THE ECOLOGY OF ELAND (*TAUROTRAGUS ORYX*) IN THE WESTERN TRANSVAAL HIGHVELD

by

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ABSTRACT

The present study was conducted on the S.A. Lombard Nature Reserve to investigate the ecology of eland on the western Transvaal Highveld. Two adaptations were evident in eland in this environment. During the rainy season when the nutrient quality of grass was high they acted like typical grazers by forming large herds and feeding mainly on grass, but during the dry winter when grasses lignified the eland changed their diet to browse and formed small social groups like typical browsers. Most females gave birth early in the wet season and a high calving rate and survival was experienced. Experiments conducted on two captive eland yielded good correlations between feed and water intake and between feed intake and faecal output. Despite large differences in body fat between the two experimental animals the combined body water/fat fraction was very similar in both eland, as well as the contents of the digestive tracts expressed as percentages of the live weights.

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CHAPTER 1

INTRODUCTION

The eland is the largest African antelope of the tribe Tragelaphini (spiral-horned antelopes). Two species are recognised, the common eland *Taurotragus oryx* (Pallas 1766) which occurs throughout the southern, central and east African savanna and woodland and the giant eland *T. derbianus* (Gray 1847) which occurs discontinuously in Senegal (in fairly dense Guinean woodland) and with remnant populations in Cameroon, Chad, Zaire and Sudan (Ansell 1971).

Ansell (1971) described three subspecies of the common eland of which *T. oryx oryx* occurs in southern Africa and was the subject of the present study.

Eland utilise a wide variety of environments and the only southern African habitat in which they have never been recorded is the western part of South West Africa/Namibia which has an average annual rainfall of less than 300 mm (Smithers 1983).

In the warmer bushveld areas males attain a mass of up to 840 kg but in the western Transvaal eland do not attain this size reaching a mass of about 500 kg (von La Chevallerie, Erasmus, Skinner & Van Zyl 1971). This difference in size could be ascribed largely to lower winter nutritive quality of the veld, although genetic factors could also possibly have an influence.

Little information is available on the giant eland, but the common eland has been the subject of many studies investigating the possibility of domestication (e.g. Posselt 1963, Treus and

Kravchencko 1968, Stainthorpe 1972, King, Heath & Hill 1977, Lightfoot 1977). Characteristics which attracted attention to eland were the size of the animal, its high reproductive rate, its apparent independence of free drinking water and the ease with which it could be tamed (Posselt 1963, Skinner 1972).

In studies on captive eland information was gained on thermoregulation (Taylor & Lyman 1967, Taylor 1970, Finch 1972), water metabolism (Taylor & Lyman 1967, Taylor 1968 & 1969, MacFarlane, Howard, Maloyi & Hopcraft 1972, King, Kingaby, Colvin & Heath 1975, King, Nyamora, Stanley-Price & Heath 1978, King 1979), energy utilisation (Rogerson 1968), growth (Stainthorpe 1972, Carles, King & Heath 1981, Jeffery & Hanks 1981), age determination by dentitional changes (Kerr & Roth 1970, Atwell & Jeffery 1981, Jeffery & Hanks 1981b), reproduction (Posselt 1963, Skinner & Van Zyl 1969, Skinner, Van Heerden & Van Zyl 1971, Treus & Lobanov 1971, Roth, Kerr & Posselt 1972, Stainthorpe 1972, Skinner, Van Zyl & Oates 1974, Jeffery 1979), feeding habits (Kerr, Wilson & Roth 1970, Nge'the & Box 1976, Lightfoot & Posselt 1977), social organisation (Kiley-Worthington 1978), activity patterns (Lewis 1977 & 1978), milk yield (Treus & Kravchencko 1968) and meat production (Van Zyl 1962, Von La Chevallerie, Erasmus, Skinner & Van Zyl 1971).

Detailed studies on the ecology of wild populations have been conducted by Hillman (1979) and Scotcher (1982). The behaviour and social organisation of wild eland has been described by Underwood (1975).

Studies on the physiological condition of wild eland have been limited to the examination of dead animals. Jeffery (1978) determined the kidney fat and bone marrow fat indices of eland carcasses, but was only able to classify live eland as being in poor, medium or good condition. Von La Chevallerie *et al.* (1971) and Keep (1972) have given the carcass composition of six wild eland from the Highveld and six from the Natal Drakensberg respectively.

Much of this research has been reviewed by Skinner (1966, 1967, 1971 & 1972), Hillman (1979) and Scotcher (1982). From these studies it was concluded that the eland are inferior for meat production to cattle under normal farming conditions, but they could be valuable in hot, semi-arid regions less suitable to cattle. Hillman (1979) found that the following features made eland unsuitable for intensive utilisation by man: a high degree of mobility, low social cohesiveness and the species' natural existence at very low densities. Selection of animals to counteract the above mentioned features could well dissipate their physiological and behavioural advantages over cattle for production.

Despite the limitations of eland as farming stock they could be a valuable asset to many farms located in suitable environments if kept under as natural conditions as possible. However, a thorough knowledge of the basic ecology of eland living in particular regions is essential if maximum productivity is to be attained.

THE PURPOSE OF THIS STUDY

Many studies have been undertaken on captive eland, but the ecology of wild eland in South Africa has only been studied in detail in the Natal Drakensberg and the more moderate Loskop Dam environment. Although it has long been recognised that eland are well adapted to survive in the drier parts of our country, our knowledge of the ecology of eland in these regions is poor.

Game farming has recently become an important industry in South Africa, especially in the drier regions where cattle farming has suffered a severe setback by the low rainfall experienced during the past few years.

To be able to manage game for farming purposes it is essential to have a thorough knowledge of the basic biology of a species under natural conditions. Although eland occur in several reserves and private farms in the western Transvaal very little information is available on the ecology of the species in this region.

The purpose of the present study was to investigate the basic needs of the eland in the western Transvaal and the way in which they react to the limitations imposed upon them by the environment.

The S.A. Lombard Nature Reserve (SALNR) is one of the largest remaining examples of the Cymbopogon - Themeda grassland which once covered the region. Although the reserve is too small to allow the highly nomadic eland to take full advantage of their ability to make use of the patchily distributed rainfall in the region, the population has been well established and adapted to the prevailing circumstances and the SALNR was thus a natural choice for this investigation.

The objectives of the present study were to determine:

1. the utilisation of the habitat,
2. the feeding adaptations,
3. the social organisation and
4. the reproduction of eland in the western Transvaal environment.

CHAPTER 2

STUDY AREA

The S.A. Lombard Nature Reserve is situated about 16 km north-west of Bloemhof in the western Transvaal (25^{o} 30'E and 27^{o} 35'S) at an altitude of 1200 - 1600m (Fig 1). The reserve is about 3300ha in extent and consists of open grassland interspersed with small patches of thicket and is situated in the *Cymbopogon* - *Themeda* veldtype (Acocks 1975).

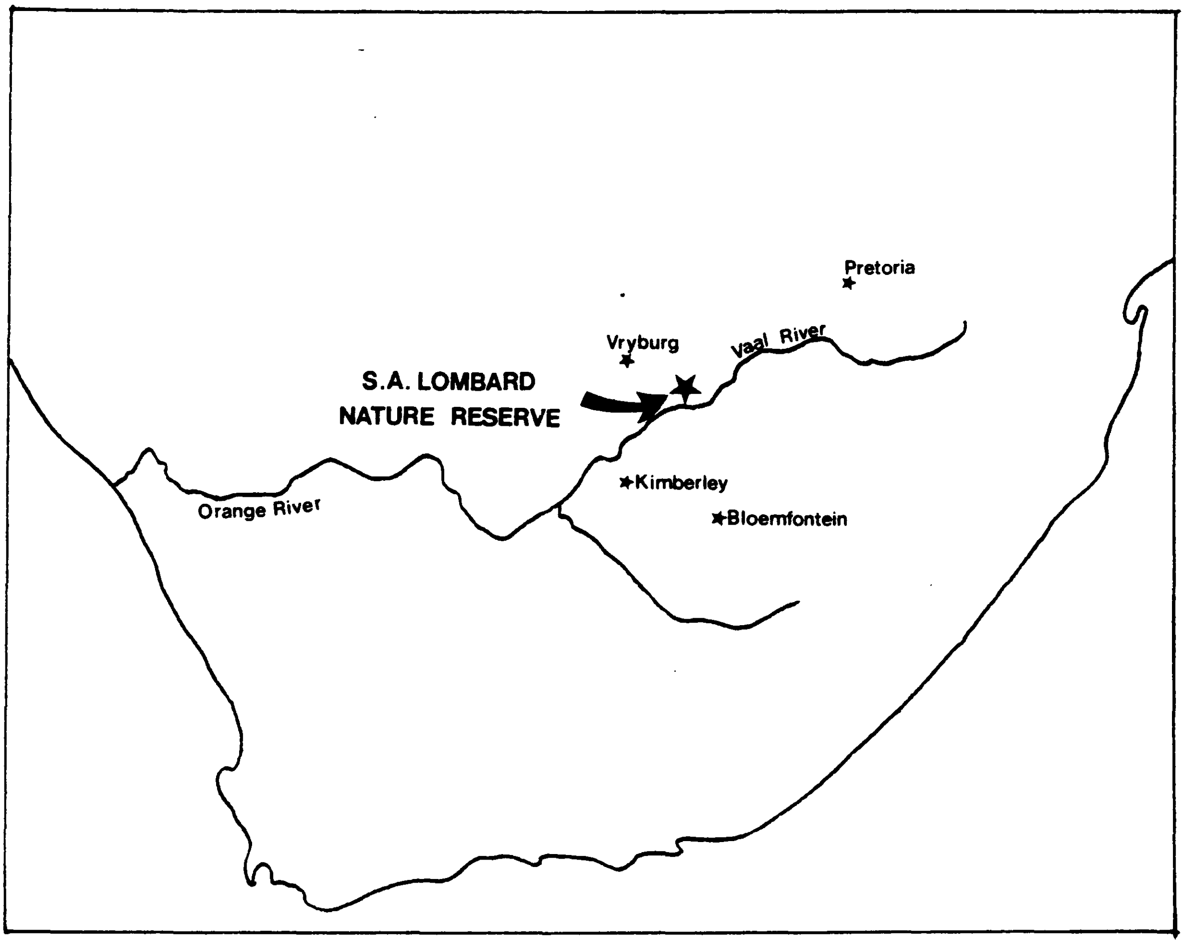


Figure 1 : The location of the S.A. Lombard Nature Reserve.

CLIMATE

The reserve has a mean annual rainfall of 460,44 mm (241,8 to 740,4 mm) which is mainly confined to the period November to April (Skinner, Van Zyl & Oates 1974). Temperatures range from a minimum of about -9° C at night in winter to a maximum 40° C on summer days.

The lowest recorded temperature during the present study was -7,0° C and the highest 38,5° C. The reserve received 408,7 mm of rain in 1984 and 405,37 mm in 1985. The average monthly temperatures and rainfall are shown in Figure 2.

GEOLOGY

The SALNR is located in the geological area classified as the Supergroup Ventersdorp (Transvaal Nature Conservation Report 1985). The largest part of the reserve consists of Glenrosa and Hutton soil types. Two other soil types, Mispah and Swartland, also occur on the reserve and pans cover 66 ha (2%) of the area. The largest pan, Grootpan, was dry and barren during the present study while Gemsbokpan and Voëlpan were covered with grass (Fig. 3).

The reserve is divided into a western and an eastern section by abandoned diamond diggings which run northwards from the reserve headquarters. The eastern section consists mainly of an alluvial plain which can be described as turfveld. The soil has a high clay content (De Korte 1986) and the plain is inundated to a depth of up to 5cm during heavy rains and carries flood waters down to the Vaal River (Van Zyl 1965).

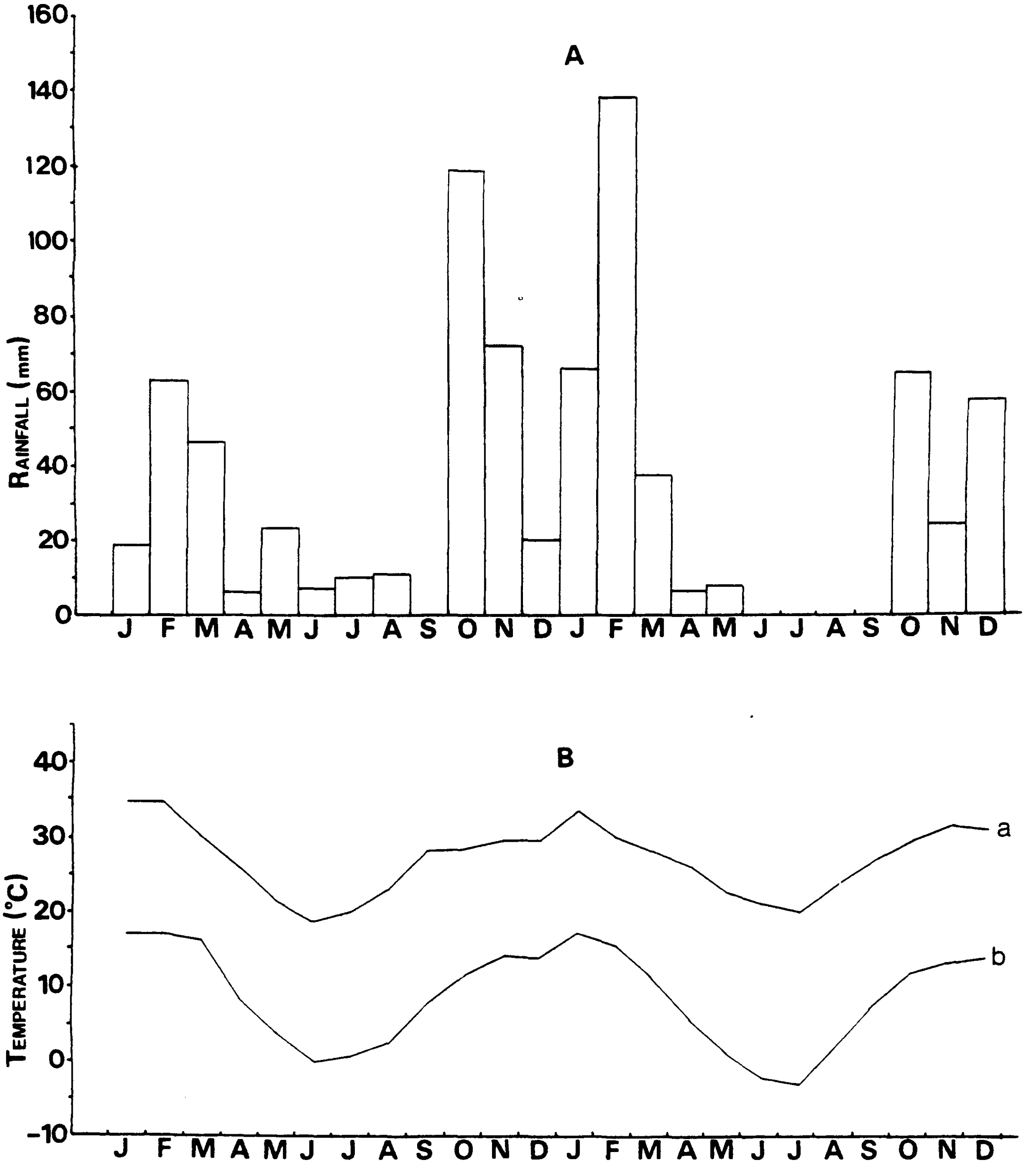
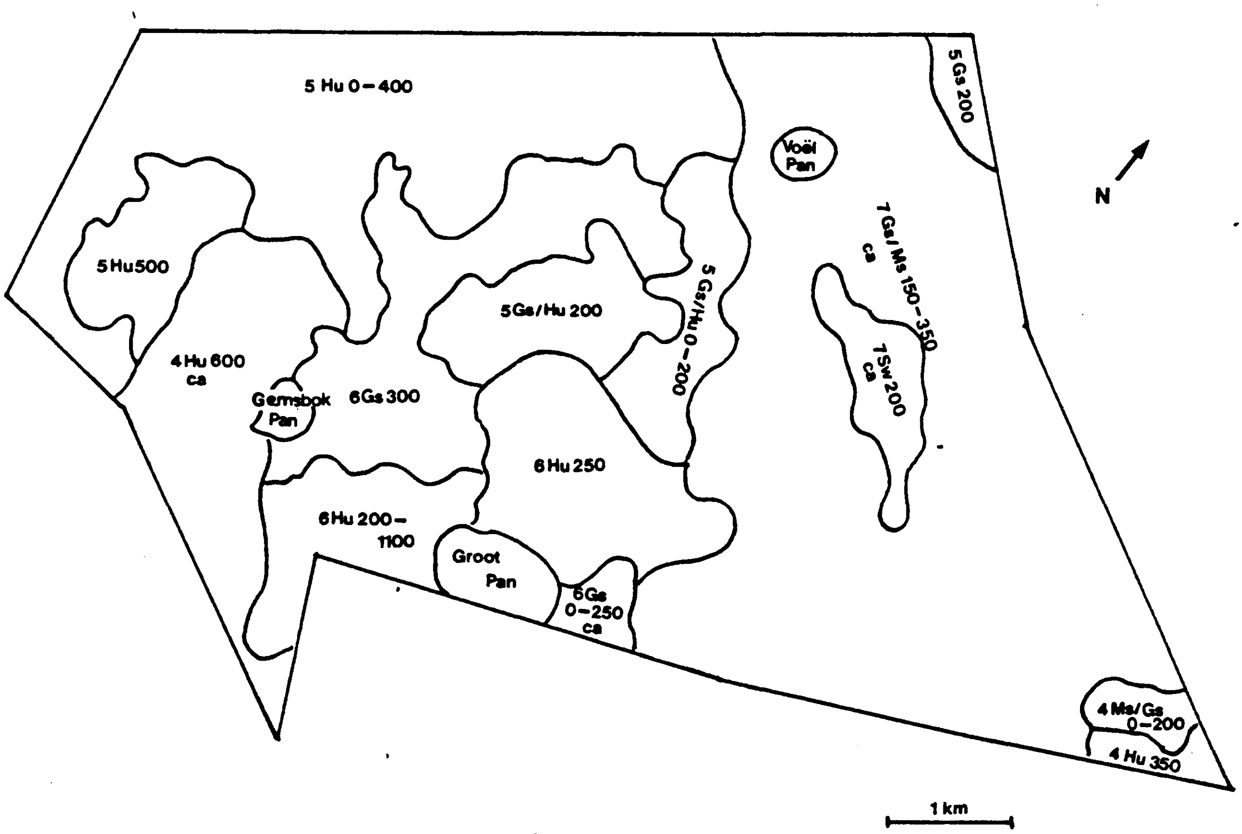


Figure 2A : Average monthly rainfall, and
2B : Average monthly maximum (a) and minimum (b) temperatures recorded during 1984 and 1985 on the SALNR.

The western section consists for a large part of old cultivated lands and is covered by red sand / loam soil of the Hutton type.

The soil depth of the reserve varies between zero and 1100 cm and overlies a white calcareous formation.

The old diamond diggings which were discontinued about 1920



7	Clay contents of soil
GS	Soil type
0-200	Effective depth in mm
ca	Calcarious substratum

Clay contents

1 : 0 - 5%
2 : 5 - 10%
3 : 10 - 15%
4 : 15 - 20%
5 : 20 - 25%

Soil types

GS : Glenrosa
HU : Hutton
MS : Mispah
SW : Swartland

Figure 3 : Soil types of the SALNR.

converted previously open grassland into numerous mounds of gravelly soil. This disturbance has provided a microhabitat in which trees have become established (Van Zyl 1965).

VEGETATION

Two hundred and thirty six plant species have been recorded on the SALNR (Van Zyl 1965) of which 195 (74%) were non-gramineous plants of 50 different families. One hundred and thirteen (43%) of the plant species were utilised by game but a mere 14 to 26 species provided the bulk of the food of any one antelope species (Van Zyl 1965).

The latest vegetation map of the SALNR (De Korte 1986) recognises nine veldtypes (Figure 4). This classification will be followed in the description of the grasslands, but the description of the wooded areas will be based on observations made during the present study.

VEGETATION TYPES.

1. *Eragrostis lehmanniana - Sporobolus fimbriatus* grassland: Occurs in the extreme eastern corner of the reserve and is dominated by the species after which it is named.

2. *Sporobolus* turfveld: Occurs in the north-eastern section on the alluvial plain. The area is characterized by a mosaic of short grass areas dominated by *S. ioclados* and long grass areas on slight elevations of the soil which are dominated by *Cymbopogon* - *Themeda* associations.

3. Old diamond diggings : The diggings in the northern corner

have been colonized by *Rhus lancea* (Thicket A). On the gravel mounds adjacent to the north-eastern edge of the reserve headquarters *R. lancea*, *Diospyros lycioides* and *Ziziphus mucronata* are common (Thicket B).

4. *Dry Cymbopogon - Themeda* grassland : Occurs in the western half of the reserve. *Aristida congesta barbicollis* and *Eragrostis lehmanniana* are also common. This veldtype is interpersed with pure stands of *Enneapogon scoparius* and clumps of bush. Old ploughed fields also occur within this veldtype.

5. *Rhus lancea - Grewia flava* scattered bush (Thickets C and D) : Occurs in the southern part of the reserve. Consists mainly of *G. flava* and *Diospyros lycioides* with scattered *Rhus lancea* trees. *Ziziphus mucronata*, *Tarchonanthus camphoratus* and *Maytenus heterophylla* also occur. The grasses are characteristic of Dry *Cymbopogon* - *Themeda* grassland.

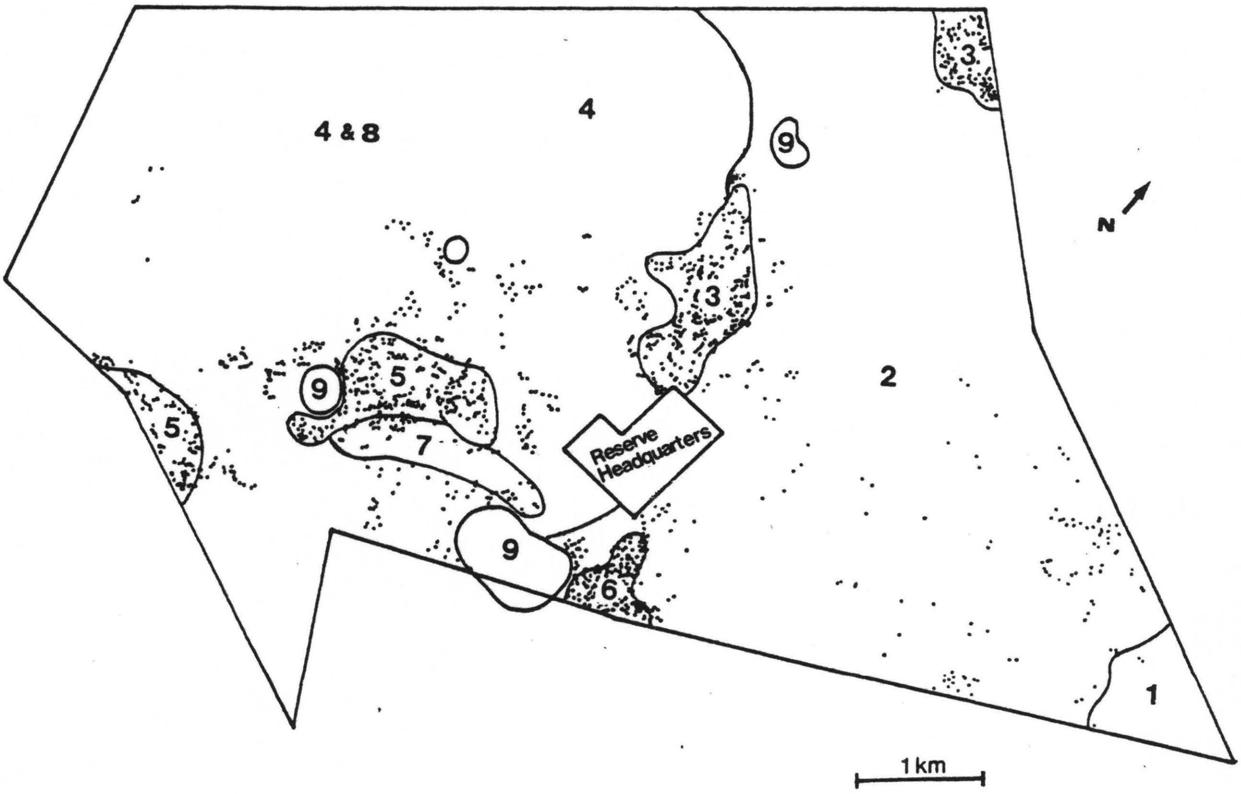
6. *Tarchonanthus - Diospyros* bush (Thicket E) : Occurs between the reserve headquarters and the southern fence of the reserve. A portion of this bush occurs on old diamond diggings. *D. lycioides*, *T. camphoratus* and *Grewia flava* dominate this area. *Acacia karroo*, *Ziziphus mucronata* and *Rhus lancea* are also common.

7. *Enneapogon scoparius* grassland : Occurs in a strip running in a south-westerly to north-easterly direction west of the large pan near the reserve headquarters and south of the *Rhus lancea* - *Grewia flava* scattered bush. This veld type varies from pure stands of *E. scoparius* to an ecotone type

of veld interspersed with other grass like Cymbopogon plurinodis, Sporobolus fimbriatus and Cynodon spp.

8. Old ploughed fields : Occur mainly in the south western part. Eragrostis lehmanniana and Aristida congesta barbicollis are common.

9. Pans : They only hold water after heavy rains. Gemsbokpan and Voëlpan were covered with grass during the present study but Grootpan never supported any cover during this time.



Veldtypes : 1) Eragrostis lehmanniana - Sporobolus fimbriatus grassland.
2) Sporobolus turfveld.
3) Old diamond diggings.
4) Dry Cymbopogon - Themeda grassland.
5) Rhus lancea - Grewia flava scattered bush.
6) Tarchonanthus - Diospyros bush.
7) Enneapogon scoparius grassland.
8) Old ploughed fields.
9) Pans.

Figure 4 : Vegetation of the SALNR.

LARGE MAMMALS

The following large mammal species were commonly seen on the reserve:

Eland	- *Taurotragus oryx*
Red hartebeest	- *Alcelaphus buselaphus*
Black wildebeest	- *Connochaetes gnou*
Blesbok	- *Damaliscus dorcas phillipsi*
Springbok	- *Antidorcas marsupialis*
Gemsbok	- *Oryx gazella*
Steenbok	- *Raphicerus campestris*
Common Duiker	- *Sylvicapra grimmia*
Burchell's Zebra	- *Equus burchelli*
Blackbacked jackal	- *Canis mesomelas*
Aardwolf	- *Proteles cristatus*

HISTORY

The SALNR was purchased by the Transvaal Provincial Administration as a farm for the breeding of mules during the Second World War (Van der Merwe 1955). After declaration of peace it fell into disuse and it was decided to dispose of the farm. The Executive Commitee reviewed its resolution, however, and the idea was born to convert the property into a game breeding farm where indigenous species of the western Transvaal could be reared for later distribution.

The request was granted on 10 February 1949 and the reserve was officially proclaimed on 8 September 1954. The name of the original farm, Panfontein, was changed to S.A. Lombard Nature Reserve after the then Provincial Secretary out of gratitude for what he had done for the Nature Conservation Section and Panfontein in particular.

In 1951 a hound depot was established on the reserve and research on vermin control was started. The game population consisted of a herd of springbok and some blesbok and steenbok when the decision was made to use Panfontein as a game breeding reserve. Eland and black wildebeest were introduced in 1949, red hartebeest in 1951, impala in 1950 and the first duiker in 1952. Gemsbok and zebra were also introduced later.

The eland were introduced for a domestication experiment and were still kraaled at night in 1960 (Van Zyl 1965).

The game was confined to the eastern half of the reserve during the earlier years (Meester 1955) and the rest of the reserve was used for agricultural purposes. The reserve was expanded through the years and is presently totally available to game with the exception of the living area and the hound depot which is separated from the rest of the reserve by a public road.

CHAPTER 3

FEEDING TRIALS, TRITIATED WATER AND BODY COMPOSITION

INTRODUCTION

Changes in the body fat contents of free-living ruminants are good indicators of the nutritional level of these animals during different seasons and environmental conditions. Bone marrow and kidney fat indices have been commonly used in the assessment of body condition (Brooks, Hanks & Ludbrook 1977) but have the disadvantage that animals have to be sacrificed.

The use of isotopes offers an alternative procedure which obviates the need to destroy animals and has successfully been applied in the prediction of the chemical composition of domestic and captive animals (e.g. Bird 1984, Torbit, Carpenter, Alldredge & Swift 1985)

To be able to calculate the energetic intake of free-living animals it is necessary to know the composition, chemical contents and digestibility of the diet as well as the amount of food ingested. The latter information is the most difficult to obtain and indirect methods have to be employed in the determination of the daily intake.

Two eland were available for the determination of body composition and some experiments were conducted before slaughter to examine the possibility of using certain techniques in the study of the food intake and body condition of the free-ranging eland on the reserve.

METHODS

Two of the free-ranging eland, an adult male and a two year old female, were immobilised and transported to the holding pens. At first they were separated by a 2,7m fence covered with plastic sheeting to prevent visual contact with each other, but this proved to be inadequate and they cleared the obstacle with ease.

The fence was removed and the animals were allowed to stay together for two weeks to settle down in captivity. After this period they were separated again and kept in cement-floored enclosures measuring 4 x 4m. These enclosures led to similar sized pens on the outside where the animals were moved while feed and water was replenished and faeces were collected twice daily.

The eland were fed whole lucerne for five days but due to selection of leafy parts which made the accurate determination of the composition of the diet impossible the feed was homogenised through hammermilling.

Two four - day feeding trials were undertaken. The eland were fed lucerne during the first and a 50 : 50 mixture of lucerne and mowed veldgrass during the second period. Feed intake was calculated by subtracting the mass of the feed left after each trial from the total amount fed.

Water intake was measured by filling the troughs to a marked level from a calibrated can which was marked at 250ml levels. Faeces was collected twice daily and the dry matter output was calculated by weighing the total wet output and then using a sample of ± 1kg to determine the water contents by dessication.

Chromogenic substances

The use of chromogenic substances (chromogens for short) for the determination of food intake was first described by Reid, Woodfolk, Richards, Kaufmann, Loosli, Turk, Miller & Blaser (1950) and a modified version was used by Fairall (1981). The method involves the measurement of indigestible chromogens in the food and the subsequent recovery of these chromogens from the faeces.

Feed and faecal samples were ground to a fine powder with an electric coffee grinder. One gram of each sample was extracted in 9 ml acetone for a 24h period. Sealed plastic bottles were used which were thoroughly shaken every hour except overnight. The supernatant was cleaned by centrifuging and 0,25 ml of each sample was diluted to a 1 : 20 concentration. The absorbance was measured in a spectrophotometer at 420 nm.

The modified technique described by Fairall (1981) was used for the creation of a standard curve. The standard curve allows one to convert the absorbances of the extracts to the arbitrary units which are used in the calculations of feed intake.

Two 1g samples were taken from the feed that was added and that was left each day. The samples for each trial were pooled and the resulting 8g of feed was extracted in 200 ml of acetone in the manner described in the previous paragraph. The supernatant was removed and the extract was concentrated by evaporation of acetone.

The absorbances of different concentrations of the extract were measured at 420nm and plotted against the concentration of the extract (ml extract/10 ml acetone) to create the standard curve. The curve was divided into arbitrary units (called chromogen units or C.U.'s) and the absorbances of the feed and faecal samples were converted to C.U.'s for the calculation of feed intake using the equation:

$$\text{Dry matter consumption (kg/day)} = \frac{\text{Feed(C.U./g)} \times \text{Faeces(kg/day)}}{\text{Faeces (C.U./g)}}$$

Tritiated water (THO)

Ten days before slaughter the eland were injected intramuscularly with darts using an airgun. The male was given a dose of 50mCi and the female 15mCi of THO. Fresh faecal samples were collected at two day intervals and frozen. Water was later extracted by vacuum sublimation. Fifty microliters of the extracted water was added to 2ml of scintillation cocktail and counted in a Beckman scintillation counter.

The log of the THO activity (lnCPM) was plotted against time after dosing to obtain linear regression equations for the THO dilution. The concentration of the isotope at equilibrium (C_e) was calculated by extrapolation of the THO activity to the time of dosing.

A sample of the THO stock was diluted to 0,15 μCi/ml H_2O and counted in the same way as the water from the faecal samples to determine the activity of the standard.

The total body water space (TBWS) and water turnover rate (WT) were calculated with the following equations:

$TBWS = D/C_e$

and $WT = D/C_x - TBWS/\ x$

where $C_e = CPM_o/CPM_{std} \times C_{std}$

and $C_x = CPM_x/CPM_{std}$

C_e = concentration of the isotope at equilibrium (uCi/ml)

D = dose administered (uCi)

CPM_o = activity of the isotope at the time of dosing (CPM by extrapolation)

CPM_{std} = activity of standard (CPM)

C_{std} = concentration of the standard (μCi/ml)

x = number of days after dosing

C_x = concentration of isotope on day_x (uCi/ml)

CPM_x = activity of the sample collected on day_x (CPM)

Carcass analysis

The eland were shot in June 1984 at the end of the feeding and THO trials. Just prior to shooting they were weighed on a cattle weighing bridge and were bled immediately after. All the blood was collected, weighed and frozen for later determination of total body fat contents.

Measurements and masses were taken of the whole animal and various body parts and organs after slaughter. The contents of the stomach and gut were removed and weighed and the water content was determined by dessication of representative sub-samples.

After removal of the horns and hooves the head, trotters, digestive tract, viscera, blood, tail and skin were frozen for chemical analysis. The left side of each carcass was kept for the same purpose, assuming that both sides of the carcass would have the same composition. The right buttock was weighed and dissected into fat, muscle, bone and sinews.

The carcass and non-carcass components were minced in a Wolfking carcass grinder fitted with die plates with 12 mm and 5 mm holes. Each of the two components was thoroughly homogenised by repeating the mincing four times. Three samples of each component were kept for the determination of fat contents by ether extraction (A.O.A.C. 1975). The water content was determined by freeze drying of subsamples. Mass loss during the mincing process was assumed to be the loss of moisture.

RESULTS

Chromogens

The chromogen contents of the feed and faeces were determined for both diets fed to the female and the mixed diet of the male. Two samples of the feed added and two of the feed left each day were used, and three samples of the faeces of each day. The average C.U. values for each trial, the faecal output and the actual feed intake are listed in Table 1.

The dry matter intake as predicted by the chromogen method showed a correlation of 0,979 with the measured average daily intake (Fig. 5A).

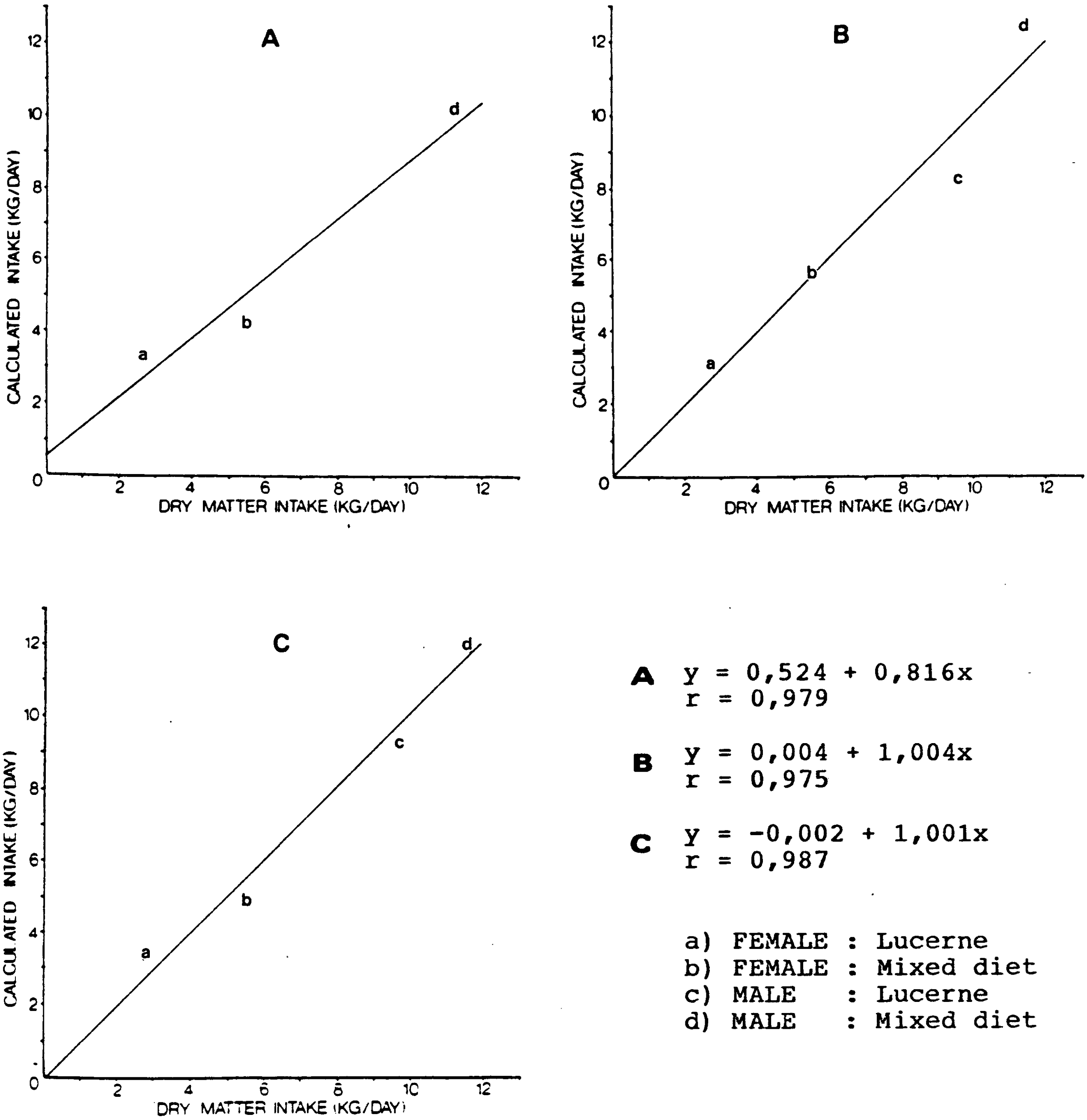


Figure 5 : Average daily feed consumption of two captive eland plotted against feed intake predicted by
A : chromogens
B : faecal output
C : water intake

The faecal dry matter output had a correlation of 0,975 with the measured feed intake (Fig. 5B) and the daily water intake had a correlation of 0,987 with the feed intake (Fig. 5C).

The predicted feed intake calculated from chromogens, faecal output and water intake are listed in Table 2.

Table 1 : Faecal output, feed and water intake and chromogen contents of the feed and faeces of two captive eland.

	DRY MATTER OUTPUT (kg/day)	DRY MATTER INTAKE (kg/day)	WATER INTAKE (l/day)	CHROMOGEN UNITS	
				FAECES	FEED
FEMALE (lucerne)	1,6	2,7	7,3	3,05	6,30
(mixed diet)	2,6	5,5	10,1	2,60	4,17
MALE (lucerne)	3,6	9,5	18,2	---	---
(mixed diet)	5,1	11,4	23,3	1,37	2,70

Table 2 : Average daily feed intake of two captive eland predicted from chromogens, faecal output and water turnover.

	FEED INTAKE (kg/day) CALCULATED FROM:		
	CHROMOGENS	FAECAL OUTPUT	WATER INTAKE
FEMALE (lucerne)	3,30	2,92	3,27
(mixed diet)	4,17	5,62	4,78
MALE (lucerne)	---	8,32	9,16
(mixed diet)	10,10	12,38	11,92

Tritiated water

The regression of the logged THO activity against time after dosing yielded correlations of -0,92 for the female and -0,94 for the male (Fig. 6). The activity at equilibrium was calculated by extrapolation to the time of dosing for the purpose of the determination of TBWS.

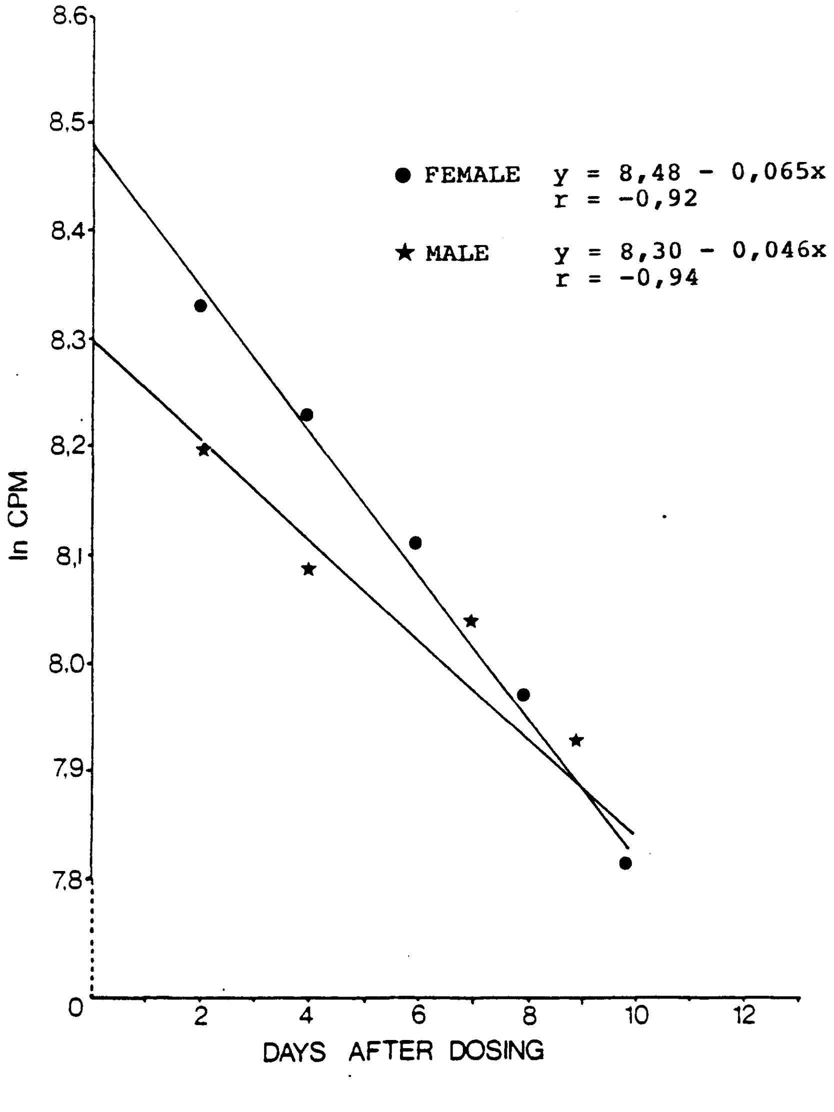


Figure 6 : Logged THO activity (lnCPM) plotted against time after dosing.

The standard (0,15 µCi/ml) had an activity count of 2964 CPM and the calculated activity of the isotope at equilibrium was 4 817,5 CPM for the female and 4 023,9 for the male. These values convert to isotope concentrations of 0,2438 and 0,2036 µCi/ml body fluid for the female and male respectively.

The calculation of TBWS yielded very inaccurate results. The THO space of the female was calculated at 61,5 ℓ while the total body water pool measured after slaughter was 115,1 ℓ. The results in the male were somewhat better, but still not accurate enough to be used with confidence. The THO space of the male was calculated at 245,5 ℓ but the actual measurement of the total body water pool was 286,1 ℓ.

The calculated water turnover rate was 5,84 ℓ/day for the female and 17,20 ℓ/day for the male. The actual measured intake was 9,15 ± 2,49 ℓ/day and 19,5 ± 8,50 ℓ/day respectively.

Body composition

The different masses and measurements of the whole body and various organs and carcass sections are listed in Table 3.

The results of the fat and water determinations are listed in Table 4. The male was in very good condition and had a body fat content of 7,3% of the empty body mass (EBM = live mass excluding stomach and gut contents). The female was much leaner and body fat comprised only 3,0% of the EBM. This was also evident from the fat contents of the buttocks (Table 5). The buttock fat content of the male was 2,4% of the buttock mass while that of the female was only 1,4%. The combined body fat/water fraction was remarkably similar in both animals. In

Table 3 : Various masses and measurements of two eland slaughtered on the SALNR.

	MALE	FEMALE
Live mass	424,5kg	163,0kg
Total length	250,0cm	186,0cm
Length of head	50,0cm	42,5cm
Length of tail	54,8cm	42,5cm
Length of ear	9,0cm	19,0cm
Lenght of horn	47,0cm	
Shoulderheight	162,0cm	122,0cm
Buttockheight	141,0cm	117,0cm
Chest girth	183,0cm	129,5cm
Carcass left side	123,7kg	44,5kg
right side	118,3kg	44,5kg
Stomach (empty)	13,6kg	5,2kg
contents	55,8kg	21,9kg
Gut (empty)	9,9kg	3,1kg
contents	14,7kg	5,9kg
Viscera (heart, lungs, spleen, liver, kidneys)	19,5kg	8,2kg
Blood	15,7kg	6,0kg
Skin	27,8kg	11,2kg
Trotters	8,2kg	4,6kg
Head (hornless)	15,0kg	7,2kg
Horns	3,7kg	1,5kg
Testis	0,3kg	--

Table 4 : Body water and fat contents of two eland slaughtered on the SALNR.

	LIVE MASS (kg) (LM)	EMPTY BODY MASS(kg) (EBM)	BODY WATER EXCL. GUT (kg)	BODY FAT (kg)	WATER + FAT(kg)	FATFREE DRY EBM (kg)	GUT CONTENTS (kg)
MALE	424,5	350,8	221,2	25,6	246,8	104,0	73,7
Percentage of EBM			63,1	7,3	70,4	29,6	
Percentage of LM		82,6	52,1	6,0	58,1	24,5	17,4
FEMALE	163,0	135,2	90,5	4,0	94,5	40,7	27,8
Percentage of EBM			67,7	3,0	70,7	30,4	
Percentage of LM		82,9	55,5	2,5	58,0	25,0	17,1

Table 5 : Body composition as percentage of the buttocks of two eland slaughtered on the SALNR.

	MUSCLE	FAT	BONE & SINEW
MALE	78,6	2,4	19,4
FEMALE	79,2	1,4	19,4

the male this fraction comprised 70,4% of the EBM and 58,1% of the live mass (LM) which included the water in the rumen and gut, and in the female these values were 70,7% of the EBM and 58,0% of the LM.

The contents of the digestive tract were also very similar in the male and female. In the former it constituted 17,4% of the LW and in the latter 17,1%.

Examination of the lungs, heart, liver and the contents of the digestive tract revealed no internal parasites.

DISCUSSION

Feed intake was predicted very accurately with the chromogen method for sheep wethers and cattle bull calves for a variety of diets by Reid et al. (1950). The technique was also employed by Fairall (1981) to determine the digestibility of the diet of redknobbed coots, but he found that considerable variation was caused by a large amount of grit in the faeces.

In the present study a good correlation was found between the predicted and the measured food intake.

Two problems arose which made the implementation of the chromogen method on the free ranging eland impossible. Both were caused by the same factor, namely the unanticipated wildness of the eland. This prevented me first from determining the composition of the diet by direct observation of food selection and secondly made the measurement of daily faecal output extremely difficult.

Faecal output was correlated well with feed intake, but more trials with varied diets will have to be conducted to examine the influence that changes in forage quality might have on this relationship. Macfarlane & Howard (1972a) found a good correlation (r = 0,93) between THO turnover and faecal output for growing sheep, which implies a good correlation between feed intake and faecal output. If the problems involved in the collection of the daily faecal output can be solved this method could be effectively used in the prediction of feed intake of wild animals.

The water intake of the eland also showed a good correlation with feed intake (r = 0,987). Siebert (1971 in MacFarlane & Howard 1972a) reported a correlation of r = 0,84 between measured feed intake and water turnover. This method seems to be the most suitable for the prediction of food intake of wild animals since only a few faecal samples collected over a period of a few days from animals injected with THO are required to calculate the water turnover rate. The rates of energy and water turnover vary together (MacFarlane & Howard 1972a) and if the composition of the diet can be determined the amount of ingested food can be calculated. Absolute accuracy will most probably never be obtained but it should be possible to detect seasonal variations in energy turnover and food intake.

The use of THO has become a reliable tool in the prediction of water turnover in wild animals (e.g. MacFarlane & Howard 1972a, King, Kingaby, Colvin & Heath 1975, Cameron, White & Luick 1976). The prediction of body composition with THO has also been investigated with good results (Bird 1984, Bird, Flinn, Caley & Watson 1982, Pfau & Salem 1972). Torbit, Carpenter, Alldredge & Swift (1985) used the technique in predicting the body composition of mule deer and found that the estimates were similar to the real values obtained by chemical analysis of the carcasses.

The experimental animals in most trials were deprived of food and water for a certain time before and after dosing to reduce the loss of isotope before equilibrium was reached, but the concentration of THO in the body fluids at equilibrium can also be calculated by extrapolation from a series of samples collected after dosing. Results obtained by this method are as accurate as those from animals which had been fasted for a certain period (Panaretto 1968, Smith & Sykes 1974).

Water and fat form a constant proportion of the chemically mature mammal body (Pfau & Salem 1972) and are inversely related to each other (Cameron & Luick 1972, Robbins 1983). Changes in the TBWS therefore reflect changes in body fat content and the THO technique is based on this principle. In ruminants however, the rumen also contains large volumes of water and corrections should be made for this.

Game species usually accumulate little fat in the body which makes accurate prediction of body condition with THO more difficult, but eland accumulate more fat than many other species

(Van Zyl 1962, Lightfoot 1977). MacFarlane & Howard (1972a) also found that eland had much less body water than species like blue wildebeest and kongoni and were therefore fatter. For this reason it was decided to test the THO technique on eland.

The results obtained in the present study were far from satisfactory. The THO space and turnover of the female were very much lower than the measured values of body water and turnover. Slightly better results were obtained with the male but the estimates were also lower than the actual measurements.

Underestimation of TBWS is usually caused by the failure of the THO to equilibrate with the water in the alimentary tract (Smith & Sykes 1974) but it is not clear how this could have happened in both animals during the present study.

It was unfortunate that only two animals were available for these experiments because a larger sample size would have improved the results. More experience in the implementation of the THO technique would probably also have resulted in a better outcome of the experiment.

From the results of other workers and the results obtained with the male I think that the THO technique is a valuable tool in predicting changes in body condition, energy expenditure and food intake of populations, provided that it is properly validated, that a sufficient number of animals is used to compensate for biological variations between individuals and that a fairly accurate knowledge of the diet composition can be obtained.

Only a few authors have published data on the carcass composition of eland (Van Zyl 1962, von La Chevallerie et al. 1971, Keep 1972). The present eland had a similar carcass composition as those taken from the SALNR by von La Chevallerie et al. (1971). However, the determination of total body fat of eland by ether extraction has never been done and the present results can therefore not be compared to other findings.

The dressing percentage of the carcass of the male (57,2% of the LM or 69,2% of the EBM) was higher than reported by von La Chevallerie et al. (1971) who recorded a maximum of 53,5% in six shot bulls. In the present study the male had been penned for a month and was fed lucerne for most of this time. It had adapted to captivity very quickly and unlike the female which was very nervous throughout the period of captivity the male seemed to be very relaxed and unstressed. This probably accounted for the accumulation of fat which was responsible for the higher dressing percentage compared to animals shot by von La Chevallerie et al. (1971).

A large difference in fat content was found between the female and the male, but the combined fat/water contents of the bodies were very similar, with respective values of 70,7% and 70,4% of the empty body mass. These figures confirm the inverted relationship between body fat and water which is an important prerequisite in the use of the THO technique for the prediction of body condition.

The contents of the digestive tracts of the female and male constituted 17,1% and 17,4% of the respective live masses. The animals had free access to feed and water up to the time of slaughter. Data are needed on the rumenfill of free ranging eland, but if they exhibit maximum amounts of ingesta at certain times, e.g. after the morning feeding session when they usually lie down to ruminate, it should be possible to determine the empty body mass by immobilising and weighing them at the right time. This would also add greater accuracy to the prediction of body composition with the THO technique.

The slaughtered eland carried a light tick load which indicated that they were healthy and in good condition (Keep 1972). In contrast to the seven helminth parasites recorded by Keep (1972) from eland shot in the Natal Drakensberg no internal parasites could be detected in the eland slaughtered during the present study.

Although the experiments described in this chapter did not yield accurate results, the THO technique for predicting body condition has successfully been implemented by other workers and should be investigated further. A number of animals have to be used because of the great variation obtained for individual animals. When predictions of body condition are made the accuracy will depend on the correct assessment of the amount of water in the rumen and the time of weighing the animals will be crucial. In populations where the animals cannot be approached closely without disturbance the determination of water turnover with THO is the only feasible manner in which information on energetic intake of free-living animals can be obtained.

Due to the limited number of experimental animals no concrete conclusions could be reached, although some of the findings might well be worth further investigations. The findings which should be explored further are the correlation between water turnover and food intake, the correlation between faecal production and the time of the day when the maximum amount of rumenfill is reached, as well as the consistency of the rumenfill as a percentage of the live mass.

CHAPTER 4

HABITAT SELECTION

INTRODUCTION

Eland are known to utilise different resources during different seasons. They are primarily browsers, but switch to grazing when the grass is green and rich in proteins (Hofmeyr 1970, Kerr, Wilson & Roth 1970, Field 1975, Lightfoot & Posselt 1977).

The SA Lombard Nature Reserve (SALNR) consists mainly of grasslands and is stocked with plains antelope such as springbok, red hartebeest and black wildebeest. These species show no signs of nutritional stress or starvation, even during exceptionally dry years as experienced for the duration of the present study. The grassland would therefore seem adequate for supporting the eland population during the wet season, while the thickets that have to supply the high energy diet during the dry season constitute a small part of the reserve. The emphasis of the present study was therefore placed on the utilisation of woody areas since these are probably the biggest limiting factor for the eland population.

Scotcher (1982) found that the physiological condition of males was consistently high with a possible stress period only during the periods of sexual activity, but that females suffer much more from nutritional stress caused by the increasing energetic demands of pregnancy and lactation. He also found a mortality of 66% for the calves in their first year after birth.

The management objectives for the SALNR during the study period included the culling of males at regular intervals for research purposes and at the end of the present study only three adult males remained. For these reasons adult males have been excluded from the following calculations and discussions.

METHODS

Vegetation

The main features of the different woody plant communities were measured along 50 x 5m strips placed randomly within the different communities. Within these plots the distance of each woody plant from the starting point, the height, the diameter at ground level, the distance of lowest foliage from the ground and the height and diameter at its broadest point were measured.

The importance value (I.V.) of each species in each community was calculated following the methods described by Mueller-Dombois and Ellenberg (1974):

$$\frac{\text{Relative \% frequency} + \text{Relative \% density} + \text{Relative \% dominance}}{3}$$

Relative percentage dominance was calculated with the equation:

$$\frac{(\text{2x Rel \% crown diameter}) + (\text{Rel \% height})}{3}$$

All relative percentages were calculated as a proportion of the total of all measurements of a specific parameter within each transect.

The intention was not to provide a detailed description of the vegetation, but only to give some guidelines when interpreting the distribution of eland.

Distribution

Eland were monitored along a fixed route from a vehicle early in the mornings and sightings were recorded on a gridded map with squares measuring 500 x 500m in the veld. The locations where the animals were seen for the first time each day were used for all further calculations because movements later in the day were often influenced by my own movements or those of the reserve staff during the course of their duties.

When eland were utilising the thickets they could not always be sighted from the roads and these areas were then revisited for closer inspection after completion of the daily count.

The total number of eland seen in a particular vegetation type during each observation period and during the whole study were used for the calculations that follow.

Cole's coefficient of association

The occurrence of young animals in a particular vegetation type is not usually the result of an independent choice but merely because they follow the adults. Sinclair (1977) used an adaptation of Cole's coefficient of association (1949) to eliminate this bias in the statistical analysis of habitat preference.

Association is the amount of co-occurrence in excess of that which can be expected if two categories are independently distributed. The coefficient of association (C) ranges from -1 to +1 where -1 indicates total avoidance, zero indicates random association and +1 total association.

In the present study, like Sinclair's, the association is one-way because the eland were associated with vegetation but the reverse could not occur. For the calculations eland were recorded as present or absent for each grid square, irrespective of the number of eland per group. The equations of Cole (1949) were used for the calculation of C, the standard error and the chi-square value.

Utilisation of different thicket-clump communities

The data collected on the utilisation of thicket were tested with the preference index used by Hillman (1979). The number of eland seen in each vegetation type were summed and preference indices were calculated for the different thicket-clump communities seasonally and overall.

The values obtained from the preference index range from -1 to +1 implicating the least and most preferred areas respectively.

Four variables were used in the calculations, namely:

Ax - the number of eland recorded in thicket "x"
At - the total number of eland recorded
Vx - the area of thicket "x"
Vt - the total area covered by woody vegetation.

Ax/At is the proportion of eland recorded in thicket "x" and Vx/Vt is the proportion of the total area covered by thicket "x"

If Ax/At > Vx/Vt then $P.I.x = \frac{1}{(1 - Vx/Vt)} \cdot \left(\frac{Ax}{At} - \frac{Vx}{Vt}\right)$

and if $Ax/At < Vx/Vt$ then $P.I.x = \frac{1}{(Vx/Vt)} \cdot \left(\frac{Ax}{At} - \frac{Vx}{Vt}\right)$

RESULTS

Vegetation

The reserve was divided into 156 grid squares of which 23 were covered with woody vegetation and 15 were located on the edges where thicket goes over into grassland. There are five clearly demarcated thicket-clump communities (Fig. 7) and one small patch (one grid square) near the main gate where scattered

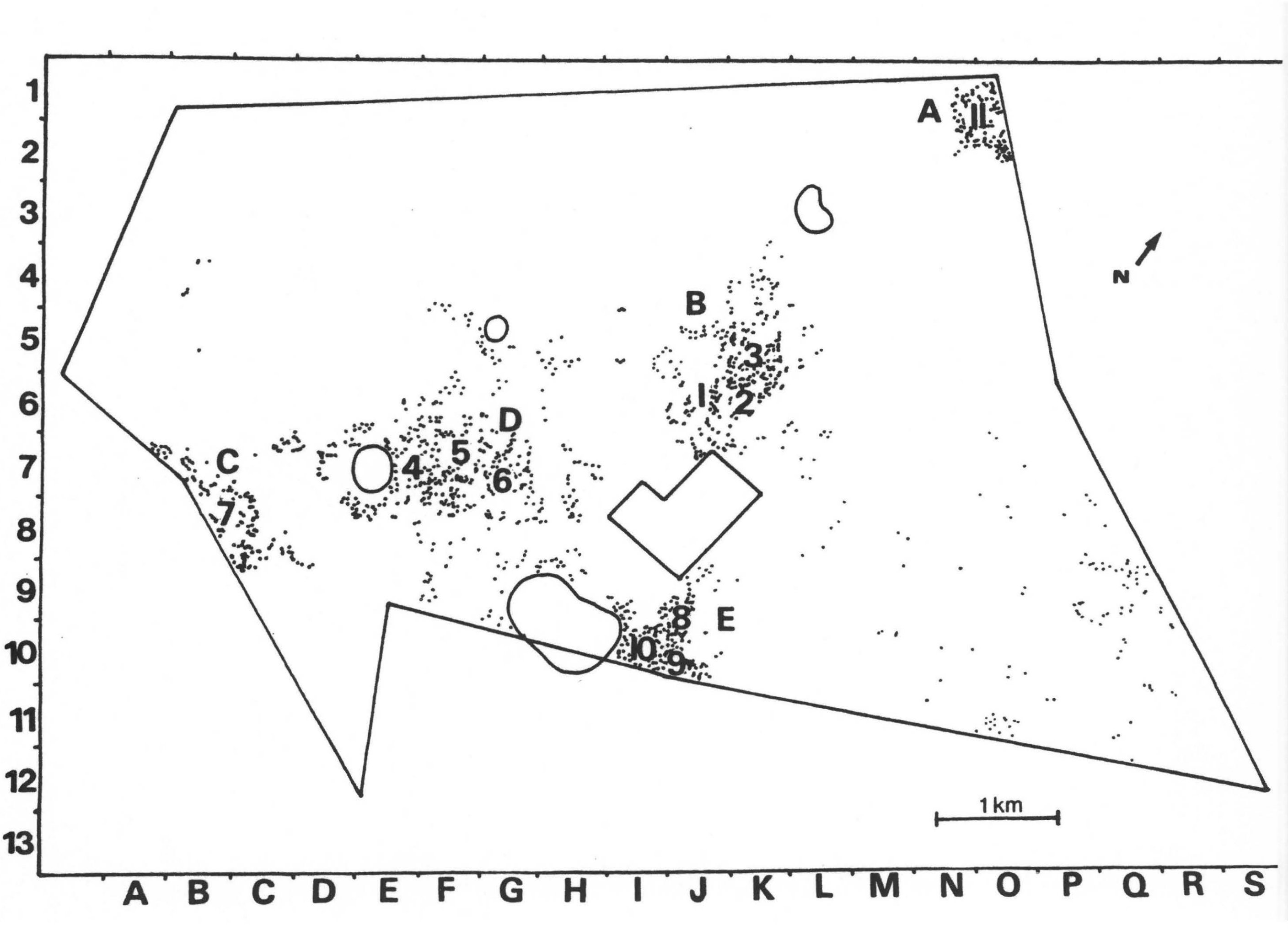


Figure 7 : The location of Thickets A to E and the positions of the transects.

shrubs (*Diospyros lycioides* and *Grewia flava*) and the occasional *Rhus lancea* occur, but this was treated as grassland.

The most important characteristics of each woody plant community were measured and are listed in Appendix I. A diagrammatical representation of the species, heights and densities of the plants occurring in the various areas are given in Figures 8 to 10.

The most important features of each thicket-clump community will be briefly discussed:

Thicket A: Only *Rhus lancea* trees with a low density (160 individuals/ha) grow in this area.

Thicket B: The most common species are *Diospyros lycioides*, *Ziziphus mucronata* and *Rhus lancea*. The density varied between 360 and 920 plants/ha.

Thicket C: The most abundant species are *D. lycioides*, *Z. mucronata* and *R. lancea* with a density of 520 plants/ha.

Thicket D: The vegetation consists mostly of *Grewia flava* (17% of plants recorded) followed by lower numbers of *D. lycioides*, *R. lancea* and *Maytenus heterophylla*. The density varies between 680 and 760 plants/ha.

Thicket E: Nine different tree and shrub species were recorded. The most common species were *Tarchonanthus camphoratus* (38%) and *D. lycioides* (29%) with substantial numbers of *Acacia karroo*, *G. flava* and *Z. mucronata* also present. *R. lancea* trees are mainly

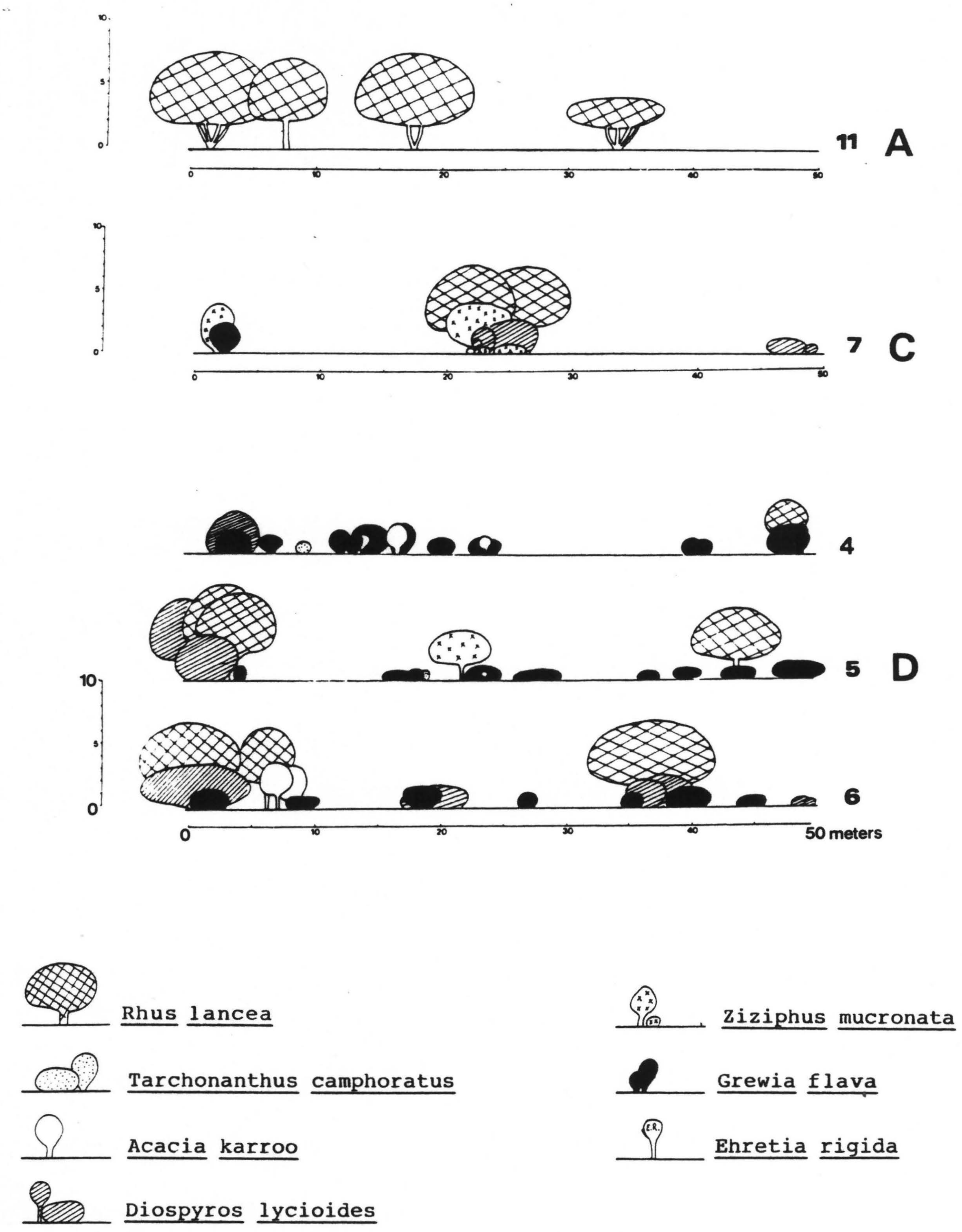
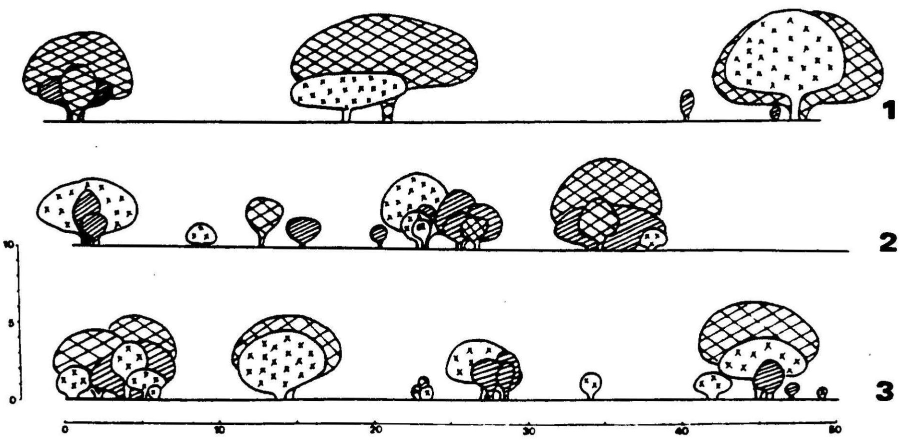


Figure 8 : Diagrammatical representation of the transects measured in Thickets A, C and D.

A

B



B

Figure 9A : Thicket B.
9B : Diagrammatical representation of the transects measured in Thicket B.

A

B

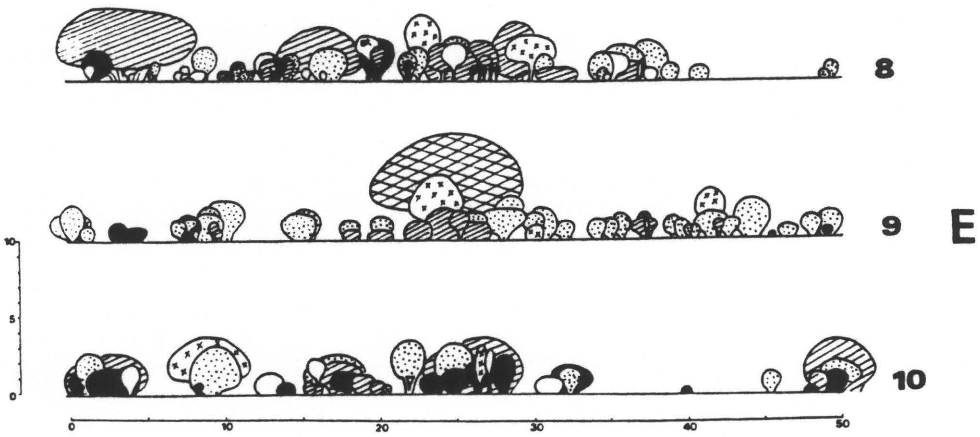


Figure 10A : Thicket E.
10B : Diagrammatical representation of the transects measured in Thicket E.

found in the southern half of this thicket-clump community. The density of woody plants varied from 1 560plants/ha on the western side to 2 520 plants/ha on the eastern side.

Distribution

The distribution of 3 088 eland females, subadults, yearlings and calves were recorded. 46,6% of these were seen in thicket, 13,9% in areas bordering thicket and 39,5% on the plains. The overall and seasonal distributions are plotted in Figure 11.

The percentage of animals seen in thicket and associated areas (Fig. 12) varied with rainfall to which it was inversely correlated. The occurrence of females and young in these areas ranged from 40% of the animals recorded in summer to 75% during the winter.

In September 1984 the percentage of animals seen in thicket was much lower than expected. The reason for this deviation from the pattern observed during the rest of the study could be ascribed to the fact that only 180 females and young out of a possible 351 were recorded. The eland were moving in small groups and many of these were probably utilising the more densely wooded areas and were therefore not seen. The addition of these animals would increase the utilisation of thicket during this period up to a possible 64,6% and would remove the discrepancy with the trend revealed by the rest of the data.

Cole's coefficient of association (C)

The calculation of C for the distribution of the eland during

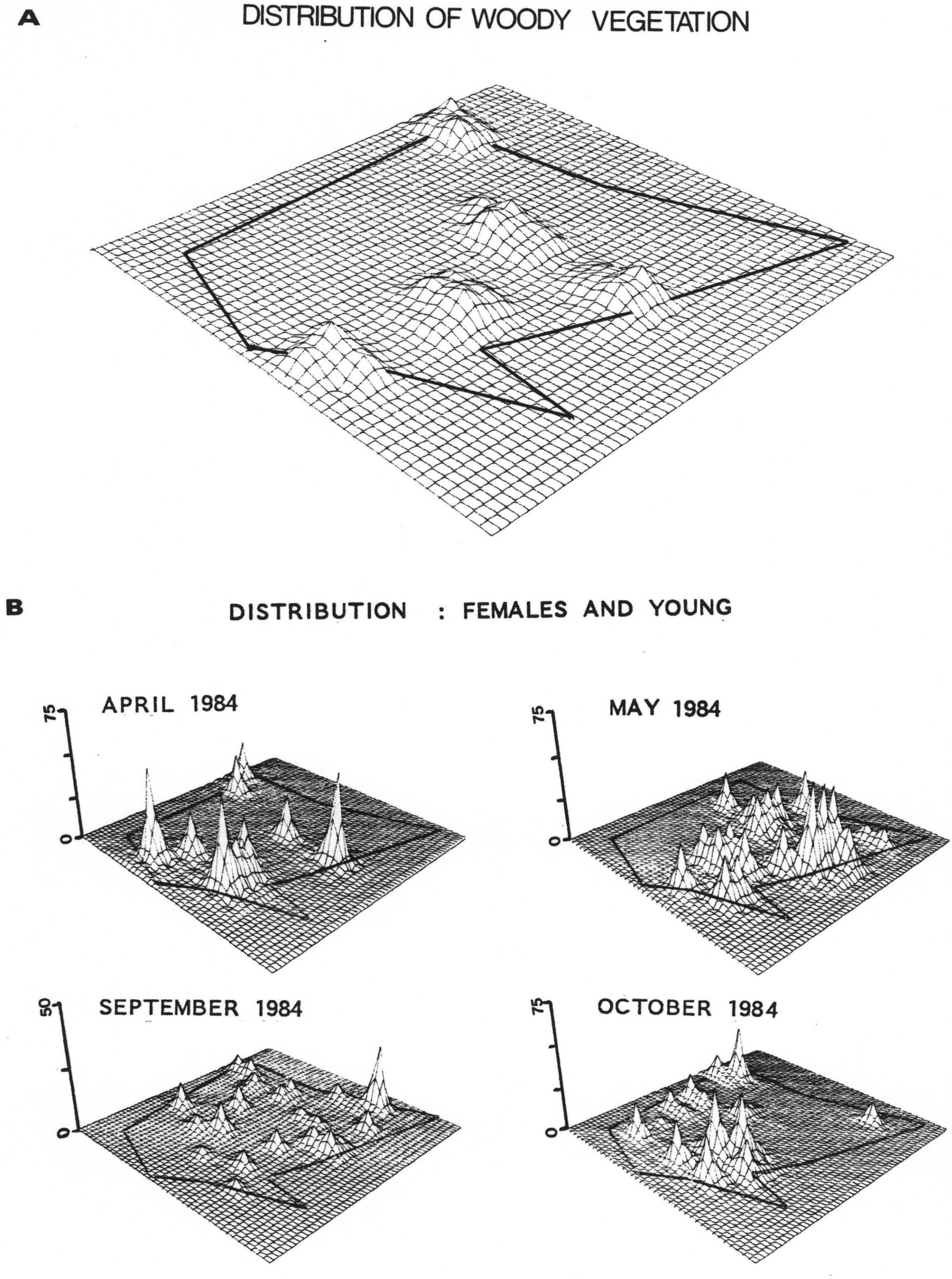


Figure 11A : Distribution of thicket on the SALNR.
11B : Seasonal distribution of eland females and young on the SALNR.

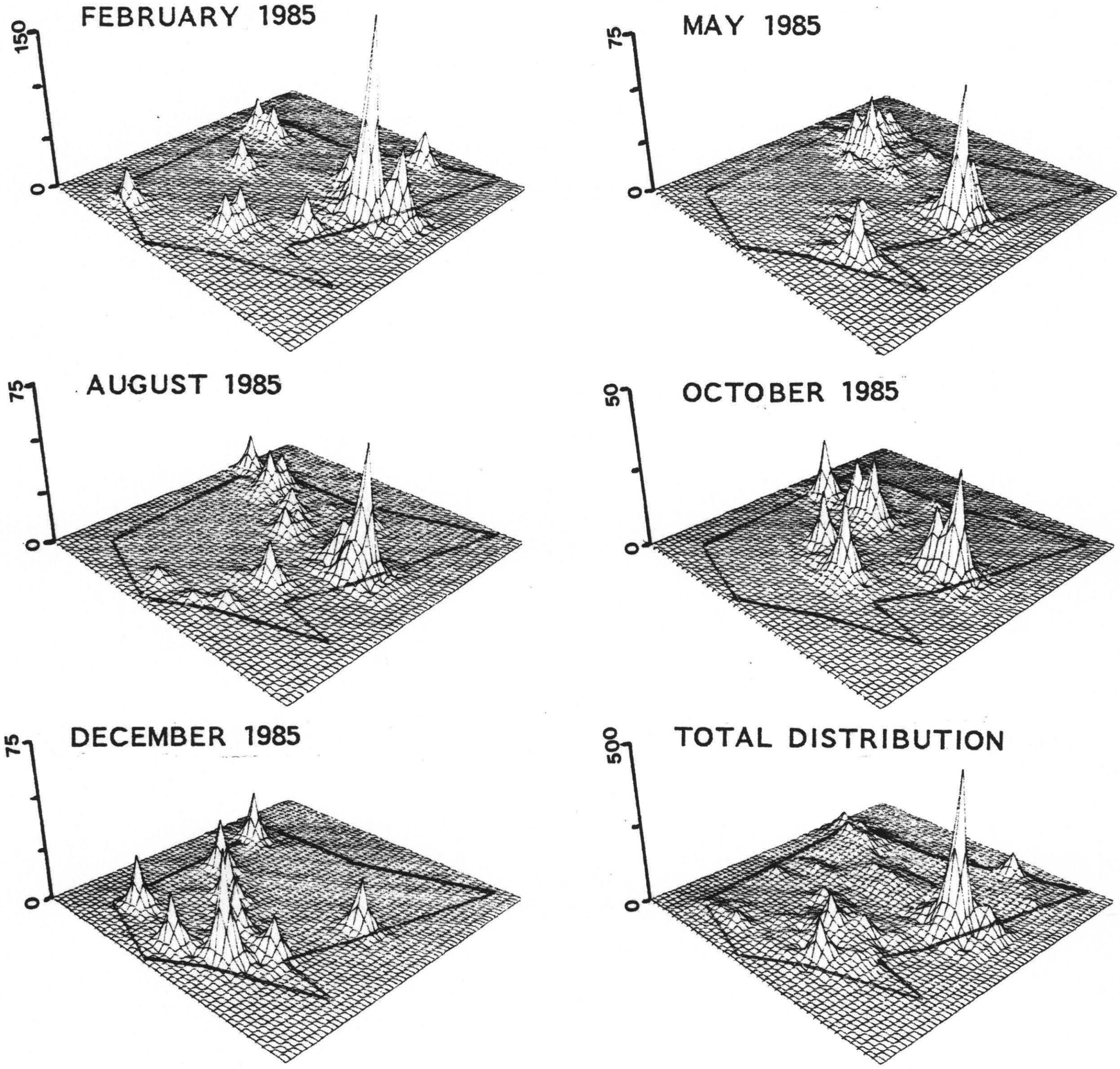


Figure 11 (continued).

the study indicates a highly significant positive association with thicket ($C = 0,436 \pm 0,033$, $p < 0,001$).

The different observation periods also yielded positive C-values when treated separately. All the associations were significant ($p < 0,005$) except during September 1984, which has been discussed above, and December 1985 when the association was very close to random (Fig. 13).

Selection between woody plant communities

The preference index of Hillman (1979) was used to compare the amount of selection for each woody vegetation type.

The values obtained ranged from -1 to +1, but since the association with thicket has already been established in the previous paragraph negative values should not be interpreted as avoidance of an area but rather that those areas were less preferred than areas with higher P.I. values.

Eland showed a stronger preference for thicket E than for any other woody area throughout the duration of the study with the exception of November 1984 when no animals were seen in this area at all (Fig. 14). Thicket D was utilised during all observation periods and the overall P.I. value was very close to zero, while the overall P.I. values for thickets C, B and A became progressively smaller.

The declining P.I. values correspond to the decreasing densities from thickets E to A. Single variable correlation between the number of eland as the dependent variable and the characteristics of the different woody areas as the independent

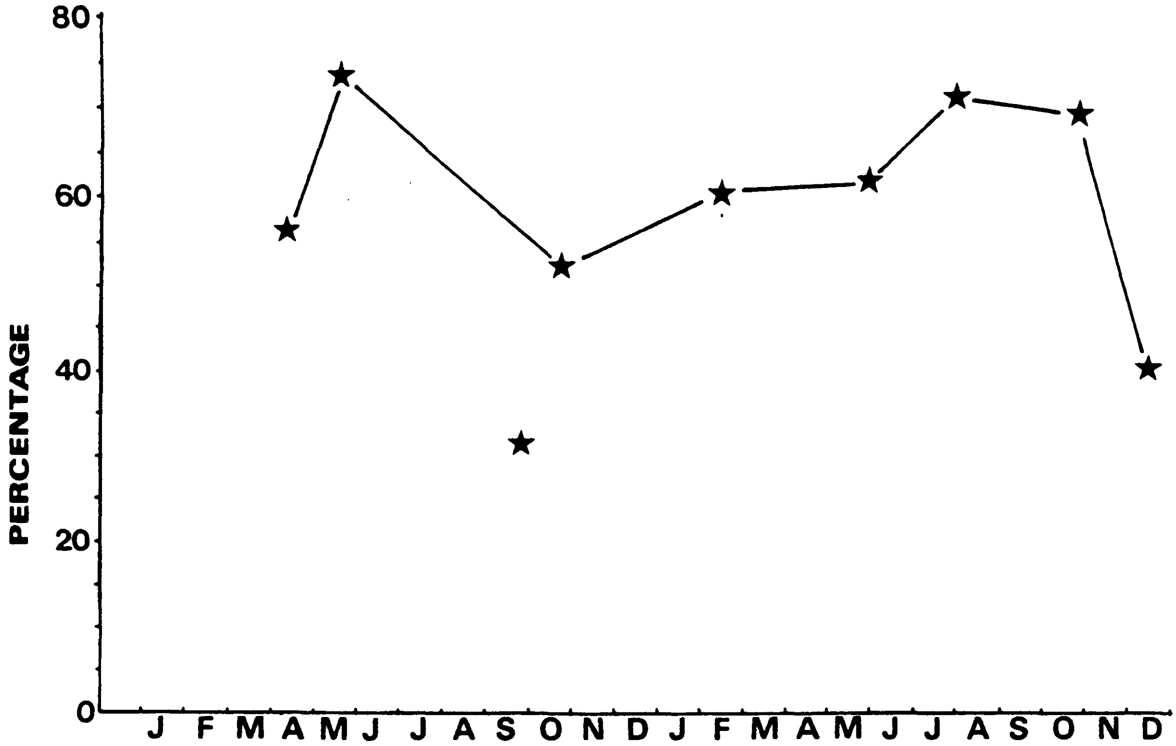


Figure 12 : Percentage of eland females and young recorded in thicket.

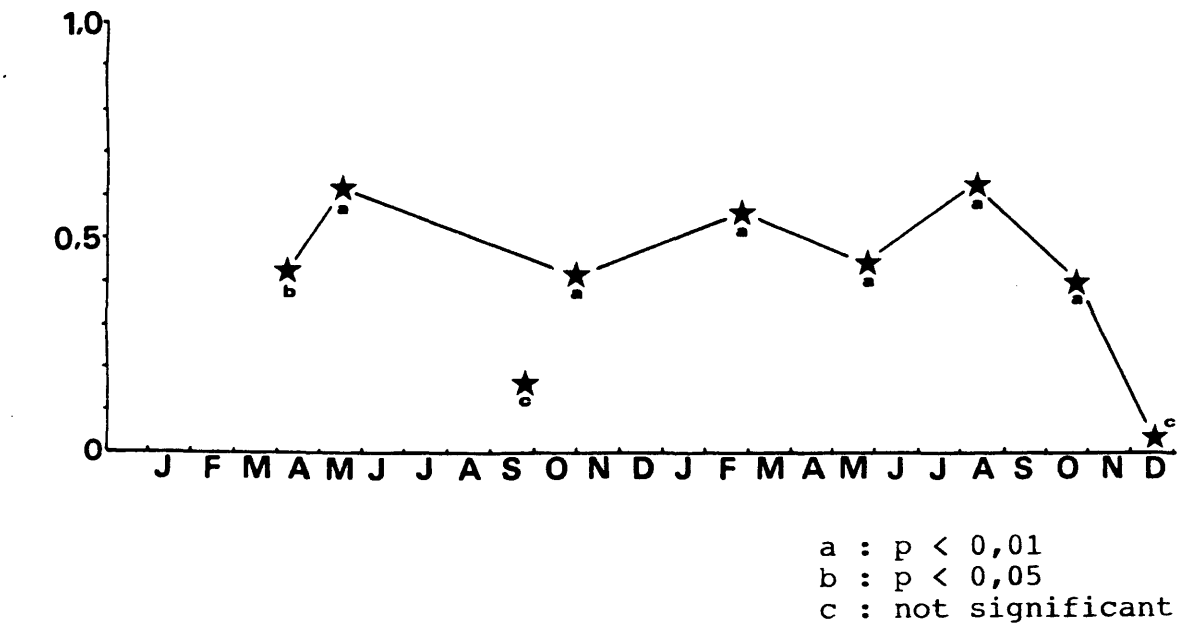


Figure 13 : Cole's coefficient of association between eland and thicket.

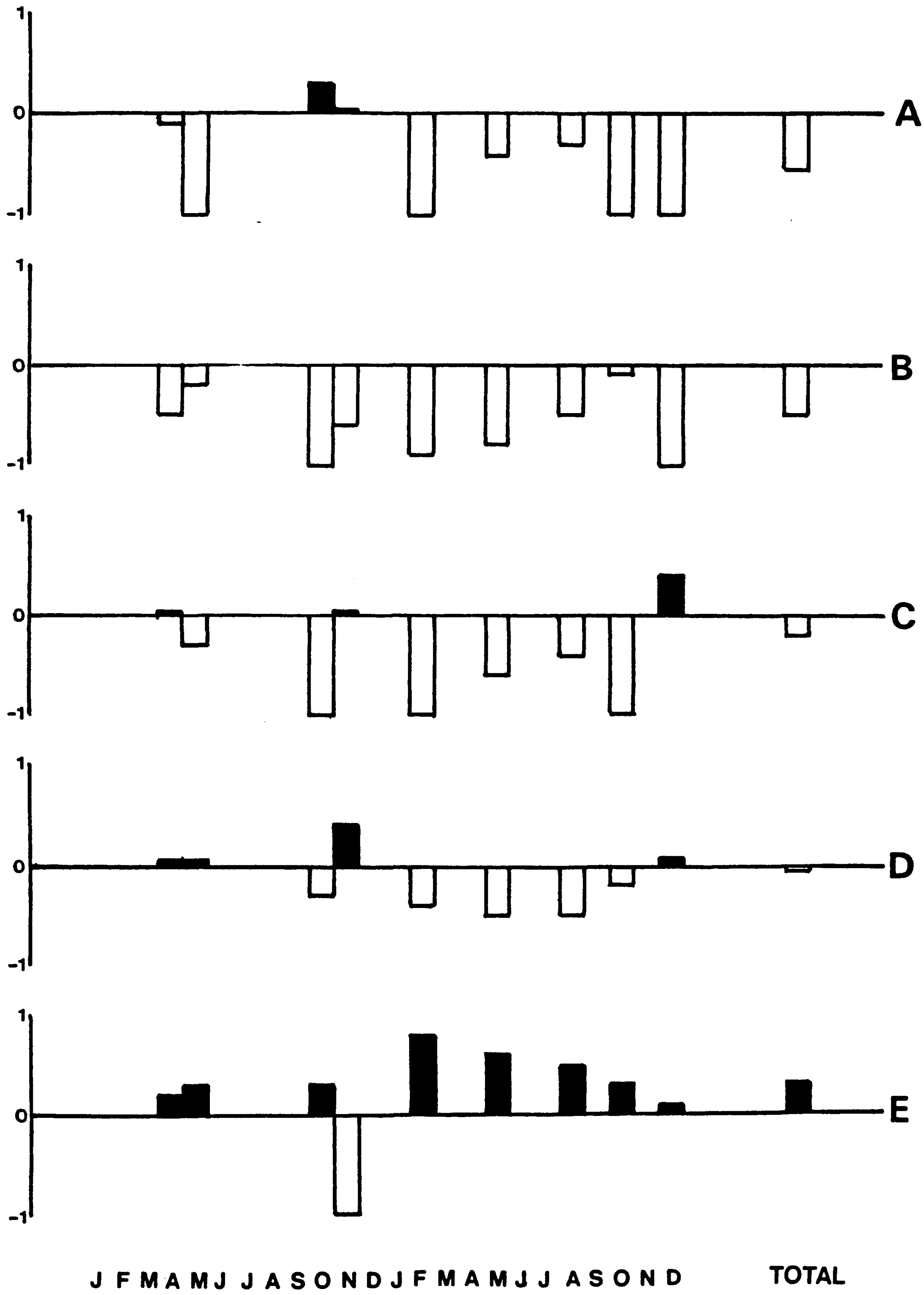


Figure 14 : Preference index for Thickets A to E.

variables confirm this finding. The r-values with a probability of less than 10% are given in Table 6. These results show that the eland select areas containing high densities of D. lycioides, T. camphoratus and A. karroo between 0,75m and 3,50m in height.

Table 6 : Correlations between the number of eland in thickets and thicket characteristics (p < 0,01).

SPECIES	HEIGHT (cm) 0 - 75	75 - 150	150 - 250	250 - 350	350 -550	DENSITY (plants/ha)
RL						-0,379
GF	0,479					0,287
DL	0,356	0,515			0,293	0,465
TC	0,350	0,443	0,476	0,562	0,311	0,510
AK	0,311	0,428	0,453	0,453		0,410
ER				0,311		
ALL PLANTS	0,429	0,584	0,464	0,457		0,555

RL = Rhus lancea
GF = Grewia flava
DL = Diospyros lycioides
TC = Tarchonanthus camphoratus
AK = Acacia karroo
ER = Ehretia rigida

DISCUSSION

Eland on the Transvaal Highveld have developed the same adaptations as eland living in other environments (Hofmeyr 1970, Lightfoot & Posselt 1977, Hillman 1979, Scotcher 1982). Although there was a high affinity for woody vegetation throughout the year a definite shift occurred from grazing to browsing which corresponded with decreasing rainfall.

The end of the rainy season and the following dry period caused a decline in the nutritional value of grasses (Chapter 6) while pregnancy placed additional nutritional demands on the females. To cope with these increasing nutritional needs the eland had to switch to browsing. The food available in the woody areas is limited and even more so where deciduous plants occur, but intraspecific competition for this food resource is reduced by breaking up into small mobile groups (Chapter 5).

In areas where large predators occur eland calves have a higher chance of survival when the females and their offspring congregate in large herds (Hillman 1979). Although calves were born throughout the year a definite peak occurred in November, which coincided with the onset of the rainy season. The abundance and availability of grass which also has a high nutritional value during this time allows for the coalescence of small groups into large groups with a reduction in intraspecific competition. Eland in very diverse environments like the Natal Drakensberg (Jeffery 1978), the Loskop Dam area (Underwood 1975) and the grass plains of Kenya (Hillman 1979) take advantage of the increase in dietary quality of grass during the summer months and display calving peaks during these periods.

The eland clearly preferred certain types of thicket more than others. The largest proportion of eland seen in woody areas was recorded in the area with the highest density of woody plants. The number of eland seen per vegetation type decreased with decreasing densities. The data further showed that in addition to density, preference was shown for the presence of *T. camphoratus*, *D. lycioides* and *A. karroo* between 0,75 and 3,50m in height.

CHAPTER 5

POPULATION, SOCIAL STRUCTURE AND REPRODUCTION

INTRODUCTION

The eland is a nomadic species which usually aggregates in small groups, but at times very large herds are formed which may contain more than 1000 animals (Smithers 1971).

Jarman (1974) assigned eland to his social class E which includes species where territoriality is absent and several reproductively mature males can be found in breeding herds. Species in this class may also live in herds of hundreds of animals under favourable conditions.

In studies on wild populations by various authors (Underwood 1975, Hillman 1979, Scotcher 1982) it was found that these aggregations were strictly seasonal with dispersion into smaller groups occurring during winter.

Seasonal changes in group size for the Transvaal Highveld eland were recorded and the possible causes for these changes discussed in this chapter.

METHODS

Population size

The data used in this section were obtained from the game register which is kept on the SALNR. Although the records were incomplete for some years enough information could be obtained to form a reliable picture of the fluxes in the eland population.

The expected maximum age of the eland was calculated from the game register data between 1960 and 1976, using the equation :

$$\text{Maximum age} = \frac{T - L}{D}$$

where T = number of eland at the beginning of each year

L = number of eland artificially removed during the year

D = number of deaths by natural causes

The upper size limit of the eland population that can be maintained on the SALNR was calculated from the increase in the population from 1950 to 1958 and from 1959 to 1963, using the equation of Stevens (1951) :

$$y = K + BR^x$$

where K = the asymptotic value of y

B = change in y when x passes from 0 to infinity

R = the factor by which the deviation of y from its asymptotic value is reduced per unit increase along the x-axis

x = year

During the period when an abnormal growth in the population was experienced as a result of a flood which caused an increase in forb growth, the equation :

$$\log ((K - N)/N) = A + Rx$$

where A = constant which is dependent on K, N and R

and N = the number of eland during year_x

was used to test the upper limit of the population which could be reached during these circumstances.

Population structure

Due to the size and nature of the S.A. Lombard Nature Reserve (SALNR) it was possible to determine the exact structure of the eland population during each observation period.

Seven categories of eland were recognised according to sex and age. The length and spirals of the horns as described by Jeffery & Hanks (1981b) were used for this classification (Fig. 15). When the animals were clearly visible the presence or absence of a penile sheath was also a very usefull criterion for sexing especially younger animals with small horns.

The following categories were recognised:

1. Adult males;
2. Adult females;
3. Subadult males: 2 to 4 years old;
4. Subadult females: 2 to 3 years old;
5. Yearling males: 1 to 2 years old;
6. Yearling females: 1 to 2 years old; and
7. Calves: both sexes less than one year old.

All the animals were placed in a higher category at the onset of the breeding season, with the exception of three year old males which remained in the subadult class. Males were regarded as adult at the age of five years.

The sex and age of all the animals seen during the study were recorded, but for the following discussion all the animals except the adult and subadult males and adult females males will be treated as one group and will collectively be referred to as young.

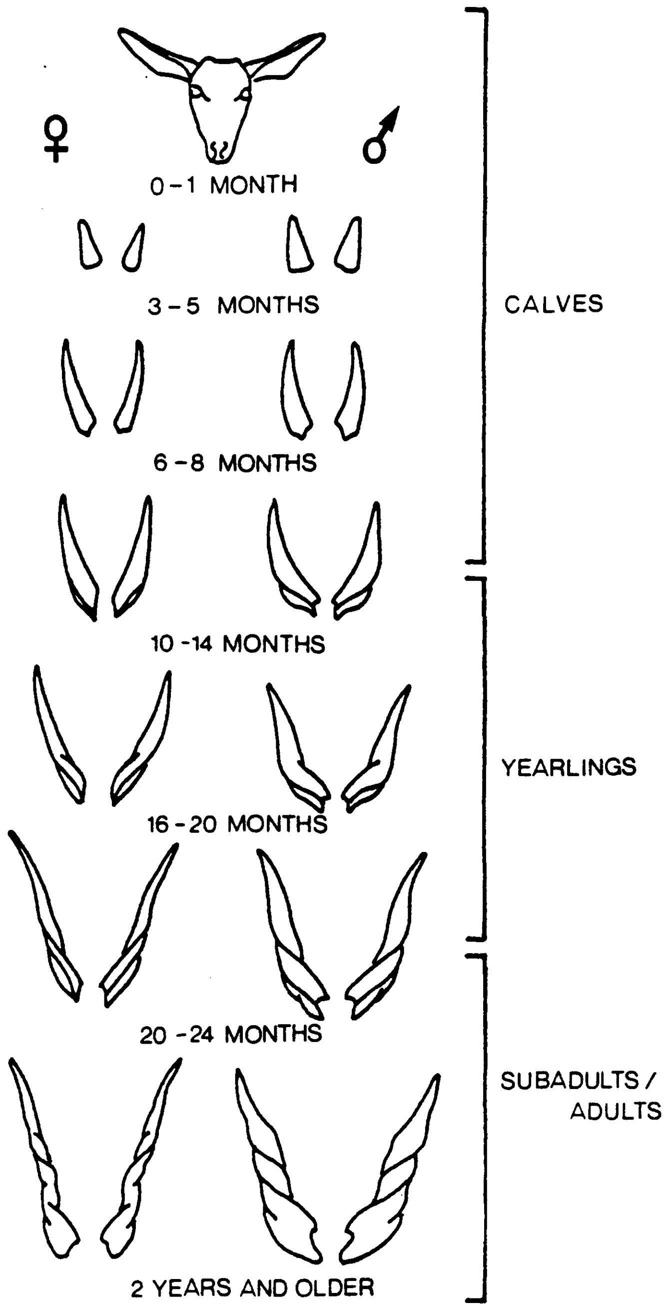


Figure 15 : Horn morphology used in the classification of eland (after Jeffery & Hanks 1981b).

RESULTS

Population size

The first eland, a male and two females, were introduced in 1949. Another male was introduced during the following year and all the eland since then are descended from this small group.

The average age expectancy of eland on the SALNR was calculated at 14,9 years.

The maximum population sizes and births for each year are plotted in Figure 16. During this time few natural deaths were recorded until 1981, while relatively large numbers were sold or distributed to other game reserves and a number of eland were shot. The number of calves born each year remained fairly constant from 1968 until 1977 ranging from 8 to 12, but increased sharply during 1978 when 24 calves were born.

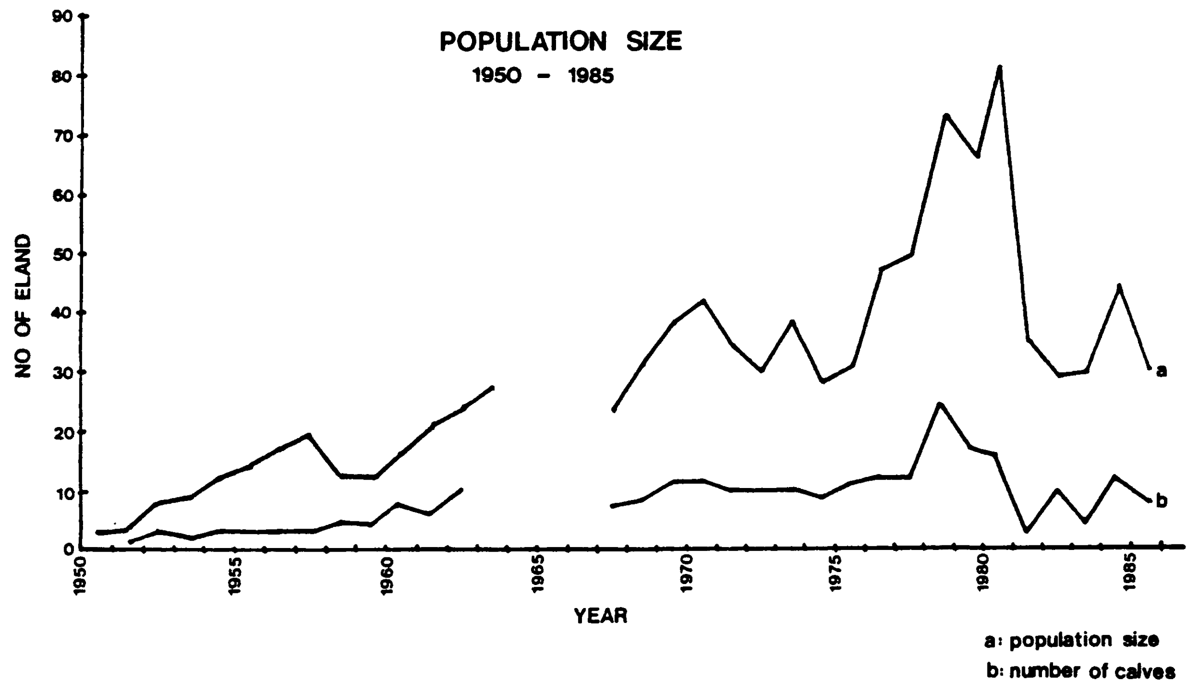


Figure 16 : Population size and number of births of eland on the SALNR from 1950 to 1985.

The upper asymptote of the population growth curve was calculated at 31,8 ± 9,6 eland for the period between 1950 and 1958 and at 34,6 ± 10,6 eland from 1959 to 1963. These figures do not differ significantly and the carrying capacity of the SALNR as derived from such growth curves would therefore be between 30 and 40 eland.

Unusually heavy rains were experienced during 1976 which caused the flooding of a large part of the SALNR and resulted in an increased growth of forbs (Transvaal Nature Conservation Division 1977). These conditions caused a temporary rise of the threshold imposed on the eland population by the winter browse supply and the numbers of eland increased rapidly. An asymptote of $K = 90$ fitted the growth curve during 1974 to 1978 best (correlation coefficient of -0,97, $p < 0,05$), but this total was never reached and the population started declining after reaching a peak of 81 in 1980. A crash in the population followed and 39 eland died of unknown causes during 1980/1981 and another 16 in the following year. The turning point was reached in 1982 when there were 29 eland left and the mortality rate has been less than 10% since that time.

The population during the present study

The size of the population varied between 25 to 45 eland during the period of the present study (Table 7). Additions were due to births of calves and the arrival of two adult females from outside the reserve. The latter probably came from Bloemhof Dam Nature Reserve when public hunting was allowed in the winter of 1984. The level of the Vaal River was very low and the entire population left the reserve. Most of the animals moved to the

Sandveld Nature Reserve in the Orange Free State, but unverified sightings of eland by local farmers on the Bloemhof/Schweizer-Reneke road (D. Zeller pers comm) indicate that some eland had wandered off in other directions. It is highly likely that the two females that joined the SALNR population later on were wanderers which were attracted to the resident eland and jumped the fence to join them. No eland escaped from the SALNR during the present study.

Losses to the population were caused by the few natural deaths and the culling of four adult males and one subadult male. A group of 15 eland (one adult and two yearling males, three adult and three yearling females and six calves) were captured and translocated to the Bloemhof Dam Nature Reserve in May 1985.

Table 7 : The population size of the eland on the SALNR during 1984 and 1985.

	MALES			FEMALES			CALVES	TOTAL
	ADULT	SUBADULT	YEARLING	ADULT	SUBADULT	YEARLING		
April 1984	9	3	2	11	2	4	4	35
May 1984	9	3	2	11	2	4	4	35
September 1984	8	3	2	13	1	4	4	35
October 1984	8	3	4	13	1	6	1 *	36
February 1985	5	3	4	13	1	6	11	43
May 1985	5	3	4	13	1	6	12	44
removed	1		2	3		3	6	15
left	4	3	2	10	1	3	6	29
August 1985	3	2	2	10	1	1	6	25
October 1985	3	4	3	9	1	3	5 *	28
December 1985	3	4	2	9	1	3	8	30

*newborn calves

Social organisation

The group structure of the eland was a very loose association for a large part of the present study. With the exception of the summer months the size and composition of groups changed almost daily due to the combination and division of different social groups.

A total of 389 groups ranging in size from 1 to 39 were recorded. The associations between the different sex/age categories are summarized in Figure 17. The figures above the squares indicate the number of groups containing only one category (including single animals). Figures on lines indicate the number of groups containing the two connected categories and figures in the middle of three or four squares indicate the number of groups containing the surrounding categories.

Adult males

When the project commenced in April 1984 there were nine males on the reserve, but in August 1985 only three remained due to culling and one translocation. No subadult males moved into the adult group during the study.

One hundred and thirty six all male groups ranging from 1 to 8 in size were recorded. Associated individuals in all-male groups formed fairly stable bonds and stayed together for long periods of time. Moreover, solitary males were also observed to stay on their own during a whole observation period without any socialising with other eland.

Males were seen in the company of other eland on 106 occasions. Adult females were present in 95 (or 89,6%) of these groups.

The number of males in these associations ranged from one to eight but the majority of sightings were of one male associated with the single herd formed by the females and young during the summer. Other males joined this group occasionally but for short periods only.

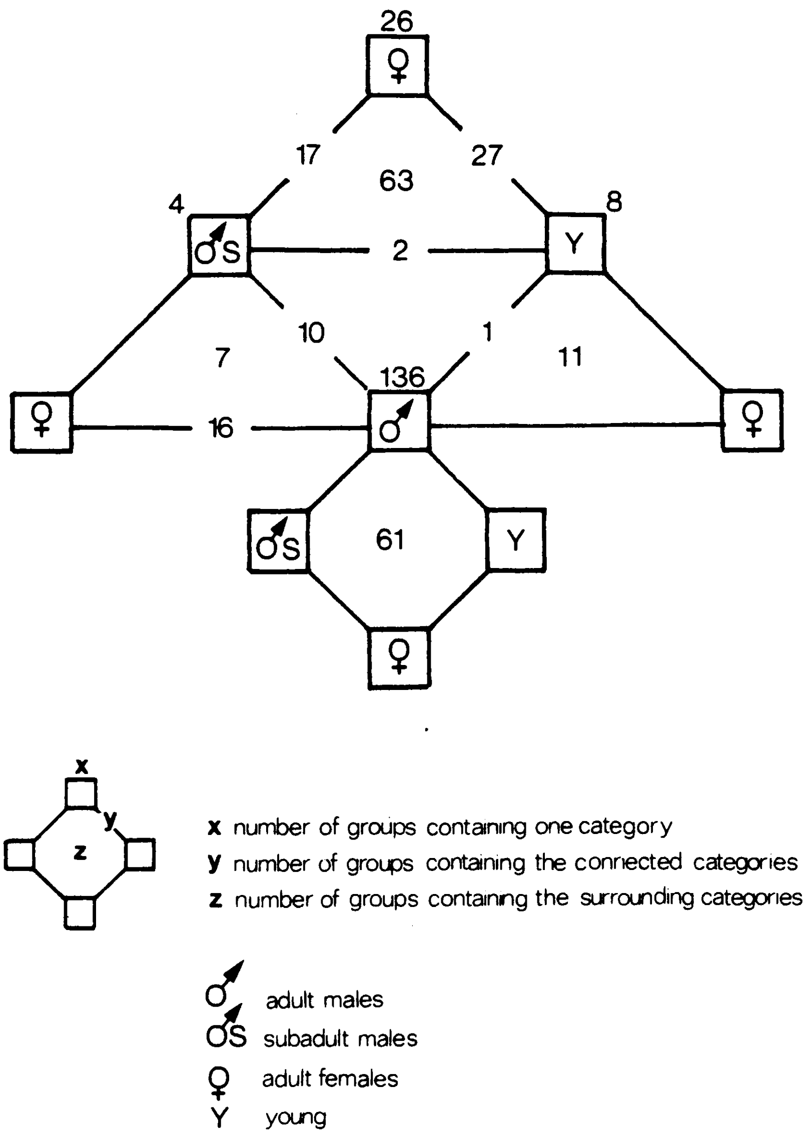


Figure 17 : Associations between different eland sex/age categories on the SALNR during 1984 and 1985.

On 10 occasions males were seen in the company of subadult males only. Seven of these observations were made during the last half of 1985 when the two subadults involved were well over three years old and would have joined the adult male category within the next twelve months.

Subadult males

Apart from the 10 cases mentioned in the previous paragraph and the four subadult male groups, subadult males were always seen in groups containing adult females and/or young (91,5%).

Adult females

A total of 228 groups containing adult females were recorded. All-female groups were mostly seen during the dry season and constituted 11,4% of the total, with the size of these groups ranging between 1 and 7.

Of the groups containing females 71,1% included young. Females were seen in the company of males and/or subadult males only on 14,5% of the observations.

During the summer months all the females on the reserve usually formed one herd which included all the young, some subadult males and one adult male for most of this time.

Young

Young were recorded in 173 groups during the study period and females were present in 93,6% of these groups. Young were seen in the company of adult or subadult males only on three occasions and eight all-young groups of one to six individuals were recorded.

Seasonal changes in group structure

Changes in group size and composition (Fig. 18) followed a strict seasonal cycle. During the rainy season the females and young formed a single herd, but in winter this herd split up into smaller groups which varied in size and composition on a daily basis.

Figure 19 shows the seasonal variation in the average group sizes for the different categories. Only the largest groups containing 75% of the total number of eland recorded during a specific season were taken into account for the calculation of the average group size, which was then expressed as a percentage of the total number of animals in that category. The reason for adopting this method for the calculation of group size was to reduce the distorting effect single animals and splinter groups had on the average, while the size of the population varied too much during the study period to use real numbers for the description of seasonal changes.

The number of females seen together varied from 100% of the total in summer to 50% or less during the winter months. The average group size of the combined young was never lower than 60% of the total number of young, while the average group size of the yearlings (except May 1985) and calves (except September 1984) was always above 80% of the total. During the summer the total of the combined female/young group was over 98% of the total.

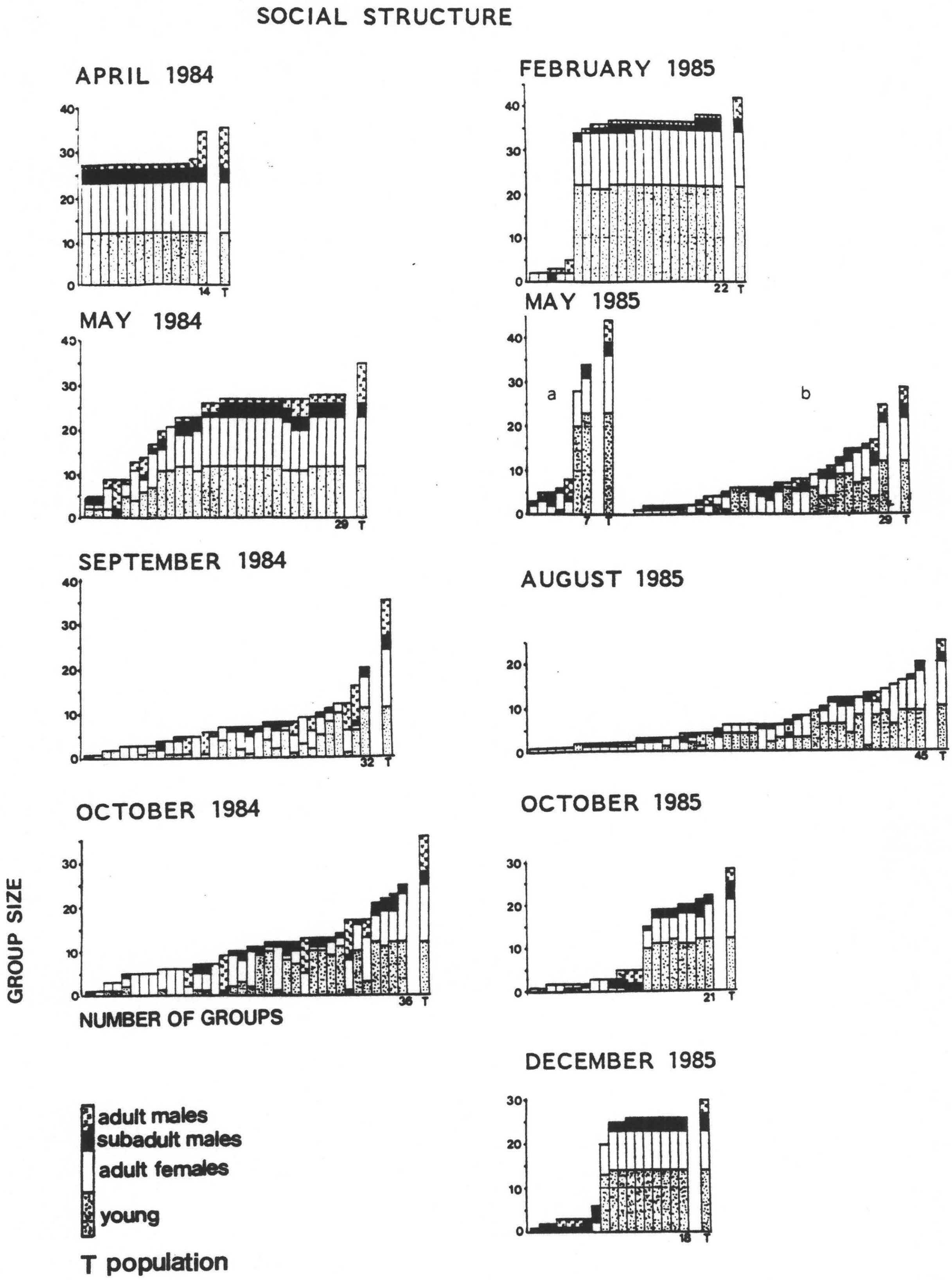


Figure 18 : Seasonal changes in eland group size and structure on the SALNR during 1984 and 1985.

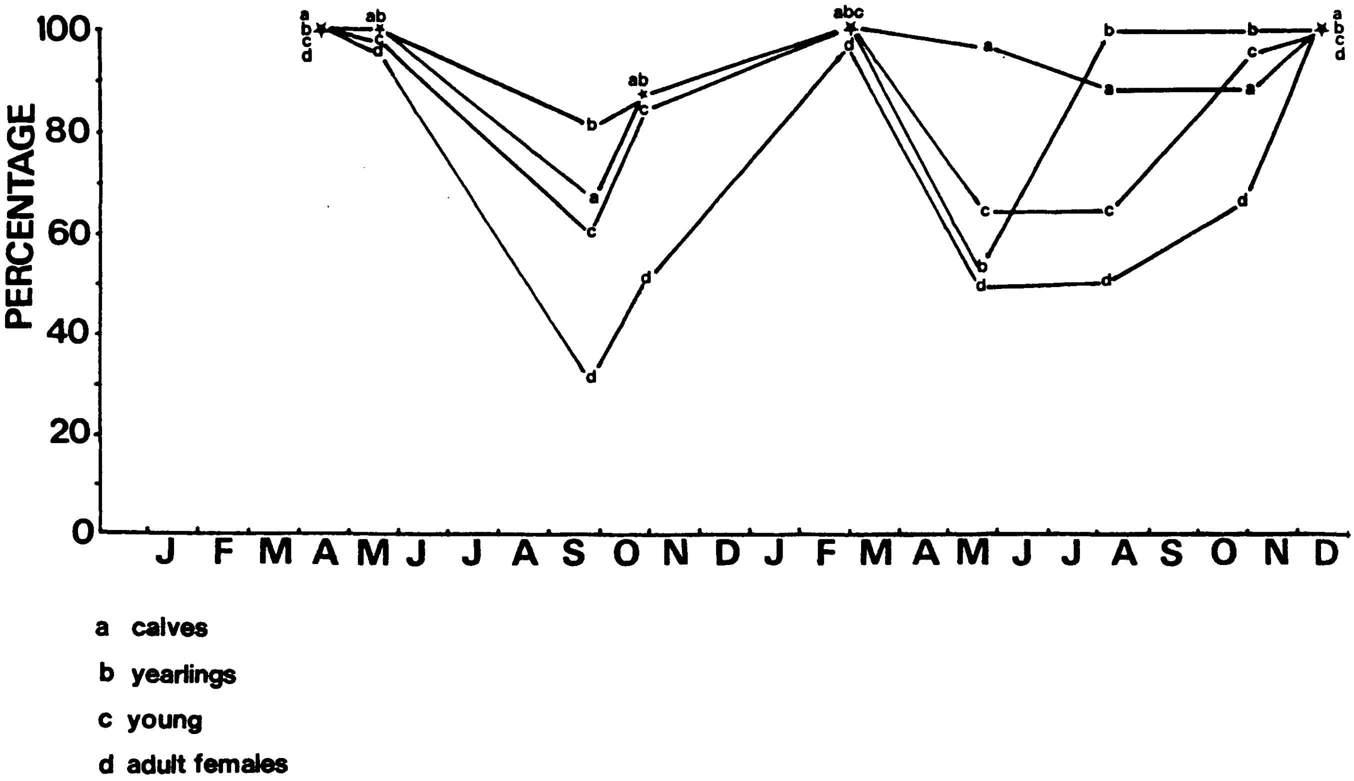


Figure 19 : Seasonal variations in the average group size of different eland sex/age categories on the SALNR during 1984 and 1985.

Reproduction

Information on the distribution of births on the SALNR was obtained from the game register which is kept on the reserve. Inscriptions where the month of birth was not precisely indicated were omitted for the calculations.

Calves may arrive during all months of the year but most are born from September to January with a peak in November (Fig. 20A). Skinner, Van Zyl & Oates (1974) recorded the births of 94 eland up to February 1973, but the addition of births since then until December 1985 alters the picture somewhat although the basic pattern does not change. The total of 224 births now shows that a larger number of calves still arrive in February and the difference between the number of births in November and the other months of the breeding peak has been reduced.

During the two years of the present study the population had a high calving rate with 12 out of 13 females giving birth from July 1984 to June 1985 and 8 out of 9 from July to December 1985. The overall calving percentage was 90,9% or a possible 95,4% if the remaining female had given birth during the first half of 1986.

The distribution of births during the present study is plotted in Figure 20B. The gestation period of eland in the western Transvaal is 279 ± 2,9 days (Skinner & Van Zyl 1969) thus if we extrapolate backwards it is found that most females conceived during March and January of the two respective years covered by the present study.

Six of the twelve calves born in the year of 1984/85 were removed from the reserve in May 1985. Of the remaining six only one died before the onset of the next calving season. This calf was born in February 1985 and had always been much smaller and weaker than the other calves of the same season. No information was available on the survival of the calves which had been removed, but the calves that remained had a high survival rate of 83,3%.

DISCUSSION

The expected age of the eland on the SALNR was calculated at 14,9 years which falls within the range of 14 to 16 years of captive eland at Askanya-Nova in Russia (Treus & Kravchenko 1968, Treus & Lobanov 1971) The age at first calving ranges from 22 to 57 months (Skinner 1966, Treus & Kravchenko 1968, Treus & Lobanov 1971, Roth et al 1972), thus if an average of

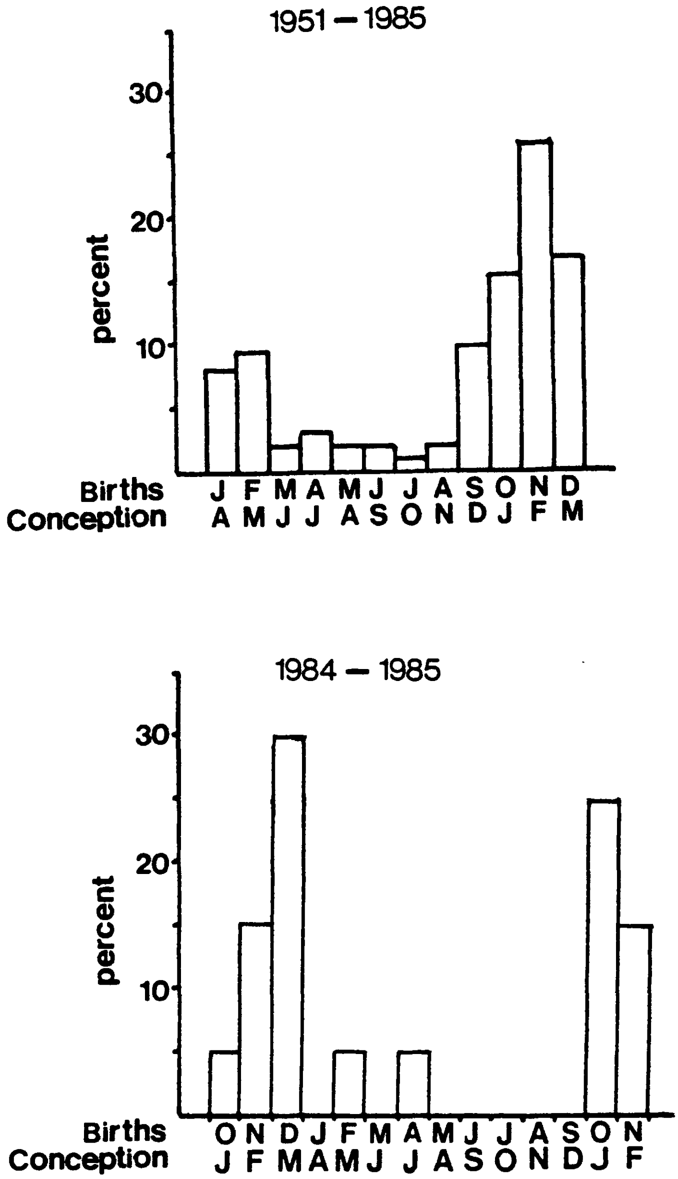


Figure 20A : Distribution of 224 eland births on the SALNR from 1951 to 1985.
20B : Distribution of 20 eland births on the SALNR during 1984 and 1985.

four years before calving is subtracted from the life expectancy it leaves the females with 11 years of potential reproductivity. The average fertility of eland at Askanya-Nova was 0,9 (Treus & Lobanov 1971), which would enable the females at the SALNR to produce 10 young during their lifespan.

The predicted upper limit of the eland population indicates that the SALNR can maintain 30 to 40 eland.

Since the introduction of the first eland in 1949 until 1970 the population was allowed to increase steadily in size despite culling and removals and fluctuated between 30 and 40 until 1975. In 1976 an abnormally wet period was experienced on the SALNR which resulted in the flooding of the eastern part of the reserve and a subsequent excess of forb growth (Transvaal Nature Conservation Division 1977).

Eland numbers were allowed to increase to peak at 81 in 1980. This resulted in a crash in the population when the food supply returned to normal and 55 eland died during a period of two years. Details on the causes of these deaths were not available but it is probable that the crash was the result of a food shortage once the effect of the flood on the vegetation had declined.

In similar cases where population crashes have occurred the population usually declined to a level well below the previous carrying capacity of the area. The feeding habits of the eland probably prevented this happening in the SALNR. During the summer months eland graze extensively and are not dependent on woody vegetation for the provision of a high quality diet, which allowed the thickets to recover sufficiently during the wet season to support the same number of eland as before the large increase in the population.

From the information on the population gained from the game register it is apparent that no excessive mortality was experienced when the population was maintained at 30 eland plus the calves of the year. Due to the limited amount of available browse this seems to be the maximum stocking rate for eland which the reserve can maintain during the periods when the nutritive quality of the grassland is too low to satisfy their high energetic needs.

Seasonal fluctuations in group size described by Underwood (1975), Hillman (1979) and Scotcher (1982) who studied eland occupying different habitats were also found to occur in the western Transvaal population.

The decrease with age in association between animals of the same age group found by Underwood (1975) at the Loskop Dam Nature Reserve and Hillman (1979) in East Africa was also observed in this study, although the yearlings on the SALNR formed a more stable group than the calves of the year.

Both Underwood (1975) and Scotcher (1982) described increases in the association of males with females during the summer months from November to January or February. During the present study the herd of females and young were still accompanied by a male as late as May 1984. When the herd had reformed after the winter of 1985 it had not yet been joined by a male during the latter half of December when the study was terminated.

Although eland do not have a marked breeding season definite peaks in calving occur. Differences in the timing of these peaks between different environments probably result from variations in nutritive quality of the winter diet (Skinner & Van Zyl 1969). Scotcher (1982) reported calving peaks in September and October in the Natal Drakensberg, which is much earlier than the peak in November for Transvaal Highveld eland. Like the study of Skinner & Van Zyl (1969) where highveld and bushveld eland were compared, the difference in breeding peaks of Highveld and Drakensberg eland is probably a result of dietary quality. In the Drakensberg winter ends in July or August (Scotcher 1982) which should result in an earlier improvement of the quality of grazing than that experienced on the Highveld where the first rains usually fall in October. Although the environmental conditions in the Drakensberg are much harsher than on the Transvaal Highveld this seems to play a less important role in the determination of calving peaks than the quality of the forage.

Scotcher(1982) postulated that the formation of large herds during summer is likely to be a measure for protection of the calves rather than a response to an increase in food quality. This is substantiated by the data collected during the present study. In October 1984 the eland were still scattered in small groups although it had already rained 51,6 mm in the ten days preceeding the start of the observations. Only one calf had been born by that time. In October 1985, however, five calves had been born and with a few exceptions all the animals excluding adult males had formed a single herd even though it had not rained at that stage at all.

This all indicates that the eland is primarily a species with a low social cohesiveness to facilitate optimal utilisation of the widely distributed browse resources, but that an increase in the quality of the grassland allows them to form large groups mainly to ensure better survival of their offspring.

The peak in parturition occurred in December of the first and October of the second year of the present study. The interval of ten months between the peaks implies that some females must have conceived very shortly after giving birth, which corresponds with the findings of several authors that eland do not have a lactation anoestrus (Skinner & Van Zyl 1969, Stainthorpe 1972).

The peak in conceptions at the SALNR derived from the distribution of births occurs in February, which is somewhat later than found in some other areas (Underwood 1975, Jeffery 1978 and Scotcher 1982). The peaks of conception during the present study were in March and January of the two respective years and both peaks occurred well within the optimal breeding season as derived from the total birth distribution.

The calving percentage of the females (90.9%) compared well with published figures (Skinner & Van Zyl (1969) (80-85%), Jeffery (1978) (88,9%), Hillman (1975) (67-68%) and Scotcher (1982) (95%)).

The mortality rate (16,7%) of the calves before they were one year of age was much lower than reported in other studies. Hillman (1979) found that calves only formed 33% of the number of females after four months of calf mortality had occurred, which means that more than half of the calves had not survived.

Scotcher (1982) reported a mortality of 66% of wild calves and Jeffery (1978) found a mortality rate of 20,9% in captive-born calves in the Drakensberg. In another captive herd in Zimbabwe a mortality rate of 32% of calves was experienced (Roth et al. 1972).

The higher survival rate of the calves on the SALNR can be ascribed to several factors like the absence of large predators, low tick infestation (Lightfoot 1977) or less harsh environmental conditions than experienced in places like the Drakensberg, but the most important factor was probably that the number of eland was maintained within the stocking rate of the reserve.

CHAPTER 6

FEEDING

INTRODUCTION

Direct observations of feeding were only possible when eland were browsing well above ground level. Attempts were made to determine food selection nearer ground level, but this caused too much disturbance and disruption of the eland's normal behaviour. For this reason the diet was studied by examination of faeces.

Faecal analysis has several limitations (Arman, Hopcraft & McDonald 1975, Holechek, Vavra & Pieper 1982a, McInnes, Vavra & Krueger 1983) of which the most important is the differential digestion of food species (Monro 1982). Stewart (1967), however, found that only species eaten infrequently and in small quantities are missed completely. The advantages of the technique which outweigh the limitations are that food ingested over a range of feeding time becomes mixed during digestion, the animals are not disturbed in any way and there is no need for killing to obtain samples. Anthony & Smith (1974) found that 15 faecal samples provided the same precision in predicting dietary composition as 50 rumen samples collected from deer so that a relative small sample size is needed.

The chemical composition of faeces is a reflection of the quality of the diet (Erasmus, Penzhorn & Fairall 1978, Holechek, Vavra & Arthun 1982b, Leslie & Starkey 1985) and is useful as an index to changes in dietary quality.

The seasonal changes in dietary intake as reflected by the analysis of the chemical contents and dietary fragments found in faeces will be discussed in this chapter.

METHODS

Ten faecal samples were collected during each of the the five observation periods in 1985. Only fresh faecal samples of eland females and young older than a year were collected after observed defecations. The samples were air dried on the reserve and oven dried for two days at 50°C before being ground and analysed in the laboratory.

Faecal samples were also collected from three other species (impala, gemsbok and black wildebeest) for comparative purposes during the same periods and were treated in the same manner as the eland faeces.

Plantmaterial

Eight grass and six browse species were collected during each period, except when the deciduous shrubs had lost their leaves. Where possible only green leaves were collected but inspection of the woody plants revealed that the growing tips of *Acacia karroo, Tarchonanthus camphoratus* and *Diospyros lycioides* were completely taken by eland during the early growing season and these were thus collected in the same way.

Collections of plant material were always made in the same location to minimise differences in nutritive quality caused by differences in soil type.

Material was collected from the following species:

a) Grasses: *Themeda triandra, Cymbopogon plurinodis, Digitaria eriantha, Sporobolus ioclados, S. fimbriatus, Eragrostis lehmanniana, E. obtusa* and *Panicum coloratum*.

b) Woody plants: *Acacia karroo, Rhus lancea, Tarchonanthus camphoratus, Diospyros lycioides, Grewia flava* and *Ziziphus mucronata*.

Fibre and nitrogen contents

Ten faecal samples from eland were analysed per season. The neutral and acid detergent fibre contents (NDF and ADF) were determined according to the methods described by Goering & Van Soest (1970) and the nitrogen contents by the Kjeldahl method (A.O.A.C. 1975). Crude protein was estimated by multiplying the nitrogen value by 6,25.

The plant material and five faecal samples of each of the other species collected during each observation period were treated in the same way.

Dietary fragments in faecal samples

Plant leaf is largely indigestible and can be used as a specific diagnostic characteristic (Storr 1961). Qualitive grazing preferences are adequately determined by the examination of epidermal characters of dietary fragments in faeces (Stewart 1967, Liversidge 1970, Stewart & Stewart 1970), but dicotyledonous material is usually underrepresented due to higher digestibility and fragments that are sometimes so transparent that the cellular structure is invisible (McInnes et al. 1983).

Despite the above-mentioned bias towards grass in faeces it is however possible to detect seasonal changes in diet selection and the emphasis was thus placed on the seasonal changes in the dicotyledon : monocotyledon ratio. Where possible browse species were identified, but no attempt was made to identify grasses.

A reference collection of epidermi from a selected number of browse species that occur on the SALNR was prepared from green material preserved in a 50:50 mixture of 10% alcohol and glycerol. The slides were prepared following the method described by Monro (1979).

Ten faecal samples per collection period were prepared in the same manner as the reference material. Cleared fragments were viewed under a binocular microscope (40x magnification or higher when necessary) along parallel transects one microscopic field apart to avoid double-counting of larger fragments. One hundred identifiable plant fragments were recorded per sample which is sufficient to reveal species comprising more than five percent of the diet (Stewart 1967).

RESULTS

Forage quality

Seasonal fluctuations in crude protein (CP) and crude fibre contents followed the same pattern in all the plant species that were studied although large differences were observed in the levels of the various chemical components between browse and grass species.

The average values for CP and fibre contents showed that the quality of browse was superior to that of grass throughout the year. Browse had higher CP and lower fibre contents during all seasons (Fig.21).

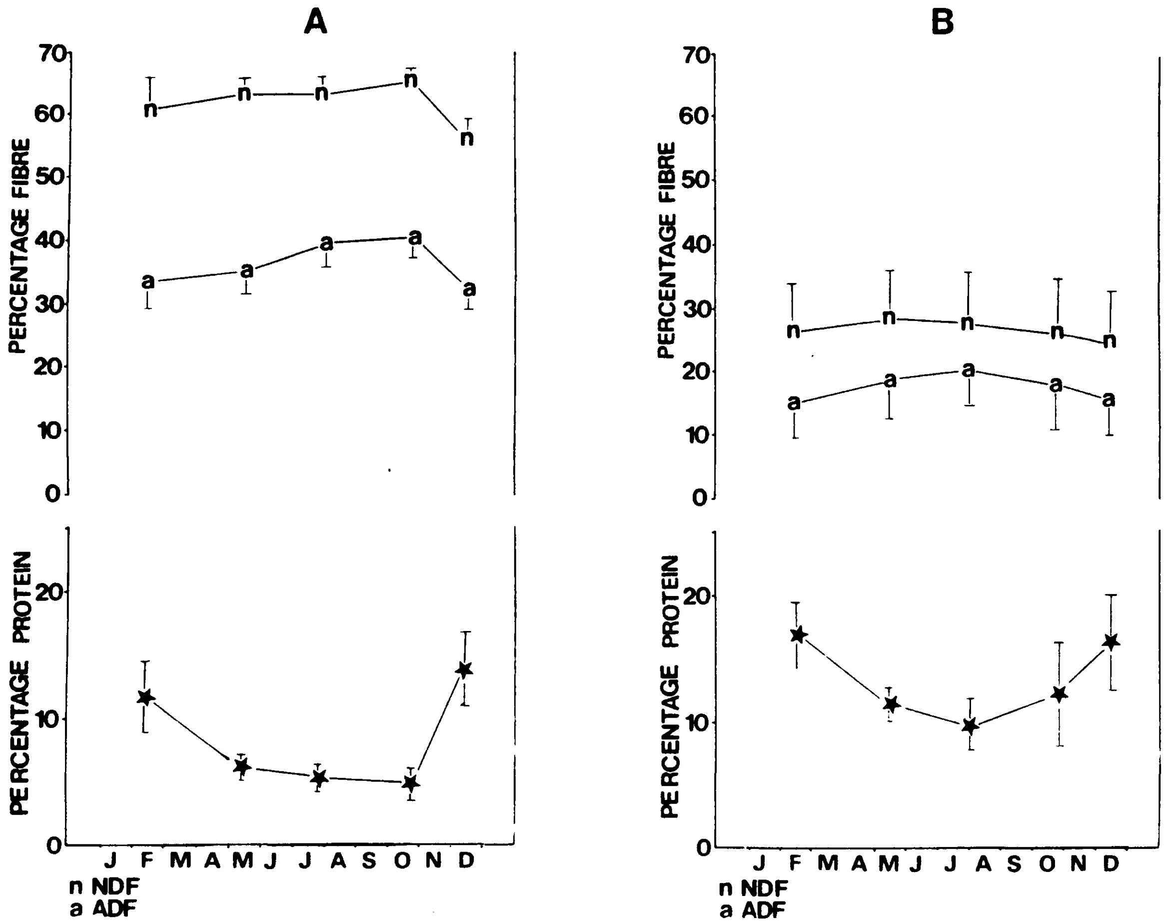


Figure 21 : Average crude fibre and crude protein contents of :
A : Grass
B : Browse.

The grasses showed less interspecific variation in CP and fibre contents than the browse species, but the sample of the latter was small in winter when no fresh material was obtained from <u>D. lyciodes</u>, <u>G. flava</u> and <u>A. Karroo</u> (Appendix II).

The nutritive quality of the browse improved earlier than that of the grass. The CP contents of the browse had started increasing before the onset of the rainy season, while that of grass was at its lowest level during this time. The fibre contents of the grass reached a peak in the same period while the fibre contents of browse was decreasing. The dependence of grass on rainfall for growth is illustrated by these trends, while the woody species can utilise the water at deeper levels and are therefore independent of rain for commencing seasonal growth.

Chemical contents of faeces

The CP concentration of the eland faeces fluctuated between 8,06 and 11,53% and reached a nadir in mid winter. The CP level started increasing in late winter and reached a peak in December (Fig. 22A).

The fibre contents increased steadily during the winter and reached a peak at the end of the winter. The concentration of both NDF and ADF declined sharply by more than 20% after the start of the rains.

Seasonal changes in the composition of impala faeces followed the same pattern, although the levels of NDF and ADF were almost 10% lower than those of eland faeces in the winter (Fig. 22B).

The CP contents of the faeces of the two grazers, the gemsbok and black wildebeest, were higher than those of the eland in midsummer, but declined sharply during winter to a level below the lowest levels of both eland and impala. The fibre contents of the faeces of the grazing species increased until the middle of winter, decreased at the end of the winter and increased again in summer (Fig. 22C & D).

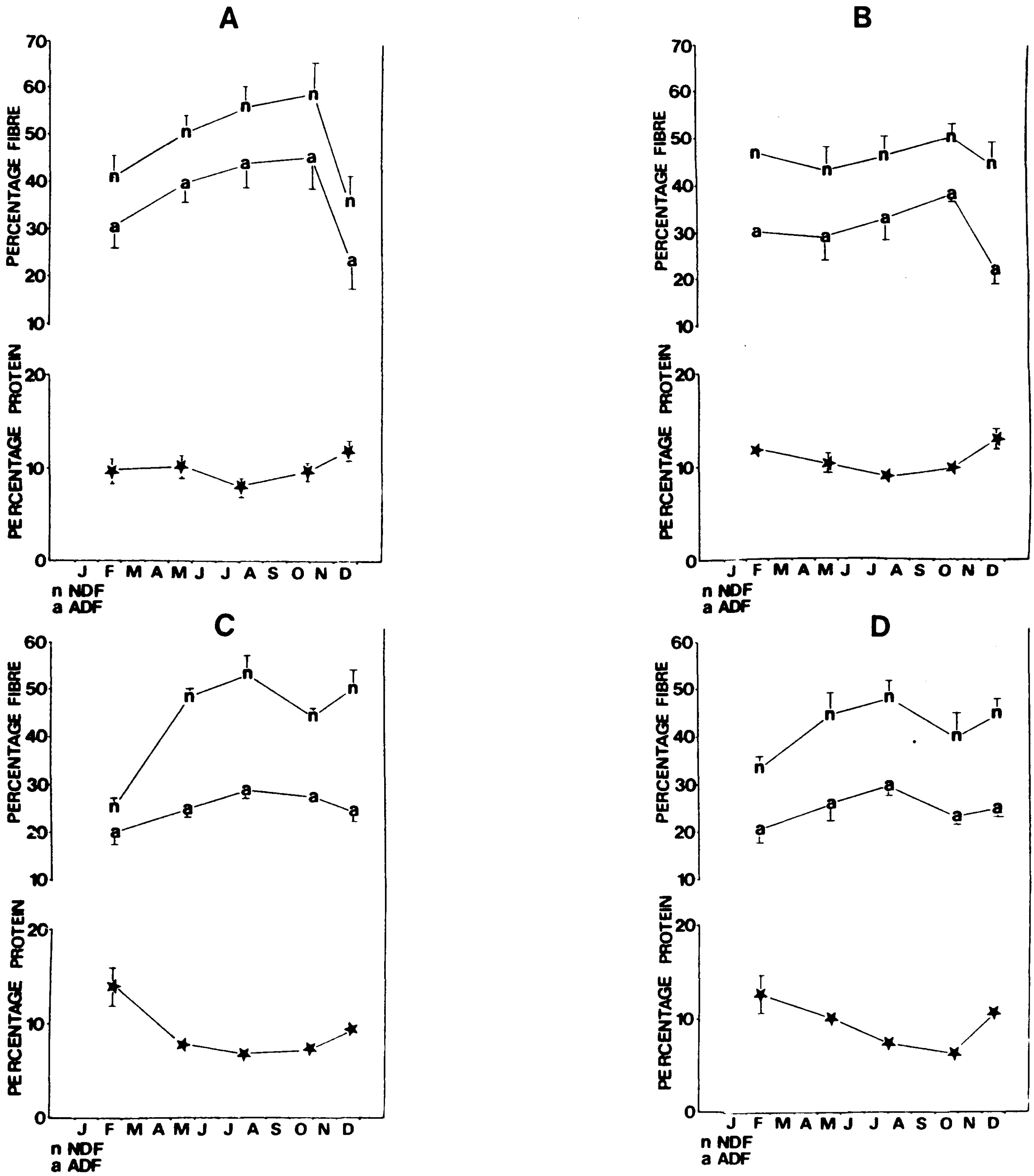


Figure 22 : Average crude fibre and crude protein contents of :
A : Eland faeces
B : Impala faeces
C : Gemsbok faeces
D : Black wildebeest faeces

Dietary fragments in faeces

The consumption of dicotyledons increased from February to May and then remained static until the end of the winter. In December there was a sharp decline of 40% in the proportion of browse in the faeces (Fig. 23A).

Five browse species were identified (Table 8) but important species like Z. mucronata could not be detected probably due to the high digestibility of the leaves. Dicotyledons other than woody species could also not be identified because of a lack of reference material.

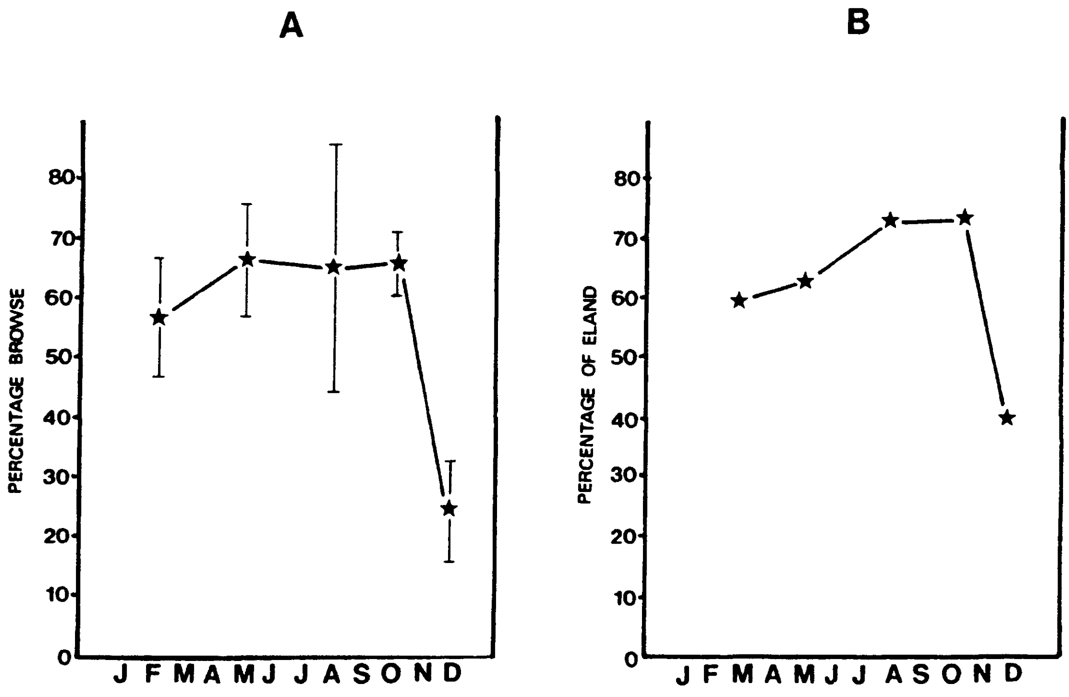


Figure 23A : Percentage fragments from browse plants in eland faeces on the SALNR during 1985.
23B : Percentage of eland females and young recorded in thickets on the SALNR during 1985.

Table 8 : Browse species identified in eland faeces on the SALNR

	FEBRUARY	MAY	AUGUST	OCTOBER	DECEMBER
Rhus lancea	*			*	*
Grewia flava	*	*		*	*
Diospyros lycioides	*	*	*	*	*
Tarchonanthus camphoratus	*	*	*	*	
Acacia karroo	*		*	*	*

Of the identifiable species D. lycioides occurred in the largest proportions during most seasons except midwinter when T. camphoratus was the most abundant. Although no fresh leaves of D. lycioides and G. flava were found in winter these species were present in the faeces, indicating that either dead material was taken or that I overlooked some of these plants.

The percentage of non-grass species in the faeces followed the same basic seasonal patterns as the percentage of observations of eland in woodlands (Fig. 23B) which confirms the assumption made in chapter 4 that frequenting woody areas implicates browsing.

DISCUSSION

When forage other than grass is included in the diet the nitrogen content of faeces is not a very accurate indicator of actual protein intake (Arman et al. 1975, Zimmermann 1978). Animals which select for a high protein diet have relatively small rumens and a high fermentation rate. The rumen epithelium is also densely papillated which facilitates absorption (Hofmann 1968). These factors cause the formation of less bacterial N, a higher digestibility of protein and lower digestibility of crude fiber which has a diluting effect on faecal N (Arman et al. 1975).

Despite the inaccuracies in the prediction of protein intake from faecal N the method has potential for monitoring trends in ruminant dietary quality (Holechek et al. 1982b) and could be used as a very general indicator of protein intake such as qualitative seasonal changes (Robbins 1983). Erasmus et al. (1978) established a positive relationship between N in feed and faeces of springbok and sheep but warned that N intake could not be estimated from the faecal N contents.

The quality of forage may also be expressed in terms of the concentrations of components like fibre, lignin and silica which limit digestibility (Hart, Abdalla, Clark, Marshall, Hamid, Hager & Waggoner 1983). Forage quality and crude fibre are inversely correlated (Yalden 1978) and lignin which increases with advancing cellular maturity is the main factor limiting the digestibility of cell wall polysaccharides (Van Soest 1964 and 1978, Robbins 1983).

Data collected by Jarrige (1965, which was further calculated by Erasmus et al. (1978)) gave a correlation of 0,94 between cellulose of food and faeces which would make faecal fibre contents a useful tool in predicting the quality of the diet.

In the present study the lignin contents of feed and faeces were not measured, but the NDF and ADF levels should be good indicators of the digestibility when related to the information given in the previous paragraphs.

The chemical composition of eland faeces showed fluctuations which correlate well with the observation on habitat selection. The low fluctuations in the N contents of faeces indicate the selection of a high protein diet during winter which could only have been obtained by changing from grazing to browsing when the protein levels in the grasses declined. The peak level of fibres in the faeces at the end of the winter when the fibre contents of browse was declining does not indicate a change to grazing, but was probably caused by the faster rate of passage which is associated with a high quality diet and which leaves a shorter time for fermentation. The sampled plant material was also carefully selected whereas it may not have been nutritionally economical for eland to spend too much time feeding on new growth which was not very plentiful at that time.

The chemical composition of impala faeces showed the same seasonal pattern as that of eland, but differed from that of gemsbok and black wildebeest. The faeces of the latter two species showed larger seasonal fluctuations in crude protein contents which also reached lower levels in winter than found in eland and impala faeces.

The fibre contents of the faeces of the two grazing species was much lower during midsummer than that of the two browsers, indicating a longer retention time of food which favours a higher fibre digestibility. At the end of winter there was a decline in faecal fibre levels for gemsbok and black wildebeest which could indicate a change in diet. Both these species are predominantly grazers, but will take browse when the grass cover is low (Van Zyl 1965, Dieckmann 1980) and this seems to be reflected in the faecal fibre levels.

Differences in faecal chemical composition between species inhabiting the same environment were also found to exist between springbok and mountain zebra (*Equus zebra*) studied by Erasmus *et al*. (1978) and seem to be real reflections of the quality of forage available to or selected by different species.

Microscopical analysis of faeces is generally acceptable when grazers are involved since grass epidermi remain largely intact during digestion (Storr 1961, Stewart 1967, Liversidge 1970, Monro 1982). The method has been criticized when dicotyledons are part of the diet due to the difficulty in differentiating between species and differential digestibility of various species. Structural differences between monocotyledons and dicotyledons are however very conspicious and after careful examination of the structure of a number of dicotyledonous epidermi it proved possible to distinguish between *R. lancea*, *A. karroo*, *G. flava*, *D. lycioides* and *T. camphoratus*.

The dietary fragments identified in the faeces of eland included large amounts of dicotyledons during the winter although grasses never formed less than one third of the fragments. These were probably taken to supply the roughage for rumen filling and regulation of passage rate. On the other hand, the proportion of browse in the faeces declined sharply during the rainy season and corresponds well with observations on habitat selection. The occurrence of browse species in faeces of which no fresh material was collected supports the findings of Lightfoot & Posselt (1977) that dry tree-leaves will be taken during periods when preferred herbage is in short supply. The high fibre contents of the eland faeces in late winter might also reflect this adaptation.

Of the identifiable browse species D. lycioides formed the most important part of the diet throughout the year except during midwinter when T. camphoratus was the best represented species. A. karroo and G. flava were also present in most of the samples. These species occur in high densities in Thicket E (Chapter 4) and the findings confirm the importance of this area to the eland.

The presence of large quantities of D. lycioides, T. camphoratus and G. flava in eland faeces reflects the abundance of these species on the SALNR. This could be an indication that although eland select a high quality diet in the form of browse during times of nutritional stress, they cannot afford to spend too much time to select for less abundant species during these periods.

The effect that eland have on the vegetation of the SALNR was best illustrated by Rhus lancea trees inside and outside the reserve (Fig. 24). The foliage of these trees reached the ground outside the reserve, but inside a clear browse line could be seen at a height of about 1,8 m. The habit of breaking branches with their horns (Kerr, Wilson & Roth 1970, Hillman 1979) was also clearly visible in the R. lancea trees and examination of freshly broken branches revealed that the eland had also fed on the leaves of these branches.

Eland have a high metabolic rate, a narrow thermal neutral zone and lose much urea in urine (Taylor & Lyman 1967). These cha-

A

B

Figure 24A : Rhus lancea trees outside the SALNR.
24B : Browse line on R. lancea trees on the SALNR.

racteristics necessitate the intake of food with a high protein content and the chemical contents of the faeces indicate that eland have adapted well to make optimal use of the available protein resources, although they have done so at the cost of a reduction of fibre digestibility when compared to predominantly grazing species.

Eland take full advantage of the grazing environment when the nutritive quality of grass is high and adapt as do grazing species (Jarman 1974).

The abundance of grass allows them to form large herds which facilitate the defence of the calves, but as the calves get older and veld quality decreases the eland adapt as would typical browsers to scatter in smaller groups which minimizes intraspecific competition for the limited browse available on the Transvaal Highveld. The overall picture that emerges when the feeding strategies are studied supports the view of Hillman (1979) that eland are essentially browsers which have to cope with living in a grazing environment.

The period of the highest nutritional stress occurs during late winter and coincides with advanced pregnancy and the following period of parturition and lactation. This emphasises the importance of allowing eland to roam around large areas to make full use of their ability to select for a diet rich in proteins, or conversely to control their numbers in restricted areas like the SALNR where browse is limited.

CHAPTER 7

CONCLUSIONS

PREDICTION OF FEED INTAKE AND BODY COMPOSITION

Faecal output has shown good correlation with feed intake of captive eland and could be a valuable tool in the study of wild animals, but further experiments are needed to determine if this relationship remains valid under varying environmental conditions. Daily faecal output can however only be determined accurately if the study animals are tame enough to be followed closely, which is also a prerequisite for the determination of the composition of the diet by direct observation.

If the study animals cannot be observed from close range, as was experienced during the present study, indirect methods will have to be employed to predict dietary intake and composition when energetics are to be studied. Food intake and water turnover are also well correlated, and although the labelled water technique did not yield accurate results during the present study it has successfully been used to predict water turnover in many other studies (e.g. MacFarlane & Howard 1972a, King, Kingaby, Colvin & Heath 1975). More experience in the administration of the isotope and its subsequent recovery from faeces should improve the results considerably.

Composition of the diet can indirectly be determined by analysis of faeces. Although the technique has several limitations (Holechek, Vavra & Pieper 1982a, Monro 1982, McInnes, Vavra & Krueger 1983) it yields valuable information if used to predict seasonal changes in feeding adaptations rather than as an absolute measurement of the dietary composition.

During the present study the proportion of fragments from browse plants in the faeces showed a good correlation with the proportion of eland recorded in woody vegetation, which confirmed the assumption that presence in thicket implies browsing.

The accurate prediction of the body fat of wild ruminants with THO depends on the accuracy with which the total body water pool can be estimated. Body water and fat are inversely correlated (Cameron & Luick 1972) but it is important to know the volume of water in the digestive tract before the fat contents of the body can be predicted.

During the present study the contents of the digestive tracts of the two slaughtered eland constituted almost exactly the same proportion of the respective live weights. If wild eland also show maximum rumenfill at certain times of the day, e.g. after a feeding or drinking session, immobilisation and weighing at these times should improve the accuracy of the prediction of body water and fat substantially.

ELAND IN THE WESTERN TRANSVAAL ENVIRONMENT

Eland are classified as Tragelaphines, but unlike the other representatives of this group which are woodland browsing species, the eland are also distributed widely in open grassland.

Being large animals with a high metabolic rate eland need a high quality diet throughout the year, which can only be acquired by utilising the patchily distributed browse during the dry winter periods. Eland therefore evolved to be highly nomadic, and, before the advent of fences, would scatter or aggregate and move great distances to make use of the resources available at a particular time. Despite the limited size of the SALNR the eland have been observed to cover large distances during their daily movements. The utilisation of thicket showed a steady increase during the dry season, which was also reflected by the proportion of browse fragments in the faeces. Eland solve the problem of inter-individual competition for the limited browse by forming small groups during the dry winter months.

The most intensively utilised area during the study was a small thicket-clump community containing high densities of Diospyros lycioides, Tarchonanthus camphoratus and Acacia karroo between 0,75 and 3,50m in height.

Although faecal nitrogen is at best an indicator of the dietary quality, analysis of faeces has shown that the nitrogen level of eland faeces is consistently higher than that of grazers like gemsbok and black wildebeest during the winter, which reflects a higher protein intake by eland.

Although eland breed throughout the year a definite peak occurs on the SALNR in November with the months between September and February also showing high numbers of births, but from March to August the births are low. The high numbers of births coincide with the rainy season and the eland in the western Transvaal seem to respond to environmental cues and produce most offspring during this period.

The summer conditions allow the females to aggregate in large numbers and to utilise the more abundant grass when its nutritive quality is high and inter-individual competition is greatly reduced.

In areas where large predators occur females in larger groups are more successful in defending their calves than females in smaller groups (Hillman 1979). Although predators are absent from the SALNR all the eland except adult and some subadult males gathered in one single herd when the calves arrived in the early summer, irrespective of whether it had rained or not.

The formation of large herds therefore seems to be triggered by the peak in calving, but this peak has been influenced by the summer rainfall pattern when the nutritive value of the grass is high.

From the data from the present study it is clear that eland are primarily browsers like other tragelaphine species, but when the dietary quality of the grassland is high they take full advantage of these conditions to secure the maximum survival of their offspring by forming large herds. The energetic needs of the females are high during lactation and grazing during this period allows them to ingest a larger quantity of forage than when selecting dicotyledonous material. When the grass lignifies and nutritive quality decreases at the end of the summer most calves are already a few months old and are less dependent on the females for feeding and protection, allowing the eland to resume their browsing habits.

MANAGEMENT RECOMMENDATIONS

Although the SALNR consists mainly of grassland, sufficient woody vegetation is present to sustain a viable population of browsers if numbers are controlled. This browser niche is filled by eland and impala. During the present study the impala population was small (±35 animals) and their distribution was mainly limited to the old diamond diggings and the *Tarchonanthus- Diospyros* bush (Thicket E), whereas the eland utilised all the woody plant communities on the reserve and were also capable of feeding at a higher level. Competition for food between the two species was thus limited during the present study and did not seem to have an effect on eland.

Although an intensive study on the carrying capacity of the thicket-clump communities had not been carried out it is evident from the records from the game register and the asymptotic values calculated for the population growth curves that the number of eland should not be allowed to exceed 40.

The present study has shown that eland cows have a high calving rate and calf mortality is low. It would therefore be realistic to assume that 18 females could produce 15 offspring per annum and the following management proposal will be based on this assumption.

Five males should be kept to maintain the selective advantages resulting from competition for mating. New males should occasionally be introduced to maintain genetic variety and old bulls can be removed by hunting.

Eighteen females should be kept as breeding stock. Calves can be kept for one year but should be removed at the end of the next rainy season when most females will have produced new offspring. As eland can be expected to reach an age of 15 years two female yearlings must be kept to replace old breeding stock which could be sold or hunted. Table 9 summarizes these proposals.

Table 9 : Proposals for the management of the eland population on the SALNR.

	MALES	FEMALES	SUBADULT FEMALES	YEARLINGS	CALVES
SUMMER	5	18	2	15	15*
AUTUMN	5	(2) 16	2	(13)	15
WINTER	5	18	2		15
SUMMER	5	18	2	15	15*
AUTUMN	5	(2) 16	2	(13)	15
WINTER	5	18	2		15
SUMMER	5	18	2	15	15*
AUTUMN	5	(2) 16	2	(13)	15
WINTER	5	18	2		15

( ) - REMOVE

* - NEW CALVES

These proposals could serve as a basic guideline for the management of the eland population and would have to be revised where there are outbreaks of disease or a reduction in calving rate and/or survival.

SUMMARY

Eland on the western Transvaal Highveld make extensive use of limited and patchily distributed browse during the winter. To reduce inter-individual competition they form small groups which vary daily in size and composition. Eland are highly mobile and are capable of covering large distances in search of food. They select for dense thicket-clump communities during the dry season and *Diospyros lycioides*, *Tarchonanthus camphoratus* and *Grewia flava* form an important part of the diet during this time.

During summer when the nutritive quality of grassland is high eland aggregate in large herds and feed mainly on grass. Most of the females give birth during the early wet season and in areas where large predators occur the formation of large groups ensures better protection of the calves. The herd is accompanied by a single male during the late summer months and most conceptions take place during this time. The females have a high calving rate and the survival of calves is high.

Although faecal analysis reflected a decline in food quality during the winter months the quality of the diet was consistently higher than that of grazing species like gemsbok and black wildebeest. Faeces of eland contained predominantly browse fragments during the dry season but the proportion of browse declined sharply with the onset of the rainy season.

The carrying capacity of the SALNR was calculated at ± 35 eland during normal circumstances. During 1976, however, heavy rains were experienced which caused the flooding of a large part of the reserve and this resulted in an abnormal increase in forb

growth. The eland population was allowed to increase to number 81 animals, but when conditions returned to normal 55 eland died within two years, emphasizing the importance of the woody vegetation during the winter months.

Two eland, a mature male and a young female, were kept in captivity to determine feed intake. Good correlations were found between feed and water intake and feed intake and faecal production. These findings should be investigated further for possible use in field studies. The determination of water turnover with tritium did not yield the expected results during the present study but this was probably caused by inexperience in the implementation of the technique and the results should improve with further experimentation.

Although the fat contents of the two eland differed considerably, the combined body water/fat fraction was almost identical for both animals. The contents of the digestive tracts expressed as percentages of the respective live weights were also similar for both eland and if further investigations yield the same results this would improve the prediction of body composition considerably.

OPSOMMING

Tydens die winter maak die elande op die Wes-Transvaalse Hoëveld intensief gebruik van die beperkte boom- en struikmateriaal wat wydverspreid voorkom. Om interspesifiese kompetisie vir hierdie voedselbron te verminder beweeg hulle in klein sosiale groepe wat daagliks varieer in grootte en struktuur. Elande is baie beweeglik en kan groot afstande aflê om voedsel te bekom.

Hulle voorkeur gebiede tydens die wintermaande is bosgebiede met 'n hoë plantdigtheid en _Tarchonanthus camphoratus_, _Diospyros lyciodes_ en _Grewia flava_ is van die belangrikste voedsel spesies gedurende hierdie tydperk.

In die somer wanneer die kwaliteit van die grasveld hoog is maak die elande van hierdie voedselbron gebruik en vorm groot troppe. Die voordeel hiervan is dat die oorlewingskanse van kalwers verhoog word deurdat koeie in groot groepe beter weerstand kan bied teen roofdiere. Alhoewel roofdiere nie in die studiegebied voorkom nie het hierdie gedragspatroon behoue gebly. Elande kan dwarsdeur die jaar teel maar op die Hoëveld word die meeste kalwers tydens die vroeë somermaande gebore. Tydens die laaste somermaande word die trop deur 'n enkele bul vergesel wat waarskynlik verantwoordelik is vir die meeste bevrugtings wat hoofsaaklik tussen Desember en Mei plaasvind. Die koeie het 'n hoë kalfpersentasie en die oorlewing van die kalwers is hoog.

Die vesel en proteien inhoud van elandmis het 'n afname in voedsel kwaliteit tydens die wintermaande aangetoon, maar was deurgaans van 'n hoër kwaliteit as die van die weidende spesies soos gemsbokke en swartwildebeeste. Die mis het ook groot hoeveelhede epidermale reste van boom- en struikmateriaal bevat tydens die winter, terwyl gras die grootste proporsie van die fragmente in die somer uitgemaak het.

Gegewens uit die wild register het getoon dat die SALNR tydens normale toestande 'n bevolking van ± 35 elande kan onderhou, maar na buitengewone swaar reëns in 1976 wat 'n abnormale toename in kruide tot gevolg gehad het, is die bevolking toegelaat om tot 81 diere te styg. Toe die toestande weer teruggekeer het na normaal het dit 'n sterfte van 55 elande binne twee jaar veroorsaak, wat die belangrikheid van die bosgebiede tydens die wintermaande vir die oorlewing van die elande beklemtoon.

Twee elande, 'n bul en 'n vers, is in gevangenskap aangehou om voedsel inname te bepaal. Goeie korrelasies is gevind tussen voedsel inname en mis produksie, asook tussen voedsel en water inname, en hierdie bevindinge behoort verdere aandag te geniet. Die gebruik van tritium om water omset te bepaal het swak resultate gelewer, maar verdere proefnemings behoort die probleme uit te skakel sodat dit met welslae in studies op vrylewende bevolkings toegepas kan word.

Alhoewel daar 'n groot verskil tussen die vet inhoude van die twee elande was, het die gesamentlike liggaamswater/vet komponent feitlik dieselfde persentasie van die leë liggaamsgewig by albei diere uitgemaak. Die inhoud van die spysverteringskanale as persentasie van die lewende massa was ook dieselfde by beide diere en verdere ondersoek behoort ingestel te word om vas te stel hoe konstant die verskynsel voorkom.

LIST OF REFERENCES

A.O.A.C. 1975. Official methods of the Association of Official Analytical Chemists. 12th ed. Ed. Horwitz, W. Washington. Ass. of Off. Anal. Chem.

Acocks, J.P.H. 1975. Veld types of South Africa, 2nd Ed. Bot. Survey Mem. No. 40. Govt. Printer, Pretoria.

Ansell, W.H.F. 1971. Order Artiodactyla. In The Mammals of Africa. An identification manual. Ed. Meester, J. and Setzer, H.W. Smithsonian Press, Washington.

Anthony, R.G. & Smith, N.S. 1974. Comparison of rumen and faecal analysis to describe deer diets. J. Wildl. Mgmt 38 : 535 - 540.

Arman, P., Hopcraft, D. & McDonald, I. 1975. Nutritional studies on East African herbivores. 2. Losses of nitrogen in faeces. Br. J. Nutr. 33 : 265 - 276.

Attwell, C.A.M. & Jeffery, R.C.V. 1981. Aspects of molariform tooth attrition in eland and wildebeest. S. Afr. J. Wildl. Res. 11 : 31 - 34.

Bird, P.R. 1984. Prediction of components of steer carcasses using tritiated body water space, fat depth and fasted live weight. Aust. J. Agric. Res. 35 : 435 - 442.

Bird, P.R., Flinn, P.C., Cayley, J.W.D. & Watson, M.J. 1982. Body composition of live cattle and its prediction from fasted live weight, tritiated water space and age. Aust. J. Agric. Res. 33 : 375 - 387.

Brooks, P.M., Hanks, J. & Ludbrook, J.V. 1977. Bone marrow as an index of condition in African ungulates. S. Afr. J. Wildl. Res. 7 : 61 - 66.

Cameron, R.D., White, R.G. & Luick, J.R. 1976. Accuracy of the tritium water dilution method for determining water flux in reindeer (*Rangifer tarandus*). Can. J. Zool. 54 : 857 - 862.

Cameron, R.D. & Luick, J.R. 1972. Seasonal changes in total body water, extracellular fluid and blood volume in grazing reindeer. Can. J. Zool. 50 : 107 - 116.

Carles, A.B., King, J.M. & Heath, B.R. 1981. Game domestication for animal production in Kenya : an analysis of growth in oryx, eland and zebu cattle. J. Agric. Sci. Camb. 97 : 453 - 463.

Cole, L.C. 1949. The measurement of interspecific association. Ecology 30 : 411 - 424.

De Korte, M. 1986. A vegetation map of S.A. Lombard Nature Reserve. Transvaal Nature Conservation Division. Unpublished Mimeograph.

Dieckmann, R.C. 1980. The ecology and breeding of the gemsbok *Oryx gazella gazella* (Linnaeus, 1758) in the Hester Malan Nature Reserve. M.Sc. Thesis, University of Pretoria, Pretoria.

Erasmus, T., Penzhorn, B.L. & Fairall, N. 1978. Chemical composition of faeces as an index of veld quality. S. Afr. J. Wildl. Res. 8 : 19 - 24.

Fairall, N. 1981. A study of the bioenergetics of the red-knobbed coot Fulica cristata on a South African estuarine lake. S. Afr. J. Wildl. Res. 11 : 1 - 4.

Field, C.R. 1975. Climate and food habits of ungulates on Galana Ranch. E. Afr. Wildl. J. 13 : 203 - 220.

Figueras, H.D., Verges, J.B., Carou, N., Parodi, J.J., Garcia Olano, H., Marangunich, L., Cavandoli, H. & Marcilese, N.A. 1972. Evaluation of radio isotope dilution to estimate the body composition of sheep in vivo. In Isotope studies on the physiology of domestic animals. IAEA/FAO Symposium, Athens, March 1972.

Finch, V.A. 1972. Thermoregulation and heat balance of the East African eland and hartebeest. Am. J. Physiol. 222 : 1374 - 1397.

Goering, H.K. & Van Soest, P.J. 1970. Forage fiber analysis. Agricultural Handbook no. 379. Agricultural Research Services, Washington D.L.

Hart, R.H., Abdalla, O.M., Clark, D.H., Marshall, M.B., Hamid, M.H., Hager, J.A. & Waggoner, J.W. 1983. Quality of forage and cattle diets on Wyoming high plains. J. Range Mgmt 36 : 46 - 51.

Hillman, J.C. 1979. The biology of the eland (Taurotragus oryx Pallas) in the wild. Ph.D. Thesis, University of Nairobi.

Hofmann, R.R. 1968. Comparisons of the rumen and omasum structure in East African game ruminants in relation to their feeding habits. Symp. Zool. Soc. Lond. 21 : 179 - 194.

Hofmeyr, J.M. 1970. A review of the food preferences of some indigenous herbivores in the Ethiopian faunal region and some studies on animal : plant relations. Proc. S.Afr.Soc. Animal Prod. 9 : 89 - 99.

Holechek,, J.L., Vavra, M. & Pieper, R.D. 1982b. Botanical composition determination of range herbivore diets : a review. J. Range Mgmt 35 : 309 - 315.

Holechek,, J.L., Vavra, M. & Arthun, D. 1982a. Relationships between performance, intake, diet nutritive quality and faecal nutritive quality of cattle on mountain range. J. Range Mgmt 35 : 741 - 744.

Jarman, P.J. 1974. The social organisation of antelope in relation to their ecology. Behaviour 48 : 215 - 267.

Jeffery, R.C.V. 1978. Age determination, growth and condition of a population of eland, Taurotragus oryx (Pallas, 1766), under semi-intensive management at Coleford Nature reserve. M.Sc. Thesis, University of Natal.

Jeffery, R.C.V. 1979. Reproduction and mortality of a herd of eland in Natal. The Lammergeyer 27 : 11 - 18.

Jeffery, R.C.V., & Hanks, J. 1981a. Body growth of captive eland Taurotragus oryx in Natal. S. Afr. J. Zool. 16 : 183 -189.

Jeffery, R.C.V. & Hanks, J. 1981b. Age determination of eland Taurotragus oryx (Pallas, 1766) in the Natal Highland. S. Afr. J. Zool. 16 : 113 - 122.

Keep, M.E. 1972. The meat yield, parasites and pathology of eland in Natal. The Lammergeyer 17 : 1 - 9.

Kerr, M.A., & Roth, H.H. 1970. Studies on the agricultural utilisation of semi-domesticated eland (*Taurotragus oryx*) in Rhodesia. 3. Horn development and tooth attrition as indicators of age. Rhod. J. Agric. Res. 8 : 149 - 155.

Kerr, M.A., Wilson, V.J. & Roth, H.H. 1970. Studies on the agricultural utilisation of semi-domesticated eland (*Taurotragus oryx*) in Rhodesia. 2. Feeding habits and food preferences. Rhod. J. Agric. Res. 8 : 71 - 77.

Kiley-Worthington, M. 1978. The social organisation of a small captive group of eland, oryx and roan with an analysis of personality profiles. Behaviour 66 : 32 - 55.

King, J.M. 1979. Game domestication for animal production in Kenya: field studies of the body-water turnover of game and livestock. J. Agric. Sci. Camb. 93 : 71 - 79.

King, J.M., Heath, B.R. & Hill, R.E. 1977. Game domestication for animal production in Kenya : theory and practice. J. Agric. Sci. Camb. 89 : 445 - 457.

King, J.M., Kingaby, G.P., Colvin, J.G. & Heath, B.R. 1975. Seasonal variation in water turnover by oryx and eland on the Galana Game Ranch Research Project. E. Afr. Wildl. J. 13 : 287 - 296.

King, J.M., Nyamora, P.O., Stanley-Price, M.R. & Heath, B.R. 1978. Game domestication for animal production in Kenya : prediction of water intake from tritiated water turnover.

J. Agric. Sci. Camb. 91 : 513 - 522.

Leslie, D.M. & Starkey, E.E. 1985. Faecal indices to dietary quality of cervids in old-growth forests. J. Wildl. Mgmt 49 : 142 - 146.

Lewis, J.G. 1977. Game domestication for animal production in Kenya : activity patterns of eland, oryx, buffalo and zebu cattle. J. Agric. Sci. Camb. 89 : 551 - 563.

Lewis, J.G. 1978. Game domestication for animal production in Kenya: shade behaviour and factors affecting the herding of eland, oryx, buffalo and zebu cattle. J. Agric. Sci. Camb. 90 : 587 - 595.

Lightfoot, C.J. 1977. Eland (Taurotragus oryx) as a ranching animal complementary to cattle in Rhodesia. 1. Environmental adaptation. Rhod. Agric. J. 74 : 47 - 52.

Lightfoot, C.J. & Posselt, J. 1977. Eland (Taurotragus oryx) as a ranching animal complementary to cattle in Rhodesia. 2. Habitat and diet selection. Rhod. Agric. J. 74 : 53 - 61.

Liversidge, R. 1970. Identification of grazed grasses using epidermal characters. Proc. Grassl. Soc. Sth. Afr. 5 : 153 - 165

MacFarlane, W.V., & Howard, B. 1972a. Comparative water and energy economy of wild and domesticated mammals. Symp. Zool. Soc. Lond. 31 : 261 - 296.

MacFarlane, W.V., Howard, B., Maloyi, G.M.O. & Hopcraft, D. 1972. Tritiated water in field studies of ruminant metabolism in Africa. In Isotope studies on the physiology of domestic animals. IAEA/FAO Symposium, Athens, March 1972.

McInnes, M.L., Vavra, M. & Krueger, W.C. 1983. A comparison between four methods used to determine the diets of large herbivores. J. Range Mgmt 36 : 302 - 306.

Meester, J. 1955. A mammal survey of the S.A. Lombard Nature Reserve (1954). Fauna Flora, Pretoria 6 : 45 - 57.

Monro, R.H. 1979. A study on the growth, feeding and body condition of impala. M.Sc. Thesis, University of Pretoria, Pretoria.

Monro, R.H. 1982. An appraisal of some techniques used to investigate the feeding ecology of large herbivores with reference to a study on impala in the northern Transvaal. Afr. J. Ecol. 20 : 71 - 80.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, Inc. New York.

Nge'The, J.G. & Box, T.W. 1976. Botanical composition of eland and goat diets on an Acacia-grassland community in Kenya. J. Range Mgmt 29 : 290 - 293.

Panaretto, B.A. 1968. Body composition in vivo. IX. The relation of body composition to the tritiated water spaces of ewes and wethers fasted for short periods. Austr. J. Agric. Res. 19 : 267 - 272.

Pfau, A. & Salem, M.A.I. 1972. Studies on the body composition of cattle by isotope dilution analysis. In : Studies on the physiology of domestic animals. IAEA/FAO Symposium, Athens, March 1972.

Posselt, J. 1963. The domestication of the eland. Rhod. J. Agric. Res. 1 : 81 - 88.

Reid, J.T., Woolfolk, P.G., Richards, C.R., Kaufman, R.W., Loosli, J.K., Turk, K.L., Miller, J.I. & Blaser, R.E. 1950. A new indicator method for the determination of digestibility and consumption of forages by ruminants. J. Dairy Sci. 33 : 60 - 71.

Robbins, C.T. 1983. Wildlife feeding and nutrition. Academic Press, New York.

Rogerson, A. 1968. Energy utilisation by the eland and wildebeest. Symp. Zool. Soc. Lond. 21 : 153 - 161.

Roth, H.H., Kerr, M.A. & Posselt, J. 1972. Studies on the utilisation of semi-domesticated eland (Taurotragus oryx) in Rhodesia. V. Reproduction and herd increase. Z. Tierzucht Biol. 89 : 69 - 83.

Scotcher, J.S.B. 1982. Interrelations of vegetation and eland (Taurotragus oryx) in Giant's Castle Game Reserve, Natal. Ph.D. Thesis, University of the Witwatersrand.

Sinclair, A.R.E. 1977. The African buffalo. The University of Chicago Press, Chicago.

Skinner, J.D. 1966. An appraisal of the eland (Taurotragus oryx) for diversifying and improving animal production in Southern Africa. Afr. Wildlife 20 : 29 - 40.

Skinner, J.D. 1967. An appraisal of the eland as a farm animal in Africa. Anim. Breed. Abstr. 35 : 177 - 186.

Skinner, J.D. 1971. Productivity of the eland : an appraisal of last five years' research. S Afr. J. Sci. 67 : 534 - 539.

Skinner, J.D. 1972. Eland vs beef : eland cannot compete except in hot semi-arid regions. Afr. Wildlife 26 : 4 - 9.

Skinner, J.D., Van Heerden, J.A.H. & Van Zyl, J.H.M. 1971. A preliminary note on the effect of season on the reproductive tract of the eland bull (*Taurotragus oryx*). S. Afr. J. Anim. Sci. 1 : 81 - 83.

Skinner, J.D. & Van Zyl, J.H.M. 1969. Reproductive performance of the common eland (*Taurotragus oryx*) in two environments. J. Reprod. Fert. Suppl. 6 : 319 - 322.

Skinner, J.D., Van Zyl, J.H.M. & Oates, L.G. 1974. The effect of season on the breeding cycle of plains antelope of the western Transvaal Highveld. J. Sth. Afr. Wildl. Mgmt Ass. 4 : 15 - 23.

Smith, B.S.W. & Sykes, A.R. 1974. The effect of route dosing and method of estimation of tritiated water space on the determination of total body water and the prediction of body fat in sheep. J. Agric. Sci. Camb. 82 : 105 -112.

Smithers, R.H.N. 1971. The mammals of Botswana. Mus. Mem. Natl. Mus. Monum. Rhod. 4 : 1 - 340.

Smithers, R.H.N. 1983. The mammals of the Southern African Sub-region. University of Pretoria, Pretoria.

Stainthorpe, H.L. 1972. Observations on captive eland in the Loteni Nature Reserve. The Lammergeyer 15 : 27 - 38.

Stevens, W.L. 1951. Asymptotic regression. Biometrics 7 : 247 - 267.

Stewart, D.R.M. 1967. Analysis of plant epidermis in faeces : a technique for studying the food preferences of grazing herbivores. J. Appl. Ecol. 4 : 83 - 111.

Stewart, D.R.M. & Stewart, J. 1970. Food preference data by faecal analyses for African plains ungulates. Zool. Afr. 5 : 115 - 130.

Storr, G.M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diet of herbivorous animals. Aust. J. Biol. Sci. 14 : 157 - 164.

Taylor, C.R. 1968. The minimum water requirements of some East African bovids. Symp. Zool. Soc. Lond. 21 : 195 - 206.

Taylor, C.R. 1969. Metabolism, respiratory change and water balance of an antelope, the eland. Am. J. Physiol. 217 : 317 -320.

Taylor, C.R. 1970. Strategies of temperature regulation : effect of evaporation in East African ungulates. Am. J. Physiol. 219 : 1131 - 1135.

Taylor, C.R. & Lyman, C.P. 1967. A comparitive study of the environmental physiology of an East African antelope, the eland, and the Hereford steer. Physiol. Zool. 40 : 280 - 295.

Torbit, S.C., Carpenter, L.H. Alldredge, A.W. & Swift, D.M. 1985. Mule deer body composition - a comparison of methods. J. Wildl. Mgmt 49 : 86 - 91.

Transvaal Nature Conservation Division. 1977. Twelfth Annual Report 1967 - 1977. Unpublished Mimeograph.

Transvaal Nature Conservation Division. 1985. Geology of the S.A. Lombard Nature Reserve (an explanation of the geological map). Unpublished Mimeograph.

Treus, U.D. & Kravchenko, N.V. 1968. Methods of rearing and economic utilisation of eland in the Askaniya-Nova Zoological Park. Symp. Zool. Soc. Lond. 21 : 395 - 411.

Treus,U.D. & Lobanov, N.V. 1971. Acclimatisation and domestication of the eland. Int. Zoo Yearbook 11 : 147 - 156.

Underwood, R. 1975. Social behaviour of the eland, (Taurotragus oryx) on Loskop Dam Nature Reserve. M.Sc. Thesis, University of Pretoria.

Van der Merwe, N.J. 1955. The history of the S.A. Lombard Nature Reserve. Fauna Flora, Pretoria 6 : 33 - 43.

Van Soest, P.J. 1964. Symposium on nutrition and forage and pastures : new chemical procedures for evaluating forages. J. Anim. Sci. 23 : 838 - 845.

Van Soest, P.J. 1978. Dietary fibers : their definition and chemical properties. Am. J. Clin. Nutr. 31 : S12 - S20.

Van Zyl, J.H.M. 1962. The meat production of South African game animals. I. The eland. Fauna Flora, Pretoria 13 : 35 - 40.

Van Zyl, J.H.M. 1965. The vegetation of the S.A. Lombard Nature Reserve and its utilisation by certain antelope. Zool. Afr. 1 : 55 - 71.

Von La Chevallerie, M., Erasmus, J.M., Skinner, J.D. & Van Zyl, J.H.M. 1971. A note on the carcass composition of the common eland (*Taurotragus oryx*). S. Afr. J. Anim. Sci. 1 : 129 - 131.

Yalden, D.W. 1978. Observations on food quality in Scottish red deer (*Cervus elaphus*) as determined by chemical analysis of the rumen contents. J. Zool., Lond. 185 : 253 - 277.

Zimmermann, I. 1978. The feeding ecology of Africander steers (*Bos indicus*) on mixed bushveld at Nylsvley Nature Reserve, Transvaal. M.Sc. Thesis, University of Pretoria, Pretoria.

APPENDIX I : Measurements of trees on the SALNR.

TRANSECT	SPECIES	NO OF TREES	MEAN HEIGHT (cm)	MEAN DIAMETER (cm)	DENSITY (plants/ha)	IMPORTANCE VALUE
1	RL	4	575	859	160	47,5
	ZM	2	475	845	80	25,0
	DL	3	163	203	120	27,5
2	RL	4	368	332	160	22,5
	ZM	5	281	343	200	28,0
	DL	9	267	249	360	44,5
	ER	1	200	120	40	5,0
3	RL	6	376	442	240	30,0
	ZM	11	214	281	440	45,5
	DL	6	227	212	240	24,0
4	RL	1	400	320	40	7,0
	GF	12	145	300	480	58,5
	DL	1	350	383	40	7,5
	TC	1	70	110	40	5,0
	MH	4	186	125	160	22,0
5	RL	3	617	622	120	22,5
	ZM	1	400	520	40	7,5
	GF	9	96	278	369	47,5
	DL	2	500	497	80	13,0
	TC	1	90	89	40	5,0
	MH	1	70	20	40	5,0
6	RL	3	633	752	120	24,3
	GF	7	129	249	280	35,0
	DL	6	190	417	240	31,3
	MH	2	355	247	80	9,4
7	RL	2	650	733	80	25,1
	ZM	4	221	360	160	29,0
	GF	1	220	270	40	8,5
	DL	5	171	248	200	30,2
	MH	1	70	50	40	7,1
8	ZM	3	272	202	120	7,0
	GF	4	185	171	160	8,5
	DL	22	164	191	880	33,5
	TC	20	160	149	800	30,0
	AK	13	107	122	520	19,0
	ER	1	300	170	40	2,0
9	RL	1	650	1030	40	5,3
	ZM	3	298	233	120	8,7
	GF	4	103	160	160	8,6
	DL	16	110	106	640	23,9
	TC	33	171	172	1320	51,3
	MH	1	140	35	40	2,2
10	ZM	4	225	183	160	11,2
	GF	13	140	182	520	30,5
	DL	9	199	302	360	21,8
	TC	8	279	264	320	22,6
	AK	5	210	149	200	13,6
11	RL	4	640	987	160	100,0

RL = *Rhus lancea*
ZM = *Ziziphus mucronata*
GF = *Grewia flava*
DL = *Diospyros lycioides*
TC = *Tarchonanthus camphoratus*
AK = *Acacia karroo*
ER = *Ehretia rigida*
MH = *Maytenus heterophylla*

APPENDIX II : Crude protein and fibre contents of grass and browse on the SALNR.

	PERCENTAGE PROTEIN					PERCENTAGE NDF					PERCENTAGE ADF				
GRASS :	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**
Themeda triandra	9,19	4,82	2,98	2,80	9,28	62,00	63,33	65,00	66,67	60,00	33.34	34,17	37,50	48,33	33,89
Cymbopogon plurinodis	6,57	6,57	4,55	3,72	9,11	58,00	60,00	60,00	61,65	53,33	30,00	31,67	41,67	45,83	30,84
Sporobolus ioclados	11,82	4,82	6,30	6,30	16,14	64,00	65,00	65 83	66,00	53,33	38,00	40,00	43,33	46,67	34,44
S. fimbriatus	14,84	6,13	4,99	4,12	15,14	62,00	63,33	63,33	63,33	55,00	35,00	36,67	38,34	43,33	31,67
Panicum coloratum	10,95	5,52	6,22	4,90	15,41	47,00	58,34	60,00	63,33	53,33	28,00	30,00	33,33	39,17	25,00
Digitaria eriantha	9,63	5,25	4,73	3,24	11,60	58,00	60,00	60,00	63,33	53,33	30,00	35,00	42,50	45,83	30,34
Eragrostis obtusa	14,01	7,01	5,82	4,68	14,36	62,00	63,33	63,33	65,00	55,00	30,00	33,33	36,67	43,33	31,67
E. lehmanniana	14,01	7,88	5,37	6,04	15,06	58,00	60,00	60,00	61.67	60,00	38,33	38,34	40,00	45,00	33,33
Mean	11,38	6,00	5,12	4,48	13,31	58,88	61,67	62,19	63,87	55,42	32,83	34,90	39,17	44,69	31,46
s.d.	2,86	1,10	1,08	1,26	2,89	5,33	2,35	2,48	1,86	2,92	3,95	3,35	3,36	2,78	2,95
BROWSE:	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**	**FEB**	**MAY**	**AUG**	**OCT**	**DEC**
Rhus lancea	12,70	9,63	10,42	8,49	12,00	22,00	23,33	24,17	23,33	18,00	10,00	16,67	18,33	17,50	13,33
Ziziphus mucronata	14,45	12,70	7,18	17,29	22,50	18,00	20,00	21,67	20,00	16,67	10,00	12,50	15,83	11,67	10,83
Grewia flava	20,14	10,07	----	----	18,50	38,00	40,00	----	----	36,67	23,33	28,33	----	----	23,33
Diospyros lycioides	17,08	12,26	----	----	12,83	26,00	28,33	----	----	23,33	11,67	13,33	----	----	12,50
Tarchonanthus camphoratus	17,51	12,26	11,16	12,78	15,45	32,00	33,33	36,67	38,33	33,33	20,00	23,33	26,67	28,33	23,33
Acacia karroo	18,39	10,95	----	9,02	14,05	21,67	23,33	----	21,67	20,00	13,33	16,67	----	15,00	15,00
Mean	16,71	11,31	9,59	11,90	15,98	26,28	28,05	27,50	25,83	24,67	14,72	18,47	20,28	18,13	16,39
s.d.	2.70	1,28	2,12	4,07	3,96	7,46	7,48	8,04	8,44	8,38	5,62	6,15	5,68	7,21	5,54