partially to blame in that newly born calves were kept in mountain veld.

The strongly motivated homing ability of leopard E, made this translocation per se unsuccessful. After almost two years since the last signal nothing further is known as to the whereabouts of this individual. This may just indicate that no problems arose due to his presence. It should be mentioned that he was initially captured on an impala carcass which he had killed. The whole translocation action did therefore meet the socio-economic function (public opinion) in that the animal was removed and sacondly, he did again integrate with the local leopard population (conservation function).

CHAPTER 6 : LEOPARD CONSERVATION IN FARMING AREAS OF THE TRANSVAAL.

INTRODUCTION

Leopards have one of the widest geographical ranges of large terrestrial mammals and are the most widely distributed of all the world's large cats. Despite years of persecution they are still to be found in China, parts of the Middle East, over most of Africa and even industrial South Africa (Norton 1984).

The status of leopards has given rise to controversy, but in Africa it is generally accepted that they are not in immediate danger of extinction (Myers 1976;Eaton, 1978; Martin & De Meulenaer 1987). However in most African countries leopards are 'threatened' mainly due to the decline in area of their natural habitat, their potential for predation on live stock and by their use in the fur trade (Hamilton 1981). The South African Red Data Book Terrestrial Mammals (Smithers 1986) listed leopards as rare, not endangered or vulnerable, but at risk. In South Africa substantial leopard populations occur on our larger game reserves (Kruger National Park, Kalahari Gemsbok National Park, and Hluhluwe/Umfolozi Game Reserve). Nevertheless, a large proportion of the South African population occurs outside these large protected areas (Norton 1984), especially in the Transvaal where leopards are gazetted as Protected Wild Animals (Ord.12, Art.15). This means that a permit is required to hunt leopards, except where they have killed livestock. In such cases the incident must be reported to the relevant authorities within 24 h.

Their presence and future survival on private land in the R.S.A. gives cause for concern. Not only is available natural habitat declining, but livestock owners lose thousands of rands from cattle losses caused by leopards. In the process indiscriminate measures (poisoning etc.) taken by farmers, negatively influence whole ecosystems in that other rare secondary consumers disappear where leopards are intensively exterminated.

OBJECTIVES

Examining a conservation strategy for a specific predator species which competes with man in agriculturaly developed areas, necessitates consideration of a number of factors. However, in the Transvaal, with its diverse farming activities, the situation is even more complex.

For this reason options for a specific strategy cannot always be applied consistantly. In a global approach the following information is necessary:

a. A distribution map for leopards in the Transvaal whereby viable populations and areas of conflict are identified.
b. Estimated number of leopards in the Transvaal.
c. Information on what is happening in these areas i.e. the scope of the problem must be ascertained.
d. Feasible solutions and human and financial resources to implement these, must be available.

METHODS

Information regarding distribution of leopards, their status in these areas as well as problems associated with their presence, was gathered from farmers, officials of the Transvaal Division of Nature and Enviromental Conservation (TPA) and the Police. Information on distribution was plotted on a 1:250 000 Topo cadastral map.

The number of leopards in the Transvaal was estimated by means of extrapolating information gained from radio collared leopards in the Transvaal Waterberg (Chapter 3), Transvaal Lowveld (Hornocker & Bailey 1986; le Roux & Skinner 1989), Kenya (Hamilton 1981), Zimbabwe (Smith 1977) and Tanzania (Bertrum 1978) to their occurrence and status in different areas of the Transvaal.

Potential solutions to the conflict between farmers (cattle and game) and leopards were discussed in depth with farmers in different areas and in different situations. The use of an electric fence, acting as a barrier between leopards and cattle calves was investigated as a possible calf protection strategy (CPS) in certain situations. A 400m paddock with a 1,2 meter high fence, consisting of five wire strains was erected in the Mabula Game Reserve. Two of the strains, 100mm and 350mm above ground level, were electrified.

Two domestic goats were kept permanently in the paddock for the period August to September 1987, to establish whether leopards could penetrate the barrier. An electric pulse with a voltage of seven thousand (0,5 Amps) was consistantly supplied over this period with a battery driven Gallager E9 energizer (Gallagher Poldenvale, Pietermaritzburg R.S.A). A sunpannel (Meps Electronics Witrivier R.S.A.) charged the battery.

RESULTS

Viable populations and high conflict areas

With the exception of areas north of the Soutpansberg and in the Lowveld, all leopard strongholds and resultant conflict zones are restricted to mountain ranges (Soutpansberg, Waterberg, Magaliesberg, Drakensberg etc.) and broken terrain in the foothills of these mountains (Fig.21).

Estimated number of leopards in the Transvaal

The following leopard densities were recorded so far in different savanna areas of Africa :

Tsavo National Park, Kenya = one leopard per 13 km^2 (Hamilton 1976),
Serengeti National Park, Tanzania = one leopard per 29 km^2 (Bertram 1978),
Kruger National Park, R.S.A. = one leopard per 6 km^2 (Bailey, pers. comm. in Hamilton 1981)
Rhodes Matobos National Park, Zimbabwe = one leopard per 5 km^2 (Smith 1977)
Waterberg (Naboomspruit) = one leopard per 53 km^2 (present study)

The leopard density in the Naboomspruit area can be regarded as fairly low, as areas with much higher densities exist (e.a. Melk River study area pers observ., Transvaal Lowveld (le Roux & Skinner 1989). Two conservative categories of leopard density were (subjectively) assumed to be representative of core and low density areas (Fig 21), namely one leopard per 30 km^2 and one leopard per 60 km^2 respectively. The total low density areas in the Transvaal (Fig 21) totalled 19500 km^2, while that of core areas were determined at 39500 km^2 (G.I.S. Lab, University of Pretoria). Thus, giving an effective population estimate of 1642 individuals for the Transvaal, outside of the Kruger National Park, Independent States and Selfgoverning States.

The scope of the problem

How are stock and game farmers being affected?

Leopards in the Transvaal are responsible for taking a considerable number of livestock each year, the majority being calves up to four months old. These calves are captured mostly in mountainous veld (rocky areas), remote from human disturbance (Chapter 4). The present economic depression

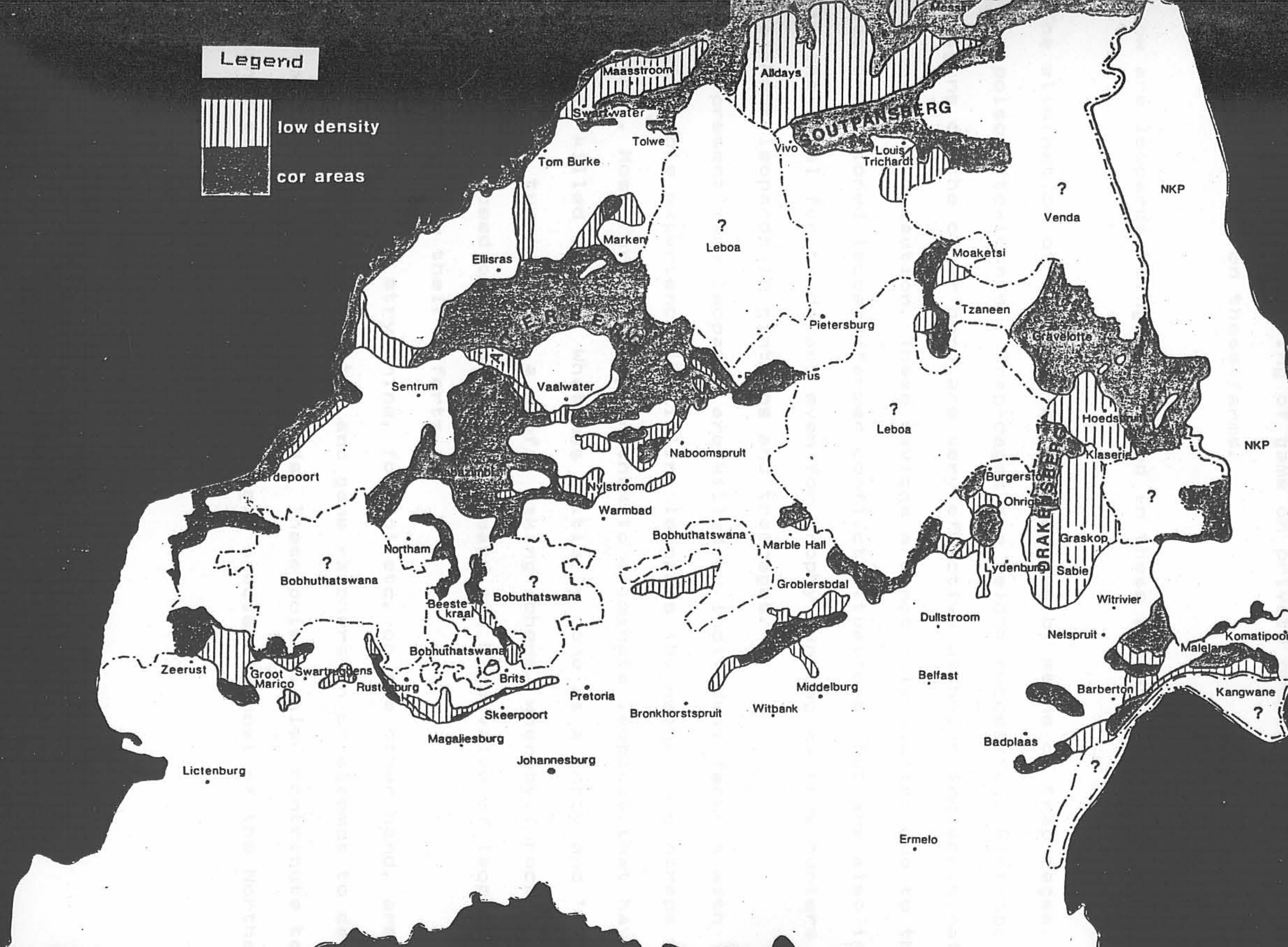

Figure 21 : Leopard distribution in the Transvaal.

necessitates that farmers get the maximum use out of their land. The current high meat prize also exacerbates these losses.

On game farms the impact of leopards on the young of valuable game animals must not be underestimated. Due to high costs, regarding the acquisition and relocating of game on private property, leopards are seldom tolerated on these farms.

How are leopards being threatened in these areas?

The elimination of leopards mainly happens by means of trap-cages, setguns and poison (toxicants). Trap-cages are seldom successful. Gintraps and setguns on the other hand are very effective although indiscriminate when not used with caution. These devices are not only applied due to the above-mentioned leopard/farmer conflict situations, but are also important in the local fur trade and even for trophy hunting as some hunters do pay to shoot leopards in gintraps and trapcages.

At present many leopards are killed by individual farmers with considerable experience in killing leopards (by means of gintraps and setguns). Most farmers rely on them to eliminate leopards that have actually killed calves. What was initially done as a hobby and 'community service' is turning into a profit making scheme, whereby innocent leopards are also disposed of. The present demand and high value of leopard pelts compensating for their efforts.

Poisons such as strychnine, folidol etc, on the other hand, are used irresponsibly by many cattle and game ranchers in an attempt to destroy all predators, including leopards. These poisons also contribute to the absence of vultures and several eagle species in most of the Northern

Transvaal (van Jaarsveld, pers comm.*).

Complete destruction of parts of the leopard's natural habitat due to crop farming (bush clearance) on mostly marginal land, may eventually lead to islands of small leopard populations. Such populations may not be viable in the long term, because of possible loss of genetic diversity (Humphrey 1985).

More emphasis must also be placed on preventing the elimination of natural prey species, especially small mammals and game birds in farming areas of the Transvaal. Most farmers are unaware of the fact that many farm labourers supplement their food supply by using dogs, snares and different traps to capture small mammals and game birds. At the end of the day, two to three large families can have a definite influence on the number of prey species.

This trend in some areas not only leads to dangerously low leopard densities, but also to an increased risk of calves being taken and the subsequent schooling of problem leopards.

All leopards are potential stock killers, a leopard that takes a calf is not necessarily a problem leopard. Only when taking calves on a regular basis, and/or making an effort to get into a paddock or enclosure, can it be regarded as a problem leopard.

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Feasible solutions

Electric fencing :

During the 60 day trial (August/September 1987), leopard spoor were found on ten occasions in the vicinity of the electrified enclosure. The fence was however not crossed and both goats survived.

DISCUSSION

Much speculation has arisen as to the minimum population size of a large mammal population to ensure genetic viability. It has been established that large carnivores generally exhibit a higher degree of homozygosity and probably possesses fewer alleles per gene within any given population than is the case in herbivore populations. It might well be that carnivores have found another way of coping with their evolutionary adaptability problems. However this aspect may make a large carnivore less genetically adaptable and therefore more vulnerable (Leyhausen 1986).

Much more intensive research is needed to answer these questions on the genetic diversity of species and of the number of individuals necessary for the long term conservation of a population (Humphrey 1985).

For Indian tigers (Panthera tigris tigris) a minimum number of 300 individuals has been suggested (Leyhausen 1986). The conservative figure of 1642 leopards in the Transvaal (outside the Kruger National Park, Independent and Selfgoverning States) seems therefore from an adaptive variability point of view out of danger.

Although information on different aspects of gene flow of free ranging leopard populations are lacking, Figure 1 shows that different leopard populations in the Transvaal are currently to a large extent linked, which makes natural gene flow a possibility.

Another encouraging tendency, from a leopard's point of view, is the vast number of private game ranches proclaimed in the Transvaal. Although suitable areas for leopards thus exist (Fig.21), these may not be available as homogeneous units in the future, due to increasing human pressure. It is therefore important to start concentrating on the monitoring of habitats providing leopards with strongholds.

What is proposed, is not to isolate these identified habitats which would comprise thousands of hectares as nature reserves, but rather request that they be reserved in the future as 'nature areas'. In order to achieve this it is proposed that details of leopard distribution be provided to the co-ordinators of the S.A. Plan for Nature Conservation. The S.A.Plan for Nature Conservation, administered by the Department of Environmental Affairs in conjunction with the provincial authorities, has as its aim the establishment of a scientifically based national network of protected areas.

The S.A. Plan, in it's selection of an area, looks at a variety of factors such as ecological diversity, threatened plants and animals scientific value etc. In the selection of an area, every effort is made to ensure that only the 'best' areas are protected. It is possible that habitats identified as leopard strongholds are also worthy of protection in terms of other characteristics. The presence of leopards would thus be an additional motivation in a decision making process.

The reservation of an area as a 'nature area' will mean that there is no change in ownership and that the landowner can continue with his current activities. It will also mean that a scientific management plan can be established for the total area. To enable this, and appropriate boundary definition for the 'nature areas', information about certain aspects of leopard ecology in different ecosystems of the Transvaal must be available. This information is also essential for proper future monitoring.

Conservation of the leopard's natural prey species, especially small mammals and game birds cannot be over emphasized. Although nature conservation officials confiscate hundreds of snares each year, the majority are not detected (K. Myburg. pers. comm.)* due to the large areas involved and the remoteness of many farms.

In this regard many farmers must definitely consider providing supplementary protein rations for labourers, to prevent unnecessary hunting pressure on small game. Conservation of this sector of the fauna will reduce the potential loss of cattle calves and valuable antelopes.

In the Transvaal, cattle farming is being conducted under intensive and extensive conditions, in different veld types (sweet, mixed, sour bushveld). This together with diverse farming policies applied by individual farmers makes a generalised solution regarding the leopard/cattle conflict very difficult.

As most losses are of new born calves, the leopard/cattle contact problem can be overcome to some extent by adapting stock management to the threat. For example synchronisation of calving and removing calves from high risk areas.

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Although many farmers do practice this, much more can be achieved in this regard. Improved synchronisation of calving periods together with advanced planning concerning rotational grazing programmes, whereby high risk camps are only used prior to the calving period, and when calves are older than six months, can be applied with considerable success.

A calf protection strategy (CPS) with the emphasis on the prevention of the risk factor in terms of locality of camps and calf age, is definitely a crucial component of a long term leopard conservation strategy in the Transvaal. On farms where such measures are impractical or where drought has complicated management, prevention of stock losses through farm management must be through other actions. The most realistic approach would be the construction of a physical barrier such as an electrified fence (Norton 1985), which may effectively deter a leopard from hunting. However the permanent exclusion of leopards from large farming units through electric fencing, might solve the conflict problem but will not satisfy the global objective, namely the conservation of the species.

Emphasis should be placed on the fact that electrified fencing should be used as a supplementary action for high-risk paddocks during specific times, when other measures are not possible.

In addition, specific use of such measures on a small scale, for instance the creation of overnight electrified paddocks (1-2 ha) may also be considered as protecting calves in exceptional circumstances.

Although the maintenance of an electrified fence, especially longer fences over rough terrain, may at first cause some difficulties from a farmer's point of view, these can be overcome. As energisers, batteries, shockboxes and sunpanels are mobile, it means that only one such unit set need be used on a farm. Expenditure wise the first kilometer will cost R2189,00.

It entails :

1 x Meps 122 (12v) Energiser	R 460,00
1 x 12 Volt Battery 610	R 120,00
1 x Shockbox	R 195,00
1 x 12 Watt Sun Panel	R 386,00
Sub.Total:	R1161,00
30 x LIM Clamps	R 18,00
30 x Strain Insulators	R 360.00
1000 x UNW Insulators	R 350,00
2 x 50 kg Steelwire (2,2mm)	R 300,00
Sub.Total:	R1028,00
Total :	R2189,00

The second kilometer up to 6 km will cost R1028,00 per/km. Problem leopards causing damage which are not deterred by the above-mentioned measures, should be eliminated immediately.

Game ranching has over the years grown into a multi million Rand farming industry. The availability of leopards for trophy hunting purposes is however still a controversial matter. At present land owners in the Transvaal can apply for permits to hunt (trophy) leopards (Ord.12, 1983 Art.18) for themselves or for any other person, providing that the species occur on the property on a permanent basis.

However landowners are not allowed to hunt a Protected Wild Animal (i.e. leopard), which has been lured by bait on account of it's edibility, smell or taste, or by any sound. (Ord.12,1983, Art.23), unless livestock* have been killed by the animal and therefore naturally lured due to the audibility, smell or taste of the kill. Many leopards are illegally hunted in this way and with the aid of gintraps or trap-cages (without stock being killed) for trophies.

Leopards outside Game Reserves are seldom seen because of their shyness. Therefore hunting of leopards under normal hunting circumstances for trophy purposes is virtually impossible. Adjustment of the Ordinance in terms of baiting (hunting from a hide) will make leopards more available, thereby turning them into an economic asset. In other words, sustainable utilization, which can be interpreted as using the interest and keeping the capital. Nevertheless it is still very difficult to bait leopards, so the actual number shot annually should not increase, but the actual figure for leopards culled in this fashion will become apparent. Such more representative statistics will eventually promote a long term conservation strategy for leopards.

A strict well controlled scientifically based permit system, together with a licence system regarding the possession of leopard skins and trophies, as applied in the case of elephant tusks, is however essential.

Recommendations for the number of permits to be issued for trophy hunting in each district of the Transvaal, are at present the responsibility of law enforcement officials of the Division of Nature and Environmental Conservation (TPA). Although decisions are made based on

*Livestock: Horse,mule,ass,bull,cow,calf,sheep,goat,pig or poultry.

inadequate data this is the only option in the absence of information regarding the different leopard populations in the Transvaal. The number of leopards hunted during the last three years, were 22 in 1986, 51 in 1987 and 47 in 1988 (F. Postma pers. comm.).

The total number of permits issued annually in the Transvaal for exporting trophies, is with effect from 1 January 1990 however subject to the granting of a CITES quota. This must definitely be backed up by a licence system for the possession of leopard skins and trophies. Such a licence system will not only provide vital representative information (up to date lacking) on how many leopards are killed (problem or trophy hunting) annually in the Transvaal, but will also identify problem areas (districts) and prevent uncontrolled trade in specimens.

Any individual who persistantly attempts to get a licence for more than one or two skins will attract attention and the case can be investigated. The current system whereby farmers in the Transvaal only need to report the killing of a leopard (that caused damage) within 24 h to a local authority are inadequate. Only the more conscientious farmers bother to notify the authorities, and a significant number of skins enter the illegal trade.

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Any landowner who legally hunted a leopard may dispose of the skin without being the holder of a permit (Postma pers. comm.).

A controversal matter is that leopards are at present included in Appendix I, of the Convention In International Trade in Endangered Species of Wild Fauna and Flora (CITES). Appendix I includes all species threatened with extinction, which are or may be affected by trade. Trade (export), in specimens of these species is subject to particularly strict regulation, in order not to endanger their survival, and is only authorised in exceptional circumstances. No trade is allowed - only export of hunting trophies or personal effects.

Trade in specimens of Appendix I species, also requires the approval of the Scientific and Management Authorities in the importing country, notwithstanding permission given by the exporting country. For species in Appendix II, only the Scientific and Management Authorities of the exporting countries are involved. There are however exceptions to the rule for which import permits are required due to stricter legislation adopted by the importing country (Postma pers. comm.)

Demanding Appendix II status for the leopard will mean that the responsibilities will be placed on the exporting country to decide on the quota to be exported. This can lead to a dangerous situation in the absence of information on population trends of different leopard populations and the proper monitoring of exploitation in many African countries.

Only if the different countries adhere to CITES stipulations, can transfer from Appendix I to II be considered. The quota of 50 granted to the R.S.A for the export of leopard trophies (1990) also seems to be rather low.

Although not a major threat, the constant elimination of individual leopards , or attempts to do so, are a cause for concern. If conflict (leopard/farmer) prevention measures, as proposed in the preceding paragraphs, could be applied successfully, the continuous elimination of individuals would be less important. More leopards will thus be available for proper exploitation (trophy hunting) rather than for just the skin.

The use of different capturing devices to eliminate individual leopards is getting out of hand. Subject to the provisions of Ordinance 12, Art 27, no person shall hunt or catch a leopard by means of gintraps, setguns or trap cages, unless this occurs in the immediate vicinity of a livestock carcass, which has apparently been killed, or if there is a reasonable suspicion that the leopard is about to cause damage to stock. It is however necessary for measures to be taken as these devices (gintraps, setguns etc.) are being misused.

Experienced farmers (with gintraps etc.) should operate under the auspices of the Transvaal Agricultural Union, to assist the Problem Animal Control Unit of the Division of Nature and Environmental Conservation, Transvaal, or be incorporated within registered problem animal clubs (private landowners). In the latter however, a lack of control regarding the use of gintraps etc. may cause problems. Registered problem animal clubs are also not found in all districts. Gintraps and setguns must definitely be made illegal and only used under these controlled circumstances by authorized individuals, for the exclusive control of problem leopards.

Poisoning game without a permit is illegal (Ord 12, 1983; Art 31). However, strychnine may be used in pill form to poison problem animals (chachma baboons, vervet monkeys, black backed jackals and bush pigs). Although a prescription from a veterinarian is required for strychnine, the poison is available without any permit from certain pharmacists in the

Northern Transvaal.

This may be irrelevant because a toxicant like folidol, that is also highly lethal to leopards, will always be freely available due to its use by crop farmers. Thus, banning poisons may serve as a deterrent. However, it is crucial to inform landowners about the destructive effect of poisons on an ecosystem and that every predator species has a definite ecological role. When eliminated in total, or from most of its area, this could mean that other predator species will partially occupy the area vacated by the original occupant. The extermination of leopards in many parts of the Transvaal bushveld has contributed for example to an increase in black backed jackals and caracals. These species are at present causing larger problems than leopards on both cattle and game farms. They are also more difficult to control (caracal to a lesser extent) and have little value as trophy animals.

In conclusion, the implications of leopard conservation are greater than merely for aesthetical and ethical considerations. As the largest predator in most farming areas of the Transvaal, they have a definite functional role to play in balancing and stabilizing the different ecosystems.

Leopard populations outside large sanctuaries in the Transvaal are not yet in danger of extinction, but it would be naive to think that they are stable or even increasing. Although prospects appear gloomy, farmers are sympathetic, and will cooperate if stock losses can be limited, and the game farm problem solved.

The biggest longterm threat however to the future survival of leopards still is the reduction of their natural habitat. What is of importance, is that we still have some time to experiment with our options, to ensure the long term survival of this prince of the bushveld.

SUMMARY:

The aims of the present study of Panthera pardus were to describe their diet relative to prey abundance, especially pertaining to domestic livestock in two farming areas of the Waterberg namely the Naboomspruit and Melk River areas. Space utilization and activity patterns of a male and female leopard were also investigated in the Naboomspruit study area. These data together with information gained with the translocation of five individual leopards, and experiments on different capture techniques, were used to propose a leopard conservation strategy in farming areas of the Transvaal with special reference to stock protection measures.

Different live capture techniques were investigated, whereby variations on conventional box-traps as well as modifications on gin-traps showed application potential.

The effective home range sizes of a radio collared male and female leopards were calculated at 303 km^2 and 157 km^2 respectively. Both leopards were not found in all parts of their home ranges, equally often. There were usually sectors of concentrated use. The male leopard in the Naboomspruit study area moved a mean distance of 8,6 km (range 0,6 - 21,5km) per diel tracking period. The female averaged a distance of 6,1 km (range 0,2 - 12,2 km) per diel tracking period. Radio tracking data together with spoor identifications showed a leopard density of one leopard per 53 km^2.

Both leopards were predominantly nocturnal with some

crepuscular activity. In the male's total activity pattern scenario two peaks were apparent, the first during the period 18h00 to 19h00 the second from period 04h00 to 05h00. The female showed a sharp peak between 18h00 to 19h00 and 19h00 to 20h00. Peaks of activity were apparent throughout the night with a noticeable decline between 02h00 and 03h00.

The opportunistic feeding habits of leopards were also apparent in this study. In the Melk River study area, ungulate hair was found in 76,3 % of the scats, impala being the best represented at 33,3 %. Cattle hair was found in 2,5 % of the scats. In addition carcass observations showed that eight cattle calves were confirmed to have been killed by leopards. Ages of calves taken differed from new-born to 103 days old, with an average age of 22 days. Mammals other than ungulates featured in 35,8 % of the scats. In the Naboomspruit study area, 67,5 % of the scats contained the hair of ungulates, impala contributing 18,9 %. Leopards took 11 cattle calves over a period of 11 months (September 1986 - July 1987). The ages of the calves varied from new-born, to 90 days old, with an average of 21 days. Mammals other than ungulates featured in 40,5 % of the scats. Information recorded on prey capture and feeding behaviour (espescially involving cattle calves) were used in the creation of a calf protection strategy.

Different aspects of leopard translocations i.e. post release movements, factors involved in preventing homing behaviour or factors that negatively influence an individual leopard settling in a released area, were investigated to determine the feasibility of translocations to areas where they were partly or totally exterminated due to reasons which don't prevail anymore. However, in evaluating the feasibility of translocations in the Transvaal, it is important to examine the different criteria being used to enable possible justification or disapproval of the action. The two objects of a translocation to be fulfilled before it can be considered a success are first, a socio-economic commitment towards the landowner and secondly a conservation commitment towards the species. Socio-economic factors such as attitude of the people in control of the original area concerned, should be taken into consideration in that the "problem" must be solved. Translocation actions could be considered a success even though individuals had moved out of the area of release and settled elsewhere in the vicinity. As long as they could complement or strenghen a leopard population anywhere without being problem leopards. A problem leopard is therefore seldom suitable for translocation.

In the creation of a proposed leopard conservation strategy for the Transvaal an attempt was first made to estimate distribution and density of leopards in the Transvaal. By extrapolating information gained from radio collared leopards in this study and elsewhere in southern Africa a density estimate of 1642 individuals was made, outside the Kruger National Park, Independent States and selfgoverning States.

Although information on different aspects of gene flow of free ranging leopards is lacking, the leopard populations in the Transvaal are currently to a large extent linked, which makes natural gene flow a possibility. Although suitable areas for leopards thus exist, these may not be available as homogeneous units in the future, due to increasing human pressure. It is therefore important to start concentrating on the monitoring of habitats providing leopards with strongholds. What is proposed is not to isolate these identified habitats which would comprise thousands of hectares as nature reserves, but rather request that they be reserved in the future as "nature areas" under the S.A. Plan for Nature Conservation, administered by the Department of Environmental Affairs in conjunction with the provincial authorities.

The leopard/cattle contact problem can to a large extent be overcome by adapting proper stock management to the threat. On farms where such measures are impractical, prevention of stock losses must be through supplementary actions such as physical barriers during high risk periods. The different applications of electrified fences showed potential. The leopard/game farm conflict will be solved by making the leopard more available for trophy hunting and thereby turning it into an economic asset. A strict well controlled scientifically based permit system, together with a licence system regarding the possession of leopard skins and trophies is however essential.

Different capturing devices being used to eliminate individual leopards (e.g. gintraps etc.) must also be made illegal and only used under controlled circumstances by authorized individuals, for the exclusive control of problem leopards. Poison will allways be available, the only option is to inform and educate landowners and the general public about the destructive effect of poisons on an ecosystem.

The implications of leopard conservation are greater than merely for aesthetical considerations. As the largest predator in most farming areas of the Transvaal, they have a definite functional role to play in balancing and stabilizing the different ecosystems. Leopard populations outside large sanctuaries in the Transvaal are not yet in danger of extinction, but it would be naive to think that they are stable or even increasing. Although prospects appear gloomy, farmers are sympathetic, and will cooperate if stock losses can be limited, and the game farm problem solved. The biggest long-term threat however to the future survival of leopards still is the reduction of their natural habitat. What is of importance is that we still have some time to experiment with our options to ensure the long term survival of these magnificent cats.

OPSOMMING

Die doel van hierdie studie van die luiperd Panthera pardus was om inligting in te win oor aspekte van voeding relatief tot die digtheid van prooi-spesies in twee boerdery gebiede van die Waterberg naamlik, die Naboomspruit- en Melkrivierareas. Spesifieke verwysing is na die vang en voedingsgedrag van luiperds met betrekking tot beeskalwers gemaak. Verder is aspekte van ruimtebenutting en aktiwiteitspatrone van 'n manlike en vroulike individu in die Naboomspruitstudiegebied ondersoek. Hierdie data tesame met inligting ingewin ten opsigte van die translokering van vyf luiperds, asook met die eksperimentering van luiperdvangtegnieke, is gebruik in die daarstelling van 'n voorgestelde luiperdbewaringstrategie vir boerderygebiede van Transvaal. Klem is in die strategie ook ondermeer op veebeskermingsmaatreëls gelê.

Variasies op bestaande vanghokke en slagysters is ook ondersoek vir die lewendige vang van luiperds in verskillende omstandighede.

Die effektiewe loopgebied van 'n manlike en vroulike luiperd wat van radionekbande voorsien is, is vasgestel op 303 km^2 en 157 km^2 respektiewelik. In beide individue is loopgebiede nie eweredig benut nie, en was daar areas van voorkeur benutting. Die manlike dier in die Naboomspruitstudiegebied het 'n gemiddelde afstand van 8,6 km (variasie 0,6 - 21,5 km), en die vroulike dier 'n gemiddelde afstand van 6,1 km (variasie 0,2 - 12,2 km) per 24 uur siklus beweeg.

Radio-opsporingsdata tesame met die identifisering van addisionele luiperds in die studiegebied dui op 'n luiperd digtheid van een luiperd per 53 km^2 in die Naboomspruitstudiegebied. Beide luiperds was oorwegend naglewend, maar het soms in die skemer aktiwiteit getoon. In die mannetjie se totale aktiwiteitsscenario was twee pieke opmerklik. Die eerste gedurende die periode 18h00 tot 19h00 en die tweede vanaf 04h00 05h00. Die wyfie het aktiwiteitspieke tussen 18h00 en 19h00 en weer tussen 19h00 en 20h00 getoon.

Die opportunistiese voedingsgedrag van luiperds was ook opmerklik in die studie. In die Melkrivierstudiegebied was die hare van hoefdiere in 76,3 % van die mismonsters teenwoordig, waarvan 33,3 % onder andere die van rooibokke bevat het. Beeshare is in 2,5 % gevind. Karkas ondersoeke het verder getoon dat luiperds verantwoordelik was vir die vang van agt beeskalwers in die gebied.

Die ouderdomme van die betrokke kalwers het gewissel tussen pasgebore en 103 dae, met 'n gemiddeld van 22 dae. Nie-hoewige soogdiere was in 35,8 % van die mismonsters verteenwoordig. In die Naboomspruitstudiegebied het 67,5 % van die mismonsters die hare van hoefdiere bevat waarvan 18,9 % ondermeer rooibokhare bevat het. Elf beeskalwers is oor 'n tydperk van 11 maande (September 1986 - Julie 1987) gevang. Ouderdomme van hierdie kalwers het gewissel van pasgebore tot 90 dae, met 'n gemiddelde van 21 dae. Soogdiere anders as hoefdiere is in 40 % van die mismonsters gevind. Informasie met betrekking tot vang en voedingsgedrag van veral beeskalwers is in die daarstelling van 'n kalfbeskermingsstrategie gebruik (bees).

Verskillende aspekte van luiperdtranslokasies onder andere inisiele bewegings na vrylating, faktore wat terugkering beinvloed/voorkom of 'n individu verhinder om in 'n gebied te vestig is ondersoek, om die lewensvatbaarheid van translokasies per se te bepaal. Die twee kriteria waaraan 'n translokasie-eksperiment moet voldoen alvorens dit 'n sukses kan wees is, eerstens 'n sosio-ekonomiese doelwit ten opsigte van die grondeienaar en tweedens 'n bewarings doelwit gerig op die spesie. Die sosio-ekonomiese doelwit behels dat die "probleem" verwyder moet word. 'n Translokasie poging kan dus as 'n sukses beskou word al beweeg die dier uit sy vrylatingsgebied, solank 'n luiperdpopulasie elders aangevul word, sonder om skade aan te rig. Probleemluiperds is dus selde geskik vir translokasie.

In die daarstelling van 'n voorgestelde luiperdbewarings-strategie in die Transvaal, was dit ook nodig om meer inligting oor die verspreiding en getalle van luiperds te bekom. Deur gebruikmaking van inligting soos uit radio-opsporing in die Naboomspruitarea verkry, sowel as die ekstrapolering van navorsing elders in Suider Afrika, is 'n digtheidsberaming van 1642 individue gemaak. Dit geld vir gebiede in Transvaal (buite die Nasionale Krugerwildtuin en onafhanklike- en selfregerende state.

Alhoewel daar geen inligting oor die genevloei in luiperdpopulasies beskikbaar is nie, is die meeste luiperdpopulasies in die Transvaal in 'n groot mate verbind, wat dus genevloei 'n moontlikheid maak.

Alhoewel geskikte luiperdhabitat tans beskikbaar is, kan dit as gevolg van verhoogde ontwikkelingsdruk in die toekoms nie as homogene eenhede teenwoordig wees nie. Dit word dus voorgestel dat alle inligting oor luiperddigtheidsgebiede by die S.A. Plan vir Natuurbewaring, geadministreer deur die Departement van Omgewingssake in samewerking met Provinsiale owerhede, geinkorporeer word.

Die luiperd/vee konflik kan tot 'n groot mate deur middel van doeltreffende veebestuursaksies opgelos word. Op plase waar sodanige maatreels onprakties mag wees, behoort veeverliese deur middel van addisionele (gedurende hoe risiko periodes) fisiese hindernisse beperk te word. Die verskillende toepassings van elektriese heinings het in die verband groot potentiaal getoon.

Die luiperd/wildboer konflik sal tot 'n groot mate opgelos word indien luiperds meer beskikbaar is as trofeediere en die se teenwoordigheid dus 'n bate vir die wildboer is. 'n Streng, gekontroleerde, wetenskaplik gebaseerde permitstelsel, tesame met 'n lisensiesisteem vir die besit van luiperdvelle en trofee is egter essensieel.

Verskillende vangapparate byvoorbeeld slagysters moet onwettig verklaar word en slegs onder gekontroleerde toestande deur gemagtigde individue vir die eksklusiewe eliminering van probleem luiperds aangewend word. Gifstowwe sal egter altyd beskikbaar wees en die enigste wyse om die probleem aan te spreek is om die grondeienaars op te voed oor die destruktiewe invloed van gifstowwe op ekosisteme.

Die implikasies van luiperdbewaring strek dus verder as slegs estetiese redes. As die grootste roofdier in meeste boerderygebiede van Transvaal het luiperds 'n definitiewe funksionele rol in die balansering en stabilisering van die verskillende ekosisteme te speel. Luiperdpopulasies buite groot reservate is nie bedreigd nie, maar dit sal naief wees om aan te neem dat luiperdpopulasies stabiel is, of aan die vergroot is. Alhoewel vooruitsigte maar vaal lyk, is die meeste boere baie positief veral as veeverliese beperk en die wildboerkonflik opgelos kan word. Die grootste langtermyn bedreiging in die Transvaal is egter die verdwyning van luiperds se natuurlike habitat. Die belangrikste is egter, dat daar nog genoeg tyd is om met die verskillende opsies te eksperimenteer, om die langtermyn oorlewing van hierdie manjifieke katte te verseker.

REFERENCES

ACOCKS, J.P.H. 1975. Veld types of South Africa. Mem. Bot. Surv. S. Afr. 40 : 1 - 128

ALT, G.L., MATULA, G.J. JR, ALT, F.W. & LINDZEY, J.S. 1977. Movements of translocated nuisance blackbears of northeastern Pennsylvania. Trans. Northeast Fish and Wildl. Conf. 34 : 119 - 126.

ANON, D.S. 1984. Drainage systems in the Waterberg. Dept. of Geography. University of Pretoria. (Unpubl. Mimeogr.)

BAILEY, T.N. 1974. Social organization in a bobcat population. J. Wildl. Mgmt 38 : 435 - 446.

BEAR, C.H., SEVERSON, R.E. & LINHART, S.B. 1978. Live capture of coyotes from a helicopter with ketamine hydrochloride. J. Wildl. Mgmt 42 : 452 - 454.

BEASOM, S.L. 1974. Selectivity of predator control techniques in South Texas. J. Wildl. Mgmt 38 (4) : 837 - 844.

BEEMAN, L.E. & PELTON, M.R. 1976. Homing of black bears in the Great Smoky Mountains National Park. In : Bears, Their biology and management. Ed Pelton M.R., Lentfer, J.W. & Folk, G.E. JR. Int. Union Conserv. Nat. Publ. New Ser. 40

BERTRAM, B.C.R, 1978. Pride of lions. J.M. Dent & Sons Ltd, London.

BERTRAM, B.C.R. 1980. Serengeti predators and their social systems. In : Serengeti : Dynamics of an Ecosystem. Ed Sinclair, A.R.E. & Norton - Griffiths, M. University of Chicago Press, Chicago.

BOTHMA, J. DU P. & LE RICHE, E.A.N. 1984. Aspects of the ecology and the behaviour of the leopard Panthera pardus in the Kalahari Desert. Koedoe Suppl. 27 : 259 - 279.

BOTHMA, J. DU P. & LE RICHE, E.A.N. 1986. Prey preference and hunting efficiency of the Kalahari Desert leopard. In : Cats of the World : Biology, Conservation and Management. Ed Miller, S.D. & & Everett, D.D. National Wildlife Federation, Washington, D.C., U.S.A. PP 389 - 414.

BOTHMA, J. DU P. & LE RICHE, E.A.N. 1989. Evidence of a flexible hunting technique in Kalahari leopards. S. Afr. J. Wildl. Res. 19 : 57 - 60.

BOVET, J. 1982. Homing behavior of mice : Test of a "Randomness" - Model. Z. Tierpsychol. 58 : 301 - 310.

BRAIN, C.K. 1981. The hunters or the hunted? An introduction to African cave taphonomy. Chicago, University Press.

BROWN, L.H. 1971. East Africa : Mountains and Lakes. East African Publishing House, Nairobi.

BURT, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24 : 346 - 352.

CARLEY, C.J. 1981. Red wolf experimental translocation project summarized. WCSRC / Wolf Sanctuary Bull.Winter 1981 : 4 - 7, Spring 1981 : 8 - 9.

COLLINSON, R.F.H. 1985. Selecting wildlife sensusing techniques. Wildlife Monographs. University of Pietermaritzburg, Pietermaritzburg.

COOK, JUDITH. A. & TERMAN, C.R. 1977. Influence of displacement distance and vision on homing behaviour of the white - footed mouse (Peromyscus leucopus noveboracensis) J. Mamm. 58: 58 - 66.

CORBETT, L.K. 1979. Feeding ecology and social organization of wildcats (Felis silvestris) and domestic cats (Felis catus) in Scotland. Ph.D. thesis, University of Aberdeen, Scotland. 296 pp.

CRAIGHEAD, F.C. 1976. Grizzly bear ranges and movement as determent by radio - tracking. In Bears, Their biology and Management. Ed Pelton, M.R. & Lentfer, J.W. Int. Union Conserv. Nat. New. Ser. 40. Morges, Switzerland. pp. 97 - 109.

DU TOIT, A.L. 1954. The Geology of South Africa. Oliver & Boyd, Edinburgh.

EATON, R.L. 1978. The conservation of the leopard in Africa : towards an authentic philosophy of conservation. Carnivore 1(3/4) pp. 1 - 75.

EISENBURG, J.F. 1986. Life history strategies of the felidae : variations on a common theme. In : Cats of the World : Biology, Conservation and Management, Ed Miller S.D. & Everett D.D, National Wildlife Federation, Washington, D.C., pp 293 - 310.

ELOFF, F.C. 1973. Ecology and behaviour of the Kalahari lion. In: The World's Cats, Vol 1, Ed Eaton, R. World Wildlife Safari, Winston, Oregon, U.S.A. pp 90 - 126.

ELTRINGHAM, S.K. 1979. The ecology and conservation of large African mammals. Macmillan Press, London.

ENGLUND, J. 1982. A comparison of injuries to leg-hold trapped and foot-snared red foxes. J. Wildl. Mgmt 46 : 1113 - 1117.

ERICKSON, A.W. & PETRIDES, G.A. 1964. Population structure, movements and mortality of tagged bears in Michigan. In : The black bear in Michigan. Ed Erickson, A.W., Nellor, J. & Petrides, G.A. Mich. Agric. Exp. Stn. Res. Bull. 4. pp 46 - 67.

ESTERHUIZEN, W.C.N. & NORTON, P.M. 1985. The leopard as a problem animal in the Cape Province, as determined by the permit system. Bontebok 4 : 9 - 16.

ESTES, R.D. 1967. Predators and Scavengers. Nat. Hist. 76 (2) : 20 - 29 ; 76 (3) : 38 - 47.

EWER, R.F. 1973. The Carnivores. Weidenfeld and Nicholson, London. 494 pp.

FENDLEY, T.T. & BUIE, D.E. 1986. Seasonal home range and movement patterns of the bobcat on the Savanna River Plant. In : Cats of the World : Biology, Conservation and Management Ed Miller S.D. & Everett D.D. National Wildlife Federation, Washington, D.C. pp 237 - 265.

FRITTS, S.H., PAUL, W.J. & MECH, D.L. 1984. Movements of translocated wolves in Minnesota. J. Wildl. Mgmt 48 : 709 - 721.

FURRER, R.K. 1973. Homing of Peromyscus maniculatus in the channelled scablands of east-central Washington. J. Mamm. 54 : 466 - 482.

GIBB, J.A., WARD, C.P. & WARD, G.D. 1978. Natural control of a population of rabbits, Oryctolagus cuniculus (Linnaeus) for ten years in the Kuorarau anelosure. New Zealand D.S.I.R. Bulletin 223,89 pp.

GITTLEMAN, J.L. & HARVEY, P.H. 1982. Carnivore home-range size, metabolic needs and ecology. Behav. Ecol. Sociobiol. 10 : 57 - 63.

GREEN, B. 1976. The use of etorphine hydrochloride (M99) in the capture and immobilization of wild dingoes, Canis familiaris dingo. Aust. Wildl. Res. 3 : 123 - 128.

GRIFFO, J.V., JR. 1961. A study of homing in the cotton mouse, Peromyscus gosypinus. Am. Midl. Nat. 65 : 257 - 289.

GRIMBEEK, A.M. 1984. Territorialiteit : Teorie en Praktyk. B.Sc. Hons. thesis, University of Pretoria, Pretoria.

GROBLER, J.H. & WILSON, V.J. 1972. Food of the leopard (Panthera pardus Linnaeus) in the Rhodes Matopos National Park, Rhodesia, as determent by faecal analysis. Arnoldia 5 (35) : 1 - 9.

HAMILTON, P.H. 1976. The movements of leopards in Tsavo National Park, Kenya, as determined by radio-tracking. M.Sc. thesis, University of Nairobi.

HAMILTON, P.H. 1981. The leopard (Panthera pardus) and the cheetah (Acinonyx jubatus) in Kenya. Report for U.S. Wildlife Service, the African Wildlife Leadership Foundation and Government of Kenya.

HARGER, E.M. 1970. A study of homing behavior of black bears. M.A. thesis, Northern Michigan Univ. Marquette. pp 81.

HARRINGTON, F.H. & MECH, L.D. 1983. Wolf pack spacing : Howling as a territory - independent spacing mechanism in a territorial population. Behav. Ecol. Sociobiol. 12 : 161 - 168.

HENSHAW, R.E. & STEPHENSON, R.O. 1974. Homing in the gray wolf (Canis lupus). J. Mamm. 55 : 234 - 237.

HENSCHEL, R.J. 1986. The socio - ecology of a spotted hyaena Crocuta crocuta clan in the Kruger National Park. D.Sc. thesis. University of Pretoria, Pretoria.

HORNOCKER, M.G. 1969. Winter territoriality in mountain lions. J. Wildl. Mgmt 33 : 457 - 464.

HORNOCKER, M.G 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildl. Monogr. 21 : 1 - 39.

HORNOCKER, M.G & BAILEY, T.N. 1986. Natural regulation in three species of felids. In : Cats of the World. Ed Miller, S.D. & Everett, D.D. National Wildlife Federation, Washington, D.C. pp 211 - 220.

HORNOCKER, M.G., MESSICK, J. & MELQUIST, W. 1983. Spatial strategies in three species of Mustelidae. Acta Zool. Fennica 174 : 185 - 188.

HUMPHREY, S.R. 1985. How species become vulnerable to extinction and how we can meet the crisis. In Animal Extinctions. Ed Hoage, R.J. Smithsonian Institution Press, Washington, D.C. London.

HUNTLEY, B.J. 1982. Southern African Savannas. In : Ecology of Tropical Savannas, Ecological Studies, No 42. Ed Huntley, B.J. & Walker, B.H. Springer - Verlag, Berlin, pp 101 - 119.

HUNTLEY, B.J. 1984. Characteristics of South African biomes. In : Ecological Effects of Fire in South African Ecosystems. Ed Booysen, P. de V. & Tainton, N.M. Springer - Verlag, Berlin.

INGLIS, J.M. 1981. The forward-null twin-yagi antenna array for aerial radio-tracking. Wildl. Soc. Bull. 9 : 222-225.

KAUFMANN, J.H. 1983. On the definitions and functions of dominance and territoriality. Biol. Rev. 58 : 1 - 20.

KLEIMAN, D.G. & EISENBERG, J.R. 1973. Comparisons of Canid and Felid Systems from an Evolutionary Perspective. Anim. Behav. 21 : 637 - 659.

KOLENOSKY, G.B. & JOHNSTON, D.H. 1967. Radio-tracking timber wolves in Ontario. Am. Zool. 7 : 289 - 303.

KRUUK, H. 1986. Interaction between Felidae and their prey species : a review. In : Cats of the World : Biology, Conservation and Management, Ed Miller, S.D. & Everett, D.D. National Wildlife Federation, Washington, D.C., U.S.A. pp 353 - 374.

KRUUK, H. & TURNER, M. 1967. Comparative notes on predation by lion, leopard, cheetah and wild dog in the Serengeti area, East Africa. Mammalia 31 : 1 - 27.

LE ROUX, P.G. & SKINNER J.D. 1989. A note on the ecology of the leopard (Panthera pardus Linnaeus) in the Londolozi Game Reserve, South Africa. Afr. J. Ecol. 27 : 167 - 171.

LEYHAUSEN, P. 1979. Cat behaviour. Translated by B.A. Tonkin. Garland Press. New York.

LEYHAUSEN, P. 1986. The Indian Tiger. In "Cat News" 4, February 1986. IUCN Cat Specialist Group Newsletter.

LIBERG, O 1981. Predation and social behaviour in a population of domestic cat. An evolutionary perspective. Ph.D, thesis University of Lund.

LIGHTFOOT, C.J. & NORVAL, R.A.I. 1981. Tick problems in wildlife in Zimbabwe. 1. The effects of tick parasitism on wild ungulates. S. Afr. J. Wildl. Res. 11 : 41 - 45.

LITVAITIS, J.A., SHERBURNE, J.A. & BISSONETTE, J.A. 1986. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Mgmt 50 : 110 - 117.

LOTT, D.F. 1984. Intraspecific variation in the social systems of wild vertebrates. Behaviour. 88 : 266 - 325.

MACKINTOSH, J.H. 1973. Factors affecting the recognition of territory boundaries by mice (Mus musculus). Anim. Behav. 21 : 464 - 470.

MARTIN, R.B. & DE MEULENAER, T. 1987. Survey of the status of the leopard (Panthera pardus) in sub-saharan Africa. Report to the CITES Secretariat. Sixth meeting of the conference of the parties. Ottowa. Canada.

Mc ARTHUR, K.L. 1981. Factors contributing to effectiveness of black bear transplants. J. Wildl. Mgmt 45 : 102 - 110.

MC BRIDE, R.T. 1974. Predator protection collar for livestock. U.S. Patent No. 3,842,806. Registered, U.S. Patent Office, Washington, D.C.

MEAGHER, M. & PHILLIPS, J.R. 1983. Management of grizzly and black bears in Yellowstone National Park. Bear. Biol. Ass. Conf. Ser. 4.

MECH, L.D. 1970. The Wolf : The ecology and behavior of an endangered species. Nat. Hist. Doubleday, New York, N.Y. pp. 384.

MILLER, S.D. & BALLARD, W.B. 1982. Homing of transplanted Alaskan brown bears. J. Wildl. Mgmt 46 : 869 - 876.

MILLS, M.G.L. 1981. The socio-ecology and social behaviour of the brown hyaena, Hyaena brunnea (Thunberg, 1820) in the southern Kalahari. D.Sc. thesis, University of Pretoria.

MOHR, C.O. 1947. Table of equivalent poulations of North American small mammals. Am. Midl. Nat. 37 : 223 - 249.

MONOD, T. 1965. Comment Discussion Section. In : African Ecology and Human Evolution. Ed Howell, F.C. & Bourliere, F. Methuen, London. pp 547 - 654.

MUCKENHIRN, N.A. & EISENBURG, J.F. 1973. Home ranges and predation of the Ceylon leopard. In : The World's Cats. Vol I. The big cats of Asia and Africa. Ed Eaton R.L. University of Washington, Seattle, Washington. pp 142 - 175.

MURIE, M. 1963. Homing and orientation of deer mice. J. Mamm. 44 : 338 - 349.

MYERS, N. 1976. The leopards Panthera pardus in Africa. IUCN Monograph 5 : 1 - 79 (Morges)

NOBILE, G.K. 1939. The role of dominance in the social life of birds. Auk. 56 : 263 - 273.

NORTON, P.M. 1984. Leopard conservation in South Africa. African Wildlife 38 : 191 - 196.

NORTON, P.M. & HENLEY, S.R. 1987. Home range and movements of male leopards in the Cedarberg Wilderness Area, Cape Province. S. Afr. J. Wildl. Res. 17 : 41 - 48.

NORTON, P.M. & LAWSON, A.B. 1985. Radio tracking of leopards and caracals in the Stellenbosch area, Cape Province. Bontebok 4 : 9 - 16.

NORTON, P.M., LAWSON, A.B. & AVERY, G. 1986. Prey of leopards in four mountainous areas of the south-western Cape Province. S. Afr. J. Wildl. Res. 16 : 47 - 52.

ODUM, E.P. & KUENZLER, E.J. 1955. Measurement of territory and home range size in birds. Auk. 72 : 128 - 137.

PENZHORN, B.L. 1971. A summary of the re-introduction of ungulates into South African national parks. Koedoe. 14 : 145 - 159.

PETTIFER, H.L. 1980. The experimental release of captive-bred cheetah (Acinonyx jubatus) into the natural environment. In : Proc. Worldwide Furbearer Conf. Maryland, U.S.A. pp 1001 - 1024.

PIENAAR, U. de V. 1969. Predator-prey relatioships amongst the larger mammals of the Kruger National Park. Koedoe. 12 : 108 - 176.

ROBERTS, D.H. 1986. Determination of predators responsible for killing small livestock. S. Afr. J. Wildl. Res. 16 : 150 - 152.

ROBINSON, W.L. & FALLS, J.B. 1965. A study of homing of meadow mice. Am. Midl. Nat. 73 : 188 - 224.

ROGERS, L.L. 1977. Social relationships, movements and population dynamics of black bears in northeastern Minnesota. Ph.D. thesis. University of Minnesota, St. Paul. pp 194.

ROWE - ROWE, D.T. & GREEN, B. 1981. Steel-jawed traps for life capture of black-backed jackals. S. Afr. J. Wildl. Res. 11 : 63 - 65.

RUDNAI, J. 1974. The pattern of lion predation in Nairobi Park. E. Afr. Wildl. J. 12 : 213 - 225.

SANDELL, M. 1989. The mating tactics and spacing patterns of solitary carnivores. In : Carnivore behaviour, ecology and evolution. Ed Gittleman J.L. Cornell University Press. Ithaca, New York. pp 283 - 301.

SCHALLER, G.B. 1972. The Serengeti lion. Chicago University, Press.

SCHULZE, B.R. 1965. Climate of South Africa. Part 8. Goverment Printer, Pretoria.

SEIDENSTICKER, J. 1976. On the ecological separation between tigers and leopards. Biotropica 8 : 225 - 234.

SHEPPE, W. 1965. Dispersal by swimming in Peromyscus leucopus. J. Mamm. 46 : 336 - 337.

SIMONS, J.W. 1966. The presence of leopard and a study of the food debris in the leopard lairs of the Mount Suswa Caves, Kenya. Bulletin of cave Exploration Group of East Africa. Vol 1 : 50 - 69.

SINCLAIR, A.R.E. 1979. Dynamics of the Serengeti ecosystem. In : Serengeti : dynamics of an ecosystem. Ed Sinclair, A.R.E. & Norton- Griffiths, M.. Chicago University, Press.

SKINNER, J.D. & SMITHERS, R.H.N. 1990. The mammals of the southern African subregion 2nd edn. University of Pretoria, Pretoria.

SKINNER, J.D. & VAN AARDE, R.J. 1987. Range use by brown hyaenas Hyaena brunnea relocated in an agricultural area of the Transvaal. J. Zool. Lond. 212 : 350 - 352.

SMITH, R.M. 1977. Movement patterns and feeding behaviour of leopard in the Rhodes Matopas National Park, Rhodesia. Arnoldia Rhod. 8 : 1 - 16.

SMITHERS, R.H.N. 1983. The mammals of the southern African subregion 1 st edn. University of Pretoria.

SMITHERS, R.H.N. 1986. South African red data book - terrestrial mammals. South African National Scientific Programmes Report No. 125. pp 211.

SMUTS, G.L. 1978. Interrelations between predators, prey and their environment. Bioscience 28 : 316 - 320.

STREAM, L. 1976. 1976 Lithium chloride coyote taste aversion experiment in Whitman County, Washington. Final report to Washington State Depart. Game, Olympia, Wash. 18 pp.

STUART, C.T. 1981. Notes on the mammalian carnivores of the Cape Province, South Africa. Bontebok 1 :1 - 58.

SUNQUIST, M. 1981. The social organization of tigers (Panthera tigris) in Royal Chitawan National Park, Nepal. Smithsonian Contrib. Zool. 336 : 1 - 98.

SUNQUIST, M.E. & SUNQUIST, FIONA.C. 1989. Ecological constraints on predation by large felids. In : Carnivore behaviour, ecology and evolution. Ed Gittleman, J.L. Cornell University Press, Ithaca, New York. pp 283 - 301.

TURNBULL-KEMP, P. 1967. The leopard. Howard Timmins, Cape Town.

VAN AARDE, R.J. & SKINNER, J.D. 1986. Pattern of space use by relocated servals Felis serval. Afr. J. Ecol. 24 : 97 - 101.

WARD, R.M.P. & KREBS, C.J. 1985. Behavioural responses of lynx to declining snowshoe hare abundance. Can. J. Zool. 63 : 2817 - 2824.

WEATHER BUREAU. 1986. Climate of South Africa. Government Printer, Pretoria.

WEIGEL, I. 1975. Big felids and cheetah. In : Grzimek's Animal Life Encyclopedia. Ed Grzimek, B. Nostrand & Rheinhold Company, London. Vol 12 : 335 - 344.

WEISE, T.F., ROBINSON, W.L., HOOK, R.A. & MECH, L.D. 1975. An experimental translocation of the eastern timber wolf. Audubon Conserv. Rep. 5. pp28.

WELLINGTON, J.H. 1955. Southern Africa, Vol 1, University Press, Cambridge.

WHITEHOUSE, S. & STEVEN, D. 1977. A technique for aerial radio-tracking. J. Wildl. Mgmt 41 : 771 - 775.