FACTORS AFFECTING ROAN AND SABLE ANTELOPE POPULATIONS ON NATURE RESERVES IN THE TRANSVAAL WITH PARTICULAR REFERENCE TO ECOPHYSIOLOGICAL ASPECTS

by

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Submitted in partial fulfilment of the requirements

for the degree of

Doctor Scientiae (Wildlife Management)

in the

Faculty of Science

University of Pretoria

Pretoria

November 1975

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ABSTRACT

This study was carried out on four nature reserves in the Transvaal, South Africa, and the Matetsi area of northwestern Rhodesia, with information obtained from other areas. A high rate of mortality occurred amongst juveniles and, to a lesser extent, amongst adult sable and roan antelope on Transvaal nature reserves. Four protozoal parasites were implicated in the mortalities.

A high incidence of reservoir Cytauxzoon parasitaemia was observed in sampled sable and roan of various ages whilst Babesia infection occurred to a lesser extent with chlamydiosis and pneumocystosis being observed in one animal. It was determined that Cytauxzoon infection was transmitted via the placenta from dam to offspring. Post-mortem and histopathological examination of tissues from dead animals indicated

that infectious diseases were secondary considerations in the mortality patterns, and that poor nutritional status was the prime factor involved. The incidence of parasitaemia of Rhodesian sable was of the same order as Transvaal sable, however, body condition of the former was considerably better than that of Transvaal sable.

The nutritional status of sable and roan antelope was investigated in some depth. Data were obtained from soil, water, forage and animal tissues (liver, blood and milk) collected from preferred dry-season feeding areas. The study adopted a screening approach to the aspect of nutrition and comparisons were made between areas to derive conclusions regarding the relationship of nutrition to disease and mortalities. The basic deficiencies on Transvaal reserves relate to protein, phosphorus and selenium. Sodium, calcium, magnesium, potassion, iron and copper are linked to the deficiency syndrome.

Habitat quality, availability and utilization by sable and roan on Transvaal nature reserves was investigated. Preferred dry season feeding areas were measured critically for various physical characteristics to elucidate the relationship between habitat use and nutritional deficiencies.

Microscopic identification of plant fragments taken from rumens and caecums provided information that interspecific feeding competion existed in varying degrees between sable antelope and waterbuck, zebra and impala on Percy Fyfe Nature Reserve.

Reproductive factors were investigated and it was determined that calving rate was of the order of 100 percent. Sable

are seasonable breeders with a gestation period of only 8 months, while roan breed throughout the year and have a gestation period of approximately 275 days. Electro-ejaculation techniques were applied to sable males and it was determined that mature bulls are sexually capable of breeding throughout the year and subadult males reach physiological and psychological sexual capability as early as 16-19 months of age.

Management considerations such as nutritional supplementation via salt blocks, range fertilization with super-phosphates and ammonium phosphates, range burning and control of competing species are discussed.

ACKNOWLEDGEMENTS

This study was sponsored by the Transvaal Division of Nature Conservation, South Africa. Supervision and direction were carried out under the research section of the Division and the auspices of the Mammal Research Institute of the University of Pretoria. My sincere thanks and appreciation are expressed to the co-supervisors of this study, Prof. J.D. Skinner and Dr. S.M. Hirst. Their wide-ranging experience in all aspects of the study was a valuable contribution to the success of the project. Many people co-operated to make this study possible and it is with grateful appreciation that I acknowledge their assistance.

I am indebted to colleagues and friends at the Veterinary Research Institute, Onderstepoort, for their co-operation: Drs. R.D. Bigalke and S.E. Thomas, Department of Protozoology, for assistance in identifying blood parasites; Drs. R.C. Bartsch, G.D. Imes and other members of the Pathology Department for assistance in performing numerous necropsies and histopathological examinations of tissue specimens: Prof. K. Van der Walt and members of his laboratory staff, Physiology Department, for assistance in various aspects of blood analyses; Dr. A. Verster, Helminthology Department, for equipment and assistance in parasite identification.

Acknowledgements are due to Dr. J. Labuschagne, Animal and Dairy Science Research Institute, Irene, for assistance with milk analyses; to Mr. H.G. Van der Merwe, General Chemistry Division, South African Bureau of Standards, for his advice and assistance in standardization of methods for nutrient analyses; to Mr. R. Ellis, Botanical Research Institute, for assistance in plant identification and rumen analyses; to Dr. R.P. Millar, Department of Chemical Pathology, University of Cape Town, for assistance in testosterone analyses of blood plasma; to the Department of National Parks and Wildlife Management, Rhodesia, for permission to collect data during the various capture operations, and especially to Mr. H.J. Herbert, research officer in charge, Wankie National Park, for his co-operative attitude and friendship during the study period in Rhodesia; to Mr. P.A. Johnstone, Rosslyn Game Ranch in Matetsi District, Rhodesia, for permission to collect invaluable comparative data on the ranch.

Various members of the Transvaal Nature Conservation Division assisted in many ways during the study and I would especially like to thank Mr. G. Catto for help during the many immobilizations carried out, Mr. N. Jacobsen for many hours of field assistance, and Mr. N. Zambatis for assistance during months of field observations and in preparing the many line drawings in this work.

I extend my appreciation to Sarah and Rudolph de Jager for their help in typing and printing this manuscript.

Finally to my wife Dee Ann, and three daughters, Karen, Kimberly and Kelli, I extend a husband's and father's gratitude for their understanding, tolerance and support during the various hardships, frustrations and disappointments encountered in the course of this work. These pages are poor compensation for the many long and lonely months.

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SECTION I

INTRODUCTION

Sable antelope *Hippotragus niger* Harris, 1838 and roan antelope *Hippotragus equinus* Desmarest, 1804 are two of the larger and more spectacular antelope in Africa (Fig. 1). Both species are still distributed over large parts of Africa, with sable occurring in the savanna regions of eastern, central and southern Africa, and roan being found in open or lightly wooded country across central and western Africa (Dorst and Dandelot 1970).

Southern Africa represents the southernmost limit in distribution for both these species, with the sable subspecies *H. n. niger* Harris, 1838 and the roan subspecies *H. e. equinus* Desmarest, 1804 occurring in parts of Mocambique, Rhodesia, northern South West Africa, northern Botswana and the northern and eastern parts of the Transvaal province of South Africa (Meester and Setzer 1971).

Populations and distributions of both species have shown alarming declines within recent decades. The principal South African conservation area, the Kruger National Park, today has only some 1100 sable (Von Richter 1974) and from 250 to 300 roan (Joubert 1970). The numbers of sable and roan outside the National Park in the Transvaal are estimated at 800 and 100 respectively (Lambrechts 1974), and these numbers have shown little change since a previous estimate in 1962 (Kettlitz 1962) despite extensive protection and establishment of new herds. Sable and roan numbers are declining in northern South West Africa (Von Richter 1974, Joubert and Mostert 1974), Botswana (G. Child[1], personal communication) and Rhodesia (H.J. Herbert[2], personal communication). The

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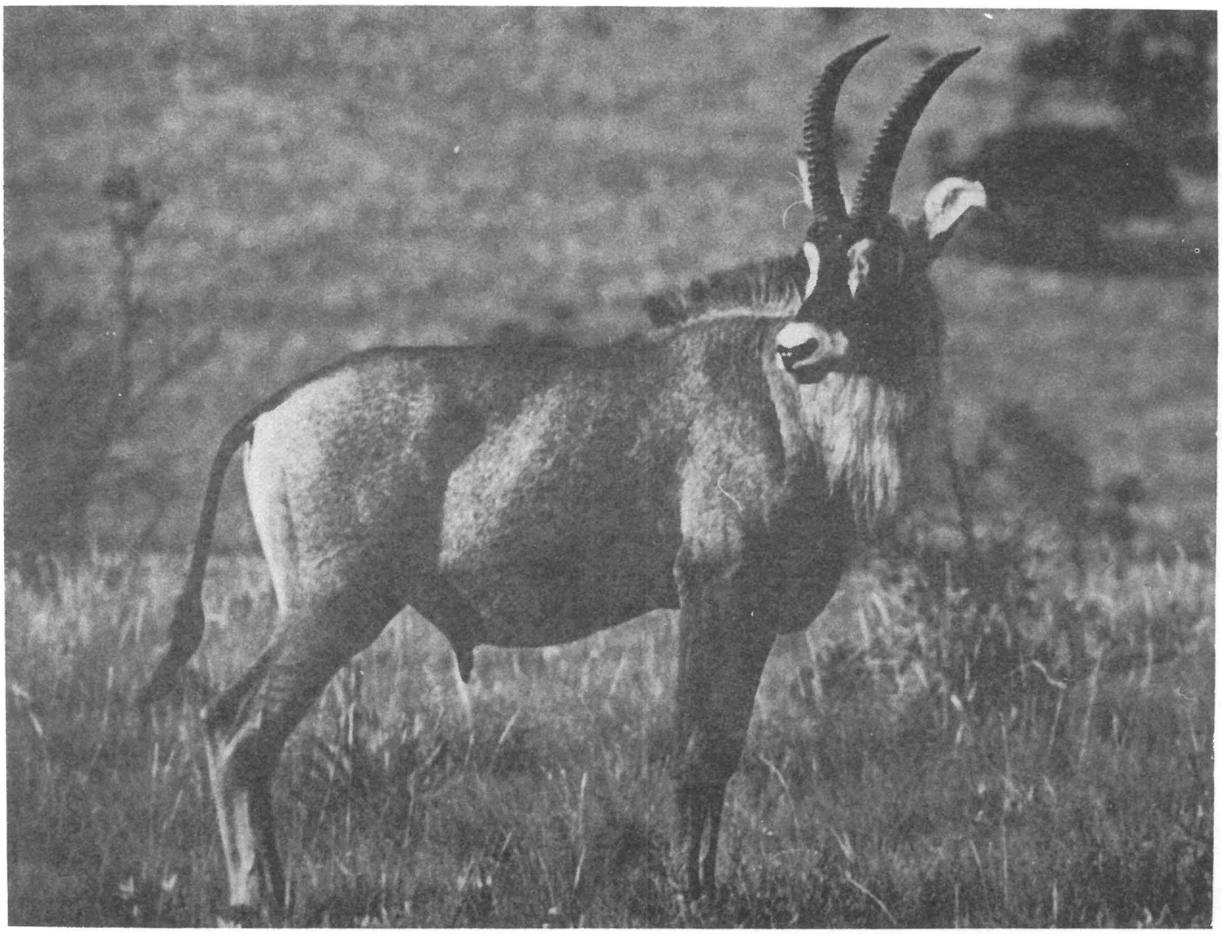
[1] G. Child, Dept. of National Parks and Wildlife Mgmt., Rhodesia.

[2] H.J. Herbert, Dept. of National Parks and Wildlife Mgmt., Rhodesia.

Fig. 1. Sable antelope (top) and roan antelope (bottom). Both are mature males.



exact reasons for declines have apparently not been studied in detail, but causes often cited include habitat deterioration, encroachment by agricultural and human activity, uncontrolled or illegal hunting and, in the case of roan, anthrax (Pienaar 1963).

Conservation measures for these rare and endangered antelope in the Transvaal centre around strict legal protection and efforts to establish and maintain viable herds in provincial nature reserves. The responsible conservation agency, the Transvaal Nature Conservation Division, maintains control over several nature reserves where sable and roan populations are protected. Although these reserves all fall within the areas covered by the known historic distribution of sable and roan in the province (du Plessis 1969), they are very restricted in size and may not offer the full spectrum of habitat required by these diminishing species.

Overall population increment rates for both roan and sable antelope on all Transvaal nature reserves have been low (Transvaal Nature Conservation Division, official files) with no indications as to possible limiting factors. In the face of future increased agricultural, industrial and urban expansion, sable and roan populations in South Africa may eventually have to exist soley on such nature reserves of restricted size. Management of these areas will have to be geared to creating and maintaining conditions suitable for viable and reproductively healthy herds.

This study was initiated to investigate those aspects of the ecology, population dynamics, nutrition, ecophysiology and pathology of sable and roan antelope germane to an understanding of population limitations. Specifically, the objectives were

1. to determine the factors limiting roan and sable antelope on nature reserves in Transvaal,
2. to compare the characteristics of sable and roan herds on Transvaal nature reserves with those of thriving populations nearer the centre of the species' distribution in Africa so as to elucidate the mechanisms of population limitation, and
3. to synthesize the findings into practical management considerations.

The study was undertaken primarily on four nature reserves in the Transvaal province and on one area in Rhodesia, with additional information from secondary areas. Field work commenced in January 1972 and terminated in June 1975.

GENERAL BIOLOGICAL CHARACTERISTICS

Morphology

Sable antelope are one of the larger species of antelope in Africa and are third or fourth in size after the eland *Taurotragus oryx*. Sable body mass rarely exceeds 225 kg and shoulder height 135 cm. Both sexes have evenly divergent horns which curve backwards and have mean lengths of some 95-105 cm for bulls and about 80 cm for cows. General colour is glossy black for the male and a paler almost chestnut for the female. Both sexes have pure white underparts and contrasting white and black face markings. Sable are generally shorter and more stocky in appearance than roan.

Roan antelope are larger than sable and are second only to eland in size. Roan attain an average mass of 225-275 kg and a shoulder height of about 138 cm. The horns are much shorter than those of sable and average about 75 cm. General colour is from dark rufous to light reddish fawn with white underparts and contrasted black and white face markings. Authoritative descriptions are given by Sclater (1900), Smithers (1966) and Dorst and Dandelot (1970).

Geographical Distribution

Of the two species of Hippotragus still existing today, roan antelope H. equinus have by far the greater distribution throughout Africa, but are paradoxically the rarer animal of the two in southern Africa. The southermost limits of the nominate subspecies H. e. equinus (Desmarest, 1804) were the northern, eastern and western Transvaal and the boundaries of the south-west arid zone in the Cape Province (Ansell 1971). As indicated above, the subspecies today survives only in the Transvaal in the Kruger National Park, Belgium Block and Percy Fyfe Nature Reserve. Northwards, H. e. equinus occurs in Rhodesia and southern Malawi.

The extinct bluebuck H. Leucophaeus Pallas, 1766, which has the doubtful distinction of having been the first African antelope to have been exterminated by human action (Harper 1945), and which occupied a limited range in the Cape Colony of South Africa until 1799, is regarded by some authors as having been a subspecies of the roan H. equinus (Haltenorth 1963).

The intergrading of H. e. equinus with H. e. cottoni is not clear, but the latter subspecies is the one today occurring across northern Botswana, Zambia, Angola, central and northern Malawi and into Zaire. North of these countries, H. e. langheldi ranges throughout Tanzania, Kenya, Rwanda, Burundi and southern Uganda, northern Zaire, Ethiopia and Sudan. The species is far more abundant in west Africa, where H. e. charicus ranges through Cameroun, western Chad, eastern Nigeria and the Central African Republic, and H. e. koba is in western Nigeria and Senegal. Ansell (1971) points out that the validity of some of the subspecies is still in doubt.

Sable antelope H. *niger* are restricted to the southern savanna zone, and the distinction between the various subspecies is not clear (Ansell 1971); most distinctions are based on colour and horn differences, and on this basis the giant sable *H. n. variani* Thomas, 1916 is almost certainly a valid subspecies. It occurs in a limited area between the Cuanza and Londo rivers in Angola, and its conservation status must be regarded as grave today (Huntley 1974). The southern subspecies *H. n. niger* (Harris, 1838) today ranges across eastern and northern Transvaal, through Rhodesia and northern Botswana. The southernmost limit seems to have been the Komati River (Pienaar 1963) which is today the southern boundary of the Kruger National Park.

The intergradation with the central subspecies *H. n. kirkii* is not clear, but is probably in the region of the Zambesi river valley. *H. n. kirkii* occurs throughout Zambia, eastern Angola, Zaire, Malawi and Mocambique. *H. n. roosevelti* (Heller, 1910) ranges through south-eastern Kenya and north-eastern Tanzania.

Social Behaviour

Roan and sable antelope are gregarious species with female-immature-juvenile herds of up to 12-15 common in roan (Sclater 1900, Smithers 1966) with a normal maximum of 20-25. Sable form larger herds of up to 40, although 20-25 are more common. In both cases the herds are dominated by an adult bull, and surplus males are either solitary or consort in small groups separate from the mixed herds. Young males appear to be ejected from the herds at 2½ - 3 years of age (Estes and Estes 1969, Joubert 1974). There are well-developed social hierarchies in both roan and sable female herds (Joubert 1974, Grobler 1974) and the alpha female plays a leading role in initiating such group activities as feeding, drinking, moving and flight.

Home Range and Territories

Various detailed observations on the Hippotragine antelope within the past decade have given some insight into the sizes and types of home ranges normally occupied. These appear to be influenced strongly by the nature of the terrain, the vegetation types, availability of water and the size and distribution of the total population and the individual herds. The distinction between home range and territory is not always clear for sable males, and this also affects the sizes of areas known to be occupied.

Estes and Estes (1969) have recorded a home range size of some 890 ha for a large herd of 48 sable antelope in open shrubland and grassland in the Shimba Hills, Kenya; this was reduced to 650 ha when the herd was in the company of a territorial bull. Estes and Estes (1970) also record a home range of about 260 ha for a large sable herd in riverine woodland and adjacent mopane *Colophospermum mopane* savanna in the Victoria Falls National Park, Rhodesia. In the grassland and open woodland associations of Matopos National Park, Rhodesia, Grobler (1974) records home ranges of 240-280 ha for sable antelope, and Johnstone (1971) has recorded areas of 260 and 470 ha for two known sable females in mopane and mixed deciduous savanna in the Matetsi area, Rhodesia. For roan antelope in mopane savanna woodlands in Kruger National Park, Joubert (1974) estimates an overall home range size of some 200 to 400 ha.

Most authors cited above note that both sable and roan characteristically spend several days at a time within an area of less than 5 ha before moving on to another small section within their overall home range. The characteristics of these smaller areas have not been investigated, but indications are that they probably contain a relative abundance of preferred food items and water. Permanent water is important to both species, neither of which seems to move further than 2-4 km from a drinking site.

The mature males of both species will actively defend territories. From Estes and Estes (1969) and Grobler (1974) it would appear that the territory defended by the sable herd bull corresponds to his home ranges. These appear to be of the order of 25-40 ha in relatively unrestricted areas. Choate (1975) cites a case of four sable males electing to leave an island of 590 ha in the Zambezi River, rather than share it with a herd of some 30 sable, presumably with a herd bull in dominant position. For the roan, Joubert (1974) describes intolerance (rather than territoriality) in terms of a zone of some 50 ha around the herd where the herd bull drives off intruding adult or sub-adult males. For sable there would seem to be a definite boundary associated with their intolerance, but this is open to further study.

Reproduction

Although sable and roan antelope are usually described as annual seasonal breeders, the timing and duration of the calving season shows variation over their distributional range. Ansell (1960, 1963) records June through September as the calving period for sable in Zambia; Fairall (1968) records February and March for Kruger National Park, South Africa; March is the peak period in Rhodesia (Child and Wilson 1964, Wilson 1969) and January and early February in northern Botswana

(Child 1968). These periods all seem to coincide with the height of vegetation growing season and the peak availability of nutritious forage for the lactating females.

Roan calving seasons are not as well defined. Ansell (1960), Blower (1961), Child and Wilson (1964), Smithers (1966) and Fairall (1968) report no definite season for areas as far apart as Uganda, Zambia, Rhodesia and the Kruger National Park (eastern Transvaal). This was confirmed by careful observations on a small roan herd in a 260 ha enclosure within the Kruger National Park (Joubert 1970).

Females of both species characteristically leave the herd to calve, and the calf is isolated for the first 2 weeks for sable and 4-6 weeks for roan antelope. The female normally returns to the herd within a day following parturition. It is not unusual for the calf to remain isolated and unattended throughout the day, but it is usually attended by the dam in the early evening and early morning hours. A very short flight distance, effective camouflage colouring and absence of characteristic odour apparently make isolated calves difficult to locate. Mother-calf relationships in both species appear to be very loose; roan cows may wander as far as 2 km from concealed calves (Joubert 1970).

Females conceive shortly after 2 years of age and calve when 3 years old. Gestation periods are recorded as approximately 270 days for both the roan (Wilhelm 1949, Smithers 1966, Joubert 1974) and the sable (Stevenson-Hamilton 1947, Wilhelm 1949, Smithers 1966, Grobler 1974). It was determined during this study, however, that the gestation period for sable is only 240-246 days (see below).

Natural and Induced Mortality

Information on mortality rates and specific causes is generally not well documented. In national parks of large size in Africa, both sable and roan are susceptible to predation by lions and large carnivores (Mitchell *et al*. 1965, Pienaar 1969), although no evidence exists to show that this is a limiting factor. In smaller fenced reserves predation on calves by leopards (Grobler and Wilson 1972) may be important, but again there is no evidence to suggest that this is a primary limiting factor.

Roan antelope are highly susceptible to anthrax, and this is an important cause of population crashes in Kruger National Park (Pienaar 1960, 1961), although it has not been recorded in roan on other nature reserves in the Transvaal. Sable are more resistant to anthrax. Other records of infectious diseases are rare, although a protozoal infection by *Babesia* has been recorded in sable (Martinaglia 1930).

Droughts have led to severe losses amongst sable antelope in Kruger National Park (Pienaar 1969) and in the Transvaal nature reserves (Transvaal Nature Conservation Division, official files). This would appear to indicate a sensitivity to adverse habitat conditions.

Mortality through human agency has far exceeded the losses inflicted by natural causes in southern and central Africa. Sable and roan were excluded from much of their peripheral range in southern Africa through indiscriminate hunting (du Plessis 1969), and illegal hunting severely reduced numbers in the Kruger National Park during the first half of this Century (Pienaar 1969). Game slaughter operations for tsetse fly control have made very serious inroads into sable and roan populations in Rhodesia, and du Plessis (1969) cites figures of 37 657 sable and 5 525 roan destroyed in Rhodesia over a 40 year period.

On fenced nature reserves in the Transvaal, controlled culling of sable males has become a periodic management measure to reduce large-scale fighting between males (Transvaal Nature Conservation Division, official files).

STUDY AREAS

The Transvaal province represents the present-day southernmost limi ts of distribution for both roan and sable antelope in Africa (Dorst and Danuelot 1970), although du Plessis (1969) indicates that roan previously ranged much further south through present-day northern Cape Province to the confluence of the Orange and Vaal rivers. Free-ranging wild roan populations were eliminated rapidly from the beginning of this century onwards, and by 1950 were limited to small numbers in the Kruger National Park, the adjacent privately owned nature reserves in the eastern Transvaal Lowveld below the eastern escarpment, and an area of some 250 km^2 in the north-western Transvaal, known locally as the Belgium Block (Kettlitz 1962). By 1971 roan populations had declined further inside the Kruger Park (Joubert 1970) and in the Belgium Block (Lambrechts 1974), and had been eliminated from the eastern Transvaal Lowveld by a veterinary game-fence around the Kruger Park erected for foot and mouth disease control (Lambrechts op cit.).

The overall distribution of sable has changed within historic times insofar as it was eliminated from the north-western areas of Transvaal where the type specimen was first recorded by Harris (1837). Over the rest of its Transvaal range, numbers have dwindled considerably, and it no longer occurs over large areas in northern and eastern Transvaal (Kettlitz 1962, Lambrechts 1974).

For the southern subspecies of sable, Hippotragus n. niger, Rhodesia represents the central area of distribution, since this subspecies probably does not range far north of the Zambezi river (Grobler 1974). Within Rhodesia the most important areas are Wankie

National Park, the Matetsi area northwest of Wankie extending to the Victoria Falls, and the eastern escarpment (Grobler, op cit.). The southern subspecies of roan *H. e. equinus* ranges further north to the Congo and parts of Uganda (Dorst and Dandelot 1970), but again Wankie National Park and the adjacent lands represent a stronghold of the distribution in Rhodesia (Child and Savory 1964).

Outside the Kruger National Park, the Hans Merensky Nature Reserve in the eastern Transvaal Lowveld is the only state-controlled reserve supporting a natural population of sable. Utilizing sable from this reserve the Transvaal Nature Conservation Division has at various times established new herds on three other provincial nature reserves: Loskop Dam, Percy Fyfe and Rustenburg. These reserves all fall within the broad historic distributional range of sable in the Transvaal. Roan antelope were not naturally available on any provincial reserve at the time of proclamation of the latter, and a new herd was established on Percy Fyfe Nature Reserve from animals captured in the Belgium Block.

The first objective of the study, i.e. determination of limiting factors of sable and roan in Transvaal nature reserves, required study of the populations on all four reserves: Hans Merensky, Percy Fyfe, Loskop Dam and Rustenburg. This approach also permitted use of comparative methods in studying aspects such as population dynamics, habitat and nutritional characteristics.

The second objective, comparison of population characteristics of sable and roan on Transvaal nature reserves with those of similar populations nearer the centre of the range, required selection of a study area much further north. Rhodesia, and the Wankie area in particular, was the obvious area of choice for sable. After initial liaison and consideration, the privately-owned Matetsi area immediately northwest of Wankie National Park was selected. This area has one of the higher sable densities known in Rhodesia (Rhodesia Department of National Parks and Wildlife, personal communication).

Roan antelope densities in Wankie and Matetsi areas are substantially lower than those of sable, although the roan is far more abundant in these areas than in the Transvaal. Initial considerations were given to a study of roan populations in Angola where they are still fairly abundant in certain areas (Huntley 1974). However, political turmoil and concomitant problems precluded any serious study within this territory, and Rhodesia was again selected as a possible general area for comparative studies of roan populations.

The general location of each study area is indicated in Figure 2, which also indicates the positions of other sites where material and information from roan and sable herds was obtained; the general distribution of sable and roan antelope in present-day Africa is also shown.

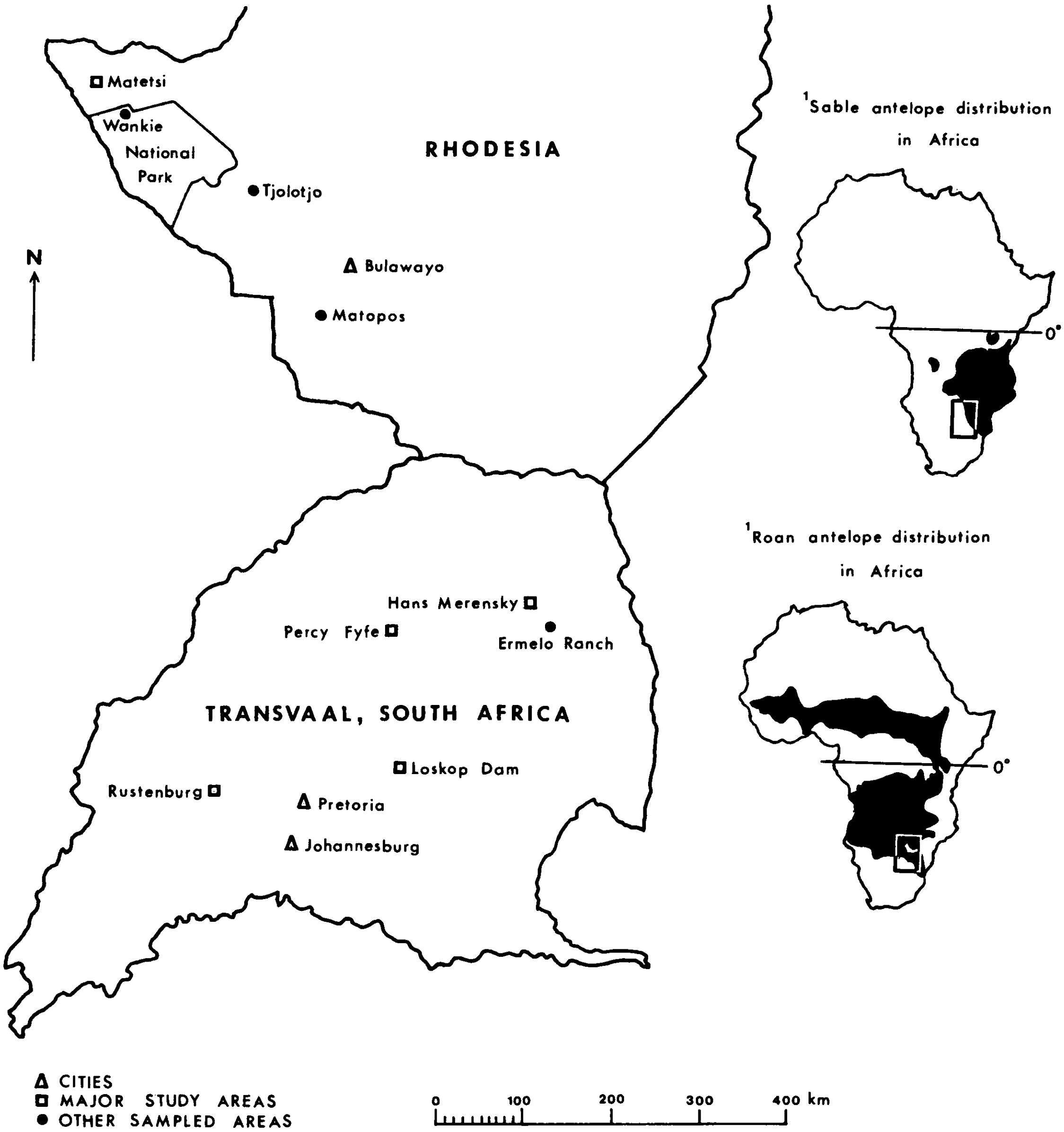


Fig. 2. Location of major study areas and other areas where data were collected in the Transvaal Province, South Africa, and Rhodesia. Major cities are indicated for ease of orientation. Distribution of sable and roan antelope in Africa is shown ([1]data from Dorst and Dandelot 1970). Inset shows position of study areas on African continent.

Percy Fyfe Nature Reserve

Percy Fyfe Nature Reserve, located at 24° 02' S, 29° 09' E, was selected as the primary study area since this was the only provincial reserve on which both sable and roan populations occurred. The general open parkland of the reserve and a good network of roads permitted better and closer observation of the animals than would have been possible on any other reserve.

The reserve is actually made up of three discrete units separated by a railroad track and a district road. The total area of the reserve was 3032 ha until 1972; of this 1631 ha was allocated to a large blesbok *Damaliscus dorcas* herd, 633 ha to a tsessebe *D. lunatus* herd, and the remaining 768 ha kept for sable, impala *Aepyceros melampus*, waterbuck *Kobus ellipsiprymnus*, zebra *Equus burchelli*, Kudu *Tragelaphus strepsiceros*, and smaller antelope. An additional 430 ha was added to the reserve in 1966 and used for the establishment of a small roan antelope herd translocated from the Belgium Block. By 1972 the blesbok herd had been removed (since they had been previously introduced and were outside their normal distributional range) and the roan herd was given free access to 2061 ha in 1973.

The reserve's topography is generally undulating with many picturesque granite hills and outcrops. The underlying geological system is basically granite with some serpentine chlorite intrusions from the Swaziland system (part of the Bushveld Igneous Complex) (Huntley 1968). The soils are accordingly sandy, eutrophic, fairly deep and porous, classed amongst the red, yellow and grey macro-associations (Verster 1974), and are poorly developed. The variable topography results in some heterogeneity in soil types. Prior to this study no detailed investigations of the Percy Fyfe soils had been undertaken.

The vegetation is broadly classified as sour bushveld and sourish mixed bushveld (Acocks 1975) which reflects its unpalatable grass constituents. Physiognomically the vegetation is an open grass savanna with a scattered tree layer dominated by boekenhout *Faurea saligna*, bushwillow *Combretum* spp. and several *Acacia* spp. The grass layer is dense, of medium to tall height and floristically varied. The dominant grasses are *Schizachyrium* spp., *Digitaria* spp., *Hyperthelia* spp., *Setaria* spp. and *Themeda triandra*. The most palatable grass, *Panicum maximum* (buffalo grass) is found only beneath trees and shrubs of substantial canopy cover. In a preliminary unpublished study of the vegetation types (B.J. Huntley, personal communication) ten homogeneous vegetation types have been identified by means of association analysis; *Themeda triandra* (red oat-grass) and *Digitaria pentzii* (finger grass) are the main differential species (Table 1).

Percy Fyfe has a fairly temperate and somewhat arid climate, due mainly to its relatively high altitude of 1295-1550 m above sea level. It has the most moderate climate of any area studied. Long-term meteorological data were not available from the reserve itself, and records for the official weather station at Pietersburg which lies at the same elevation some 30 km away have been used. A climate diagram (Fig. 3) prepared from Pietersburg weather data using the method of Walter (1971), reveals that the wet season is only some 4 to 5 months long, and moisture stress on the vegetation is high. Maximum day temperatures seldom exceed 30^{o} C in summer; ground frosts are fairly

TABLE 1. - MAIN VEGETATION ASSOCIATIONS OF PERCY FYFE NATURE RESERVE AND THE APPROXIMATE AREAS COVERED. DATA DERIVED FROM B.J. HUNTLEY (PERSONAL COMMUNICATION)

Association	Area Covered (ha)	% Total Area
[illegible]hemeda-Diheteropogon	488	16.1
[illegible]-Tragus	388	12.8
[illegible]	415	13.7
Digit[illegible]	506	16.7
Digitaria-[illegible]	303	10.0
Digitaria	424	14.0
Old lands	[illegible]2	6.0
Rocky outcrops		5.5
Riverine thickets		2.4
Bushclumps and termitaria		2.7

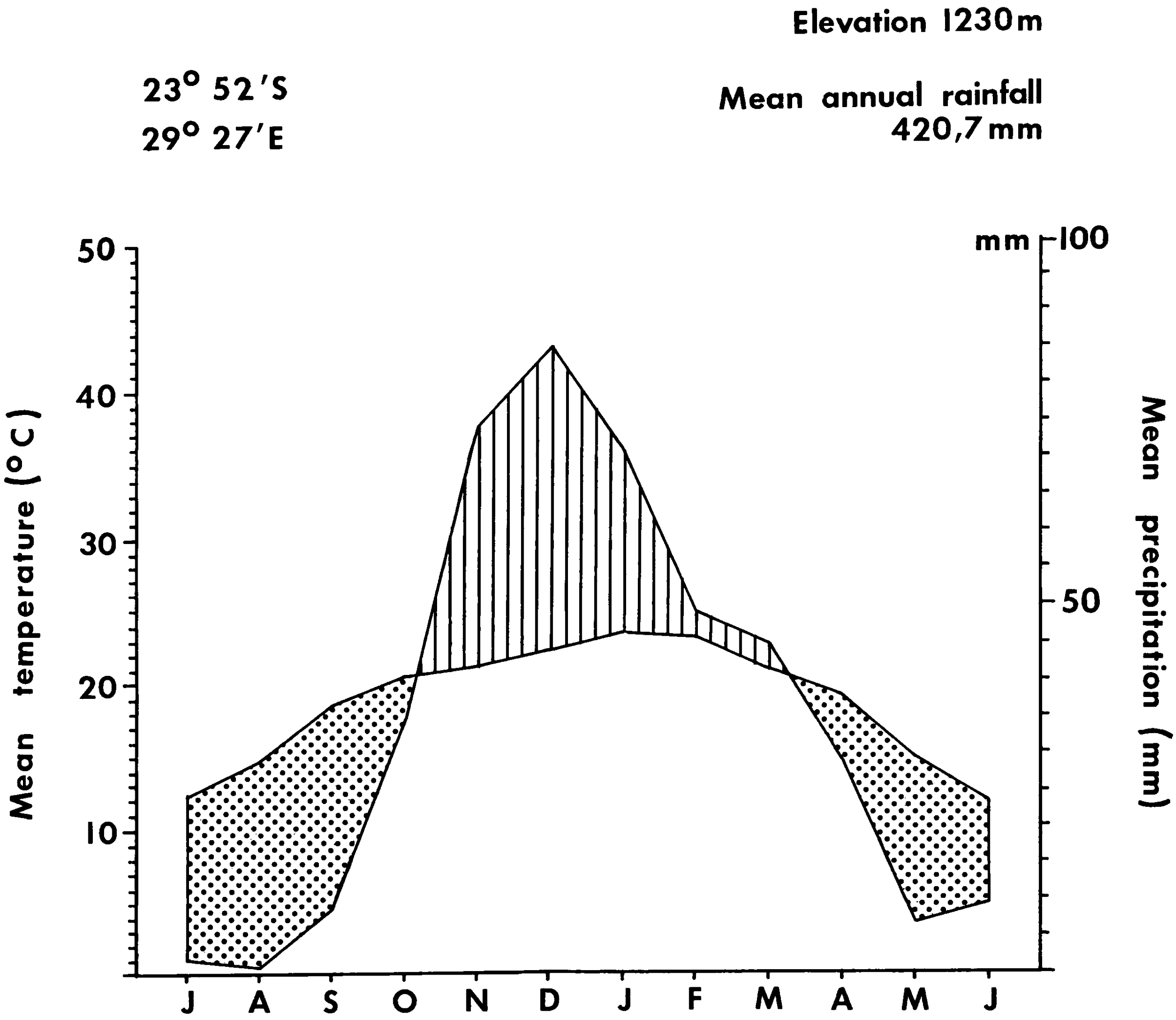


Fig. 3. Climate diagram for Percy Fyfe Nature Reserve. Data is from Pietersburg (weather station 677/802) on similar terrain and elevation 30 km away. Diagram prepared according to Walter (1971).

common in June, July and August (Weather Bureau 1960-1971); mean monthly temperatures range from 12,0^{o} C in July to 22,8^{o} C in January. The relative humidity normally drops from 80-85 percent in the early morning to 40 percent or less during the day. Mean rainfall over a 12 year period 1960-1971 for the Pietersburg station was 420,7 mm with variation from 324,0 to 573,4 mm. Rainfall actually measured on the reserve during the study period exceeded the long-term average for all years with totals of 455, 665 and 638 mm recorded in 1972/73, 1973/74 and 1974/75 respectively. The bulk of the rainfall falls from October through March in the form of short thunder-showers with high run-off. The poor soil moisture regime resulting from this is reflected in the relatively undeveloped sandy-loam soils.

Percy Fyfe Nature Reserve was utilized as a cattle ranch from 1912 (Verschuur 1955) until about 1963. During this period a large herd of blesbok, which are not indigenous to this area, were allowed free run of most of the reserve. The biomass of cattle and blesbok alone towards the end of this period exceeded 90 kg/ha (Riney and Kettlitz 1964), and range over-utilization in the form of severe soil erosion, bare ground and bush encroachment was evident. Total ungulate biomasses were substantially reduced by 1972, but the long-term effects of grazing plus burning have left the vegetation in an unstable grazing-fire subclimax state. The primary production of portions of the reserve have been investigated (Huntley 1972) and continuous heavy utilization was shown to be responsible for lowered net primary production of grasses. Huntley (op cit.) also measured live weight changes of blesbok in enclosures on natural range in the reserve over a 3-year period and recorded weight losses of 18 percent during the arid dry season when forage palatability and nutritional quality dropped significantly low.

Loskop Dam Nature Reserve

The largest of the study areas, Loskop Dam Nature Reserve, surrounds a large irrigation reservoir located at 25^{o} 24' S and 29^{o} 22' E. The reserve's terrain is extremely rugged and broken with deep gorges and steep slopes interspersed with small plateaus and flat bottomlands along the dam shoreline. Elevation varies from 990 to 1420 m above sea level. The dam itself was completed in 1938 and the surrounding lands have been maintained as a nature reserve since 1940. The reserve was fenced in the early 1950's and enlarged by subsequent land purchases to encompass the present 12 754 ha.

The climate (Fig.4) shows some similarities to that of Percy Fyfe Nature Reserve, but is generally hotter and moister. Mean annual rainfall over a 12-year period was 640,3 mm, and during the actual study period, recorded rainfall was 361, 671, 665 and 615 mm respectively for the years 1971/72, 1972/73, 1973/74 and 1974/75. Rainfall in January normally exceeds 100 mm, the point beyond which Walter (1971) describes climate as humid. The rainfall period is longer than that of Percy Fyfe and extends typically from October through April. Mean monthly temperatures vary from 24,9^{o} C in January to 13,8^{o} C in July; extremes of 33,9^{o} and 3,4^{o} C have been recorded for the same respective months during the past two decades (Weather Bureau 1960-71). Ground frosts are rare. Relative humidity patterns are very similar to those of Percy Fyfe, and range from 76-88 percent in the mornings to 30-40 percent and less in midday.

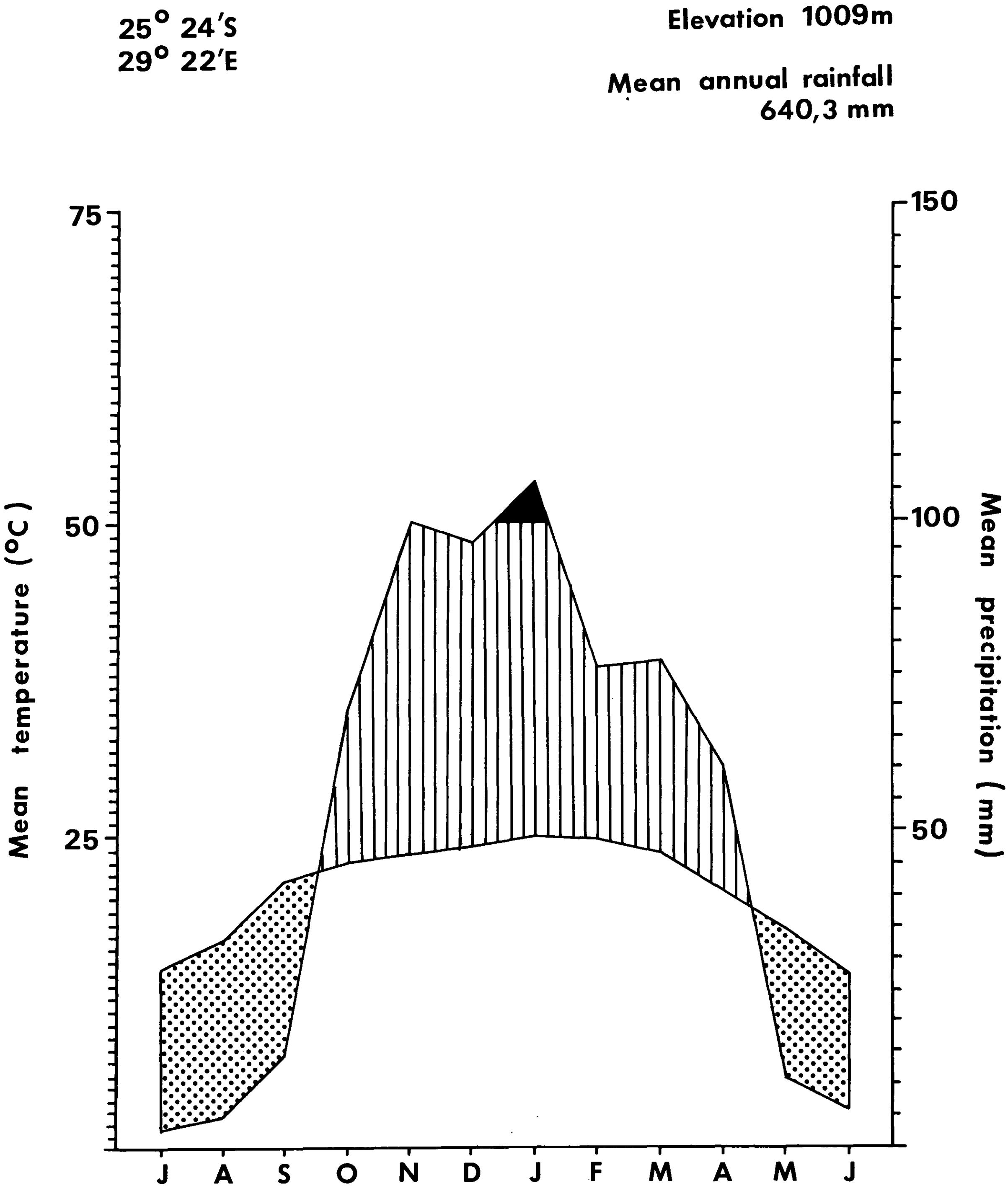


Fig. 4. Climate diagram for Loskop Dam Nature Reserve (weather station 552/654).

The hilly terrain naturally leads to marked local mesoclimatic variations, and Theron (1973) records differences of 300 mm precipitation in the same year between a gorge and a north-facing slope. Temperatures on north-facing slopes and in sheltered south-facing habitats can differ by as much as 3^{o} C on a mean maximum or minimum basis.

The underlying geological structures come mainly from the Waterberg and Loskop systems (van Biljon 1960) which include mainly sand-stones, quartzites, shales and conglomerates. The areas frequented by sable during the study period are underlain by intrusions from the Rooiberg felsites, which are granitic in nature, and which give rise to soils and vegetation somewhat similar to those on Percy Fyfe Nature Reserve.

The vegetation of Loskop Dam Nature Reserve is generally described as mixed bushveld and sourish mixed bushveld (Acocks 1975) and is known for its floristic and vegetational complexity. The terrain and mesoclimatic variations on Loskop Dam Nature Reserve compound this heterogeneity. Theron (1973) has identified and studied in detail 24 vegetation types, and has shown that aspect, soil depth and local altitude are important enviromental factors determining vegetation type.

The soils and soil nutrients show wide variation over the reserve (Theron op. cit.). During the study period, sable made most use of the Faurea saligna - Setaria perennis tree savanna and some of its close variations on the Rhenosterhoek portion of the reserve. The underlying soils here were generally shallow, rarely more than 1 m deep, acid (pH from 4,2 to 5,9), moderately stony, sandy-clay loams. The topsoils generally are low in organic matter and poor in many macro- and micro-elements, including phosphorous, sodium, zinc, copper and cobalt. The calcium content of the soil exceeds that of phosphorous in many localities by a factor of up to 23.

Physiognomically the vegetation utilized by sable on the reserve is an open tree savanna, dominated by boekenhout *Faurea saligna*, wild syringa *Burkea africana*, *Acacia caffra* and *Combretum molle*. *Acacia caffra* forms dense invasion clumps in many areas. Grasses are tall and the graminaceous layer is dominated by many unpalatable species such as *Setaria perennis*, *Loudetia simplex*, *Tristachya biseriata* and *Trachypogon spicatus*.

The reserve encompasses only marginal lands (from the agricultural viewpoint) and grazing by domestic stock prior to the establishment of the reserve in 1948 was limited to some sheep, goat and cattle grazing on the bottomlands along the Olifants river. Many species of wild ungulate were subsequently introduced (du Plessis 1955) although there was little evidence to show that all of these had in fact ranged over the hilly terrain in earlier times. Introduced animals, in addition to sable, included impala, waterbuck, zebra, kudu, blesbok, wildebeest *Connochaetes taurinus*, giraffe *Giraffa camelopardalis*, ostrich *Struthio camelus* and broad-lipped rhinoceros *Ceratotherium simum*. Mountain reedbuck *Redunca fulvorufula* occurred naturally in the hills, and were the subject of a study by Irby (1973) who showed that population declines were due to very poor body condition brought about by poor nutritional quality of the range. Other ungulate species such as zebra and impala have shown large population increases over the past decades and localized overgrazing has taken place. Some burning has occurred accidentally, but the reserve is protected by a firebreak system, and burning is not used as a management measure. Consequently the vegetation on the reserve varies from grazing subclimaxes to climax types, depending on the vegetation type, its palatable constituents and its topography.

Rustenburg Nature Reserve

The latest provincial nature reserve on which a sable herd has been established is the 2898 ha Rustenburg Nature Reserve, situated 100 km west of Pretoria at 25^{o} 43' S, 27^{o} 11' E. It falls within the sour bushveld vegetation type (Acocks 1975). The reserve lies along the Magaliesberg mountain range and is close to the site of Harris' first sighting of the sable antelope in 1837. However, there is no evidence that the habitat types encompassed by the present reserve are similar to those where sable occurred in the last century.

Climatically, Rustenburg shows striking similarities to Loskop Dam (Fig. 5), although the humid period is more pronounced, and the total mean annual rainfall slightly higher (652,2 mm). The temperature and humidity regimes are very similar to those on Percy Fyfe (Fig. 3), with mean monthly temperatures ranging from a low of 11,2^{o} C in July to a high of 23,8^{o} C in January (Weather Bureau 1960-1971). Rustenburg is mountainous, however, and the same mesoclimatic variations as found on Loskop Dam can be expected here. Van Vuuren and Van der Schiff (1970) note maximum weekly temperatures 1,82^{o} C higher at the foot of northern slopes than on northern facing summits in the Magaliesberg range. The elevation of the reserve (1230-1660 m above sea level) is somewhat higher than that

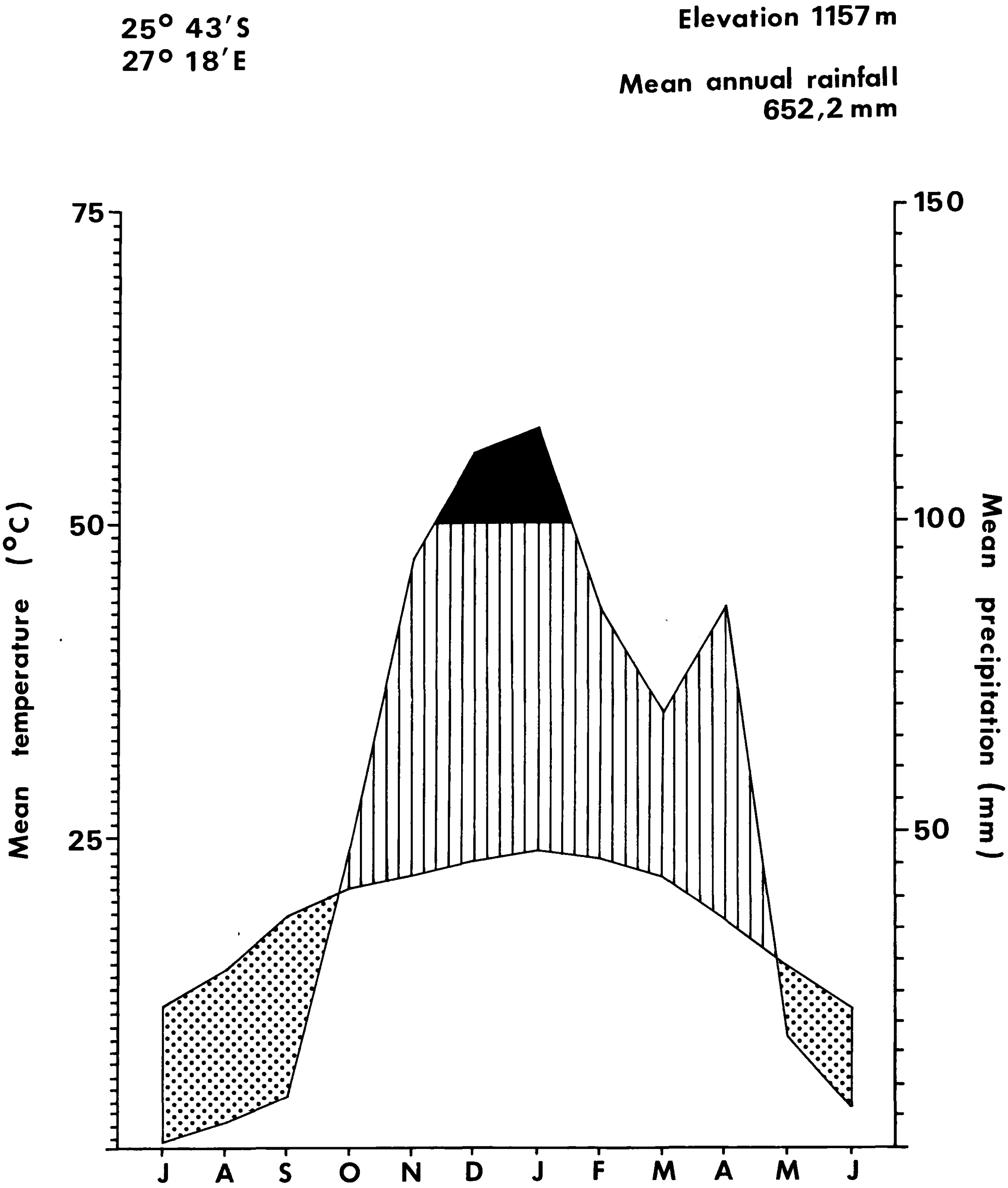


Fig. 5. Climate diagram for Rustenburg Nature Reserve (weather station 511/523).

of the site of the Rustenburg weather station (1119 m), and rainfall on the reserve itself may be higher on the long term basis than that recorded at the Rustenburg site (Coetzee 1975). Light ground frosts are fairly common in June and July.

The reserve lies over the geologically complex Transvaal system which is sedimentary quartzite with diabase intrusions (Coetzee 1975). Soils differ accordingly, and the most marked variations are caused by the aspect. Western slopes in the reserve are characterized by litholitic, sandy-clayloams which are dominated by sugarbush Protea caffra. The reserve consists mostly of a broad plateau, and here soils are deep, gravelly clay loams with high organic content and well-developed horizons. On the eastern slopes soils tend to be poorer, more shallow lithosols with a much higher stone content.

Coetzee (1974) has differentiated 17 vegetation types on the reserve and these can be grouped into five broad physiognomic types. The western and north-western slopes support a xeric, open Combretum seyheri Acacia caffra woodland with dense grass cover made up predominantly of Setaria and Eragrostis spp. Much of the central plateau is covered by open grassland with a reed swamp, dominated by Phragmites mauritianus, centrally located. The grassy layer is floristically varied, with many dominants and subdominants scattered according to minor changes in soil characteristics. The north-eastern and south-western rims of the central plateau basin are covered by various woodland types in which Protea caffra is usually dominant. The soils within these woodlands are sandy or sandy clay loams with pH ranging from 4,8 to 6,0. Some minor vegetation types, including forest and woodland types occur in gorges and under preciptous overhangs.

The reserve was taken over by the Nature Conservation Division in 1962 and was stocked with several species of wild ungulate not associated with sable on other reserves. These include hartebeest *Alcelaphus buselaphus*, black wildebeest *Connochaetes gnou* and springbok *Antidorcas marsupialis*. A small number of sable were introduced in 1968. The utilization history prior to the establishment of the nature reserve is vague, but it is fairly certain that various intensities of grazing by both cattle and horses were common, and that burning at sporadic intervals took place.

Hans Merensky Nature Reserve

Hans Merensky Nature Reserve, situated at 23° 39' S, 30° 40' E, is the only provincial nature reserve where sable occurred naturally at the time of proclamation, although Kettlitz and Verschuur (1958) record that numbers were very low. The reserve was first proclaimed in 1950, and was enlarged by additional land purchases in 1951, 1954 and 1965, to bring it to its present size of 5184 ha. The land added in 1965 comprised an area (Black Hills) where sable had previously been very abundant and where a small resident herd was still present. This area of 1028 ha was fenced separately from the rest of the reserve in an attempt to maintain and manage it exclusively for the sable population. In 1969 a small research enclosure of 172 ha adjacent to the sable camp was fenced and stocked with a small resident herd of sable to facilitate observations and research in the dense Lowveld woodland vegetation of the area.

Hans Merensky lies within the great southern savanna plain which extends down the south-eastern side of Africa through Mocambique and the eastern Lowveld, and which lies below the eastern escarpment. The local elevation varies from 428 to 530 m above sea level. Long-term temperature records were not available for the reserve for the construction of the climate diagram, so data utilized were taken from the nearest first-order weather station at Phalaborwa, some 30 km to the south of Hans Merensky Nature Reserve. The Phalaborwa area has the same type of vegetation and occurs at approximately the same elevation (Fig. 6).

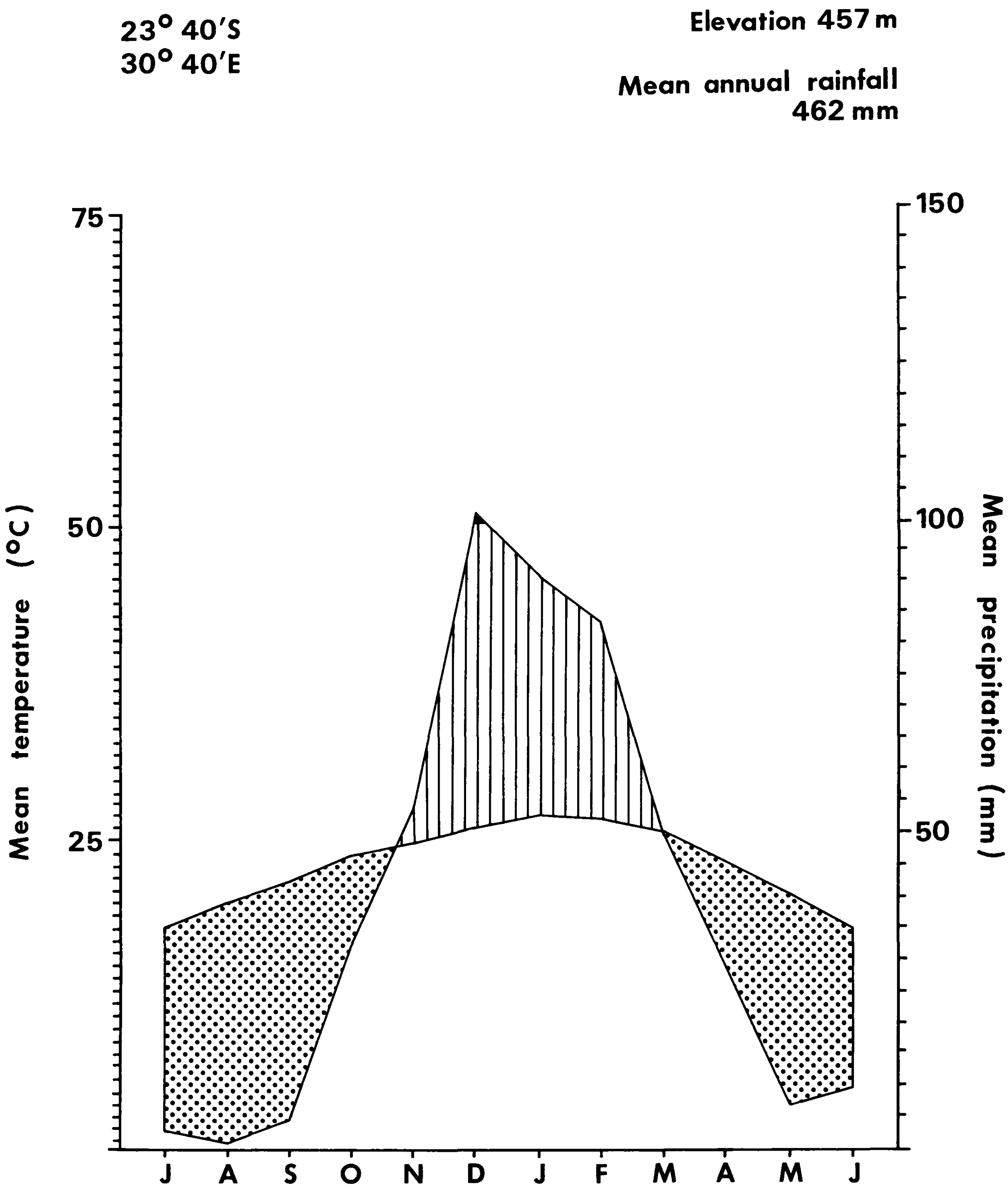


Fig. 6. Climate diagram for Hans Merensky Nature Reserve. Rainfall data from Eiland/Black Hills (weather station 680/280) and temperature data from Phalaborwa (weather station 681/209).

In comparison to the reserves described above, Hans Merensky has a much hotter and more arid climate due to the lower altitude and more eastern longitude. The "wet" period of the year extends only from Novermber to March and there is a 7-month period of moderate to severe moisture stress. Total mean annual rainfall (462 mm) slightly exceeds that of Percy Fyfe Nature Reserve, but the evapotranspiration is a great deal higher.

The actual rainfall measured on the reserve during the study period fluctuated around the long-term mean, as is typical of the climate of the arid Lowveld, and values recorded in 1972/73, 1973/74 and 1974/75 were 368, 834 and 664 mm respectively. Examination of the rainfall records for 12 years (1960-1971) for the reserve showed that only 6 of the 12 years had an annual rainfall within 20 percent of the long-term mean, and only 7 of the 12 years had an annual rainfall within 40 percent of the mean. Rainfall is thus very erratic and unpredictable. The lowest monthly mean temperature is $17,3^{o}$ C occurring in July, and the highest is $26,6^{o}$ C occurring in January.

The underlying geological formations are remarkably homogeneous in this area and are all archaean granite. The Black Hills, a range of low hills forming the southern boundary of the reserve are dolorite intrusions. The soils have not been studied in any detail, but preliminary examination (Oates 1971) indicates that they are reasonably uniform clay and clay-loams. They are poorly differentiated, and Valsrivier, Mispah and Hutton forms have been found (Oates op cit.). The mean soil pH is 5,8 and approaches neutrality (pH 6,4) along the doloritic intrusions. Characteristic of the area are saline patches 1-2 ha in extent, with no topsoil and an extremely alkaline soil reaction (pH exceeding 10). These patches support poor stands of very palatable grasses and are the prime targets for grazing ungulates. The rest of the soils appear to be generally poor in organic matter and in macro-and micro-elements.

The vegetation is generally classified as arid Lowveld (Acocks 1975). Little is known about the vegetation types, apart from some preliminary observations by Oates (1971). The vegetation types of a similar reserve, Timbavati Nature Reserve, some 110 km directly south, have been investigated in detail (Hirst 1975) and found to be markedly heterogeneous, with slight variations in topography and soil type giving rise to a patchwork mosaic of different vegetation types. On Hans Merensky the vegetation is dominated by various associations of *Combretum* woodland and various types of mopane trees and shrub savanna.

The vegetation of Hans Merensky is generally in an unstable subclimax state because of frequent and erratic variations in rainfall and frequent drought periods, coupled with ungulate overpopulations. Riney and Kettlitz (1964) indicate that droughts have led to the reduction of ungulates such as wildebeest, zebra, impala, waterbuck, kudu and warthog *Phacochoerus aethiopicus* by up to 70 percent. Sable numbers have been known to fluctuate widely, due to drought deaths and to movement away from the reserve (by crossing the perennially flowing Letaba river). Game reduction has become a standard management practice to remove surplus numbers and minimize range deterioration.

Matetsi Area, Rhodesia

The Matetsi area, lying northwest of the Wankie National Park, is located at approximately 18° 35' S, 25° 55' E. The elevation varies between 1066-1200 m above sea level, and the area comprises a group of privately-owned lands, some of which have been or are used for cattle ranching activities while others have been conserved mainly for use by indigenous wild ungulates. Some boundaries are fenced. Sable antelope populations in the area are considered to be thriving (Johnstone 1971). Roan antelope are not abundant in this particular area, but occur in larger numbers to the south within the confines of Wankie National Park.

The terrain in the Matetsi area consists generally of low broken basalt hills of the Karroo system (Thompson 1965). This contrasts markedly with the underlying geology of Wankie National Park which lies mainly over aeolian Kalahari sands. The soils in the Matetsi area are derived primarily from decomposed basalt under conditions of high temperatures and fairly high rainfall and are consequently clay-loams with little differentiation. Because of the high montmorillonite content, a great deal of internal churning takes place (Thompson op cit.). Soil depth varies considerably, and those on ridges and slopes are fairly shallow, while on the flats they tend to be deep vertisols. Soils are neutral or mildly basic and have relatively abundant amounts of calcium, magnesium, sodium and free carbonates (Thompson op cit.). Topographic variations are common, the most important being the so-called "vlei" grasslands in lower-lying areas, where the soils are deeper and moist throughout most of the year. Free-standing water is common in patches. The shallow ridges surrounding the flatlands are well-drained, and the soils are shallower and sodic.

Vegetational patterns are closely correlated with the soil catena. The vlei grasslands are covered with tall and medium height grasses, and are dominated by species such as Hyperthelia dissoluta, Setaria spp., Eragrostis spp. and Heteropogon contortus. Particularly moist areas are characterized by hydrophytic species such as Imperata cylindrica and Miscanthidium spp. (Johnstone 1975). The vlei edges are characterized by a dense grass and with Heteropogon contortus, Digitaria nemoralis, Eragrostis rigidior and Urochloa brachyura dominant. Scattered trees, mainly Terminalia and Bauhinia line the edges of the vleis. On the well-drained sodic slopes, mopane is dominant, and appears in both shrub and tree form as an open to fairly dense woodland. A tree savanna occurs along the tops of the basalt ridges with tall mopane, various Combretum spp., knobthorn Acacia nigrescens and marula Sclerocarya caffra the most common trees (Johnstone 1975). The understory is primarily an Aristida grassland with an admixture of many other species, of which annuals make up a significantly large proportion (Rattray 1957).

A climate diagram (Fig 7) indicates that the climate of the Matetsi area is very different from that of the Transvaal nature reserves. Total mean annual rainfall is some 685 mm, although the 6-year mean for 1967/72 was only 513 mm (Johnstone 1975). The bulk of the rainfall falls within the period November through March, and mean figures for December, January and February are 134, 173 and 140 mm respectively.

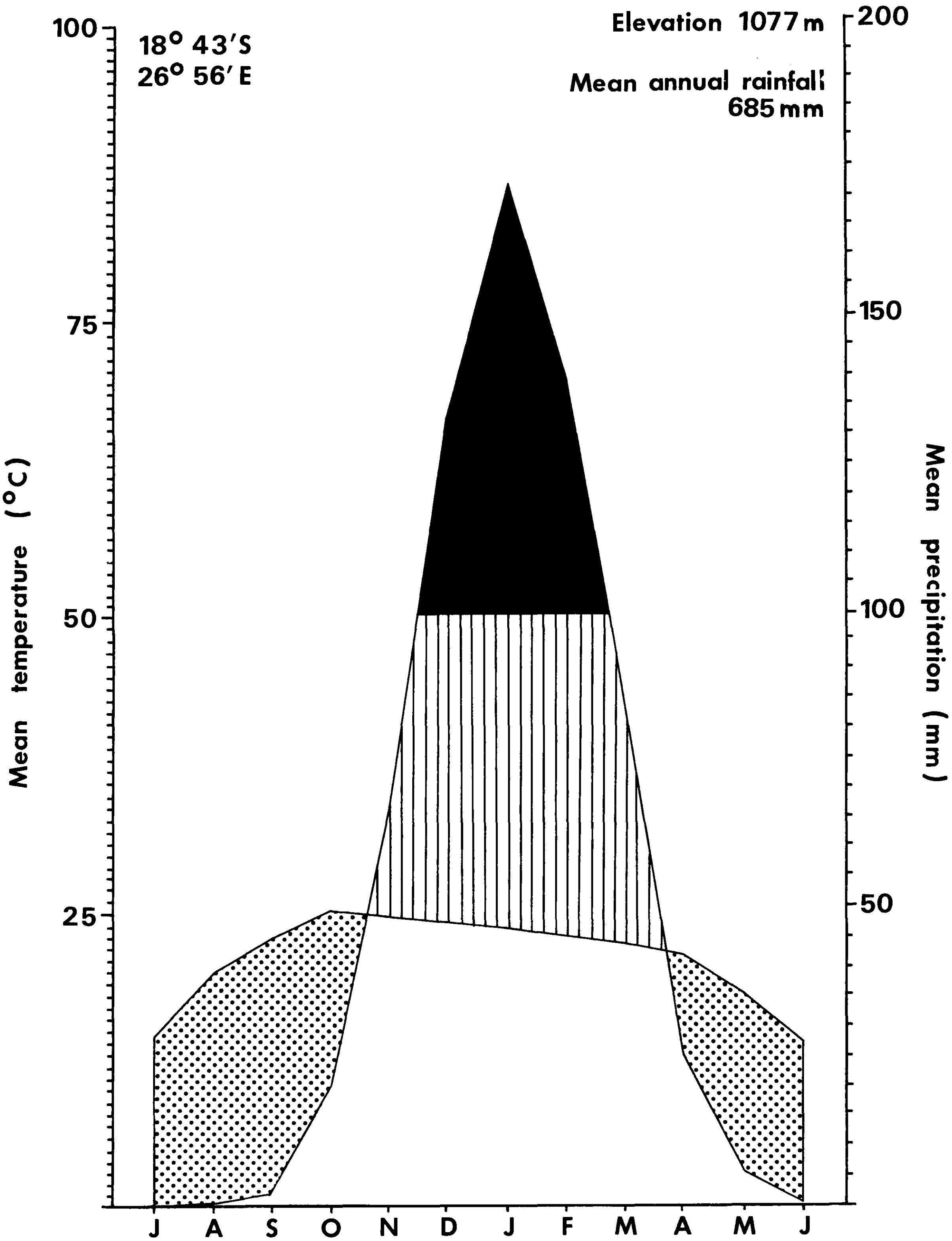


Fig. 7. Climate diagram for Matetsi area, Rhodesia. Data derived from Thompson (1965) for Dett, 80 km east of Matetsi.

Other Sampling Areas

In the course of the study, a number of roan and sable antelope populations in other areas were sampled for blood and body tissues. Sampling in these areas was usually coincidental and accomplished while capture and translocation operations were in progress. Much of this information was later found to be invaluable for analysing nutritional status and protozoal infection rates in both Transvaal and Rhodesian roan and sable antelope populations.

Matopos National Park, Rhodesia

A number of sable in the Matopos National Park, Rhodesia, were sampled in 1973. This reserve of 43 200 ha is situated amongst granitic hills 48 km south-west of Bulawayo, and the vegetation bears strong resemblances to that of Percy Fyfe and Loskop Dam Nature Reserves. Grobler (1974) has identified eight habitat types, of which several types of open woodland and grassland are the most important. The graminaceous layer is dominated by species such as *Hyperthelia dissoluta*, *Heteropogon contortus*, *Schizachyrium* spp., *Aristida* spp. and *Eragrostis* spp. Sable antelope were probably common in this area in the last century since cave paintings nearby commonly depict them. The present population is an introduced one. Translocations have been made over the past 70 years from various sources. The present population numbers at least 200 (Grobler 1974). The numbers of calves and yearlings observed over the 1970/73 period were both high (Grobler 1974), and the population appears to be expanding. The present density is of the order of 2,9 /km^2.

Ermelo Ranch

In the Transvaal a number of sable were captured by means of helicopter and nets on an area known locally as Ermelo Ranch, some 30 km directly south of Hans Merensky Nature Reserve. The climate, soils and vegetation approximated those of Hans Merensky very closely. The numbers of sable in the area could not be reliably ascertained, but they shared the range with a fairly high density of cattle, and habitat over-utilization was evident in patches.

Tjolotjo Tribal Trust Area, Rhodesia

Opportunity also arose to sample several roan antelope captured in the Tjolotjo Tribal Trust Area by the Rhodesian Department of National Parks and Wildlife. This area, lying south-east of Wankie National Park, lies within the vast area covered by aeolian Kalahari sand. These soils are undifferentiated and contain less than 15 percent clay and silt (Thompson 1965). The vegetation is dominated by mopane in several growth forms, but mainly shrub woodland, with tall mopane tree savanna being found on higher ridge tops. The densities of roan or sable in the area could not be determined, but they were wide-spread over a large area. Range condition was generally poor because of heavy continuous use by cattle and shifting cultivation practices.

The area was not ideal habitat for roan antelope, which were in only fair condition. The data gathered were nonetheless valuable for comparative purposes and this represented the only area in Rhodesia where these animals could be sampled.

TECHNIQUES AND PROCEDURES

The objectives of the study called for identification of the main limiting factors operating on roan and sable antelope herds on Transvaal nature reserves. Since population limitations can operate in many ways with many ramifications, it was difficult at the outset to specify exact operational procedures and techniques to be used.

Review of available literature on the Hippotragine antelopes in Africa revealed only that both species are regarded as being specific both in their feeding habits and in their selection of habitat. These facts, coupled with the knowledge that several Transvaal nature reserves were located on poor soils with possible nutrient deficiencies, suggested a detailed study of feeding habits, food availability, nutrient availability, habitat selectivity and availability and seasonal body condition (especially of breeding females and calves).

Population limitation could be effected through poor reproductive performance brought about by physiological or behavioural factors, or by increased mortality amongst juveniles and/or adults. A review of all Divisional records for roan and sable antelope on various nature reserves indicated that mortalities occurred most frequently amongst young calves and, at times to a lesser extent, amongst adults. To achieve a better insight into the complexities of the reproductive and mortality situation, it was decided as an initial approach to select one herd of each species and observe them closely over a prolonged period.

Percy Fyfe Nature Reserve was slected as the primary study area because of the presence of both sable and the only roan herd on a provincial nature reserve. The area lent itself to detailed observations due to the relative tameness of the roan and sable, the general open parkland-type vegetation and the good road network which facilitated location and observation of the herds. Living and storage facilities were also available on the reserve.

Subsequent to the initial observations, the study was extended to other Transvaal nature reserves and to Rhodesia for measurement of habitat, disease and nutritional characteristics of other roan and sable antelope populations.

Observations

Direct observation played a vital role in providing basic information on the overall ecology of roan and sable antelope in the context of delineating possible limiting factors on nature reserves. The roan and sable herds on Percy Fyfe Nature Reserve occupied separate enclosures and, for the first 18 months of the study, approximately equal time was devoted to observation of each herd. A herd would be sought and located as soon as possible after first light and would be followed by vehicle at a distance throughout the day. Observations through 10 x 40 binoculars provided information on daily activities, feeding habits, home range utilization, general social behaviour and interactions between individuals, the respective roles of herd bulls and dominant females in herd activities, reproductive behaviour, and other aspects such as vocalizations and inter-specific relationships.

After several months of intensive observation, the periods of peak activity were known and surveillance was curtailed during periods when animals were resting or ruminating. Although there were several solitary males in both roan and sable enclosures, these animals were not sought out for specific observations. Detailed notes were kept of behavioural traits of the herd bulls, the immature males, the individual females and their calves. Interactions relating to breeding and aggression were specially noted. Collar marking of the herd animals (see below) facilitated identification of individuals. During periods of feeding, attempts were made to identify the plants being eaten. This was often possible in the case of species such as Themeda triandra which had easily recognizable inflorescences. Constant attendance by vehicle enabled close approach when necessary to within approximately 25 metres of the animals without disturbance. When a herd moved away from a feeding site, a follow-up search of the area was made and newly bitten plants found and identified.

The location and recording of animal distribution and movements were facilitated by the field use of large-scale aerial photographs (see Distributional Plotting).

Due to a high mortality rate among newly born calves, particular attention was paid to the activities of parturient females when they appeared ready to calve to gain information on where calving took place, the activites of the female before and after parturition, the general location of calves after birth and calf activity. The location and observation of calves was given high priority when it was determined that high mortality occurred in newly born calves during the 2 to 6-week isolation period of sable and roan calves, respectively.

This detailed surveillance of the two herds was maintained on a daily basis for a 7-month period, January through July, 1972. Whenever a calf disappeared from the herd or was not observed in its area of isolation, a team of 16-20 observers was mobilized to search the immediate area where it was last seen in attempts to locate either the live animal or the carcass. When live calves were found and if handling was necessary for blood sampling, shoulder length plastic gloves were worn to minimize the chance of tainting the animal with foreign odour (Fig. 8).

Fig. 8. Blood smear being taken from the ear-tip of a newly born sable calf 1 hour old to determine intrauterine transmission of Cytauxzoon parasites. All young animals were handled with shoulder length plastic gloves to prevent tainting with foreign odour.

Dead Animals

Whenever dead calves were located in the field, they were brought to field headquarters for further examination. Some calves in moribund condition were also located and were kept in pens and treated with antibiotics and parenteral cortisone preparations. Those that survived were returned to the field.

Dead animals were examined for condition, signs of injuries, external parasites and any obvious abnormalities or lesions. A thin blood smear was taken from the tip of the ear. The animal was cut open and impression smears made from sections of the spleen, liver, kidney, lung, heart, adrenal gland and a peripheral lymph gland. Brain smears prepared from the hippocampus were taken if the carcass was in a relatively fresh condition. Sections of each organ approximately 2 x 2 x 2 cm in size were taken and placed in 10 percent buffered formalin solution for later histological examination. Ingesta from the abomasum, small intestine, caecum and large intestine were collected, flash-heated to 80° C to kill all helminths present, and placed in large containers with 10 percent buffered formalin for later examination in the laboratory. This procedure was later abandoned when it became evident that helminths were present only in very low numbers and that helminthiasis was not a probable limiting factor.

Carcasses were placed in a deep freeze and held at -5° C until they could be removed to the Veterinary Research Institute at Onderstepoort some 270 km south of Percy Fyfe. At the Institute, detailed post-mortem examinations were conducted to establish the reasons for pathological changes, infections and other diseases.

Additional material was collected where necessary for bacteriological or histological examination. Formalinized specimens were sectioned, stained with standard haematoxylineosin and examined microscopically for lesions. Blood smears were stained with standard Giemsa reagent and examined microscopically for intra- and extraerythrocytic parasites. Some 400 to 500 erythrocytes were examined in each case, and where intracellular piroplasms were present, a scale of abundance was applied, viz. one or two parasites found in a 3 minute search = very rare; less than one parasite seen per 15 microscopic fields searched = rare; more than one parasite per 15 fields = not rare.

At times carcasses of both roan and sable adults were available for examination. These moralities resulted from capture operations by a game capture unit on other reserves, traumatic injuries, or other causes. Animals found dead in the field on Percy Fyfe were treated as described above. Those that died during capture operations were also examined when possible, and specimens were taken when the author was present, otherwise arrangements were made to have blood smears only taken.

Sampling from Live Animals

Collection of information from dead animals was of the utmost importance in the study, but collecting opportunities were limited due to the difficulty in locating carcasses in the field, and the rapid rate of decomposition in the warm climate. Results from preliminary observations and necropsies suggested that protozoal infections and nutritional deficiences were responsible, at least in part, for mortalities, and it was considered essential to obtain blood, milk and other samples as well as weights and measurements from live animals. A further need for handling live animals was to mark them for easy identification in the field.

Most live capture for the specific purposes of marking and obtaining samples was undertaken on Percy Fyfe Nature Reserve. Additional opportunities were given by capture and translocation operations on Hans Merensky Nature Reserve and Ermelo Ranch, Transvaal, and Matopos National Park, Wankie National Park, and the Tjolotjo Tribal Trust Area, Rhodesia.

Immobilization

Chemical immobilization was the method of choice for capturing individual animals which were relatively approachable by vehicle, as was the case on Percy Fyfe Nature Reserve. Temporarily immobilized animals could be isolated from the herd, captured, weighed, measured, checked for pregnancy and blood and ectoparasite samples collected. Chemical immobilization was used for the capture of all adult and subadult sable and for adult and subadult male roan antelope. No authority could be obtained for the immobilization of roan females due to the relative rarity of the animals on the reserve, and the possible risks of mortality from immobilization and capture.

The initial equipment used was a commercial rifled .500 calibre powder-charged projector[1] and 3 ml dart syringes activated by a small internal powder charge. The range was found to be inadequate for general use however, since the sable rarely permitted repeated approaches to close range after an initial shot. A modified 20-gauge shotgun[2] and 3 ml dart syringes[2] were then used with moderate success, although the heavy darts had a marked trajectory which made accurate placing of the shot difficult over ranges exceeding 60 m. Most animals had to be darted from ranges of 50-90 m. A bored-out .500 gauge projector with a non-rifled barrel used with lighter 3 ml darts[3] gave a much flatter trajectory and better flight characteristis for the dart, however, the high velocity of the powder-charge propelled darts led to excessive localized tissue damage at the point of impact and occasionally dart penetration into the animal. After considerable experimentation a modified dart was fabricated utilizing the favourable aspects of the various darts available. This projectile was lightened in weight by

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[1] Palmer Cap-Chur Equipment Co., Atlanta, Georgia, U.S.A.

[2] G.L. van Rooyen, National Parks Board, Skukuza, South Africa.

[3] Don-Joy Industries, Bulawayo, Rhodesia.

approximately 50 percent, employed an enlarged nose piece to prevent penetration into the animal on impact, and constructed so as to inject the drug with either a powder-detonated charge or a mixture of sodium bicarbonate and acetic acid interchangeably. The CO_2 pressure mechanism within the dart proved reliable and resulted in minimal damage at the injection site. This modified equipment was used for all subsequent chemical immobilization.

Initial drug combinations used were those suggested by Pienaar (1973), viz. Fentanyl[1] and Azaperone[1] combinations. Both sable and roan are agressive by nature, and although in a deeply drugged state, this drug combination led to excessive struggling and frequent attempts by the animal to ward off captors by potentially dangerous horn thrusts. The animals had to be roped and physically manhandled into a suitable position for weighing, measuring and blood sampling. The stress thus induced by the immobilization process was considered unacceptable and a better drug combination sought.

Etorphine hydrochloride[2] was used in combination with Azaperone and found to have a much shorter induction period, but animals remained aggressive and difficult to handle under its influence.

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[1] Jannssen Pharmaceutica, Beerse, Belgium.

[2] Reckitt and Colman Ltd., Hull, England.

The safety margin of drug excess was reduced. The sedative and analgesic drug Rompun[1] was added to the drug mixture to counter the excitatory effects of the Etorphine or Fentanyl, and found to give good results. It was subsequently found that Fentanyl and Rompun together gave the best results and Azaperone was omitted from the mixtures.
The dosage rates were adjusted until a combination was found which permitted sable and roan to be immobilized and handled with the help of only one assistant to hold the head up while samples were being taken.

Wherever possible, two vehicles were used while capturing roan or sable. One vehicle would carry the immobilizing crew while the other would keep the herd and the darted animal under distant observation, and signal when the immobilized animal went down. No attempts were made to approach a darted animal until it lay down, since premature approaches or attempted handling could lead to flight and the animal covering an appreciable distance before it again came to a standstill.

Wherever possible, animals were darted in the rump, shoulder or other identifiable large muscle mass. Care was taken to avoid the head, thorax and abdomen. Immobilized animals were handled as rapidly and quietly as possible, and then given nalorphine hydrobromide[2] intravenously to counteract the effects of the Fentanyl or Etorphine. Preventative

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[1] Bayer Leverksen, South Africa.

[2] 'Lethidrone' Burroughs-Wellcome, South Africa.

therapy in the form of antibiotics and cortisone preparations were given intramuscularly to all immobilized animals. If necessary a respiratory stimulant was given intravenously. Dart wounds were treated locally with antiseptic ointments.

Marking

Attempts were made to mark as many adult and subadult sable on Percy Fyfe Nature Reserve as possible to facilitate observations on behaviour, movements, reproduction and mortality. Roan females were not marked due to the possible danger of immobilization mortalities. Natural identifying features such as unusually shaped horns or facial markings were uncommon and not reliable enough for accurate and rapid identification in the field.

The marking method selected was a long-wearing plastic collar[1] in bright colours, recommended by Hanks (1969) (Fig. 9). Bright red was used initially for females and bright blue for males, with black numbers embossed on either side. The collar was secured with a heavy brass buckle, the weight of which served to keep it in the correct position on the ventral aspect of the neck. During subsequent milk sampling (see Milk Sampling) the collars of lactating cows which still had suckling calves were changed from red to blue, but the same number was retained. This permitted quick identification in the field of cows which still had young calves, as opposed to those who had lost their calves.

[1] Dalton Supplies, Ltd., England.

Fig. 9. Immobilized sable antelope female with bright coloured marking collar. Number 71 embossed in black identifies animal.

The numbers on the collars were difficult to read over long distances, even with the use of binoculars. Also the possibility of collar loss could not always be excluded. An alternative method of marking, viz. by freeze-branding, was employed for sable antelope on Rustenburg Nature Reserve.

These animals were in the process of being moved from a capture site in the eastern Transvaal Lowveld to the reserve, and were in quarantine pens at the time of branding. They were released onto the reserve after branding. The method used was a modification of that employed by Hanks (1969) and Pienaar (1970). The branding irons were modified insofar as the numbers were made of mild steel with a 19 mm face and a depth of 7,6 cm. The total height of each numeral was 15 cm. This ensured a branded numeral large enough to read over a distance of several hundred meters, with the use of binoculars, but not so large that problems of sloughing and secondary infection would be encountered. The cooling agent used was crushed dry ice in methyl alcohol at a temperature of -70^{o} C and the area slected for branding was a clean-shaven patch on the lateral rump. Application of the branding iron was made for 30 seconds.

Blood Sampling

Blood smears were made from the tip of the ear of all captured sable and roan antelope. These were air-dried and wrapped in clean, thin paper for despatch to the Veterinary Research Institute, Onderstepoort. In addition, discovery of Babesia parasites led to the necessity of taking thick blood smears from the ear tip. These were stained as described above and searched for intra-eryth rocytic parasites.

Blood samples for the quantitative determination of plasma macro- and micro-elements and other plasma constituents were drawn from the jugular, saphenous or superficial abdominal veins of immobilized animals. Consideration was given to the use of arterial blood for constituent determination. However, under the field conditions encountered during this study, collection of arterial blood was considered impracticable and dangerous to the animals. Blood samples were collected in 10 ml sodium heparin vacuum tubes and were drawn from animals at the same time each day and the same time after initial immobilization to minimize inter-sample variation. Samples were subsequently treated in exactly the same fashion.

Blood samples were removed as soon as possible to a sheltered site where they were centrifuged in a portable centrifuge powered by a 220 v field generator at 3000 rpm for 30 minutes. A fully articulated head on the centrifuge permitted the tubes to spin horizontally so that the erythrocytes were packed down with a perfectly horizontal meniscus.

This facilitated accurate reading of packed cell volume. Four such haematocrit tubes were spun and read for each blood sample. The supernatant plasma was pipetted off into aseptic glass tubes, labelled and stored in a portable gas freezer at -4^{o} C, for eventual transfer to the chemical analytical laboratory.

Milk Sampling

Milk was collected from immobilized, heavily lactating female sable on Percy Fyfe, for the determination of milk constituents. Attempts were made to gather a series of samples covering the whole lactation period from post-partum to the onset of weaning. In a few cases, milk was taken from the same animal at different stages of lactation.

Cows were immobilized for milk collection during the middle of the day, i.e. between normal suckling periods, which appeared to be in the early morning and late evening. Immobilized animals were given 15 I.U. oxytocin intravenously in an ear vein to stimulate the let-down reflex of the udder. This usually occurred within 2 minutes. One teat was selected from the pair that were being suckled by the calf (apparent from their relative size) and milked out as completely as possible. Since each teat was served by a separate reservoir, the total sample was representative of the milk being taken in by the suckling calf. Complete stripping was necessary to obtain an unbiased sample, since fat tends to remain until the last, and the first milk is highest in protein. Milk was collected in large polyethylene plastic containers which had been rinsed out with concentrated, chemically-pure hydrochloric acid followed by distilled water to remove any possible mineral residues. Ten percent buffered formalin was added at the rate of 1 ml per 200 ml milk and the entire container was placed in a freezer as soon as possible for eventual transfer to the analytical laboratory.

Weights, Measurements and Ageing

Whenever circumstances and time permitted, all immobilized animals, and those captured by mechanical means by the game capture unit, were weighed, measured and aged in the field. Exceptions were made when it was deemed inadvisable for the well-being of animals to maintain them under deep narcosis for periods longer than a few minutes, or when the nature of the terrain precluded the approach of the weighing vehicle.

Weighing equipment comprised a telescopic 10 cm diameter tubular A-frame attached to the back of a four-wheel drive vehicle and which extended up to 5½ m. A block-and-tackle attached to the apex via a 1000 kg spring scale was used to hoist the animal clear of the ground. Lifting of the animal was facilitated by the use of a 1,8 x 1,8 m net of 9½ mm nylon rope, equipped with large steel rings around the periphery. This was spread under the animal and the rings brought overhead to connect to the block-and-tackle hook. Weights were read to the nearest kg.

Morphometric measurements were made wherever possible. These are listed in Table 2. The measurements selected were not all standard or internationally comparable, but were those which could be taken fairly

TABLE 2. - MEASUREMENTS TAKEN FROM IMMOBILIZED AND CAPTURED SABLE AND ROAN ANTELOPE IN THE TRANSVAAL AND RHODESIA. ALL MEASUREMENTS TAKEN IN CM, WEIGHT IN KG

Total body weight
Length of each horn- - right and left
Number of horn rings on each horn
Circumference at base of each horn
Distance between horn tips
Length of each ear
Circumference of head in front of ears
Length of head from nose to base of horns
Length of head from nose to atlas joint
Total length against body- - nose to tip of tail
Length of tail
Circumference of neck at top and at base
Circumference of chest behind front legs
Circumference of abdomen in front of rear legs
Length of front leg from tip of hoof to knee
Length of rear leg from tip of hoof to elbow
Length of hind foot from tip of hoof to dew-claw
Body condition estimate (visual)

rapidly under field conditions with one assistant, and which appeared to be most useful for later comparisons of geographical variations in morphometry.

Distributional Plotting

The animal habitat interface was considered to be of major importance in the present study, since it was intended to relate all limiting factors back to habitat quality and to factors which could be managed on nature reserves. Initially nothing was known of habitat or feeding requirements, or how animal activity related to these parameters. Detailed analysis of feeding and habitat preferences required a knowledge of seasonal and daily movement patterns, activity patterns and activity areas. From this an estimation could be made of home range size in relation to area availability and the degree of competition from other grazing ungulates. The localities of the preferred feeding and loafing areas could be established.

Accurate plotting of positions, activities and other important parameters was carried out monthly throughout most of the year 1974 for the sable antelope herds on Percy Fyfe, Loskop Dam and Rustenburg Nature Reserves. Similar systematic observations were planned for Hans Merensky Nature Reserve, but due to the density of the vegetation, difficulty in approaching the animals for observation, and lack of representative aerial photographs of the recently altered habitat, distributional plotting was replaced by frequent visits for less systematic observations. Similar detailed plotting was also done for the roan antelope herd on Percy Fyfe.

Standard 1:30000 aerial photographs of each reserve were obtained[1]

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[1] Trigonometric Survey Office, Pretoria.

and enlarged six times to approximately 1:5000. The exact scale was checked by ground measurements. Each set of photographs was covered by a grid of squares 6 x 6 cm in size, corresponding to the scale markings on the photographic prints. Each square was subdivided into nine equal blocks, each of which was again subdivided into four blocks. The resultant smallest blocks had a true ground area of 0,32 ha, and were each given serial identification numbers.

From 4 to 7 (mean approximately 6) days per month were spent in plotting the positions of the sable or roan herds on the three reserves. A routine was set up so that each reserve was sampled at approximately the same period within each month. Herds were located as soon as possible each day so that observations could begin at daybreak. This was not always possible on Loskop Dam and Rustenburg, where animals could move into rugged and inaccessible terrain. Observations were made from a vehicle kept at a distance so as not to disturb the animals, and were continued throughout the day until dark. Gridded aerial photographs were carried in the field and the exact blocks occupied by the entire herd recorded every 2 minutes. Information recorded at the same time related to activities and other species present, and is detailed in Table 3. Special note was made of other species feeding in the same area. Field data were subsequently punched onto magnetic tape and summarized and analyzed by computer.[1]

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[1] Department of Finances, Transvaal Provincial Administration, Pretoria.

TABLE 3. - DATA RECORDED EVERY 2 MINUTES WHILE OBSERVING ROAN AND SABLE ANTELOPE HERDS ON PROVINCIAL NATURE RESERVES. NUMERALS INDICATE CODES USED FOR COMPUTER ANALYSES

Species:
- 1 = roan
- 2 = sable

Nature reserve:
- 1 = Percy Fyfe
- 2 = Rustenburg
- 3 = Loskop Dam

Date:
- i.e. 240874 = 24th day, 8th month, 1974

Time:
- 2400 hours

Coordinates:
- 01234

Activity:
- 1 = other
- 2 = feeding
- 3 = ruminating
- 4 = breeding
- 5 = moving not feeding
- 6 = drinking

Associated species feeding in the same habitat
- 0 = none
- 1 = waterbuck
- 2 = zebra
- 3 = impala
- 4 = kudu
- 5 = wildebeest
- 6 = springbok or tsessebe (depending on reserve)
- 7 = blesbok

Habitat Evaluation

Although the several provincial nature reserves, which today provide refuge for roan and sable herds, are all within the known historic distributional range of these species, there is no certainty that they provide adequate habitat for the species. The vegetational and soil variations of the whole savanna region of the Transvaal are vast in number (Acocks 1975), and these, coupled with topographic and mesoclimatic variations, make for many different types of habitat. Roan and sable were apparently never abundantly distributed over the entire historic range, but the vague historical descriptions (du Plessis 1969) make identification of preferred habitats difficult.

Some ungulate species in Transvaal savanna are known to be specific in their choices of habitat (Hirst 1975) and selectivity is based on the physical characteristics of the vegetation types, e.g. the grass height and woody plant density. As relatively rare species, roan and sable are probably also highly selective for habitat, and in addition may be selective for their food plants. Detailed characterization of preferred habitats and detailed analysis of feeding preferences and food plant availability were thus considered priority undertakings.

Areas selected for detailed study were those where the highest proportion of feeding observations in the dry season, July through September, were made during the monthly distributional plotting. These were considered to be key areas in so far as they constituted the habitat carrying the animals through the critical dry season.

In most cases, however, preferred wet season areas overlapped the dry season habitats, and it was possible to select areas which had year-round use. Sampling transects were spaced over the whole area utilized by roan or sable and thus varied in size from some 36 ha for a sable area on Loskop Dam to over 136 ha for the roan herd on Percy Fyfe.

Habitat is a complex of vegetation and micro-relief and has innumerable facets which can be measured and quantified. The parameters selected for measurement were those which had been found in another study of ungulate-habitat relationships (Hirst 1975) to be significant for determining animal distribution. These related mainly to density of cover, density of grass cover and density of shade cover.

Vegetation Density

A density board, suggested by the descriptions of Wight (1938, cited by Giles 1969) was used for measuring lateral cover density for grasses, forbs, shrubs and trees. It was also utilized for measuring maximum grass height in each sampling locality. The board was 2 m high and divided into 10 alternate black and white panels of 20 cm height each. Along one side of the board was a scale indicating height from ground level in 4 cm increments (Fig. 10).

A random starting point was selected and the other points spread systematically over the whole area along evenly spaced transects, marked by temporarily sited marked poles. At

Fig. 10. Density board in use on Hans Merensky Nature Reserve during dry season, 1974. Maximum grass height was measured against scale along left side of board. Vegetation density was recorded on a 'strike' or 'obscurity' basis. In this case the bottom panel number 1 is obscurred by grass and strikes are recorded for panels 2-4.


10
9
8
7
6
5
4

each point an assistant would hold the board erect while the observer moved 15 m along the transect and then recorded the number of panels obscured by the different classes of vegetation. An obscurity was defined as the point where the centrally-painted numeral on each panel, measuring 12 x 12 cm, could not be seen. Grass height was noted, using the scale on the board, and was the mean maximum height at each sampling site over the 15 m between the observer and the board.

Sampling adequacy was considered before the field measurements were taken. The obscurity of the panels was measured on a 'hit' or 'miss' basis, and the data would thus be expected to follow a binomial distribution (Tidmarsh and Havenga 1955). Time and manpower were also major considerations at this point, since six areas had to be measured within the space of a month to minimize variation over the end of the dry period and to ensure that data from the various areas were comparable. A total of 300 points per area was selected as the most practical sampling intensity. This gave standard errors of 10 percent or less of the mean if total 'strikes' were 25 percent or more, and standard errors of some 15 percent when strikes were in the vicinity of 10 percent. It was an inadequate sample for very low vegetation density, e.g. obscurity caused by overhanging tree foliage, but it did give an adequate sample of the important lateral obscurity by grass and shrub cover. The 300 sampling points were systematically spread over the entire sampled area, and thus the distance between transects varied considerably from one reserve to another.

Lateral Visibility

An additional measurement of lateral visibility was made to quantify the distance the animal could see while in its preferred habitat. This had particular significance since both sable and roan are commonly described as animals of open woodland or woodland-grassland edges. At each point where the density was observed, an assistant moved away from the transect at right angles, and the point where he disappeared from view was noted and the distance measured with the use of an optical range-finder.

Canopy Cover

An important parameter characterizing open woodland with scattered tall trees, which is frequently cited as prime sable and roan antelope habitat, is the canopy crown cover. This is equivalent generally to the shade cover offered to the animals.

Two independant approaches were utilized initially. A wheel-point survey (Tidmarsh and Havenga 1955) was carried out on Percy Fyfe Reserve which supplied information on ground area covered by overhanging canopy crowns. The same area was then located on the large scale aerial photograph, and canopy cover estimated from a similar point survey by placing a transparent dot grid (prepared by drawing 25 dots per cm^2) over the photograph and counting percentage "strikes" on canopies utilizing a standard stereoscope to delineate tree canopies.

The two methods gave very close results (30,9 and 29,5 percent cover respectively). The photographic method was then used to estimate canopy cover on all study areas, although the total number of points checked varied with the size of the preferred areas.

Grass Cover, Frequency and Species Composition

The wheel-point method of vegetation analysis (Tidmarsh and Havenga 1955) was used as a basis for determining grass basal cover, frequency of occurrence of grasses and forbs and the species composition. One wheel in place of the originally described two was used, to facilitate entry into rough terrain and into dense cover. A total of 1000 points was regarded as adequate for each reserve, since this gave a standard error of 10 percent and less of the mean for basal covers and frequencies of occurrence of 10 percent and over. Transects were marked as described above, and spaced so that the sampling points were systematically spread over the whole area. Strikes on basal portions of plants were recorded, as well as the identification of the nearest plant to the point. Note was made whether the nearest plant had been grazed or not. Accurate identification of grasses required that infloresences be present, hence the wheel-point surveys were carried out in February 1975.

Feeding Preferences

Observations of plants seen being eaten were carried out at every opportunity. Although this method enabled identification of many of the grass species being utilized, it gave little quantitative information except for browsing by roan antelope on Percy Fyfe Nature Reserve. Feeding preferences varied throughout the year according to availability, growth form, phenology, rainfall and other factors. However, the actual feeding habits during the critical dry season were considered to be of primary importance since nutrition was probably critical at this stage.

The presence of several grazing ungulates made field measurements of grazing preferences of sable antelope entirely impracticable, so two alternative approaches were used: temporary feeding enclosures and the analysis of rumen contents. The latter method was also employed to measure feeding preferences of other ungulates on Percy Fyfe to determine the degree of interspecific competition with sable antelope.

Temporary Feeding Enclosures

The preferred feeding areas for both the roan and sable antelope herds on Percy Fyfe Nature reserve were identified from the distributional plotting data and information on feeding activites. A small site in the center of each preferred area was selected and a temporary ½ ha enclosure was erected. The enclosure had 3 m high sides made of steel wire strands covered with light brown plastic sheeting. The animals within could not see out and were not disturbed by outside stimuli. One roan male leaped the fence and had to be replaced by another captured animal. A small enclosure was constructed to one side of each larger enclosure to temporarily isolate the animals while survey or removal operations were being undertaken. Water was made available in temporary troughs serviced via a small hatch in the fence.

Two male animals were immobilized, weighed and placed in each enclosure. Each pair was made up of an adult and subadult of about 2 years of age. The animals were permitted to graze freely, and at the end of the grazing period they were immobilized, weighed and released back into the field.

The size of the enclosure, relative to the number of animals it contained, was worked out from simple daily dry weight forage intake estimations. The original plan was to maintain the animals in the enclosures for 6 weeks and to make periodic surveys of eaten plants during this period. In practice, however, it was found that both roan and sable were so food specific that within ten days they had apparently taken all the palatable grasses and were refusing to take what grass was left. The animals had dropped markedly in body condition so the grazing period in the enclosures was curtailed.

The availability of two 2-year old hand-reared, semi-tamed sable males enabled the feeding experiments to be duplicated concurrently for close observations of feeding animals. This was not possible with wild-caught sable or roan, because they were aggressice when approached in close confinement. Another ½ ha enclosure identical to the others was erected a short distance from the enclosure containing the wild-caught sable. The semi-tamed animals were immobilized, weighed and treated in exactly the same fashion as were the wild-caught animals.

Before the roan and sable were placed in the temporary enclosures, a 2000 point wheel-point survey was made in each of the three. As described above, strikes on basal portions of plants as well as frequencies of nearest plants were recorded. The 2000 point survey was repeated immediately after the animals had been released from the enclosures after the period of 10 days continuous grazing. The intensity of feeding on plants was recorded on a three-point scale, viz. 0-33, 34-66 and 67-100 percent grazed.

Rumen Contents Analyses

An alternative method of determining grass species utilized by sable antelope on the various provincial nature reserves was used, viz. quantitative microscopic analyses of the plant fragments in the rumen, suggested by the work of Martin (1955). A great deal of work has been done on microscopic analysis of faecal plant fragments for determination of diets of African wild ungulate (cf. Stewart 1971, Stewart and Stewart 1970, McAllister and Bornman 1972), but this is a very time-consuming operation. With the shooting of sable males on nature reserves for analysis of blood and liver nutrients and the availability of males of other species on Percy Fyfe Nature Reserve for similar sampling, it was decided to utilize rumen contents directly for determination of diets and interspecific dietary competition on Percy Fyfe, and to determine to what extent the same grass species were being utilized on the other nature reserves.

The techniques used were combinations and modifications of those recommeded by Croker (1959), Hercus (1960) and Storr (1961). Preliminary work had to be undertaken to collect and prepare reference microscopic slides, so that the plants represented in the rumen samples were exactly the same as those in the reference slides used for identification. Plants growing in different habitats have been shown to have slightly different epidermal characteristics (Stewart 1965). Sable and the other principle grazing species on Percy Fyfe-- waterbuck, zebra and impala -- were observed closely over a period of several days, and the areas grazed searched carefully for eaten plants. Samples of all portions of the plants were collected, the plants were identified and voucher specimens taken to the National Herbarium for positive identification.

Reference slides of grass leaf epidermal tissue for each species were prepared in two ways; manual scraping and chemical maceration of leaf fragments (Storr 1961). For the purposes of this study, comparison was based on leaf fragments only, since identification of every fragment of every other portion of the grass plant, including the culms, would have involved an impracticable expenditure of time and man-hours. Reference slides were photomicrographed and photographic prints prepared to the same size as the magnification used in scanning rumen samples. This made visual comparison much easier and faster.

Two sable males were shot during the dry season 1974 on Percy Fyfe, Loskop Dam, Rustenburg and Hans Merensky Nature Reserves. Although sable were also shot on the Matetsi area, grass species identification from rumen samples were not directly comparable due to the absence of a reliable reference slide series.

To determine interspecific feeding competition on Percy Fyfe, males of each of the common grazing species -- waterbuck, impala and zebra -- were shot during the same season while grazing on the same area preferred by sable. All animals were shot in mid-morning while feeding. Detailed descriptions of the shooting are given below.

After removal, the rumens (or caecums in the case of zebra) were cut open along the dorsal aspect, and the contents thoroughly mixed. Approximately 1 liter of mixed rumen contents was removed, placed in a polyethylene container, covered with 10 percent formalin solution, and stirred.

In the laboratory the entire contents of the containers were thoroughly washed to remove all traces of formalin, and then placed in a blender for 5 seconds (20 000 rpm) to reduce all plant fragments to a maximum size of 1½ mm. Blended material was then filtered through a Buchner funnel and oven-dried to constant weight at 60^{o} C. A 1,0 g sample of the dried material was then gently boiled in a reflux condensor for 5 minutes with a mixture consisting of 10 ml F.A.A. (85 ml of 50 percent ETOH, 10 ml of 36 percent formaldehyde and 5 ml of 100 percent acetic acid) and 10 ml concentrated nitric acid. The mixture was then diluted and boiled for a further 10 minutes after which it was filtered again through the Buchner funnel and thoroughly washed. The fragments were stained with a few drops of Ruthenium Red in a 10 ml glass tube and a droplet of the sample was spread evenly over a slide and covered with a coverslip.

A quantitative method of recording frequency of occurrence of epidermal fragments was used. The micrometer scale of the mechanical range of the projecting microscope was moved 2 mm in each direction at a time.

A point drawn in the centre acted as a means of recording 'strikes' or 'nearest fragment', much the same as in a standard wheel-point survey for plant frequencies in the field. A 63x magnification of the microscopic field was projected onto a screen (Reichert Univar projecting microscope) for rapid scanning of plant fragments. A total of 100 fragments was examined for each rumen sample. Thorough mixing at all stages in the handling process ensured that the sample was an unbiased representation of the plant volumes in the respective rumens.

Determination of Nutritional Status

Results from techniques and procedures already described indicated that the nutritional status of roan and sable antelope herds on Transvaal nature reserves was a critical factor in the whole limiting factor study, and had to be examined in detail. The status of Transvaal animals could then be compared to that of animals in Rhodesia, where they were considered to be thriving. Body condition of both roan and sable had been noted to be very poor during dry seasons in the Transvaal, and there was evidence of nutritional deficiencies, viz. osteophagia by sable on Percy Fyfe and geophagia and osteophagia on Loskop Dam. An analyses of body condition, body protein levels and body reserves of all the important macro- and micro-elements was considered of primary importance.

Sampling from Animals

Due to the rarity of the species authority to shoot only two male sable on each provincial nature reserve was obtained from the Transvaal Nature Conservation Division. No authority for shooting of roan could be obtained. In addition, the owners of Rosslyn Game Ranch in the Matetsi area, Rhodesia, granted permission for the shooting of five animals specifically for sampling purposes. The overall sampling was thus of low intensity, but variability was reduced by including adult animals in each sample per reserve, and by shooting all animals at the end of the 1974 dry season--August through September. Subsequent statistical analyses were selected which permitted efficient comparisons in spite of the low sampling intensity.

Animals were shot through the head with a 7 mm high velocity rifle, and an attempt was made to insure that they were in no way excited at the time of shooting. Immediately after being shot, each animal was bled from the jugular vein; 60 ml of blood was collected in sodium heparinized tubes while the heart was still beating. Blood samples were removed as soon as possible to field headquarters, centrifuged and processed as already described. Thick and thin blood smears were prepared from the tip of the ear. Animals were then weighed and measured as described above.

Eack kidney was dissected out, together with its total perinephric fat, weighed with and without the fat, and a kidney fat index (KFI) for body condition computed according to the suggestions of Riney (1955), Ransom (1965) and Smith (1970). The liver was removed and a 30-60 g wedge cut from the edge. The wedge was preserved in 10 percent buffered formalin. The value of liver analyses for determining mineral nutritional status is described by Boyazoglu _et al_. (1972), who also showed that there was an insignificant difference between the mineral contents of fresh and preserved livers.

Blood samples were taken to a chemical laboratory[1] for measurement of blood enzymes and plasma protein content, while both liver and blood plasma samples were analysed[2] for protein and for liver and blood mineral content.

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[1]Department of Medicine, Faculty of Veterinary Science, University of Pretoria.

[2]South African Bureau of Standards, Pretoria.

Sampling from Vegetation and Soils

Vegetation and soil samples were collected on each preferred area within a 1-month period during the dry season to provide background information on availability of nutrients and minerals to the animals and to the forage plants respectively. Along the transect lines described above, which ran across the entire preferred areas, preferred grasses were identified and pulled up. Preferred species varied from one reserve to another, depending on overall species composition and availability, but in most areas the species *Themeda triandra*, *Hyperthelia dissoluta* and *Heteropogon contortus* were collected. Soil was removed from the grass plants, and leaves, stems and roots included in a pooled sample for each species. Approximately 1 kg of each species (fresh weight) was collected. Samples were removed to the laboratory where they were oven-dried to constant weight at 80° C and ground through a Wiley mill. After thorough mixing, sub-samples were drawn from the milled samples for chemical analyses.

Soil samples were collected from 1000 sites along the same transects over the whole preferred area. Samples were limited to the top 10 cm of the topsoil. Samples were pooled and passed through a 4 mm sieve to remove stones and coarser particles. At the laboratory, the pooled samples were oven-dried at 80° C, then thoroughly mixed, and subsamples taken for chemical analyses.

Sampling from Water

Most water available to roan and sable antelope on nature reserves was in the form of deep subsurface water pumped out by engine or windpump and supplied in eathern or concrete-lined dams. In the Matetsi area, surface water was freely available from streams or standing water in vleis. The mineral status of water was not known, but because of its hardness in many areas, it was suspected of being of significance in mineral intake by roan and sable.

Water samples were drawn from watering points close to preferred areas, and which were known to be used as drinking points by roan or sable. Containers were 15 liter polyethylene plastic bottles, rinsed out with concentrated hydrochloric acid to remove possible mineral residues. Water samples were brought to the laboratory[1] and analyzed within 24 hours of collection to prevent any chemical changes in the dissolved salts.

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[1] South African Bureau of Standards, Pretoria.

Chemical Analyses

Liver samples were removed from the formalin preservative and 1 g was digested in 1 ml of a 1:7 mixture of concentrated sulphuric acid and 72 percent perchloric acid plus 5 ml of concentrated nitric acid. Blood plasma samples were diluted with distilled water before analysis. Milk samples were first thawed, then homogenized and digested in a mixture of concentrated nitric acid (8 parts) and 72 percent perchloric acid (4 parts) at a rate of 2 g of milk to 12 ml acid mixture. Grass samples were digested in a mixture of concentrated nitric acid (4 parts) and 72 percent perchloric acid (2 parts) at a rate of ½ g of dried milled grass per 6 ml acid. Soil samples were dissolved in concentrated hydrofluoric acid and ethyl alcohol (proportion 2:1:2) at a rate of 1 g dried soil per 25 ml acid-alcohol mixture.

All the resultant digests were filtered and diluted, and subjected to atomic absorption analyses for calcium, phosphorus, magnesium, sodium, potassium, iron, copper, zinc, cobalt, manganese, molybdenum and selenium. Selenium concentrations were extremely low, and a modified technique was used to detect this important trace element: generation of selenium hydride and measurement of the atomic absorption in a heated silica tube. Nitrogen analyses was carried out using the standard Kjeldahl technique.

Use of Hand-reared Animals

During the early phases of the study, three young sable male calves were acquired and hand-reared. These animals were born in captivity while the pregnant females were being held in quarantine pens on Hans Merensky Nature Reserve. Approximately 21 days separated the birth dates of the youngest and the oldest. Shortly after birth they were transferred to specially-constructed pens on Percy Fyfe Nature Reserve where they were fed on cows milk and good quality lucerne hay. At 6 months of age they were weaned onto concentrates in the form of commercial antelope cubes to supplement the lucerne hay. A mineral lick was provided at a later stage. Because of dominance relationships, one bull had to be separated from the other two.

The semi-tamed animals permitted the close presence of observers, and were useful for observations on growth and ageing. Periodic weights and measurements were taken throughout their period of captivity.

The semi-tamed animals were used in temporary feeding enclosures in the field to determine feeding preferences (see above). The experience of Leuthold (1971) suggested that feeding behaviour has a major innate selective mechanism, which permits hand-reared animals to select basically the usual preferred plants even when faced with a choice the first time in the field. It was also considered likely that intraspecific variation in feeding habits was likely to prove as great as interspecific variation between a wild-caught, and a hand-reared animal. These suppositions were later borne out by the results of the feeding enclosure experiments.

Since the three semi-tamed males were fed a balanced and fully supplemented diet, they represented an additional control for the determination of nutritional status of wild sable. Two of the three animals were sacrificed at the end of the dry season, 1974, when sample animals were shot on other reserves and study areas. Each animal was then approximately 2½ years old. Blood and tissue samples were collected as described above. The third animal was later used in a field controlled experiment.

Determination of Reproductive Capability in Male Sable

During the initial surveys of literature and the first period of intensive observations in the field, it became evident that the age of sexual maturity amongst sable and roan antelope was a factor of importance in understanding many of the behavioral patterns observed, and especially of elucidating the aggression shown by the dominant herd bull towards young sable males at certain times. Such aggression was linked apparently to the age of the young males, i.e. at about 17-19 months of age, and possibly to the reproductive history of the dominant bull. Knowledge of the age of sexual maturity would have an important bearing on the establishment of new necleus herds.

Literature sources (cf. Smithers 1966, Grobler 1974) were conclusive on the age of first sexual activity in sable females--2½ years. They thus calved down for the first time at approximately 3 years of age. No information was available on sable males and the development of sexual activity.

A programme of systematic sampling of young males was planned to elucidate the development of sexual maturity. Two methods were used: electro-ejaculation to obtain semen samples for analyses, and blood sampling to measure testosterone levels. Sampling of subadult males would possibly indicate when animals were physiologically capable of reproducing and whether this coincided with their psychological state of reproductive capability.

Collection of semen samples was planned to take place on a quarterly basis, using both wild-caught and the penned immature and developing males. However, difficulties were encountered initially in obtaining ejaculates due to a combination of immobilizing drugs which produced an insufficient depth of narcosis and inadequacies of the ejaculating apparatus to stimulate ejaculation. In addition the pressure of other research tasks interferred with a regular programme, so sampling was done on an irregular basis throughout the study period.

The objective of sampling adult males was to provide information on whether seasonal variability occurred in the reproductive capability of the males and if this was a factor of importance in the reproductive health of the herds. It was initially planned to obtain semen samples from both adult and subadult animals in the middle of the breeding season, after termination of the breeding season and during the inactive season. However, subsequent observations and record keeping throughout successive calving seasons showed that the maximum number of calves were being dropped each year during the study period, which indicated that maximum breeding took place, so regular sampling was disregarded in favour of obtaining samples when time and circumstances permitted.

Animals to be electro-ejaculated were immobilized with Fentanyl-Azaperone drugs initially. When this combination was determined to produce insufficient narcosis, Rompun was substituted for Azaperone in combination with Fentanyl.

The fore and hind-legs were bound to avoid injuries to both the animal and the assistants.

A battery-powered electro-ejaculator (Rollison and Nunn 1962) was used initially, but found to give very poor results and only a small amount of ejaculate no matter what technique or rhythm was used. This particular rectal probe had two brass rings placed approximately 1 cm apart along the anterior portion. Although the length of the probe was sufficient to place these rings on the ampulla (see REPRODUCTIVE FACTORS), and electrical stimulation appeared to be adequate by the muscular contractions of the animal, only small secretions of accessory fluid were obtained. The ejaculator apparatus was later modified to include brass electrodes that ran longitudinally along the length of the probe, and was increased in size to a length of 24 cm and a diameter of 5 cm. Power was taken from a 220 v field generator, and the ejaculator was equipped with a rheostat to control current intensity. Semen samples were collected in clear glass tubes via a plastic funnel, protected from direct sunlight, and taken to field headquarters for microscopic examination. Smears were then prepared and stained in standard fashion with nigrosin-eosin.

Planned Experiments in Small Enclosures

Systematic planning, timing and execution of field sampling provided the basis for most data collections in this study. However, the ability to immobilize and capture specific animals on Percy Fyfe Nature Reserve at any selected time, coupled with the fact that temporary field enclosures could be relatively rapidly and economically set up, provided a capability of organizing specific experiments to elucidate certain aspects of the ecology and reproductive physiology of sable antelope.

One such approach, viz. the use of temporary feeding enclosures, has been described above. Three others relating to disease transmission, nutritional status and reproductive success, and to the ages of breeding capability in young sable were also employed.

Intra-uterine Transmission of Cytauxzoonosis

The detailed examinations of recovered carcasses and of blood smears from live animals had indicated that sable and roan on Percy Fyfe Nature Reserve, and on other similar areas, suffered from a high incidence of *Cytauxzoon* infection. This is discussed in detail below.

The infection was shown to be of major importance in young calves. Since it is known to be a tick-borne disease, the question arose as to whether calves were infected via tick infestations, or whether infection was passed from dam to young via the placenta. Most protozoal diseases have an incubation period of at least 10-14 days (Henning 1956), but calves of both roan and sable had been found to disappear in less than 10 days after birth, which indicated either infection of the newly-born calf via the placenta or death of the calf due to non-disease factors, e.g. specific deficiencies, malnutrition etc.

Three separate but adjacent pens were constructed within the sable enclosure on Percy Fyfe Nature Reserve. Each small pen was 30 x 30 m in size and provided with natural shade and piped water. Fences were 3 m high and covered in light brown plastic sheeting to prevent disturbance from visual stimuli. Pens were sufficiently large to provide natural forage for individual females for a few days only.

Five healthy pregnant females were immobilized and translocated into the pens during the active calving season. Two past-partum cows were released before the pens were utilized for holding another two. Cows were allowed to drop their calves in the pens, and an observer was assigned to keep constant watch so that the newly-born calf could be blood-sampled as soon as possible after birth. The females were blood-sampled at the time of immobilization and translocation into the temporary pens to ascertain that they carried the Cytauxzoon parasite. After parturition and sampling of the calves, both mother and young were allowed to leave the pens and join the rest of the herd. Since forage within the pens was limited, only cows which were within a day or two of parturition were placed in them.

Nutritional Deficiences and Calf Mortality

As will be discussed in detail, the supposition that mortalities amongst young roan and sable were linked to the nutritional status of the pregnant and lactating females was strongly borne out by analytical results of blood, tissue, vegetation and soil sampling. The availability of temporary pens in the field provided an opportunity to test this theory critically. It could be adequately proved if the diet of pregnant females could be supplemented during pregnancy and lactation and, if by so doing, the survival rate of young calves was found to be significantly improved. The implications were considered very significant to habitat management for better nutritional availability to pregnant and lactating females, and the possibilities of supplementing natural diets with protein and mineral feeds.

A 30 x 90 m pen was erected in the sable enclosure, and was constructed as already described. Five sable cows were immobilized in November 1974 and palpated rectally to determine pregnancy. They were weighed, blood sampled then translocated into the pen and allowed to remain there for 7 months. This ensured that the calves born in the pen attained an age of at least 4 months, and the total period of potential mortality was adequately covered. It also ensured that the cows were in the pens for 3 months prior to calving and that their nutritional reserves were adequately enhanced.

The cows were fed a diet of lucerne hay and commercial antelope cubes. The latter contained a minimum of 16 percent protein and 0,7 percent phosphorus. A nutrient supplement lick containing 30 percent protein, 1 percent fat, 12 percent fibre, 5 percent calcium, 2,5 percent phosphorus, 0,011 percent copper, 0,021 percent manganese, 0,00042 percent cobalt, 1,042 percent sulphur and 0,0021 percent iodine was made freely available. The supplementation was intended to completely eliminate any protein, energy or mineral deficiency which would normally have occurred on natural range lands.

The danger existed that wild-caught sable cows would take an appreciable amount of time to learn to eat supplementary concentrated feeds, during which time their condition in the pens would deteriorate to dangerous levels. The two semi-tamed males were placed in the pen at the same time. Since the latter were accustomed to feeding on antelope cubes, the period of learning in the females was shortened to less than a week.

After a 7-month stay in the pens, including the parturition period and lactation, the cows were again immobilized, milk and blood samples taken, and then released into the field with their respective calves.

Age of Reproductive Capability in Sable Males

The desirability of determining exact ages of sexual capability in young males is discussed above. It may be possible however, that physiological capability may proceed behavioral capability, and that even though young sub-adult males may be capable of breeding, they may be so dominated by the sexually mature or adult cows that they fail to mate. In a normal herd these young males are either dominated by the herd bull or are driven off, and so do not normally acquire the opportunity to breed. Establishment of new nucleus herds, however, is frequently based on translocation of mature males as the breeding stock, and knowledge of the potential breeding capability of the young males would provide management information.

A separately fenced enclosure of 20 ha was available on Percy Fyfe Nature Reserve. Two young sable males, 18 months old, and two sable females, one adult and one 18 months old, were immobilized and removed to this small enclosure. Translocation took place in early autumn well before the normal onset of breeding activity. Frequent observations were made to detect breeding behaviour, and during mid-summer the females were immobilized and rectally palpated to determine pregnancy.

The animals were permitted to remain in the enclosure until well after calving season, and were then returned to the main herd.

Statistical Analyses

All quantitative data which could safely be assumed to be normally distributed, e.g. grass heights, distances measured, etc., were summarized and the normal parameters of mean, variance and standard deviation determined. Group comparisons were made using an analysis of variance with a one-way classification (Steel and Torrie 1960). When significant differences were found between groups, Duncan's multiple range test (Steel and Torrie op cit.) was used to separate the means into groups which did not differ significantly from each other internally.

Much of the data collected were of the point variety, e.g. wheel-point surveys for grass basal cover or plant frequencies of occurrence, and could be expected to follow the binomial distribution (Steel and Torrie op cit.). Variances were computed accordingly. Comparisons of groups of mean values were made by doing sequential analyses of variance (F-tests) and deleting extreme mean values until a point of non-significance was reached.

Small samples were taken in the case of animals shot for tissue samples, milk samples from lactating females and blood samples from live animals. Values for many of these nutrients and parameters such as kidney fat index were found to vary greatly from one area to another, and any assumption of normality would have been incorrect. The analyses were accordingly done by use of non-parametric methods (Siegel 1956). The Spearman rank correlation coefficient was computed to measure the degree of correlation between pairs of possibly related variables, and tests for significance between groups of values were done with the Kruskal-Wallis test and paired comparisons by means of the Mann-Whitney U test. The non-parametric tests had the advantage of being unaffected by the distribution or actual magnitudes of the values, but were more affected by changes in numerical direction. They were thus particularly valuable for the analyses of biological data of the type encountered in this study.

HERD HISTORIES ON TRANSVAAL NATURE RESERVES

With the exception of Hans Merensky Nature Reserve, situated in (then) relatively undeveloped country in the eastern Transvaal Lowveld, no provincial reserve had roan or sable populations at the time of proclamation and perimeter fencing. Percy Fyfe, Rustenburg and Loskop Dam Nature Reserves were all situated within semi-extensive ranching and agricultural areas, and most wild ungulate populations had been shot out or populations severely diminished within the first decades of this century.

Sable on Hans Merensky Nature Reserve

At the time of its acquisition by the Nature Conservation Division in 1950, Hans Merensky had several herds of wild sable antelope which probably ranged over a substantial area. No information is available on seasonal movements prior to fencing, but it is known for the southern section of the eastern Transvaal that seasonal east-west movements were undertaken by other large ungulate species such as wildebeest and zebra (Hirst 1975).

Rainfall and available surface water were known to be key factors causing movements, and the mopane shrub woodland where Hans Merensky is today located is a semi-arid ecological type. However, the Letaba River, which forms the northern boundary of Hans Merensky, is a perennial river and may have substantially altered movement patterns in the area. The river was not an effective boundary, since a herd of 70 sable was known to have crossed it, out of Hans Merensky, in 1959 (Riney and Kettlitz 1964).

Divisional records for sable histories on Hans Merensky are very poor. In part, this is due to the relatively dense woodland on the Reserve, and the wildness of the herds. The recorded information on young juveniles seen in the veld and which were taken to be recent births, as well as actual carcasses recovered, is given in Table 4. No causes for mortalities were given in Divisional records, since carcasses were invariably located by the presence of vultures or other scavengers and were usually in an advanced state of decomposition.

The areas surrounding Hans Merensky Nature Reserve have over the past decades carried several herds of sable. One such herd was incorporated into the Reserve in 1965 by the purchase of the entire range frequented by them; this is today the Black Hills sable enclosure. The Reserve records do not reflect the large numbers of sable which have died from starvation during acute drought periods over the past two decades (S.M. Zaayman,[1] personal communication). Several herds were introduced onto the Reserve in the early 1960's by lowering the boundary fences and driving them in from the adjoining areas. Animals captured elsewhere in the lowveld and maintained in the quarantine pens on the Reserve for various periods were also at times released into the Black Hills enclosure.

From the available records it is apparent that in both the Black Hills enclosure (Table 4) and in the small 172 ha research enclosure (Table 5), most mortalities have involved either juveniles 1-4 months after birth,

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[1] S.M. Zaayman, Reserve Manager, Private Bag 502, Letsitele, South Africa.

TABLE 4 - RECORDED DEATHS AND NATURAL INCREMENTS OF SABLE ANTELOPE ON HANS MERENSKY NATURE RESERVE (BLACK HILLS ENCLOSURE), 1968-1974. DATA FROM NATURE CONSERVATION DIVISIONAL FILES

Date	Recorded Deaths [1]	Recorded Births [2]	Approximate Herd Size [3]
March 1968		7	43
February 1969	8 juveniles	9	52
January 1971		3	55
February 1971		11	66
August 1971	5 juveniles		
March 1972		3	64
April 1972	1 juvenile	8	71
May 1972		2	73
June 1972	4 not specified	2	69
March 1974		22	99
August 1974	2 juveniles		97
November 1974	2 adult females		95

[1] Only reflects number of carcasses actually recovered.

[2] Only reflects young juveniles actually noticed in field.

[3] Helicopter counts during game-capture operations.

TABLE 5.-RECORDED DEATHS AND NATURAL INCREMENTS[1] OF SABLE ANTELOPE IN 172 HA RESEARCH CAMP, HANS MERENSKY NATURE RESERVE, 1970-1975

Date	Recorded Deaths	Recorded Births	Approximate Herd Size
January 1971	2 female adults	2	8
February 1971		2	10
March 1971	1 juvenile		9
November 1971	1 adult male[2]		8
February 1972		1	9
May 1974		5	14
September 1974	2 adult males[3]		12
March 1975		4	17
April 1975	2 (1 adult male) (1 adult female)		15

[1] Reflects only juveniles actually seen in field.

[2] Broke out through fence.

[3] Shot for research sampling.

or else adult females at the end of the dry season.

Despite the relatively high mortalities, the sable numbers in the enclosure have shown an intermittent increase over the past 9 years from about 30 in 1966 to over 100 in early 1975. This has resulted in overall densities in the 1028 ha enclosure rising from 2,8 animals/km^2 in early 1966 to 9,2/km^2 in early 1975 (Fig. 11). This is, surprisingly, much higher than the mean density of four animals/km^2 in the Matetsi area of Rhodesia (Johnstone 1971), which could be accepted as representing the best habitat available in southern Africa. The sable in the smaller enclosure on Hans Merensky, which adjoins the large enclosure and includes the same habitat types, have shown a rise in density from 4,6 animals/km^2 to 6,8 animals/km^2 over a 4-year period (Fig. 11).

The population increases in the sable enclosure would seem to have been substantially affected by releases of sable caught in adjacent areas, 27 animals having been so released within a 7-year period, during which time the population rose from 30 to 100. During this period the Reserve represented the best available habitat within any provincial reserve for sable, and animals becoming available for capture from lands subjected to intensified agriculture and other forms or land-use were brought to Hans Merensky in preference to other areas.

A correlation of note is the high number of sable calves (22) born on Hans Merensky from a total pre-calving population of 69 in early fall 1974, following a very high annual rainfall for that season (834 mm), and concomitant abundant

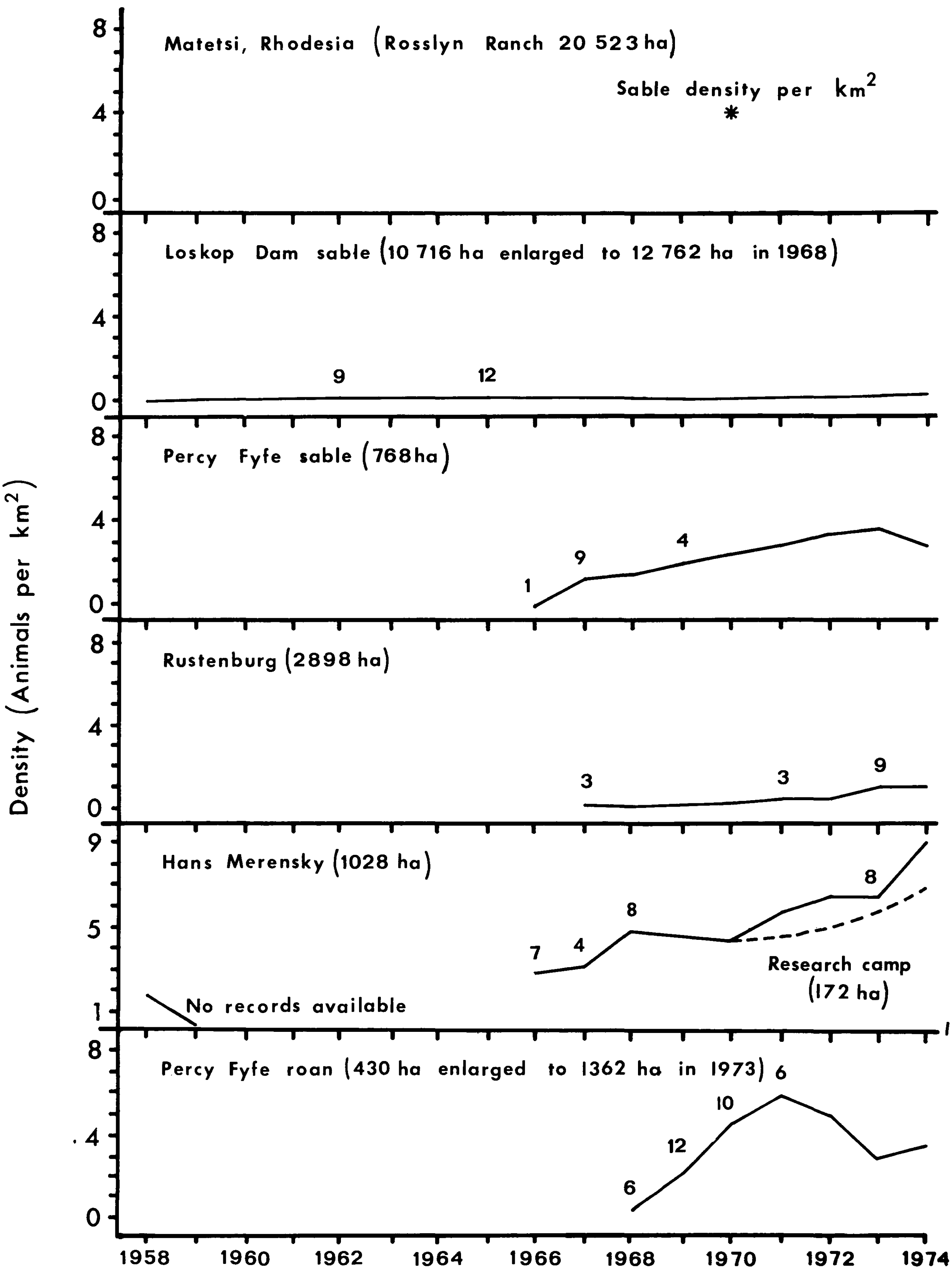

Fig. 11. Mean densities of sable antelope per km^2 on the primary study areas in Rhodesia and South Africa. Mean density of roan antelope on Percy Fyfe Nature Reserve is shown for comparison. Numbers on graph indicate numbers of animals introduced from outside the reserves.

Sable on Loskop Dam Nature Reserve

Loskop Dam was the first provincial nature reserve to be restocked with sable antelope. An adult male, an adult female and a calf were introduced (apparently at three different periods) between 1955 and 1958 (Riney and Kettlitz 1964). In 1958 eight juveniles were translocated to the reserve, five of which were known to be surviving by 1963 (Riney and Kettlitz op cit.).

Loskop Dam is an area with rugged terrain and recovery of carcasses is purely by coincidence. Only 10 sable carcasses, all in advanced stages of decomposition or already reduced to mere skeletons, have been located over a 17-year period (Table 6). The same rugged terrain makes for difficult censuses of game animals and records of numbers prior to 1963 are inadequate.

The sable population on Loskop Dam has not thrived; since its inception in 1955-1958, it has grown to only 53 animals, which is a mean density of only 0,4 animals/km^2 over the 12 672 ha reserve, i.e. one-tenth that of the sable density in the best Rhodesian area. Divisional records for population structure are poor, but in general a very low proportion of juveniles and yearlings has been recorded, with the former usually making up some 8 to 14 percent of the herd in the calving season, and the latter making up 4 to 10 percent. This would indicate a high juvenile mortality.

Divisional records and observations (C.J. Smit[1], personal communication) indicate that bodily conditions of most ungulates, including sable, are usually poor to very poor in the late dry seasons with tick and lice infestations usually heavy during this period.

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[1] C.J. Smit, Reserve Manage, P.O. Damwal, Groblersdal, South Africa.

TABLE 6. - RECORDED DEATHS AND NATURAL INCREMENTS OF SABLE ANTELOPE ON LOSKOP DAM NATURE RESERVE, 1958-1975. DATA FROM NATURE CONSERVATION DIVISION FILES

Date	Recorded Deaths [1]	Recorded Births [2]	Approximate Herd Size
1958 - 1962	4 (3 juveniles) (1 adult female)		7
April 1963		4	11
April 1972		5	46
October 1972	1 juvenile		45
February 1973		1	46
March 1973		2	48
June 1973		2	50
July 1973	3 not specified		47
October 1973	2 adult females		45
February 1974		2	47
May 1974		2	49
February 1975		2	49
March 1975		3	52
July 1975		1	53

[1] Only reflects number of carcasses actually recovered.

[2] First animals introduced in 1955. Only reflects young juveniles actually noticed in field.

Sable on Percy Fyfe Nature Reserve

Percy Fyfe Nature Reserve represents a valuable area in the study since better records (Table 7) were available for sable (and roan) numbers than for other reserves, due mainly to the better visibility, the more open landscape, the relatively smaller sable enclosure (768 ha), and the number of trackers available to make routine checks of the area and the animals.

Population growth (Fig. 11) has been relatively steady since the establishment of the herd in 1966. The first decline appeared in 1974, following the known deaths of 10 juveniles from a pre-calving population of some 26 animals, plus mortalities amongst adult cows too poor in body condition to calve down properly. The peak density reached this far had been 3,8 animals/km^2 which is comparable to the Matetsi sable density.

Recovery of juveniles which had died in the veld was far more efficient than for the other areas, since this area was used as a base during the 3½ year study and special efforts were made to search for missing calves. During the study a number of carcasses were recovered, many of which were young calves of various ages. Recovery of these carcasses was a key factor in determining the actual causes of mortality, at least on Percy Fyfe. Discussion of these mortalities and the diagnoses are given below.

TABLE 7. - POPULATION STRUCTURE OF THE SABLE ANTELOPE HERD ON PERCY FYFE NATURE RESERVE AFTER CALVING SEASONS AND AT END OF DRY SEASONS, 1972-1975. NUMBERS IN PARENTHESES ARE PERCENTAGES.

Date	Adults		Yearlings[1]		Juveniles[2]		Total
	M	F	M	F	M	F	
April 1972	1 (3,7)	10 (37,0)	6 (22,2)	2 (7,4)	4 (14,8)	4 (14,8)	27
September 1972	1 (4,0)	10 (40,0)	8 (32,0)	6 (24,0)	0	0	25
April 1973	1 (3,4)	12 (41,4)	4 (13,8)	3 (10,3)	4 (13,8)	5 (17,2)	29
September 1973	1 (3,7)	11 (40,7)	8 (29,6)	6 (22,2)	0	1 (3,7)	27
April 1974	4 (14,3)	11 (39,3)	4 (14,3)	4 (14,3)	3 (10,7)	2 (7,1)	28
September 1974	4 (18,2)	10 (45,5)	4 (18,2)	3 (13,6)	1 (4,5)	0	22
April 1975	7 (25,9)	12 (44,4)	1 (3,7)	0	5 (18,5)	2 (7,4)	27

[1] 7-24 months of age.
[2] 0-6 months of age.

Sable on Rustenburg Nature Reserve

Rustenburg Nature Reserve represents the latest area to be stocked with sable antelope and numbers are low. Numbers have shown a very slow increase since establishment of the herd in 1967, and maximum density thus far reached is just under one animal/km^2 after 7 years. Twelve animals were brought in from outside during this period. This would appear to indicate an appreciable mortality rate; recovery rate of carcasses is low, and only seven have been found on the 2898 ha reserve over the 7 years.

The population structure of the Rustenburg sable herd shows some differences to those from other reserves (Table 8). The proportions of juveniles seen annually are relatively higher as are the annual proportions of yearlings. However, the numbers of adults, and particularly adult females, has remained reasonably constant, suggesting a high death rate amongst this age and sex class.

TABLE 8.- POPULATION STRUCTURE OF THE SABLE ANTELOPE HERD ON RUSTENBURG NATURE RESERVE AFTER CALVING SEASONS AND AT END OF DRY SEASONS, 1972-1975. NUMBERS IN PARENTHESES ARE PERCENTAGES

Date	Adults		Yearlings[1]		Juveniles[2]		Total
	M	F	M	F	M	F	
April 1972	2 (20,0)	3 (30,0)	3 (30,0)	0	2 (20,0)	0	10
September 1972	2 (20,0)	3 (20,0)	5 (50,0)	0	0	0	10
April 1973	5 (20,8)	10 (41,7)	2 (8,3)	2[3] (8,3)	4 (16,7)	1 (4,2)	24
September 1973	5 (20,0)	10 (40,0)	4 (16,0)	3 (12,0)	2 (8,0)	1 (4,0)	25
April 1974	7 (29,2)	8 (33,3)	4 (16,7)	3 (12,5)	1 (4,2)	1 (4,2)	24
September 1974	5[4] (22,7)	9 (40,9)	5 (22,7)	3 (13,6)	0	0	22
April 1975	9 (33,3)	10 (37,0)	1 (3,7)	2 (7,4)	5 (18,5)	0	27

[1] 7-24 months of age.

[2] 0- 6 months of age.

[3] Seven adult and two yearling females introduced from outside source.

[4] Two adult males shot for reaseach.

Roan on Percy Fyfe Nature Reserve

Roan antelope were first introduced into a special 430 ha enclosure on Percy Fyfe Nature Reserve in mid-1968; six animals were translocated from the Belgium Block. Calving rates amongst the cows were apparently high, and this, coupled with several additional translocations, resulted in the roan antelope population reaching a peak size of 30 animals in late 1972, a density of almost $6/km^2$. This appeared to be about the carrying capacity for the enclosure since numbers remained at this level until late 1973. Calf mortalities during this 2-year period were very high, as reflected by the population structure of the herd (Table 9).

During 1973 the roan enclosure was enlarged from 430 ha to 2061 ha, and although much of this new area had been heavily grazed by blesbok, the roan population increased dramatically due to a high calving rate coupled with a high calf survival rate. Juvenile animals made up more than 20 percent of the total herd in mid-1974. By late 1975, the population appeared to be again nearing the carrying capacity of the enclosure, and increment rates were dropping. Overall density at this point was slightly less than $3/km^2$.

TABLE 9.- POPULATION STRUCTURE OF THE ROAN ANTELOPE HERD ON PERCY FYFE NATURE RESERVE, 1971-1975. ROAN CALVE THROUGHOUT YEAR SO NO CALVING PEAK IS IDENTIFIED. NUMBERS IN PARENTHESES ARE PERCENTAGES

Date	Adults		Yearlings[1]		Juveniles[2]		Total
	M	F	M	F	M	F	
June 1971	5 (27,7)	10 (55,6)	0	1 (5,6)	0	2 (11,1)	18
October 1971	5 (19,2)	15[3] (57,7)	0	1 (3,8)	2 (7,7)	3 (11,5)	26
February 1972	5 (19,2)	14 (53,8)	0	2 (7,7)	3 (11,5)	2 (7,7)	26
June 1972	4 (14,8)	14 (51,9)	2 (7,4)	3 (11,1)	3 (11,1)	1 (3,7)	27
October 1972	4 (13,3)	15 (50,0)	4 (13,3)	3 (10,0)	1 (3,3)	3 (10,0)	30
February 1973	4 (16,0)	15 (60,0)	4 (16,0)	2 (8,0)	0	0	25
June 1973	4 (14,8)	15 (55,6)	4 (14,8)	2 (7,4)	2 (7,4)	0	27
October 1973	4 (8,3)	15 (41,7)	5 (13,9)	2 (5,6)	6 (16,7)	4 (8,3)	36[4]
February 1974	6 (16,7)	16 (44,4)	9 (25,0)	4 (11,1)	0	1 (2,8)	36
June 1974	6 (13,0)	16 (34,8)	9 (19,6)	5 (10,9)	5 (10,9)	5 (10,9)	46
October 1974	8 (17,4)	17 (36,9)	10 (21,7)	6 (13,0)	2 (4,3)	3 (6,5)	46
February 1975	8 (17,4)	18 (39,0)	12 (26,1)	7 (15,2)	1 (2,1)	0	46
June 1975	8 (15,1)	18 (33,9)	12 (22,6)	6 (11,3)	5 (9,4)	4 (7,5)	53

[1] 7-24 months of age.

[2] 0-6 months of age.

[3] Six adult females introduced from outside the reserve .

[4] Size of camp enlarged from 430 ha to 1792 ha.

Population Characteristics and Increments

In assessing the reasons for low population incremental rates, it is difficult to differentiate between lowered reproductivity and high juvenile mortality simply from the age and sex structure of the population. In the present study, this would have been the case with sable populations on areas such as Hans Merensky and Loskop Dam Nature Reserves, where observations on the animals over the years are relatively infrequent and recovery of carcasses of very low incidence. Detailed study of the Percy Fyfe sable and roan herds, and to a lesser extent, the Rustenburg sable herd, provided a much better insight into the actual dynamics of the populations.

The respective populations on Percy Fyfe and Rustenburg Nature Reserves were observed closely over a 3½ year period. The herd structures were followed through four calving seasons. Observations on the females proved beyond all doubt that pregnancy rates were initially 100 percent when a bull was in attendance during the breeding season. Pregnancy rates of 70 percent and 50 percent were noted for the total Rustenburg sable population in 1973 and 1974 respectively, but this population consisted of two herds, one of which was introduced in 1972, and which did not have a bull in full-time attendance. The pregnancy rate of the other herd, with a bull always present, was 100 percent.

This information, coupled with the high number of juvenile mortalities observed on Percy Fyfe (Tables 10 and 11) and a fairly high rate of disappearance of both juveniles and yearlings from the herds (Tables 7 and 9), left little doubt

TABLE 10.- AGES OF SABLE JUVENILES FOUND DEAD OR DYING, PERCY FYFE NATURE RESERVE, 1971-1975

Sex	Birth			Death			Age Years - Days
M	18	January	1971	20	March	1971	62
ND	30	January	1971	23	March	1971	53
ND	1	February	1971	23	March	1971	51
M	4	February	1971	2	December	1971	300
M	5	February	1971	5	December	1971	302
M[1]	1	March	1971	18	November	1972	1 - 263
M	6	February	1972	31	August	1972	208
M	15	February	1972	2	September	1972	201
M	15	February	1972	21	February	1973	1 - 5
F	23	February	1972	7	April	1972	45
ND	24	February	1972	29	February	1972	5
F	6	June	1972	6	September	1974	1 - 213
M	9	June	1972	30	August	1972	83
F	17	February	1973	30	April	1973	73
F	17	February	1973	28	September	1973	224
F	27	April	1973	26	June	1973	61
F	17	February	1974	12	March	1974	24
F	17	February	1974	26	March	1974	38
M	17	February	1974	28	March	1974	40
M	17	February	1974	20	April	1974	63
F	18	February	1974	20	April	1974	62
F	18	February	1974	2	May	1974	73
M	20	February	1974	20	February	1974	(Born dead)
F	22	February	1974	8	December	1974	290
M	26	February	1974	26	February	1974	(Born dead)
M	1	March	1974	1	March	1974	(Born dead)
F	3	March	1974	2	May	1974	60
M	19	February	1975	29	April	1975	70

[1] Killed by herd bull.

M = Male.

F = Female.

ND = Sex not determined.

TABLE 11.-AGES OF ROAN JUVENILES FOUND DEAD OR DYING, PERCY FYFE NATURE RESERVE, 1971-1975

Sex	Birth	Death	Age Years - Days
F	25 May 1971	5 November 1972	165
F	16 January 1972	18 January 1972	2
ND	16 March 1972	31 March 1972	15
M	8 April 1972	4 November 1972	211
M	25 May 1972	4 October 1972	132
F	10 July 1972	15 December 1972	158
ND	1 August 1972	14 August 1972	13
M	9 August 1972	29 August 1972	20
F	18 September 1972	5 November 1972	49
M	22 October 1972	4 November 1972	13
F	3 November 1972	16 November 1972	13
F	25 April 1973	20 June 1973	57
F	13 October 1973	12 January 1975	1 - 101
ND	14 June 1974	22 June 1974	9
ND	2 August 1974	16 September 1974	45
ND	9 August 1974	16 September 1974	38
ND	17 August 1974	16 September 1974	30

M = Male.

F = Female.

ND = Sex not determined.

that juvenile mortality was the primary reason for low population increment rates. Reproductive failure appeared not to be an important factor in established herds, but may well have represented a population limitation in newly translocated herds, where a mature bull was not present during the breeding season (May through July), which also corresponded to the dry season period when game capture and translocation operations took place.

SECTION II

DISEASES AND PATHOLOGICAL CONDITIONS

Obtaining Roan and Sable Antelope Carcasses for Necropsy

Although the study lasted from January 1972 until June 1975, intense efforts to recover juvenile roan and sable antelope for post-mortem examinations were limited to 1972 and 1973. Subsequent to this, the demands made by sampling of live animals and of vegetation for nutrition and habitat studies, and the need to study populations on other reserves and in Rhodesia, made continuous intensive searching impractical. Carcasses of yearlings and adults became available intermittently throughout the study period. Post-mortem findings on juveniles, although based on a few necropsies, are fairly conclusive as to the causes and patterns of disease. This is especially true when the information is correlated with findings of blood smear analyses of animals of all age and sex groups on both Percy Fyfe and other nature reserves, and from Rhodesia.

A typical pattern which developed was that a calf would be seen for the first time in the field during daily observations and shortly afterwards would disappear. Occasionally during parturition periods heavily-pregnant females would be missing from the herd. It is characteristic of both roan and sable females to leave the herd to calve. The females would later be seen with distended udders, which indicated they had given birth to a calf, but were keeping it isolated from the herd. Sable females were found to keep their calves isolated in dense grass or undergrowth for periods of up to 2 weeks, although 1½ weeks was more common.

Roan cows, on the other hand, kept their calves in isolation for periods of up to 4-6 weeks, contrary to the findings of Joubert (1970) for roan in the Kruger National Park. Attempts were made to locate calves, as described under Methods, but success hinged heavily on luck. More success was obtained by searching for calves that had already joined the herd, but were then noticed to have disappeared. Invariably, when they were found they were either dead or dying and in a moribund state. Detailed records kept of birth dates permitted the exact ageing of all calves dying during 1971 to 1975. These are summarized in Tables 10 and 11.

Mortality Patterns

A total of 21 carcasses of sable (16) and roan (5) were recovered on Percy Fyfe. The principle findings are summarized in Tables 12 and 13. Five juvenile sable and three juvenile roan were necropsied in detail, and organs examined histopathologically. Seven sable yearlings, four sable adults, and two roan adults were also examined in detail.

Samples are too few to analyse statistically, but the high numbers of males amongst the yearlings which died or were killed is noteworthy. Three of these were killed by the herd bull, while the others succumbed to stress conditions, e.g. capture, or pursuit by the dominant bull, while suffering from sub-clinical or even clinical Cytauxzoonosis.

No fewer than four protozoal parasites were implicated in the deaths of the juvenile sable and roan. *Cytauxzoon* sp. was identified in blood and organs of the majority of juveniles, whilst *Babesia* sp. was unquestionably the cause of death in one sable, and appeared in combination with *Chlamydia* and *Cytauxzoon* in two others. *Pneumocystis carinii* was found in one sable calf. *Cytauxzoon* infection rates reached very high proportions (up to 31,2 percent) in the roan calves, but normally erythrocytic infection rates, as measured in blood smears, were fairly low. Large *Cytauxzoon* schizonts were fairly commonly seen in myocardium and adrenal sections, but were never found in blood smears.

Examination of adult animals confirmed the mortality

TABLE 12.-RECORD OF SABLE ANTELOPE RECOVERED DEAD AND WHICH WERE NECROPSIED; PERCY FYFE NATURE RESERVE, 1971-1974

Age	Sex	Date of Death	Cause of Death
Yearling	M	25 Mar 1971	Killed by herd bull in large camp.[1]
Yearling	M	28 May 1971	Killed by herd bull in large camp.
Adult	M	12 July 1971	Killed by herd bull in large camp.
Yearling (1 years 61 days)	M	20 Mar 1972	Killed by herd bull in large camp.
Juvenile (82 days)	M	30 Aug 1972	Chlamydoisis and Babesiosis.
Yearling	M	2 Sept 1972	Probably Babesiosis. Driven from herd by bull; died in pens after being removed from field. 4,4% erythrocytes infected.
Adult	F	18 Sept 1972	Killed by herd bull after release from quarantine pens. She never joined herd when introduced into camp.
Yearling (302 days)	M	5 Dec 1972	Died after translocation; 0,8% *Cytauxzoon* infestation of erythrocytes.
Yearling	M	21 Feb 1973	Died after capture. Poor body condition; infected with *Cytauxzoon*.
Juvenile (133 days)	M	23 June 1973	Cytauxzoonosis.
Juvenile (157 days)	F	30 Sep 1973	Babesiosis.
Juvenile	F	2 May 1974	Babesiosis and Cytauxzoonosis.
Juvenile	F	5 Sept 1974	Exposure to wetand cold conditions.
Yearling	F	6 Sept 1974	Exposure to wet and cold conditions.
Adult	F	6 Sept 1974	Exposure to wet and cold conditions.
Adult	F	8 Dec 1974	Killed by bull in experimental enclosure.

[1] Camp size 768 ha.

TABLE 13.- RECORD OF ROAN ANTELOPE FOUND DEAD ON PERCY FYFE NATURE RESERVE, AND WHICH WERE NECROPSIED, 1972-1974

Age	Sex	Date of Death	Cause of Death
Adult	M	11 Mar 1972	Killed by herd bull.[1]
Juvenile (132 days)	M	4 Oct 1972	Exposure to wet and cold conditions. 1,4% *Cytauxzoon* infection of erythrocytes. Chronic fibrous pleuritis.
Juvenile (13 days)	M	4 Nov 1972	Cyauxzoonosis. 31,2% infection rate of erythrocytes.
Juvenile (49 days)	F	5 Nov 1972	Cyauxzoonosis. 17,4% infection rate of erythrocytes.
Yearling (1 year 101 days)	F	12 Jan 1975	Killed by herd bull.[2] Spleen smears showed *Cytauxzoon* infection.

[1] Size of camp 430 ha.

[2] Size of camp 2061 ha.

patterns suspected (see above), viz. that the two main causes of death were poor condition coupled with some sudden stress factor such as cold exposure, or else traumatic injury, normally brought about by fighting or attacks from the aggressive herd bull.

Helminthiasis

Helminthiases was found to be only a secondary problem with sable and roan antelope on Transvaal reserves, and probably not an important factor by itself. Worm burdens found in the few animals which were critically examined for helminths indicated that Haemonchus (wireworm) and Trichostrongylus (bankruptworm) could reach levels where they may have led to some loss of body condition, however, the loss in body condition caused by primary deficiencies in diet was considered to vastly over-shadow any helminth effect. Table 14 briefly lists the helminths recovered from sable and roan on Percy Fyfe. Impalaia tuberculata was recovered for the first time from sable antelope.

TABLE 14.-HELMINTH PARASITES RECOVERED FROM SABLE AND ROAN ANTELOPE ON PERCY FYFE NATURE RESERVE

Antelope Species	Helminth Species
Sable	*Cooperia punctata*
	C. pectinata
	Haemonchus contortus
	Impalaia tuberculata
	Oesophagostomum columbianum
	Setaria sp.
	Trichostrongylus colubriformis
	Trichuris sp.
Roan	*Skrjabinema ovis*

Cytauxzoonosis

Cytauxzoon was first described by Neitz and Thomas (1948) from a duiker Sylvicapra grimmia (Cytauxzoon sylivicaprae) and subsequently from kudu (Cytauxzoon strepsicerosi) by Neitz (1957). Brocklesby (1962) described Cytauxzoon taurotragi from eland in East Africa, and ascribed mortality to it. In 1964 Neitz and Hirst (unpublished data) recorded Cytauxzoon for the first time on Percy Fyfe Nature Reserve in an eland which had been translocated from the Orange Free State, and which had a concomitant (and probably primary) infection with Babesia.

The taxonomy, host specificity and validity of the several species of Cytauxzoon in southern African ungulates are not yet clear (R.D. Bigalke[1], personal communication). It is uncertain at this stage whether the same species is involved in mortalities in sable, roan and tsessebe on Percy Fyfe. Detailed life-cycle studies on the parasite and tick-host transmission experiments remain to be undertaken.

The vector of Cytauxzoon in sable and roan is unknown at this stage, but infective forms of the parasite have been recovered from the brown tick Rhipicephalus appendiculatus from tsessebe on Percy Fyfe (S.E. Thomas[2], personal communication). This tick, together with R. evertsii and Boophilus decoloratus, was commonly recovered from sable and roan.

The detailed pathology of the lesions and morphology of the parasites in its various forms are described in detail by Neitz (1957). In the case of sable and roan on Percy Fyfe, two stages of the parasites

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[1] R.D. Bigalke, Associate Director, Onderstepoort Veterinary Research Institute, Pretoria, South Africa.

[2] S.E. Thomas, Onderstepoort Veterinary Research Institute, Pretoria, South Africa.

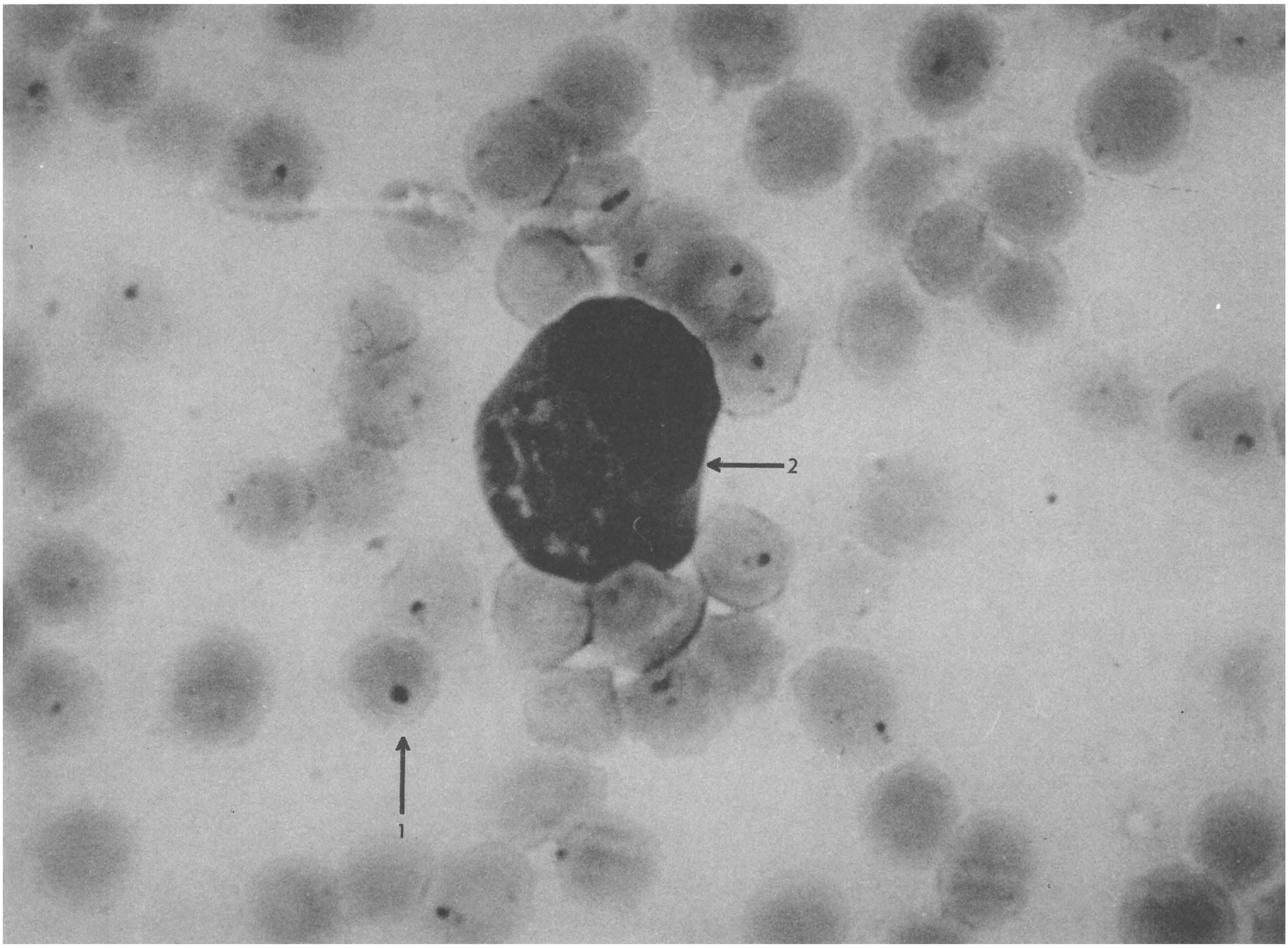
were found. In blood smears, small piroplasms of various shapes were seen within the erythrocytes. These were indistinguishable from Theileria spp. (Fig. 12). Overall erythrocytic infection rates were found to be quite variable. In one roan calf, parasitaemia was 31,9 percent at the time of death; the second roan calf showed a 17,4 percent infection rate at death.

In organ smears, organ sections and sometimes even in blood smears, both macro- and microschizonts were found (Fig. 12). These were variable in size, with diameters averaging some 5-10 µm. Microschizonts had one to five nuclei, staining dark purple within a pale blue cytoplasm; these increased to 100 or more in the macroschizonts. Firm diagnosis was based on the finding of the schizonts in blood smears of organ sections.

The only sable calf on which a firm diagnosis of a pure infection of Cytauxzoonosis was made (in contrast to mixed infections with Babesia or with Chlamydia) was unfortunately too decomposed for necropsy. In the roan calves that died, the outstanding pathological changes were severe anaemia, ascites and hydrothorax. Fibrinous pericarditis and hydropericardium were also present. Microscopically, animals showed a mononuclear cell infiltration of the heart and adrenal. Visceral haemosiderosis was present in both animals. The brains showed focal gliosis and polymorphonuclear infiltration. Over 40 percent of erythrocytes in brain organ sections were parasitized by small piroplasms.

The incubation period of the disease was not reliably established, but the youngest ages of sable and roan calves which died in the field (Tables 10 and 11) were 5 and 2 days respectively. Many such animals

Fig. 12. Photomicrograph (1200 x magnification) of Erythrocyte parasitized by Cytauxzoon piroplasm (1). Schizont multiplication stage of Cytauxzoon parasite in reticulo-endothelial cell (2).


1
2

died within 1-2 months of birth, and the incubation period may last this long, assuming that infection takes place either at birth or via the placenta (see below). However, it became evident during the study that Cytauxzoonosis was a complex condition and definitely affected by factors such as body condition and the degree of environmental stress.

The rapid loss rate of very young calves of only a few days old on Percy Fyfe was explained when it was found that Cytauxzoon could be passed from dam to offspring via the placenta. As indicated earlier, specific attempts to prove intra-uterine transmission were made by placing heavily pregnant females in small enclosures, allowing them to calve, and making blood smears from the newly born calf before transmission of the infection from ticks could take place. Only three such examinations were possible in practice since most pregnant cows were so poor in condition at the time that they failed to calve properly and calves were either born dead or had to be obstetrically removed under narcosis. One of the neonates examined was positive for Cytauxzoon parasites in the blood, and intra-uterine transmission was most probable in this case. As indicated later, the milk of lactating females on Percy Fyfe was found to be deficient in protein, phosphates and certain trace elements, and the resistance of calves to the Cytauxzoon infection was apparently very low.

Cytauxzoon was present in virtually all yearlings and adults which were examined, but infection rates were low. In each case, the actual death of the animal was ascribed to another etiological factor; in two cases of yearling mortality it followed on drug capture, and in a third case on severe stress induced by aggression from the herd bull. In all three yearlings, it was apparent that the animals had only a marginal resistance to the stress condition. Drug capture was in fact carried out on many sable and roan without harmful incident, and it is apparent that these yearlings were in a weakened condition. It is naturally not conclusive that *Cytauxzoon* infection played a major role in their general malaise, but since this parasite has been diagnosed as the primary cause of death in the juveniles, it is fairly safe to assume that it was an important factor.

Although not specifically investigated during this study, Cytauxzoonosis was known to have infected many of the wild ungulate species on Percy Fyfe. The mortality rate amongst tsessebe calves exceeded 50 percent in some years, and *Cytauxzoon*-like parasites were found in smears made from shot waterbuck and kudu. Mortalities from the disease seemed to be limited to roan, sable and tsessebe however.

The epizootiology of Cytauxzoonosis on other nature reserves was not studied, but data from examination of blood smears from both sable and roan (see below) reveals it to be a widespread infection, but of uncertain role in causing actual mortalities.

Babesiosis

Babesiosis of cattle is a major disease in South Africa (Henning 1956) and is caused by Babesia bigemina and B. bovis transmitted by the blue tick Boophilus decoloratus. A Babesia was first found in a sable antelope in 1930 (Martinaglia 1930) where it apparently caused mortality, but its exact identity was not investigated. Neitz and Hirst (unpublished data) found Babesia together with Cytauxzoon in an eland which died on Percy Fyfe Nature Reserve in 1964; pathological changes induced were pronounced anaemia, icterus, hydrothorax, hydropericardium, ascites, swollen spleen, and liver and kidney degeneration, all typical post-mortem changes associated with redwater (babesiosis) in domestic animals.

Pathological changes found in sable calves during this study were mainly related to anaemia. Apart from general pallor of all the organs and mucous membranes, no specific macroscopic changes were found. Some fatty degenerative changes in the centrilobular hepatocytes were also noted. Rate of parasitaemia in erythrocytes within the organ tissues was high, but only 0,8 percent and 4,4 percent parasitaemia was noted in peripheral blood smears.

Significantly, Babesia has not thus far been found in the other ungulates on Percy Fyfe (excluding roan antelope), despite their exposure to the same adverse environmental and nutritional conditions, and exposure to the same tick vectors. The identity of the tick vector for Babesia in sable was not established, but it is likely to be Boophilus decoloratus, the transmitter of bovine redwater, which was commonly encountered on sable.

Chlamydiosis

Only one positive case of chlamydiosis was diagnosed, and this in combination with babesiosis. In such cases it is difficult to ascribe primary causation to any one, but it is likely that both were in fact precipitated by the same nutritional deficiency or environmental stress factor.

The importance of *Chlamydia* infection in sable mortality patterns is very difficult to assess and many more necropsies would have to be performed. In the one case recovered, it showed up in lung smears. The carcass was in very poor condition with severe anaemia. Ticks were abundant in the ears, under the tail and in the inguinal region. There was a pronounced lymph node enlargement, oedema and focal red atelectases in the lungs, mild hydropericardium, small contracted spleen, haemoglobinuria, cerebral petchial haemorrhages and petechiae in various joint synovia. Microscopically, the lymphoid tissue showed hyperplasia and haemorrhages, the lungs displayed oedema, pneumonitis, peribronchial lymphocytic infiltration, and the spleen had some lymphoid nodular atrophy. The haemoglobinuria and possibly the hydropericardium were probably caused by the concomitant *Babesia* infection, but the other lesions were suggestive of chlamydiosis. The latter is normally a subacute or chronic disease of domestic calves and lambs (Storz 1971); this appeared to have been the case with the 3-month old sable as well.

A concomitant infection in this particular animal was *Pneumocytis carinii*, described here for the first time in a wild African ungulate. It has been reported for a domestic goat (McConnel *et al*. 1971). The sporozoan parasites were present in the proteinaceous alveolar material in the lungs. It is unlikely, in view of their isolated occurrence, that they caused any primary ill-effects in this case, however.

Traumatic Injuries

It is evident from the information available (Tables 12 and 13) that intraspecific aggression is a very important source of mortality in both sable and roan. The data for Percy Fyfe Nature Reserve are better than for other reserves, for reasons given above, but it is recorded in Divisional records that sable on Hans Merensky frequently fight. In most cases, actual mortalities were much higher on Percy Fyfe for yearling males, but two cases of females being killed by a sable herd bull and one roan yearling female by another roan were recorded.

Fighting between sable bulls has been recorded for other areas, e.g. Kenya (Estes and Estes 1969) and also for roan antelope bulls in Kruger National Park (Joubert 1970), but no cases of males attacking females are yet reported from the literature.

The sable herd bull in dominance over the Percy Fyfe herd at the commencement of this study had been maintained in isolation (quarantine) for 14 months prior to his release on Percy Fyfe (due to a prolonged Foot-and-Mouth disease outbreak) and this had apparently had a severe psychological effect. Not only was this male extremely aggressive towards young maturing males within the herd, but he also fatally attacked a newly arrived adult female released on the reserve plus a mature waterbuck bull and a mature kudu bull. Over a period of 3 years this male killed a total of 15 animals. He was eventually shot and replaced with a wild-caught sable bull, and the attacks on females ceased. The new bull remained aggressive towards pubertal males, however, and in an 18-month period killed two.

While mortalities from trauma incurred during fighting are apparently rare when sable and roan have abundant space available, it may become a factor of significance when areas are limited, as in small enclosures on relatively small nature reserves. This naturally relates to home range and territory sizes, and is discussed in depth below.

Mortalities Resulting from Exposure

A common weather occurrence over much of South Africa in the early spring is a sudden drop in ambient temperature accompanying the first heavy spring rains. Temperatures may drop to mean winter levels, and in themselves are probably not fatal, but the sudden drop accompanied by wet conditions imposes a severe stress on animals in poor bodily condition. Mortalities amongst wild ungulates at such times are not uncommon, even in the relatively warmer and drier Lowveld, where losses amongst species such as impala and giraffe have been reported (Hirst 1969, Hall-Martin 1975).

Mortalities from exposure to wet and cold occurred once during the present study on Percy Fyfe Nature Reserve (Table 15). Ambient temperature dropped 16^{o} C within 12 hours as the first heavy rains fell, and 29 carcasses of eight ungulate species were recovered on the reserve within a few days. Three female sable and three roan calves succumbed. Body condition in all these animals was very poor.

Post-mortem signs of exposure deaths were not specific, and were confounded to some extent by lesions caused by poor condition and nutritional anaemia. The kidney and heart fat deposits were cachectic and yellow. There was a general severe anaemia present, and some signs of mild kidney and liver degeneration. The lungs were usually congested, and there was frothy mucous in the trachea and bronchi. Absence of a clinical infection of Cytauxzoon or blood parasite confirmed that death was caused primarily by exposure to adverse conditions, but that poor condition

TABLE 15.- RECORDED MORTALITIES OF WILD UNGULATES ON PERCY FYFE NATURE RESERVE IN SEPTEMBER 1974. AMBIENT TEMPERATURE DROP FROM 14^{o} C TO -2^{o} C ACCOMPANIED FIRST SPRING RAINS

Species	Ages	Sexes	Totals Dead
Sable	2 adults 1 yearling	3 females	3
Roan	Juveniles	Undetermined	3
Tsessebe	Adults	1 male 4 females	5
Kudu	5 adults 3 yearlings	2 males 6 females	8
Waterbuck	2 adults 2 yearlings	1 male 3 females	4
Impala	Adult	Male	1
Bushbuck	Adult	Male	1
Duiker	Adults	3 males 1 female	4

was the major predisposing factor.

These types of mortalities lent greater credence to the theory that infectious diseases were also secondary considerations in the population mortality pattern, and that poor nutritional status was the prime factor involved.

Incidence of Blood Protozoal Infections

The discovery of *Cytauxzoon*, *Babesia* and several other protozoal infections in roan and sable antelope on Percy Fyfe Nature Reserve, and the knowledge that these were responsible for mortalities, led to the sampling of other populations in efforts to elucidate the role played by protozoal infections. Absence of the infection from other areas would suggest an enzootic focus on infection in this area, and would suggest the fact that it might be dangerous to translocate ungulates from Percy Fyfe to other areas. It is noteworthy to record that eland were found to die from *Cytauxzoon* and *Babesia* infection on Percy Fyfe, but apparently thrive on other provincial nature reserves, despite a high rate of tick infestation. Tsessebe die in large numbers from *Cytauxzoon* infection on Percy Fyfe, but the disease has not been found in clinical form amongst the largest tsessebe population in Transvaal, viz. on Fleur-de-Lys estate in the eastern Transvaal Lowveld (R. Garstang[1], personal communication). Wide-spread occurrence of the infections, on the other hand, would suggest that the infection is really of secondary importance and merely a mechanism whereby the animal is actually killed, whereas the primary cause should be sought elsewhere,e.g. in the physiology of the animals, and how it is affected by their environment on small fenced reserves.

During the course of the study smears from 156 sable and 21 roan antelope were taken in eight different areas in the Transvaal and Rhodesia. All smears were examined for incidence of blood parasites,

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[1] R. Garstang, P.O. Box 20, Ohrigstad, Transvaal, South Africa.

and the results are reflected in Tables 16 and 17.

TABLE 16.-INCIDENCE OF PROTOZOAL PARASITES IN BLOOD SMEARS TAKEN FROM SABLE ANTELOPE IN DIFFERENT AREAS IN THE TRANSVAAL AND RHODESIA, 1972-1975

Area	Age / Sex		No. Sampled	Cytauxzoon			% Total	Babesia			% Total	No. Negative
				VR	R	NR		VR	R	NR		
Percy Fyfe N.R.	Adult	M	9	4	0	4	88,0	0	0	0	0	1
	Adult	F	21	5	1	15	100,0	1	0	0	4,8	0
	Adult	M	3	0	0	3	100,0	0	0	0	0	0
	Yearling	M	8	1	0	4	62,5	0	0	1	12,5	2
	Yearling	F	2	0	0	2	100,0	0	0	0	0	0
	Juvenile	M	3	0	0	0	0	0	0	1	33,3	2
	Juvenile	F	6	1	0	3	66,7	0	0	1	16,7	1
	Total		52	11	1	31	82,7	1	0	3	7,7	6
Hans Merensky N.R.	Adult	M	5	1	0	2	60,0	0	0	0	0	2
	Adult	F	13	2	2	5	69,2	0	0	0	0	4
	Yearling	M	3	0	0	3	100,0	0	0	1	33,3	0
	Yearling	F	1	0	0	1	100,0	0	0	0	0	0
	Juvenile	M	1	0	0	1	100,0	0	0	0	0	0
	Juvenile	F	3	0	0	2	67,7	0	0	0	0	1
	Total		26	3	2	14	73,1	0	0	1	3,8	7

TABLE 16.- (Continued)

Area	Age / Sex		No. Sampled	Cytauxzoon VR	Cytauxzoon N	Cytauxzoon NR	% Total	Babesia VR	Babesia R	Babesia NR	% Total	Negative
Rustenburg N.R.	Adult	M	2	0	0	0	0	0	0	0	0	2
	Adult	F	13	2	2	5	69,2	0	0	0	0	4
	Yearling	M	3	0	0	3	100,0	0	0	1	33,3	0
	Yearling	F	1	0	0	1	100,0	0	0	0	0	0
	Juvenile	M	1	0	0	1	100,0	0	0	0	0	0
	Juvenile	F	3	0	0	2	100,0	0	0	0	0	1
	Total		23	2	2	12	66,7	0	0	1	4,3	7
Loskop Dam N.R.	Adult	M	2	0	0	2	100,0	0	0	0	0	0
Ermelo Ranch	Adult	M	1	0	0	0	0	0	0	0	0	1
	Adult	F	6	0	1	1	33,3	0	0	0	0	4
	Yearling	M	2	0	0	0	0	0	0	0	0	2
	Yearling	F	2	0	0	1	50,0	0	0	0	0	1
	Total		11	0	1	2	27,3	0	0	0	0	8
Matopos, Rhodesia	Adult	M	5	1	2	2	100,0	0	0	0	0	0
	Adult	F	7	2	2	3	100,0	0	0	0	0	0
	Yearling	F	2	0	0	2	100,0	0	0	0	0	0
	Juvenile	M	2	0	0	1	50,0	0	0	0	0	1
	Juvenile	F	2	0	0	1	50,0	0	0	1	50,0	1
	Total		18	3	4	9	88,9	0	0	1	5,6	2

TABLE 16.- (Continued)

Area	Age / Sex		Sampled	Cytauxzoon VR	Cytauxzoon R	Cytauxzoon NR	% Total	Babesia VR	Babesia R	Babesia NR	% Total	Negative
Matetsi, Rhodesia	Adult	M	1	0	0	0	0	0	0	0	0	1
	Adult	F	7	1	2	2	71,4	0	0	0	0	2
	Juvenile	M	3	0	0	0	0	0	0	0	0	3
	Juvenile	F	2	0	0	0	0	0	0	0	0	2
	Total		13	1	2	2	38,5	0	0	0	0	8
Robins Camp, Wankie, Rhodesia	Adult	F	1	0	1	0	100,0	0	0	0	0	0
	Yearling	M	4	0	1	0	25,0	0	0	0	0	3
	Yearling	F	6	2	0	1	50,0	0	0	0	0	3
	Total		11	2	2	1	45,5	0	0	0	0	3

VR = Very rare (one to two parasites per 3 minute microscope search).
R = Rare (less than one parasite per 15 microscopic fields searched).
NR = Not rare (more than one parasite per 15 microscopic fields searched).

TABLE 17.-INCIDENCE OF PROTOZOAL PARASITES IN BLOOD SMEARS TAKEN FROM ROAN ANTELOPE IN TWO DIFFERENT AREAS IN THE TRANSVAAL AND RHODESIA, 1972-1975

Area	Age / Sex		No. Sampled	Cytauxzoon VR	Cytauxzoon R	Cytauxzoon NR	% Total	Babesia VR	Babesia R	Babesia NR	% Total	No. Negative
Percy Fyfe N.R.	Adult	M	4	0	2	2	100,0	0	0	0	0	0
	Yearling	M	5	1	1	3	100,0	2	0	0	40,0	0
	Juvenile	M	2	0	0	2	100,0	0	0	0	0	0
	Juvenile	F	1	0	0	1	100,0	0	0	0	0	0
	Total		12	1	3	8	100,0	2	0	0	16,6	0
Tjolotjo, Rhodesia	Adult	M	2	0	1	0	50,0	0	0	0	0	1
	Adult	F	5	2	1	0	60,5	0	0	0	0	2
	Yearling	F	1	0	0	0	0	0	0	0	0	1
	Juvenile	F	1	0	0	0	0	0	0	0	0	1
	Total		9	2	2	0	44,4	0	0	0	0	5

VR = Very rare (one to two parasites per 3 minute microscopic search).
R = Rare (less than one parasite per 15 microscopic fields searched).
NR = Not rare (more than one parasite per 15 microscopic fields searched).

Incidence of Blood Parasites in Sable and Roan Blood Smears

The incidence of *Cytauxzoon* piroplasms in the blood smears of sable antelope varied quite considerably from one area to another. Loskop Dam showed a maximal incidence of 100 percent, but the sample size here was low (n = 2). The incidence ranged down to 27,3 percent for a sample taken from captured sable on Ermelo Ranch in the Lowveld (three out of 11 animals infected). The incidence for Hans Merensky sable in similar habitat as those on Ermelo Ranch, had a *Cytauxzoon* infection rate of 19 animals out of 26 (73,1 percent). Apart from Loskop Dam, the highest incidence rate encountered was in sable antelope in the Matopos National Park, Rhodesia, where 16 out of 18 animals were found to be infected (88,9 percent).

Blood smears from roan antelope were only available from two areas. Percy Fyfe roan had a 100 percent infection rate (n = 12), while free ranging roan in the Tjolotjo area south of Wankie National Park, Rhodesia, had a 44,4 percent infection rate (four out of nine sampled).

The semi-quantitative scale of abundance used was probably not linear in its representation of the abundance of *Cytauxzoon* piroplasms, but did permit an appraisal of the extent of infection within populations. Thus, for Percy Fyfe sable and roan, the majority of blood smears showed an abundance of piroplasms, i.e. more than one piroplasm seen in 15 microscopic fields traversed. A similar incidence was encountered in all animals from the Transvaal, whereas *Cytauxzoon* was generally less abundant in blood smears from roan from Rhodesian areas. Matopos was the exception where nine out of

16 positive cases had a "not rare" rating.

Negative findings were not necessarily exactly that, but indicated rather that the piroplasms could not be found in the smears taken during a normal microscopic search. It is not unlikely that all animals in all areas were infected, some to a very low and undectable degree. The question of complete resistance to the parasites remains to be studied, but is unlikely to be the case, in view of the premunity usually prevailing with protozoan infections in mammals. In any event, the same methods for sampling and examinations were used in all cases, hence intra-area comparisons are valid.

Infection rates of the various age and sex categories show considerable variation, but group sample sizes in most cases are small and may not show up significant differences. Some noteworthy features of the results, however, are the absence of detectable piroplasms in blood smears from three sable male juveniles on Percy Fyfe; the age group which in fact shows the highest mortality rate from cytauxzoonosis. The infection rate in female juveniles was four out of six. This would appear to be a case where infections were of such low incidence that they could not be detected, since these intra-sexual differences are probably artefacts of the small number of samples. The results (Table 16) also appear to suggest that adult females harbour a higher incidence of parasites than do the other age groups and the males; this is the case with sable from Ermelo Ranch and from Matetsi. The data do not lend themselves to tests of significance, however, due to the relatively large number of zero incidences in some sex and age groups.

Babesia parasites were encountered in small numbers of animals from all Transvaal areas with the exception of Ermelo Ranch. Two young roan males on Percy Fyfe were found to have a very low incidence of Babesia infection, the first time this parasite has been recorded in the roan antelope. The parasite was found in only one sable from a Rhodesian area-- a female calf from Matopos National Park. The incidence of Babesia was, expectedly, somewhat higher in Percy Fyfe sable than in others.

Relationship Between Protozoal Infections and Body Condition

A very strong inverse relationship was found to exist between incidence of Cytauxzoon infections in sable antelope and their bodily condition. One parameter of body condition is the packed erythrocyte volume of the blood. These were measured for all areas listed above, and mean values established. If Matopos' results are excluded, then the correlation coefficient between Cytauxzoon incidence and packed cell volume is -0,96 ($p < 0{,}001$) (Fig. 13). The sable on Matopos represent an interesting deviation from this pattern, since their body condition was good, yet they had a Cytauxzoon incidence of 88,9 percent.

Cytauxzoon parasites may well have an influence on erythrocytes, however, since anaemia is a common finding in cytauxzoonosis. The distinction between parasitic anaemia and nutritional anaemia is a difficult one to make in the present case; both may have been present. The high incidence of parasitaemia in Matopos sable, however, seems to suggest that the basic anaemia, as reflected in low blood packed-cell volumes of Transvaal sable, is a nutritional one.

This is borne out by the significant correlation ($r = -0{,}72$; $p < 0{,}05$) between mean total plasma protein content of the blood and the mean incidence of Cytauxzoon parasitaemia (Fig. 14). Total plasma protein content has been found to be a good indicator of relative body condition and is strongly correlated with the Kidney Fat Index (KFI), a standard body condition parameter (Spearman rank correlation coefficient between KFI and total plasma proteins = 0,739; $p < 0{,}001$; $n = 15$; see discussion on nutritional status).

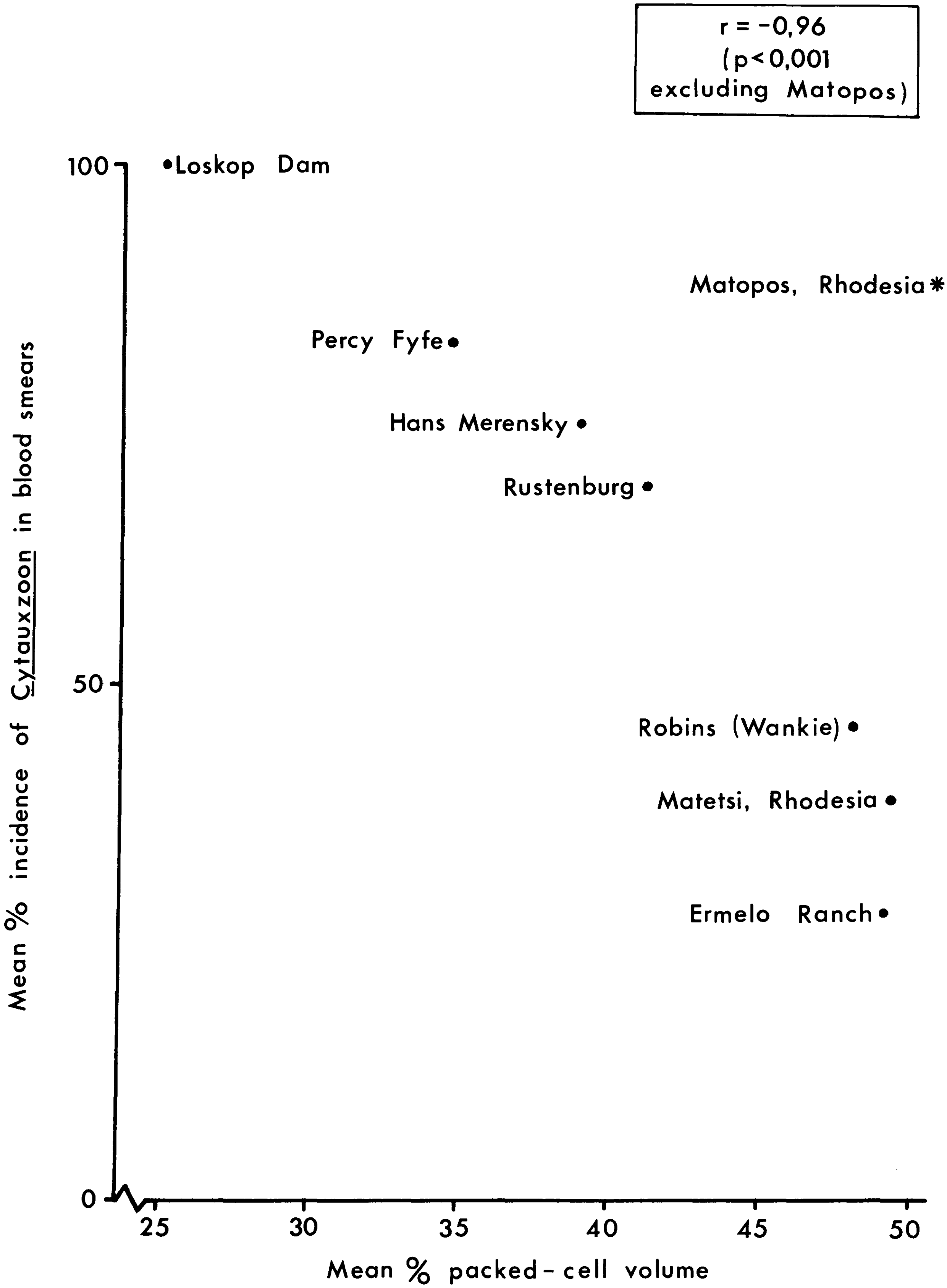

Fig. 13. Relationship between mean percent packed-cell volume in sable antelope from different areas and incidence of *Cytauxzoon* infection.

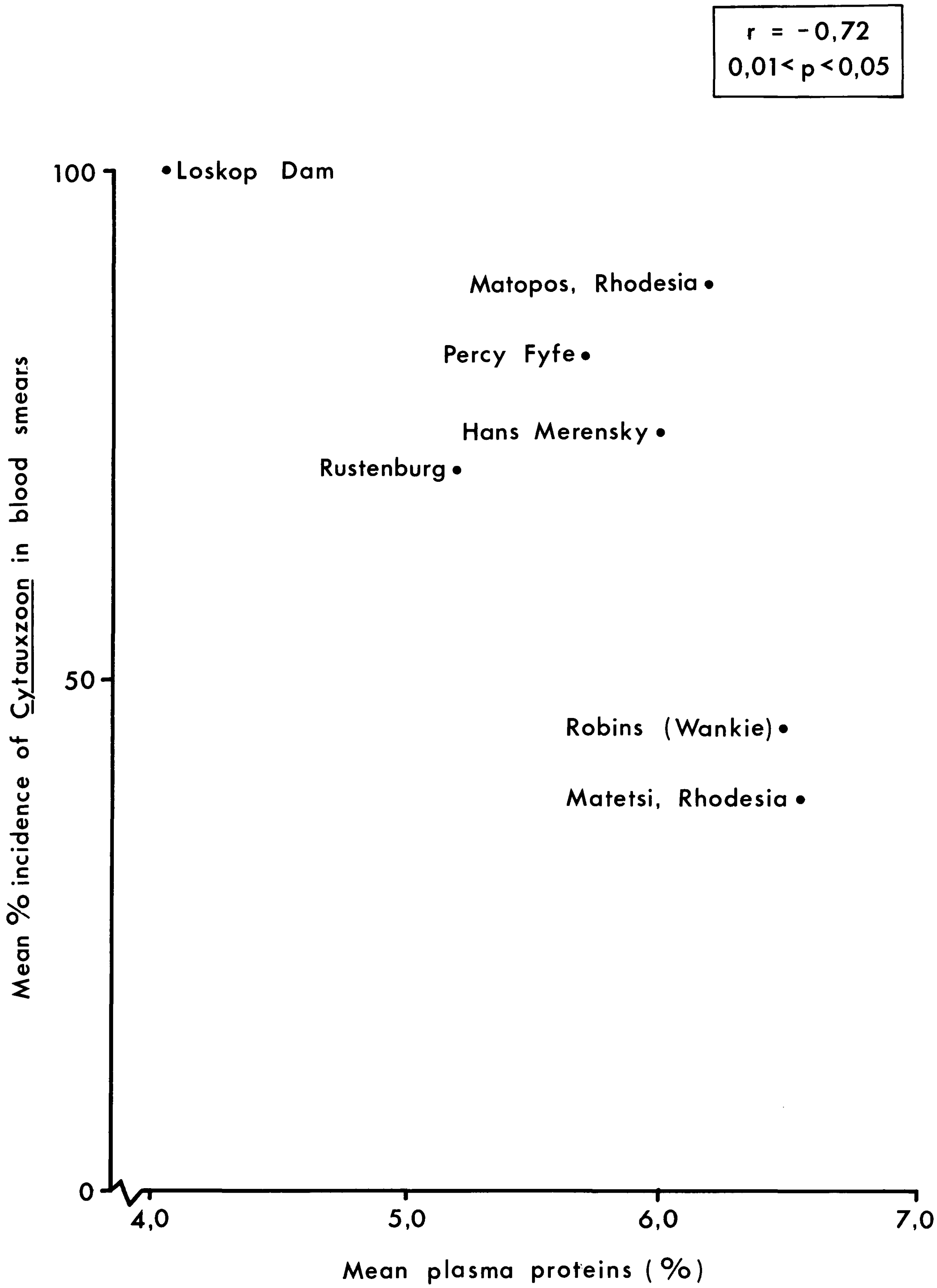

Fig. 14. Relationship between mean blood plasma protein values for sable antelope on various study areas and incidence of *Cytauxzoon* infection.

This is conclusive evidence that the incidence of parasitaemia is related and is inversely proportional to the body condition of sable. Small sample sizes prevent similar analyses for roan antelope, but there is little reason to doubt that a similar relationship exists, particularly in view of the mortality patterns in roan on Percy Fyfe and the higher rate of deaths in the dry seasons, and the much lower parasitaemia rate and better body condition in Tjolotjo roan.

NUTRITION AS A LIMITING FACTOR

It is characteristic of the so-called "sourveld" areas of South Africa that forage grasses lose both palatability and nutrient content in the drier months. Palatability changes are related mainly to the drop in protein and carbohydrate content of the food plants and the relative increase in cellulose. Certain minerals, notably phoshporus, are known to be deficient during this period in most sourveld areas.

Because of the severe drop in protein content (from 12 to 2 percent in a typical sourveld area) domestic livestock are typically fed supplementary rations during the dry season; free-ranging livestock show marked weight losses and drop in production and reproduction when protein and mineral levels are not supplemented. Similar weight fluctuations have been noted in wild ungulates which live in sourveld areas (Transvaal Nature Conservation Division, official files).

On a broad categorization basis Percy Fyfe, Rustenburg, Loskop Dam and the Matopos National Park in Rhodesia would be regarded as sourveld or mixed sourveld areas, while Hans Merensky and the surrounding areas in the eastern Transvaal Lowveld, and the areas within the sub-tropical savanna of Rhodesia would be classed as "sweetveld" or mixed sweetveld; the latter terms implying no substantial loss in palatability or nutritional quality during drier months.

Wild ungulates typically display a variety of feeding strategies to utilize the best potential of any occupied area. These may relate to feeding specificity, nomadism and feeding habit flexibility to ensure a sufficient intake of nutrients, even in poor seasons.

Studies on some wild ungulates in sourveld areas have shown that they tend to be specific for certain types of natural or man-induced habitats, e.g. blesbok utilizing only burnt range in sourveld areas (du Plessis 1972), or steenbok grazing mainly palatable forbs on sourveld on Percy Fyfe (Huntley 1972).

The whole complex of habitat-use and the relevant feeding strategies of roan and sable antelope on Transvaal nature reserves are of major significance in their maintenance and successful conservation. As indicated above, nothing is known of the actual habitat preferences of these rare species in past times when they ranged widely across Transvaal. There are few records to indicate that they actually utilized the areas which are today Loskop Dam, Rustenburg and Percy Fyfe reserves, although circumstantial evidence suggests that they could have, possibly on a seasonal or nomadic basis. The Belgium Block, from where roan were translocated to Percy Fyfe, is regarded as a very marginal area for farming or ranching. However, nutritional deficiencies have been shown to exist for other species on Transvaal nature reserves, e.g. mountain reedbuck on Loskop Dam (Irby 1973).

The nutritional status of roan and sable antelope was thus considered a potential primary limiting factor within Transvaal, at least for the sourveld areas, and this aspect was investigated in some depth. Because of their relative rarity, roan could not be sampled as intensively as sable throughout their present-day Transvaal and Rhodesian ranges.

Body Condition of Animals

The Kidney Fat Index (KFI) (Riney 1955, Ransom 1965, Smith 1970) was used as the primary indicator of body condition, but could naturally only be used on specially slaughtered animals. The number of animals specially culled for such determinations on Transvaal nature reserves was limited to only two per reserve, and five from Matetsi. A larger sample would have been preferred, but due to the rarity of the species this was not possible. A body condition index was thus sought for live animals which were sampled in the course of the study.

Since body weights were available from several areas, as were several blood parameters, notably total plasma protein content (TPP), the packed-cell volume of the blood, and the respective albumin and globulin content of the blood, these were investigated as body condition indicators.

All these parameters were measured for a total of 15 animals shot on the five major study areas: two each on the Transvaal nature reserves and five on the Matetsi area, Rhodesia. Correlations between the various pairs of parameters and between these parameters and the KFI, based on the total shot sample, were made using the Spearman rank correlation technique (Siegel 1956). The majority were highly significant (Table 18), and KFI was very significantly related to live weights of animals, TPP, packed cell volume (= haematocrit), blood albumin and blood globulin content. The highest correlation coefficients ($p < 0{,}01$) were those between KFI and TPP, and KFI and haematocrit readings. On the basis of this, it seemed acceptable to use the latter two blood parameters as valid body condition indicators in live animals.

TABLE 18.-SPEARMAN RANK CORRELATION COEFFICIENTS (r_s) BETWEEN VARIOUS BLOOD PARAMETERS, KIDNEY FAT INDEX (KFI) AND LIVE WEIGHTS IN SABLE ANTELOPE SHOT IN TRANSVAAL AND RHODESIA DRY SEASON, 1974 (n = 15)

	KFI	Live Weight	TPP	Haematocrit[1]	Blood Albumen %	Blood Globulin %
KFI	----					
Live Weight	0,714**	----				
TPP	0,739**	0,605**	----			
Haematocrit	0,753**	0,703**	0,726**	----		
Blood Albumen	0,631**	0,624**	0,474*	0,424*	----	
Blood globulin	0,453*	0,342	0,837**	0,520*	-0,056	----

[1] Haematocrit reading = % packed cell volume

* $p < 0,05$.

** $p < 0,01$.

Body condition of sable and roan differ markedly from Rhodesia to the Transvaal (Table 19). Both species in Rhodesia have mean haematocrit values near 50 percent and TPP values well above 6. Notable exceptions to the latter were adult males in Matopos National Park (mean TPP = 5,35 percent) and a young heifer at Tjolotjo (TPP = 3,80 percent). Transvaal sable were shown to be in poor condition, with the possible exception of Rustenburg. Haematocrit values as low as 18 percent were recorded for sable on Loskop Dam, which is probably close to the value where an animal becomes moribund. Two hand-reared sable males kept in pens on Percy Fyfe, and fed a balanced and supplemented diet of lucerne hay, antelope cubes and trace elements, had haematocrit levels as high as those of Rhodesian animals, and TPP values higher than other Transvaal animals, but not as high as most sable sampled in Rhodesia.

Roan antelope on Percy Fyfe were found to be in far better condition than sable on Percy Fyfe, with haematocrit values comparable to Rhodesian roan (and sable) and TPP values of the same order as in Rhodesian animals. This reflected a number of differences in feeding and food availability between roan and sable on Percy Fyfe. The roan had far more area available for grazing (2061 ha as compared to 768 ha for sable; about 37 ha per roan compared to about 28 ha available per sable). Interspecific grazing competition in the sable enclosure was fairly intense, but non-existent in the roan enclosure; and roan would readily make use of available browse in the enclosure when grass forage palatability dropped to low levels. Browse was significantly higher

TABLE.19-BODY CONDITION[1] OF SABLE AND ROAN ANTELOPE IN THE TRANSVAAL AND RHODESIA, AS REFLECTED BY BLOOD PARAMETERS

Species	Area	Age / Sex		No. Sampled	Mean Haematocrit %	Mean TPP %
Sable	Percy Fyfe	Adult	M	6	33,0	5,33
		Adult	F	16	34,7	6,21
		Yearling	M	4	38,6	5,45
		Yearling	F	2	32,5	5,15
		Juvenile	F	3	33,0	6,00
	Percy Fyfe[2] Pens	Adult	M	3	49,0	6,01
	Hans Merensky	Adult	M	2	38,5	3,02
	Rustenburg	Adult	M	2	41,0	5,20
	Loskop Dam	Adult	M	2	25,0	4,05
	Matopos, Rhodesia	Adult	M	3	50,0	5,35
		Adult	F	3	49,7	6,37
		Yearling	F	1	53,0	6,90
	Matetsi, Rhodesia	Adult	M	1	51,0	6,50
		Adult	F	7	47,6	6,59
	Robins Camp, Wankie, Rhodesia	Adult	F	1	46,0	6,40
		Yearling	M	4	49,5	6,60
		Yearling	F	6	47,7	6,48
Roan	Percy Fyfe	Adult	M	4	47,5	5,27
		Yearling	M	5	46,6	6,16
	Tjolotjo, Rhodesia	Adult	M	1	57,0	5,80
		Adult	F	4	50,3	5,55
		Yearling	F	1	47,0	3,80

[1] Mean conditions for whole year for Percy Fyfe: for mainly dry season for other areas.

[2] Hand-reared animals in pens, fed lucerne hay and concentrates in the form of antelope cubes.

in protein content than was grass (see later).

By considering only adult animals, all shot in the dry season of the same year, from each of the different areas, the variability induced by intraspecific variation and changes throughout the year are greatly reduced (Table 20). On this basis, sable from Matetsi are shown as being in far better condition than Transvaal animals, with KFI's exceeding 100, whereas the highest KFI's measured for Transvaal sable were on Hans Merensky Nature Reserve, with values of 35,7 and 43,0 being determined. Sable on Percy Fyfe, Rustenburg and Loskop Dam show up as being in extremely poor condition generally. Very high KFI's were recorded for the two pen-reared animals, although their blood values did not exceed those of Rhodesian animals.

TABLE 20.- BODY CONDITION PARAMETERS OF ADULT SABLE ANTELOPE SAMPLED IN THE DRY SEASON, 1974, IN DIFFERENT AREAS IN THE TRANSVAAL AND RHODESIA

Area	Animal Sample No.	KFI	TPP %	Haematocrit %
Percy Fyfe	28	14,2	5,1	35
	29	12,5	4,6	32
Percy Fyfe (pen-reared)	101	342,0	5,8	49
	103	734,6	6,9	49
Hans Merensky	127	35,7	6,2	33
	128	43,0	5,8	34
Rustenburg	123	23,5	5,6	42
	124	23,0	4,8	40
Loskop Dam	125	29,8	4,3	33
	126	6,8	3,8	17
Matetsi, Rhodesia	43	170,8	6,0	50
	46	145,9	6,5	51
	48	168,1	7,1	48
	50	162,0	6,5	50
	51	172,0	6,4	48

Mineral Nutrition

The sable (n = 15) culled on the various areas served as a basis for determining the mineral status of the liver and the blood. Although the liver is an accepted storage depot of several essential minerals, the blood samples were also examined for macro- and micro-element levels to complete the picture. This was particularly relevant in view of the high correlations shown between body condition and blood protein levels. Blood levels of minerals were useful in assessing the mineral nutritional status of live animals where liver samples could not be collected. The normal problems associated with assessment of blood mineral levels relate to the extremely small amounts of some elements present in blood. To some extent this was overcome by the analysis of blood elements by extremely sensitive methods such as atomic absorption, and some variability between samples was reduced by comparing only samples taken at the same time of the year. Table 21 reflects values measured for all important liver and blood elements for 15 sable antelope sampled in the Transvaal and Rhodesia during the peak of the 1974 dry season. Two of these animals were pen-reared males which had lived on concentrated and nutritionally balanced (based on domestic animal standards) rations. As indicated already, their body condition was very good, and at 2 years of age their body masses were greater than those of wild mature sable bulls in the field on Transvaal nature reserves or in Rhodesia.

Blood calcium levels (expectedly) do not show much variation from one area to another, because of strong homeostatic body

TABLE 21.-MINERAL CONTENT OF BLOOD AND LIVER OF ADULT SABLE ANTELOPE SAMPLED IN THE TRANSVAAL AND RHODESIA, DRY SEASON, 1974. ALL VALUES GIVEN AS PARTS PER MILLION, EXCEPT FOR SODIUM AND NITROGEN (= % m/m)

Area	Animal Sample No.	Calcium Blood	Calcium Liver	Phosphorus Blood	Phosphorus Liver	Magnesium Blood	Magnesium Liver	Sodium (% m/m) Blood	Sodium (% m/m) Liver	Potassium Blood	Potassium Liver	Nitrogen (% m/m) Blood	Nitrogen (% m/m) Liver
Percy Fyfe	28	173	132	93	13000	26	267	0,31	1,85	210	600	1,05	12,29
	28	133	164	75	13000	25	417	0,33	1,79	220	1000	8,5	13,42
Percy Fyfe	101	185	455	129	14600	26	146	0,34	1,92	216	1200	8,5	13,00
(pen-reared)	103	163	232	111	11900	29	275	0,34	2,17	242	2700	10,4	14,12
Hans	127	167	---	57	14800	26	121	0,33	3,37	343	2300	9,3	12,87
Merensky	128	183	112	104	14800	22	87	0,36	0,57	278	4200	8,9	12,62
Rustenburg	123	199	91	68	14800	34	87	0,34	1,83	217	2200	9,3	11,42
	124	175	57	79	15200	24	117	0,35	2,42	444	700	11,0	11,75
Loskop Dam	125	136	64	50	15100	29	121	0,32	7,02	350	4500	7,8	12,00
	126	142	120	50	15100	32	112	0,33	3,19	342	2200	7,4	11,42
Matetsi,	43	183	1529	83	13100	34	191	0,33	3,77	356	1300	9,3	13,12
Rhodesia	46	154	62	111	13400	45	208	0,33	1,44	442	400	9,9	11,50
	48	166	174	144	14600	42	225	0,37	2,10	332	1800	11,6	11,87
	50	127	32	111	13100	26	158	0,33	1,33	210	700	9,8	11,87
	51	235	696	108	13300	37	46	0,37	2,56	250	900	10,4	12,29

TABLE 21.- (Continued)

Area	Animal Sample No.	Iron		Copper		Zinc		Manganese		Molybdenum		Selenium	
		Blood	Liver	Blood	Liver	Blood	Liver	Blood	Liver	Blood	Liver	Blood	Liver
Percy Fyfe	28	0,11	408	0,69	79	3,5	321	0,002	1,4	< 0,05	< 0,8	< 0,005	< 0,08
	29	0,09	433	0,71	165	1,9	479	0,002	1,7	< 0,05	< 0,8	< 0,005	< 0,08
Percy Fyfe pen-reared	101	0,12	433	0,68	208	4,5	146	0,003	1,7	< 0,05	1,3	0,015	0,29
	103	0,11	583	0,74	287	3,5	308	0,002	1,6	< 0,05	1,3	0,011	0,37
Hans Merensky	127	0,12	96	0,72	29	5,2	137	0,003	2,0	< 0,05	1,3	0,005	0,17
	128	0,10	254	0,96	65	4,2	146	0,002	2,3	< 0,05	1,7	0,008	0,17
Rustenburg	123	0,12	1521	0,74	589	5,2	87	0,023	1,6	< 0,05	< 0,8	0,017	< 0,08
	124	0,10	704	0,82	244	8,1	104	0,004	2,1	< 0,05	< 0,8	0,021	< 0,08
Loskop Dam	125	0,09	137	0,71	201	2,3	158	0,003	1,8	< 0,05	1,7	< 0,005	< 0,08
	126	0,09	96	0,78	56	2,3	117	0,004	1,7	< 0,05	1,7	< 0,005	< 0,08
Matetsi, Rhodesia	43	0,10	383	0,63	50	8,1	125	0,004	2,6	< 0,05	1,7	0,014	0,46
	46	0,10	383	0,79	43	2,3	117	0,008	1,9	< 0,05	2,5	0,013	0,54
	48	0,08	354	0,82	14	6,1	104	0,003	2,2	< 0,05	1,3	0,025	0,21
	50	0,08	262	0,60	79	2,9	112	0,004	3,0	< 0,05	1,7	0,016	0,46
	51	0,10	441	0,59	137	4,8	142	0,007	1,6	< 0,05	1,7	0,011	0,42

Cobalt blood levels < 0,01: liver levels < 0,4 in all samples.

regulations of this vital blood element. Liver calcium, contrarily, shows considerable variation, but intra-area variation far outweights inter-area variation.

Phosphorous levels are of particular interest because of the known deficiencies over large parts of southern Africa: blood phosphorous levels varied from 50 p.p.m. for the Loskop Dam animals to 144 p.p.m. for one of the Matetsi sable. Blood phosphorous levels differed significantly from area to area (Kruskal-Wallis "H" = 11,07; $p < 0,05$), and although small sample sizes prevent comparisons between specific areas, it is obvious that sable on Loskop Dam have very significantly low values. This was correlated to the marked degree of pica observed in Loskop sable. Geophagia was frequently observed in certain localities. This soil was later found to contain very high quantities of iron. Based on visual comparisons of the data, it would appear that phosphate deficiencies may also be a factor for all the Transvaal nature reserves, including the Lowveld area of Hans Merensky Nature Reserve. Liver phosphorous values show remarkable consistency.

Blood and liver values for elements such as magnesium, sodium, potassium and nitrogen show no specific or noteworthy differences between animals from different areas. Variability is fairly high for these minerals, and it is not unlikely that large numbers of samples would show up differences between the various areas. For now, they must remain subjects of speculation.

Liver values for trace elements such as iron, copper and zinc are more reliable as nutritional indicators, since this is the principle storage depot, and blood values are naturally affected by homeostasis, anaemia, etc. Lower iron values differ significantly from area to area (Kruskal-Wallis H = 12,04; $p < 0,05$), and again Loskop Dam values are much lower than other areas. The free-ranging Percy Fyfe animals show liver iron of the same order of magnitude as the fed animals in the pens, and are higher than values for Matetsi sable. The two Rustenburg sable show very high liver iron values, and this may be a reflection of the substrate in that reserve or simply the result of high variability produced by low sampling.

Although liver copper values differ quite markedly between areas, and Rustenburg animals are again very high (Table 21), intra-area variation is high, and no significant differences could be detected (Kruskal-Wallis H = 10,16; $0,05 < p < 0,10$).
Liver zinc values were significantly different, (Kruskal-Wallis H = 11,19; $p < 0,05$), with the essential difference being high values for Percy Fyfe sable. There appeared to be little difference between Rhodesian sable and sable from the other Transvaal reserves in the respect of zinc.

Selenium showed up as being very much higher in Rhodesian sable, with liver values ranging from 0,21 to 0,54 p.p.m. Similar values were attained by the penned animals fed on concentrates and lucerne hay. Selenium values in the livers of free-ranging sable on Percy Fyfe, Rustenburg and Loskop Dam were lower than the minimum detectable by the atomic absorption method, and were recorded as $<0,08$ p.p.m. The differences between areas were thus markedly significant (Kruskal-Wallis H = 16,40; $p < 0,01$).

Manganese and molybdenum values measured were of similar magnitude for all samples taken (Table 21), and no further conclusions were drawn.

Nutritional Content of Milk

Since mortality rates of juvenile roan and sable from infectious diseases and related conditions were of prime importance in the study, their nutritional status was of special concern. Body condition of calves recorded for necropsy was always very poor. Of three live sable calves sampled in the field, the incidence of blood parasites was found to be relatively high (Table 16). Blood constituents were not measured in these three juveniles, but the high incidence of blood parasites was a direct indication of their poor body condition.

Only seven milk samples were available for the basic constituent analyses[1] (Table 22). Both roan and sable milk had protein values of 5-7 percent. Other values were comparable, but it must be mentioned that all milk samples in Table 22 were from animals in relatively poor areas. Protein levels of milk analyzed later[2] from Percy Fyfe and Matetsi were derived by multiplying nitrogen levels (measured by Kjeldahl method) by 6,25 (Table 23). From this it is evident that milk from sable females in the Matetsi area had protein levels of 9,63 and 10,13 percent respectively, while those of Percy Fyfe sable were of the order of 4 to 5 percent. Colostrum was obtained from sable on two occasions and had protein levels of 9 and 11 percent respectively.

Apart from the disparity in protein levels, milk from Matetsi sable had much higher levels of iron, copper and cobalt than those from Percy Fyfe sable. These values can be related back to blood, liver and forage content of these essential trace elements.

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[1] Animal and Dairy Science Research Institute, Irene.

[2] South African Bureau of Standards, Pretoria.

TABLE 22.-MAIN CONSTITUENTS OF SABLE AND ROAN ANTELOPE MILK, PERCY FYFE NATURE RESERVE AND TJOLOTJO AREA, RHODESIA

Species	Area	Date Sampled	Total Solids	Fat %	Total Protein %	Lactose	Ash %
Sable	Percy Fyfe N.R.	13 February [1]	31,63	11,44	13,71	5,50	0,94
		25 March	18,82	6,99	5,42	5,14	0,97
		25 March	17,69	6,00	5,10	5,52	0,87
		2 April	16,28	5,50	4,14	6,30	0,83
		5 April	17,26	6,00	5,10	5,17	0,95
Roan	Tjolotjo	19 May	20,18	6,55	7,15	5,39	1,09
		29 May	18,83	6,55	5,75	5,85	0,98

[1] Colostrum.

TABLE 23.- MAIN MINERAL CONSTITUENTS OF MILK SAMPLES TAKEN FROM LACTATING SABLE COWS ON PERCY FYFE NATURE RESERVE AND MATETSI AREA, RHODESIA, 1974. NUMBER IN PARENTHESES IDENTIFIES ANIMAL

Element	Percy Fyfe Nature Reserve.			Dates Sampled.			Matetsi and Dates	
	4 6 September	8[1] 22 February	9 24 May	10[1] 26 May	11 27 May	12 28 May	47[2] 5 July	48 5 July
Calcium % (m/m)	0,34	0,43	0,34	0,44	0,45	0,52	1,13	0,08
Phosphorus % (m/m)	0,17	0,16	0,12	0,15	0,15	0,17	0,36	0,05
Magnesium p.p.m.	170,00	322,00	170,00	243,00	218,00	206,00	198,00	220,00
Sodium % (m/m)	0,52	0,07	0,03	0,05	0,04	0,07	0,12	0,48
Potassium % (m/m)	0,04	0,15	0,15	0,17	0,17	0,17	0,18	0,01
Nitrogen % (m/m)	0,80	1,47	0,59	0,53	0,78	0,85	1,54	1,62
Protein %[3]	5,00	9,19	3,69	3,31	4,88	5,31	9,63	10,13
Iron p.p.m.	7,50	11,00	4,40	6,00	10,90	7,40	10,00	21,00
Copper p.p.m.	0,18	0,23	0,10	0,13	0,07	<0,05	0,20	0,44
Zinc p.p.m.	2,70	8,00	3,60	3,90	3,40	3,30	8,70	2,30
Cobalt p.p.m.	0,92	0,25	<0,05	0,62	0,14	0,09	0,77	1,10
Molybdenum p.p.m.	Less than 0,2 in all samples							
Manganese p.p.m.	0,047	0,033	0,056	0,032	0,059	0,045	0,06	0,067
Selenium p.p.m.	Less than 0,05 in all samples							

[1] Same animal sampled at different times during same lactation. Sample on 22 February was colostrum.
[2] Animal injured by lion prior to milk sample. Wounds were septic and body condition was down.
[3] N x 6,25.

Nutrient Availability in Forage

Detailed information on the preferred forage grasses of roan and sable was available only from temporary feeding enclosures on Percy Fyfe Nature Reserve. For the other areas, grasses of known relatively high palatability were collected in each preferred feeding area. For the Matetsi area, some feeding preferences of sable were mentioned by Johnstone (1971). These preferred grasses were subjected to chemical analyses for their principle contents (Tables 24 to 30).

No information is available on the amounts of each species eaten daily or periodically by the roan or sable antelope. This would have entailed an in-depth study of feeding habits beyond the scope of the present study. Comparisons of the nutrient contents of grasses are made more meaningful if the relative frequency occurrences of these grasses (Tables 24 to 30) are also taken into consideration. This parameter to some extent simulates the frequency intake of grasses, assuming they are all of the same palatability.

Calcium content of grasses differs considerably, since it is a reflection of cell wall construction and makes up a large proportion of crystals present in many grasses. What is of particular significance is that the calcium:phosphorus ratio in many grasses is strongly biased towards calcium. The optimal (rule-of-thumb) ratio in forage of domestic animals is frequently stated to be 2:1; in some species analyzed in this study, e.g. Eustachys mutica, the ratio went as high as 13:1. The distorted ratios are brought about principally by deficiencies in phosphorus and phosphates.

TABLE 24.-NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY SABLE, DRY SEASON 1974, PERCY FYFE NATURE RESERVE

Element	Heteropogon contortus	Hyparrhenia hirta	Cynodon dactylon	Eragrostis gummiflua	Rhynchelytrum repens	Themeda triandra	Digitaria pentzii
Calcium % (m/m)	0,23	0,11	0,19	0,08	0,20	0,17	0,36
Phosphorus % (m/m)	0,03	0,03	0,04	0,03	0,05	0,03	0,06
Magnesium % (m/m)	0,12	0,13	0,18	0,05	0,18	0,09	0,19
Sod ium % (m/m)	0,03	0,04	0,03	0,03	0,04	0,02	0,03
Potassium % (m/m)	0,16	0,27	0,37	0,24	0,25	0,20	0,23
Nitrogen % (m/m)	0,35	0,37	0,61	0,69	0,58	0,46	0,58
Iron % (m/m)	0,17	0,05	0,04	0,07	0,11	0,05	0,13
Copper p.p.m.	5,10	4,60	9,90	5,80	9,00	3,70	4,80
Zinc p.p.m.	34,60	28,20	55,60	32,40	56,40	33,40	23,20
Cobalt p.p.m.	0,02	0,01	0,01	0,008	0,03	0,016	0,04
Manganese p.p.m.	73,00	35,00	47,00	22,00	50,00	47,00	124,00
Molybdenum p.p.m.	----------All samples less than 4----------						
Selenium p.p.m.	----------All samples less than 0,5----------						

TABLE 25.- NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY SABLE, DRY SEASON 1974, LOSKOP DAM NATURE RESERVE

Element	*Heteropogon contortus*	*Hyperthelia dissoluta*	*Eustachys mutica*	Unidentified species
Calcium % (m/m)	0,18	0,14	0,52	0,11
Phosphorus % (m/m)	0,04	0,04	0,04	0,04
Magnesium % (m/m)	0,11	0,12	0,14	0,12
Sodium % (m/m)	0,01	0,01	0,005	0,01
Potassium % (m/m)	0,40	0,61	0,54	0,51
Nitrogen % (m/m)	0,75	0,77	0,93	0,88
Iron % (m/m)	0,10	0,10	0,14	0,23
Copper p.p.m.	4,40	4,40	4,70	9,60
Zinc p.p.m	46,20	48,20	24,40	44,80
Cobalt p.p.m.	0,01	0,016	0,016	0,036
Manganese p.p.m.	94,00	110,00	162,00	202,00
Molybdenum p.p.m.	---------All samples less than 4 ---------------			
Selenium p.p.m.	---------All samples less than 0,5--------------			

TABLE 26.-NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY SABLE, DRY SEASON, 1974, RUSTENBURG NATURE RESERVE

Element	*Themeda triandra*	*Heteropogon contortus*	*Setaria perennis*	*Trachypogon spicatus*
Calcium % (m/m)	0,08	0,14	0,09	0,10
Phosphorus % (m/m)	0,02	0,04	0,05	0,03
Magnesium % (m/m)	0,07	0,06	0,14	0,07
Sodium % (m/m)	0,01	0,01	0,02	0,01
Potassium % (m/m)	0,14	0,21	0,43	0,24
Nitrogen % (m/m)	0,45	0,46	0,67	0,48
Iron % (m/m)	0,07	0,25	0,18	0,14
Copper p.p.m.	16,10	13,00	13,80	10,30
Zinc p.p.m.	11,60	25,80	26,60	10,00
Cobalt p.p.m.	0,04	0,06	0,04	0,02
Manganese p.p.m.	159,00	135,00	200,00	72,00
Molybdenum p.p.m.	------------ All samples less than 4--------			
Selenium p.p.m.	------------ All samples less than 0,5------			

TABLE 27.-NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY SABLE, DRY SEASON, 1974; HANS MERENSKY NATURE RESERVE

Element	Brachiaria nigropedata	Heteropogon contortus	Panicum maximum	Hyperthelia dissoluta	Themeda triandra	Pogonarthria squarrosa	Urochloa bolbodes
Calcium % (m/m)	0,07	0,17	0,34	0,07	0,20	0,13	0,30
Phosphorus % (m/m)	0,04	0,04	0,09	0,02	0,03	0,03	0,05
Magnesium % (m/m)	0,10	0,11	0,28	0,17	0,10	0,09	0,28
Sodium % (m/m)	0,01	0,01	0,08	0,02	0,01	0,01	0,06
Potassium % (m/m)	0,30	0,35	0,85	0,45	0,29	0,23	0,43
Nitrogen % (m/m)	0,78	0,53	0,96	0,51	0,53	0,62	0,61
Iron % (m/m)	0,11	0,03	0,02	0,04	0,06	0,07	0,03
Copper p.p.m.	4,70	5,70	11,1	4,60	8,40	11,10	9,20
Zinc p.p.m.	16,00	22,20	51,20	22,00	10,80	17,40	21,20
Cobalt p.p.m.	0,02	0,01	0,006	0,006	0,012	0,01	0,01
Manganese p.p.m.	65,00	69,00	68,00	84,00	58,00	62,00	126,00
Molebdenum p.p.m.	----------------------------All samples less than 4------------------------------						
Selenium p.p.m.	----------------------------All samples less than 0,5----------------------------						

TABLE 28.- NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY SABLE, DRY SEASON, 1974; MATETSI AREA, RHODESIA

Element	Panicum dregeanum	Themeda triandra	Digitaria milanjiana	Urochloa mosambicensis	Setaria anceps	Heteropogon contortus	Eragrostis superba
Calcium % (m/m)	0,34	0,29	0,34	0,41	0,38	0,27	0,36
Phosphorus % (m/m)	0,10	0,08	0,19	0,36	0,12	0,16	0,14
Magnesium % (m/m)	0,36	0,22	0,37	0,60	0,41	0,25	0,28
Sodium % (m/m)	0,07	0,05	0,07	0,04	0,06	0,04	0,04
Potassium % (m/m)	0,48	0,35	0,77	1,03	0,74	0,53	0,42
Nitrogen % (m/m)	0,45	0,41	0,55	0,78	0,56	0,42	0,45
Iron % (m/m)	0,24	0,17	0,13	0,16	0,26	0,15	0,22
Copper p.p.m.	16,60	8,10	6,29	15,60	23,50	8,10	11,70
Zinc p.p.m.	47,60	29,40	37,60	62,40	40,00	25,80	38,00
Cobalt p.p.m.	0,06	0,04	0,03	0,03	0,07	0,03	0,04
Manganese p.p.m.	103,00	62,00	75,00	44,00	116,00	50,00	60,00
Molybdenum p.p.m.	All samples less than 4						
Selenium p.p.m.	All samples less than 0,5						

TABLE 29.-NUTRIENT CONTENT OF FORAGE GRASSES GRAZED BY ROAN ANTELOPE, PERCY FYFE NATURE RESERVE DRY SEASON,1974

Element	*Heteropogon contortus*	*Brachiaria nigropedata*	*Rhynchelytrum repens*	*Themeda triandra*	*Digitaria pentzii*	*Hyperthelia dissoluta*
Calcium % (m/m)	0,19	0,15	0,29	0,19	0,38	0,18
Phosphorus % (m/m)	0,05	0,04	0,05	0,03	0,04	0,03
Magnesium % (m/m)	0,13	0,07	0,17	0,10	0,18	0,15
Sodium % (m/m)	0,02	0,02	0,01	0,01	0,01	0,02
Potassium % (m/m)	0,23	0,16	0,29	0,19	0,28	0,25
Nitrogen % (m/m)	0,58	0,53	0,62	0,42	0,64	0,43
Iron % (m/m)	0,03	0,12	0,20	0,11	0,25	0,09
Copper p.p.m.	5,30	1,40	3,50	3,30	4,70	2,50
Zinc p.p.m.	47,60	32,00	38,20	18,60	24,60	9,00
Cobalt p.p.m.	0,01	0,03	0,03	0,02	0,06	0,02
Manganese p.p.m.	45,00	44,00	49,00	51,00	94,00	55,00
Molybdenum p.p.m.	All samples less than 4					
Selenium p.p.m.	All samples less than 0,5					

TABLE 30.-NUTRIENT CONTENT OF CONCENTRATED ANTELOPE CUBES AND LUCERNE HAY FED TO SEMI-TAMED SABLE MALES IN PENS, PERCY FYFE NATURE RESERVE

Element	Antelope Cubes	Lucerne Hay
Calcium % (m/m)	0,24	0,91
Phosphorus % (m/m)	1,50	0,13
Magnesium % (m/m)	0,30	0,26
Sodium % (m/m)	0,50	0,11
Potassium % (m/m)	0,88	2,15
Nitrogen % (m/m)	2,70	2,21
Iron % (m/m)	0,02	0,02
Copper p.p.m.	13,10	8,20
Zinc p.p.m.	44,00	4,00
Cobalt p.p.m.	0,016	0,008
Manganese p.p.m.	77,00	23,00
Molybdenum p.p.m.	All samples less than 4,0	
Selenium p.p.m.	All samples less than 0,5	

Most grasses in Transvaal areas had phosphorus levels of 0,02 to 0,05 percent (m/m), the highest value being that of the very palatable Panicum maximum (0,09 percent) on Hans Merensky Nature Reserve. Matetsi grasses, contrarily, had phosphorus values of 0,08 to 0,36 percent. Heteropogon contortus, a frequently occurring grass throughout southern Africa, had phosphorus contents of 0,03 to 0,04 percent in Transvaal reserves, but a value of 0,16 percent on Matetsi. Magnesium and potassium were also substantially higher in Rhodesian grasses than on Transvaal areas sampled.

Of the trace elements, iron and copper are far more abundant in Rhodesian grasses than in Transvaal species, although Rustenburg grasses sampled also showed comparably high levels (10 to 16 p.p.m). Zinc levels were noticeably low in Rustenburg grasses. Since grasses sampled from the various areas differed in species and in number of species sampled, the data (Tables 24 to 30) do not lend themselves to statistical evaluation for significant differences. The above-mentioned deficiencies in Transvaal areas are, however, fairly evident, simply from visual examination of the results.

Protein content of the forage grasses can be estimated by multiplying the nitrogen content by a factor of 6,25. From this (Table 31) it is evident that dry season grass protein levels are exceptionally low in the "sour" areas of Percy Fyfe and Rustenburg. Measured values for Loskop Dam grasses were substantially higher, but these samples were taken from a previously burned area (the area used primarily by sable on Loskop Dam) and the relatively younger and greener shoots could be expected to have a higher protein content than unburned drier forage. Even the

TABLE 31.- PROTEIN CONTENT OF PREFERRED SABLE AND ROAN ANTELOPE FORAGE GRASSES IN VARIOUS AREAS IN DRY SEASON, 1974. PROTEIN VALUES = NITROGEN x 6,25

Area	Percentage Protein Content (range)		
Percy Fyfe N.R. (Sable enclosure)	2,2	-	4,3
Percy Fyfe N.R. (roan enclosure)	2,6	-	4,0
Rustenburg N.R.	2,8	-	4,2
Matetsi, Rhodesia	2,6	-	4,9
Hans Merensky N.R.	3,3	-	6,0
Loskop Dam N.R.[1]	4,7	-	5,8
Antelope cubes[2]		16,9	
Lucerne Hay[2]		13,8	

[1] Burnt area.

[2] Fed to penned animals.

Matetsi area grasses were relatively low in protein value, and actually contained less protein, on the average, than those on Hans Merensky Nature Reserve.

For the purposes of this study, Matetsi has been considered to be the best available area for sable antelope in southern Africa. Results of the forage analyses would suggest that protein levels in most areas are low, but may be sufficient in the dry seasons for survival, provided other nutrients are not deficient. Blood and liver nitrogen levels (Table 21) do not differ significantly, suggesting that the animals sampled were receiving adequate protein levels during the dry season. The penned animals, living on a diet of 13,8 to 16,9 percent protein content (Table 31) had similar blood nitrogen values. However, these findings are at variance with the body conditions of the various animals (Tables 19 and 20), suggesting either that digestibility of protein is a further factor to be considered, or that protein alone is not involved in maintaining body health and condition in roan and sable antelope: a nutritional complex of several minerals with or without protein would appear to be involved.

Nutrient Availability in Soils

Mineral and nitrogen content of the whole topsoil of areas most frequently utilized for breeding by roan and sable were assessed, mainly to complete the information on the whole soil-vegetation-animal nutrient flow process. Knowledge of soil nutrients available to plants also becomes of importance in the practical context, since fertilization with nitrogenous, phosphate and other chemicals is a well established range management procedure, and one of potential value in the management of small nature reserves.

Mineral and nitrogen content of the various soils is given in Table 32. As anticipated, the whole Transvaal shows up as phosphorus deficient when compared with the basaltic soils of Matetsi. Loskop Dam shows up in a particularly poor light. Rustenburg soils, on the other hand, have a particularly low calcium content. Transvaal soils would also appear to be deficient to some extent in magnesium.

The soils of Matetsi generally appear to have a much higher trace element content, particularly iron, copper, zinc, cobalt and manganese, than most soils of Transvaal nature reserves. The balances and ratios between these various trace elements in the substrate which are optimal for plant growth and uptake are unknown, but in general it appears that each Transvaal area is low in some or other specific soil mineral, e.g. iron on Hans Merensky and copper on Rustenburg.

The data presented reflect total mineral content of the

TABLE 32.-MINERAL AND NITROGEN CONTENT OF SOILS FROM PREFERRED FEEDING AREAS IN TRANSVAAL AND RHODESIA SABLE OR ROAN-FREQUENTED AREAS. POOLED SAMPLES REPRESENTING EACH AREA COLLECTED IN DRY SEASON, 1974

Element	Matetsi	Percy Fyfe Sable Camp	Percy Fyfe Roan Camp	Rustenburg	Loskop Dam Lick Area [1]	Loskop Dam	Hans Merensky
Calcium % (m/m)	1,50	0,22	0,24	0,05	0,15	0,16	0,45
Phosphorus % (m/m)	0,29	0,10	0,10	0,10	0,05	0,04	0,10
Magnesium % (m/m)	0,34	0,11	0,08	0,05	0,19	0,11	0,09
Sodium % (m/m)	1,80	1,50	1,50	0,35	0,80	0,48	2,60
Potassium % (m/m)	1,18	2,50	2,50	0,22	1,86	1,35	1,44
Nitrogen % (m/m)	0,10	0,14	0,10	0,09	0,05	0,13	0,10
Iron % (m/m)	0,53	0,21	0,23	0,21	0,56	0,20	0,09
Copper p.p.m.	174,00	29,00	40,00	13,00	150,00	50,00	17,00
Zinc p.p.m.	185,00	60,00	42,00	20,00	110,00	105,00	20,00
Cobalt p.p.m.	5,70	4,50	4,20	6,90	4,60	6,20	4,60
Manganese p.p.m.	920,00	928,00	529,00	234,00	686,00	510,00	140,00
Molybdenum p.p.m.	-----------------------------All samples less than 4-----------------------------------						
Selenium p.p.m.	-----------------------------All samples less than 0,5-----------------------------------						

[1] Soils sampled from eroded area where sable antelope licked and even bit chunks of soil. High concentrations of reddish coloured soil were found in faecal pellets in the eroded area.

soils. They do not in fact reflect elements actually available to the plants, or those which are actually taken up by plants. Thus, although elements such as zinc and cobalt may be marginally sufficient according to the raw data, they may not be totally available to plants, and therefore to feeding animals because of insoluble compounds formed or gross excesses of other minerals. The latter possibility would, however, appear not to be the case with the soils sampled in this study (Table 32).

Nutrient Availability in Water

Depending on the geological formations present, water in many South African areas can have a fairly high mineral salt content. Most drinking water available to sable or roan antelope on Transvaal nature reserves is deep water pumped out to small earth dams or drinking troughs. Flowing water is only available on Loskop Dam and Rustenburg Nature Reserves, but even here, dissolved minerals may reach high levels if the stream bottoms have soluble mineral salts available.

Water samples, drawn from drinking sites most frequently used by roan or sable on each studied area, were analyzed by chemical and atomic absorption methods. Results are given in Table 33. Samples were taken during the dry season, when animals were dependant on the sampled sites and could not have obtained water from temporary rain pools or other sources. The samples were thus not affected by rain dilution.

The most significant finding was that water available to sable in the Matetsi area and on Hans Merensky Nature Reserve was hard because of the presence of calcium and magnesium salts, respectively. The stream water on Rustenburg was virtually mineral free. Trace element content of all water samples was very low. Water intake contributed very little to total mineral nutrient intake by sable and roan, and deficiencies had thus to be sought in forage uptake.

TABLE 33.-MINERAL CONTENT OF WATER AVAILABLE TO ROAN AND SABLE ANTELOPE, TRANSVAAL AND RHODESIA. DRY SEASON 1974

Element or Salt	Hans Merensky NR Dam 1	Hans Merensky NR Dam 2	Matetsi Stream	Percy Fyfe NR Sable Enclos. Dam 1	Percy Fyfe NR Sable Enclos. Dam 2	Percy Fyfe NR Roan Enclos. Dam 1	Percy Fyfe NR Roan Enclos. Dam 2	Rustenburg NR Stream	Loskop Dam NR [1] Dam 1	Loskop Dam NR [1] Dam 2
Copper as Cu in mg/l	0	0	0	0,06	0	0	0,03	0	0	0,03
Zinc as Zn in mg/l	0	0	0	0	0	0	0	0	0	0
Cobalt as Co in mg/l	0	0	0	0	0	0	0	0	0	0
Manganese as Mn in mg/l	0	0	0	0	0,10	0	0,06	0	0	0
Selenium as Se in mg/l	0	0	0	0	0	0	0	0	0	0
Calcium Hardness as $CaCO_3$ in mg/l	35,0	39,0	150,00	21,00	30,00	25,00	23,00	2,00	14,00	37,00
Ortho-phosphate as P in mg/l	0,01	0,01	0	0,02	0,08	0,01	0,01	0	0	0
Sodium as Na in mg/l	59,00	72,00	22,00	48,00	56,00	39,00	15,00	2,00	20,00	24,00
Magnesium hardness as $CaCO_3$ in mg/l	140,00	127,00	101,00	29,00	22,00	27,00	43,00	5,00	11,00	34,00
Potassium as K in mg/l	31,00	37,00	1,00	2,00	8,00	3,00	4,00	1,00	3,00	4,00
Iron as Fe in mg/l	0	0	0	0,20	5,00	5,70	6,70	0,06	0	0,1

[1] Loskop Dam sample one from small earth dam, sample two from large irrigation dam.

Nutrient Intake and Body Condition

The present study adopted essentially a screening approach to the aspect of nutrition, and makes use of comparisons between sable and roan on various areas to derive conclusions regarding nutritional status and the relationship of nutrition to disease and mortalities. Where only one nutrient is in poor supply throughout most areas, but much higher in the reference area, i.e. Matetsi or adjacent Rhodesian areas, the conclusions are fairly self-evident. However, in many cases, it is not as straight forward as this, and possible deficiencies differ from one area to another. The possibility also exists that deficiencies are interrelated or otherwise related to excesses of certain minerals.

Minerals have an important role in enzyme systems and they serve a variety of functions as soluble salts in the blood and other body fluids. Many of their vital functions are due to an ionic interrelationship that can be expressed as "antagonistic action" and "balanced solution". Iron is a good example. Most of the iron of the body occurs in blood haemoglobin and in the liver, and plays a vital role in the formation of red blood cells. A shortage of red blood corpuscles causes a nutritional anaemia similar to that produced on a low-protein intake. Nutritional anaemia may occur at any time of life when the available supply of the mineral becomes deficient relative to the needs for haemoglobin formation. It is particularly likely to develop in certain species during the suckling period, since milk is very low in iron. The store of iron in the newborn calf is influenced by the diet of the mother during gestation. A maternal diet deficient in iron during gestation can cause nutritional anaemia in the calves. Even if the store of iron is normal, a long nursing period without iron-rich food may exhaust it.

It is known that, although adequate amounts of iron may be absorbed from the diet, yet no normal blood regeneration occurs if copper is deficient. When copper is deficient in the diet, there is a decreased absorption of iron, a lowering of its total content in the body, a decrease in its mobilization from the tissues, and the development of a severe microcytic hypochromic anaemia (Maynard and Loosli 1969).

As far as this study is concerned a visual comparison is made of the various elements in soils, vegetation, the body tissues and milk of sable antelope on the various study areas. These are shown in Figures 15 to 26. Consistency in the changes in concentrations for any one mineral from one site in the environment or the body tissues, suggests that initial concentrations in soil and vegetation are primarily responsible for setting the tissue levels of the animals. This is the case where mineral levels are not especially controlled by the adrenal corticoid hormones, or where absorption from the intestine does not change significantly with concentrations within the food.

Calcium is far more abundant in the basaltic soils of Matetsi than in the granitic soils of the Transvaal areas (Fig. 15) and this is carried through to the preferred food plants of sable antelope. Blood levels do not differ markedly, however, due to hormonal control, but the continual higher calcium intake in Rhodesian animals is reflected in the very high liver calcium levels, and the milk calcium content.

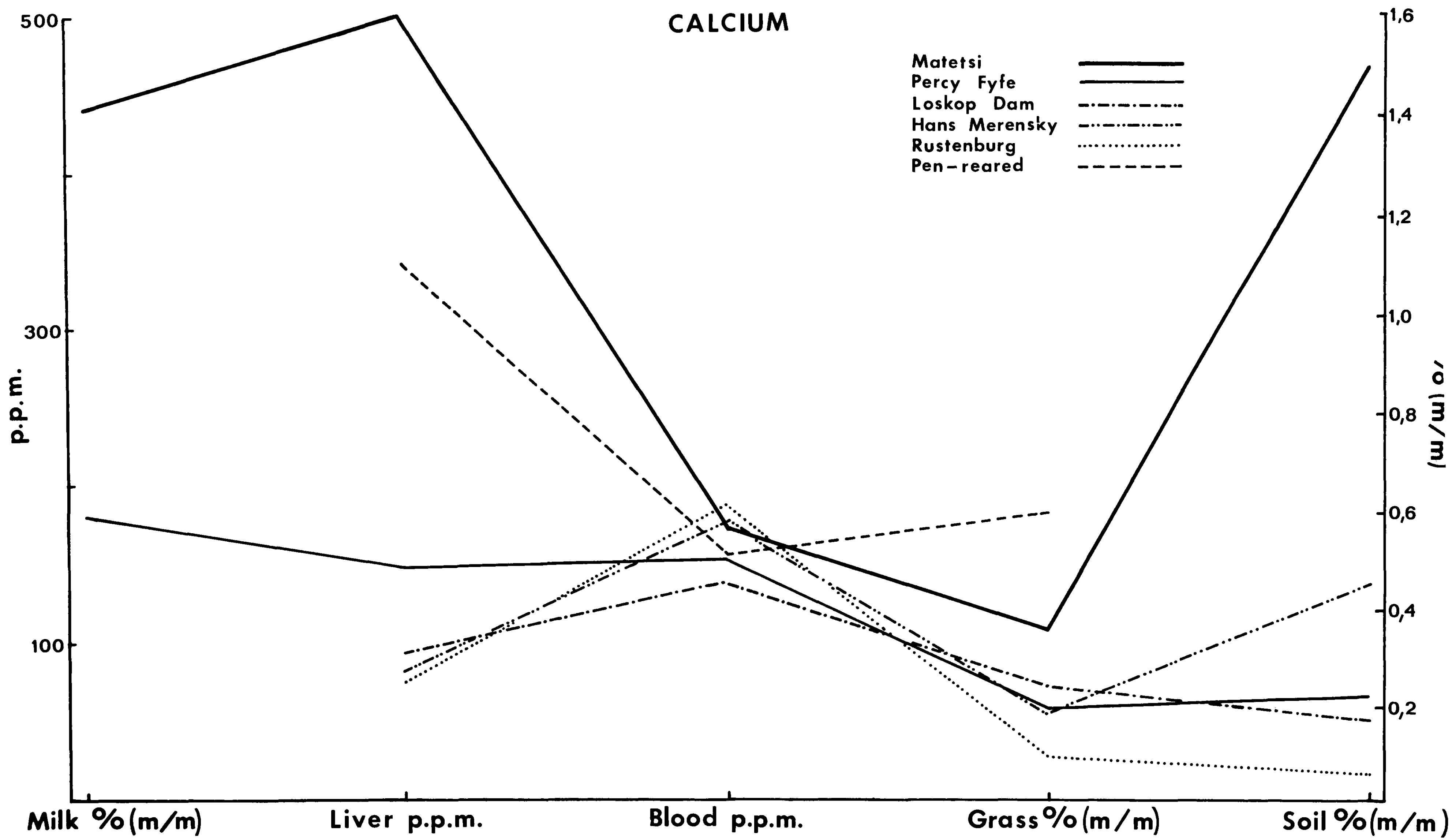

Fig. 15. Concentrations of calcium in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

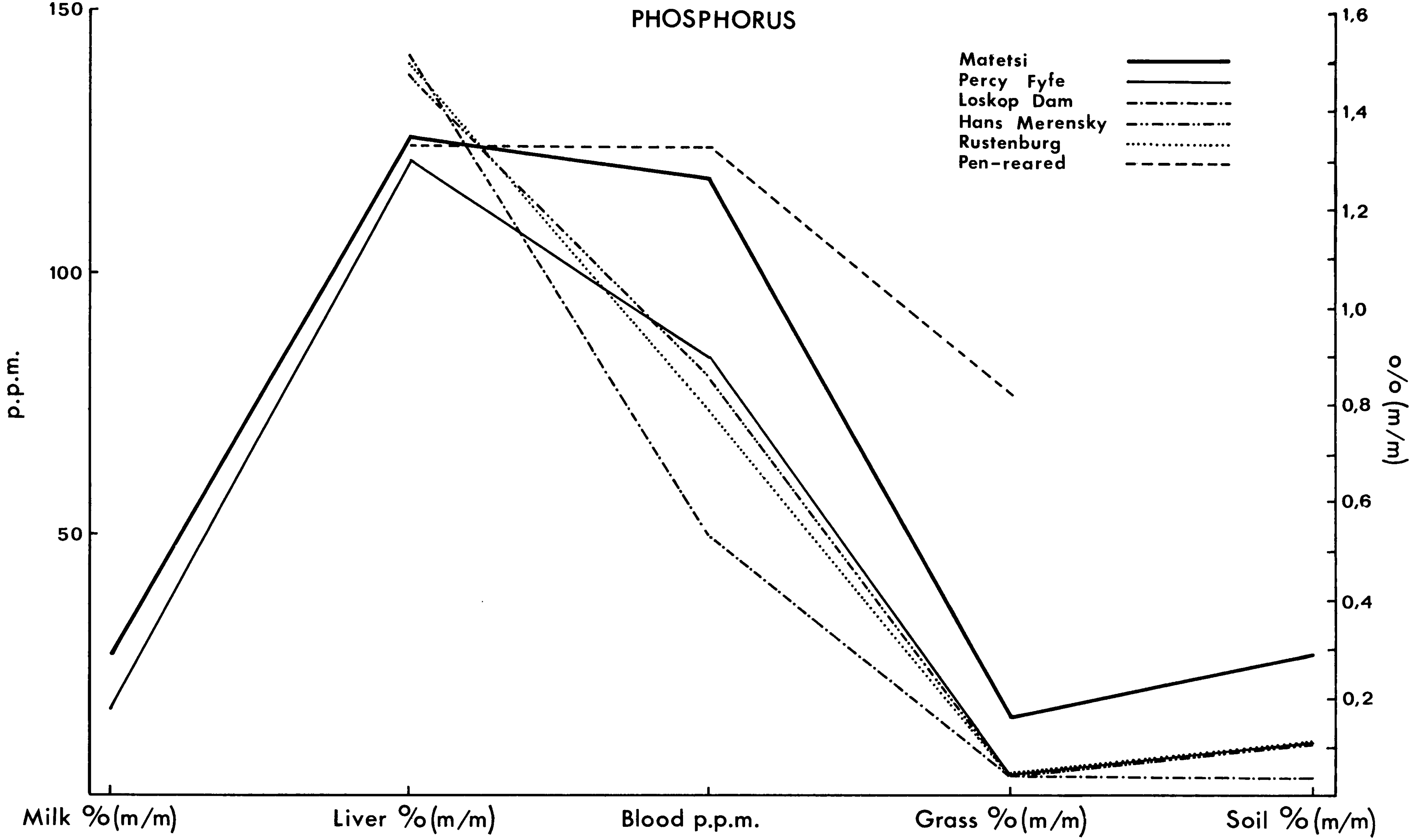

Fig. 16. Concentrations of phosphorus in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

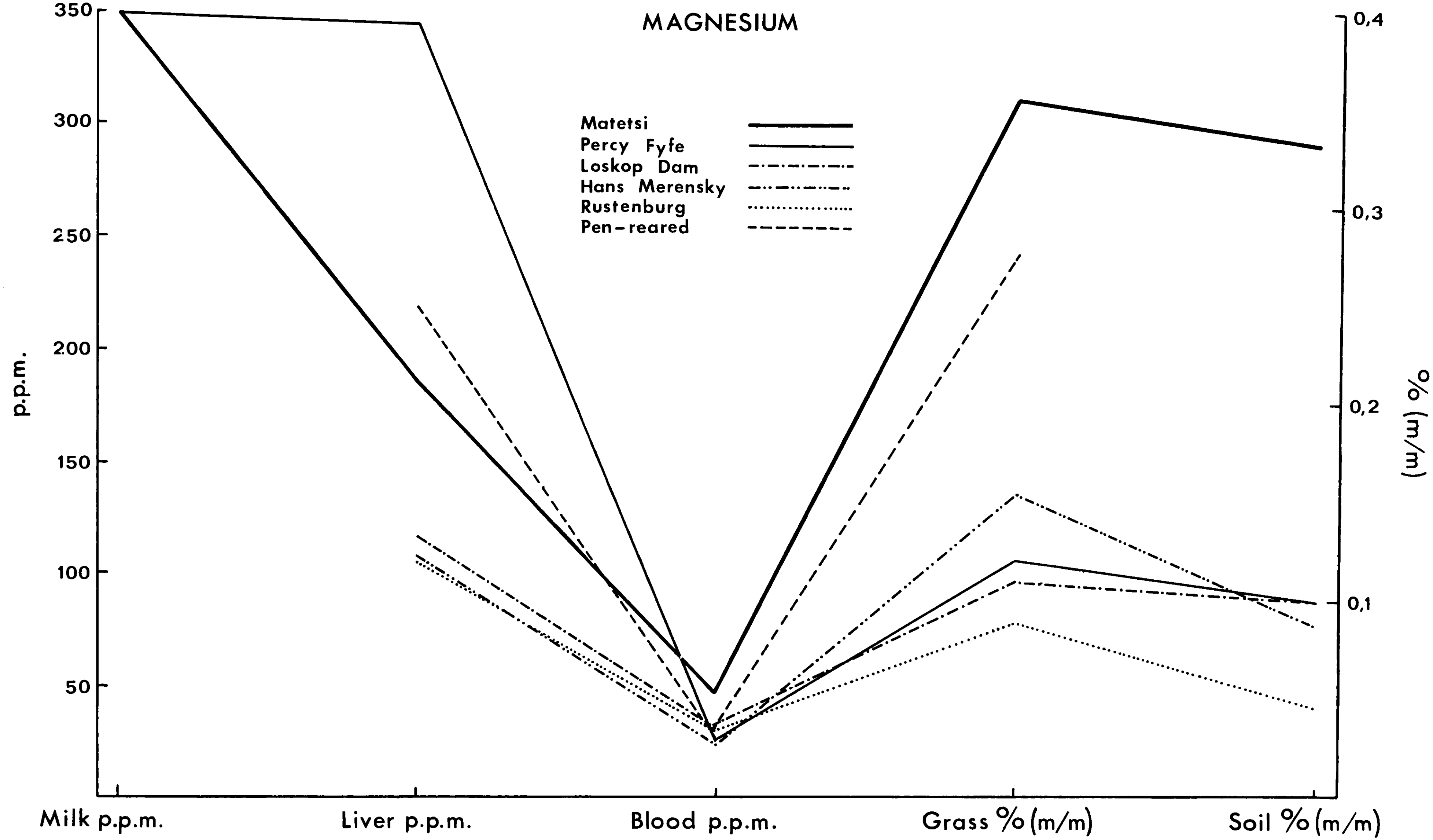

Fig. 17. Concentrations of magnesium in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

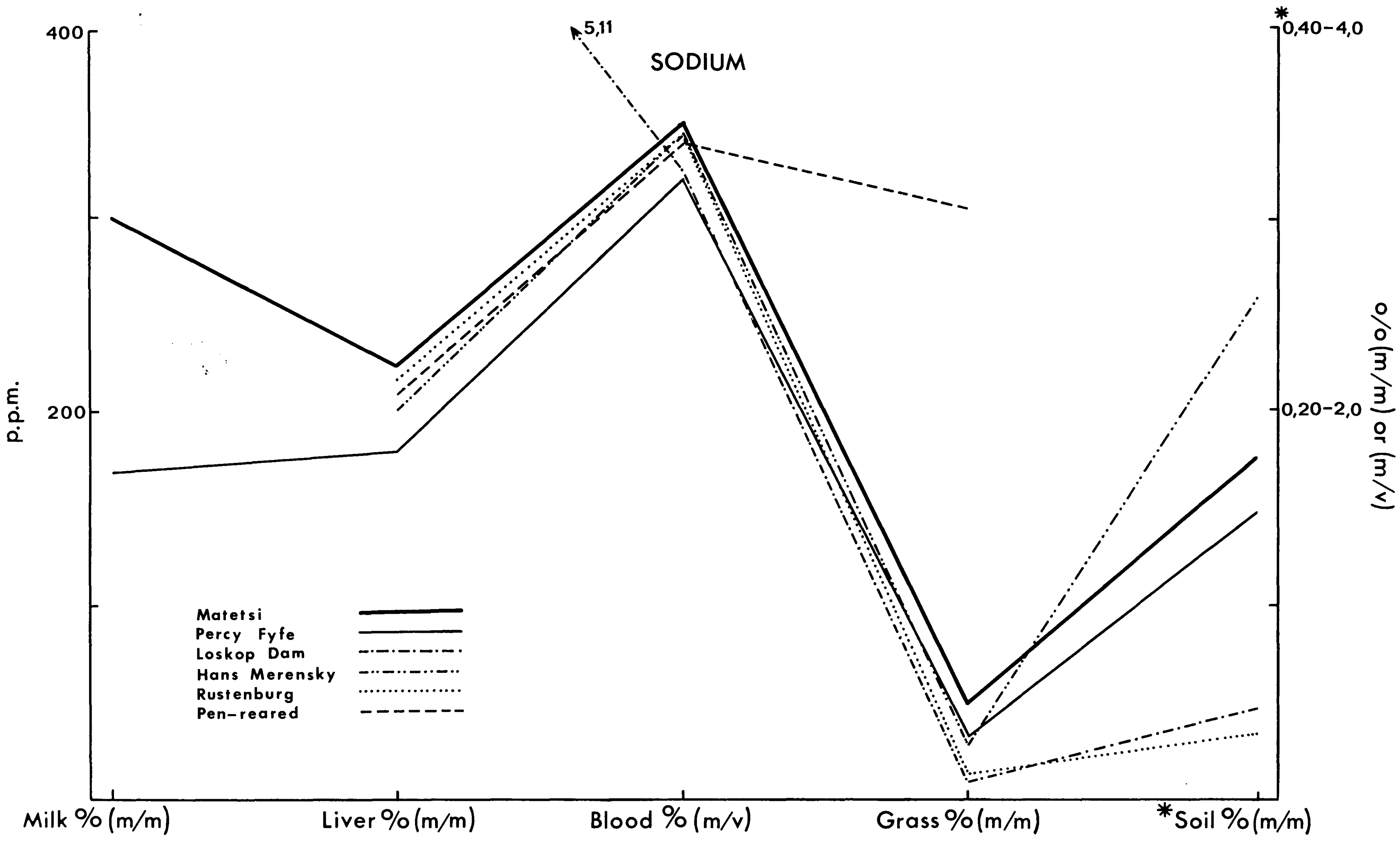

Fig. 18. Concentrations of sodium in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

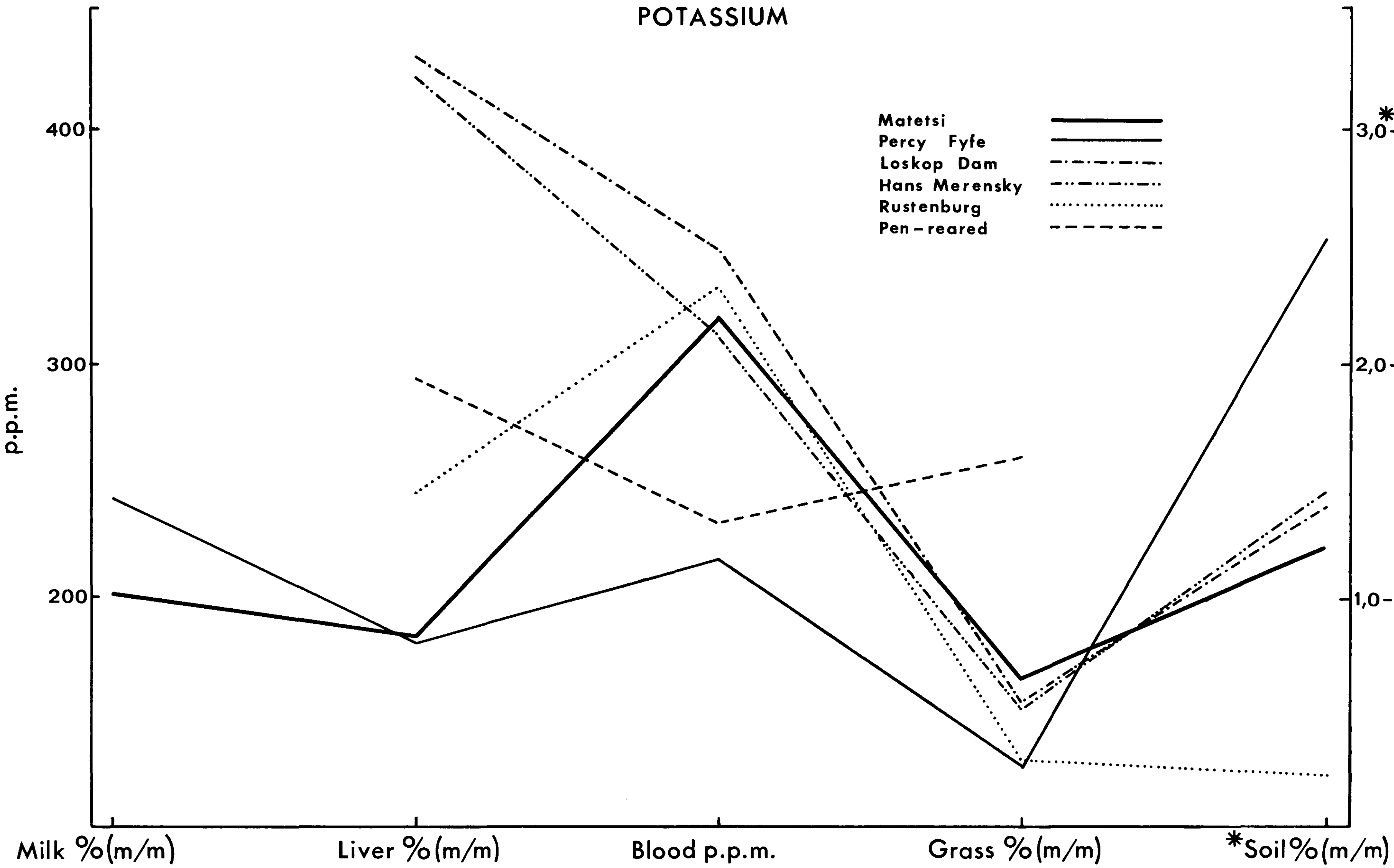

Fig. 19. Concentrations of potassium in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

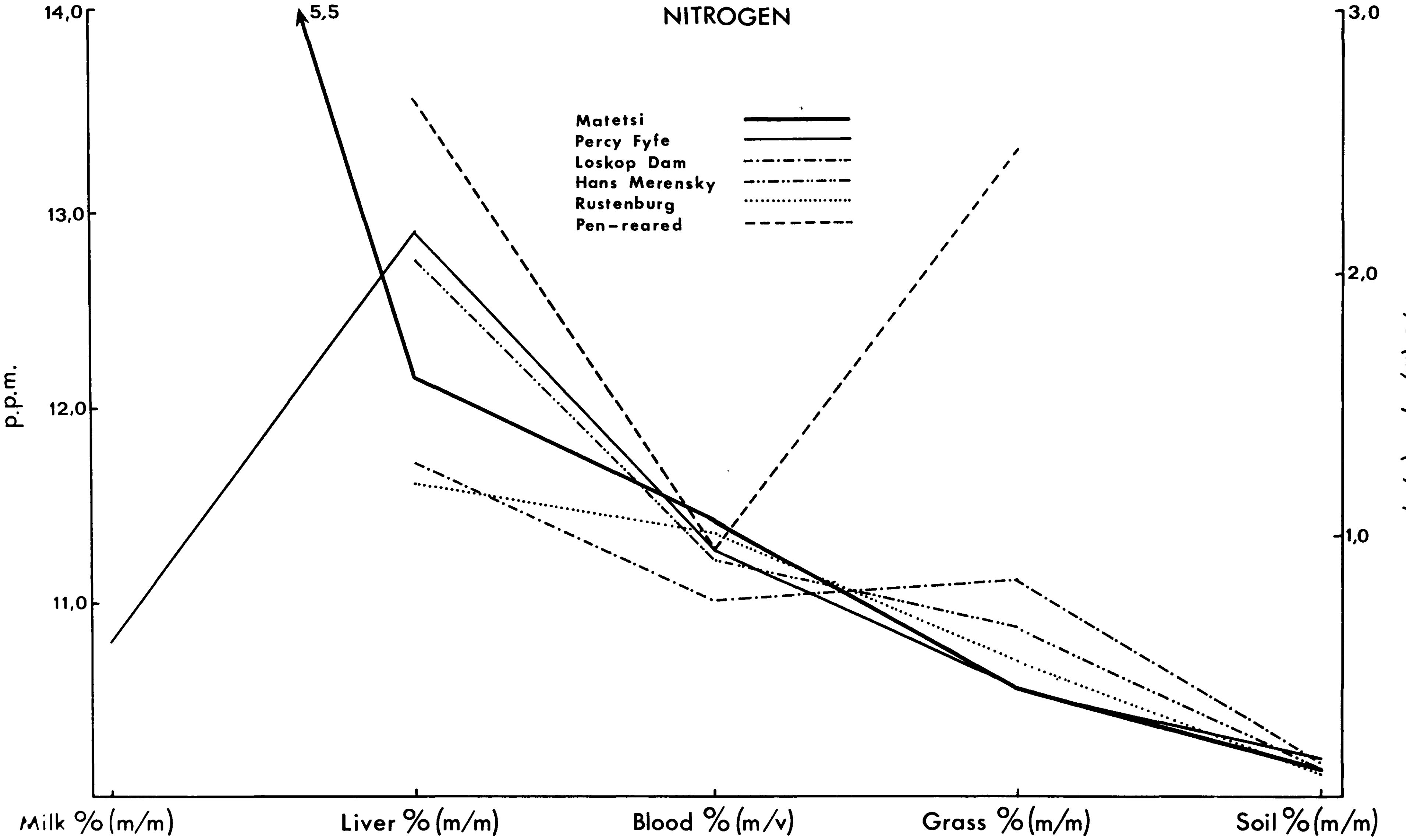

Fig. 20. Concentrations of nitrogen in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

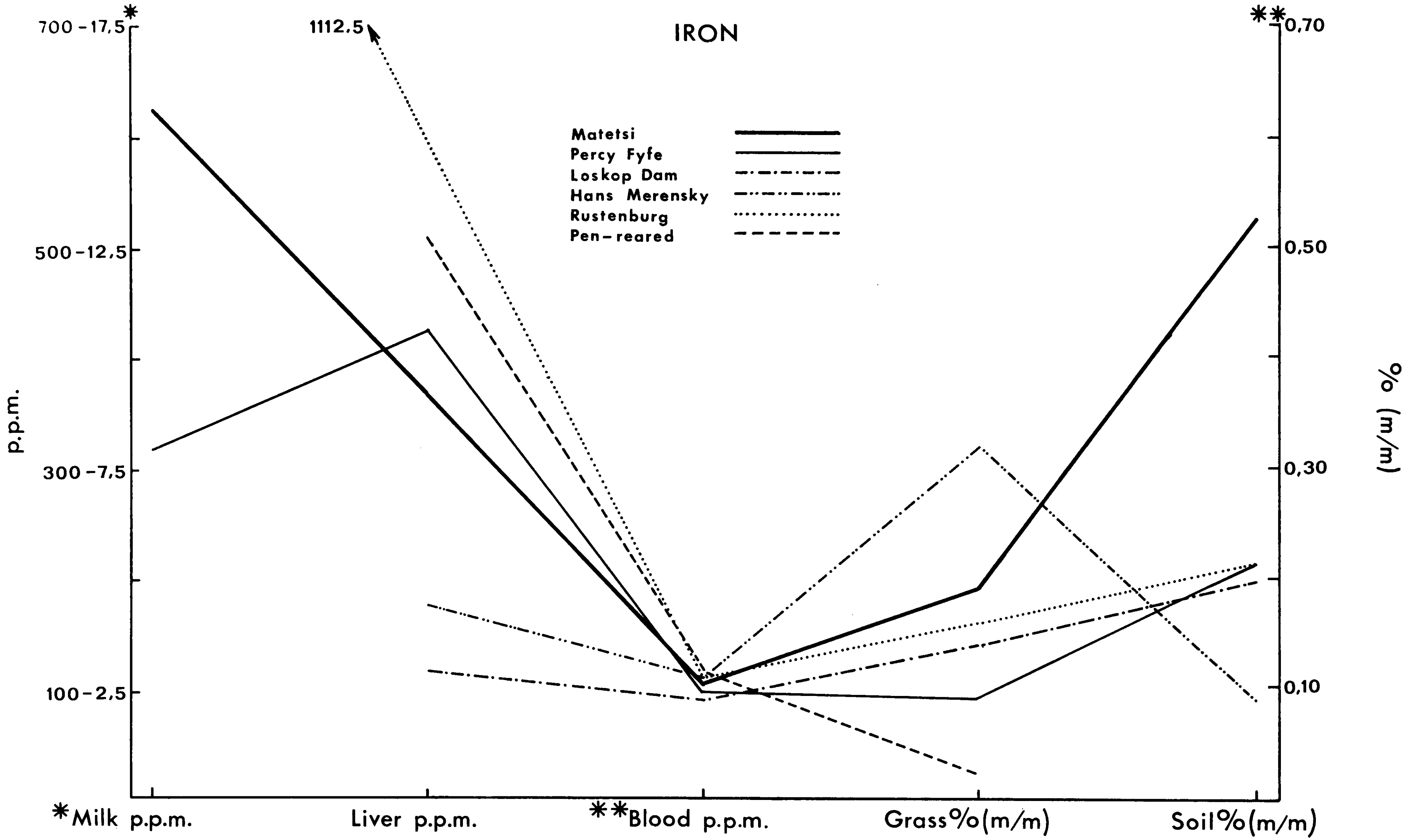

Fig. 21. Concentrations of iron in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

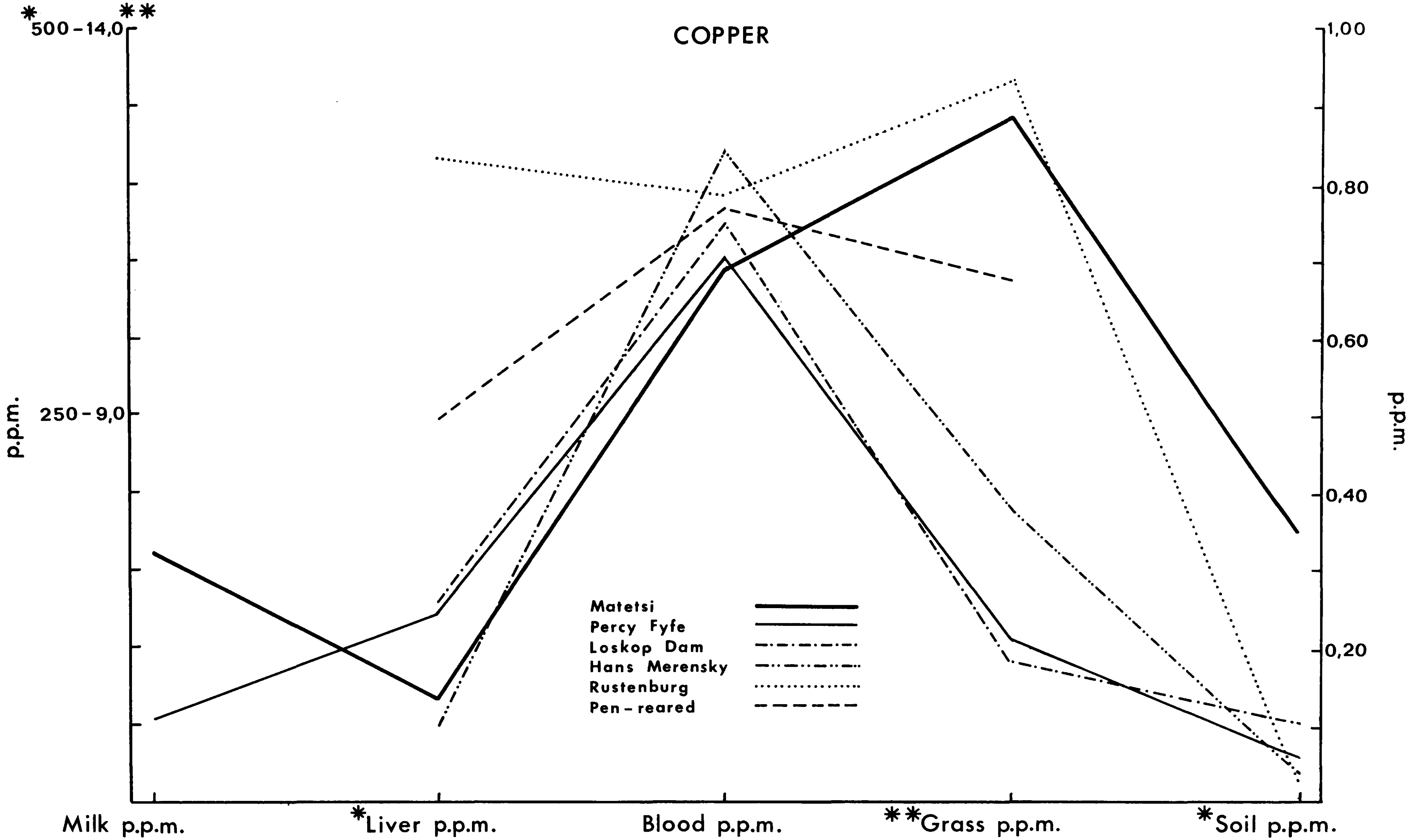

Fig. 22. Concentrations of copper in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

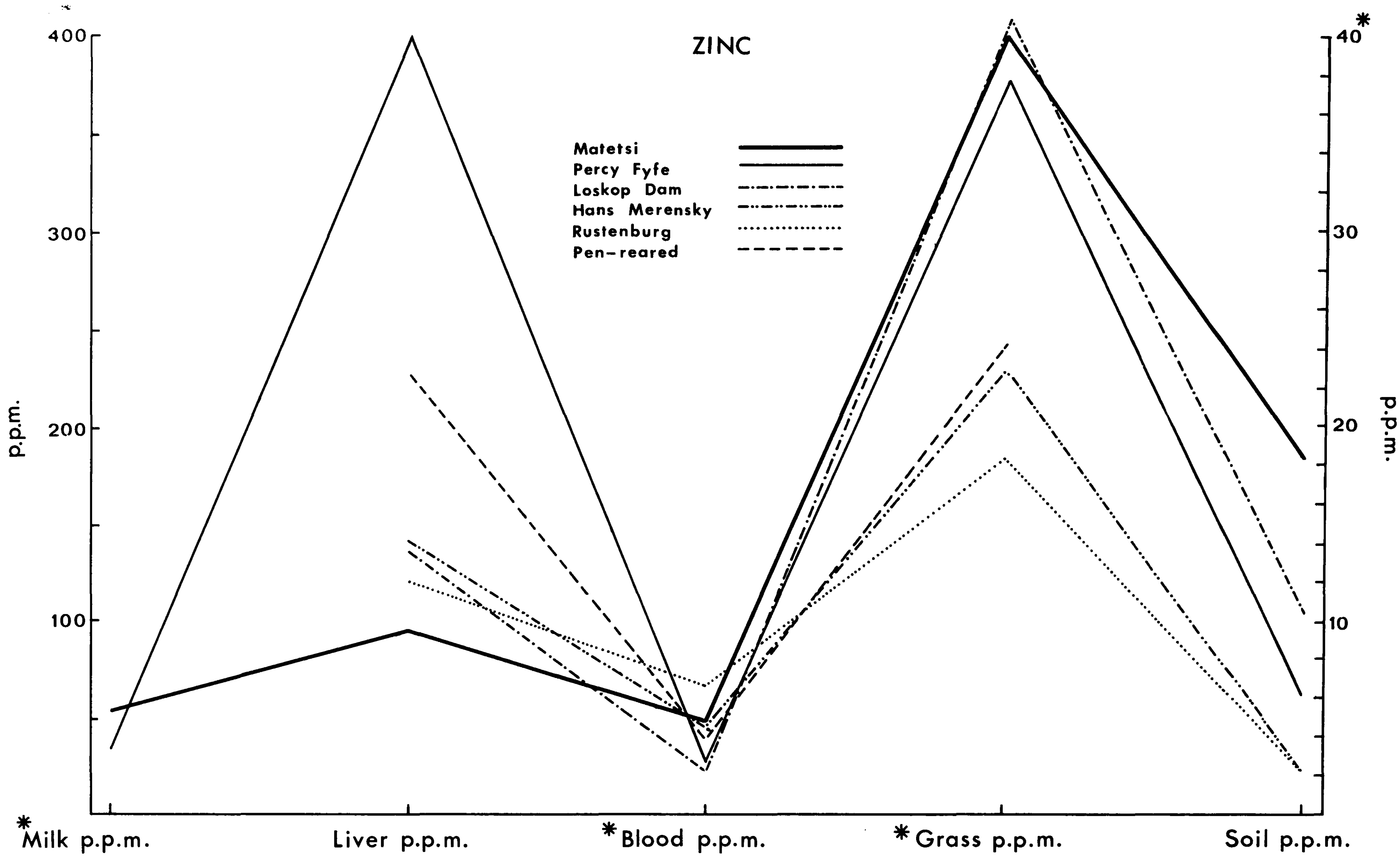

Fig. 23. Concentrations of zinc in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

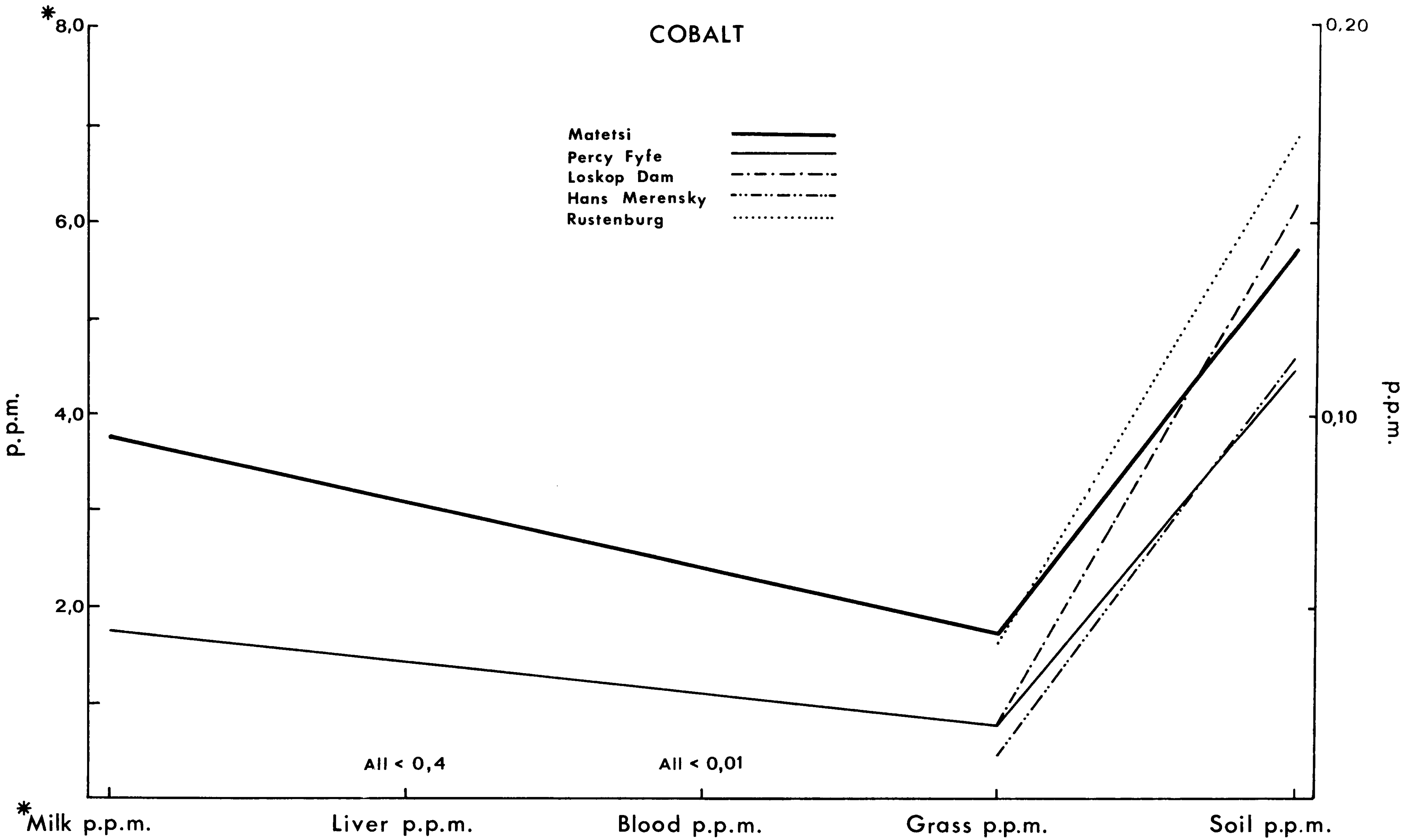

Fig. 24. Concentrations of cobalt in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

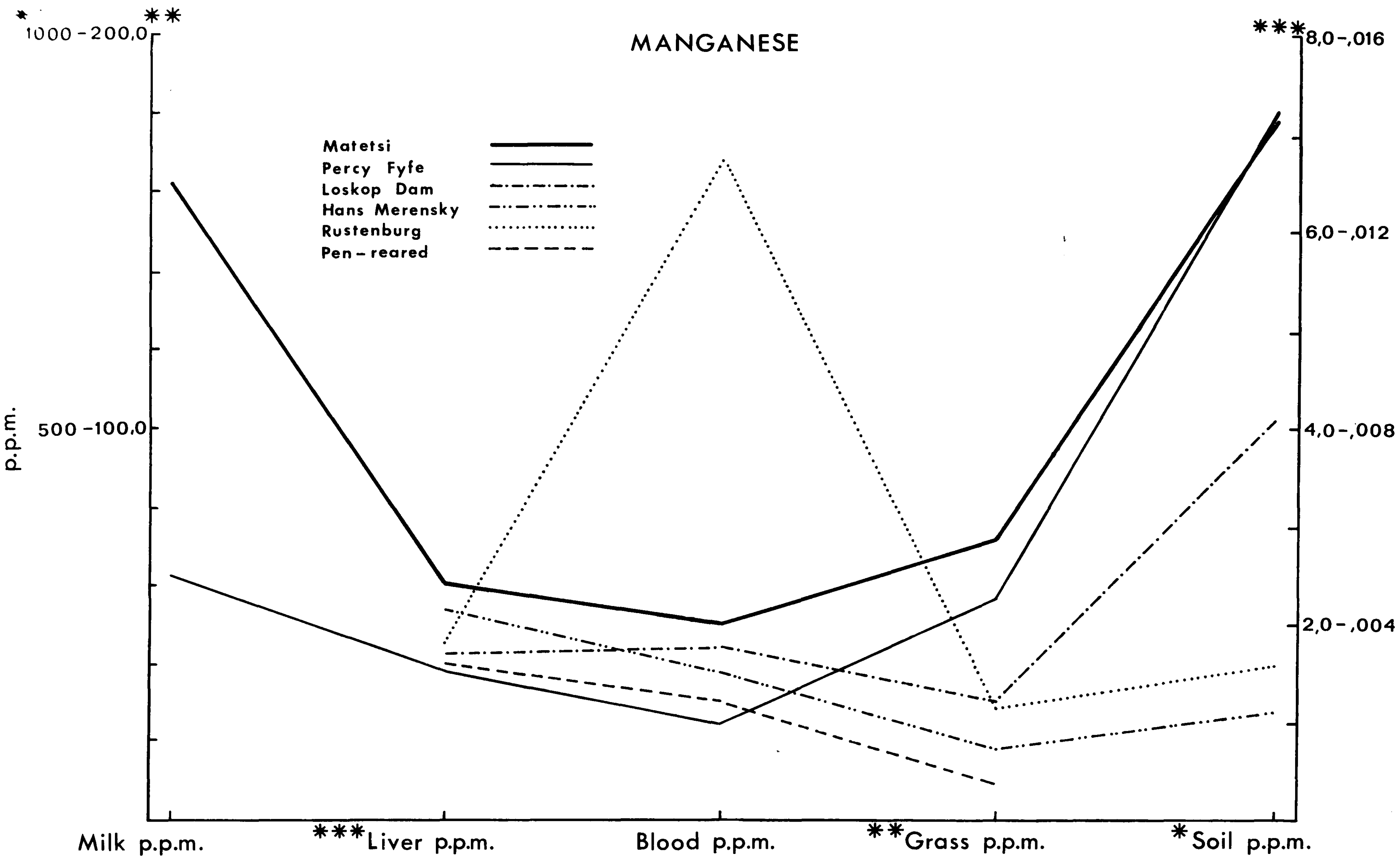

Fig. 25. Concentrations of manganese in soil, grass and body tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974.

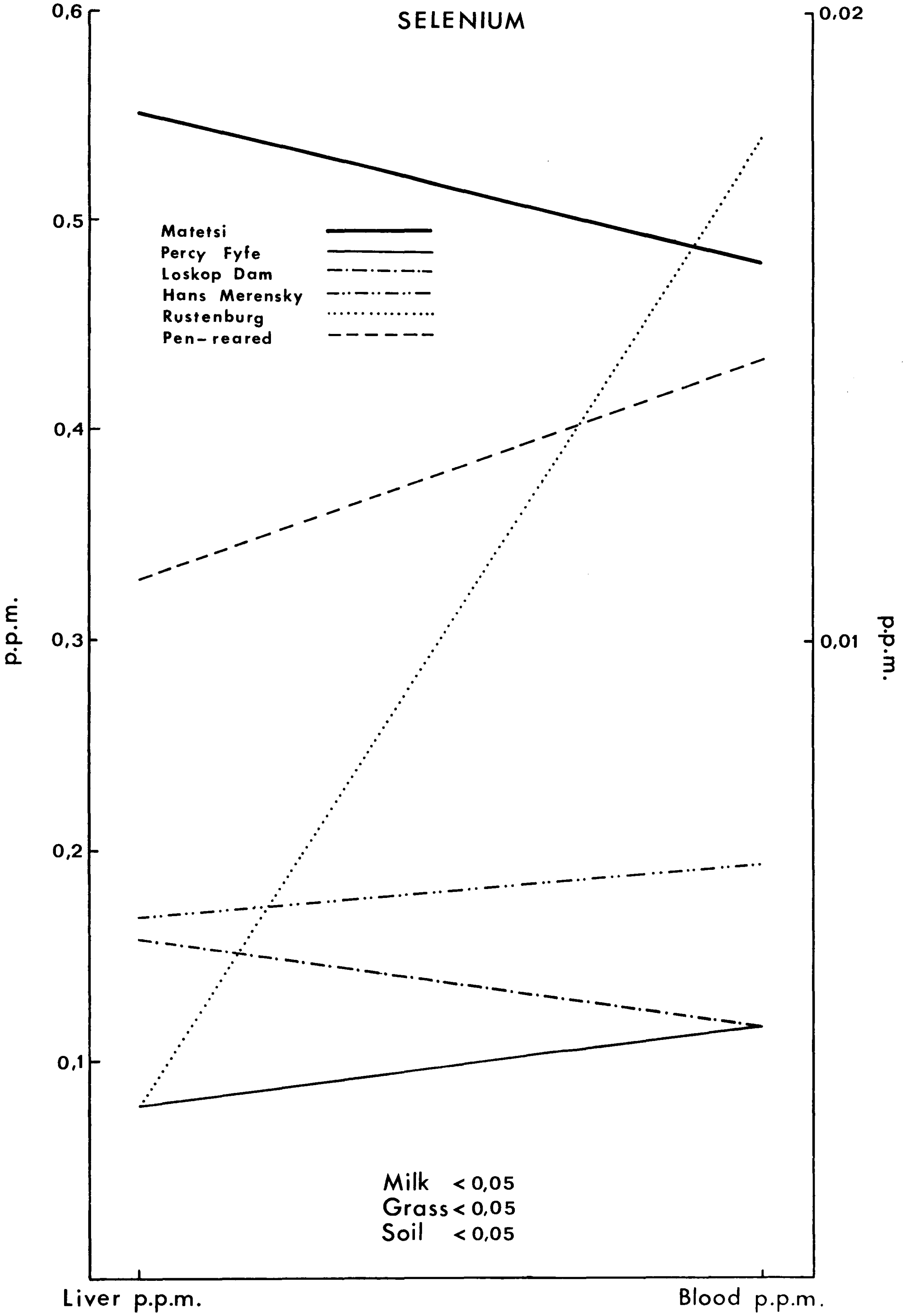

Fig. 26. Concentrations of selenium in liver and blood tissues of sable antelope, Transvaal and Rhodesian study areas; dry season 1974. Concentrations in milk, grass and soil were too low for detection by atomic absorption.

This is somewhat contrary to the findings for phosphorus (Fig. 16), where higher soil and vegetation levels head to substantially higher blood phosphate levels, but milk content seems to remain at a constant level regardless of dietary uptake. Of particular interest here is the fact that although supplementary pen-fed animals have a much higher phosphorus intake than those on free range, their blood phosphate levels are not substantially higher than Rhodesian sable (but much higher than other Transvaal sable), and liver phosphorus is slightly lower than most. Bone deposits were not studied in this case, and it is likely that phosphate levels in bone would be substantially higher in supplementary fed sable.

Magnesium shows more similarities to phosphorus in its passage from soil to grass through the animal. Availability in the forage differs very substantially, but blood and milk magnesium levels are strikingly constant (Fig. 17). The implications of the milk analyses are that phosphorous and magnesium are supplied from the lactating female at constant levels regardless of their own intake. Whereas Rhodesian sable are able to meet these demands from their diet, lactating sable on sourveld areas such as Loskop Dam and Percy Fyfe are probably in a state of pronounced phosphate and magnesium negative balance during the demands of lactation.

As essential blood i ons, sodium and potassium show interesting differences in their passage from vegetation to animal. Both differ markedly in their soil concentrations, sodium naturally being more abundant in the sodic soils of Hans Merensky Nature Reserve, and potassium much higher on the weathered granite of Percy Fyfe (Figures 18 and 19). Grass levels of these two elements are similarly varied, and in the case of sodium, the pattern is maintained in the blood, and even liver. However, Rhodesian sable calves are able to take in nearly twice as much sodium via the milk than are Percy Fyfe calves, suggesting a much higher absorption of sodium by the lactating cow during the suckling period. Potassium levels on the other hand show wide variation in concentrations in all tissues.

Changes in nitrogen concentration (Fig. 20) reflect protein levels in the case of grass and milk, but due to the presence of non-protein nitrogenous compounds in blood and liver, they cannot show protein concentrations in the latter tissues. The outstanding difference that shows up is the very high protein content of milk from Rhodesian sable (9,63 and 10,13 percent in two animals sampled) compared to that of Percy Fyfe sable (3,31 to 5,31 percent). Protein levels in available grasses do not appear to differ much, in fact sable on the burned area of Loskop Dam were ingesting slightly higher crude protein levels (4,7 to 5,8 percent) than in Rhodesia (2,6 to 4,9 percent), Hans Merensky (3,3 to 6,0 percent), or any other reserve. The low survival rate of calves on most other Transvaal reserves, with the exception of Hans Merensky, would suggest that milk nutrients and especially protein, are as low as those in Percy Fyfe sable. The poor protein output by the Percy Fyfe sable females in their milk would then appear to be a result of prolonged undernutrition and possible deficient intake of energy (cf. Maynard and Loosli 1969).

Trace element levels within forage are affected by concentrations in soil, and the latter appear to be reflected again in blood and liver levels. This means that higher levels of any trace element in the soil are carried through to the animal. It was not possible to complete the picture in milk in every case, since milk samples were only available from two areas. The only element which did not fit this pattern was zinc (Fig. 23), where higher soil and grass levels are not necessarily reflected in higher blood or liver levels, in fact, an inverse relationship appears to be true in most areas.

An important consideration is the mineral nutrition of the young calf via the milk, and whether milk content of macro-elements and trace elements is influenced by the dietary intake of the pregnant or lactating sable or roan cow. The general findings in domestic animals (Maynard and Loosli 1969) are that protein, calcium, phosphorus and iron levels in milk are not influenced by diet during lactation, but the values for certain trace elements may well be. The findings for Rhodesian and Percy Fyfe lactating sable confirm this for phosphorus and magnesium, which have very different concentrations in the forage grasses, but which are approximately constant in the milk. Calcium and iron certainly do not follow the pattern, however, and the concentrations of these elements in milk from Rhodesian animals and the available forage are very much higher than in the case of Percy Fyfe sable. This appears to be true for virtually all trace elements as well (Figs. 21 to 26).

A point of special interest here is that liver values of these elements in Rhodesian animals are frequently lower than those for Percy Fyfe or other Transvaal sable. Dietary intake of trace elements would thus appear to be strongly influential in determining milk content of these elements. The findings that milk differs so markedly in protein, probably because of general physical condition, may also be applicable here; i.e. that Rhodesian sable are capable of producing milk with a much higher protein and trace nutrient content because of overall better condition and nutrient intake. This is shown by the strong correlations between body condition (as indicated by total plasma protein content of the blood) and the milk content of elements such as calcium, nitrogen, iron and manganese (Table 34).

The question of whether intake of these various nutrients is indeed related to body condition was evaluated by computing correlation coefficients (Spearman rank, see Siegel 1956) between indices of body condition and the levels of each element in the soil and grass of each study area, and the mean blood and liver content of these elements of sampled sable from these areas (Tables 35-37). Four body condition indices were used in each case to compare bodily nutrient content: KFI, which is a standard for dead animals, and TPP, haematocrit values (packed erythrocyte volume), and plasma albumin and globulin content. The latter blood parameters have already been shown to be good indicators of body condition in live animals. All these indices are highly correlated with each other (Table 17).

TABLE 34.- CORRELATION COEFFICIENTS (DETERMINED BY SPEARMAN RANK METHOD) BETWEEN TPP (= BODY CONDITION INDICATOR) AND LEVELS OF ELEMENTS IN MILK OF SABLE ANTELOPE. COEFFICIENTS DETERMINED FROM RHODESIAN (n = 2) AND PERCY FYFE (n = 4) LACTATING SABLE

Element	Coefficient (r_s)	Significance
Calcium	0,829	$p < 0,05$
Phosphorus	0,129	NS
Magnesium	-0,028	NS
Sodium	0,200	NS
Potassium	-0,028	NS
Nitrogen	0,829	$p < 0,05$
Iron	0,886	$p < 0,05$
Copper	0,543	NS
Zinc	-0,200	NS
Cobalt	0,372	NS
Manganese	0,943	$p < 0,01$
Selenium	Not determined	

TABLE 35.-CORRELATION COEFFICIENTS (SPEARMAN RANK METHOD) BETWEEN SABLE BODY CONDITION INDICES (KFI, TPP, HAEMATOCRIT, BLOOD ALBUMIN, BLOOD GLOBULIN) AND BLOOD AND LIVER LEVELS OF MACRO- AND MICRO-ELEMENTS. SAMPLES BASED ON 15 SABLE SHOT IN DRY SEASON, 1974, TRANSVAAL AND RHODESIAN STUDY AREAS

		KFI	TPP	Haemat-ocrit	Blood Alb. %	Blood Glob. %	Liver Elements Ca	P	Mg	Na	K	N	Fe	Cu	Zn	Mn	Mo	Se
	TPP	,739**																
	Haemat-ocrit	,753**	,726**															
	Blood Albumin	,631**	,474*	,424*														
	Blood Globulin	,453*	,837**	,520*	-,056													
Liver Elements	Ca	,457*	,092	,188	,146	-,026												
	P	-,375	-,427	-,415	,108	-,507*	-,446*											
	Mg	,260	,364	,331	-,230	,518*	,361	-,849**										
	Na	,04o	-,233	0,230	-,236	-,201	,225	,307	-,097									
	K	,054	-,214	-,426	,168	-,385	,088	,289	-,419	,371								
	N	,428	,155	,048	,070	,121	,508*	-,570*	,503*	,171	,313							
	Fe	,188	,100	,338	,450*	-,157	,324	-,279	,196	-,174	,280	,096						
	Cu	-,005	-,324	-,029	,362	-,581*	,065	,004	-,127	-,076	,202	,132	,714**					
	Zn	,016	-,251	-,187	-,261	-,130	,360	-,468*	,453*	,026	,272	,743**	-,038	,171				
	Mn	,154	,262	,245	,075	,335	-,321	,246	-,149	-,061	-,021	-,040	-,460*	-,492*	-,396			
	Mo	,294	,224	,285	-,068	,296	,049	,062	,019	,072	,140	-,012	-,455*	-,379	,068	,437*		
	Se	,688**	,638**	,742**	,238	,521*	,246	-,321	,246	-,034	-,206	,032	-,103	-,348	-,155	,320	,698**	
Blood Elements	Ca	--	--	--	--	--	,430											
	P	--	--	--	--	--	--	-,460*										
	Mg	--	--	--	--	--	--	--	,176									
	Na	--	--	--	--	--	--	--	--	,052								
	K	--	--	--	--	--	--	--	--	--	,098							
	N	--	--	--	--	--	--	--	--	--	--	-,086						
	Fe	--	--	--	--	--	--	--	--	--	--	--	,484*					
	Cu	--	--	--	--	--	--	--	--	--	--	--	--	-,140				
	Zn	--	--	--	--	--	--	--	--	--	--	--	--	--	-,480*			
	Mn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	,241		
	Se	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	,256

TABLE 35.-(Continued)

	KFI	TPP	Haemato-crit	Blood Alb. %	Blood Glob. %	Blood Elements Ca	P	Mg	Na	K	N	Fe	Cu	Zn	Mn	Se
Ca	,315	,079	,180	,509*	-,157											
P	,751**	,735**	,751**	,564*	,529*	,145										
Mg	,333	,439	,466*	,014	,418	,104	,226									
Na	,552*	,455*	,351	,656**	,160	,626**	,467*	,247								
K	,083	-,058	,054	-,028	-,067	-,036	-,270	,233	,201							
N	,286	,612*	,458*	,285	,531*	,220	,529*	,221	,370	,026						
Fe	,189	,034	,115	,375	-,176	,651**	-,029	-,065	,044	-,122	,063					
Cu	-,288	,009	-,241	,329	-,190	-,064	-,038	-,066	,191	,446*	,131	-,031				
Zn	,325	,302	,279	,452*	,118	,704	,146	,098	,698**	,242	,489*	,363	,085			
Mn	,057	,095	,246	,195	-,055	,429	-,116	,354	,442*	,215	,030	,017	-,092	,460*		
Se	,480*	,508*	,643*	,719*	,206	,280	,740**	,249	,622*	,011	,580*	,040	,229	,587*	,390	

* p<0,05.

** p<0,01.

TABLE 36.-CORRELATION COEFFICIENTS (SPEARMAN RANK METHOD) BETWEEN SABLE BODY CONDITION INDICES AND NUTRIENTS AVAILABLE IN FORAGE IN PREFERRED FEEDING AREAS; DRY SEASON, 1974, TRANSVAAL AND RHODESIAN STUDY AREAS

	KFI	Live Wt.	Haemat-ocrit	TPP	Ca	P	Mg	Na	K	N	Fe	Cu	Zn	Co
Live Weight	,943**													
Haemat-ocrit	,829*	,886*												
TPP	,886*	,829*	,943**											
Ca	,543	,486	,371	,429										
P	,943**	,943**	,771	,771	,714									
Mg	,714	,543	,657	,829*	,714	,657								
Na	,657	,600	,714	,771	,657	,600	,829*							
K	,829*	,771	,543	,600	,829*	,943**	,657	,456						
N	,429	,314	-,086	,029	,543	,543	,200	,143	,657					
Fe	,829*	,657	,543	,714	,143	,657	,543	,371	,543	,429				
Cu	,543	,714	,829*	,657	-,143	,486	,143	,314	,200	-,314	,371			
Zn	-,200	-,257	-,257	-,200	,600	,086	,257	-,029	,314	,200	-,429	-,600		
Co	-,257	-,057	,200	,000	-,314	,057	-,229	-,286	-,286	-,657	-,400	,457	,114	
Mn	-,429	-,371	-,486	-,543	-,543	-,257	-,675	-,943**	-,257	-,029	-,200	-,143	,086	,457

* p < 0,05.

** p < 0,01.

TABLE 37.-CORRELATION COEFFICIENTS (SPEARMAN RANK METHOD) BETWEEN SABLE BODY CONDITION INDICES AND NUTRIENTS AVAILABLE IN SOIL IN PREFERRED FEEDING AREAS, DRY SEASON, 1974; TRANSVAAL AND RHODESIAN STUDY AREAS

	KFI	Live Wt.	Haemat-ocrit	TPP	Ca	P	Mg	Na	K	N	Fe	Cu	An	Co
Live Weight	,900*													
Haemat-ocrit	,800	,900*												
TPP	,900*	,800	,900*											
Ca	,600	,300	,400	,700										
P	,700	,700	,900*	,900*	,700									
Mg	,175	,075	,075	,175	,675	,425								
Na	,500	,100	,200	,600	,900*	,500	,375							
K	-,500	-,800	-,600	-,300	,300	-,100	,225	,500						
N	-,625	-,775	-,675	-,525	,175	-,175	,550	,175	,825					
Fe	,225	,475	,625	,375	,225	,725	,525	-,488	-,375	-,050				
Cu	,200	,100	,000	-,550	,600	,300	,975*	,300	,100	,475	,425			
Zn	,175	,175	,075	,075	,475	,325	,950*	,125	-,025	,425	,575	,975*		
Co	,200	,500	,200	-,100	-,600	-,100	-,325	-,700	-,900	-,625	,125	-,200	-,025	
Mg	-,400	-,300	-,100	-,200	,200	,300	,725	-,100	,300	,675	,675	,600	,675	,400

*p<0,05.

Phosphorus, calcium, selenium and sodium show up as very significantly correlated to body condition. Blood values for phosphates are useful in this regard, since liver phosphates have no real significance as nutritional indicators and the correlation between liver calcium content and body condition is also questionable in nutritional terms. Blood phosphorus is a standard parameter for estimation of deficiencies of this essential element (Maynard and Loosli 1969). Daily requirements of phosphorus for wild ungulates are not known, but from the data on phosphorus content of available forage in the respective areas (Tables 24-29) it can be calculated that adult sable in the Matetsi area ingest about 9 g phosphorus daily in the diet, whereas those on Loskop Dam, Percy Fyfe and Rustenburg get no more than 2-3 g daily. Maynard and Loosli (1969) indicate that adult cattle require some 10 g daily.

Selenium correlations with body condition are interesting, since a deficiency in selenium has been cited as a possible cause of muscular dystrophy in wild ungulates (Herbert and Cowan 1971, Harthoorn 1973). Deficiencies in selenium cause many symptons in domestic animals, and unthriftiness in sheep and cattle have been reported (Underwood 1971). The precise levels of selenium in forage plants available to sable on Transvaal reserves could not be accurately assessed by conventional or modified analyses, but it is obviously very low and probably deficient. The dietary requirements of selenium for wild ungulates and indeed for domestic livestock in southern Africa have yet to be established.

The correlations matrices point out some relationships which are already known for domestic animal nutrition, viz. that there are positive relationships between iron and copper (r_s value for liver = 0,714: $p < 0,01$), and negative relationships between phosphorus and zinc ($r_s = -0,468$; $p < 0,05$) and between iron and copper on one hand, and manganese and molybdenum on the other. It appears unlikely, in view of the relative amounts of each of these elements present in forage, that one has a depressive influence on the other.

Correlation coefficients between body condition indices and nutrients available in forage and soils (Tables 36 and 37) give further insight into the nutritional status of sable antelope in the critical dry season. Although phosphorus in grass has a very high correlation with the KFI and the live weights of the animals living off those grasses, it is not correlated to TPP or packed cell volume. Iron and potassium show similar correlations with KFI, but not with TPP. Soil phosphorus levels do, however, correlate significantly with TPP, but not with KFI. This points out the necessity of using several applicable body condition indicators when assessing the nutritive status of many elements of different concentrations and biochemical action in the body.

Nutritional Status and Calf Survival

Although it is evident that sable (and probably roan) on reserves such as Loskop Dam and Percy Fyfe suffer severe nutritional deficiencies, the relationship of these deficiencies to actual mortalities is thus far only circumstantial. The evidence for higher calf mortalities due to disease incidence being high because of poor nutritional status is nevertheless good. Since antibodies are produced from serum globulin protein, undernutrition that results in hypoproteinaemia is linked with the occurrence of infectious diseases. This link has been definitely established, resulting in the conclusion that adequate nutrition is critical from the standpoint of resistance to infection (Maynard and Loosli 1969).

The milk available to sable calves in the Matetsi area is infinitely superior in protein, iron, copper, cobalt and manganese, and possibly in other trace elements as well, than that available to calves on a typical Transvaal reserve such as Percy Fyfe.

The possibility of averting high mortalities amongst juveniles by somehow supplementing the diet either of the lactating or heavily pregnant cows, or of the calves themselves, which commence feeding on forage at about 2 weeks of age, is one of great importance. Several alternative approaches are available, which are discussed in a later section. One approach, which was used here to prove the direct relationship of nutritional status to disease influence and mortality, is to provide balanced supplementary foods to the pregnant and lactating females in the form of concentrates.

Five heavily pregnant sable cows placed in a 0,27 ha feeding enclosure on Percy Fyfe Nature Reserve in November 1974, were supplied with balanced concentrates and lucerne hay ad lib. Nutrient content of the concentrates (antelope cubes) and lucerne hay are given in Table 30, and were more than sufficient to meet all nutritive needs of the pregnant and, later, lactating cows. The same rations had been fed to pen-reared males and resulted in superlative body condition (Tables 19 and 20). The presence of two pen-reared young sable males in the same enclosure ensured that the females rapidly became accustomed to the supplementary rations.

The control group consisted of three pregnant sable cows ranging free in the main sable camp outside the feeding enclosure. They were in no way supplemented with food and were permitted to feed naturally and rear their calves on naturally occurring range forage. One cow in the experimental feeding enclosure was killed by one of the aggressive pen-reared males before she calved, which reduced the experimental number to four.

Table 38 and Figures 27 to 29 reflect the results of the experiment. The total number of sable cows on Percy Fyfe during 1974 was small, and sample sizes within the feeding enclosure and outside in the control herd were thus very small. All the experimental females which were fed supplement rations had calves, of which one died of a navel infection (post-mortem results by G.D. Imes[1], personal cummunication). No signs of cytauxzoonosis or babesiosis could be found in this calf, and its death could not be ascribed to any specific condition relating to nutrition. It had considerable body fat deposits discernible at

1 G.D. Imes, Onderstepoor Veterinary Research Institute, Pretoria, South Africa.

TABLE 38. - RESULTS OF SUPPLEMENTARY FEEDING OF PREGNANT AND LACTATING SABLE COWS ON CALF SURVIVAL, PERCY FYFE NATURE RESERVE; NOVEMBER 1974 to JUNE, 1975

	Free-ranging Females in Herd	Females in Enclosure, Fed Concentrates and Lucerne Hay
Number available	3	4
Calves produced	2	4
Calves dying	1	1
Mortality rate	50%	25%
Death from Cytauxzoonosis	?	0

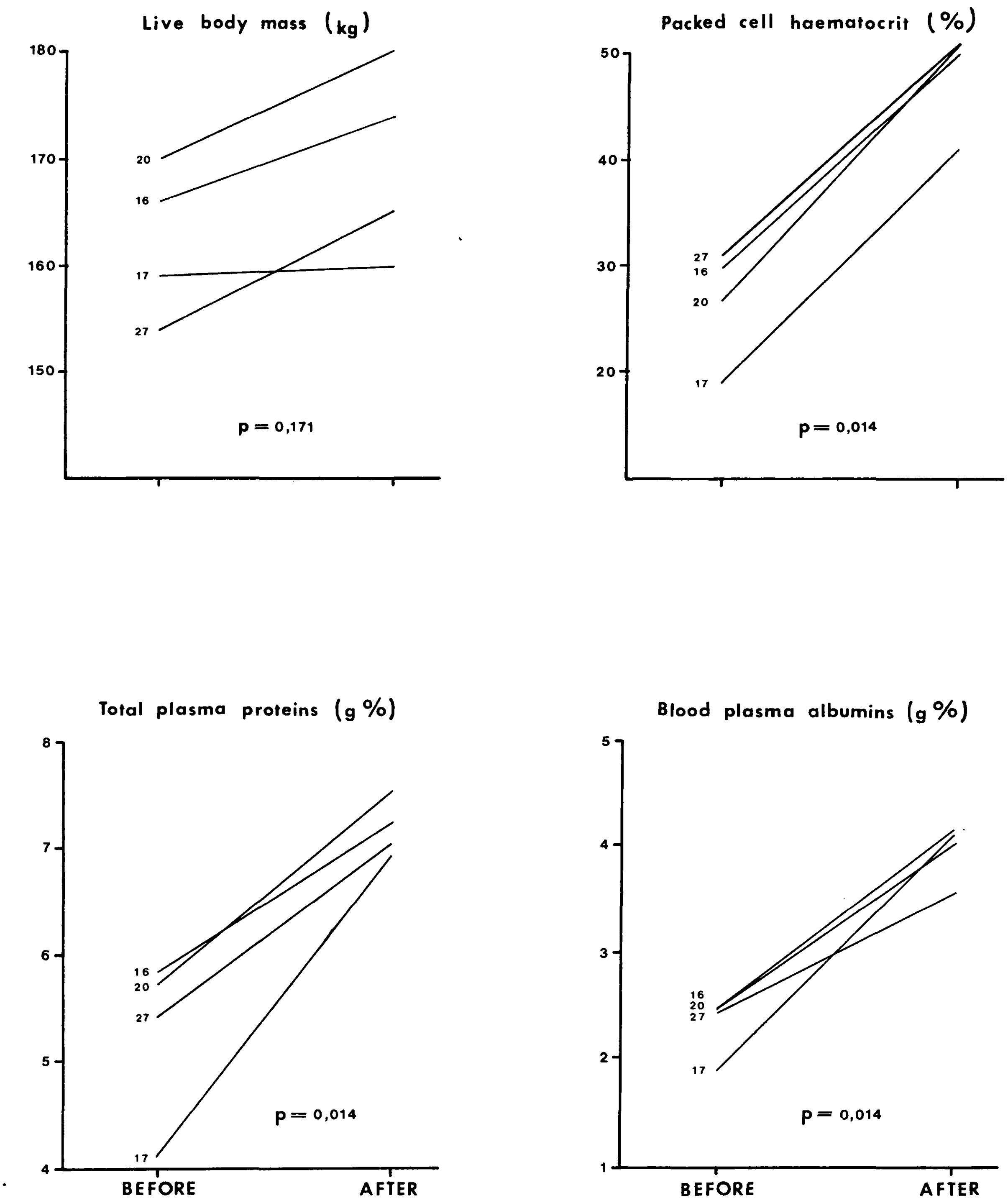

Fig. 27. Changes in body condition indicators of four lactating sable antelope after being placed on a diet of concentrates (antelope cubes) and lucerne hay for 7 months in a 0,27 ha enclosure on Percy Fyfe Nature Reserve, 1974/75. The females were placed in the enclosure 3 months prior to parturition and were fed for 4 months after parturition. Numbers next to graph identify animal.

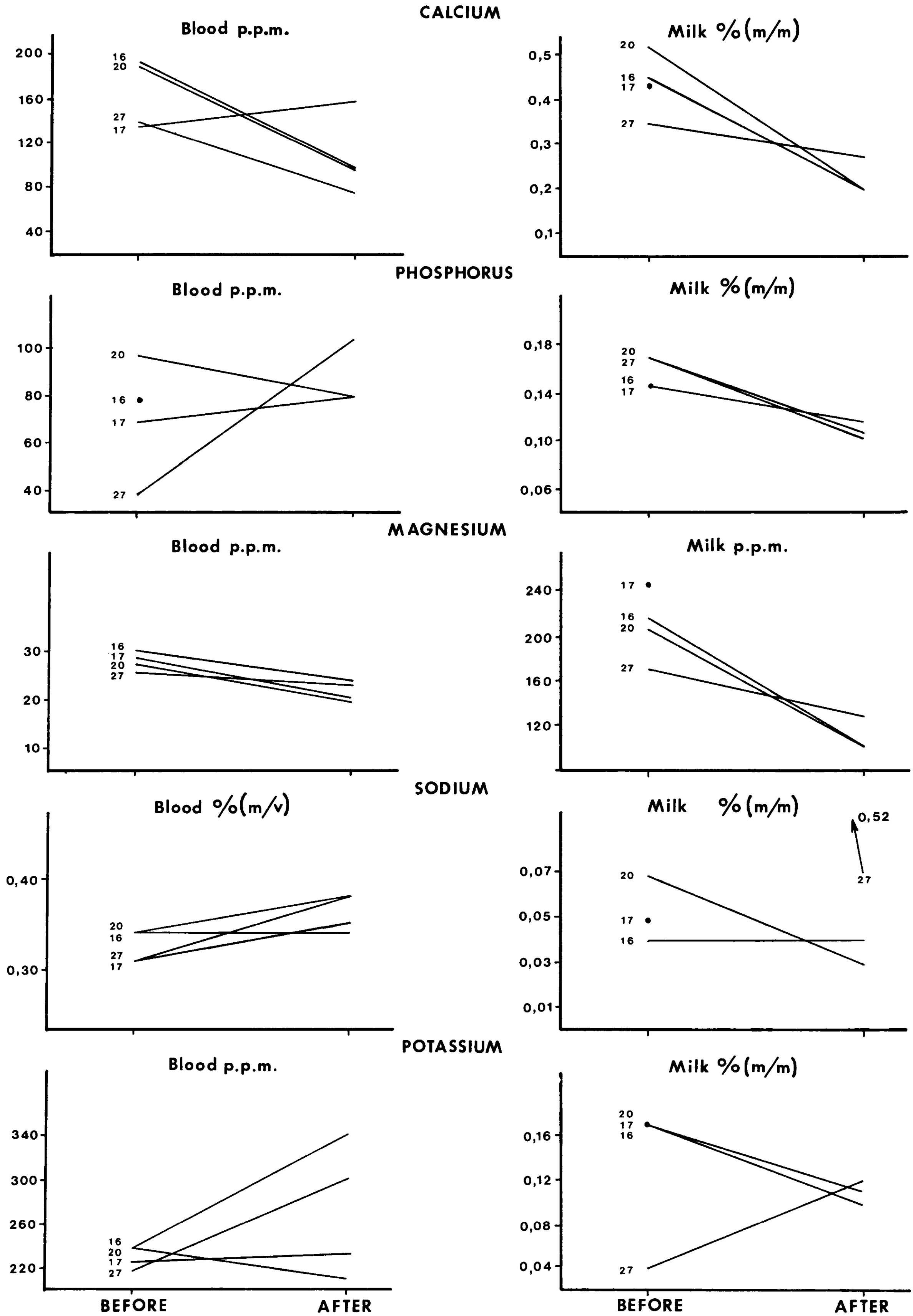

Fig. 28. Changes in blood and milk mineral constituents of four lactating sable antelope after being fed concentrates (antelope cubes) and lucerne hay for 7 months in a 0,27 ha enclosure on Percy Fyfe Nature Reserve, 1974/75. In some cases insufficient sample was available for the "after" determination. Numbers next to graph identify animal.

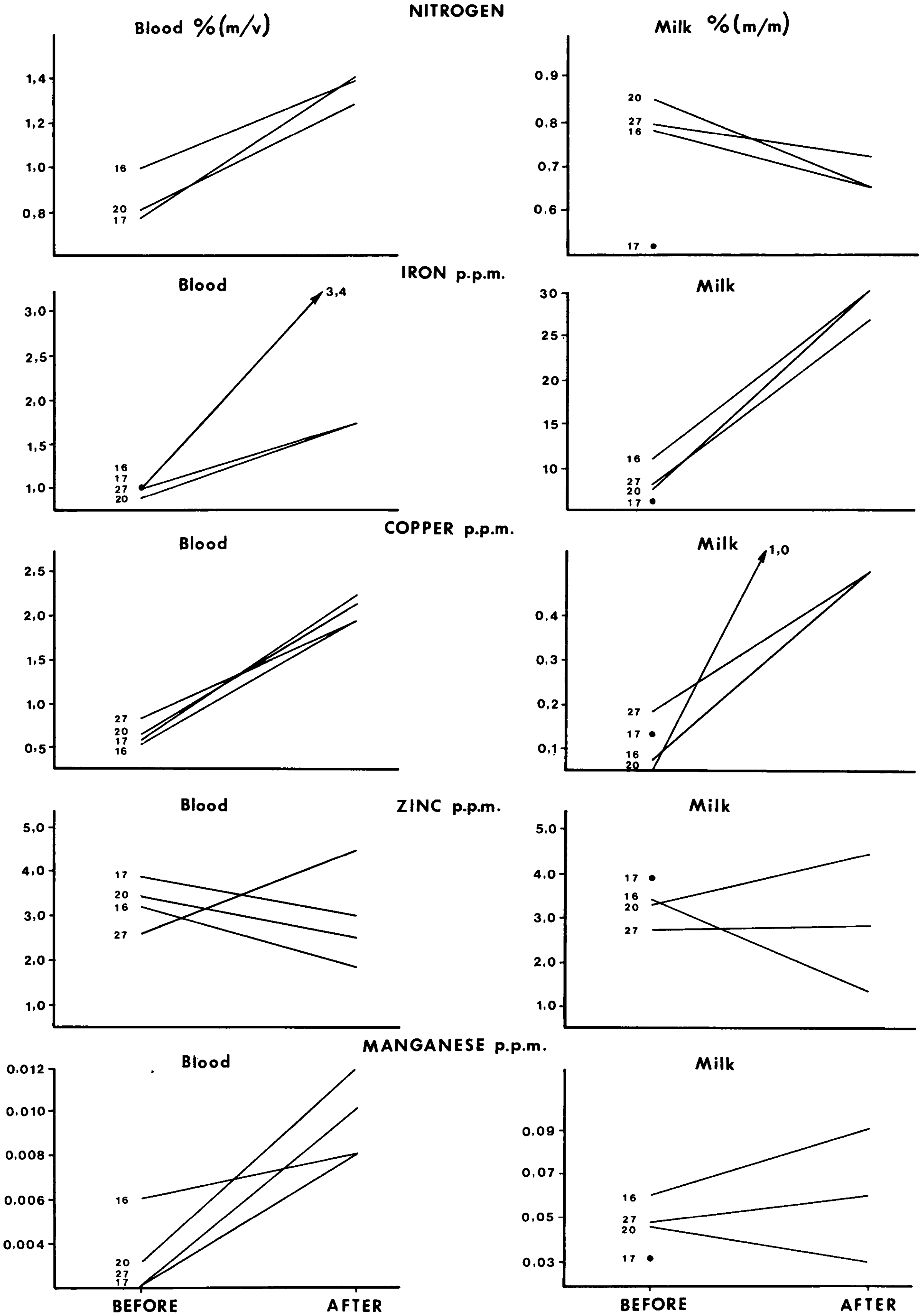

Fig. 29. Changes in blood and milk mineral constituents of four lactating sable antelope after being fed concentrates (antelope cubes) and lucerne hay for 7 months in a 0,27 ha enclosure on Percy Fyfe Nature Reserve, 1974/75. In some cases insufficient sample was available for the "after" determination. Numbers next to graph identify animal.

necropsy and the condition, considering its infection with Corynebacterium pyogenes, was good. Of the animals in the field, two calved and one calf subsequently disappeared and was not relocated for examination. The third cow failed to calve. This may have been failure to conceive (although calving rate throughout the study period had been 100 percent), or she may have either aborted or resorped a foetus.

The probability of the above data distribution is 0,33 (Fisher's exact probability test, Siegel 1956).) If it can be assumed that the third cow in the field lost a calf or foetus, then the probability is reduced to 0,14. The very small sample sizes here were detrimental to a conclusive result, since even if all three cows in the field had lost calves, and all four in the enclosure had reared theirs, the probability would have been barely significant (p = 0,03).

Results of blood and milk analyses, however, confirm the beneficial effects of supplementary feeding on the females and the calves. Live weights were increased by an average of 7½ kg per animal over the 7-month period, which is nearly statistically significant (p = 0,171); Mann-Whitney test, Siegel 1956). Haematocrit values were very significantly increased from a mean of some 27 percent to 48 percent (p = 0,014). Total plasma proteins and plasma albumin content also increased very significantly (p = 0,014), and plasma globulins showed a rise but not a significant one (p = 0,243). Of the trace elements, both copper and iron showed dramatic increases in both milk and blood; milk copper content rising by a factor of seven. Milk magnesium content actually dropped markedly over the 7-month period. Contrary to the normally accepted pattern in domestic animals (Maynard and Loosli 1969), dietary intake of iron and copper by sable antelope during lactation very strongly influences milk levels of these animals. This fact becomes of cardinal importance in the case of neonatal calves suffering from nutritional anaemia resulting from iron or copper dificiency; a condition which could easily reduce premunity and precipitate a clinical Cytauxzoon or Babesia infection resulting in mortality. Significantly, milk phosphorus levels are not affected.

HABITAT UTILIZATION

Although sable and roan antelope numbers were definitely reduced by illegal or ill-considered shooting during the latter half of the last century and during the first decades of the present century, subsequent reduction in numbers was more influenced by ecological factors. It has already been shown in this study that nutrition and concomitant disease are the main factors involved in population reduction on the highland nature reserves such as Percy Fyfe, Loskop Dam and Rustenburg. The overall quality of nutrition is, however, much better in the Lowveld reserve of Hans Merensky, where limitation appears to be mainly due to population crashes brought about by periodic and severe droughts.

Whatever the limiting factors on Transvaal reserves are, they all relate back to habitat quality, habitat availability and habitat utilization by roan and sable antelope. Nutritional deficiencies, whether specific and persistent as in the case of certain minerals, or general and drastic as in large-scale droughts, can be avoided to some extent by animals through habitat and food-plant specificity. They could also be amplified by animal use of habitats or food-plants notably deficient in essential nutrients. If such factors are to be avoided, then management procedures must aim to modify or to supplement missing habitat factors.

Habitat is a complex of vegetation, soil and topographic factors, and the present study aimed mainly at assessing the critical dry-season habitat available to sable and roan on the various nature reserves, measuring the degree of use of the available habitat, and determining the relationship between such use and the already discernible nutritional deficiencies.

Home Range and Activity Areas

Monthly plotting of distribution and activities of each herd on each reserve served as a basis for measurement of actual home range utilization by roan and sable antelope. As indicated earlier, this could not be undertaken for Hans Merensky or Matetsi areas; however, some comparative data are available from these areas.

Two distinct types of areas utilized had to be dinstinguished. The "home range" was found to be that area over which the animals ranged in the course of their normal activities, principally feeding, drinking and shelter-seeking. This is the standard concept of a home range. However, within each home range, there was found to be a smaller area or areas which received more intensive use by the sable or roan over periods of several days at a time. These smaller areas, termed "activity areas" varied from one month to another and, although specific measurements of their characteristics were not measured, it appeared that they did not differ significantly in vegetation composition or in structure. A sable or roan herd could change its activitiy area within a space of a few hours, and activity areas noted during each monthly survey sometimes corresponded or overlapped, but more often than not they were completely separate.

Figures 30 to 33 indicate the home ranges measured monthly for each of the three highland reserves: Loskop Dam, Rustenburg and Percy Fyfe during 1974. There was considerable overlap of monthly home ranges on each of the three reserves, and home range sizes differed markedly from month to month (Table 39).

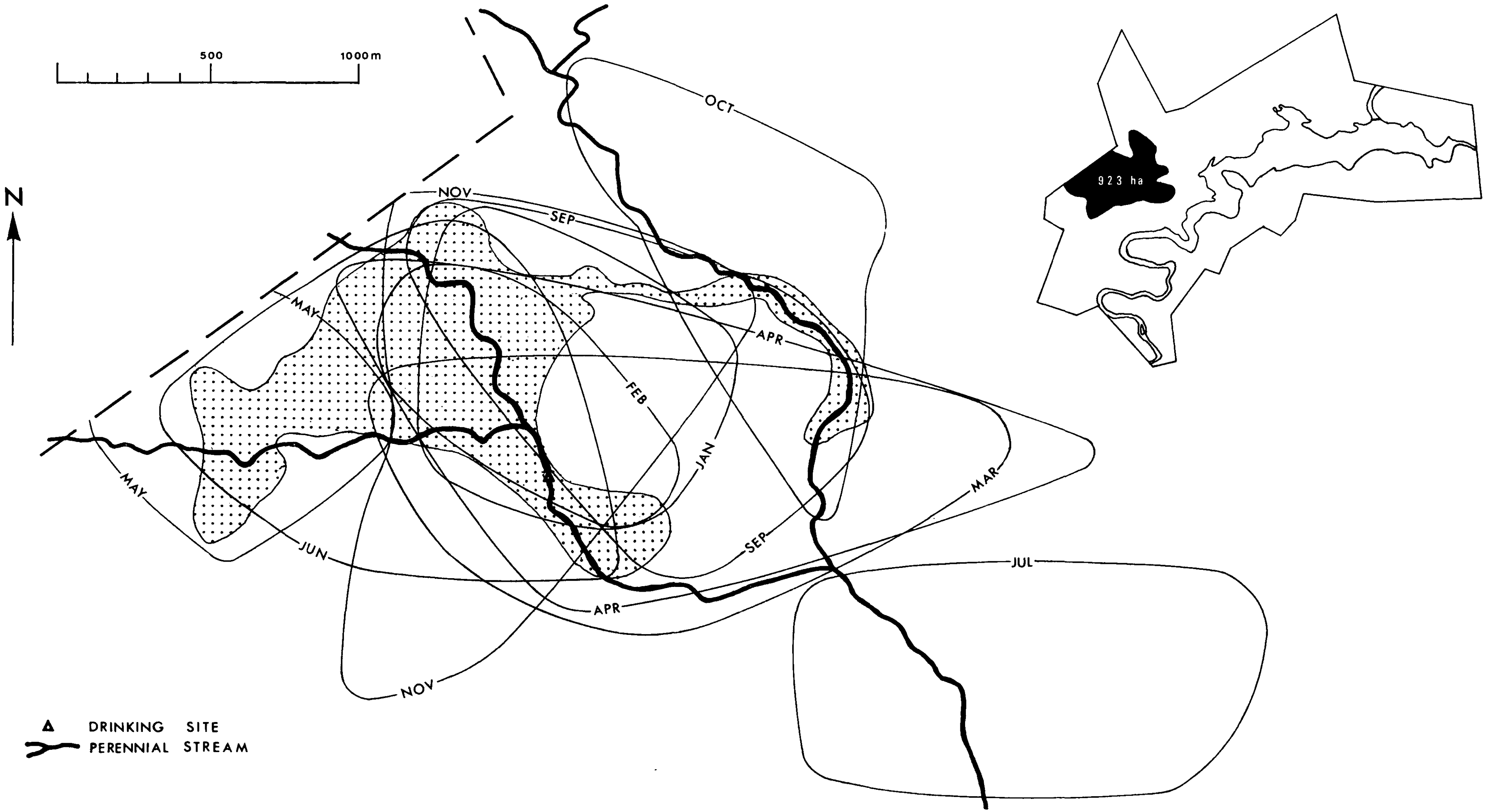

Fig. 30. Monthly home ranges of sable antelope herd on Loskop Dam Nature Reserve, 1974. Shaded section indicates area utilized for feeding during dry season. Note proximity of dry season feeding area to perennial streams. Inset shows relationship of total annual home range to total area available (12 754 ha).

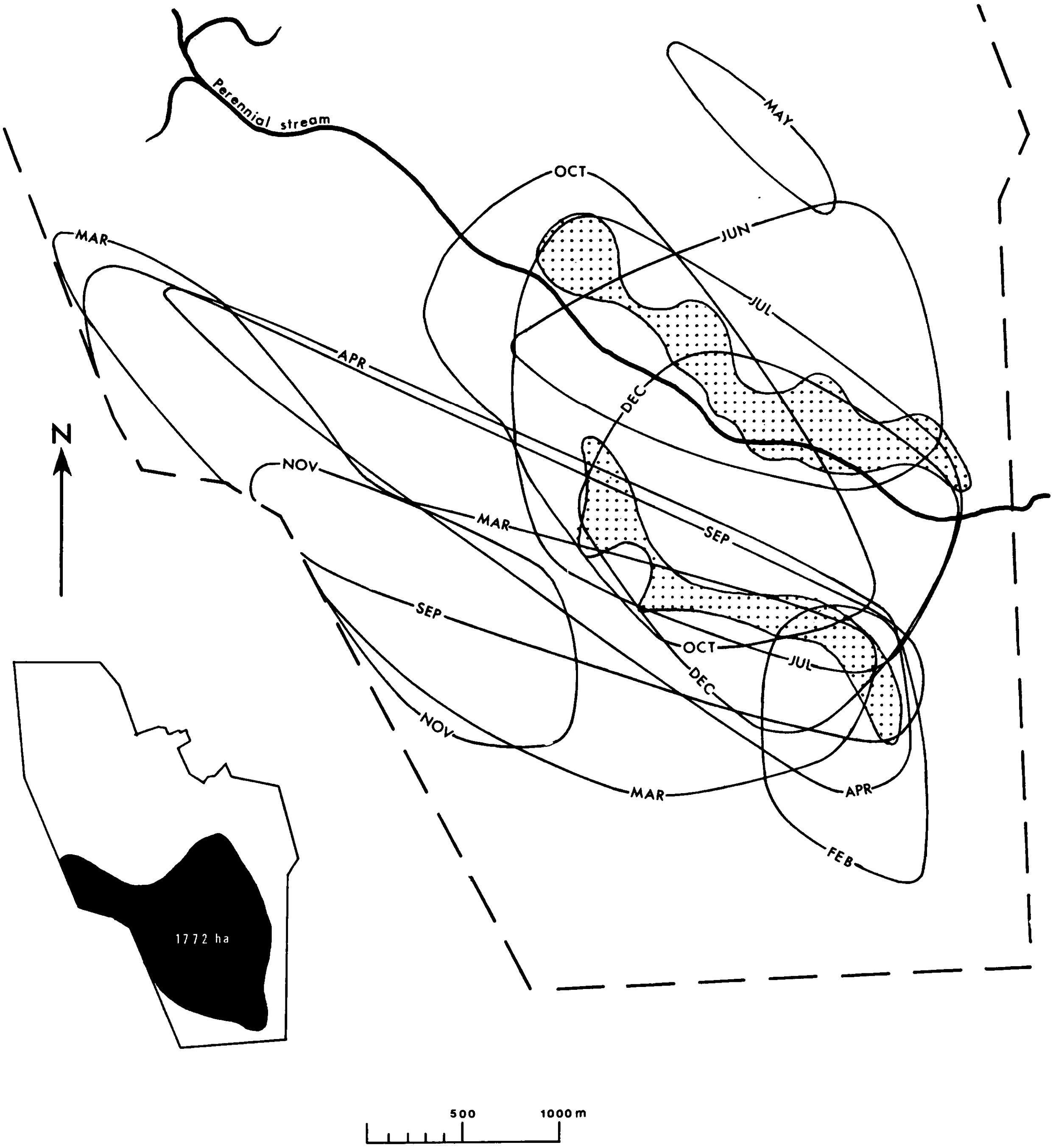

Fig. 31. Monthly home ranges of sable antelope herd on Rustenburg Nature Reserve, 1974. Shaded section indicates areas utilized for feeding during dry season. Vlei area ran parallel to stream. Note proximity of dry season feeding to vlei area. Inset shows relationship of total annual home range to total area available (2898 ha).

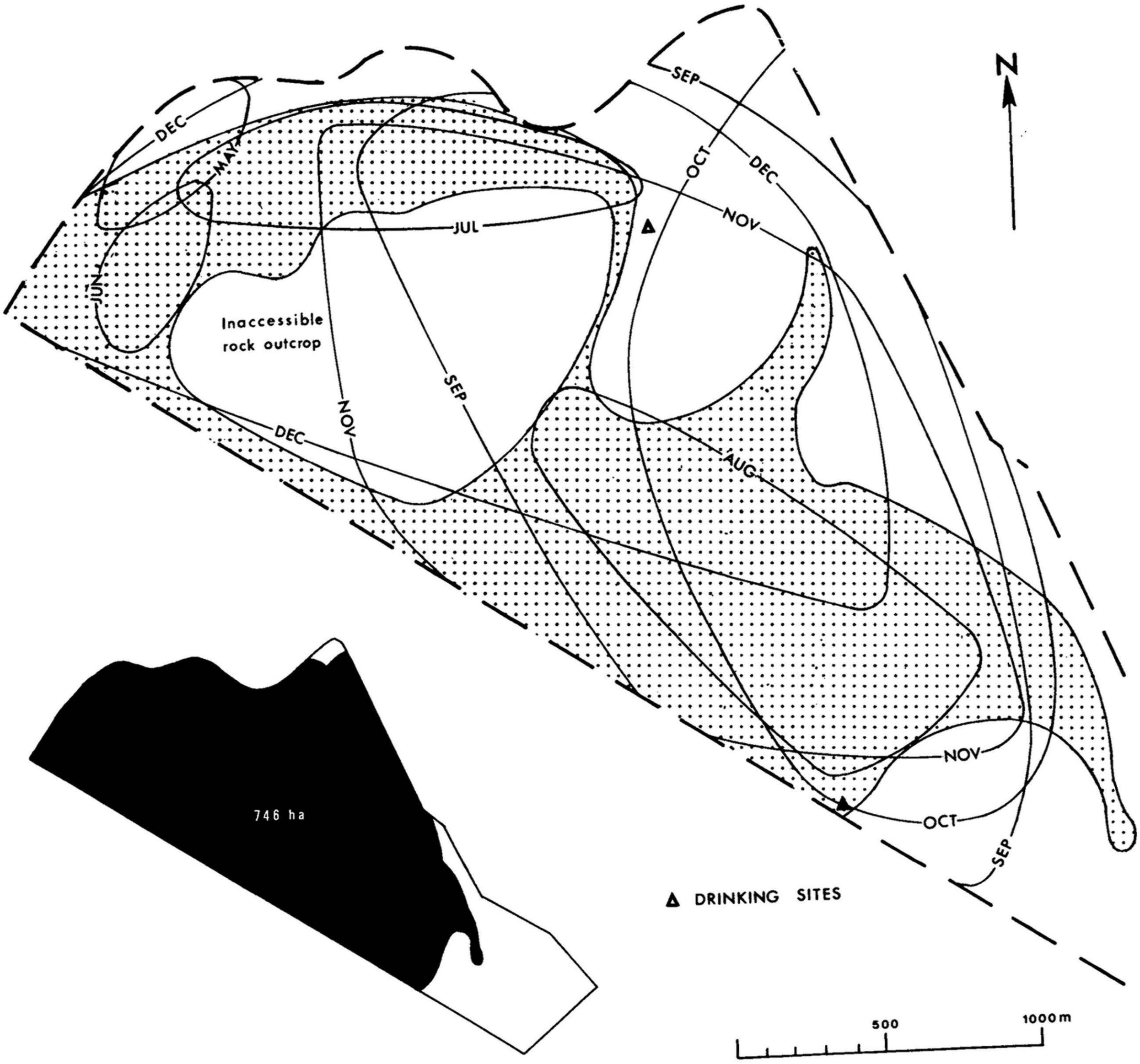

Fig. 32. Monthly home ranges of sable antelope herd on Percy Fyfe Nature Reserve, 1974. Shaded section indicates area utilized for feeding during dry season. Inset shows relationship of total annual home range to total area available (768 ha).

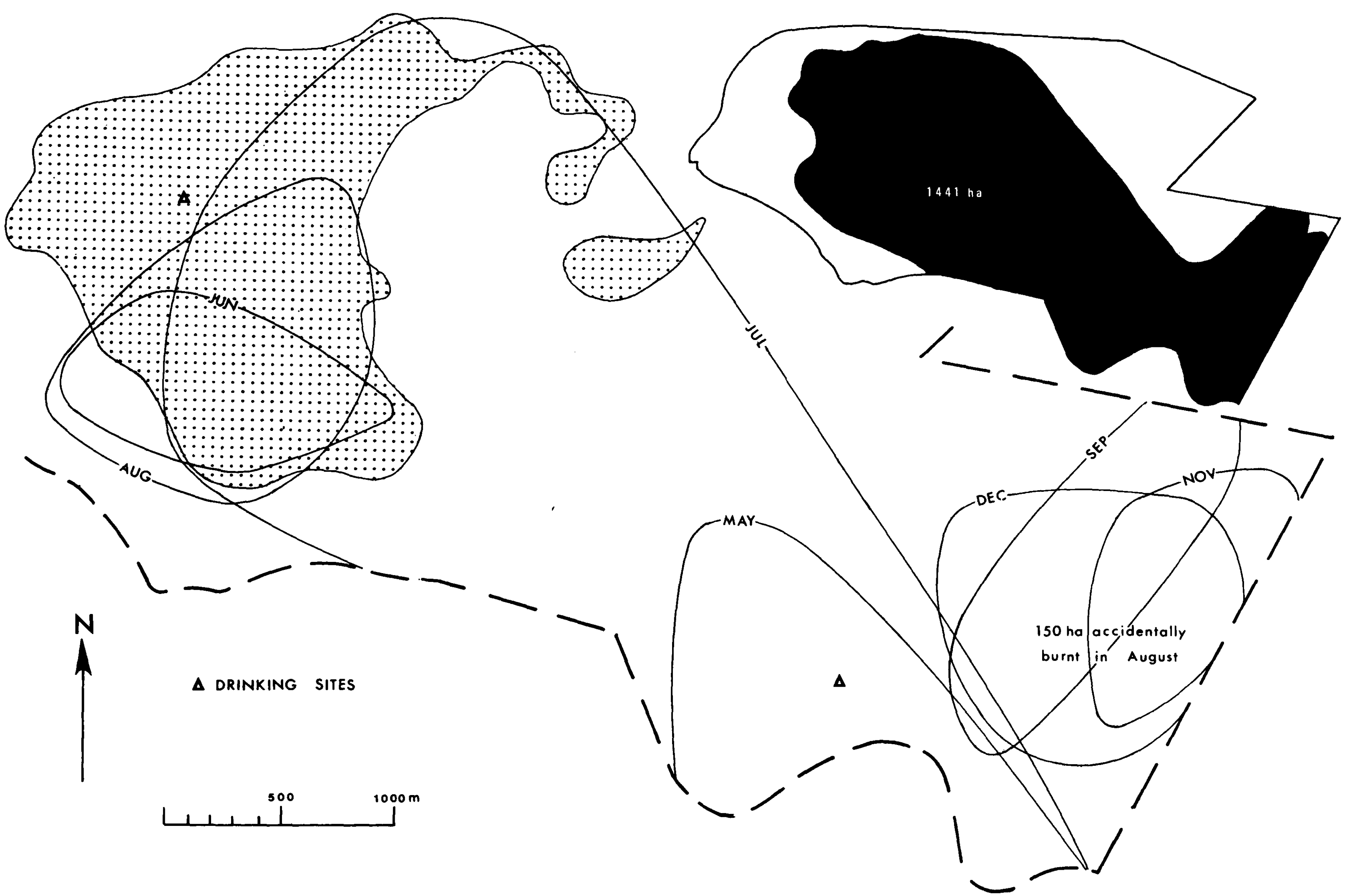

Fig. 33. Monthly home ranges of roan antelope herd on Percy Fyfe Nature Reserve, 1974. Shaded section indicates area utilized for feeding during dry season. Note 150 ha area which accidentally burnt in August and the subsequent use by roan herd. Inset shows relationship of total annual home range to total area available (2061 ha).

TABLE. 39.-MONTHLY HOME RANGE AND ACTIVITY AREA SIZES FOR SABLE AND ROAN ANTELOPE ON THREE TRANSVAAL NATURE RESERVES, 1974. MEASUREMENTS ARE GIVEN IN HA

Month	Sable Percy Fyfe N.R. Home Rng.	Sable Percy Fyfe N.R. Act. Area	Sable Loskop Dam N.R. Home Rng.	Sable Loskop Dam N.R. Act. Area	Sable Rustenburg N.R. Home Rng.	Sable Rustenburg N.R. Act. Area	Roan Percy Fyfe N.R. Home Rng.	Roan Percy Fyfe N.R. Act. Area
January	----	----	111	24	----	----	----	----
February	----	----	75	33	124	47	----	----
March	----	----	153	35	505	84	----	----
April	----	----	67	17	332	18	----	----
May	16	5	66	20	32	8	196	16
June	19	10	241	15	184	37	84	15
July	61	16	208	28	502	49	884	33
August	103	17	----	----	----	----	161	21
September	585	60	159	26	357	50	113	9
October	272	59	91	31	265	46	----	----
November	412	38	180	42	191	42	74	20
December	401	49	----	----	242	38	160	26
Mean	234	32	135	27	273	42	239	20
Mean herd size	26		47		24		43	

Most herds showed a tendency to increase their home ranges quite considerably during parts of the dry season, but no significant correlations could be found between home range sizes and the monthly rainfall, or the previous month's rainfall. Nevertheless there is a tendency for home range to be associated with factors such as grass growth and relative availability. Sable on Loskop Dam fluctuated less in their utilization of area, since they were remaining on an area which had been burned in January 1974, and where the protein content (see Table 31) was, to a certain extent, higher than in the surrounding areas. Mean home range size was thus less for Loskop Dam (135 ha) than for other areas.

Although monthly home range sizes are similar for the Transvaal (excluding Loskop Dam burned area) and Rhodesian areas (some 240 to 280 ha), the annual home range, i.e. the area covered by all the monthly home ranges, was very much larger in the Transvaal (Table 40). Within the sable enclosure on Percy Fyfe it encompassed all the area available, except for the inaccessible ridges and rock outcrops. Roan on Percy Fyfe made use of 70 percent of the area available to them, and Rustenburg sable over 60 percent. The estimated are use for Hans Merensky was some 30 percent, and information derived from Johnstone (1971) for Matetsi, and Grobler (1974) for Matopos indicate that sable in Rhodesia make use of only some 1 to 3 percent of the total area available, although they naturally have far larger ranges available to them.

Activity areas also differ in size (Table 39), but the variability is less than in the case of home ranges. Size of activity areas

TABLE 40.-AREA UTILIZATION BY SABLE AND ROAN ANTELOPE HERDS ON TRANSVAAL NATURE RESERVES AND RHODESIAN AREA (HA)

	Sable			Roan		
	Total Area Available	Annual Home Range Size	%	Total Area Available	Annual Home Range Size	%
Percy Fyfe N.R.	768	746	97,1	2061	1441	69,9
Loskop Dam N.R.	12 754	923	7,2			
Rustenburg N.R.	2 898	1772	61,1			
Hans Merensky N.R.[1]			30,0			
Matetsi, Rhodesia[2]	20 400	260 470	1,3 2,3			
Matopos N.P.,[3] Rhodesia	43 200	280	0,6			

[1] Estimated from data in Johnstone (1971), two known sable females.

[2] Estimated from observations and aerial censuses.

[3] From Grobler (1974).

apparently bears little relation to the size of the herd using the area, but is probably more related to degree of food availability, food palatability and distance to water. Grobler (1974) indicates activity areas of only 2 to 4 ha for sable in Matopos National Park, which are thus only 1/10 to 1/5 the size of those for sable in Transvaal reserves.

Habitat Charateristics

It would have been desirable to have measured quantitatively the habitat available to roan and sable on all the nature reserves, and to draw comparisons between them and the typical habitats utilized in Rhodesia and elsewhere. In practice this approach was modified by a number of factors. Considerations of time and manpower largely ruled out any year-round habitat evaluation on several areas. Review of the area utilization by roan and sable (Table 40) suggests that for the three highland nature reserves in the Transvaal the animals were using as much area as was available, within limits of topography and distance from water. In contrast, sable in Rhodesia and Hans Merensky Nature Reserve in the Lowveld savanna get by with substantially less area. In light of this, a detailed habitat evaluation was limited to the preferred feeding areas utilized during the dry season only, to characterize these habitats at the critical time of the year and to compare them to those utilized by sable and roan in seemingly better areas. Critical comparison was used to show up deficiencies in habitats. The presence of a modified (burned) and well-used habitat on Loskop Dam gave the opportunity to evaluate to some extent the effects of modification on habitat characteristics.

The factors assessed in each of the habitats all related to the density or bulk of the vegetation in some way. Hirst (1975) has shown that the more common species of ungulate in the Transvaal Lowveld are strongly influenced in their choice of habitat by the physical features of those habitats, including those factors such as grass height, woody plant density and grass cover, all of which relate to lateral density. In this study, these factors were assessed together as an integrated measure by an obscurity reading on a vertical board. Lateral visibility was also measured in each habitat, and differs from obscurity in that the latter is a measure of plant density at 10 different levels, whereas lateral visibility is affected by topography as well, and is an overall indication of the vegetation density and the extent to which animals can perceive their immediate surroundings. A measure of canopy cover gave an indication of available shade. Basal cover and grass frequency data provided information on the herbaceous stratum and the availability of food plants.

Results from the density board readings, (Table 41) show that vegetation density at the various levels all differ very significantly from reserve to reserve, and there is no general uniformity between any two areas. The comparisons are unfortunately affected by two biases: the preferred area on Loskop Dam was previously burned and so differed from its unburnt structure, and the area on Hans Merensky had been brushcleared as a habitat management measure, and the sable were utilizing the edge of clearings which had reduced tree densities. However, even these comparisons proved of value.

Table 42 shows that the density of the main vegetation components differed strongly from one preferred feeding area to another. If Matetsi can be assumed to be closest to the ideal, then no area on the Transvaal reserves approaches it in overall vegetation structure. The general physiognomy of the Matetsi savanna is an open savanna

TABLE 41.-VEGETATION LATERAL DENSITY AND DENSITY VARIATION IN TEN DIFFERENT STRATA ON SABLE AND ROAN ANTELOPE STUDY AREAS, AS MEASURED BY VEGETATION DENSITY BOARD. FIGURES IN PARENTHESES ARE VARIANCES

Area	Percent Obscurity at Each Level									
	Ground Level to 20 cm	21 to 40 cm	41 to 60 cm	61 to 80 cm	81 to 100 cm	101 to 120 cm	121 to 140 cm	141 to 160 cm	161 to 180 cm	181 to 200 cm
Percy Fyfe N.R. Sable	35,9 (7,67)	5,6 (1,76)	2,3 (0,75)	1,3 (0,43)	0,3 (0,10)	0,3 (0,10)	0,3 (0,10)	----	----	----
Percy Fyfe N.R. Roan	79,2 (5,49)	7,2 (2,23)	2,6 (0,84)	2,3 (0,75)	1,9 (0,62)	1,9 (0,62)	2,3 (0,75)	1,3 (0,43)	2,3 (0,75)	1,6 (0,52)
Loskop Dam[1] N.R.	2,8 (0,91)	1,1 (0,36)	0,4 (1,13)	0,4 (1,13)	0,4 (1,13)	0,4 (1,13)	0,4 (1,13)	----	0,4 (1,13)	0,7 (0,23)
Rustenburg N.R.	95,4 (1,46)	52,3 (8,31)	24,0 (6,08)	19,7 (5,27)	20,7 (5,47	----	----	----	----	----
Hans Merensky N.R.	95,7 (1,37)	37,8 (7,84)	6,3 (1,97)	----	----	----	----	----	----	----
Matetsi, Rhodesia	79,9 (5,35)	30,3 (7,04)	19,1 (5,15)	13,5 (3,89)	9,9 (2,97)	5,9 (1,85)	5,9 (1,85)	4,9 (1,55)	2,3 (0,75)	2,3 (0,75)

[1] Area burned and very heavily utilized.

TABLE 42.-GRASS, FORB, SHRUB AND TREE LATERAL DENSITY IN TEN DIFFERENT STRATA ON SABLE AND ROAN ANTELOPE STUDY AREAS, AS MEASURED BY VEGETATION DENSITY BOARD

Area	Percent Obscurity at Each Level									
	Ground Level to 20 cm	21 to 40 cm	41 to 60 cm	61 to 80 cm	81 to 100 cm	101 to 120 cm	121 to 140 cm	141 to 160 cm	161 to 180 cm	181 to 200 cm
GRASS										
Percy Fyfe N.R. (Sable)	30,9	2,6	0,3	----	----	----	----	----	----	----
Percy Fyfe N.R. (Roan)	75,3,	3,6	----	----	----	----	----	----	----	----
Loskop Dam N.R.	0,7	----	----	----	----	----	----	----	----	----
Rustenburg N.R.	75,9	32,6	4,6	----	----	----	----	----	----	----
Hans Merensky N.R.	95,4	37,2	5,6	----	----	----	----	----	----	----
Matetsi, Rhodesia.	48,0	6,5	0,7	----	----	----	----	----	----	----
FORBS										
Percy Fyfe N.R. (Sable)	----	----	----	----	----	----	----	----	----	----
Percy Fyfe N.R. (Roan)	1,6	0,9	0,7	0,3	----	----	----	----	----	----
Loskop Dam N.R.	----	----	----	----	----	----	----	----	----	----
Rustenburg N.R.	1,0	1,0	0,7	0,3	0,3	----	----	----	----	----
Hans Merensky N.R.	----	----	----	----	----	----	----	----	----	----
Matetsi Rhodesia	0,3	----	----	----	----	----	----	----	----	----

TABLE 42.-(Continued)

Area	Percent Obscurity at Each Level									
	Ground Level to 20 cm	21 to 40 cm	41 to 60 cm	61 to 80 cm	81 to 100 cm	101 to 120 cm	121 to 140 cm	141 to 160 cm	161 to 180 cm	181 to 200 cm
SHRUBS										
Percy Fyfe N.R. (Sable)	3,9	2,0	1,6	1,0	0,3	0,3	0,3	----	----	----
Percy Fyfe N.R. (Roan)	0,7	0,7	0,3	0,3	----	----	----	----	----	----
Loskop Dam N.R.	----	----	----	----	----	----	----	----	----	----
Rustenburg N.R.	----	----	----	----	----	----	----	----	----	----
Hans Merensky N.R.	----	----	0,3	----	----	----	----	----	----	----
Matetsi, Rhodesia	25,3	18,8	12,2	7,9	4,9	1,1	2,3	1,6	0,3	0,3
TREES										
Percy Fyfe N.R. (Sable)	0,7	0,7	0,3	0,3	----	----	----	----	----	----
Percy Fyfe N.R. (Roan)	1,6	1,9	1,6	1,6	1,9	1,9	2,3	1,3	2,3	1,6
Loskop Dam N.R.	0,7	0,7	0,4	0,4	0,4	0,4	0,4	----	0,4	0,7
Rustenburg N.R.	18,4	18,7	18,7	19,4	20,4	19,7	24,7	26,3	25,6	30,3

TABLE 42.-(Continued)

Area	Percent Obscurity at Each Level									
	Ground Level to 20 cm	21 to 40 cm	41 to 60 cm	61 to 80 cm	81 to 100 cm	101 to 120 cm	121 to 140 cm	141 to 160 cm	161 to 180 cm	181 to 200 cm
Hans Merensky N.R.	0,3	0,7	0,3	----	----	----	----	----	----	----
Matetsi Rhodesia	6,3	4,9	6,3	5,6	4,9	4,2	3,6	3,3	1,9	1,9

woodland, with the bulk of the grass 20 cm and less in height. Maximum grass height at any point is about 75 cm (Table 42), but these are scattered tussocks. The preferred areas on Rustenburg Nature Reserve are similar in physiognomy, but the Protea caffra woodland is dense in woody plants at all levels, and particularly so in the higher strata up to 2 m where the dense Protea canopies cause 25-30 percent vision obscurity. By contrast, Percy Fyfe Nature Reserve is essentially a tall-grass savanna grassland, with scattered trees and shrubs. Maximum grass height is similar to Matetsi. A similar habitat is selected on Loskop Dam and Hans Merensky (Table 42) although the latter was not typical of the natural woodland, since it had been cleared. It was nevertheless a preferred area.

Maximum grass height, lateral visibility, canopy cover and basal cover are indicated in Table 43. Variations in maximum grass height and lateral visibility are great, reflecting the generally uneven nature of the lower vegetation strata on most areas. Broken topography coupled with changeable interspersions of grass, shrubs and trees, makes for a certain amount of variation in lateral visibility.

There appear to be similarities amongst the areas, notwithstanding the considerable differences in lateral vegetation density. Analyses of variance (completely randomized design) for each of the parameters measured for all areas together indicated very significant ($p < 0,01$) differences in all cases. Using Duncan's multiple range test (Steel and Torrie 1960) for parameters which were normally distributed, and sequential F-tests for the point data,

TABLE 43.-MEAN VALUES MEASURED FOR MAXIMUM GRASS HEIGHT, LATERAL VISIBILITY, CANOPY COVER AND BASAL COVER IN PREFERRED DRY SEASON HABITATS; ROAN AND SABLE ANTELOPE STUDY AREAS, FIGURES IN PARENTHESES ARE VARIANCES

Area	Grass Height cm	Lateral Visibility m	Canopy Cover %	Basal Cover %
Percy Fyfe N.R. (Sable)	63,2 (568,0)	125,6 (4642,5)	15,3 (1,42)	16,2 (0,68)
Percy Fyfe N.R. (Roan)	74,1 (414,3)	143,3 (3340,5)	8,9 (0,59)	18,6 (0,74)
Loskop Dam N.R.	18,1 (217,0)	118,0 (3975,7)	18,7 (2,06)	7,8 (0,59)
Rustenburg N.R.	128,0 (1056,7)	41,9 (2361,2)	20,0 (2,01)	8,0 (0,62)
Hans Merensky N.R.	67,5 (2967,8)	123,1 (2027,0)	24,5 (4,49)	11,1 (0,89)
Matetsi Rhodesia	74,5 (1337,8)	54,4 (577,3)	24,9 (0,65)	6,4 (0,24)

which were binomially distributed, (and progressively eliminating extreme means until the F-value was not significant at $p = 0{,}05$), the mean values for each parameter for each area could be grouped (Table 44). These showed that maximum grass height was not significantly different for any area, with the exception of Loskop Dam, where the sable were utilizing a burnt area with heavily grazed grasses. Matetsi, Loskop Dam and Rustenburg were similar in herbaceous basal cover, with Hans Merensky significantly different, and Percy Fyfe significantly different from these yet again. In habitat lateral visibility, Rustenburg and Matetsi were again similar; the other four areas being grouped apart. Canopy cover did not vary significantly between Matetsi, Rustenburg and Hans Merensky Nature Reserves. Although bush-clearing had been carried out on the latter area, it was confined mainly to dense shrub understory, and canopy or shade cover was not materially affected.

The area selected by roan antelope on Percy Fyfe Nature Reserve differed in one respect from that selected by sable, viz. there was significantly less canopy cover. This appears to indeed reflect their preferences, since habitats of more woodland character were available over the 2061 ha utilized by this species on Percy Fyfe.

The broad similarities between Matetsi and Rustenburg in respect of the habitat selected are remarkable in view of the very great ecological differences between these areas as a whole. The similarity is more striking if it is borne in mind that sable did occur naturally in the Magaliesberg (du Plessis 1969), of which Rustenburg is a part, whereas there are no records to indicate

TABLE 44.-SIMILARITIES IN MAXIMUM GRASS HEIGHT, LATERAL VISIBILITY, BASAL COVER BETWEEN VARIOUS SABLE AND ROAN ANTELOPE STUDY AREAS. GRASS HEIGHT AND LATERAL VISIBILITY ANALYZED BY DUNCAN'S METHOD AND CANOPY COVER AND BASAL COVER BY SEQUENTIAL F-TESTS. FIGURES IN PARENTHESES ARE MEAN VALUES MEASURED IN EACH CASE. BRACKETS ENCLOSE AREAS WHICH DO NOT DIFFER SIGNIFICANTLY (p = 0,05)

MAXIMUM GRASS HEIGHT (cm)

Rustenburg	Matetsi	Percy Fyfe (Roan)	Hans Merensky	Percy Fyfe (Sable)	Loskop Dam
(128,0)	(74,5)	(74,1)	(67,5)	(63,2)	(18,1)
Bracket group 1	1	1	1	1	2

HERBACEOUS BASAL COVER (%)

Matetsi	Loskop Dam	Rustenburg	Hans Merensky	Percy Fyfe (Sable)	Percy Fyfe (Roan)
(6,4)	(7,8)	(8,0)	(11,1)	(16,2)	(18,6)
Bracket group 1	1	1	2	3	3

LATERAL VISIBILITY (m)

Rustenburg	Matetsi	Loskop Dam	Hans Merensky	Percy Fyfe (Sable)	Percy Fyfe (Roan)
(41,9)	(54,4)	(118,0)	(123,1)	(125,6)	(143,3
Bracket group 1	1	2	2	2	2

CANOPY COVER (%)

Matetsi	Hans Merensky	Rustenburg	Loskop Dam	Percy Fyfe (Sable)	Percy Fyfe (Roan)
(24,9)	(24,5)	(20,0)	(18,7)	(15,3)	(8,9)
Bracket group 1	1	1	2	2	3

that this was the case with Loskop Dam or Percy Fyfe Nature Reserves. Greater similarities between Matetsi and Hans Merensky could probably have been found, had the latter area's shrubs and woody understory not been disturbed by brush encroachment measures about 2 years prior to the habitat evaluation.

The Loskop Dam sable herd's preference for an area which differed in many respects from those on other reserves points out the importance of palatability as a governing factor, particularly in an area where forage palatability drops to very low levels in the dry season. Protea caffra woodland is abundant in many parts of Loskop Dam (Theron 1973), but has never been known to have been utilized by sable antelope to any marked degree (C.J. Smit[1] personal communication). It is characteristic of Loskop Dam reserve, however, that Protea caffra woodland occurs on very steep north-facing slopes, and topography may mitigate against sable using this since they show definite preferences for flatlands and gently sloping terrain. As indicated above, the protein and nutrient content of the grasses in the preferred area on Loskop Dam were significantly affected by the burn, and were probably far more palatable than normal dry-season grasses. This indicates that burning offers a very definite means of changing sable distribution patterns, and is a very useful management tool, provided it is used in conjunction with nutrient supplementation.

Examination of the grass composition on the various areas (Tables 45 - 50) indicates some similarities between Matetsi and Percy Fyfe Nature Reserve. In both areas, the predominant grass

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[1] C.J. Smit, Reserve Manager, P.O. Damwal, Groblersdal, South Africa.

TABLE 45.- GRASS SPECIES COMPOSITION IN ENCLOSURE IN PREFERRED SABLE HABITAT ON PERCY FYFE NATURE RESERVE, MARCH 1974

Species	% Frequency Occurrence	% Basal Cover
Digitaria pentzii	50,3	6,76
Heteropogon contortus	8,72	2,50
Hyperthelia dissoluta	7,92	1,35
Aristida congesta	6,11	0,95
Brachiaria nigropedata	5,11	1,30
Themeda triandra	4,16	0,80
Rhynchelytrum repens	3,81	0,30
Trichoneura grandiglumis	2,76	0,25
Cymbopogon excavatus	2,30	0,65
Hyparrhenia hirta	2,05	0,30
Pogonarthira squarrosa	1,95	0,20
Eragrostis rigidior	0,95	0,05
Schizachyrium jeffreysii	0,65	0,15
Eragrostis gummiflua	0,60	0,25
Cynodon dactylon	0,50	0,05
Tricholaena monachne	0,45	----
Elionurus argenteus	0,45	0,15
Eragrostis chloromelas	0,40	0,05
Schizachyrium sanguineum	0,20	0,05
Aristida scabrivalvis	0,15	----
Aristida stipitata	0,15	0,05
Aristida diffusa	0,10	----
Sporobolus festivus	0,10	----
Eragrostis curvula	0,05	----
Michrochloa caffra	0,05	----

TABLE 46.-GRASS SPECIES COMPOSITION IN ENCLOSURE IN PREFERRED ROAN HABITAT ON PERCY FYFE NATURE RESERVE, MARCH 1974

Species	% Frequence Occurrence	% Basal Cover
Digitaria pentzii	53,44	8,11
Aristida congesta	12,60	1,32
Elionurus argenteus	7,13	2,78
Aristida stipitata	4,59	0,64
Heteropogon contortus	4,10	1,86
Cynodon dactylon	4,10	0,59
Eragrostis gummiflua	2,29	0,98
Trichoneura grandiglumis	2,19	0,39
Hyparrhenia hirta	1,95	0,44
Eragrostis chloromelas	1,61	0,34
Rhynchelytrum repens	1,61	0,34
Aristida diffusa	1,56	0,49
Pogonarthia squarrosa	0,44	0,09
Eragrostis curvula	0,39	----
Eragrostis barbinodis	0,39	----
Themeda triandra	0,39	0,05
Eragrostis superba	0,34	0,05
Aristida scabrivalvis	0,19	----
Schizachyrium sanguineum	0,09	----
Eragrostis cilianesis	0,09	----
Diheteropogon amplectens	0,09	0,05
Aristida junciformis	0,09	0,05
Sporobolus festivus	0,09	0,05
Andropogon schirensis	0,09	----
Urochloa panicoides	0,05	----

TABLE 47.- GRASS SPECIES COMPOSITION IN PREFERRED SABLE HABITAT, LOSKOP DAM NATURE RESERVE, FEBRUARY, 1975

Species	% Frequency Occurrence	% Basal Cover
Elionurus argenteus	14,2	0,99
Loudetia simplex	13,4	2,24
Diheteropogon amplectens	12,7	0,58
Setaria perennis	11,6	1,66
Digitaria eriantha	7,1	0,25
Aristida stipitata	6,6	0,83
Digitaria monodactyla	5,9	----
Eragrostis gummiflua	4,5	----
Eragrostis chloromelas	3,9	0,17
Heteropogon contortus	3,2	0,33
Eragrostis capensis	2,0	----
Hyparrhenia hirta	1,9	0,17
Schizachyrium jeffreysii	1,9	----
Hyperthelia dissoluta	1,6	0,17
Eragrostis curvula	1,5	----
Brachiaria nigropedata	1,2	----
Aristida congesta	1,0	----
Themeda triandra	0,9	----
Brachiaria serrata	0,8	----
Cynodon dactylon	0,8	----
Rhynchelytrum repens	0,5	----
Pogonarthia squarrosa	0,5	0,17
Sporobolus stapfianus	0,4	----
Eragrostis superba	0,4	0,08
Eragrostis barbinodis	0,3	----
Microchloa caffra	0,3	----
Perotis patens	0,2	0,08
Enneapogon pretoriensis	0,1	0,08

TABLE 48.- GRASS SPECIES COMPOSITION IN PREFERRED SABLE ANTELOPE HABITAT, RUSTENBURG NATURE RESERVE, FEBRUARY, 1975

Species	% Frequency Occurrence	% Basal Cover
Setaria perennis	22,1	1,85
Rhynchelytrum repens	17,1	0,93
Trachypogon spicatus	16,3	0,67
Diheteropogon amplectens	9,6	0,84
Themeda triandra	6,6	1,68
Tristachya rehmannii	5,4	----
Eragrostis racemosa	4,9	0,67
Brachiaria serrata	3,3	0,17
Tristachya biseriata	2,8	0,34
Andropogon schinzii	2,2	0,17
Urelytrum squarrosum	2,2	0,08
Schizachyrium sanguineum	2,0	0,25
Diplachne biflora	1,1	----
Monocymbium ceresiiforme	0,9	----
Eragrostis capensis	0,8	----
Loudetia simplex	0,7	----
Stipa dregeana	0,6	0,17
Heteropogon contortus	0,6	----
Elionurus argenteus	0,6	0,17
Digitaria diagonalis	0,3	----
Brachiaria nigropedata	0,1	----
Digitaria eriantha	0,1	----
Hyparrhenia hirta	0,1	----

TABLE 49.-GRASS SPECIES COMPOSITION IN PREFERRED SABLE ANTELOPE HABITAT, HANS MERENSKY NATURE RESERVE, FEBRUARY, 1975

Species	% Frequency Occurrence	% Basal Cover
Urochloa mosambicensis	53,2	7,06
Panicum maximum	15,9	1,63
Pogonarthria squarrosa	11,1	11,05
Schmidtia papporphorides	6,2	0,27
Rhynchelytrum repens	2,0	0,18
Themeda triandra	1,8	0,54
Eragrostis rigidior	1,8	----
Aristida argentea	1,6	0,09
Aristida congesta	1,5	----
Aristida scabrivalvis	1,4	----
Heteropogon contortus	1,1	----
Cenchrus ciliaris	0,7	----
Bothrichloa radicans	0,5	0,09
Panicum deustum	0,4	----
Urochloa bolbodes	0,3	----
Andropogon amplectens	0,2	----
Microchloa caffra	0,2	----
Hyperthelia dissoluta	0,2	----
Eragrostis species	0,1	----
Enneapogon cenchroides	0,1	----
Chloris virgata	0,1	----

TABLE 50.-GRASS SPECIES COMPOSITION IN PREFERRED SABLE HABITAT, MATETSI AREA, RHODESIA, DECEMBER, 1974

Species	% Frequency Occurrence	% Basal Cover
Digitaria nemoralis	25,6	0,93
Heteropogon contortus	12,1	0,97
Eragrostis rigidior	9,4	0,36
Urochloa brachyura	8,5	0,32
Aristida adscensionis	8,7	0,56
Eragrostis superba	6,2	0,44
Panicum dregeanum	4,3	0,97
Brachiaria nigropedata	3,6	0,64
Dichanthium papillosum	3,3	0,48
Hyperthelia dissoluta	2,8	0,36
Schmidtia pappophoroides	2,3	0,08
Pogonarthria squarrosa	1,9	----
Loudetia flavida	1,9	0,08
Michrochloa kunthii	1,7	0,12
Eragrostis nidensis	1,3	----
Andropogon gayanus	1,2	0,04
Chloris virgata	1,2	----
Setaria anceps	1,1	----
Panicum maximum	0,8	----
Tragus berteronianus	1,1	0,08
Rhynchlelytrum repens	0,6	----
Schizachrium sanguineum	0,4	----
Sporobolus panicoides	0,3	----
Diheteropogon amplectens	0,1	----

is Digitaria, normally considered a highly palatable genus. Heteropogon contortus is an important secondary species. Matetsi appears to offer a greater grass species diversity, since although the total numbers of grass species encountered were similar, the first 75 percent frequency occurrence on Matetsi is made up by eight species, whereas on Rustenburg it is six, Percy Fyfe five and Hans Merensky only three. The burned area on Loskop Dam is thus similar to Matetsi since some eight grass species are encountered in the first 75 percent frequency. Percy Fyfe sable and roan areas are heavily dominated by Digitaria pentzii, which makes up more than half the total grass frequency.

Palatability is a relative concept and naturally varies from area to area and is affected by species composition and general availability. However, a crude comparison can be made from a knowledge of the relative palatabilities of certain grass genera for common ungulate species (e.g. Hirst 1975). Thus it can be seen that of the grasses making up the first 75 percent frequency on Matetsi, only one (Aristida) can be regarded as unpalatable. On Hans Merensky two out of three of the most frequent grasses are palatable, on Percy Fyfe two out of five, and on Rustenburg only one or two out of six. Few, if any, of the common grasses on Loskop Dam are palatable in the unburned mature state, and this suggests strongly that they can only be utilized to any useful extent when they are in a young shooting stage following burning or intensive grazing. Palatability and food preferences are discussed more fully below.

Feeding Preferences

The data in Tables 45 to 50 indicate that the study areas differ somewhat in their availability of palatable forage. Most ungulates will remain sedentary within their feeding areas if they can obtain sufficient forage of good quality, but will increase their searching patterns within limits if they encounter a high frequency of unpalatable plants. Thus, the size of the area over which a herd typically feeds is some indication of the availability and palatability of the forage within that area.

Table 51 compares the respective areas, and it is apparent that Rhodesian sable are far more sedentary during feeding than sable in Transvaal nature reserves. The presence of burned range with relatively more palatable grasses restricted feeding areas on Loskop Dam. The fact that animals may remain in areas throughout the year suggests that forage is available on a year-round basis. The less the overlap between summer and winter ranges, the stronger the suggestion that forage palatability is changing with factors such as rainfall, stage of growth and possibly phenology. Table 51 indicates that feeding areas on Hans Merensky remain the same regardless of season, but that only 1/5 of the total feeding area is utilized in all seasons on the other Transvaal reserves. No comparative data are available from Matetsi.

A common assumption regarding rare or endangered species is that they are more specific in their feeding habits than are other more common species. If this is in fact the case with the roan and sable

TABLE 51.- COMPARATIVE SIZES OF AREAS USED FOR FEEDING; ROAN AND SABLE ANTELOPE STUDY AREAS

Area	Wet Season Feeding Area in ha	Dry Season Feeding Area in ha	% Overlap
Percy Fyfe N.R. (Roan)	42 (November - December)	137 (July- September)	0[1]
Percy Fyfe N.R. (Sable)	106 (October-December)	120 (July-September)	21
Loskop Dam N.R.	70 (November- March)	42 (May - September)	21
Rustenburg N.R.	113 (October - March)	102 (June - September)	21
Hans Merensky N.R.	57 (approximately)	57 (approximately)	100
Matetsi, Rhodesia		37	

[1] Moved to burned area in dry season

antelope it poses further limitations on their well-being on enclosed nature reserves. The overall low densities at which roan and sable occur, particularly along the fringes of their present-day distribution in southern Africa, suggest that they do indeed show preferences in their feeding habits.

This was measured critically on Percy Fyfe Nature Reserve with both antelope species. Two males of each species were placed in ½ ha feeding enclosures for periods of 11 days in each case. A control enclosure was stocked for the same period with two pen-reared sable males which had been raised on lucerne hay and concentrates, and which had never had prior experience of grazing natural range. Results are indicated in Tables 52 to 54.

Roan antelope showed a marked preference for several species, notably Heteropogon contortus, Rhynchelytrum repens, Eragrostis superba and Schizachyrium sanguineum. In each case, about 1/3 of the plants encountered were heavily grazed (67-100 percent) and the remainder moderately or lightly grazed. Other well-utilized species were Hyparrhenia hirta, Trichoneura grandiglumis and Themeda triandra . Known unpalatable species such as Elionurus argenteus, Aristida congesta and A. diffusa were lightly grazed, if at all. The findings indicate that the animals were highly specific in their choice of food plants, even under a stress situation. Their body weights dropped by 20 kg over a period of 11 days indicating severe nutritional stress, yet they did not feed to any appreciable extent on the dominant grass Digitaria pentzii or on the next four most frequent grasses, i.e. they virtually limited their diet

TABLE.52- PREFERRED GRASS SPECIES AND PERCENT UTILIZATION IN ROAN FEEDING ENCLOSURE ON PERCY FYFE NATURE RESERVE, AUGUST 1974

Species	% Frequency Occurrence	% Utilization		
		0-33	34-66	67-100
Digitaria pentzii	55,9	6,5	6,5	0,6
Aristida congesta	13,0	0,3	---	---
Elionurus argenteus	6,6	4,6	0,7	2,3
Cynodon dactylon	4,6	4,4	---	---
Aristida stipitata	4,5	6,8	3,4	1,1
Heteropogon contortus	2,7	22,6	11,3	32,0
Eragrostis gummiflua	2,6	14,0	8,0	12,0
Hyparrhenia hirta	2,1	20,0	27,5	10,0
Rhynchelytrum repens	1,6	27,2	18,7	28,1
Aristida diffusa	1,4	3,7	---	---
Eragrostis chloromelas	1,3	3,8	11,5	7,6
Trichoneura grandiglumis	1,1	---	9,5	14,2
Eragrostis curvula	0,8	12,5	12,5	18,7
Themeda triandra	0,5	22,2	11,1	22,2
Eragrostis barbinodis	0,4	---	---	---
Eragrostis superba	0,2	---	25,0	50,0
Schizachyrium sanguineum	0,2	---	25,0	50,0
Pogonarthria squarrosa	0,2	25,0	---	---
Aristida junciformis	0,2	---	---	---
Setaria perennis	0,1	---	---	---
Digitaria monodactyla	0,1	---	---	---

TABLE 53.-PREFERRED GRASS SPECIES AND PERCENT UTILIZATION IN SABLE FEEDING ENCLOSURE ON PERCY FYFE NATURE RESERVE, AUGUST 1974

Species	% Frequency Occurrence	% Utilization		
		0-33	34-66	67-100
Digitaria pentzii	53,6	10,9	2,9	1,0
Heteropogon contortus	8,1	29,9	8,3	7,1
Aristida congesta	7,4	---	---	---
Hyperthelia dissoluta	7,1	22,6	8,5	6,7
Rhynchelytrum repens	5,9	20,4	7,3	1,6
Themeda triandra	3,9	30,8	12,3	17,2
Brachiaria nigropedata	3,9	25,0	10,0	23,7
Hyparrhenia hirta	1,5	16,1	3,2	9,6
Trichoneura grandiglumis	1,5	10,0	3,3	---
Schizachyrium jeffreysii	1,3	7,6	19,2	11,5
Pogonarthria squarrosa	1,0	9,5	---	9,5
Cymbopogon excavatus	1,0	---	---	---
Eragrostis barbinodis	0,7	6,6	---	---
Eragrostis gummiflua	0,7	28,5	14,2	14,2
Eragrostis chloromelas	0,5	30,0	---	---
Aristida scabrivalvis	0,4	---	---	---
Cynodon dactylon	0,4	25,0	---	---
Elionurus argenteus	0,3	---	---	---
Eragrostis rigidior	0,1	---	---	---
Eragrostis curvula	0,1	40,0	20,0	---
Tricholaena monachne	0,1	---	50,0	---
Aristida diffusa	0,1	---	---	---
Digitaria monodactyla	0,1	---	---	---
Setaria perennis	0,1	---	---	100,0

TABLE 54.- PREFERRED GRASS SPECIES AND PERCENT UTILIZATION IN CONTROL SABLE EXPERIMENT ON FEEDING BEHAVIOUR, PERCY FYFE NATURE RESERVE, AUGUST 1975

Species	% Frequency Occurrence	% Utilization		
		0-33	34-66	67-100
Digitaria pentzii	38,5	7,1	3,0	1,5
Aristida congesta	22,6	---	---	---
Heteropogon contortus	16,1	20,4	8,7	7,7
Cynodon dactylon	8,5	6,9	---	---
Brachiaria nigropedata	4,2	10,3	7,7	5,1
Eragrostis gummiflua	3,4	19,8	14,2	25,3
Eragrostis barbinodis	1,6	---	6,6	---
Pogonarthria squarrosa	1,2	---	---	---
Rhynchelytrum repens	1,1	9,5	---	---
Setaria perennis	0,7	7,6	23,0	23,0
Aristida stipitata	0,7	---	---	---
Themeda triandra	0,5	22,2	22,2	11,1
Eragrostis curvula	0,2	---	---	---
Eragrostis rigidior	0,2	---	---	---
Hyperthelia dissoluta	0,2	25,0	---	50,0
Hyparrhenia hirta	0,1	---	---	---
Aristida scabrivalvis	0,1	---	---	---

to 15 percent of the available grasses.

Sable showed a similar selectivity, and although they grazed Digitaria pentzii to a slightly greater extent than did the roan, they avoided it wherever possible (Table 53). Brachiaria nigropedata received the main feeding pressure, but had a frequency occurrence of only 3,9 percent. Other well grazed species included Themeda triandra, Heteropogon contortus, Hyperthelia dissoluta, Hyparrhenia hirta, Schizachyrium jeffreysii and Eragrostis gummiflua. The sable also showed a weight loss of some 20 kg per animal over an 11 day grazing period, and so were also subjected to nutritional stress. The bulk of the dietary intake was made up from 35 percent of the occurring grasses.

Despite their being pen-reared, the two semi-tame sable displayed very similar grazing habits to the wild-caught ones (Table 54). They displayed marked preferences for Setaria perennis (not present to any extent in other sable enclosure), Themeda triandra, Hyperthelia dissoluta, Eragrostis gummiflua and Heteropogon contortus. The results indicate that plant selection is indeed an instinctive process, and probably modified by smell and texture. Because the animals were relatively tame and permitted close presence of an observer, it was possible to watch their feeding habits closely. Although not quantified in this case, it was apparent that they were feeding first on Heteropogon contortus, Themeda triandra, and Brachiaria nigropedata.

The results of the trial with semi-tamed animals indicate that they could have been used to measure feeding preferences on other reserves as well. This was in fact the intention at the outset of the project, but was later shelved due to time and material limitations. The results nevertheless point the way to the use of semi-tamed animals as a valuable research tool in feeding studies with other ungulate species.

Throughout the course of the study it became apparent that roan on Percy Fyfe could maintain themselves in better body condition than sable, despite a relatively greater degree of food plant specificity. The reason for this became obvious in late 1972, when the roan herd were still confined to a small enclosure of 430 ha. During the peak months of the dry season,August and September, the incidence of browsing by roan increased dramatically, and browsing was measured as having a total incidence of 61 percent of total feeding at that time (Table 55). Browsing was directed at 10 woody species on the reserve, of which Acacia karroo and Rhus lancea received the most attention.

The nutrient value of browse was not measured in the present study, but both leaves and pods of savanna trees are known to have high levels of protein and other nutrients compared to those of grass at that time (Bonsma 1942). The relatively lower disease incidence and better body condition in roan (see later) could almost certainly be ascribed to their willingness to switch to browsing in critical periods. It is significant, however, that the browsing incidence dropped markedly when the roan herd was given access to the larger enclosure of 2061 ha in 1973 (Table 55).

Although sable antelope are known to browse to a certain extent in other geographical areas, it was interesting to note that at no

TABLE 55.- INCIDENCE OF BROWSING BY ROAN ANTELOPE ON PERCY FYFE NATURE RESERVE DURING THE DRY SEASON OF 1972, AS COMPARED TO 1973[1]

Browse Species	Feeding Occurrences Recorded
1972	
Acacia caffra	777
Acacia Karroo	1265
Acacia sieberiana	481
Carissa bispinosa	250
Dombeya rotundifolia	311
Faurea saligna	524
Maytenus species	324
Olea africana	535
Rhus lancea	626
Rhus pyroides	445
Total feeding occurrences on browse	5993
Total feeding occurrences on grass	3780
Incidence of browsing	61 %
1973	
Acacia karroo	311
Acacia caffra	25
Rhus lancea	113
Olea africana	25
Total feeding occurrences on browse	474
Total feeding occurrences on grass	3881
Incidence of browsing	10,9 %

[1] The size of the roan enclosure was increased from 430 ha to 2061 ha just prior to the dry season, 1973.

time during the course of the study were sable observed to browse on Transvaal reserves. However, analyses of rumen contents obtained from sable on Transvaal and Matetsi study areas during the dry season 1974 showed that dicotyledons were in fact utilized to a limited extent on Transvaal reserves and to a much greater extent on the Matetsi area (Table 56). Several of the same grass species were also utilized on all areas. Grass species identifications in the rumens were based on the reference microscopic slides prepared from grasses collected on Percy Fyfe and made accurate identification of all grass species impossible because of the variations in growth form of the same species occurring in different habitats, hence the large "unidentifiable" category.

Extrapolation of the Percy Fyfe feeding preference results to the other nature reserves shows that forage on most highland or sourveld reserves is in short supply, at least in the dry season. Grasses with a relatively high palatability rating (based on Percy Fyfe results), only make up some 30 percent of the total frequency. On Rustenburg, however, they make up more than 50 percent of the total grass frequency, as much as on the Matetsi area. Hans Merensky's grass stratum was 75 percent frequency of palatable grasses, which gives some indication as to why it has such a high sable carrying capacity in good rainfall years.

TABLE 56.-PERCENTAGE FREQUENCY OCCURRENCE OF PLANT FRAGMENTS IN RUMENS OF SABLE ANTELOPE SHOT ON PREFERRED FEEDING AREAS ON TRANSVAAL RESERVES AND MATETSI AREA, RHODESIA, DRY SEASON 1974

Vegetation Species	Percy Fyfe[1] N. R.	Rustenburg N.R.	Loskop Dam N. R.	Hans Merensky N. R.	Matetsi Area Rhodesia
Hyperthelia dissoluta	1	0	0	0	0
Hyparrhenia hirta	1	1	4	1	2
Themeda triandra	8	45	4	26	0
Heteropogon contortus	24	8	7	3	5
Trachypogon spicatus	9	0	0	0	0
Digitaria pentzii	7	0	0	0	0
Setaria perennis	5	1	6	1	0
Cynodon dactylon	9	0	0	2	0
Eragrostis gummiflua	8	0	0	0	0
Aristida species	3	6	5	3	0
Tricholoaena monachne	1	0	0	0	0
Rhynchelytrum repens	3	0	0	0	0
Eragrostis species	4	8	7	3	2
Loudetia simplex	0	0	1	0	0
Dicotyledons	1	3	1	5	64
Unidentifiable	16	28	65	49	27

[1] Animal found dead and may not have been feeding in exact preferred area prior to time of death.

Feeding Competition

Competition from other wild ungulates may be a constant menace to highly selective feeders such as roan and sable, and of special significance in small reserves where numbers per unit area tend to rise more rapidly than in larger areas. Because of their sensitivity to nutritional deficiencies and associated diseases, roan and sable may be in an even more unfortunate position. A counter-argument, however, is that by being more specific, sable and roan may in fact avoid competition to a large extent by selecting plant species largely avoided by other ungulates. In view of the somewhat catholic diet of zebra and impala, two species commonly associated with sable antelope on nature reserves, the latter possibly seems remote.

The degree of competition on Percy Fyfe could be quantified by an analysis of rumen (or caecum in the case of zebra) contents. A microscopic technique was used, as described above. One zebra, one impala and two waterbuck were shot in September 1974 (dry season) while feeding in a sable preferred area. A female sable died on the reserve from cold and exposure in the same month and gave an opportunity for a comparative study. She was not, as far as was known, feeding on the exact same area at the time of death. The samples were thus low in each case--one or two animals-- but as described under techniques used, the samples were tested specifically to avoid heterogeneity of the distribution of the plant fragments. Sequential sampling from the same rumen sample later proved that percentage freqeuncy occurrences of fragments were very constant.

Table 57 summarizes the findings from the rumens (and caecum) of potential competing species. The bulk of the sable diet was made up of Heteropogon contortus, Trachypogon spicatus, Cynodon dactylon, Themeda triandra and Eragrostis gummiflua. Waterbuck showed a strong preference for all these species, and impala had a high preference rating for Cynodon dactylon and Eragrostis gummiflua. The zebra diet was spread over many more species than in the case of the sable,and many fragments came from unidentifiable species (reference slides for identification by epidermal characteristics were prepared for only 17 species). The frequency occurrence of fragments in one waterbuck rumen was significantly correlated with that of the sable rumen (Spearman rank correlation coefficient r_s = 0,525, $p < 0,5$) but other rumen samples showed no similar significant correlation.

It would appear that competition is a factor of importance, but it arises mainly from waterbuck, which are not animals which normally attain high densities, and which, when offered a choice of habitats, are strongly selective for riverine woodland with dense cover (Hirst 1975) which does not correspond to choice sable or roan habitat. Both zebra and impala could certainly offer a degree of competition, especially if present in large numbers, and if permitted to reach such numbers that they appreciably deplete the available supply of grasses such as Heteropogon, Themeda and Brachiaria.

Data on the use of sable preferred areas were extracted from the monthly distributional plotting undertaken throughout 1974 (Tables 58-60). Every 2 minutes during daylight hours when note was

TABLE 57.-PERCENTAGE FREQUENCY OCCURRENCE OF PLANT FRAGMENTS IN RUMENS AND CAECUM OF ANIMALS SHOT ON PREFERRED SABLE AREA, PERCY FYFE NATURE RESERVE, SEPTEMBER 1974

Vegetation Species	Sable[1]	Zebra[2]	Impala	Waterbuck No. 1	Waterbuck No. 2
Hyperthelia dissoluta	1	3	0	3	11
Hyparrhenia hirta	1	2	1	2	0
Schizachryium jeffreysii	0	0	0	2	0
Themeda triandra	8	4	0	3	6
Heteropogon contortus	24	6	0	4	47
Trachypogon spicatus	9	4	0	24	5
Digitaria pentzii	7	4	2	2	2
Setaria perennis	5	5	0	4	0
Brachiaria nigropedata	0	0	0	1	0
Cynodon dactylon	9	7	16	20	0
Eragrostis gummiflua	8	5	12	1	0
Pogonarthria squarrosa	0	0	0	1	0
Aristida diffusa	3	0	7	7	3
Tricholaena monachne	1	0	4	5	2
Rhynchelytrum repens	3	1	0	5	2
Eragrostis species	4	0	4	4	3
Dicotyledons	1	16	40	0	2
Other species	16	43	14	12	16

[1] Animal may not have been feeding in exact preferred area prior to time of death.

[2] Sample taken from caecum.

TABLE 58.- RECORDED PRESENCE OF OTHER UNGULATES WITHIN SABLE ANTELOPE PREFERRED HABITATS AND ACTIVITY AREAS ON PERCY FYFE NATURE RESERVE, 1974. FIGURES GIVEN ARE NUMBERS OF 2-MINUTE RECORDINGS OF PRESENCE OF EACH SPECIES WITHIN IMMEDIATE VICINITY OF SABLE

	Sable	Waterbuck	Zebra	Impala	Kudu
May	234	---	---	7	---
June	663	---	1	8	---
July	481	---	7	20	---
August	717	25	275	109	9
September	1075	5	555	30	---
October	1276	53	451	67	34
November	721	3	284	44	21
December	783	6	188	69	17

TABLE 59.-RECORDED PRESENCE OF OTHER UNGULATES WITHIN SABLE ANTELOPE PREFERRED HABITAT AND ACTIVITY AREA ON LOSKOP DAM NATURE RESERVE, 1974. FIGURES GIVEN ARE NUMBERS OF 2-MINUTE RECORDINGS OF PRESENCE OF EACH SPECIES WITHIN IMMEDIATE VICINITY OF SABLE

	Sable	Waterbuck	Zebra	Impala	Kudu	Wildebeest	Blesbok
January	1040	---	170	6	---	---	---
February	2295	2	16	99	---	57	9
March	2133	---	360	238	8	12	49
April	1799	---	1	348	---	23	2
May	1184	2	80	17	17	---	---
June	630	2	14	59	31	36	---
July	1243	---	---	5	---	84	---
September	1213	8	14	71	---	24	---
October	1188	4	20	16	---	2	---
November	1491	5	32	35	9	119	37

TABLE 60.- RECORDED PRESENCE OF OTHER UNGULATES WITHIN SABLE ANTELOPE PREFERRED HABITATS AND ACTIVITY AREAS ON RUSTENBURG NATURE RESERVE, 1974. FIGURES GIVEN ARE NUMBERS OF 2-MINUTE RECORDINGS OF PRESENCE OF EACH SPECIES WITHIN IMMEDIATE VICINITY OF SABLE

	Sable	Waterbuck	Zebra	Impala	Kudu	Wildebeest	Springbok	Blesbok
February	1529	1	2	7	---	2	---	---
March	2180	2	59	87	---	---	16	---
April	682	---	---	---	---	---	---	---
May	455	---	3	---	25	---	---	---
June	1522	---	71	4	---	---	---	1
July	1360	1	8	7	---	---	---	---
September	1211	1	10	3	1	63	---	39
October	1295	25	13	83	---	---	---	---
November	654	1	150	6	---	2	---	3
December	1103	---	7	---	---	5	---	18

made of other ungulate species in the immediate vicinity. Their activity was also recorded, but since they could have differed from sable in their diurnal and nocturnal habits, and may have fed when sable were inactive, the total presence has been taken as indicative of potential feeding competition. In the case of Percy Fyfe Nature Reserve, it is apparent (Table 58) that zebra use of the preferred sable areas is heavy in the dry and early spring months of August through November. Waterbuck use is much lighter, but as noted above, there is a much greater overlap in feeding habits between them and sable. Competitive use of areas by zebra is a factor to consider in the case of Loskop Dam too, but impala made even greater use of the previously burned area (Table 59). Overall ungulate use of this area was heavy, point out the disadvantage to the sable of burned range: although nutritional status may be improved, competition from other species may completely negate any possible advantage.

The area with the most favourable situation for sable was Rustenburg, where competitive ungulate use of sable areas was comparatively light (Table 60).

REPRODUCTIVE FACTORS

It was stated earlier that the objectives of the study called for identification of limiting factors operating on roan and sable antelope herds on Transvaal nature reserves. One area of initial consideration was that population limitation could be effected through poor reproductive performance brought about by physiological or behavioural factors.

In order to elucidate the various factors operating on reproduction, observations were made to delineate the occurrence and duration of the breeding seasons, and the length of gestation periods and calving seasons. Note was made of the behavioural traits of herd bulls, individual females and immature males over the 18-month field observation period to record various interactions relating to breeding and aggression. Limited physiological information on the reproductive capabilities of sable males was obtained by examination of semen samples taken by means of electro-ejaculation from live animals and by extrusion from epididymides of dead animals shot for nutritional information (see Methods).

Breeding Seasons and Gestation Periods

Various authors have adequately documented the fact that sable antelope are highly seasonal breeders although this period varies considerably over the distribution range of sable from central and southern Africa (Ansell 1960). Field observations showed that sable females undergo only one oestrous cycle during a relatively short breeding season, which for Transvaal reserves occurs from May to July, with a peak in June. Parturition follows an 8-month gestation period (see below) and occurs from January to March with a peak in February. Occasionally, the first calf of a young adult female is born as late as June (Table 10). Weaning takes place 6 months after parturition and corresponds to the latter part of the dry season when "sourveld" vegetation is at a criticial low point in protein and other nutritional constituents.

Roan antelope are not seasonal breeders and drop their calves throughout the year (Table 11). Two to 3 weeks after parturition the roan female enters a postpartum oestrous cycle and after a gestation period of approximately 275 days she may drop another calf. This means that every 10-10½ months a roan ~~calf~~ cow has the potential to give birth to a calf. In a period of 2 years, seven adult roan cows gave birth to 15 calves in an experimental camp in the Kruger National Park (Joubert 1970).

Although it has been generally stated in the literature that the gestation period for sable is approximately 9 months, it was found during this study that gestation lasted only 8 months (240-248 days) on Percy Fyfe. This was determined by close observation of breeding activities throughout the 18-month field observation period. Special note was made of male-female interaction while breeding took place. Collar marking (see Methods) facilitated identification of animals.

Mating behaviour is initiated by the herd bull and includes dominance postures, sniffing the vulva area of the female, an olfactory test of the female oestrous status ("flehmen"), leg lifting ("laufschlag") and mounting, if the female is receptive. The mating ritual is almost identical in both sable and roan and is described in detail by Joubert (1970). Mounting may occur many times before successful intromission takes place, and as many as 17 mountings have been observed without intromission occurring. The exact date intromission took place was recorded and subsequently compared to the date the individual females dropped their calves during the calving season. This was not possible in the case of every sable female on Percy Fyfe because intromission was of very short duration (only two to three thrusts required for ejaculation), and unless the observer was favourably located in relation to the position of the mating animals, positive identification of intromission was difficult and could not be accurately recorded. However, dates of intromission and subsequent calving were recorded for seven females and the duration of gestation was found to be 240-248 days.

The sexual behaviour by the bull, i.e. dominance posture approaches and sniffing the vulva area of females, was displayed throughout the entire year although to a much greater extent during the active breeding season. However, the females never "stood" (remained stationary) for the mating ritual except during their single oestrous cycle during the breeding season. Attempted approaches by the bull after the initial oestrous period always resulted in the females moving away from the bull. It was therefore surmized that the sable female entered only one oestrous cycle per breeding season, but that the herd bull displayed libido throughout the entire year.

Seasonal Variation in Sexual Capability of Sable Bulls

Although adult sable males showed sexual interest in sable females throughout the year (see above), the question remained whether there was a physiological drop in sexual capability during periods other than the normal breeding seasons. Electro-ejaculation techniques were applied to a number of sable males utilizing several different types of ejaculators and various drug combinations before a successful ejaculate was obtained. Drug combinations that produced deep narcosis made the animal more tractable and facilitated collection of the ejaculate.

The battery powered rectal probe used initially was thought to produce insufficient stimulation to induce ejaculation, although various stiumulation techniques and rhythms were applied. The first consideration was that the probe was too short and the brass conducting rings were not reaching the ampulla. However, upon dissecting out the reproductive tract of an adult male sable that had to be destroyed, it was found that the probe was sufficiently long to position the brass rings exactly over the ampulla. Only accessory fluid secretions were obtained with the battery probe and no spermatozoa were observed.

Prior to destroying the adult sable male various combinations of drugs and battery probes were used to obtain semen, but were unsuccessful. After the animal was destroyed the testes were removed and a droplet of semen was extruded from the epididymis. Upon examination it was found to contain highly motile, normal spermatozoa.

Subsequently, a new probe was manufactured which embodied logitudinal brass strips along the length of the probe, which was also increased in length and diameter. Power was supplied by a portable generator and attached to a rheostat for control of the stimulating current (see Methods). This combination produced more favourable results with only a few stimulations required to obtain ejaculates. There appeared to be no visual difference in the animals' muscular response to either the battery- or generator-powered probe, and at no time did an erection occur with any combination of drugs or apparatus.

Electro-ejaculation of herd bulls both during, and outside the active breeding season indicated that there was little difference in the appearance of the semen other than a slight reduction in motility outside the breeding season. Microscopic examination showed that although the total sperm density was slightly greater during the active breeding season, the general morphology of the spermatozoa was much the same and there was no reason to believe that the male was incapable of breeding throughout the year.

A general description[1] of semen collected by electro-ejaculation from a sable herd bull on Percy Fyfe shortly after the peak of the breeding season is presented below:

1. volume: 0,75 ml
2. appearance: milky
3. density: 0,193 x 10^9 sperm/ml
4. motility: good progressive motility
5. morphology: 60,5 percent presumably normal, 26 percent deformed tails, 7 percent deformed head and 6,5 percent tailless heads

[1] Information supplied by H.M. Dott, Agricultural Research Council, Cambridge England.

6. head dimensions (each measurement is the mean of 30 sperm; 10 from each of three slides):

   a. length μm 7,122 ± coefficient of variation 4,620

   b. width μm 4,869 ± 0,05 coefficient of variation 5,805

   c. w/l μm 0,686 ± 0,009 coefficient of variation 7,140

   d. projected area μm^2 26,78 ± coefficient of variation 8,075.

Blood testosterone levels of three sable herd bulls measured during the same month (just after the active breeding season) on Rustenburg, Loskop Dam and Hans Merensky Nature Reserves were 5, 16, 3, 14 and 2,06 ng/ml, respectively. The mean blood testosterone level of 12 subordinate males varying in age from 18 to 31 months (all capable of breeding, see below) was 0,737 ng/ml (range was 0,36 to 1,43 ng/ml). From visual comparison of the data there appears to be some correlation between the dominant herd position and the level of testosterone in the blood. However, there was no apparent adverse effect on breeding due to the lower testosterone level in the case of the Hans Merensky sable bull because calving success was 100 percent.

The incidence of calving clearly defined the duration of most breeding for sable (up to 6 months on Percy Fyfe in 1972, see Table 10) and the 100 percent calving rates throughout the study period indicated that the reproductive health of the sable herds was as good as could be expected within the narrow limits of the strictly seasonal breeding characteristics of the species.

Age of Reproductive Capability in Sable Males

The age of first sexual activity in roan and sable antelope females (shortly after 2 years of age) has already been mentioned. No information was available on sable males and development of sexual activity. The desirability of determining exact ages of sexual capability in young males has also been discussed above.

Observations on the pen-reared sable males showed that at 16-18 months of age marked changes occurred in the appearance of the genitalia, e.g. rapid increase in the size of the scrotum, the tip of the penis sheath hung freely away from the body and erections occurred more frequently (male behaviour appeared as early as 3 weeks in the form of mounting, and masturbation occurred at approximately 14 months). This age also corresponded to aggressive interaction on the part of the herd bull towards 17-19 month old males which were violently driven from the herds. This behaviour indicated that the young males were reaching sexual capability.

On relatively small provincial reserves such as Percy Fyfe these young males were frequently pursued and killed by the herd bull (Transvaal Nature Conservation Division, official files and personal observations). In other cases the stress of pursuit reduced premunity and precipitated lethal blood parasite infections which resulted in death (see DISEASES AND PATHOLOGICAL CONDITIONS). Intraspecific aggression was considered a limiting factor for this sex and age group of sable on smaller provincial reserves. If this age corresponded to the age of psychological reproductive capability, the management implications would be to relocate these young males to other reserves to establish nucleus herds.

Electro-ejaculation was undertaken to elucidate the development of sexual capability in subadult sable males. The youngest sable male from which an ejaculate was obtained was 16 months of age. The sample was obtained just prior to the breeding season and was compared to that taken from a herd bull several months prior. Macroscopically there was no difference in the overall appearance or motility of the sample. Microscopically the semen from the 16-month old animal contained 60 percent live spermatozoa. The proportion of eosinophilic spermatozoa was 40 percent and included secondary abnormalities such as heads off, coiled tails and primary abnormalities, mainly pear-shaped heads. This was basically of the same order as that found in the adult ejaculate (see above) except that proximal and distal droplets appeared in the semen sample from the 16-month old animal and not in the sample from the adult indicating immature sperm. Testosterone levels in the blood were 0,71 and 1,84 ng/ml for the young and adult males respectively. Subsequent visual examination of semen samples from other young males up to 29 months of age obtained by electro-ejaculation and extrusion from epididymides indicated that the young males were sexually capable of breeding as early as 16-19 months of age, but not at the same rate as adult males.

The question arose whether this age group of sable males was psychologically capable of breeding. In a mixed herd, breeding would certainly be prevented by a dominant bull. Moreover, in the absence of a herd bull the subadult males may not have been able to dominate adult females to breed.

To elucidate this aspect two 18 month old males and two females (one immature and one adult) were relocated from the sable camp at Percy Fyfe to a separate enclosure several miles from the main camp (see Methods). The time of relocation was prior to the onset of the breeding season to insure no possible insemination of the two females by the herd bull prior to relocation. The new area was self - sufficient in food and water and no attempt was made to supplement the natural vegetation.

The animals remained in this separate area for approximately 12 months, during which time successful breeding took place. Six months after breeding the two females were immbolized and rectally palpated to determine pregnancy. The adult female was pregnant and 2 months later dropped a normal calf. It was thus determined that subadult males were physiologically and psychologically capable of breeding in the absence of a dominant herd bull.

DISCUSSION AND RECOMMENDATIONS

A growing proportion of southern Africa's wild ungulate species are today being classed as rare and even endangered (Von Richter 1974). In many cases the root causes can be traced to habitat changes brought about by man-induced factors, or to the fact that such diminishing species are being forced into sub-optimal habitats. It is becoming more obvious that sincere attempts to preserve these species for future generations will entail a greater committment to habitat procurement and conservation than has hitherto been the case.

The theme of this study has been to examine the limiting factors operating on roan and sable antelope within the confines of their present-day habitats in Transvaal. It is apparent that the actual limiting process is a complex one involving disease, malnutrition and habitat quality, but these factors are complicated and compounded by interspecific competition and attempts to manipulate the populations on the respective reserves.

Densities of the animals in their pristine free-ranging state apparently varied considerably, and historic accounts (cf. du Plessis 1969) indicate that roan and sable were very abundant in certain localities and extremely rare in others. They can today reach considerable densities in circumscribed localities where environmental factors are all favourable, e.g. sable along the Zambesi river, Rhodesia (Estes and Estes 1970) and roan in west Africa (Poché 1974). However, even in large conservation areas such as national parks,

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their densities over all habitats combined are low; e.g. less than 0,5 animals/km^2 sable density in Matopos National Park, Rhodesia, and less than 0,1 animal/km^2 for sable in the whole Kruger National Park. The mean density for favourable areas only is of the order of 4 animals/km^2, e.g. sable in the Matetsi area, Rhodesia (Johnstone 1971). Thus the densities attained in the Transvaal provincial nature reserves must be regarded as being of a very high order: Percy Fyfe sable densities have been almost as high as those in the Matetsi area despite the fact that habitat quality on the former is vastly inferior; sable densities on Hans Merensky have already reached 9/km^2, which is well over double their normal densities in the best Rhodesian range and this on an area where the rainfall is erratic and averages well below that in Rhodesia. It is then not so surprising that population declines and crashes are encountered, rather it borders on the incredible that sable and roan manage to survive at all in the face of such environmental pressures.

Both roan and sable antelope have been shown to be very food-specific in any area where grasses differ a great deal in their relative palatabilities, even in the "sweetveld" areas of the Lowveld savanna. This in itself would prove a severe limitation on overall carrying capacity of the range. It is, however, compounded by several magnitudes by the mineral and protein deficiencies in the naturally available sourveld forage. Forage deficiencies are so marked in most sourveld reserves that even selective feeding on the most palatable grasses cannot sustain the animals adequately through critical dry periods of the year.

The basic deficiencies on the highland sourveld reserves of Loskop Dam, Rustenburg and Percy Fyfe relate to phosphorus, selenium and protein. Sodium, calcium, magnesium and potassium are certainly linked to the deficiency syndrome, but in themselves are not basically deficient. Calcium is neither deficient nor in excess, but the gross imbalance between it and phosphorus in the forage and the soil frequently enhances the phosphate shortage. Other trace elements may be marginally deficient in some of the reserves, but cannot be regarded as causing severe nutritional problems. It is likely that in the face of adequate protein, phosphorus and selenium levels in the available forage, trace element deficiencies would be marginal or of a sub-clinical nature.

However, it is also evident that a higher intake of all trace elements coupled to enhance protein and phosphorus nutrition would greatly improve the body condition of the roan and sable and the quality of the milk taken by the young calves. Lactacting cows are probably in a chronic state of nitrogen and phosphorus negative balance, and maintain the levels of these nutrients in their milk at their own expense. The protein content of sable milk, and probably roan, on the highland reserves is insufficient to sustain adequate body condition and growth of calves in the presence of protozoal blood parasites such as Cytauxzoon and Babesia. Forage protein and phosphate content is too low to provide adequate nutrition during the critical weaning period which often coincides with the end of the dry season.

Protozoal blood infections are no more than secondary factors in the mortality patterns, and are in fact shown to be very widespread amongst otherwise clinically normal animals. They do not lead to death in all cases of nutritional debility either, and in many cases are superseded as mortality factors by the sudden advent of cold and exposure.

Conservation of roan and sable populations on provincial nature reserves, and even in the larger national parks, must take cognizance of their specific susceptibility to nutritional deficiencies and resultant disease. Based on the findings in this study, some fairly obvious and logical recommendations for the future conservation and management of these diminishing species can be made.

Habitat Availability

There is a lack of historical evidence to indicate that Percy Fyfe and Loskop Dam Nature Reserves were ever inhabited naturally by sable antelope. The deficiencies which these animals suffer today in these areas make it unlikely that they would have, or could have, remained for long in these areas under free-ranging conditions. These areas differ so much in habitat structure, nutrient availability and general climatic environment from known good sable habitat that they must be considered as being very marginal at best. The failure of the sable population on Loskop Dam to attain greater numbers over the past two decades indicates that the habitat and nutritional deficiencies must be widespread over the whole reserve.

On a long-term basis, it seems unreasonable to expect any area to sustain roan or sable populations of a density greater than four animals/km^2. This would suggest that even in an area where no nutritional deficiencies are present, the minimum size area required to sustain a healthy population of some 40 to 50 animals would be 1200 to 1500 ha. On the basis of this, it appears that both Percy Fyfe and Loskop Dam are basically deficient in the primary factors; nutritional adequacy in the latter and nutritional adequacy plus space in the former. The types of habitat provided for sable antelope would appear to fall far short of the optimal.

It is certainly possible to supplement the diet of free-ranging animals. The value of protein and mineral supplementation has been shown clearly in this study. However, this is expensive and requires management skill to be effective. Providing the deficient components is discussed below, but the basic question is whether it is worthwhile in the long term to supplement diets on areas where the animals perhaps never occurred before and where numbers, even with relatively intensive management, can never be expected to be adequate because of the lack of space.

The considerable intra-specific aggression demonstrated by roan and sable is probably an evolutionary adaption to ensure sufficient range of good quality for each herd. It is a factor of major importance in the maintenance of herds on relatively small, fenced areas. In the absence of sufficient space to accommodate two or more herds plus small bachelor herds and singletons, it must be expected that young maturing males of 2-3 years of age will be killed by the dominant herd bull. The degree of aggression is amplified when animals are maintained on poor quality habitats of small size, such as Percy Fyfe.

The resultant decision would seem fairly obvious in this case, viz. that both Percy Fyfe and Loskop Dam Nature Reserves be abandoned as conservation areas for sable antelope, and that alternative conservation areas within the Lowveld be sought.

Roan antelope have been shown in this study; and in previous descriptions, to be animals of open grasslands and parkland savanna. Providing certain nutritional deficiencies are supplemented (see below), Percy Fyfe is an adequate refuge for a small population not exceeding about 50 animals. No further limitations of home range should be imposed in this reserve, and careful population control would be required to maintain healthy herds. Loskop Dam is not seen as a potential refuge for roan for obvious reasons.

Hans Merensky is seen as the most important sable antelope refuge under present control of the Nature Conservation Division, but it cannot sustain the present sable numbers on a long-term basis. Forty to 50 animals is the maximum sustainable number for the present Black Hills enclosure . Provided habitat quality and diversity is maintained, and interspecific competition is kept at a low level, no dietary supplementation appears to be required.

Rustenburg Nature Reserve provides adequate habitat for sable antelope, provided the protein and phosphorus deficiencies are corrected (see below). The present sable population can be seen as an expanding one, but even so, the maximum sustainable numbers cannot be expected to exceed about 40, bearing in mind the competition which is likely to occur from the many other grazers present.

It is apparent that there are inadequate provincial conservation areas for rare species such as roan and sable antelope, and those that are established are too small and of poor habitat quality. Substantial areas of at least 10 000 ha in the Lowveld would provide better habitat quality and sufficient space for sable than anything which is available at the present time. Areas of a similar order of size in the north western section of the province are required for sustained conservation of roan antelope. In all cases the available habitats should be carefully surveyed for structure and nutritional adequacy.

Nutritional Supplementation

Supplementing the diets of free-ranging roan or sable antelope on nature reserves could be effected in two ways: either by direct feeding of concentrates and mineral supplements, or by supplementing the soil and thereby raising the nitrogen and mineral levels of the forage plants.

Direct feeding of the animals with protein-rich concentrates in the field is fraught with problems. Except under abnormal 'farmyard' conditions, it will be impossible to feed roan or sable only and not the many other ungulate co-inhabitants of the reserves. Feeding in special enclosures is not a practical propostion for long-term management needs, but is a useful possibility in cases where animals are to be translocated from a refuge to a new site, and adequate milk and body reserves of nutrients are required. Feeding, in all cases, will be expensive.

Direct feeding of mineral supplements is a practical management consideration, however, but is also problematical where a multi-species situation is encountered. A most important consideration, however, is that roan and sable are extremely suspicious of any form of lick or supplement block in the field, and under ordinary conditions will not readily take anything which has a distinctive odour or taste. This eliminates the usefeulness of most standard stock supplements which use molasses as a basic ingredient. However, both roan and sable will readily take salt in the field, and this offers a way in which to supplement trace elements as well, since the latter are usually colourless and tasteless in the concentrations required for dietary supplementation. Each area has its own particular set of deficiencies, however, and salt-trace element licks must be formulated to specifically provide the deficient elements in each case. Rustenburg would required supplementation of selenium (in very small amounts) and probably molybdenum, whereas roan antelope on Percy Fyfe require additional iron, copper, manganese and cobalt, but not zinc which is in abundant supply. Copper, iron, cobalt and selenium supplementation would be adequate for Hans Merensky Nature Reserve.

The salt lick itself would naturally provide the sodium needed to supplement forage levels, and this element alone appears to bear a strong relationship to body condition and body weights. It is not possible, in the case of sable at least, to provide any form of macro-element supplementation along with the salt licks, since this changes the taste of the lick. Phosphorus supplementation can only be provided along with nitrogen in the form of higher plant levels via range fertilization.

Range Fertilization

It has been shown by comparisons of soil, forage and animal tissue levels of the macro-elements in the various study areas that higher levels in the soil are reflected by higher levels in the plants and increased uptake and bodily reserve in the animals. This appears to be the only practical way to supplement phosphates and protein, the two most deficient components, in the diet of free-ranging roan and sable.

A suggested approach would be to select the home ranges of each sable herd, and especially the activity areas known to be frequented, and to systematically and repeatedly apply phosphate and nitrogenous fertilization in the form of superphosphates and ammonium phosphate. Amounts of fertilizer applied will vary with the soil concentrations of phosphates and the amount of leaching taking place. Constant monitoring of the soil phosphate levels, and the forage nitrogen and phosphate contents will have to be undertaken, to be able to adjust application amounts and intensities of application to suit local pedological and topographic conditions.

The effect of long-term nitrogenous fertilizer application will be to change the successional status of the vegetation, and make it revert to a grazing sub-climax. This is in itself beneficial, since sub-climax species are frequently more palatable than climax species, but do not necessarily provide better nutrition. Application of fertilizers will have to be done over a large area, not less than 40-50 ha to avoid severe overgrazing by other resident ungulates, particularly zebra, wildebeest and impala.

Range Burning

Burning has generally the same effects on the successional status of the range as has fertilization, i.e. it pushes the succession back to sub-climax and even pioneer stages. It may well enhance the protein content of the available forage, but will not materially affect the mineral contents, especially if the soil is deficient in elements such as phosphorus.

Burning is thus seen as a valuable management technique to be used in conjunction with fertilization, not necessarily of the same areas, to achieve a better utilization of the whole reserve area by all grazing ungulates. Burning and fertilization of alternative areas could lead to diminished competition between roan and sable on one hand, and other grazers on the other, while providing the rarer species with nutritionally adequate forage in their preferred areas.

Control of Competing Species

All nature reserves today have a multi-purpose role to play in conservation, and it is not always possible, nor even desirable, to eliminate all other species where roan and sable populations are being conserved. Maintenance of a whole spectrum of grazers and browsers is one of the basic tenets of management of any African natural area, and the goal should be to maintain healthy roan and sable herds within such environments, and preferably not in isolation in small unnatural enclosures. This can only be done efficiently in reserves which have sufficient space available, and acquisition of these should be the prime objective at all times.

Competition from other grazing species is something which roan and sable have had to contend with over millenia, but it can assume unnatural proportions on fenced areas. Specific feeders such as roan and sable are always at a disadvantage in a competitive situation, and maintenance of numbers of other species compatible with well-being of roan and sable herds should be a basic management goal for all natural areas where the latter occur.

SUMMARY

Populations and distributions of sable and roan antelope throughout southern Africa have shown alarming declines within recent decades. In the Transvaal province, South Africa, conservation measures centre around legal protection and efforts to maintain viable herds on provincial nature reserves. However, overall population increment rates on these reserves have been low. This 3½ year study was initiated to investigate those aspects of disease, pathology, nutrition, ecology and ecophysiology germane to an understanding of population limitations on nature reserves. Findings were compared to thriving populations nearer the centre of the species' distribution in Africa to elucidate the mechanisms of population limitation and enable the formulation of management considerations.

The study was undertaken primarily on four nature reserves in the Transvaal (Percy Fyfe, Loskop Dam, Rustenburg and Hans Merensky), and on one area in Rhodesia, with additional information from secondary areas. At the beginning of the study an 18-month field observation period was undertaken on Percy Fyfe to elucidate various factors operating on sable and roan populations.

A high number of mortalities was found to occur amongst juveniles, and to a lesser extent amongst older animals. A total of 21 carcasses of sable (16) and roan (5) were recovered on Percy Fyfe. Post-mortem and histopathological examination showed that four protozoal parasites were implicated in the deaths of juvenile sable and roan: _Cytauxzoon_ sp., _Babesia_ sp.,

Chlamydia and *Pneumocystis carinii*. Other mortalities occurred from stress factors and traumatic injuries. Helminthiasis was determined not to be a factor of key importance in body condition. Other sable and roan populations throughout southern Africa were sampled to elucidate the role played by protozoal infections. *Cytauxzoon* piroplasms were found in blood smears of sable and roan from all areas sampled. *Babesia* parasitaemia was encountered in small numbers from all but one Transvaal area, but was found in only one sable from a Rhodesian area. It was determined that *Cytauxzoon* was transmitted from dam to foetus via the placenta.

A significant relationship was found to exist between incidence of *Cytauxzoon* infections in sable antelope and their bodily condition. Further investigation showed that protozoal blood infections were secondary factors in the mortality patterns, and indicated that nutritional factors were a precipitating force operating on the various aspects causing mortality.
The body condition of sable and roan on the various study areas was investigated using several different parameters: total body mass, total plasma proteins (TPP), packed-cell volume of the blood (haematocrit) and the respective albumin and globulin content of the blood.

Body condition of sable antelope differed markedly from Rhodesia to the Transvaal--Transvaal sable were shown to be in very poor condition. The nutritional status of sable and roan was thus considered a primary limiting factor within Transvaal nature reserves, and this aspect was investigated in some depth.

Data from nutritional analyses were obtained from soil, vegetation, water and animal tissues (liver, blood and milk) collected from preferred feeding areas. Most samples were collected during the dry season for comparative purposes. The study adopted essentially a screening approach to the aspect of nutrition, and made use of comparisons between areas to derive conclusions regarding nutritional status and the relationship of nutrition to disease and mortalities. The basic deficiencies on the highland sourveld reserves of Loskop Dam, Rustenburg and Percy Fyfe relate to phosphorus, selenium and protein. Sodium, calcium, magnesium, potassium, iron and copper are linked to the deficiency syndrome.

The various limiting factors on Transvaal reserves all relate back to habitat quality, availability and utilization by sable and roan. An assessment was made of the critical dry-season habitat by measuring the degree of use and the various physical characteristics of preferred areas, and determining the relationship between such use and the already discernible nutritional deficiencies.

Interspecific feeding competion between zebra, waterbuck and impala and sable on Percy Fyfe was measured by microscopic identification of plant fragments taken from the rumens (caecum in the case of zebra) of animals shot while feeding on areas preferred by sable. It was determined that competition was a factor of importance.

Reproductive factors were investigated and it was determined that when a bull was in constant attendance, the calving rate was 100 percent for sable and roan. The gestation length for sable on Percy Fyfe was found to be only 8 months (240-248 days). Roan gestation length is approximately 275 days.

It was determined that sable females entered only one oestrous cycle per year. Roan females enter a post-partum oestrous 2-3 weeks after parturition and can drop a calf every 10-10½ months. Sable antelope were strictly seasonal breeders, however, the herd bull showed sexual interest throughout the year. Roan breed throughout the year and have no defined calving season.

Electro-ejaculation techniques were applied to both immature and mature sable males to elucidate reproductive capability. Subadult males were considered physiologically capable of breeding as early as 16-19 months of age from the appearance of spermatozoa and were shown to be psychologically capable of breeding when separated from the herd bull. Intraspecific aggression by the herd bull towards subadult males was found to be a major limiting factor for this sex and age group of males on smaller nature reserves. Semen examination of adult bulls indicated that there was no reason to assume they were incapable of breeding throughout the year. Breeding success of the sable herds was considered satisfactory.

Management considerations were presented and it was stated that it seems unreasonable to expect any area to sustain sable or roan populations of a density greater than four animals/km^2 on a long term basis. Percy Fyfe and Loskop Dam are considered basically deficient in the primary factors of nutritional adequacy and/or space and it is recommended that they be abandoned as conservation areas for sable. Nutritional supplementation in the form of trace element additives to salt blocks was recommended. Fertilizers were recommended for application on certain areas in conjunction with range burning to enhance the protein content of the forage and to distribute interspecific competition over a greater area. Providing certain nutritional deficiencies are supplemented, Percy Fyfe is considered an adequate refuge for a population of roan not exceeding 50 animals. Rustenburg is seen in a similar light for up to 40 sable. Hans Merensky is seen as the most important sable refuge now under control of the province, however, sable densities should be reduced and maintained at 40-50 animals.

OPSOMMING

Gedurende die afgelope paar dekades het die swartwitpens- en bastergemsbokbevolking en verspreiding onrusbarend afgeneem. In die Transvaal, Suid-Afrika, is bewaringsmaatreëls toegespits op wetlike beskerming en pogings om lewenskragtige kuddes op provinsiale natuurreservate te behou. Die totale bevolkingsaanwastempo op hierdie reservate is egter laag. Hierdie 3½ jaar studie is geloods om ondersoek in te stel na daardie aspekte van siektes, patologie, voeding, ekologie en ekofisiologie nodig vir 'n begrip van bevolkingsbeperkings in natuurreservate. Bevindings is vergelyk met dié van florerende bevolkings nader aan die middelpunt van die spesies se verspreiding in Afrika, om die meganismes van bevolkingsbeperkings toe te lig en om bestuursoorwegings te formuleer.

Die ondersoek is hoofsaaklik op vier natuurreservate in Transvaal (Percy Fyfe, Loskopdam, Rustenburg en Hans Merensky) gedoen, en op een gebied in Rhodesië, met bykomende inligting vanaf sekondêre gebiede. Die ondersoek is begin deur 'n 18 maande -waarnemingsperiode te Percy Fyfe om verskillende faktore wat van toepassing is op bastergemsbok- en swartwitpensbevolkings, toe te lig.

'n Groot aantal vrektes het voorgekom onder jong diere en tot 'n mindere mate onder ouer diere. 'n Totaal van 21 karkasse van swartwitpense (16) en bastergemsbokke (5) is op Percy Fyfe teruggevind. Nadoodse en histo-patologiese ondersoeke het getoon dat vier protosoïese parasiete betrokke was by die vrektes van jong bastergemsbokke en swarwitpense: Cytauxzoon sp., Babesia sp., Chlamydia en Pheumocystis carinii. Ander vrektes het voorgekom as gevolg van spanningsfaktore en traumatiese beserings. Daar is vasgestel dat helmintiase nie 'n sleutelfaktor is in liggaamskondisie nie. Ander swartwitpens- en bastergemsbokbevolkings dwarsoor

suidelike Afrika is gemonster om die rol wat deur protosoïese besmettings gespeel word, toe te lig. Cytauxzoon - piroplasmas is in die bloedsmere van swartwitpense en bastergemsbokke vanuit al die gebiede wat gemonster is, gevind. Babesia parasitemia is orals in klein gevalle gevind behalwe vanaf een Transvaalse gebied, maar is slegs in een swartwitpens vanaf 'n Rhodesiese gebied gevind. Daar is vasgestel dat Cytauxzoon deur die plasenta vanaf die moeder na die fetus versprei word.

Daar is bevind dat daar 'n betekenisvolle verwantskap bestaan tussen die voorkoms van Cytauxzoon besmettings in swartwitpense en hulle liggaamlike toestand. Verdere ondersoek het bewys dat protosoïese bloedinfeksies sekondêre faktore in die mortaliteitspatrone was, en het daarop gedui dat voedingsfaktore 'n bepalende invloed het op die verskillende aspekte wat sterftes veroorsaak. Die liggaamlike toestand van swartwitpense en bastergemsbokke op die verskillende gebiede is ondersoek deur middel van verskeie parameters: totale liggaamsmassa, totale plasmaproteïnes (TPP), die saamgepakte selvolume van die bloed (hematokrit) en die albumien en globulien inhoud respektiewelik van die bloed.

Die liggaamlike toestand van die swartwitpense het noemenswaardig verskil tussen Rhodesië en die Transvaal - Transvaalse swartwitpense het geblyk in 'n baie swak toestand te wees. Daar is dus gevoel dat die voeding standaard van swartwitpense en bastergemsbokke 'n primêr beperkende faktor in die Transvaalse natuurreservate is, en hierdie aspek is deeglik ondersoek.

Gegewens vir voedingsanalises is verkry vanaf die grond, plantegroei, water en dierweefsel (lewer, bloed en melk) wat in die verkose voedingsareas verkry is. Vir vergelykende doeleindes is die meeste monsters gedurende die droë seisoen versamel. Die ondersoek is hoofsaaklik benader vanuit 'n siftingsoogpunt ten opsigte van die voedingsaspek, en het gebruik gemaak van vergelykings tussen verskillende gebiede om gevolgtrekkings te maak ten opsigte van die voedingstandaard en die verhouding van voeding tot siektes en sterftes. Die basiese tekortkominge op die hoër liggende suurveld reservate te Loskopdam, Rustenburg en Percy Fyfe dui op fosfor, selenium en proteïen. Natrium, kalsium, magnesium, yster en koper word gekoppel aan hierdie tekortsindroom.

Die verskillende beperkende faktore op Transvaalse reservate kom almal neer op habitatgehalte, beskikbaarheid, en benutting deur die bastergemsbok en swartwitpens. 'n Waardebepaling van die kritieke droëseisoenomgewing is gemaak deur die mate van benutting en die verskillende fisiese eienskappe van verkose gebiede te meet; en deur die vasstelling van die verband tussen sulke benutting en die reeds waarneembare voedingstekorte.

Voedingskompetisie tussen die kwagga, waterbok en rooibok en swartwitpens op Percy Fyfe is gemeet deur mikroskopiese uitkenning van plantfragmente geneem uit die rumen (caecum in die geval van kwagga) van diere wat geskiet is, terwyl hulle gewei het op gebiede wat deur swartwitpense verkies word. Daar is vasgestel dat kompetisie 'n belangrike faktor is.

Voortplantingsfaktore is ondersoek en daar is vasgestel dat, waar 'n bul gedurig beskikbaar was, die kalfpersentasie 100 was vir die swartwitpens en bastergemsbok. Die dragtigheidsperiode vir die swartwitpens op Percy Fyfe het geblyk slegs 8 maande te wees (240-248 dae). Die bastergemsbok se dragtigheidsperiode is sowat 275 dae. Daar is vasgestel dat swartwitpensooie slegs een oestrusperiode per jaar het. Bastergemsbokooie het 'n verdere bronstige periode van sowat 2-3 weke na geboorte en kan elke 10-10½ maande kalf. Swartwitpense het egter streng volgens seisoen geteel, maar die kuddebul het dwarsdeur die jaar seksuele belangstelling getoon. Bastergemsbokke teel dwarsdeur die jaar en daar is geen definitiewe kalfseisoen nie.

Elektro-ejakulasie tegnieke is toegepas op jong sowel as volwasse swartwitpensbulle om hulle voorplantingsvermoë toe te lig. Jeugdige bulle, op 16-19 maande ouderdom, is volgens die voorkoms van die spermatozoa, beskou as fisiologies in staat te wees om te teel. Dit is bewys dat hulle sielkundig in staat is om te teel wanneer hulle verwyder is van die kuddebul. Intra-spesifieke aggressie van die kuddebul teenoor jeugdige bulle was 'n belangrike beperkende faktor vir hierdie geslags- en ouderdomsgroep op die kleiner natuurreservate. Semen ondersoeke van volwasse bulle het daarop gedui dat daar geen rede was om aan te neem dat hulle nie in staat was om dwarsdeur die jaar te teel nie. Die teelsukses van die swartwitpenskuddes was as bevredigend beskou.

Bestuuroorwegings is voorgelê en daar is vermeld dat dit onredelik sou wees om te verwag dat enige gebied swartwitpense of bastergemsbokke in digter bevolkings as vier diere per km^2 kan dra op 'n langtermynbasis. Percy Fyfe en Loskopdam word beskou as basies gebrekkig aan die primêre faktore van voldoende voedsel en/of ruimte en daar word voorgestel dat hulle nie langer as bewaringsgebiede vir swartwitpense gebruik word nie. Byvoedings in die vorm van spoorelementtoevoegings by soutblokke is aanbeveel. Daar is aanbeveel dat misstowwe op sekere gebiede toegedien word tesame met selektiewe veldbrande om die proteïninhoud van die weiding te verbeter en om kompetisie oor 'n groter area te versprei. Mits sekere voedingstekorte aangevul word, word Percy Fyfe beskou as 'n bevredigende heenkome vir 'n bastergemsbok bevolking van uiters 50 individue. Op dieselfde basis kan Rustenburg tot 40 swartwitpense dra. Op die oomblik word Hans Merensky beskou as die belangrikste swartwitpenstoevlugsoord, tans onder die Provinsie se beheer, maar swartwitpensbevolkings behoort op 'n vlak van 40 tot 50 diere gehou te word.

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