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Abstract: Cheetah were relocated to the Suikerbosrand Nature Reserve between 1975 and 1976. A rapid increase in cheetah numbers with simultaneous declines in certain ungulate species warranted intensive management-oriented research. Social grouping, population dynamics and prey selection of cheetahs are briefly discussed. Home ranges are shown to overlap considerably, although an effective spacing system is in operation. Home range size appears to depend largely upon social dominance and possibly territoriality.

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THE ECOLOGY OF THE CHEETAH (ACINONYX JUBATUS) ON THE SUIKERBOSRAND NATURE RESERVE

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INTRODUCTION

The cheetah is listed as an Endangered Species in Southern Africa (Skinner et al,1977). Myers (1974 and 1976) states that Africa supports as few as 10 000 cheetahs which could again be halved by 1980. Conversely, Joubert and Mostert (1975) feel that cheetahs have increased on farmland in Namibia, possibly due to the reduction in lions, spotted hyaena and Cape hunting dogs and the consequent increase in kudu populations. A similar trend appears to be the case in the Northern Transvaal. Either way, there is considerable public concern for the future survival of cheetahs in South Africa. The ever increasing encroachment placed upon their natural habitat by agricultural demands justifies further concern.

The Suikerbosrand Nature Reserve offered the opportunity of using cheetahs in the biological control of excess small to medium sized game, in particular blesbuck which were annually cropped in fair nambers. Between August 1975 and October 1976 eight adult cheetahs comprising five males and three females were trapped in live-stock farming areas and relocated to this reserve. Within two years the cheetah population had risen to an estimated 24(Cohen et al, 1978) with a simultaneous dramatic drop in the blesbuck and springbuck numbers. An intensive research programme on relocated cheetahs was immediately launched with the major objectives of studying the predator-prey relationships, population dynamics, movements and social structure of relocated cheetahs.

This paper reports on certain aspects of the ecology of the cheetahs on the Suikerbosrand Nature Reserve with particular emphasis on home range and movements.

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STUDY AREA

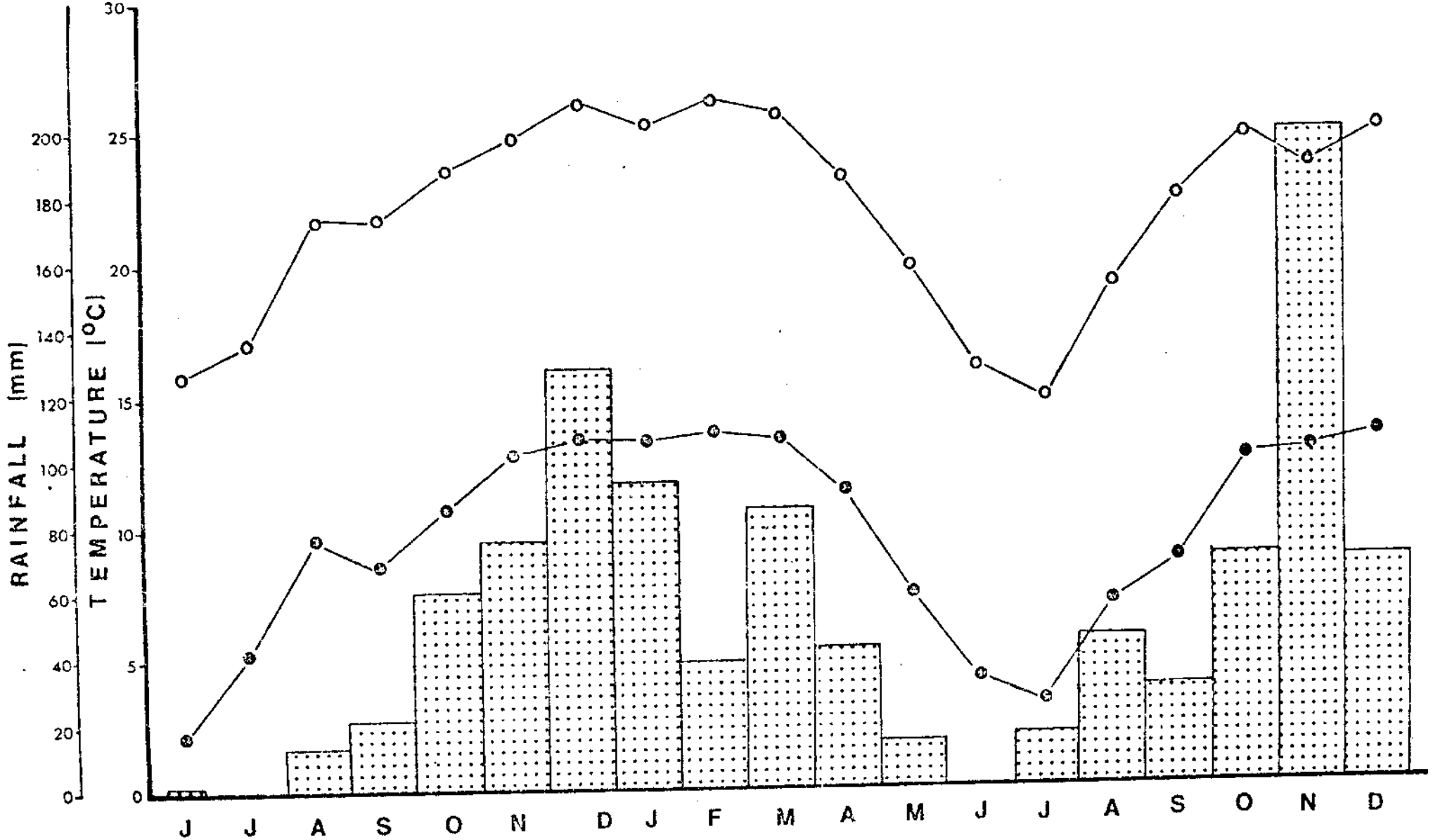
The Suikerbosrand Nature Reserve is situated approximately 40 km. south of Johannesburg in the south-central Transvaal (26° 27' - 26° 34' S, 28° 09' - 28° 21' E). The reserve, comprising somewhat 13 400 ha., falls within Acocks' (1953) Bankenveld, characterized by predominantly open grassveld with dense thickets in some of the rivines. Bredenkamp and Theron (1976) classified the grasslands into 13 communities. These grassland communities are greatly affected by the diversity of the topography (the altitudes range from 1525m to 1916m).

The reserve is bisected by an east-west ridge. Two geological formations, namely the Ventersdorp System in the central and western regions and the older Witwatersrand System in the east, comprise the Reserve. The latter System has undergone considerable faulting, folding and erosion (du Toit,1954) and is relatively game-free due to the sour vegetation on the quartzite soils.

The reserve falls within the summer rainfall region. Winters are cold and harsh with icy mountain winds, summers are temporate with frequent thunder, lightening and hail storms. Annual rainfall varies between 650mm - 730mm, the majority falling between October and March(Fig. 1). Monthly mean minimum temperatures are normally below 5°C during winter whereas the mean monthly maximum temparatures seldom exceed 27°C during summer (Fig. 1).

Suikerbosrand supports 12 ungulate species of which blesbuck (Damaliscus dorcas phillipsi) and springbuck (Antidorcas marsupialis) are the most important prey species of the cheetahs. Brown hyaenas (Hyaena brunnea) and black-backed jackals (Canis mesomelas) are the most important carnivores other than the cheetah which is the terminal

FIGURE 1: The monthly rainfall and mean monthly maximum and minimum temperatures for Jan Smuts Airport, 40 km north of the Suikerbosrand Nature Reserve for June 1978 to December 1979. (Data from Weather Bereau Department of Transport, Pretoria).



METHODS AND MATERIAL

Cheetahs were live-trapped on the Suikerbosrand Reserve using the method developed by A.T. Scholtz(Transvaal Division of Nature Conservation: unpublished). The cheetahs were radio-marked with transmitters designed by the Department of Electronic Engineering, University of Pretoria, on frequencies ranging from 148,359 MHz to 148,625 MHz. AVMLA12 recievers with sweep option and hand-held four element directional yagi antennae were used in locating the marked cheetahs. A vehicle-mounted omni-directional whip antenna (ASPS 17-7) was frequently used in the initial search for an individual.

A set of ortho-aerial photographs on a 1:10 000 scale of the reserve was provided with permanent 1km^2 grids which were further subdivided into 1 ha. grids (100mx100m). Each grid was identified by three numerals on both the x and y axes. In order to fix the the locality of radio-marked cheetahs two sets of reading were taken from two positions using the directional yagi antennae. From each position compass readings were taken in the direction from which the signal was the strongest(peak) and to the left and right of the signal at the precise point where the signal becomes inaudible using earphones and the reciever set at the lowest clearly audible gain. The angle so formed by the latter two readings was divided by two and the angle formed by this line and the peak line again divided by two give a finaldirection. A Casio fx 202P digital calculator was programmed to calculate the position of the radio-marked animal by entering the co-ordinates of the locality of the observers and the three compass readings taken at each locality. A magnetic deviation of 18,6° was subtracted automatically from each reading.

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Inaccuracies in plotting radio-marked animals are increased the greater the transmitter reciever distance (Heezen and Tester,1967) and the smaller the angles between reading localities and the transmitter (Tester,1971). Plots with angles less than 10° were rejected and readings were taken as close to the animal as feasibly possible without causing any disturbance.

A further problem on Suikerbosrand is caused by the reflection of signals oof the mountaincus terrain. In 50 trial plots where the cheetahs were flushed after the readings had been taken, it was found that all plots except two fell within 100m x 100m of true location, the remaining two plots being 200m out of true location. Both these plots were taken from distances over 4 km. from the animal.

Where possible daily plots were taken on all radio-marked cheetahs. One selected cheetah was periodically continuously tracked at a time and all data relevant to the ecology of the cheetahs recorded. Behavioural aspects and habitat descriptions were recorded onto micro-cassette.

For the purpose of this paper, home range was based on the minimum area method (Stickle,1954) and high utilization areas calculated by plotting the geographical position of the daily diurnal resting sites of all the study animals and by progressively excluding successive observations that contributed the most to the total home range size, until a difinite core area remained which consisted of observations that were closely situated to each other. These calculations were conducted using a Fortran programme on a Burroughs B 6700 digital computer as used by Ferguson(1980). The initial plotting of the localities of each cheetah was performed using a Versatec Plotter coupled to a Cyber 174 digital compute.

STUDY ANIMALS

The first cheetah was radio-marked on 4 July 1978 on the Suikerbosrand Nature Reserve. The animal was an approximately 18 month old female (Purdey) originating from a group of four - the other three were relocated to the Eastern Shores Nature Reserve in Natal. On 26 July 1978 an adult female (Mary) with four 3 month old cubs was radio-marked, followed by an adult female singleton (Rosina) on 18 September 1978. On 23 September 1978 two adult males (Kojak and Seizure) were marked bringing the total to three females and two males. All these animals are still under study.

All the study animals were immobilized using ketamine hydrochloride mixed 250mg/ml at the dosage rate of 12mg/kg. 0,5 ml. 4% Rompun (thiazine hydrochloride:Bayer) was added to each dose.

RESULTS

Social Structure

Throughout the study period the radio-marked females were either singletons or accompanied by their cubs. Their only physical encounter with other cheetahs on the reserva was during mating with one of the two radio-marked males. These males were only seperated from each other during mating encounters, which seldom lasted longer than two days. Seizure mated with Purdey and Rosina whilst it would appear that Kojak mated with Mary. All sightings of unmarked cheetahs on the reserve were also of singletons or females accompanied by cubs. Mixed groups were not encountered.

Population Dynamics

The total cheetah population on Suikerbosrand was estimated at between 29 and 31 in December 1979 (Pettifer et al, 1979). Since that report, Mary has produced six cubs. Her cubs from her previous litter were relocated to the Eastern Transvaal. A further 14 cheetahs have been relocated to Nature Reserves in the Cape Province, Natal and Eastern Transvaal between July 1978 and December 1979.

From July 1978 to date eight litters totallying 33 cubs have been captured and marked. The sex ratio of cubs was 13 males: 20 females, with a mean litter size of 4,13 (range 3 - 6). Mortality of cubs is low with only five losses among the 33 marked cubs (15,15%).

Home Ranges of Radio-Marked Cheetahs

Home range is defined as the area habitually traversed by an individual in its normal activities within a specific period of time (Brown,1966). Burt 1943) excluded random excursion trips out of the normal home range, but

cheetahs the definition described by Koeppl et Al. (1975) was applied whereby only one-time excursion trips were considerably beyond the normal home range were ommitted. Accordingly by calculating the 95% home range area, it was found that a more realistic pattern of home ranges on Suikerbosrand was achieved.

The home ranges of the cheetahs on Suikerbosrand as described in this paper were calculated on the localities of diurnal resting sites. This method shows little difference over a long period of time to continuous half-hourly plots over a shorter period (Pettifer,in prep).

By the calculation of the 50% home range, the uniformity of home range use or the converse can be readily determined. The sizes of the 50% and 95% home ranges of the study animals are given in Table 1.

Figure 2 shows the plotted localities of Purdey as well as her 95% and 50% home range. When the 50% home-range area is dubbled, no significant difference from the 95% home range size is evident (χ^2=0,01,p=0,05),thus indicating no significant preference for any given area. From the locality plots, however, it would appear that Purdey spent much time in the sour eastern sections of the reserve. This can be ascribed to the considerable time she spent in this area during whelping of her cubs in early June 1979. Throughout June she remained in this area, but on two occasions was observed as far as 7 km. away from her cubs. Whilst a singleton, Purdey appeared to roam ad.lib. throughout her home range and was noted to have traversed large sections of the reserve in a single day. The joined plots indicate consecutive days. The greatest straight-line distance between consecutive diurnal resting sites was 8,7 km.

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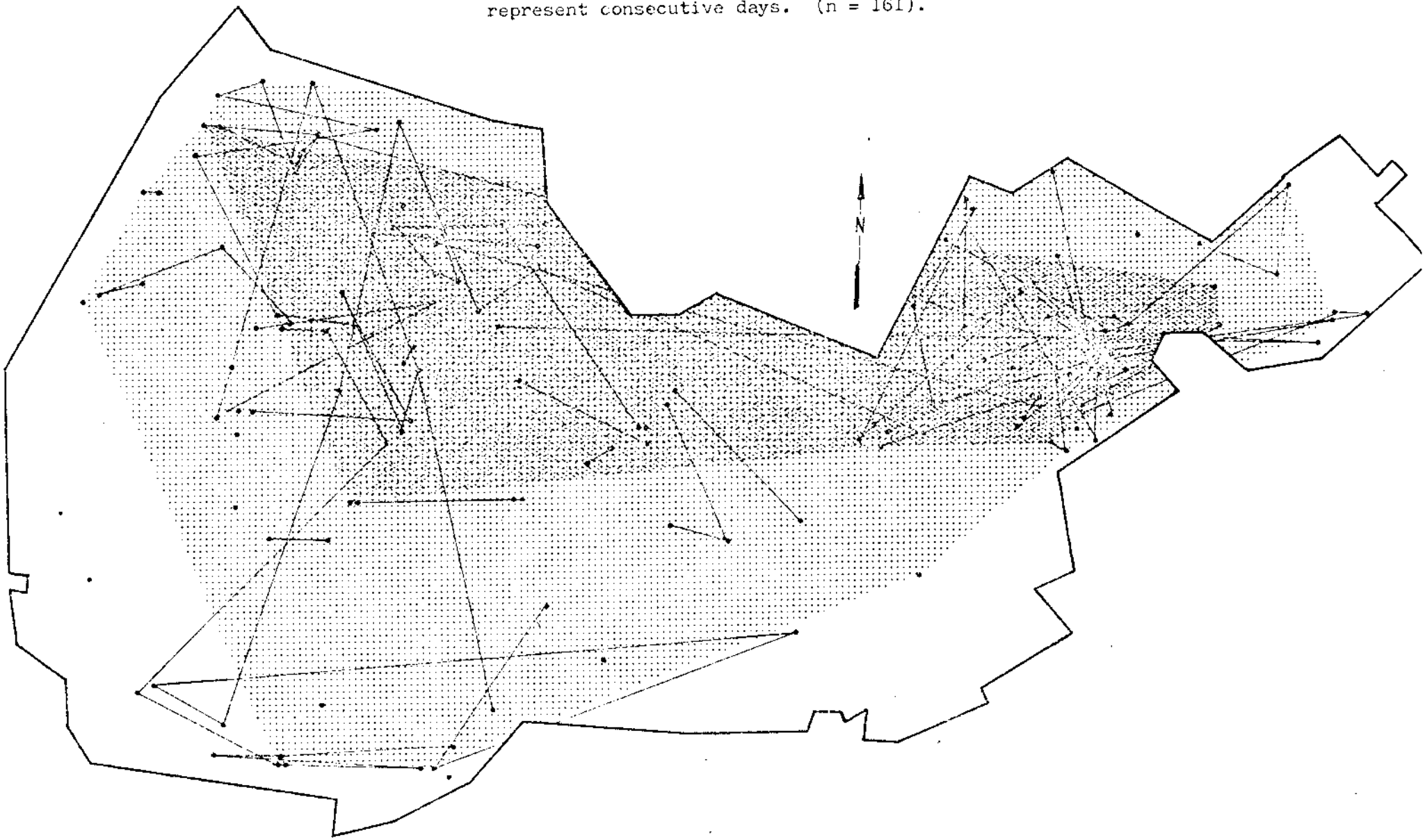
TABLE 1 The number of radio-telemetry fixes on daily diurnal resting sites and sizes of the 50% and 95% home ranges of the radio-marked cheetah on the Suikerbosrand Nature Reserve (All data up to the end of December 1979)

INDIVIDUAL	DATE MARKED	NUMBER OF DAYS PLOTTED	SIZE OF 95% HOME RANGE (km^2)	SIZE OF 50% HOME RANGE (km^2)
PURDEY	78-07-04	161	85,9	34,6
MARY	78-07-26	167	69,5	14,4
ROSINA	78-10-18	123	74,3	30,1
KOJAK & SEIZURE	78-10-23	151	48,8	7,7

FIGURE 2: Daily radio-telemetry fixes on the diurnal resting sites of Purdey on the Suikerbosrand Nature Reserve. The dark shaded area represents her 50 % home range and the lighter shaded area the 95 % home range. Joined plots represent consecutive days. (n = 161).



Mary (Figure 3) had a somewhat smaller home range than Purdey or Rosina. Her 50% home range is significantly less than half the 95% home-range (χ^2=23,83,p=0,05), indicating a definite area of preference. Mary was accompanied by four cubs when marked. These cubs broke ties with her during September 1979. She produced six cubs during December 1979. Notable was the fact that she whelped these cubs in the preferred area and with both litters remained reasonably constantly within this area. She did, however undertake several excursion trips, which differed from those of the males in that they normally stretched over several days, with the exception of those to the east of the reserve. These excursion trips have greatly influenced the determination of her home range. Although Mary had a more predictable home range, and distances between consecutive diurnal resting sites were normally short, she did on occasion move considerable distances in a single day - the greatest straight line distance being 12,5 km. Rosina (Figure 4) showed a similar uniform utlization of her 95% home-range to Purdey (2 x 50% home-range not significantly different from 95% home-range, χ^2=3,30,p = 0,05). During February 1979 she gave birth to three cubs in the central-western section of the reserve. Once her cubs were mobile, she exhibited a more unpredictable pattern of movement and yet again moved large distances over short periods - the greatest straight line distance between diurnal resting sites being 13,8 km. Rosina undoubtely the most mobile of all the radio marked cheetah, was on one occasion followed for 26 km. in eight hours. Notable is the fact that Rosina spent very little time within Mary's preferred area.

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FIGURE 4: Daily radio-telemetry fixes on the diurnal resting sites of Rosina on the Suikerbosrand Nature Reserve. The dark shaded area represents her 50 % home range and the ligther shaded area the 95 % home range. Joined plots represent consecutive days. (n = 123).

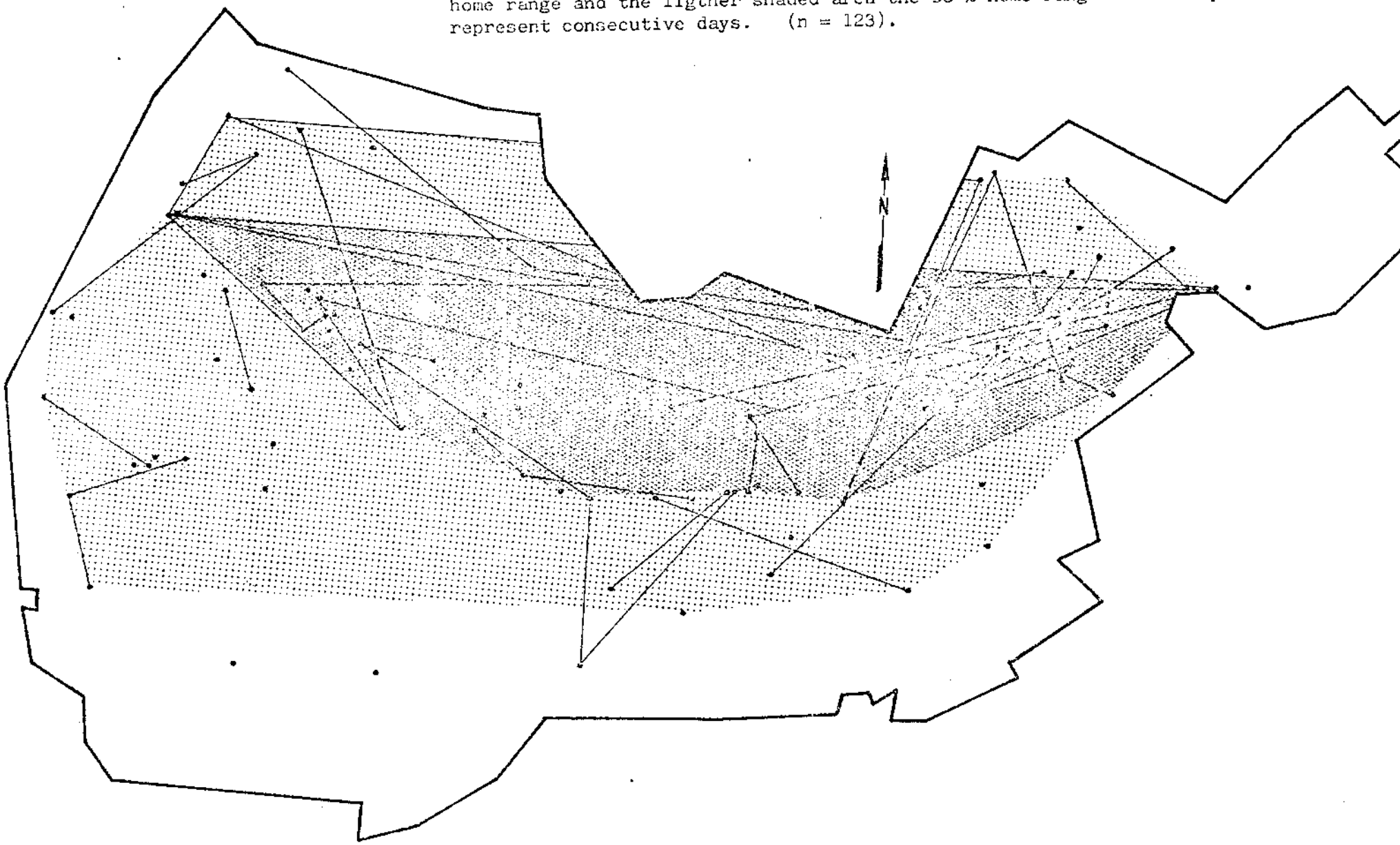
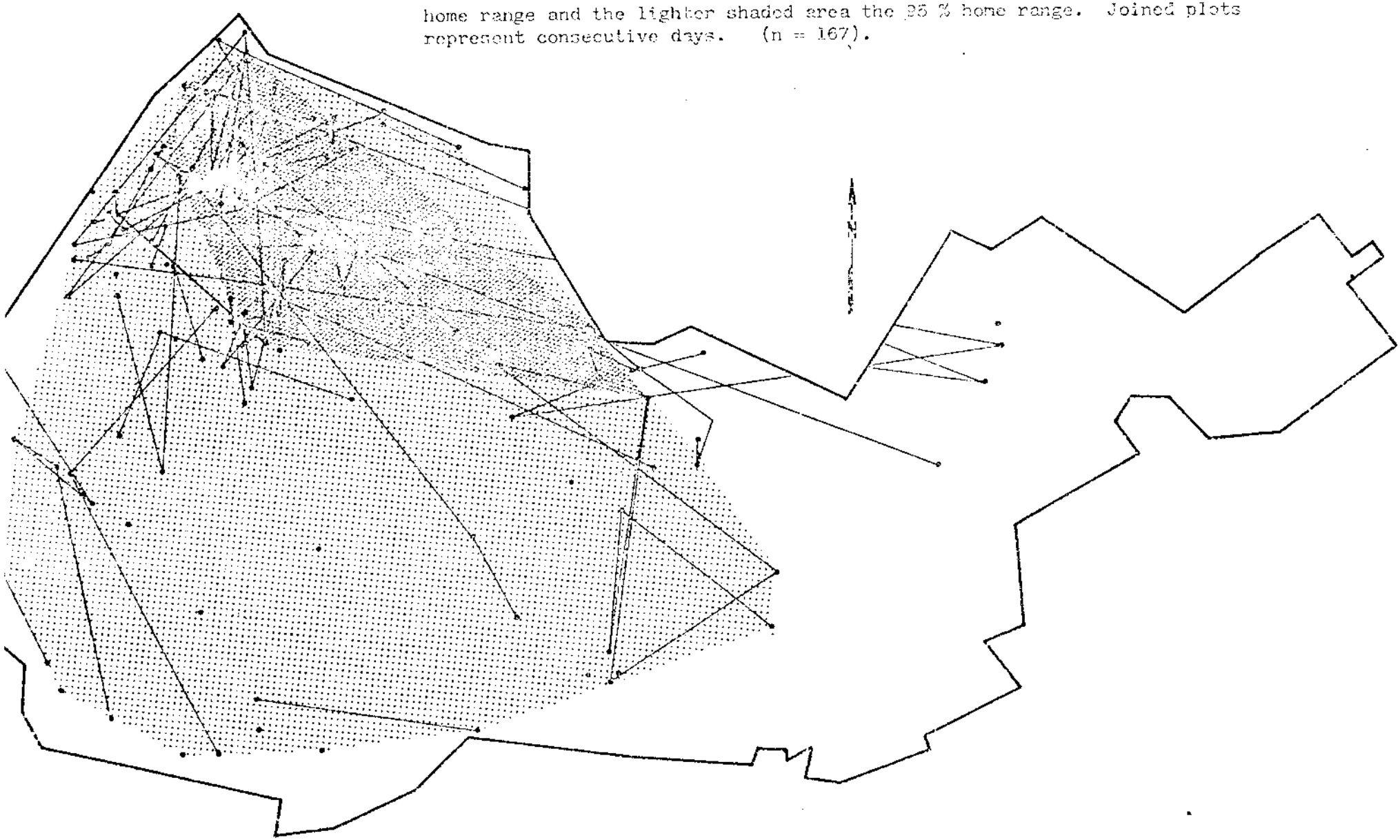


FIGURE 3: Daily radio-telemetry fixes on the diurnal resting sites of Mary on the Suikerbosrand Nature Reserve. The dark shaded area represents het 50 % home range and the lighter shaded area the 95 % home range. Joined plots represent consecutive days. (n = 167).



The males Kojak and Seizure showed a more predictable home range (Figure 5). Their 50% home range is significantly smaller than half the 95% home range ($\chi^2 = 22,86.p0,05$) suggesting a well defined preferred area. Several short duration trips occurred, often over reasonably large distances. They consistantly returned to their preferred the following day with the exception of a few excursions to the west of their preferred area (this area being included in the 60% home-range).

In all cases the radio-marked cheetah seldom returned to the identical spot even when they had spent considerable time within an area. No tree or bush could be identified as being a regular visiting site. The selection of sleeping or resting sites was opportunistis with the provision that the site offered a clear panoramic view of the surrounding area - normally situated on high ground.

Cheetah Movements in Relation to Prey Movements

The cheetahs on Suikerbosrand hunt predominantly within the shaded areas shown in Figure 6. These areas concur with the preferred habitats of blesbuck and springbuck on the reserve. Although the cheetah is commonly regarded as an animal of vast open plains, the contrary was observed at Suikerbosrand. The cheetahs tended to utilize the slopes and rivines and would very seldom venture out onto the plains. They did, however, frequently roam the smaller plateaux and open valley bottoms where, along with the slopes, the majority of kills were made.

On no occasion were cheetahs observed to follow prey herds for any length of time. The general trend was to make their kill, eat their fill, then vacate the area.

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FIGURE 5: Radio-telemetry fixes on the diurnal resting sites of Kojak and Seizure on the Suikerbosrand Nature Reserve. The dark shaded area represents their 50 % home range and the lighter shaded area the 95 % home range. Joined plots represent consecutive days. (n = 151).

FIGURE 6: The major hunting areas of cheetah on the Suikerbosrand Nature Reserve superimposed on the topographical map. (Contour intervals 60 m).

Predator - Prey Relationships

Blesbuck are the principal prey species of cheetahs on Suikerbosrand. Table 2 summarizes prey species deficits on the reserve between November 1978 and November 1979. This data was accrued by direct observations on cheetah kills as well as from carcasses recorded during regular line-sweeps conducted on the reserve. Although not all the deficits can be ascribed to cheetahs it can be safely postulated that the majority of them were cheetah kills. Of perticular intrest is the high proportion of blesbuck females and juveniles selected.

From regular helicopter cencusses on the reserve and the carefull monitoring of the blesbuck lambing season a total deficit of 266 blesbuck was recorded between September 1978 and August 1979, giving a total blesbuck mortality to cheetah ratio of 11,6 per annum (based on a cheetah population of 23 - Pettifer et al. 1979). With the cheetah population at approximately 30 (December 1979) the postulated blesbuck mortality for 1980 will be in excess of 348. This excludes all other prey species.

TABLE 2 Recorded cheetah kills and carcarces located in the field on the Suikerbosrand Nature Reserve between November 1978 and November 1979.

SPECIES	♂♂	♀♀	YEARLINGS	LAMBS	SEX/AGE NOT DETERMINED	TOTAL
BLESBUCK Damiliscus dorcas phillipsi	11	49	33	11	24	128
SPRINGBUCK Antidorcas marsupialis	13	2	2	2	1	20
DUIKER Sylvicapra grimmia	6	4	2		3	15
GREY RHEBUCK Pelea capreolus	6				3	9
MOUNTAIN REEDBUCK Redunca fulvorufula	4					4
ORIBI Ourebia ourebi	4	1				5
STEENBUCK Raphicerus campestris	1				1	2
UNIDENTIFIED *						32
						215

*Comprises predominantly of the females of oribi, steenbuck, mountain reedbuck and grey rhebuck

DISCUSSION AND CONCLUSIONS

Social Structure

Eaton (1970a,1970b,1974) reported adult groups consisting of both sexes in cheetahs in the Nairobi National Park. Wrogemann (1975 states, however, that Mc Laughlin's study on cheetahs in the same park showed no mixed adult groups. Graham and Parker (1965) recorded mixed adult groups from a questionnaire survey. Schaller (1972) reported a similar social structure for the Serengeti as that at Suikerbosrand with adult singletons, small all-male groups and females accompanies by cubs and no mixed adult groups. He maintains that the all-male groups consist of litter-mates, a point we have not been able to verify due to the short study period, although this does appear to be the case.

A possible explanation to Eaton's (op cit) findings is that the mixed groups he studied were litter-mates recently seperated from their mother. The only litter to have broken ties with their mother on Suikerbosrand during the study period was Mary's, this having taken place when the cubs were approximately 16,5 months old. The litter-mates stayed together for three months before being trapped and relocated to the Eastern Transvaal. With three litters presently being studied, it is hoped that the period in which litter-mates remain together can be recorded.

Questionnaire surveys are unreliable at the best of times, and since it often takes an experienced observer to distinguish the mother from a litter over 12 months of age, or to distinguish litters recently having left the mother, it can be concluded that mixed groups are only of a temporary nature and normally consist of litter-mates.

Population Dynamics

The cheetah population density on the Suikerbosrand Nature Reserve at the end of December 1979 was 1/45 ha, this notwithstanding the removal of 16 cheetahs in the foregoing 18 months. This density is somewhat seven times higher than that reported for the Nairobi National Park (Graham and Parker, 1965). Myers (1975) and Eaton (1970a & 1974) stressed the high mortality

of cheetah cubs to predation by the larger predators, in particular the spotted hyaena. Since the cheetah is the terminal predator on Suikerbosrand, this hypothesis is further supported by the low mortality rate of cubs at Suikerbosrand.

Data on sex of wild cheetahs are scanty. Schaller (1972) did, however, report a sex ratio in favour of females, as did Wrogemann (1975) in her summary of the literature. A point worth mentioning is that the sex ratio of cubs on Suikerbosrand appears to be moving towards equality, since the ratio of 1:2,5(6:15) in favour of females in 1979 (Pettifer et al 1979) has narrowed to 1:1,5(13:20) at present. These discrepancies in sex ratio can propably be attributed to the small sample size.

Home Range in the Cheetah

In the cheetah at Suikerbosrand, a clearly defined home range is not evident since the outside plots are situated far from each other, a trend one would expect from a predator that has to roam large areas in search of prey. A similar finding was described by Ferguson (1980) for the black-backed jackal.

There is considerable overlap in the home ranges of all the radio collared cheetahs on Suikerbosrand - in fact the home ranges of Purdey and Rosina are very similar in shape, size and location. Mary, in the other hand, has shown a distinct preferred area. Initially it was thought that this preference was due to her being accompanied by cubs while the other two females were singletons, and that there appeared to be a system of respect and right-of-way to a female with cubs. From the time all the radio-collared females were accompanied by cubs, it was found that both Purdey and Rosina continued to give Mary the right-of-way, possibly indicating Mary to be the dominant female since the preferred area always carries a high density of potential prey species.

Eaton (1970a, 1974) advocates a "time plan" territorial system in cheetahs, whereby scent marking is used to warn conspecifics. He does mention, however, that urination in females is soley excretory, except when they are in estrous. A captive adult female used for behavioural studies persistently urine - marked on conspicious objects within her campt and defecates only on specific spots. Schaller (1967) also found tigers and lions to urine-mark.

In the present study males have been noted to mark in three ways - by retorgrade spray urination of conspicious objects, by defecating on conspicious objects or mounds and by scratching trees. Antagonistic behaviour of cheetah males was recorded by Stevenson Hamilton (1974), in both cases culminating in the death of one animal. In a recent study on captive-bred cheetah released into the wild, a fight developed between a resident group of male cheetah and the study animals, with one of the animals seriously injured (Pettifer, 1980). Strange cheetah, both males and females not on heat, placed into a camp with other cheetahs at the De Wildt Cheetah Breeding Station, Pretoria, will culminate in intensive fighting (David Meltzer, pers. com..). Since aggressive behaviour in cheetah in the wild appears to be rare, it can be concluded that an effective spacing system is in operation, probably controlled by scent marking. This is further supported when considering the amount of time cheetah have been noted to semll around marked bushes, trees or defecate.

Territoriality as defined by Noble (1939) as any defended area against conspecifics cannot be discounted - particularly if scent - marking is regarded as a form of defence or territorial adverticement. What deserves verification is wheterh cheetahs defend a specific area or the immediate proximity in which they encounter other cheethas and what and when is aggressive behaviour elicited.

Predator - Prey Relationships

Blesbuck are the most abundant ungulate on Suikerbosrand and are encounted in large herds of over 500 and small herds of less than 20. Cheetahs show a high preference for hunting from the smaller herds (Pettifer et al, 1979), a similar observation being made by Eaton (1970b) in the Nairobi National Park.

Of importance is the high proportion of blesbuck females and juveniles taken at Suikerbosrand. Sex and age ratios of prey in the literature vary considerably, for example Schaller (1968) found that 54 % of Thompson's gazelle killed by cheetahs were subadult and that there appeared to be no selection for sex in the adult class, whereas Kruuk and Turner (1967) found a preference for adult females in the same species.

Likewise, prey species selection appears to vary, for example Pienaar (1969) found reedbuck to be an important prey species in the Kruger National Park, while Mitchell et al (1965) found reedbuck not to be important at Kafue National Park, Zambia, even though they were more abundant there.

Kruuk and Turner (1967) postulate that selection for female prey could be due to females fleeing first and thus stimulating the cheetahs to give chase. Eaton (1972) showed esperimentally that the flight of prey releases attack in cheetahs.

Eaton (1970b) also states that there appears to be a differential selection for females and juveniles. On Suikerbosrand the selection for females and juveniles could be due to the size catagory of the prey. Adult male blesbuck weigh over 80 kg. Blesbuck are not fleety animals and individual selection is thus made easier.

Implications of cheetahs on the Suikerbosrand Nature Reserve

The reproductive success of cheetahs on Suikerbosrand has already led to the relocation of 16 cheetahs. A simultaneous phenominal breeding success of cheetahs in captivity has been achieved at the De Wildt Cheetah Breeding Station near Pretoria. The advantage of the Suikerbosrand cheetahs is, however, the fact that they are born and reared in the wild and are thus easily relocated to natural areas, although it has also been established that captive - bred cheetahs may adapt to the wild (Pettifer, 1980).

The success of cheetahs on Suikerbosrand is not without it's repercussions. With the rapid increase of cheetahs, a drastic reduction in certain prey species, particularly blesbuck and springbuck, has followed. In the absence of other large predators, limiting factors which could operate on the cheetahs on Suikerbosrand at present are depletion of food resources, disease and social intolerance. At present none of these factores appear to have any signigicant influence.

Suikerbosrand, being situated close to Johannesburg, is an important outdoor recreation centre with game-viewing as an integral facet. To allow the cheetah population to stabilize by depletion of it's own food supply can thus not be considered. The cheetah population will therefore always have to be managed.

One of the major questions that now arises is to what level should the cheetah population be managed? To establish a safe cheetah to prey ratio is complicated by the obvious selection of cheetahs on this reserve for female blesbuck. Furthermore experience has shown that the trapping of cheethas is both expensive and time-consuming with it's own limitations in that certain individuals are repeatedly captured whereas others actively avoid the traps.

At present the blesbuck population is being augmented by excess stock from other reserves. This will probably have to be continued until such time as the blesbuck reach numbers whereby their increment will greatly surpass the predation rate to allow for the cropping of excess rams to balance out the sex ratio.

The research at Suikerbosrand is being continued in order to find a practical management policy.

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