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THE POPULATION ECOLOGY OF THE ROAN ANTELOPE, *HIPPOTRAGUS EQUINUS EQUINUS* (DESMAREST, 1804), IN THE KRUGER NATIONAL PARK.

BY

SALOMON CORNELIUS JOHANNES JOUBERT

Submitted in partial fulfilment of the requirements
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in the

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by

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ABSTRACT

The past and present distribution of the roan antelope, *Hippotragus equinus equinus* (Desmarest, 1804), is given. Although endangered in several areas the roan is still widely distributed over Sub-Saharan Africa. Age determination may be accomplished by several criteria and ensure a high degree of accur among sub-adult animals. Population attributes, including reproduction, mortality factors and population trends, are presented. Feeding behaviour and the specific preference of roan for particular food plants is discussed. Habitat preferences were determined with emphasis on the structural features of roan habitats. Taking into consideration the socio-ecological needs of roan, suggestions are made for the management of this antelope in the Kruger National Park.

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CHAPTER 1 : INTRODUCTION

The results presented in this dessertation represent the second part of a long-term study of the bio-ecology of the roan antelope Hippotragus equinus equinus (Desmarest, 1804) in the Kruger National Park (henceforth also referred to as Kruger Park or the Park). The project was initiated at the end of 1967 and concentrated primarily on those factors which influence roan population growth and contribute to a better understanding of the management of the species.

STUDY AREA

Details of the localised study areas within the Kruger Park are given in the relevant chapters in this study and will receive no elaboration here. As a whole, the Kruger Park is situated along the north-eastern border of the Transvaal Province of the Republic of South Africa. It falls within the area generally known as the Lowveld, i.e. the area below the escarpment of the Drakensberg Mountain Range which extends, with a gradual decline, to the coastal plains bordering the Indian Ocean. It lies between latitude 22°25' to 25°32' S and longitude 30°50' to 32°02' E with the highest altitude (approximately 835 m) in the south-west and a gradual decline eastward to altitudes varying from 180 to 240 m .

The Kruger Park comprises an area of just over 19 400 km^2 and thus represents one of the world's largest national parks. The area is elongate in shape with a total length of approximately 320 km and an average width of roughly 65 km, being slightly broader in the southern areas where it extends to the foothills of the Drakensberg Mountains.

Topographically the area is generally flat or undulating with a number of inselbergs spread over its length in the western half. High mountain ranges are absent although the Malelane and Punda Milia areas could be termed mountainous. The Lebombo Mountain Range which extends northwards along the eastern border, is rugged and fairly mountainous in a few areas

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but generally forms a flat plateau and disappears completely halfway between the Shingwidzi and Limpopo rivers.

The relief of the Park being from west to east, all the major rivers and seasonal watercourses are east flowing. The Kruger Park is drained by two major systems, i.e. the Incomati System in the south and the Limpopo System in the north (Pienaar 1968). Apart from a limited portion of the Limpopo River forming the extreme northern boundary, neither of these rivers are ecologically important to the Park. However, some of their primary tributaries flow through the Park and form an integral part of the ecology of the area. The rivers of the Incomati System include the Crocodile, which may be considered perennial although its flow diminishes to a mere tricle in dry years, and the Sabi River which at present represents the strongest flowing river of the Park. The Sand River is a major tributary of the Sabi and is also perennial. The Limpopo System is represented by the Olifants, Letaba, Shingwidzi and Levubu rivers of which all but the Shingwidzi River are perennial. Both the Letaba and Levubu rivers were strongly perennial until as recently as 1965 but now also stop flowing during particularly dry winter seasons.

In addition to the larger rivers mentioned above, each also has its own series of tributaries (Fig. 1) and although all those traversing the Park are only seasonal, many have large permanent or semi-permanent waterholes which retain their water through, or at least well into, the dry season. Other natural water supplies in the Park include a limited number of springs which are sparsely but well distributed throughout the area.

According to the diaries and memoirs of the early pioneers in the Lowveld, the distribution and volume of the natural water resources have progressively diminished through the years. To stabilize the once permanent rivers and waterholes in the Park, large concrete dams and weirs are being

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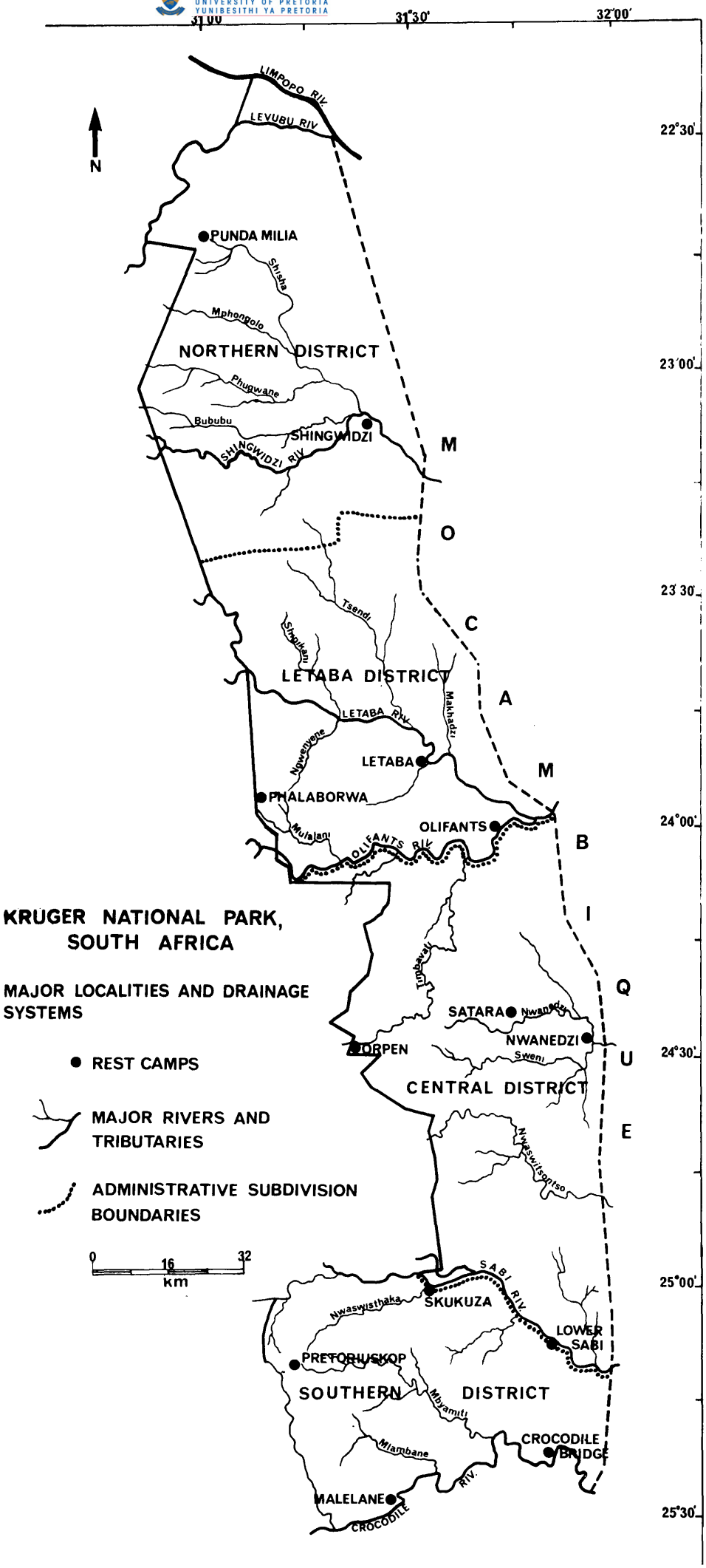

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built in some of the main rivers while further watering points have been provided by a multitude of earthen dams and boreholes fitted with windmills.

The geology of the Kruger Park (Fig. 2) has been discussed in some detail by Van der Schijff (1957), Pienaar (1966) and a detailed account of the northern areas by Schutte (1972 a and b, 1974). The geological composition of the area is represented by the Swaziland System, Archaic granite, the Dominium Reef, Loskop, Waterberg and Karoo systems. Irrespective of their origins, the western areas of the Park are predominantly represented by granite formations with local dolerite intrusions. The eastern half consists mainly of basalt while rhyolite is the dominant rock formation of the Lebombo Mountains. Sandstone is represented by a narrow belt stretching north-south which forms a division between the granites and the basalt. The area to the north of Punda Milia is also largely composed of sandstone.

Although considerable local variation is apparent in the structure, texture, chemical composition and colour of the numerous soil-types of the Park (Van Wyk pers. comm.*), three major groups of soil may be differentiated on the basis of their origin, i.e. those derived from granite, basalt and sandstone. The granitic soils are generally fairly sandy with some clay elements in the subsoil or depressions due to leaching or erosion and are usually light in colour; the soils derived from sandstone are usually deep sands while those of basaltic origin are usually heavy clay, red or brown to black in colour and attain depths of up to a metre or more.

Climatically two distinct seasons may be differentiated, i.e. the hot summer season with temperatures frequently exceeding 40°C and the cold, dry winter season. The summer starts towards the end of September (spring) and continues until March (autumn). The higher temperatures of the summer

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*References cited as personal communication or In litt are listed in a separate reference list on page 268.

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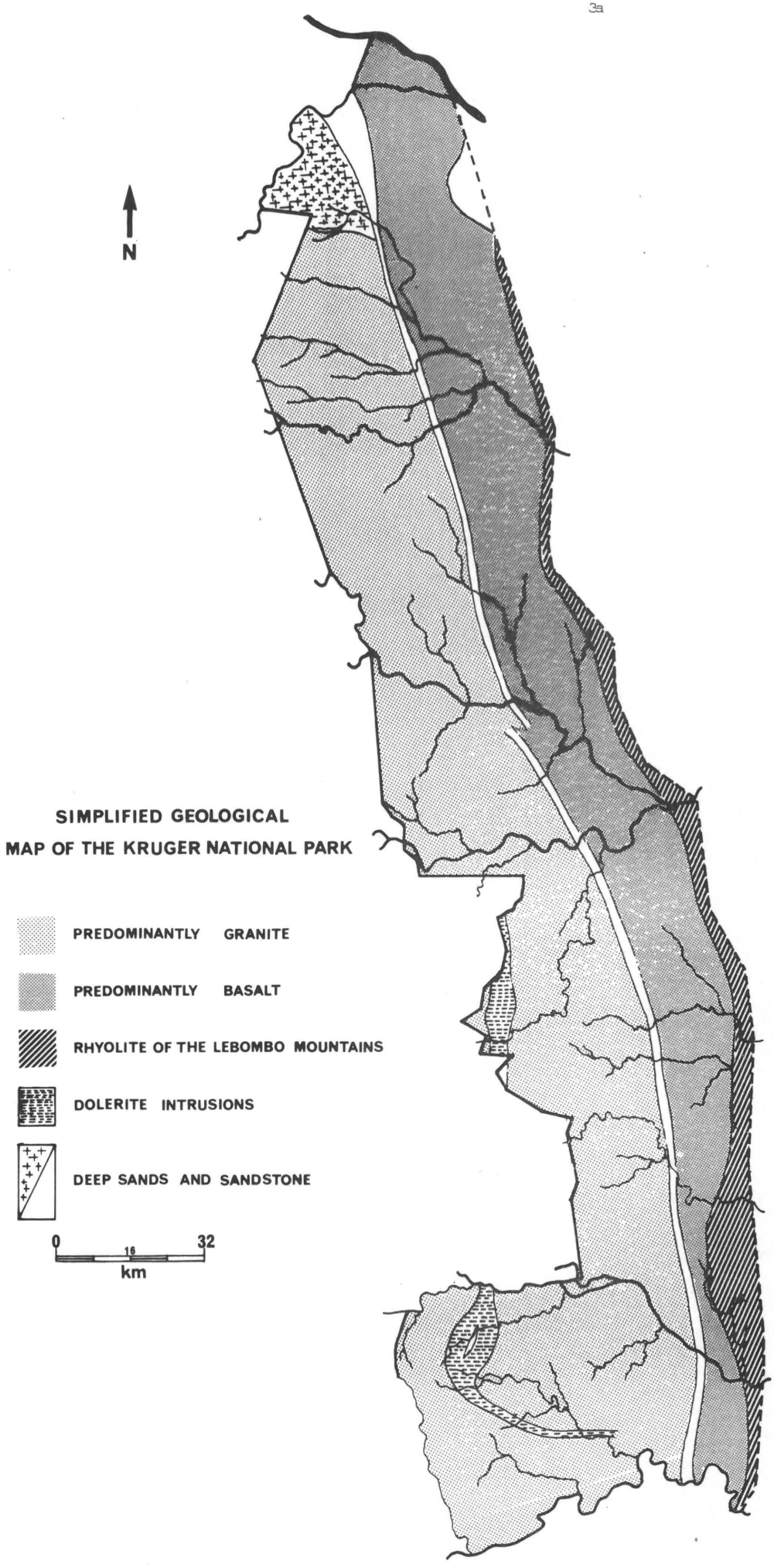

Figure 2 : Simplified geological map of the Kruger National Park, South Africa.

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months are also accompanied by an increase in the length of daylight. The period from early April to September delimits the winter season with temperatures that only occasionally drop to zero and with longer nights and shorter days. Frost is exceptional and then mainly limited to low-lying depressions.

Phillips (1965) has described the area as sub-arid to arid wooded savanna, hereby indicating the relatively low annual precipitation. Rainfall occurs in and is largely limited to the summer months while the winter months represent the 'dry' season with only occasional showers. Precipitation may be either in the form of short, severe thunderstorms which result in rapid run-off, flooding of the drainage systems and consequent erosion, or occurs as soft drizzles lasting for two or three days. The highest mean annual rainfall occurs in the southern areas (706,1 mm; n = 20 years, Table 1), and the lowest, approximately 400 mm, in the extreme north-eastern areas. The greater part of the Park receives an average rainfall in the region of 500 to 600 mm (Table 1). One of the main features of the rainfall is its extreme variability from one year to the next, in some years exceeding 900 mm while dropping to as low as 350 mm in others. Due to the irregularity of the rainfall the area is frequently subjected to droughts, the severity of which depend on the rainfall of the preceding years and the duration of the drought. A further consequence of the rainfall pattern is the variability in the natural water resources available to wildlife from one year to the next.

The vegetation of the Kruger Park has been discussed in great detail by Van der Schijff (1957, 1959) with supplementary notes by Pienaar (1963), Brynard (1964) and Van Wyk (1971, 1972). Eight major vegetation zones, each with numerous sub-divisions depending on the degree of detail required, are identifiable, i.e. *Terminalia sericea* - *Dichrostachys cinerea* communities, *Combretum* spp. - *Acacia* spp. communities, *Acacia nigrescens* - *Sclerocarya caffra*

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Table 1 : Mean annual rainfall (mm) at various stations in the Kruger National Park, South Africa (Brynard 1964).

STATION	NUMBER OF YEARS SAMPLED	MEAN RAINFALL (mm)
Pretoriuskop	20	706,1
Malelane	19	604,3
Crocodile Bridge	20	621,3
Skukuza	43	571,0
Tshokwane	21	587,8
Satara	25	550,2
Letaba	26	427,7
Shingwidzi	23	435,6
Shangoni	17	569,7
Punda Milia	26	528,1
Pafuri	21	398,3

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communities, Colophospermum mopane Shrub Savanna, Combretum apiculatum - Colophospermum mopane communities, the communities of the Sandveld and Lebombo Mountains and mixed Combretum spp. communities (Fig. 3).

Faunistically the area is particularly well endowed and, in addition to the rich variety of freshwater fishes (Pienaar 1968), amphibians (Pienaar In press), reptiles (Pienaar 1966), birds (Kemp 1974) and smaller mammals (Pienaar 1964), the larger mammals (Pienaar 1963) are also well represented. In Appendix 1 the various larger mammal taxa and their respective population estimates for 1973/1974, as derived from ground and aerial censusses, are given.

MOTIVATION FOR THE PRESENT STUDY

On examining the numerical status of the roan antelope in Appendix 1, it is immediately apparent that it represents one of the rarest herbivores in the Kruger Park. The loss of a major portion of the roan's favoured habitats in the erstwhile Sabi Game Reserve with the proclamation of the present-day Kruger National Park, and with it a substantial proportion of the roan population in the excised areas, the roan's susceptibility to anthrax and their apparent inability to increase their numbers and extend their range within the Kruger Park are all factors which caused grave concern for the future safety of the roan antelope. More than anything else, the two anthrax epizootics between 1959 and 1962 (Pienaar 1960, 1961) and the losses suffered by the roan population dramatically exposed their vulnerability. The need for a detailed scientific investigation into the limiting factors affecting this antelope and the subsequent management of existing populations of roan therefore became a matter of priority to ensure the perpetuation of these populations. The results contained in this study and in Joubert (1970) are the outcome of a project on the bio-ecology of the roan with the aim of achieving the above-mentioned objectives.

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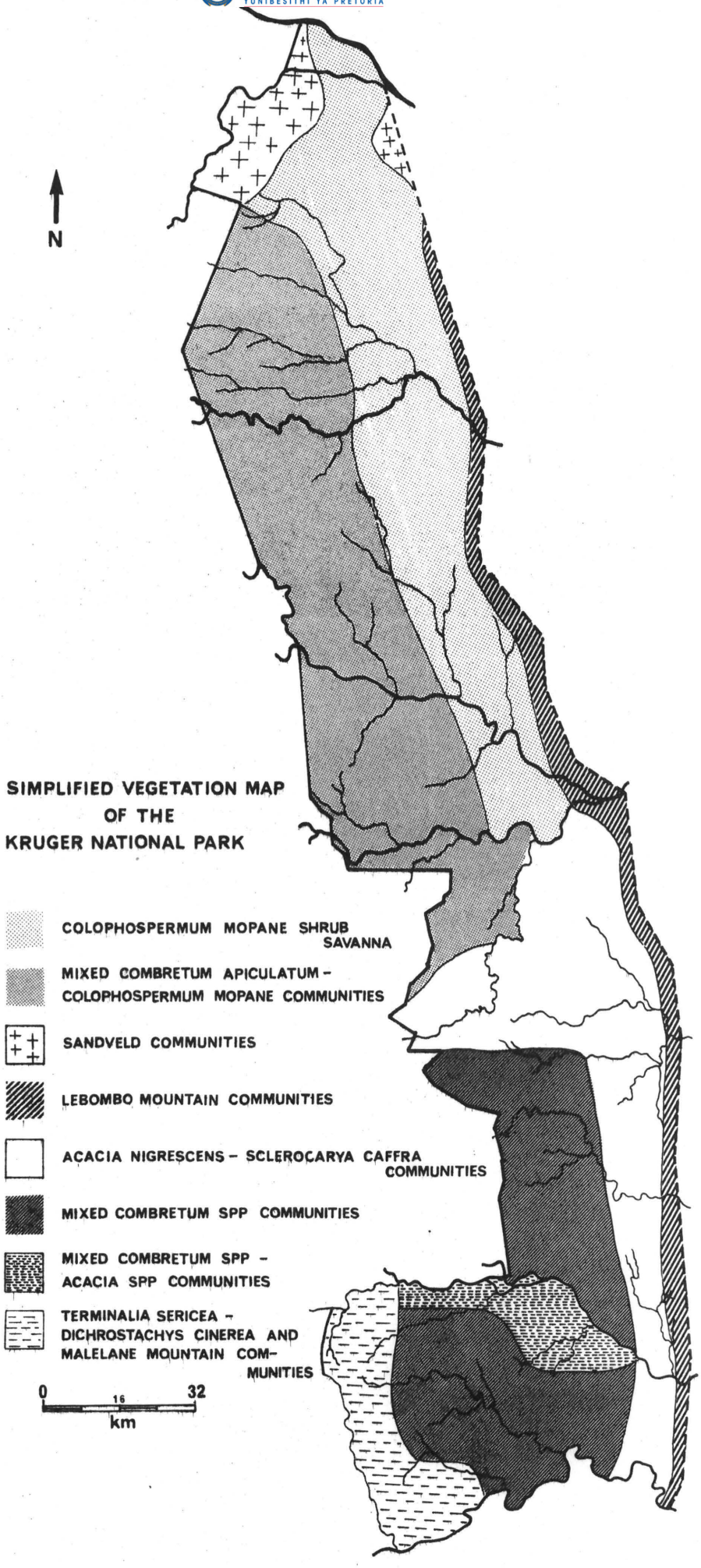

Figure 3 : Simplified vegetation map of the Kruger National Park, South Africa.

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PREVIOUS STUDIES ON THE ROAN ANTELOPE

In spite of the wide geographical occurrence of the roan antelope in Sub-Saharan Africa, no thorough study on the ecology of the species has, as yet, been undertaken. General notes on the obvious characteristics of the roan antelope are common in the literature but rarely convey anything more than a superficial description of herd sizes, herd structure and habitat preferences in the broadest terms. The most detailed of these articles include those of Jobaert (1951) and Blower (1961).

In more recent years Gaerdes (1966) and Best, Palmer, Shephard and Wilson (1970) have undertaken detailed surveys of the past and present distribution of the roan in South West Africa and Rhodesia respectively.

The only study which has been undertaken on some aspects of the ecology of the roan is that of Child and Wilson (1964). This study was conducted during tsetse-fly (Glossina morsitans) operations in parts of Zambia and Rhodesia and yielded valuable, though limited, data on aspects such as seasonal movements, feeding behaviour and reproduction.

Morphological studies of phylogenetic and possibly taxonomic interest have been undertaken by Oboüssier (1963, 1974).

Joubert (1970, 1974a) gave a detailed account of the social organisation of the roan and indicated that some aspects of their social organisation, especially herd unity, spatial distribution in exclusive activity zones and some features of the mother/young relationship, play an important role in their ecology by influencing calf survival and population densities.

Huntley (1971a) obtained some data on sexual maturity of roan in the Percy Fyfe Nature Reserve, South Africa, while Wilson (pers. comm.) is at present involved in an intensive study of the limiting factors affecting the roan antelope and its congeneric, the sable antelope (H. niger).

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CHAPTER 2 : STATUS OF THE ROAN ANTELOPE

INTRODUCTION

In spite of the wide range of distribution of the roan antelope throughout most of Sub-Saharan Africa, very little is known of its biology or even of its present status in the areas where it still exists. As in the case of many other African antelopes, the general tendency pertaining to roan since the turn of the century has been one of declining numbers and steadily decreasing range of distribution. In this chapter an attempt is made to assemble the information available on the roan's present distribution and the status of the various subspecies.

TAXONOMIC STATUS

The most recent reappraisal of the taxonomic status of the roan appears in Ansell (1971). Evaluating the evidence presented by Simpson (1945), Ellerman and Morrison-Scott (1951), Haltenorth (1963) and others (In: Ansell 1971), Ansell acknowledges the sub-family Hippotraginae (family Bovidae) with five tribes, i.e. Peleini (Pelea), Reduncini (Redunca and Kobus), Ammodorcadini (Ammodorcas), Hippotragini (Addax, Hippotragus and Oryx) and the Alcelaphini (Connochaetes, Alcelaphus and Damaliscus).

Three distinct species are recognised under Hippotragus of which one, H. leucophaeus (Pallas, 1766) has recently become extinct while the other two, H. niger (Harris, 1838), the sable antelope and H. equinus (Desmarest, 1804), the roan antelope, are still well represented. Mohr (1967) and Klein (1974) have reviewed all available literature on H. leucophaeus (the blaauwbock) which inhabited a restricted range in the south-western and southern districts of the Cape Province, South Africa. During the latter half of the eighteenth century the blaauwbock became uncommon (Thunberg 1774, In: Mohr 1967) and the last one was

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recorded towards the end of that century and thereby became the first recorded African mammal to become extinct within historical times (Harper 1945). The second species, H. niger, is still widely distributed, albeit in reduced numbers, from the eastern and northern Transvaal in the south, in patches throughout most of central southern Africa and northwards to Kenya and Tanzania in East Africa. The third species, H. equinus, has the widest distribution (Fig. 4, 5 and 6) extending from the Transvaal in the south (historically the Orange River) northwards into the Northern Savanna zone (Ansell 1971).

Although numerous subspecies have been described for H. equinus, no thorough taxonomic investigation of the species has, as yet, been undertaken. With the lack of any detailed knowledge of the anatomy of the various geographical races, the only criteria on which the differentiation of subspecies have been based are general pelage colour and the relative lengths of the horns and ear tufts. However, as Bryden (1936) has pointed out " ... even among the roan antelopes found in South Africa great variation of colour is often seen". After inspection of museum collections of roan skins from different parts of Africa, Bryden (1936) came to the conclusion that " ... too much importance has been attached ... to these colour variations in naming the sub-species ... ", and mentions a case in which the colouration of two subspecies, H. e. typicus (now equinus) and H. e. langheldi were " ... precisely similar in colour, and might well have come out of the same herd." Ansell (1971) also stated that "the validity and limits of several subspecies are unclear" and cautioned that his listed subspecies should be considered as provisional.

In spite of the rather uncertain situation, many of the earlier writers accepted four races or subspecies (among others Bryden 1936, Blower 1961). However, Ansell (1971) listed six subspecies and as his results represent the most recent investigation into the taxonomic status of the species,

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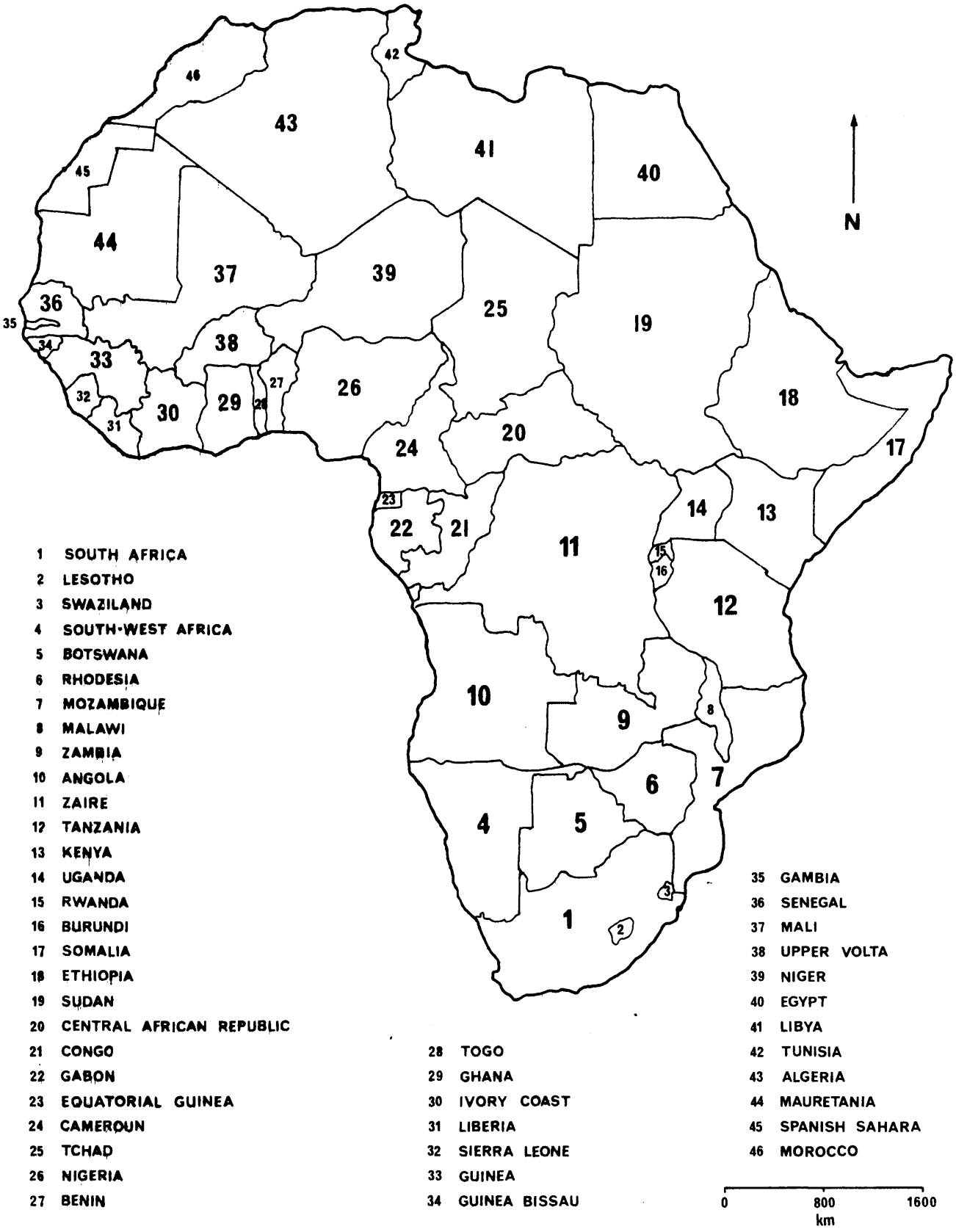

Figure 4 : The political divisions of Africa.

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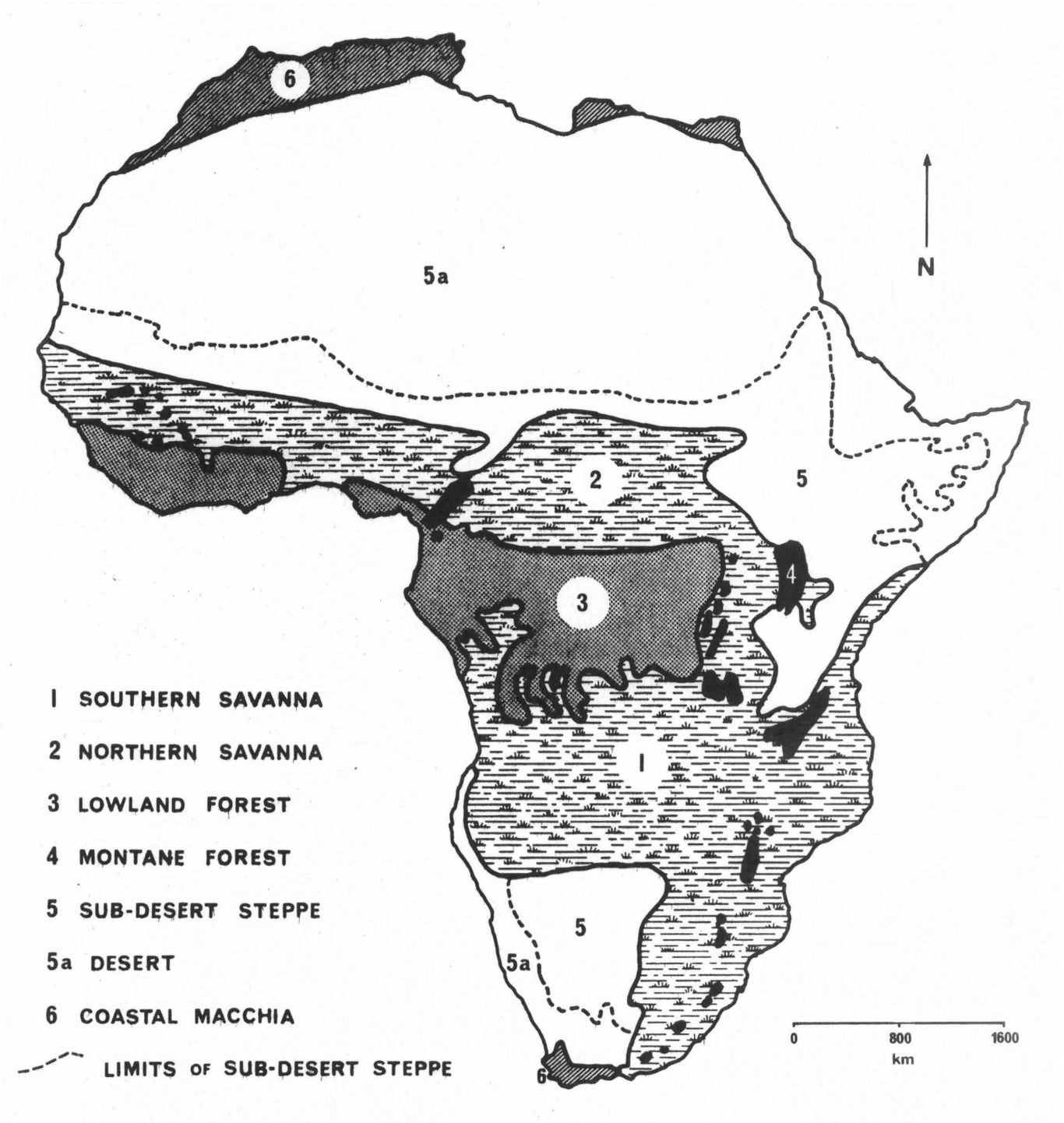

Figure 5 : The major biotic zones of Africa (From Moreau 1952 and Ansell 1971).

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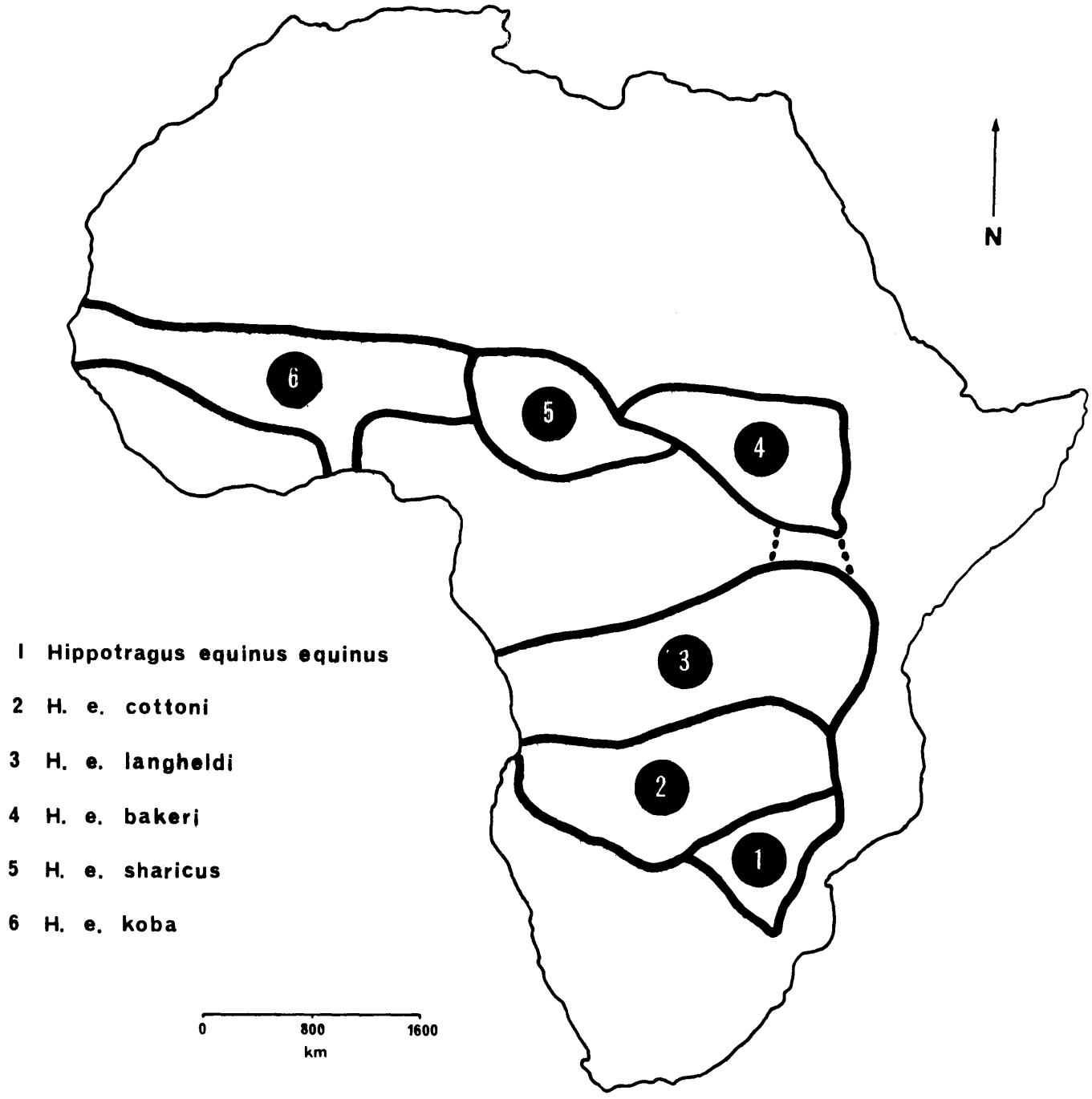

Figure 6 : The geographical distribution of the six subspecies of the roan antelope.

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his classification follows below.

(i) H. e. equinus (Desmarest, 1804). This subspecies has also been referred to as aethiopica Schinz, 1821; jubata Goldfuss, 1824; barbata H. Smith, 1827; aurita H. Smith, 1827; truteri Fischer, 1829 and typicus Sclater and Thomas, 1899.

In historical times the roan antelope's range extended to the Orange River in the south but presently it occurs from the northern and eastern Transvaal northwards through Rhodesia, Mocambique and the southern parts of Malawi. (Ansell 1971).

According to Best, Edmond-Blanc, Raw and Courtenay Witting (1962) the characteristic features of this subspecies are the black forehead in both sexes and a general ground colour of greyish-roan.

(ii) H. e. cottoni Dollman and Burlace, 1928. Its range extends from Angola and southern Zaïre in the west, eastwards through Zambia and possibly to central and northern Malawi. According to Ansell (1971) there are extensive areas of intergrading and therefore no distinct limits between this subspecies and equinus to the south and langheldi to the north of it. This probably accounts for the fact that it was only differentiated as a new subspecies in 1928, by Dollman and Burlace on the basis of the "rich rufous tint" of the ground colour. The horns reportedly also "average somewhat less in length than in the typical race." Subspecies (i) and (ii) have often been referred to as constituting the "southern race" of the roan antelope (Best et al. 1962).

(iii) H. e. langheldi Matschie, 1898. The typical east African form which separates from cottoni in northern Malawi - southern Tanzania and extends further northwards through Tanzania, Kenya, Ruanda, Burundi and into southern Uganda. Neumann (1898) described it as rufopallidus and

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based his description on the "pale reddish" body colour which is "lighter in some specimens and more red in others". Its main difference from equinus is the lack of any "brownish or greyish tints" and is never as dark red as the western subspecies (H. e. koba). The terminal ear tufts are not as long as in H. e. bakeri (Neumann 1898). The forehead of both sexes of langheldi are chestnut in colour and the horns are shorter than in the southern forms (Best et al. 1962).

(iv) H. e. bakeri Heuglin, 1863. Although the limits between bakeri and sharicus are not clear, with some intergrading between the two, bakeri's distribution includes northern Uganda, north-eastern Zaïre, Ethiopia, the Sudan and south-eastern Tchad. It has also been referred to as doggetti de Beaux, 1921. According to Sclater (1868) this subspecies is characterised by its pale fulvous colour and described as a "paler animal altogether" than equinus by Best et al. (1962).

(v) H. e. sharicus (Schwarz, 1913). Its main range includes Cameroun, western Tchad, the Central African Republic and eastern Nigeria, while "intergrading with forms to east and west indeterminate" (Ansell 1971).

(vi) H. e. koba (Gray, 1872). The typical "western form" of the roan antelope and extends from western Nigeria westwards along the Northern Savanna zone into Gambia and Senegal. It has also been referred to as docoi Gray, 1872 and gambianus Sclater and Thomas, 1899.

This subspecies is distinguished by its deep red colour especially in the immatures, and which becomes a "pale tawny" in adults but without any of "the bluish grizzling of the typical race". In both sexes the forehead is chestnut (Best et al. 1962).

From this brief account it is clear that the taxonomic status of this species is all but settled, with little progress being made since 1936, when Bryden (1936) wrote: "The conclusion I come to after the examination of all

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these skins and specimens is that there is but one roan antelope all over Africa".

DISTRIBUTION

Under this section the original intention was to attempt to trace the past distribution of the roan throughout its range and to compare it with its present position. However, it was soon realised that in many areas even its present status is so poorly known that such an attempt would have been futile. Not discarding this idea entirely, it is still considered worthwhile to present the information gained from various correspondents, as much of it is not readily available in the literature and may therefore be of some value.

In evaluating the present conservation status of the roan, special mention has been made of the protected areas in which it occurs. It is encouraging to find that the roan still exists in numerous national parks, game reserves or controlled hunting areas throughout its range of distribution. However, one has to caution that the standards of protection and law enforcement differ considerably from one area to the next and in many areas hunting and poaching appear to be rife in poorly guarded and irregularly patrolled national parks. This is not a problem affecting only roan antelope but all other species are involved and it can only be hoped that aid will be forthcoming to many of the developing countries to preserve their rich wildlife heritage while they are still in a position to do so.

South Africa

Probably the first documented encounter with the roan antelope in southern Africa is mentioned by Barrow (1806, In: Du Plessis 1969) in an appendix to a review of the journey of Truter and Somerville into the interior of the Cape Province in 1801. The roan is mentioned from the neighbourhood of the present-day town of Kuruman. According to Sclater and Thomas (1894) the

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first explorer to describe and illustrate the roan was Daniell in 1804 in his "African Scenery and Animals", from two animals observed in the vicinity of Leetakoo (between Kuruman and Vryburg, according to Du Plessis 1969). While referring to the period in the eighteen-thirties, Sir Andrew Smith is quoted by Sclater and Thomas (1894) as stating that "not very many years ago the animal was frequently seen within the northern boundary of the Cape Colony, and if we are to credit the statements of the aborigines there was a time when it occurred much more to the southward than even the locality alluded to, and from which it has now in great measure disappeared".

Exactly how far south the range of the roan extended is not clear and Sclater (1900) is adamant that "there is no evidence that this species ever extended south of the Orange River". Buckley (1876) speculated on the possibility that the Kalahari desert formed the south-western limits in its distribution. However, fossil remains indicate that the roan also occurred in the eastern Cape (Klein 1974).

North of the Orange River the roan's range of distribution covered most of Griqualand West and the adjoining areas of southern Botswana although its numbers were already dwindling in these areas in the latter half of the nineteenth century (Sclater 1900). Further mention of the occurrence of the roan in Griqualand West is made by Cumming (1850) and Bryden (1899), and according to Kirby (1899), Smith encounterd it along the Malopo River in 1835. Semi-fossil remains also indicate that it once ranged widely in the present-day Orange Free State as horns have been collected at Florisbad, Cornelia, Mahemspan, Rusfontein and Koffiefontein (Hoffman In litt.)

In historic times the roan was also known to occur extensively over most of the western, northern and eastern areas of the Transvaal. Probably the first authentic record of this species in the Transvaal dates back to 1835 when

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Smith (according to Kirby 1940, In: Du Plessis 1969) found it at the confluence of the Little and Great Marico rivers in the western Transvaal. A few years later Methuen (1848) recorded it from the Mosega (Zeerust) area, and Harris (1852) found it along the upper reaches of the Crocodile River in the vicinity of the Magaliesberg. Harris (1852) also mentioned that it "inhabits the elevated ridges near the source of the Vaal and Limpopo rivers".

Bryden (1899) gave the roan's general distribution as the northern and eastern Transvaal. Kirby (1846) drew attention to the rarity of the roan but pointed out that it still occurred along the foothills of the Drakensberg Mountain Range in the vicinity of Mariepskop along the upper reaches of the Timbavati River and along the Olifants River. Rendall (1895) also referred to "a few" still occurring along the Olifants River. Glynn (1926) referred to roan in the White River, Legogote and Pretoriuskop areas of the eastern Transvaal in the final quarter of the nineteenth century.

In a letter to Stevenson-Hamilton (1924) he was informed by an early hunter, whose name is not mentioned, but who frequently hunted between the Usutu and Crocodile rivers between 1870 and 1877, that neither roan nor giraffe (Giraffa camelopardalis) were encountered south of the Incomati River. In what is apparently the Crocodile-Incomati region along the Lebombo Mountains the same informer wrote that " ... blue wildebeest (Connochaetes taurinus), zebra (Equus burchelli) and impalas (Aepyceros melampus) were in swarms; they were simply a nuisance, ... no end of warthogs (Phacochoerus aethiopicus) also; roan, kudus (Tragelaphus strepsiceros), waterbuck (Kobus ellipsiprymnus) and tsessebe (Damaliscus lunatus lunatus) were plentiful, but I seldom saw a sable along the Bombo (sic) belt".

The furthest south-eastern extension in the distribution of the roan seems to have been Swaziland (Buckley 1876). Bryden (1899), Sclater (1900), and Bryden (1936) also refer to their occurrence in Swaziland although no indi-

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cation of their distribution within the area is given.

It is noteworthy that Drummond (1875) who hunted extensively in northern Zululand and the adjoining areas between 1867 and 1872, fleetingly mentions hunting oryx (Oryx gazella) in this region. However, it is accepted that the range of the true oryx never extended so far east (Buckley 1876) and in all probability the 'oryx' referred to may have been roan antelope. Unfortunately Drummond (1875) does not give any indication of the locality of his camp during the 'oryx' hunt and as he occasionally crossed the Usutu River and the Lebombo Mountain further to the north, the incident referred to may well have taken place in Swaziland or southern Mocambique. However, the occurrence of roan in northern Zululand must be regarded as a distinct possibility. Baldwin (1863) who also hunted in this area and who was well acquainted with both roan and oryx from hunting expeditions further afield, does not mention either of these antelopes for Natal or Zululand.

The general impression gained from the references of the pioneer travellers and hunters is that the roan was never abundant in South Africa, in spite of its wide distribution. Buckley (1876) referred to it as "probably the rarest of the genus; nowhere does it appear very common", the latter statement being confirmed by Selous (1881). By the turn of the century Sclater (1900) regarded it near to extinction in the Griqualand West area and very rare in the eastern Transvaal.

It is probable that within the first thirty years of this century it became extinct over the major part of its erstwhile range in South Africa and natural populations (Fig. 7) are presently confined to:

(i) A remote area on the plateau of the Waterberg Mountain Range in the northern Transvaal. No systematic census of this remnant population has been undertaken but it is possible that 40 to 50 animals still survive within an area of some 3 500 ha of privately owned land in

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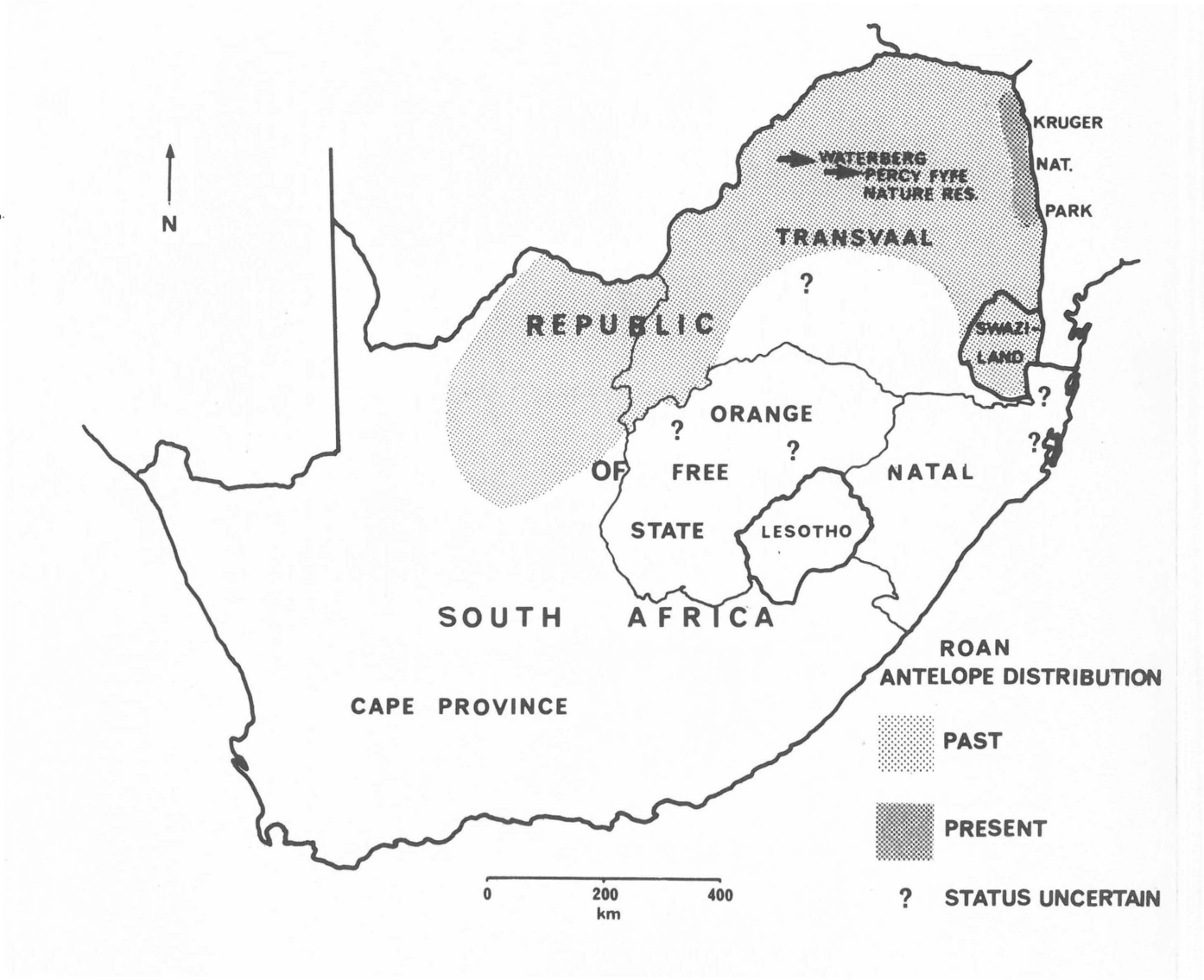

Figure 7 : The past and present distribution of the roan antelope in South Africa.

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the New Belgium Block, situated between the Palala River in the north, the Goud River in the north-west and the Koedoesloop in the south (Kettlitz In litt.).

In a more recent survey, Lambrechts (1974) estimated the total Waterberg roan population at 80 which occur in two subpopulations of about 40 each. Of these only about 10 are in properly fenced enclosures. His total estimate for the Transvaal, excluding the Kruger National Park, is not more than 100.

(ii) The confines of the Kruger National Park in the eastern Transvaal with a population of 260 to 300.

According to the late Ranger D.H. Swarts of the Kruger Park, who was employed as a policeman in the Squamans area in the south-eastern extremes of the Transvaal (on the Swaziland border) in the early 1950's a few roan then still existed in the remote areas of that district. No information has since been received of these roan and the remnant population is believed to have become extinct (Pienaar pers. comm.).

In the late 1960's the Transvaal Provincial Administration captured and translocated a number of roan from the Waterberg district to the Percy Fyfe Nature Reserve near Potgietersrust in the northern Transvaal. This herd adapted well to their new environs and by 1975 had increased their numbers to 50 (Wilson pers. comm.).

In the Kruger Park the major limiting factor of the roan population, i.e. anthrax epizootics, has been overcome by annual innoculation of the roan (De Vos, Van Rooyen and Kloppers 1973) and, together with other management practices being implemented, a gradual increase of the population is apparent. At present the Kruger Park population numbers approximately 260 to 300 (see Chapter 4). Although precariously few in number, the greatest care is being taken by the responsible authorities for the protection of this species and its

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future chances of survival now appear to be better than ever before in South Africa.

In Swaziland the last stragglers disappeared during the late 1950's or early 1960's and roan are now most probably extinct in this area (Riley pers. comm.). Kirk (1966) believed roan to have disappeared from Swaziland in 1961.

South West Africa

Shortridge (1934), Gaerdes (1966) and Du Plessis (1969) give detailed reviews of the past distribution of roan antelope in South West Africa and the Caprivi.

In historic times roan ranged widely over the northern areas, including the eastern extension of the Caprivi, and extended southwards into the north-central areas (Fig. 8) of the region, " ... to 150 to 200 miles (240 to 320 km) south of the Okavango" (Shortridge 1934). Livingstone (1857, In: Du Plessis 1969) recorded roan in the Caprivi on his way from Linyanti to Sesheke. Streitwolf (1910, In: Gaerdes 1966) encountered them in 'fairly' large herds in the Caprivi and also shot a number. Wilhelm (1933) and Haerlem (1939/'45, In: Gaerdes 1966) also recorded roan in the Caprivi.

Petermann (1867, In: Du Plessis 1969) mentioned that Green came across roan near the Cunene River and Shortridge (1934) shot one at Otjumbumbi, some 25 km east of the Rua Cana Falls. The Rua Cana Falls are further given as the western extreme of the roan's range by the latter author who could find no evidence of them ever occurring further west in the Kaokoveld. However, Steinhardt (1924, In: Gaerdes 1966) hunted roan in the northern Kaokoveld and Gaerdes (1966) himself encountered this antelope in the same area to the west of the Ehombo Mountains in 1922 and 1927.

Roan are reported to have entered the Etosha Pan on the eastern side in the Namutoni area (Shortridge 1934). Their favoured areas however, appear

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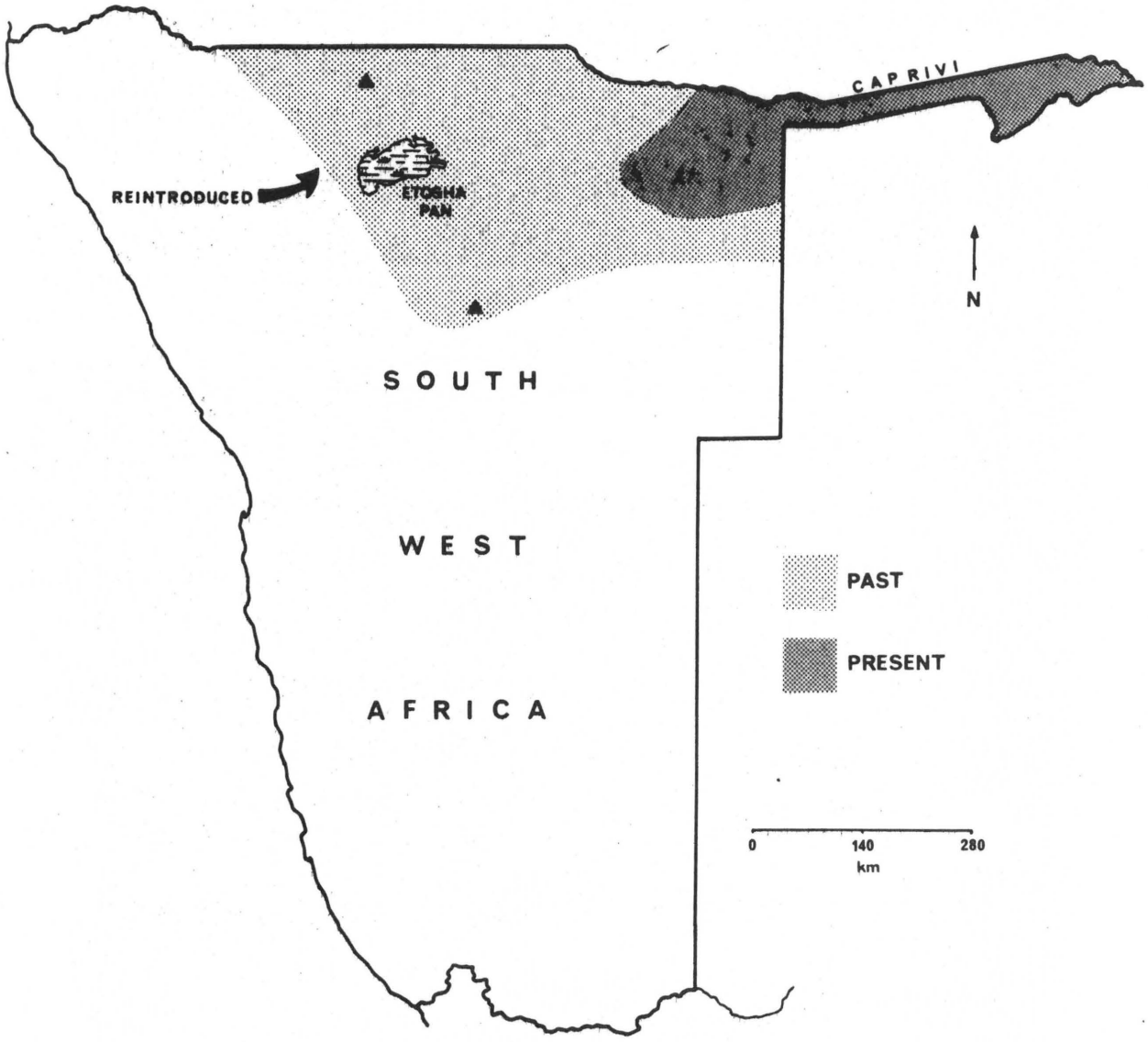

Figure 8 : The past and present distribution of the roan antelope in South West Africa.

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to have been the north-eastern districts of Tsumeb, Grootfontein and Waterberg (Wilhelm 1931). The southern-most limit of the roan was on the farm Kalidona in the Otjiwarongo district, belonging to Gaerdes. According to the previous owner, Zirzow, roan were still seen on the farm in 1911/'12 (Gaerdes 1966).

Apart from their western limits where roan were not plentiful (Shortridge 1934) and mostly only moved into the area during the rains (Halma, In: Shortridge 1934) they appeared to be quite common further to the east. In the north-eastern areas of Karakuwisa, Tsumeb and Grootfontein Fisher (1914, In: Gaerdes 1966) estimated their total at 3 000 to 4 000 although Gaerdes was of the opinion that this figure was an over-estimate. Shortridge (1934) also noted that roan were quite numerous in the Grootfontein area "although nowhere approaching wildebeest, kudu, or eland (Taurotragus oryx) in numbers" and Gaerdes (1966) found them quite numerous in the vicinity of the Otavi Spring until the late 1930's after which they rapidly declined in number.

The present status of the roan in South West Africa is not clear although it is believed to be extinct in the Grootfontein district (Gaerdes 1966) and probably also in the western reaches of Ovamboland, the eastern areas of the Etosha Pan and Otavi. In 1962 Gaerdes (1966) was informed by Mr B. de la Bat, Director of Nature Conservation and Tourism for South West Africa, that a small group was still surviving in the northern Kaokoveld but that they were being threatened by extinction. In 1974 Swart (In litt.) stated that it was doubtful whether any of these roan were still in the area.

Hofmeyr (1974) stated that "in recent times there has been an alarming decline in these (S.W.A.) roan populations and they became restricted to the most north-easterly part of the country, where surveys revealed that there are no more than 400 left (excluding the Caprivi)".

During the latter half of 1970 the South West Africa Administration captured a total of 81 roan in the Khaudum Omuramba in the extreme north-eastern

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corner of the territory - where there was a concentration of an estimated 240 animals - and translocated 74 to the Otjovasandu area of the Etosha National Park (Hofmeyr 1973, 1974, Hofmeyr and De Bruine 1973). Initial losses amounted to four animals but the rest adapted well and subsequent surveys revealed a steady increase in the population with aerial censusses indicating totals of 89 (Sept. 1971), 107 (Sept. 1972), 107 (March 1973), 159 (Sept. 1973), 149 (March 1974) and 177 (July 1974). It is believed that by November 1974 the population had exceeded the 200 mark (Hofmeyr In litt.).

In the Caprivi roan used to be numerous in the Hukweveld of the central regions (Wilhelm 1931) while Bahue and Neale (In: Shortridge 1934) reported them to be numerous in the eastern Caprivi. Roan still occur throughout the area although their numerical status is unknown. For the western Caprivi, Tinley (1966b) stated that they were "frequently seen".

Botswana

From the notes of the early travellers it is clear that the roan once ranged extensively from the southern limits of the territory northwards up the eastern regions and along most of the northern frontier. Sclater (1900) noted that roan occurred in southern Botswana in the area adjoining Griqualand West, while Selous (1881) encountered them along the Lotsani (Notuani) and Limpopo rivers to the south of Bamangwato. Bryden (1899) also recorded roan on the Lotsani River and the upper Limpopo and westwards between Soda Garre and the Mababe Flats.

In the north-eastern reaches of the territory roan were recorded from the Tati area (Selous 1881, Anderson 1888, In: Du Plessis 1969), Nata River, Makarikari Salt Pan, Panda ma Tenka, Gazuma (Bryden 1936) and the Chobe River (Selous 1881, Bryden 1899, Shortridge 1934). Roan were also known from the Botletle River (Shortridge 1934, Bryden 1936).

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In the extreme north-western areas roan were recorded along the Okavango River (Bryden 1936) and Fischer (1914, In: Gaerdes 1966) stated that there was a to and fro movement of roan between South West Africa (in the vicinity of Karakuwisa) and Botswana along the main drainage lines (omurambas) to the southern banks of the Okavango River.

Southern Botswana was apparently sparsely populated by roan and by the turn of the century they were on the verge of disappearing (Sclater 1900) and in 1936 Bryden wrote that their range extended as far south as the Nata River, or possibly a bit further south.

The major concentrations, where roan were reported to be represented in "fair numbers" and by no means "uncommon" were in the northern reaches along the Chobe River and in the regions of Gazuma and Panda ma Tenka (Bryden 1899, 1936). Selous (1881) considered the roan to be quite common in the neighbourhood of Tati but quite scarce along the Chobe River and in the Mababe area.

During the early part of this century roan were apparently quite rare along the lower reaches of the Botletle River and in the region of the Makarikari Pan. They were, however, quite common along the southern bank of the Okavango River and the area adjoining the Kaukauveld of South West Africa (Fischer 1914, In: Gaerdes 1966).

Probably the most reliable general summary of the roan's earlier status was given by Selous (1881) when he stated that " ... it is to be found over a vast extent of country in central South Africa, but is nowhere to be met with in very large numbers".

The present distribution of the roan is given as the "northern part of the territory and the fringes of the Okavango delta and the Chobe River area as far south as c. 10 miles (16 km) north of Toten, the Botletle River and the Rhodesian border at c. latitude 19°45' S" (Smithers 1968, Child 1968). It therefore still occurs widespread throughout the northern areas with the Nata River

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forming its southern-most limit along the eastern side and the western Makarikari Pan area in north-central Botswana (Fig. 9).

Child (1968) found the roan to be well represented in the extreme north-eastern corner along the Chobe River (within the Chobe National Park) but only in "small numbers" to the west and south. They were further reported to be plentiful in the western Makarikari area and also present in fair numbers along the south-western fringes of the Okavango. Tinley (1966a) found them to be rare in the Moremi Wildlife Reserve and encountered them on only three occasions during an ecological survey of the area.

With the possible exception of the western Makarikari area, old residents reported that the roan's numbers had dropped drastically during the last 10 to 40 years throughout its range of distribution in Botswana, and Child (1968) came to the conclusion that "the species should be considered as in danger of disappearing from much of its range and should receive special protection", and "in several areas are now approaching a critical level". Roan are at present protected in two conservation areas, i.e. the Chobe National Park and the Moremi Wildlife Reserve.

Rhodesia

From the accounts of the early pioneers Rhodesia was particularly well endowed with roan, both in range of distribution as well as numbers.

Baines (1864, In: Du Plessis 1969) found roan along the Matetsi River in the Wankie area while Selous (1881) recorded them from Tati to the Zambezi and throughout Mashonaland. Roan were also reported from Mashonaland by Selous (1893), Bryden (1899), Haagner (1920), Shortridge (1934) and Bryden (1936).

Ward (1899) stated that roan also occurred in south-western Matabeleland and Bryden (1899) also referred to them in southern and western Matabeleland, while Shortridge (1934) and Bryden (1936) merely indicated Matabeleland.

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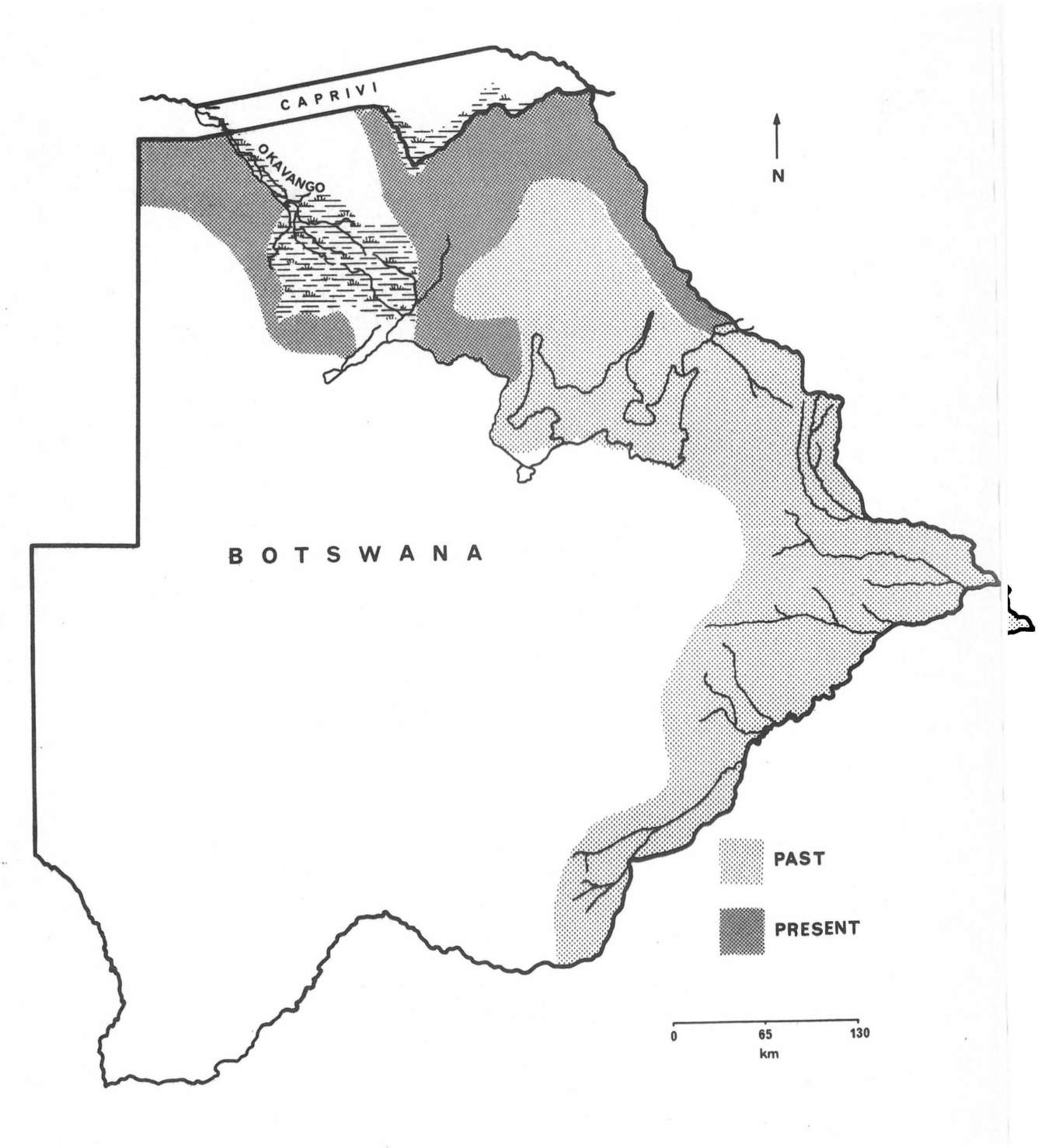

Figure 9 : The past and present distribution of the roan antelope in Botswana.

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Bryden (1899) noted the absence of roan along the low-lying areas of the Zambezi valley to the east of the Victoria Falls. Stabb hunted roan in the Seribe-Macloutsie area in 1875 (Tabler 1967) and Oates (1889) hunted them between the Tamasanka and Tlhamaganyana rivers. Baldwin (1894[63]) encountered roan from the vicinity of the Shashi River and the Victoria Falls while Millais (1899) found them between the Nuanetsi and Bubye rivers in southern Matabeleland. Selous (1893) shot two roan along the Ruwa River in the upper reaches of the Manyani (or Hunyani) River.

Roan also occurred in the hilly areas 130 km east of the Victoria Falls between the confluence of the Garaai and Zambezi rivers and the Umniati Highlands of Mashonaland (Selous 1907). The latter author also hunted them along the Tati River.

Selous (1881) found the roan not too common between the Tati and Zambezi rivers but "tolerably plentiful" thoughout Mashonaland, and in the Umniati Highlands they could be seen daily (Selous 1907). In Matabeleland and Mashonaland roan were still considered "fairly abundant" at the turn of the century (Sclater 1900). Nicolls and Eglington (In: Sclater and Thomas 1894) stated that "in the less frequented portions of Matabeleland it is still fairly common, and although once numerous in Mashonaland, is now only to be found there in the low country towards the east coast" while Fflolliot Darling (In: Sclater and Thomas 1894) considered them scarce over most parts of Mashonaland.

Summarising the evidece pertaining to the late nineteenth century Best, Palmer, Shephard and Wilson (1970) came to the conclusion that"wherever the hunter went, roan were to be found" and that "it can be justly inferred therefore that at that period roan enjoyed a wide distribution in an equally wide range of habitats". Considering the numerical status of roan during the same period Best et al. (1970) pointed out that the early hunters almost invariably referred to small numbers in their encounters with roan and again con-

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cluded that " ... in spite of a wide distribution the roan was nowhere abundant".

Tracing the trends of the roan populations in Rhodesia from the turn of the century, Best et al. (1970) found that in many areas where they were once common they were now either extinct or severely reduced in numbers. The reduction in numbers was apparent between 1900 and 1930 but became increasingly evident from 1940 onwards and by 1960 many of the farms on which roan had once occurred had lost their populations. The most common causes of the reductions appeared to have been the advancement of agriculture, and with it the associated human settlement and habitat disturbances, hunting, poaching and tsetse fly control operations. As for the tsetse fly control operations, White (1954) gave a total of 2 862 roan shot in Rhodesia between 1924 and 1945. Best et al. (1970) further mention that roan were "very common" in the Tuli Circle up to the early 1940's but are now extinct in that area.

Child and Savory (1964) described the more recent distribution of roan as " ... generally absent along the Southern Rhodesian watershed and their distribution elsewhere suggests their range is being reduced". According to the recent detailed survey by Best et al. (1970) the largest concentrations are to be found in the north-western areas along the Botswana border and the northern extremes along the Zambezi River. Scattered localities are also indicated in the north-central, north-eastern, south-eastern and central areas (Fig.10). According to Kerr (pers. comm.) roan still occur in scattered groups along the Zambezi escarpment between Matetsi and the Angwa River and have also been seen near Bumi Hill, south of Lake Kariba.

Roan antelope are still well represented in the Rhodesian national parks and although they have disappeared from many areas of their former range their future existence in the territory seems to be secure. According to Anderson (In: Best et al. 1970) there were at least 350 roan in the Wankie National Park. This figure was considered conservative by Austen, once Regional

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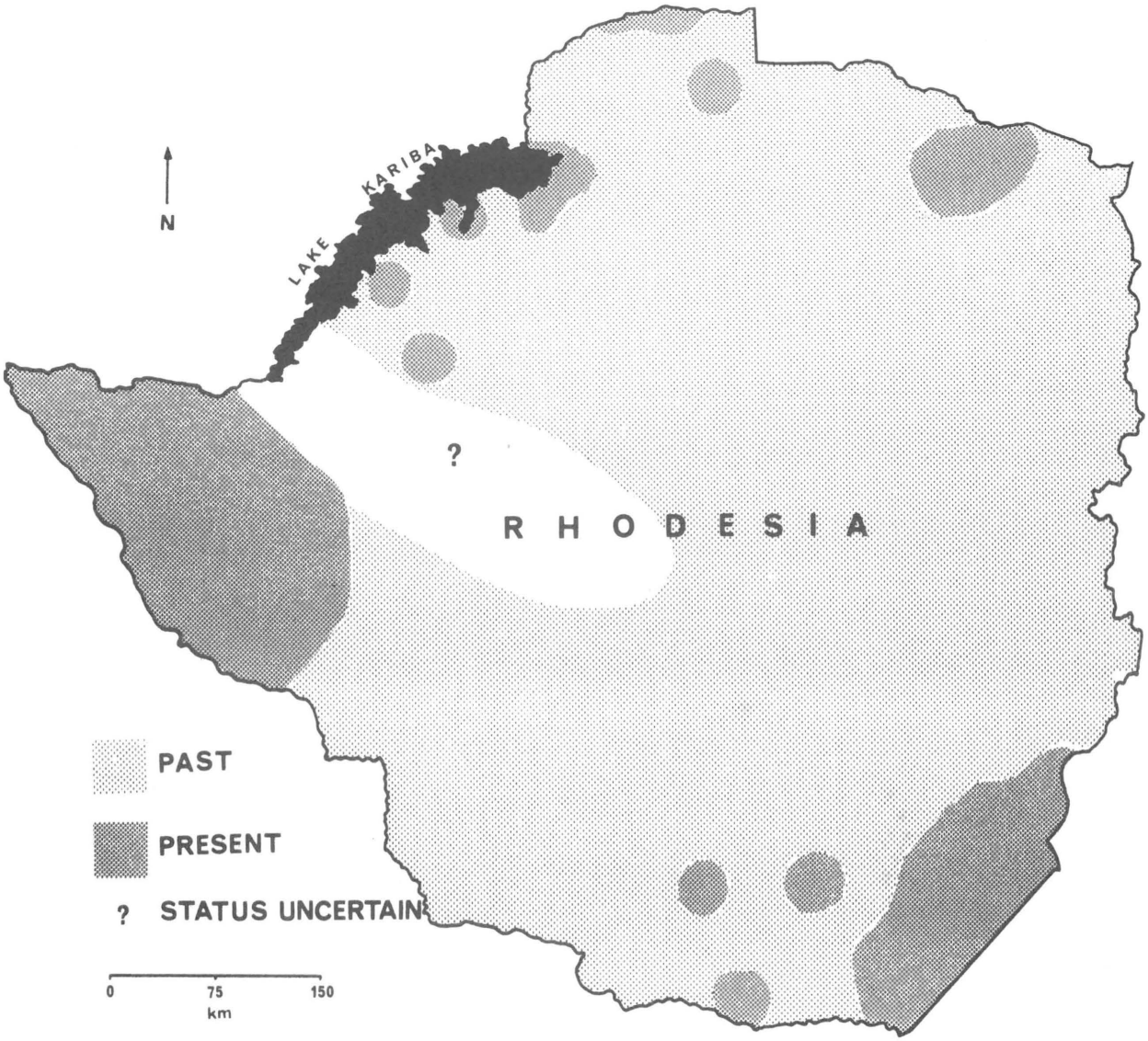

Figure 10 : The past and present distribution of the roan antelope in Rhodesia.

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Warden for Wankie National Park (Best et al. 1970). Another 85 plus occurred in the surrounding controlled hunting area. Davison (In litt.) observed a gradual increase in the Wankie National Park roan population until 1945 - partly due to immigration from Botswana - after which a decrease was detected, apparently caused by competition from rapidly increasing buffalo (Syncerus caffer) herds and increased predator pressure. Other figures provided by Best et al. (1970) and Anderson (In litt.) are: Ghona-re-Zhou Game Reserve: 30 (70), Victoria Falls National Park: "very few" (15), Chizirira Game Reserve: 20 (70), Matusadona and Chete Game Reserves: 50 (65). An estimated 40 were still to be found in the Buffalo Bend area, about 15 between the Victoria Falls National Park and the Botswana border and another 40 between the Kariba Dam and the Chewore Game Reserve (15), and Mana Pools Game Reserve (15). Anderson's estimates are given in brackets.

All areas mentioned in the previous paragraph fall within either a national park, game reserve or controlled hunting area and therefore represent protected areas.

Two attempts to establish roan in the Matopos National Park have been unsuccessful. Four roan translocated to Matopos from the Wankie National Park in 1966 died within a week of being released (Best et al. 1970) and of six translocated from the Tjolotjo Tribal Trustlands in 1973 to Matopos all but one, or possibly two, have met the same fate (Reece In litt.).

Roan occur in a number of forest reserves, which also afford protection, viz. Kazuma-Pandamasui Forest Reserve 20 (60), Ngamo - Sikume Forest Reserve 75 (70), Sijirira Forest Reserve 10 (10), Umguza Forest Reserve 15 (10) and Gwaai Forest Reserve 27 (10) (Best et al. 1970). Figures in brackets are those of Anderson (In litt.).

The following tribal trustlands were also reported by Best et al. (1970) to contain roan : Tjolotjo 50 (a total of 44 roan were captured in the

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Sehubu area of the Tjolotjo T.T.L. during July 1973 for translocation to the Kruger National Park, South Africa and the Matopos National Park and all indications were that the total for this area was somewhat higher than 50), Lupane 8, Maitengwe 12, Gokwe 40, Playfree 25, Mudzi 20, Dande 8, Omay 15 and Chenjuri 20.

A few private landowners also still have roan on their property with the largest concentrations in the north-western and south-eastern areas. According to Best et al. (1970) an estimated 64 roan still occur on the farms and ranches in the Matetsi area, north-west of the Wankie National Park. This may have been an under-estimate as Savory (In litt.) reported that, prior to the expropriation of his nature reserve in this area, his largest herd of roan counted 74. Movement of roan from the Wankie National Park into the Matetsi area is also possible.

Mocambique

Bryden (1899) excluded the roan antelope from most of Mocambique by his statement that "I cannot remember to have met with them in any part of south-east Africa where the altitutde of the country was much less than 3 000 feet (914 m) above sea level". He also stated that the roan was unknown between the mouth of the Buzi River and the Zambezi. Kirby (1899), however, mentioned roan from the Gorongoza District and found them quite common to the west of the Zangwe and Urema rivers but not plentiful elsewhere. On the other hand, Maughan (1906) wrote that "although I have been informed of the occurrence of ... the roan antelope in Gorongoza and elsewhere I have never succeeded in obtaining a specimen, in seeing him myself, or of meeting with any person who was able to give me precise information on the subject".

Vasse (1909) recorded roan from the Chitote area along the upper reaches of the Buzi River and according to Du Plessis (1969) he also encountered them near the Mavuzi, a tributary of the Pungwe River.

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Hubbard (1926) stated that "from Shamva (north-east of Salisbury) to Tete and on up to Chiputo they (roan) were to be found everywhere". Shortridge (1934) merely referred to roan as occurring in "the western parts of Mocambique", while Bryden (1936) recorded that they "are found but sparingly".

Tello (In litt.) who has had access to rather obscure Portugese publications and notes, has given their historical distribution as the entire length of the western boundary of Mocambique, south of the Zambezi River. In the southern areas the range of the roan extended as far east as Chibuto and Panda and apparently occurred eastwards to the coast just south of the Save River (Fig. 11).

North of the Save River the roan's distribution formed a narrow belt along the western border except in the Tete region where it extended up to the Zambezi River. North of the Zambezi River the position of the roan, either past or present, is uncertain although a few visual records exist from the Quelimane area and the extreme northern areas, just south of the Rovuma River, while scattered and unconfirmed records are also known from the Mocambique District (Smithers and Tello In prep.).

By all accounts, roan never seem to have been well represented in Mocambique, either in range of distribution or numerical strength although Smithers and Tello (In prep.) referred to them as "common up to recent times".

At present roan are in a precarious position in this African state and the few severely reduced populations are in grave danger of total extinction (Smithers and Tello In prep., Tinley pers. comm.).

Tello (In litt.) gives the roan's present distribution as five isolated populations, i.e. in the Chioco area, south-west of Tete near the Rhodesian border, in the Zinave area along the Save River, in the recently proclaimed Banhine National Park and two small areas to the east of Banhine. In 1969 Broadley (In litt.) encountered a solitary bull in the Inhamitanga area which

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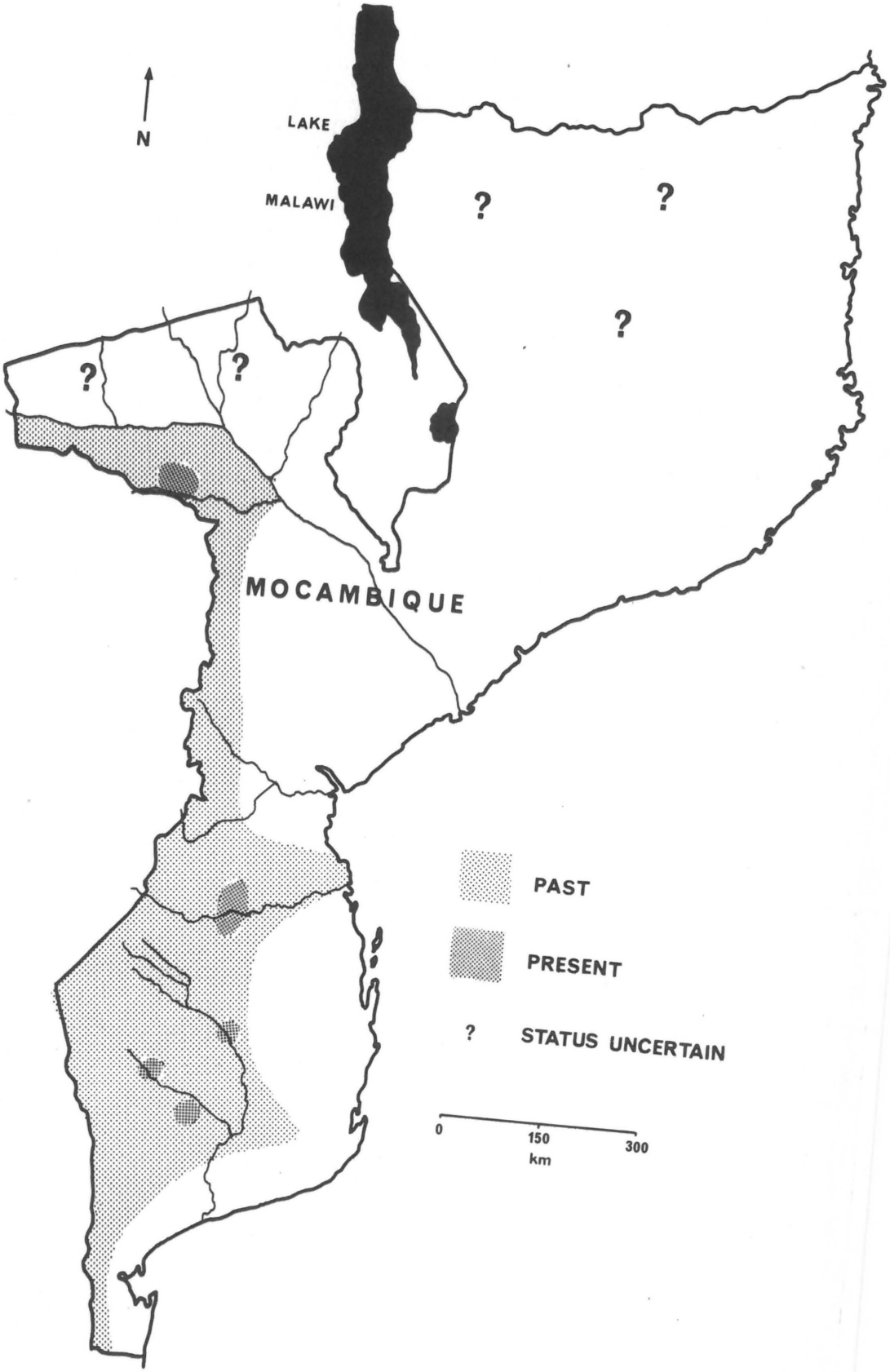

Figure 11 : The past and present distribution of the roan antelope in Mocambique.

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was probably a vagrant from the Tete District (Smithers and Tello In prep.)

According to the older inhabitants of Mocambique roan were once quite numerous on the open grasslands of the Banhine Flats where they were subjected to heavy hunting (Pias Memeda pers. comm.). The roan's present position in this area is uncertain and it is doubtful whether they number more than 20 to 30.

Roan have been protected for at least 20 years in the Zinave area - which was run by the Safarilandia hunting concessionaires - and increased from the verge of extinction to a viable population of over 100 by 1971/'72 (Von Alvensleben pers. comm.).

In 1973 a large tract of land to the south of the Save River which had previously been administered by the Safarilandia organisation, was proclaimed the Zinave National Park and included within its boundaries the majority of the roan population of the area, i.e. approximately 90 to 100. On the northern side of the Save River roan have apparently been exterminated (Tello pers. comm.).

The status of the roan in the Chioco area is uncertain and although the area was proposed as a national park its proclamation has not, as yet, been confirmed (Tinley pers. comm.). The roan in Mocambique may therefore still be saved provided adequate measures are taken to ensure its protection in the national parks.

Malawi

Most of the older authors (such as Sclater 1900, Shortridge 1934, Bryden 1936), indicated a wide range of distribution for the roan in Malawi by merely referring to it as occurring in Nyasaland.

The early encounters with roan in Malawi were reviewed by Sclater and Thomas (1694) who mentioned that Crawshay did not include it in his list

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of mammals for this area and concluded that it could therefore not have been common. They also referred to Capt. Sclater who found it between Blantyre and Milanje on the Tochila Plains of the Shire Highlands and Major Frank Trollope who was reported to have shot a number on the eastern shores of Lake Nyasa. Sclater and Thomas (1894) further referred to Yule who found the roan to be one of the most abundant species "on the Nyasa - Tanganyika Plateau between the two lakes".

According to Sclater (1893) he was informed by a Mr Steblecki that roan were also common on the Chola Plateau while McClounie (1903, In: Benson 1953/'54) found roan, together with zebra and klipspringer (Oreotragus oreotragus) to be common on the Nyika Plateau.

Lyell (1912) stated that roan were "found in central Angoniland, plentiful in the country near Fort Manning, and very numerous in the adjacent territory of north-eastern Rhodesia" (Zambia). Lyell (1923) also hunted roan on the Bua River.

In more recent times roan were still to be found in the Mijete protected area in the southern sector, the Kasungu and Kota-Kota game reserves in the central areas and the Nyika protected areas in the north (Mitchell 1953/'54). Reductions in the various wildlife populations were, however, evident and Benson (1953/'54) in referring to the Nyika Plateau, stated that "roan ... no longer exist in very large numbers". For the same period Cater (1953/'54) estimated the total for the entire Plateau at 150.

At present roan appear to have disappeared from the southern parts of Malawi (Fig. 12) and Hayes (In litt.) is of the opinion that they have not occurred south of Dedza for at least the last 45 years, while Duckworth (In litt.) stated that none have been reported from the southern regions for the past decade (prior to 1970).

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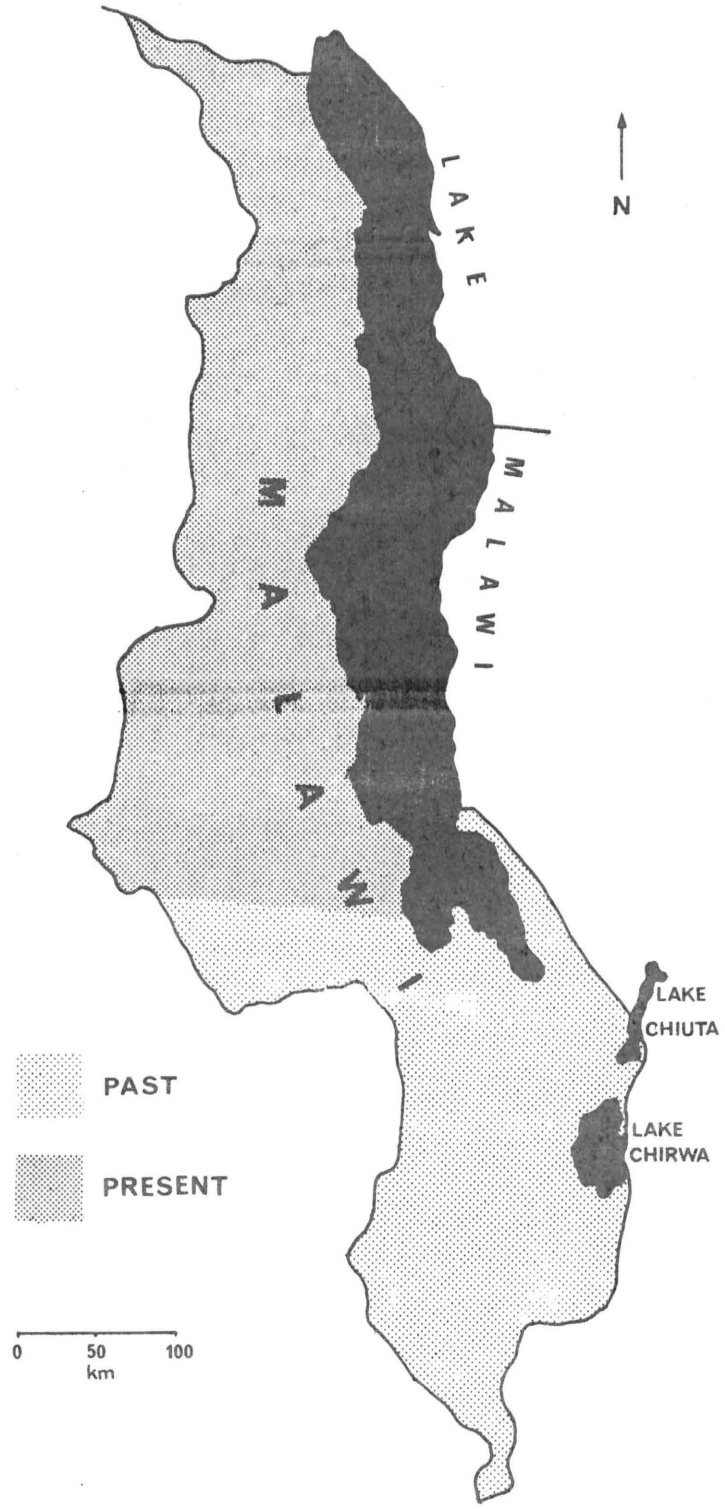

Figure 12 : The past and present distribution of the roan antelope in Malawi.

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In the central areas Kettle (In litt.) estimated their numbers in the Kasungu Game Reserve at 100 to 150 but gave no indication regarding their status in the Kota-Kota Game Reserve.

For Vwaza Marsh - Lake Kazum controlled area and the northern regions of Malawi as a whole, Thomas (In litt.) stated that wildlife, in general, is very rare outside the areas in which some form of protection is afforded. However, his estimate for the total roan antelope population in the unprotected areas of the north, based on the assumption that sightings represent 5 per cent of the population, is 660. An estimated 2 539 roan are given for the Vwaza Marsh area - a total derived from 10-day patrols over a period of 23 months (Thomas In litt.). Thomas himself doubted the reliability of these figures and cautioned that they should not be regarded as accurate.

Lemon (1964) noted that "the roan antelope was once quite common in both the central and northern regions but now it is in significant numbers only in reserves and remote places". In the Malawi National Park (Nyika Plateau) Lemon (1964) estimated a total of 125 roan on 80 000 acre (32 000 ha) of the central grasslands. Cater (1953/'54) and Lemon (1964) pointed out that roan leave the Nyika grasslands during the height of the dry season for lower-lying areas of Brachystegia woodlands where they are vulnerable to poaching. Lemon (1964) further stated that "with sufficient protection to guard them during the short time in the woodlands there is every reason to expect steady increase in their numbers".

Zambia

According to the memoirs of the early hunters roan were once encountered almost throughout Zambia (Fig. 13). Selous (1881) found "a good many" in the Manica country in the eastern parts of the territory. Sclater (1893) was informed by Sharpe that the species was quite abundant in the Lake Mweru area. Sclater (1900) also referred to the roan as not "uncommon" in Barotseland.

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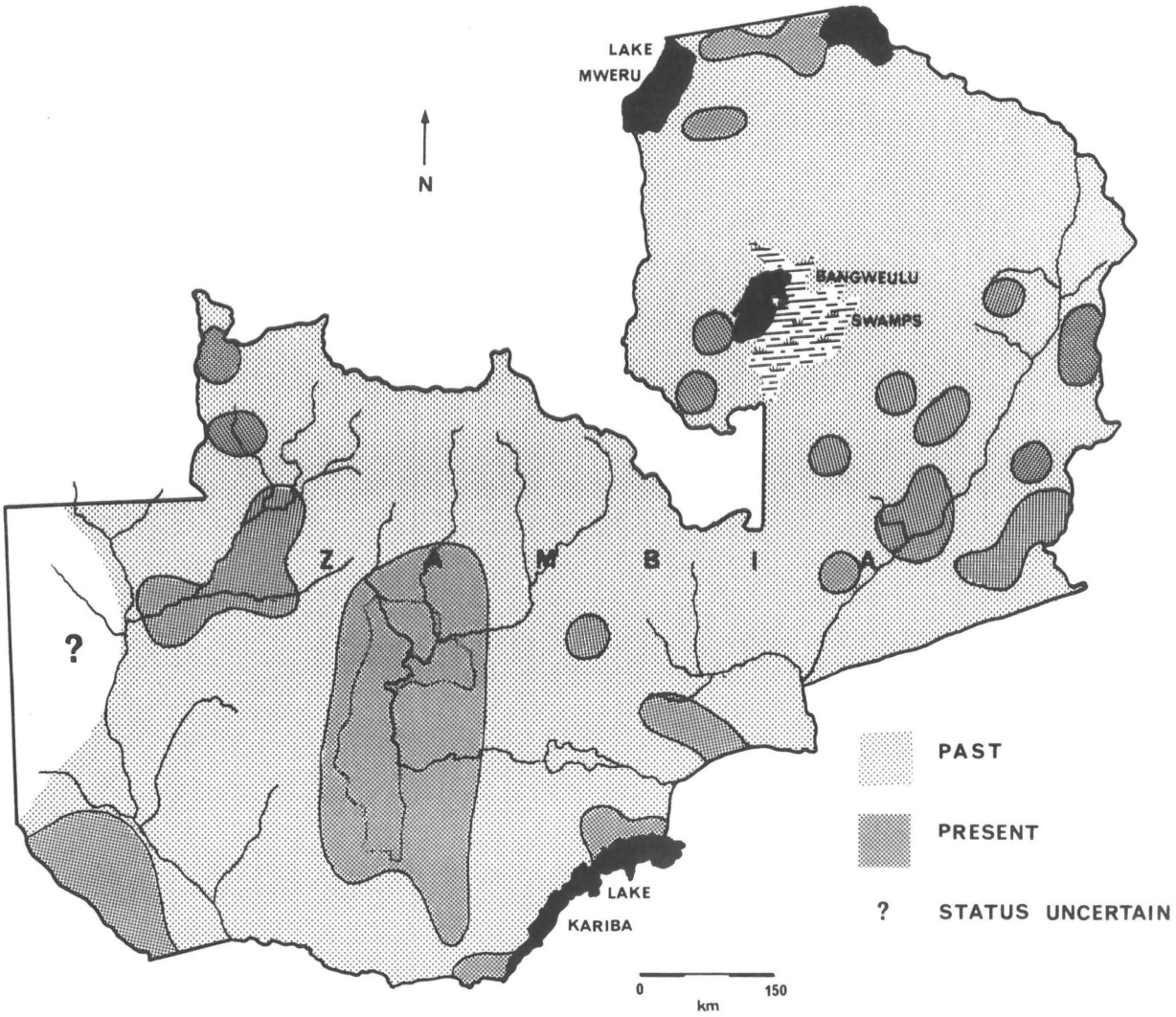

Figure 13 : The past and present distribution of the roan antelope in Zambia.

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Gibbons (1895/'96) hunted roan along the tributaries (Niambe) of the Luena River, in the western districts, and in the south-western areas in the neighbourhood of Manyekanza. Gibbons (1898) also hunted them on the Seshela Flats.

Both Warburg (1903) and Statham (1926) encountered roan during their expeditions down the Zambezi River and mentioned their occurrence as far as the Cuando River.

Schomburgk (1910) found roan fairly plentiful in the areas of Quelle and Ghelenda in northern Zambia and also common around the Bangwuelu Swamps and at Gian-Gian at the southern extremity of Lake Tanganyika. He also found them common in the neighbourhood of Kalomo in the south-central area and along the Kafue River.

Letcher (1911) encountered roan "in great numbers" along the western bank of the Luangwa River and at the confluence of the Luvi and Luangwa rivers. He also hunted them further to the north in the Mpika district. During his hunting trips in north-eastern Zambia, Letcher (1911) found roan, eland and hartebeest (Alcelaphus sp.) "the most widely distributed and plentiful of the larger antelope" with the roan "to be found everywhere". On his trip he estimated to have seen 150 to 200 roan. Lyell (1912, 1913 and 1923) also found the roan "very numerous" in the north-eastern districts of Zambia and especially mentioned the localities of Mzaza, Sasare Gold Mine in the Ft Jameson district and the Bua and Luangwa rivers.

An indication of the abundance of the roan antelope in Zambia was given by Pitman (1936) who estimated their total population for the area at 60 000, and thereby placed it in the same category as buffalo and Lichtenstein's hartebeest (Alcelaphus lichtensteini) as the most abundant large ungulates in the territory.

According to a distribution map compiled by Ansell (In litt.) for his atlas of Zambian mammals, roan are still distributed over most areas along the western boundary with Angola, the central-southern areas from the Kafue and

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Lunga rivers to the Zambezi River, most of the areas along the eastern border and in the extreme north between Lake Mweru and the southern extremity of Lake Tanganyika (Fig. 13).

Compared with their distribution before 1940 roan have become extinct in some areas in the south-western districts and also to the north-west of Lake Kariba. Although some of the populations were severely reduced, the species still occurred over most of the area it once occupied (Smithers 1966, Critchley In litt.).

According to Day (In litt.) the number of roan calculated from the average herd size multiplied by the known number of herds and from the average activity zone of a herd divided by the habitat available for the species, indicated a total population of 1 000 to 1 500 for the Kafue National Park. On the Kafue Flats the Blue Lagoon Ranch and surrounding areas supported approximately 300 roan (Critchley In litt.). Ansell (In litt.) considered them common between the Kafue confluence and Feira but very rare between the Kafue confluence and the Batoka Gorge.

Bainbridge (In litt.) estimated the total roan population for Zambia anywhere between 5 000 and 10 000. An indication of the status of the roan in the following areas has been provided by Bainbridge (In litt.).

(a) National parks and game reserves: Rare in Lochinvar, Isangano, Sumbu, Mweru Marsh and Lusenga Plain game reserves. Widespread but nowhere abundant in North and South Luangwa, Lukususe Luangwa , Nsefu, Luambe, Lunga, Kasanku, Lavushi and Manda game reserves. Common in Kafue National Park and Blue Lagoon Ranch.

(b) Controlled hunting areas: Rare in Munwamadzi, Kasonso-Busangu, Kasempa, Chizera, Musele-Matabo, Chibwika-Nkambu, Lukwakwa, Kawambwa, Kabwa, Sumbu, Senga, Lundazi-Chewa, Kamba, Sandwe, Chisomo and Petauke. Fairly common in Sichifula, Ngezi, Mumbwa West, Zambezi Valley and East Lunga.

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It is obvious that the roan is represented in a large number of variously protected areas in Zambia although the status of the species in the vast majority of these areas is considered rare.

Angola

Relatively little appears to be known of the roan antelope in Angola prior to the turn of the century. Sclater and Thomas (1894) mentioned its occurrence in Mossamedes and the "interior of Angola". They further pointed out that Van der Kellen included it in his list of mammals for Mossamedes (according to Jentink 1887, In: Sclater and Thomas 1894) and that Barboza du Bocage (1890, In: Sclater and Thomas 1894) recorded it at Golunga Alto.

Both Warburg (1903) and Statham (1926) mentioned roan from the vicinity of Chitanda, a tributary of the Cunene River, and further eastwards to the Cuando River, though the latter author mentioned that it "was nowhere numerous and usually met in herds of half a dozen animals". Varian (1932) encountered it along the upper reaches of the Cuanza River in the districts of Luando and Cangandala, while Bryden (1936) merely stated that they were to be found in "fair abundance" in suitable country.

Shortridge (1934) noted that the roan ranged through southern and central Angola. Sokolowsky (1903, In: Hill and Carter 1941) recorded it from the Chitanda, Cuando and Habunga rivers and also the Cubango River above the confluence of the Cuatiri, while the Vernay Expedition (In: Hill and Carter 1941) collected specimens at Chitau, Capelongo, Luvando, Quipungo and Chipopis. Referring to the distribution of the roan in Angola, Hill and Carter (1941) noted that it "probably (occurs) throughout the interior of Angola, south of the Congo region" (Fig. 14).

Pienaar (pers. comm.) found roan to be quite common along the western shores of the Cuando River and along its tributary, the Luiana, in the early 1950's.

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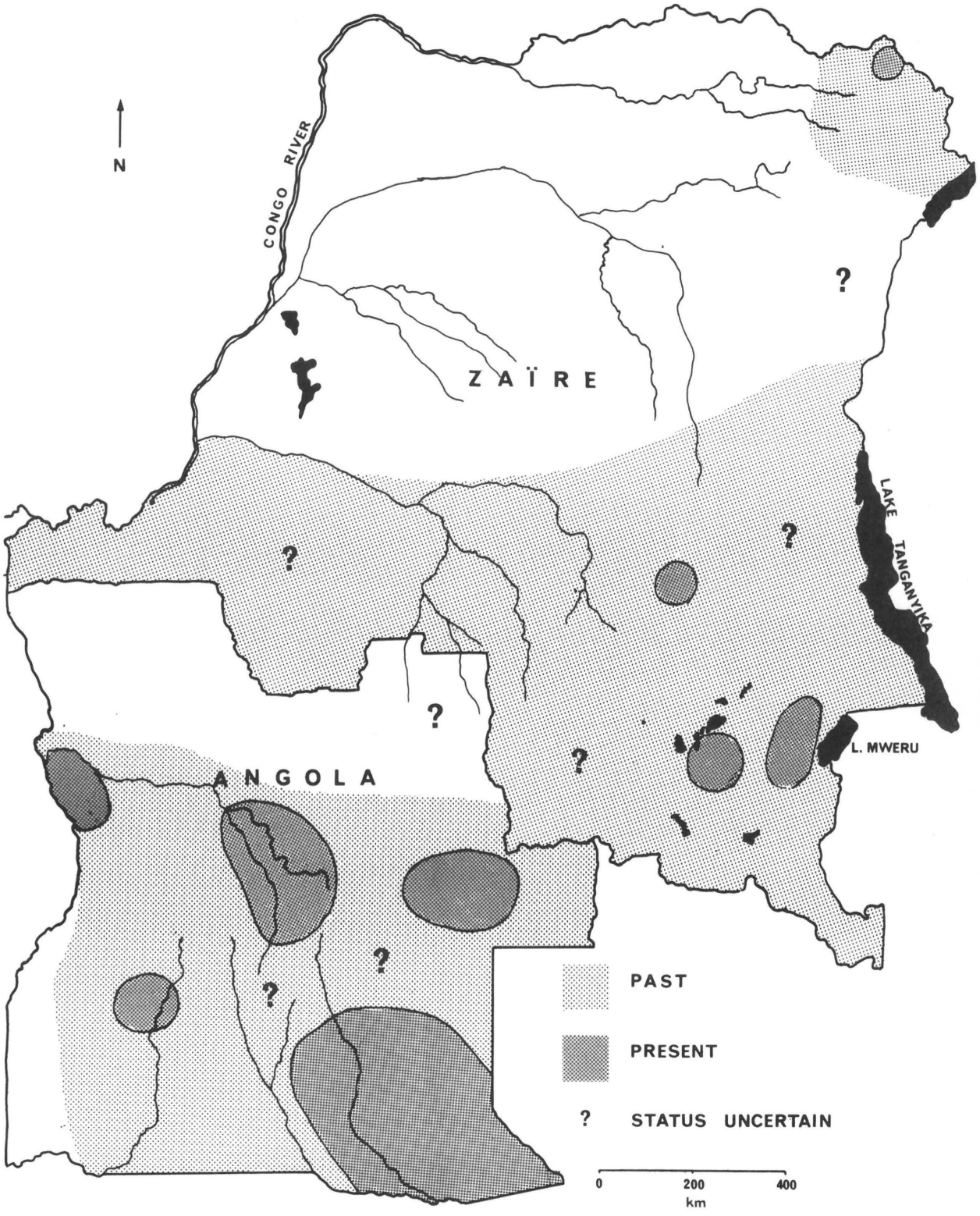

Figure 14 : The past and present distribution of the roan antelope in Angola and Zaïre.

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In spite of the severe decimation of wildlife in general (Huntley 1971b, Cabral pers. comm.) roan are still well represented in the national parks, sanctuaries and controlled hunting areas of Angola. The Quicama National Park with its approximately 2 000 roan probably has the highest concentration of the species in Africa (Joubert 1969, Huntley 1971c). In the Bicuar National Park the local ranger, Neto, estimated a population of around 600 (Joubert 1969) while Huntley (1971) gave a population estimate of 300. Good populations also exist in the Cangandala Reserve (± 100 to 150) and the Luando Reserve.

Viable populations were also reported from the Carmeia (De La Tour 1957) and Mupa (Huntley 1971c) national parks. Roan are also said to occur in the controlled hunting areas in the south-eastern areas of the territory (Cabral pers. comm.). According to local residents to the east of Malange roan also occurred on some of the privately owned farms in that area although their numbers have diminished considerably.

Zaïre, Ruanda and Burundi

Very little appears to be known of the early history and distribution of the roan in these areas other than its absence from the Congo Basin (Sclater and Thomas 1894). Sclater (1899) mentioned roan collected from the "Lower Congo". Bryden (1936) reported that he had been informed that roan were present in the southern areas but that he was not aware of their occurrence in any other areas of the territory.

Schouteden (1947) indicated a wide range of distribution for the roan from south of the Congo River mouth in the west, all along the southern areas to the south-eastern extremes of Zaïre and extending north into the interior to approximately the Susambu-Lebefu areas. The following localities were recorded: In the upper Katange District - Lukatawa, upper Kibalashi River, Kipushia, Elizabethville - Kasenga area, Mulando, Kasipa River, Malambwe, Lubombo, Futwe, Mwabo and Kauki. In the Tanganika District - Kiambi, Kasiki and Kapulo. In

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the Lualaba District - Lupweshi River, Tsano River confluence, Lukoshi River, Katotongo, Kabeleshi, Ngule, Kakumonge, Dilolo and Guba. In the Maniema District - Luama Marshes, south of Kabambare, Luama. In the Kasai District - West of Tshikapa and south of Luisa. In the Sankuru District - Lusambo and Tshofa. In the Kwango District - The Frans-Jozef Waterfalls, Nduzi, Mzasi and Mukete. Roan were also recorded from the Marunga Mountains, Lufira and Dikulwe rivers and east of Lake Moero, Bukama, Sankisa, Lake Kabwe, the Fungwe Valley, Leplae, Schwetz and the Kundelungu Highlands, the Sangama River, Buila, Kitobola, Thihsville, Isangila and Fetish Roch. Strangely, Schouteden (1947) did not mention roan from the north-eastern extremes of the territory. He did, however, note that Frechkop recorded roan in northern Ruanda in the Kagera Valley and from the Katjumbura-Katodjo area where they were considered rare by Verhulst (In: Schouteden 1947).

Schouteden (1947) recognised three subspecies for the area, i.e. gambianus in the lower Congo River area, cottoni over the major part of the territory to the east and langheldi in northern Ruanda. Jobaert (1951) confirmed the earlier distribution of the roan in all the areas mentioned above (Fig. 14) and maintained that the race in the north-eastern districts (l'Uele) represented the subsp. H.e. bakeri. He further reported that they were almost extinct in the lower Congo River area and in the north-eastern regions while they were also suffering badly in other areas of the Congo due to the indifference of the local inhabitants towards the conservation of wildlife.

Bourgoin (1958) referred to the occurrence of the roan in the Oubangui District in the north-east of the territory while Backhaus (1959) stated that they were very rare in the Garamba National Park in that area. During a four-month study in the Garamba National Park in 1957, Backhaus (1959) could only contact one herd of 10 and a few isolated little groups and noted that d'Elzius could not find them to the south of the Garamba National Park. Verschuren (1958) also

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referred to roan in the Garamba National Park and gave their status as "a few times ten".

Roan were also recorded from the Mutara District and in the Upemba National Park they were reported to be "common" but on the brink of extinction in the adjoining unprotected areas (Verschuren 1958).

While flying over the Kundelungu Plateau along the south-eastern border of the territory, Berteaux (pers. comm.) encountered large concentrations of roan during 1961. However, in the ensuing Katanga political warfare, large numbers of animals were reported killed by automatic rifles and it is not known to what extent roan suffered in this area.

In the Bushimaie Reserve the estimates of roan numbers were 264 and 303 for 1949 and 1950 respectively (Verschuren 1958). Guggisberg (1970) mentioned roan for the Upemba National Park but not for the Garamba National Park, which had "suffered badly owing to political troubles". Verschuren (1958) recorded that roan were very rare in the Kagera National Park of Ruanda and showed no signs of increasing. No information could be obtained of the present position of roan in Burundi.

Tanzania

In historic times roan ranged widely throughout most of Tanzania. According to Sclater and Thomas (1894), Neumann encountered roan on the upper Bubu River between Irangi and Mt. Gurui in 1893 while Matschie reported them from the upper Pangani River, south of Kilimanjaro, between Lumbwa and Kavirondo and in the vicinity of Ufipa in Ukonongo. Johnston (1886) also hunted roan in the foothills of Kilimanjaro along the Lumi River. During the early part of this century the distribution of roan was given as mainly along the western side of the country (Fig. 15) and in some areas it was reported to be the dominant antelope. Areas of sparse distribution included the Arusha, Kondoa-Irangi and Handeni districts while centres of abundance included the area to the east

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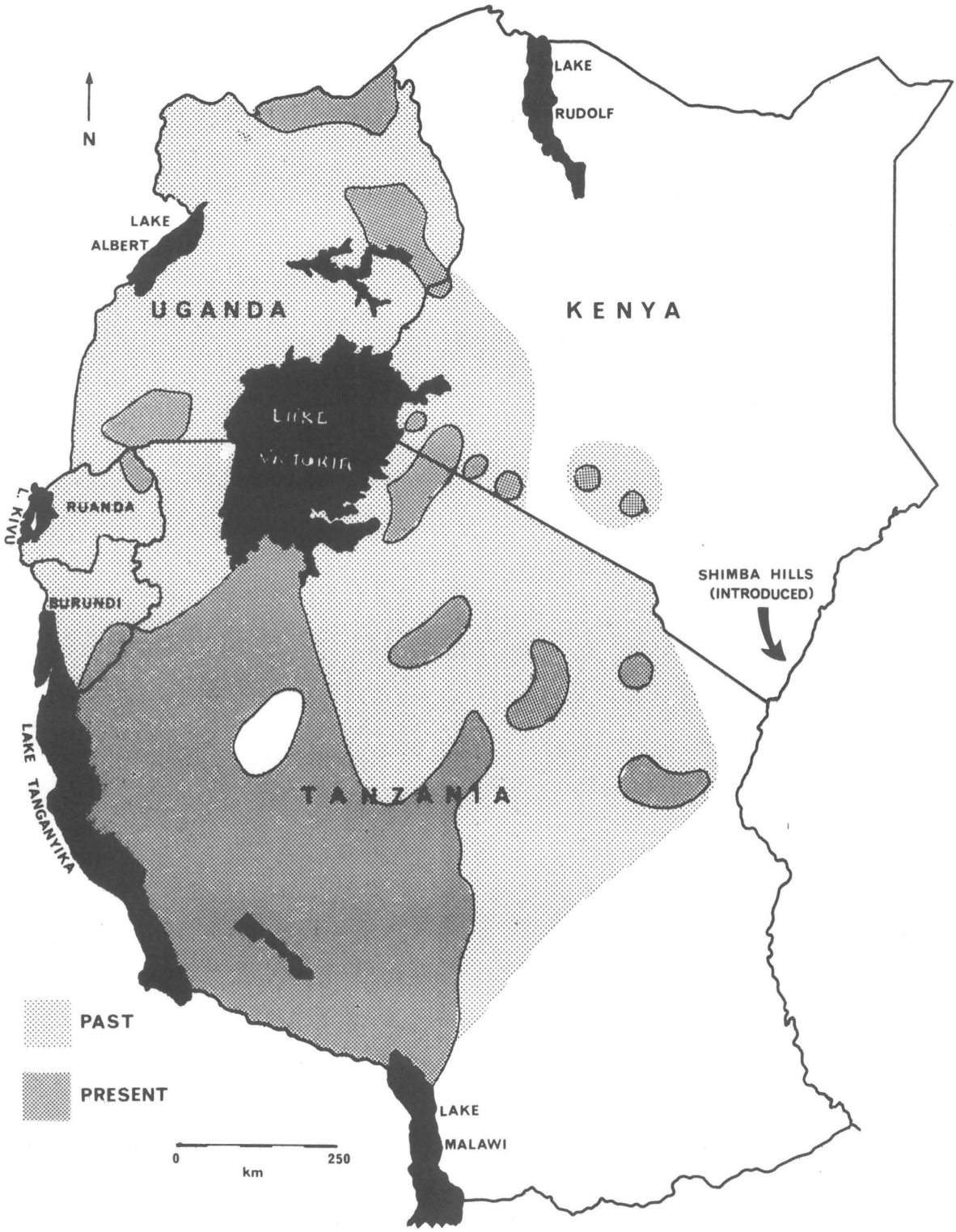

Figure 15 : The past and present distribution of the roan antelope in Tanzania, Kenya, Uganda, Ruanda and Burundi.

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of Lake Victoria and in the Bagamoya and Ufipa districts (Anon 1922).

In more recent times Swynnerton and Hayman (1950) gave the following localities for the distribution of the roan: Mkata, Mswaki, Mandera, Mangati, Kikore, upper Bubu River, Ruruma, between the Mara and Ruwana rivers, west from Maji Moto and Nata to Lake Victoria, Banagi northwards to the Kenya border, Gugu River, Kimali, Machanta Hill, Nyaruboro Hill, Shonu, near Simiya River, Zagayu, Kiziba, west of Kitalala, Mwamalasa, widespread in western Kondoa, south-western Manyoni, south-western Mbeya, Chunya, western Mwanza, Biharamula, Bykoba, Nzega, Kahama, Buha, Tabora, Kigoma, Mpande and Ufipa districts.

Vesey-Fitzgerald (1953/'54) considered the sable antelope the most characteristic antelope of Tanzania's vast woodlands covering most of the western and central parts of the territory but stated that the "roan is commoner than the sable and more widespread" throughout these regions. Herds of up to three dozen could be seen. In areas where roan had become less numerous, it could be attributed to human activities.

Ansell (1971) has given their distribution as western Tanzania while Guggisberg (1966) referred to roan as occurring only in "certain, widely isolated localities", and (Guggisberg 1970) reported their presence in the Serengeti and Ruaha national parks.

In the 13 000 km^2 Ruaha National Park roan are still widely distributed and appear to be locally common but no indication of the population size is available (Savidge In litt.).

Roan are reported to be absent in the south-eastern districts (Nicholson In litt.).

The species is well represented in controlled hunting areas in central and western Tanzania (Turner In litt.) and also occurs in the recently proclaimed Kataui National Park near Mpanda, and the Ugalla Game Reserve (Stevenson In litt.).

During 14 years experience in the Serengeti National Park, Turner

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(In litt.) could detect no increase in the roan population but rather suspected a decrease. He estimated the total population to be between 150 and 200. He further noted that due to heavy poaching, wildlife populations in the adjoining areas of the Serengeti National Park have been severely decimated and roan have probably disappeared altogether.

Kenya

According to Jackson (1899) the roan in East Africa was unknown to Europeans before 1890 and was first encountered on Mt Elgon. He also gave the following localities in their distribution: Athi Plains, Moto River, Mau Plateau, Gabrauni in the Kiyu Hills and south of Machakos. Jackson (1899) remarked that "this beast is very rare in East Africa, though fairly well distributed". Roosevelt (1910) also hunted roan - which were apparently quite common - on the Uasin Gishu Plateau in the neighbourhood of Mt Elgon.

Chapman (1908) stated that "this (the roan) has always been considered a rare animal in East Africa" and mentioned their occurrence in the Athi area, between Nakuru and Baringo, the Lumbwa Valley where only "small herds are known", the Muhoroni and Kibigori areas, and southwards to the Guaso Nyiro River where they were "fairly numerous".

By 1923 all hunting of roan had been prohibited - except in the areas where they were still considered to be plentiful (Percival 1923). Percival (1923) further noted that roan were poorly represented in game reserves and in the Southern Reserve there were only an estimated 100 which showed no sign of increase. They were also reported, but not seen, from the Northern Game Reserve.

In the early 1920's roan were still seen in "good numbers" along the Mara River and also near Lake Victoria, while they had become extinct on the edge of the Kikuyu Forest (Percival 1928, In: Simon 1963). The same author also reported them from the Mau and Nandi forests.

According to Simon (1963) roan were scarce in the Rift Valley and were

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confined to the edge of the Njoro Forest, towards Eldama Ravine and at Solai.

It is not certain who Simon (1963) was quoting but for 1906 he stated that "along the Chania and Thika rivers, on the Yatta Plateau, in the Nyando valley, at Kukungu on Lake Victoria and along the Anglo-German border small numbers of roan were to be found". By 1932 they had ceased to exist in some of their old haunts but were still "fairly numerous" in the Masai Reserve in the south of the territory and the southern Kavirondo District (Ritchie 1932).

In more recent years the position of the roan in Kenya has deteriorated to the stage where its very future is in jeopardy. Cowie (1958) stated that 30 years ago they were still found in the hills south-east of Nairobi and in the late 1950's they were seen in the Chyulu Hills west of Tsavo National Park. "Today only small numbers remain in one part of Kenya where they are well protected" (Cowie 1958).

Simon (1963) mentioned approximately 20 roan for the Mara Triangle, 62 on the Isuria Escarpment, "probably a few" on the Ithanga Hills, 23 on privately owned land north of Endebess and more than 100 in the Lambwe Valley, South Nyanza where they were subjected to heavy poaching.

Stewart and Stewart (1963) indicated that roan were (historically) well represented in south-west Kenya but that they were always fairly restricted in their distribution (Fig. 15). In more recent years they summarised the roan's status as "declining in most of the scattered localities in which it still exists and in the south-west it is threatened in one of its last strongholds, near Lake Victoria, by the spread of cultivation".

According to information from Downey (In litt.) roan were regarded as "common" in the Masai-Mara Game Reserve until 1950, on both the eastern and western sides of the Mara River but, according to the Warden, only six were left on the eastern side while on the western side there were still 50 to 70 animals.

Fraser Darling (1960) counted 21 roan in the Mara Triangle and estimated

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that there could have been 30 to 40 in total. However, he was of the opinion that "this species is in great danger of extinction in the Mara area". A few, "possibly a dozen", also persisted in the neighbourhood of the Sand River and a few in the Siannas.

Roan are presently fully protected from hunting throughout Kenya (Anon 1973).

One of the last surviving populations of roan inhabited remote areas of the Tana Ranch in the Ithanga Hills, between Thika and Meru. Because of poaching the East African Wildlife Society decided to capture and translocate the roan to the Shimba Hills National Reserve, although roan had never occurred in the area. Initially 20 of these animals were successfully rounded up and it was decided to capture the remaining approximately 50 as well (Story 1970). Eventually nearly 40 animals were released in the Shimba Hills (and 12 on Solio Ranch) in 1971/'72 and the latest reports indicate that they have settled well in their new environment (Parkinson 1972).

Uganda

The remarks of Jackson (1899) and Chapman (1908) reflecting a wide distribution (Fig. 15) but low numbers probably best reflected the position pertaining to the roan in Uganda.

Roan were reported from the north-eastern districts by Johnston (1902) and also from the Nile Province and northern Unyoro, while Roosevelt (1910) found them between Nimule and Gondokoro in the Eastern Province. Duke (1932) recorded roan from the Bukedi District in the neighbourhood of the Siroko River and from the Lango District along the Maroto River, near Abako, and in the headwaters of the Toshi River.

Referring to the Ankole roan population it was stated that there "is reason to believe that there are plenty left and that the herds continue to increase" although it was admitted that there was little authoritative information

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on the population (Anon 1935). In East Madi the herd of 20 between Pakelli and the Nile, apparently one of the last herds in the area, was harassed to such an extent by poachers that it crossed the Nile (Anon 1935).

In 1936 it was reported that the roan population in Ankole "indicates a steady increase, accompanied by an extension of range towards the east and north-east". During this period roan appeared to be immune to rinderpest in the southern Ruampara region where some other species suffered heavy losses (Anon 1936).

In more recent times Bere (1958) stated that roan " ... are found in limited localities outside the National Parks but not within their boundaries." Subsequent to the statement by Bere (1958) the Kidepo National Park was proclaimed in the extreme north-eastern regions along the Sudan border and contained approximately 120 roan in 1958 (Ross In litt.). In subsequent years their numbers were thought to have increased but this could not be substantiated by sufficiently reliable counts (Field In litt.).

During the early 1960's roan were still known from the Ankole District in south-western Uganda where they were subjected to poaching, south of the Sudan border in the northern half of the Acholi District where they were "scattered and few in numbers" and in the Karamoja District in eastern Uganda (Robson In litt.). The Karamoja District contained the healthiest populations and in 1963 the total population (excluding those of the Kidepo National Park) was estimated at 455 while the results of an aerial census in 1964 indicated a total of 316 (Robson In litt.). The majority of the roan were concentrated in the Debasien Animal Sanctuary in the south of the area with an estimated total of 350 in 1963 and a censussed total of 242 in 1964. The remainder were dispersed throughout the area though mainly concentrated in the northern (50 in 1963; 32 in 1964) and southern (50 in 1963; 33 in 1964) areas (Robson In litt.). South of the Karamoja District the Sebei thorn plains were also "much favoured

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by roan" but subsequent to resettlement of the area in 1964/'65 most of the roan emigrated to Karamoja (Robson In litt.).

Ethiopia

Heuglin (1863, In: Sclater 1868) first described the Ethiopian - Sudanese race of the roan antelope from material provided by Sir Samuel Baker (naming it after Baker, i.e. H. bakeri) and mentioned the following localities in its distribution: The Qualabat River, the Djebel Qedani, Bahr Salaam, Atbara, Eastern Sennaar and the side of Fazogloa on the Tjebel Qud. In the same paper Heuglin (1863, In: Sclater 1868) related that he was informed by Baker that he first saw the 'new' roan in 1861 on the border of Abyssinia (Ethiopia) but subsequently also encountered it in "the Latooka country in 4°40' E longitude". In these areas it was "by no means rare". However, he found roan most numerous between Bahr Salaam and the Nahoot Guddavi Mountains.

De Winton (1900) mentioned that Lord Lovat collected roan in southern Ethiopia in the Blue Nile Valley while Baker (1890) mentioned that he first encountered them near the Bahr Salaam and subsequently also along the Settite River.

In an earlier publication Baker (1867) referred to roan as being very numerous in the valley above the Salaam River. Baker (1892) also saw them frequently in the south-western areas of the region (Fig. 16).

Roosevelt and Heller (1914) gave the roan's range as the "whole of Ethiopia from the Sahara desert south ... ". Ansell (1971) has subsequently given its range as western Abyssinia and referred to Von Rosen (1953) who considered the roan as rare in the territory.

No information could be obtained on the present status of the species and Guggisberg (1970) did not mention its occurrence in any of the country's national parks or game sanctuaries. Riney and Hill (1967) stated that there is "abundant evidence that considerable populations of a great variety of animals still exist in Ethiopia" but made no specific mention of roan and did not include it in their list of "rare animals" in the area.

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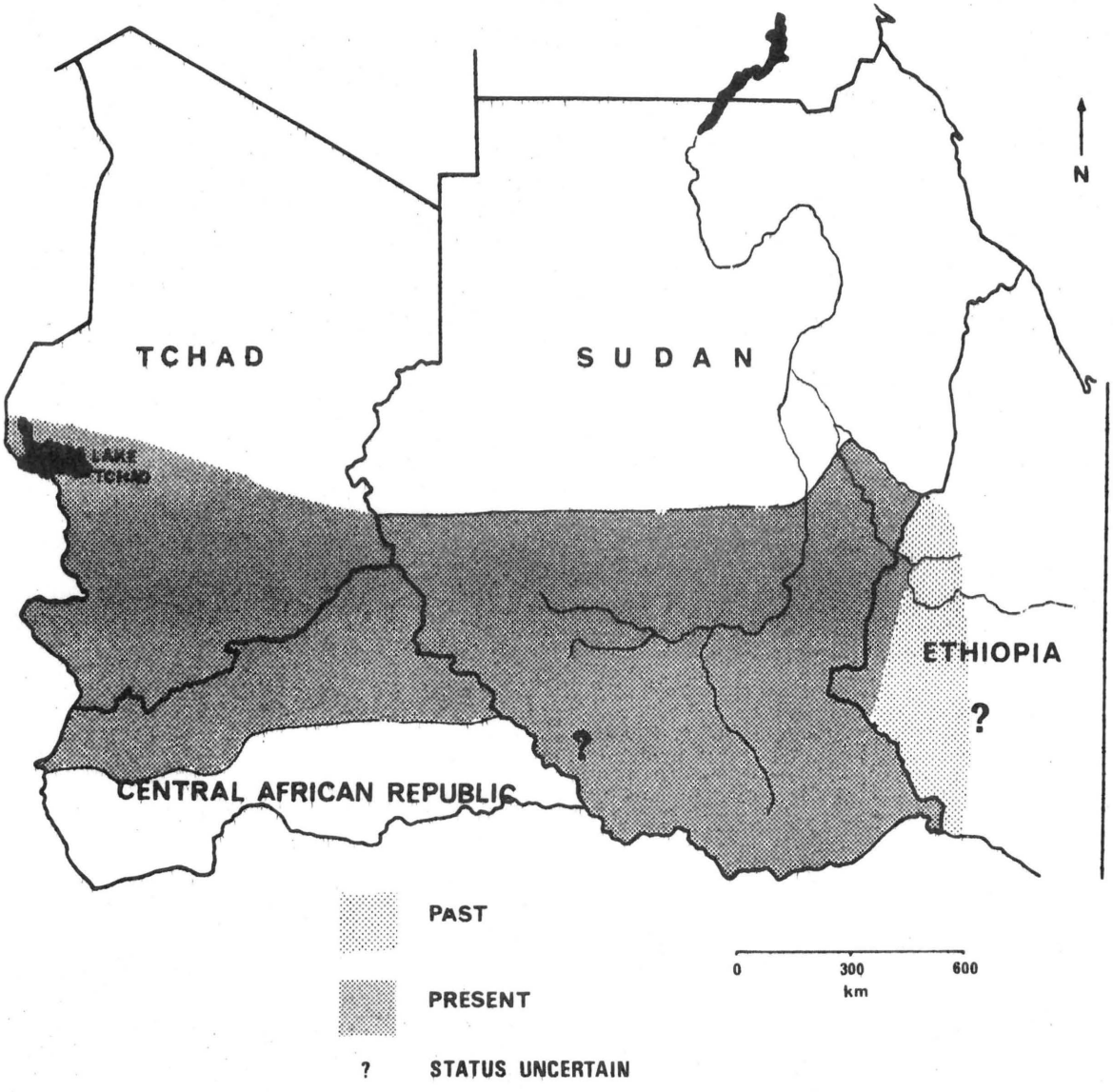

Figure 16 : The past and present distribution of the roan antelope in Ethiopia, Sudan, Central African Republic and Tchad.

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Sudan

According to Brocklehurst (1931) roan ranged widely throughout the Sudan (Fig. 16) and were encountered "almost anywhere where there was sufficient water and grazing".

Millais (1924) hunted roan in the Rumbek neighbourhood and the Gelle River of the Bahr-el-Ghazal Province and was informed by local inhabitants that they were numerous in the area. Roan were also reported from Renk, "where they are now rare", and along the Shat-el-Arab in the Bahr-el-Ghazal Province (Millais 1924).

Dugmore (1926) referred to the roan's distribution in the southern parts of the Sudan and also mentioned its occurrence in the provinces of Kassala, the White Nile, Fung, Mongalla and Bahr-el-Ghazal. He further pointed out that it was common in the vicinity of the White Nile and Bahr-el-Zeraf. Butler (1932) also shed some light on the distribution of the roan and indicated the Setit (or Settite) and Atbara rivers, "the upper reaches of the Dinder, and the upper Blue Nile". In the Sensis and Phor Galequ areas roan were reported to be "plentiful" (Butler 1932).

Mackenzie (1954) merely referred to the roan's distribution as "fairly common throughout the southern savannas". In more recent years Schomber (1962) referred to the roan, among others, as one of "the more important and plentiful species" of the Southern National Park, which is situated in the provinces of Equatoria and Bahr-el-Ghazal. Roan were also mentioned for the Boma Reserve in the Pibor District of the Upper Nile Province.

There are no roan in the Nimule National Park (Kock 1961) but they do occur in the northern Dinder National Park (Dassman 1972, Cloudsley-Thompson 1973). Other protected areas harbouring roan include: Tokar, Rahad and Mongalla game reserves (Guggisberg 1970). Roan are obviously well represented in the Sudan conservation areas and are not regarded as rare or endangered.

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Central African Republic and Tchad

In historic times this area probably had one of the most widespread and numerically abundant roan populations from latitude 7°N in the region of the Oubangui and Chari rivers northwards to latitude 13°N. Even in more recent times the total population was estimated at 30 000 of which 20 000 occurred in Tchad and 10 000 in the Oubangui-Chari area of the Central African Republic (Dekeyser 1955, Blancou 1958, 1960).

In the Central African Republic the roan's present distribution is still indicated as comprising the northern half of the country (Fig. 16), extending southwards to the vicinity of Bossembele, Bouca, Bria and Yalinga (Damango In litt.). However, in latter years their numerical status appears to have deteriorated, especially in unprotected areas, with the main concentrations presently confined to the north-eastern regions (Damango In litt.).

In the Central African Republic roan populations are protected in the Vassako-Bolo Nature Reserve and the Bamingui-Bangoran, Saint Floris and Andre Felix national parks, all situated in the north-eastern sector of the country (Guggisberg 1970).

According to Anna (In litt.) the roan populations in Tchad have steadily declined in number, especially since the Second World War, but are still widely distributed (Fig. 16) and common. In the northern areas their range extends into the outskirts of the Sahelian region at latitude 13°N but during the rainy season they move even further north.

Areas of highest roan concentrations are found along the Chari and Logone rivers but they are also abundant in the Moyen-Chari area (Fort Archambault region), Salamat (Am-Tuman), south of Quaddai (Goz-Beida) and in the vicinity of Guera in the Melfi District. Recent estimates indicated a minimum total population for the area of 5 000 with the following minimum populations in protected areas: 600 in the Zakouma National Park, 100 in the Manda National Park, 1 000 in the

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Bahr Salamat Game Reserve and 500 in the Siniake-Minia Game Reserve (Anna In litt.).

Senegal and Gambia

According to Gray (In: Sclater and Thomas 1894), Whitfield collected roan in the upper Gambia region. Sclater (1898) also mentioned roan in his list of mammals from Gambia.

According to Sclater and Thomas (1894) Llewelyn, an early Governor of Gambia, hunted roan along the Gambia River and also reported them from some areas in Gora and Kiaug and considered them to be "common" in eastern Niammina.

Budgett (1899) encountered large herds of roan during his travels through Gambia and clearly implied that the roan was common although not as plentiful as the 'tankong' (Damaliscus korrigum).

Dekeyser (1956) referred to roan as common in the Niokolo-Koba National Park of Senegal, while De la Tour (1957) stated that they inhabited the savanna and tree steppes of Senegambia (Fig. 17).

At present roan are well established in the Niokolo-Koba National Park with a total population of approximately 1 500 (Dupuy In litt.). Apart from the Niokolo-Koba National Park roan also occur in four other areas, i.e. in Oriental Senegal where there are still a "few hundred", in Upper and Middle Casamance with only a few herds left, in the region of Sine Saloum, also with only a few surviving herds and in the region of Linguere where only a few animals are still seen occasionally (Dupuy In litt.).

With the exception of the Niokolo-Koba National Park and Oriental Senegal, where they are holding their own, roan numbers are declining and are faced with extinction (Dupuy In litt.).

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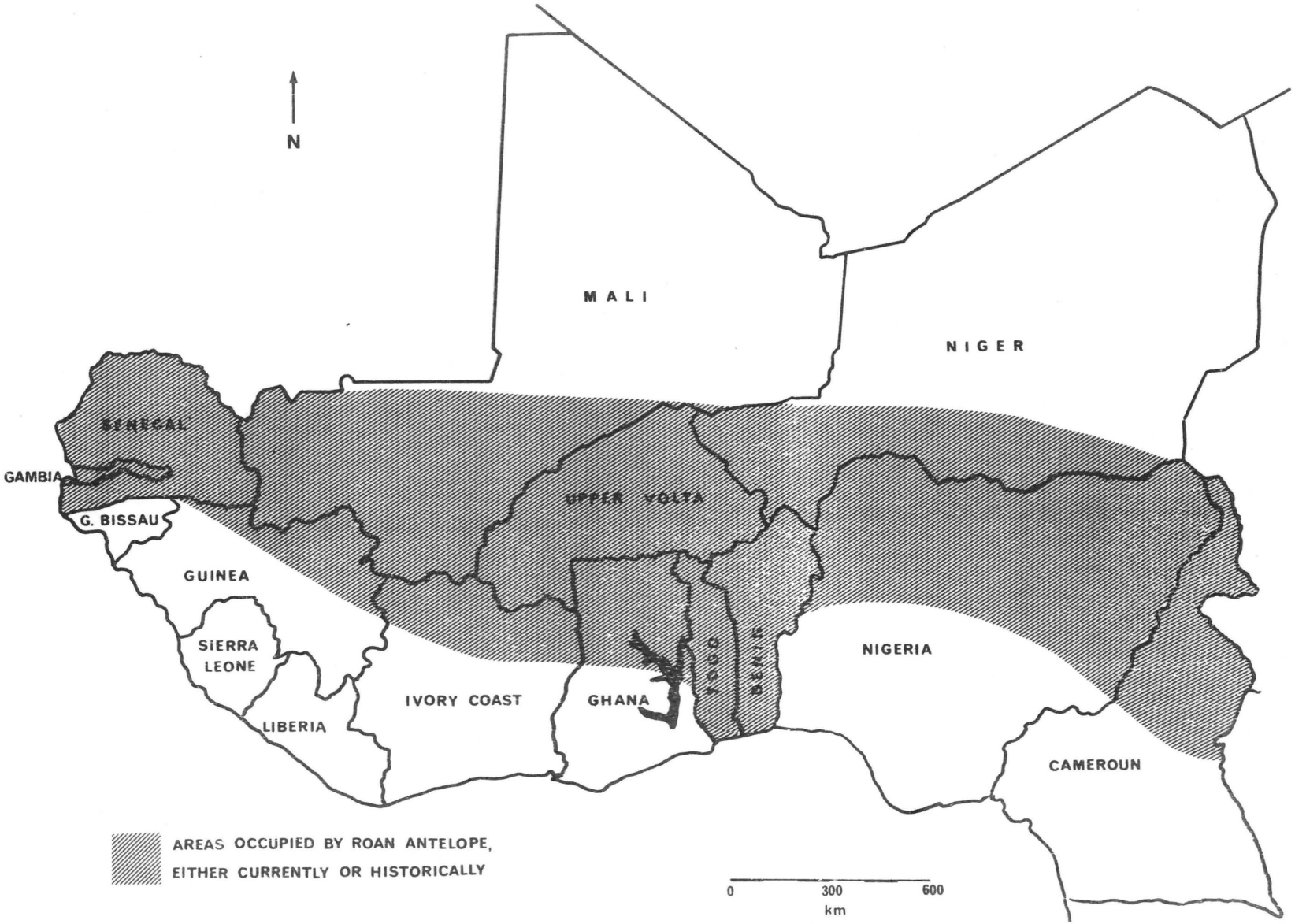

Figure 17 : The past and present distribution of the roan antelope in West Africa.

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Countries of the West African Coast (Guinea, Ivory Coast, Ghana, Togo and Benin).

In all but Togo and Benin the distribution of roan is restricted to the northern areas due to extensive forests along the southern coastal regions. In Togo and Benin the Northern Savanna zone extends almost to the coast and thus facilitates a similar extension (Fig. 5 and 17) in the range of the roan (De la Tour 1957).

In Guinea "many hundreds" of roan still existed in the 1950's but poaching was severe (Melo Cristino 1958). They were apparently not represented in any protected areas and their present status is unknown.

In the Ivory Coast some roan are found in the Bouna Total Reserve (Guggisberg 1970) while a small population also occurs in the Konoe Reserve (King and Woodley 1971).

In Ghana roan are protected in the Mole Game Reserve but do not occur in "great numbers" while a remnant population is also included in the proposed Volta Game Reserve (Child G.S. In litt.).

In Togo roan occur in two reserves, i.e. the Koue Total Faunal Reserve and the Keran Game Reserve (Guggisberg 1970).

In northern Benin roan occur in the National Park W and probably also in the Pendjari Bend National Park. It is also probable that roan still exist in some of the controlled hunting areas surrounding the two national parks (Riney and Hill 1967).

Nigeria and Niger

In historic times roan appear to have been widely distributed and numerous throughout the northern regions of Nigeria (Fig. 17).

Arnold (1899) considered roan "fairly numerous" on the Middle Niger and Benue River northwards to Lake Tchad. The southern limit of the roan's distribution was given as latitude 3°30' N and they were considered common around Yauri, on the left bank of the Niger (Arnold 1899). Hartet (1901/'02) also recorded

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them from these areas and further referred to roan occurring in the Lokoja and Ushiambisa districts.

Roan were also found in "fair numbers" by Haywood (1926) at Zungeru in northern Nigeria.

De la Tour (1957) referred to roan in the Northern Savanna areas and Rosevear (1953) also indicated a wide distribution from Kokoja and Makurdi northwards.

Henshaw and Child (1972) stated that "the status of this large savanna antelope in Nigeria gives much cause for concern", while the present distribution of the roan in southern Niger was given by Poche (1974) as the "area south of a line extending from 10 km south of Say to 10 km north of Torochi". Regarding its present numerical status Poche (1974) recorded that between Say and Tamou roan densities were "relatively low" but increased gradually towards Tapoa and considered their general status as "favourable".

Roan antelope are found in the Yankari Game Reserve, where they are represented by a poor population, and the Borgu Game Reserve where they are common (Henshaw and Child 1972). In the Borgu Game Reserve the population is estimated at between 1 500 and 2 000 (Child In litt.). Roan are further found in a few isolated localities in the Guinea Savanna zone (Child In litt.). In the National Park W, which also includes areas of Benin and Upper Volta, a "viable", if depleted, population still exists (Poche 1973). In a subsequent publication Poche (1974) estimated a total roan population of 11 320 for the National Park W on the basis of road-strip counts, and of these roan 3 000 were in the Niger portion, 3 300 in that of Upper Volta and 5 020 in the Benin portion of the park.

Cameroun

Roan once occurred widespread throughout the central and northern savanna zones (Fig. 5 and 17) of the Cameroun (De la Tour 1957).

More recent information on the status and distribution of roan in this

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country could not be obtained but they are apparently well represented in some of the protected areas. In the Waza National Park the roan population was estimated at 4 000 in 1962 (Anon 1962). Guggisberg (1970) also mentioned them from the Boubandijidah National Park in the east-central region.

Upper Volta

Upper Volta falls almost entirely within the Northern Savanna zone (De la Tour 1975) and it can consequently be assumed that roan were once widely distributed throughout the area. No recent information could be obtained on the distribution or status of the roan but there was still a "viable" population of 3 300 in the National Park W (Poche 1973, 1974).

Riney and Hill (1967) also mentioned the occurrence of roan in the Bouche du Baoule, Elephant and Asongo Manaka reserves. Although roan appear to be well represented in the conservation areas of Upper Volta their numerical status is unknown.

Mali

Roan were widely distributed in the southern half of Mali which falls within the Northern Savanna zone (Fig. 5 and 17) and are present in the Baoule National Park (Guggisberg 1970).

CONCLUSIONS

In addition to its extremely wide geographical range of distribution the roan antelope is also adapted to exploit suitable rangelands varying in altitude from sea level (cf. Angola) to almost 2 438 m (8 000 feet) above sea level (Cater 1953/'54, Stewart and Stewart 1963).

In its distribution the roan is largely confined to the Northern and Southern Savanna zones (Fig. 5 and 6) though Ansell (1971) has pointed out that it is strikingly absent from the eastern areas of the Southern Savanna. As a species inhabiting open savanna communities, the roan also overlaps into the South West Arid, Somali Arid and Sudanese Arid zones but is notably absent from the moister, heavily wooded zones.

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Generally the population trends of the roan have followed similar lines to those of most animal species, i.e. decreasing numbers associated with a decrease in available land due to an increase in human populations. However, the roan is well represented in numerous protected areas throughout its range of distribution and provided these areas are properly administrated to serve their intended function, the species is in no immediate danger of extinction. Though this may be true in general there are, however, areas where the roan has either already become extinct (cf. Swaziland) or has decreased to the level where only special attention and the strictest protection can save it from extinction. This is especially true of southern Africa including South Africa, South West Africa, Botswana, Mocambique and Rhodesia (Bothma 1975) and the eastern and western areas of central Africa, including Zaïre, the Central African Republic, Ruanda, Uganda and Kenya.

It is also noteworthy that, in spite of the roan's wide distribution, it seldom ranks as one of the dominant species in any faunal community. Characteristically it occurs in relatively small herds scattered over large areas. Exceptions do exist (cf. Quicama National Park, Angola) where the roan is particularly numerous but even in these areas the number per unit area is low when compared with the concentrations of the more gregarious species, e.g. wildebeest, for which Africa has become renowned.

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CHAPTER 3 : AGE DETERMINATION

INTRODUCTION

For the purpose of practical wildlife management it is essential to have a thorough knowledge of the age structure of the various wildlife populations in any particular community. A wide variety of criteria for determining the age of mammals have therefore been suggested. Diverse characteristics such as tooth growth, sequence of eruption and wear, horn development, eye lense mass, total body mass and various measurements of the body have all been employed with satisfactory results on different animal species.

It is, however, an unfortunate fact that many of the methods in current use necessitate either the handling of the animal or are dependent on material collected from carcasses. This is probably due to the fact that work of this nature has largely been focussed on species which are culled or hunted in large numbers and where sufficient material is readily available. Where the destruction of large numbers of animals is done on a routine operational basis, the necessity for a reliable means of ageing individuals is understandably a prerequisite for the successful management of the species involved.

However, in the management of ecosystems it is also equally important that less numerous species be taken into consideration as the reduction of one or more species in an animal community will inevitably also influence the associated species. Where the age structure of populations of less numerous species is required to determine population trends it is therefore desirable - if not mandatory - to find reliable criteria by which age classes can easily be identified in the field and at the same time ensure a reasonable amount of accuracy.

METHODS

With the introduction of the initial herd of ten roan antelope into the enclosure at Nwashitsumbe a record was made of the annular horn rings of

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each animal. Each animal was also marked by means of a combination of coloured ear tags and streamers which enabled individual identification. During the study period of six years, a careful record was kept of the number of horn rings of various individuals. Horn ring counts were made by means of a 40 x 60 mm Hensoldt Wetzlar Dialyte telescope or 10 x 50 mm Halina binoculars from a vehicle.

The animals originally released into the enclosure were of unknown age though they represented all age classes from immature to fully adult. Horn development and the accumulation of rings could, however, be determined over a three year period and the results thus obtained were later correlated with those observed in animals which were subsequently born in the enclosure and for which the date of birth was known.

In all operations necessitating the capture and handling of roan antelope note was taken of the tooth eruption sequence of the incisors and canines. Other relevant data, e.g. horn length and body measurements, were also collected during such operations. From a sample of six adult animals, representing various age groups from young adults to very old adults, the first permanent tooth in the dentition, i.e. molar 1, was taken from either the mandible or maxilla to determine the presence, or absence, of cementum layers. Preparation of the teeth involved decalcification by using Gooding and Stewart's Fluid (Culling 1957) with 25 per cent formic acid. Sections, 6u thick, were made and stained with gentian violet. Staining with eosin also gave good results although the former was considered superior.

RESULTS

HORNS

Horns are present in both sexes of the roan antelope. From the age of approximately 24 months the sexes may be differentiated on the basis of the stouter build of the horns of the male. Up to the age of two years the horns of both sexes are quite similar in size and shape and it is only in the older

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age groups that the differences become more conspicuous. From the age of two years the sexes are easily differentiated on the basis of horn characteristics. Initially the horns emerge as two straight spikes and only in the yearling stage does the gradual backward curvature become apparent. Adult animals are characterised by their backward sweeping scimitar-shaped horns, unique among African antelopes for the roan and sable.

During the first year the horns are smooth-surfaced after which distinctive annular rings start emerging at the base.

Horn growth and development

Horn length

Roan antelope calves are born without horns and with only two twisted crests of hair indicating the sites where the horns are due to appear.

In four calves the tips of the emerging horn buds were first observed on the 34th, 35th (± 1 day), 39th and 40th day after birth. These observations were all made on free-roaming wild animals by using a 40 x 60 mm telescope and the possibility exists that the horns may have emerged a few days earlier but only became visible under field conditions once they had surfaced the covering tufts of hair.

By the age of two months the horns are clearly visible as distinct spikes, approximately 3 to 6 mm long. During the first year of life the horns grow into sharp-tipped spikes almost parallel to one another but diverging slightly at the tips. Between the second and twelfth month the horns grow at a rate of roughly 15 mm per month to attain a length of approximately 140 to 180 mm at the age of one year. Data on horn growth are presented in Appendix 2 and Fig. 18 A to L.

Three sources of data were used to determine horn length from which linear regressions could be obtained:

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A Two weeks

B Five weeks

C Six to eight weeks

D Three months

E Five months

F Six to seven months

Figure 18: Horn growth and development as an indication of the age of roan antelope in the Kruger National Park, South Africa

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G Ten months

H Twelve months

I Sixteen months

J c. Thirty months

K Young adult

L Adult

Figure 18: (cont.): Horn growth and development as an indication of the age of roan antelope in the Kruger National Park, South Africa.

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(i) A limited sample of only 10 measurements of known-age animals was available and of these five fell within the age-class four to seven months. In spite of the small sample a correlation coefficient (r) of 0,989 (S.D. = 2,396) was obtained (Fig. 19 A). The sample was too small to differentiate between males and females.

(ii) In a second approach a considerably larger sample of measured horn lengths, but of animals of unknown age, was used. However, the ages were calculated from combinations of alternative ageing criteria. In this sample of 57 animals, regressions were determined separately for males (n = 34) and females (n = 23). In both these regressions there was a definite correlation between horn length and age (males: r = 0,938; S.D. = 4,706 and females: r = 0,948; S.D. = 4,118). However, these regressions indicate a significantly higher rate of increase in horn length in males than in females (t = 8,919; P 0,05; d.f. = 55) (Fig. 19 B = females and C = males).

(iii) As it has been the objective of this study to determine ageing criteria which could be applied in the field, estimates of horn length by a number of different observers was examined as a third alternative. Estimates of horn length of known-age animals are represented in Fig. 19 by regression D (r = 0,946; S.D. = 2,134).

In determining the relationships between age and horn length only animals in the age group 0 to 36 months were considered. This limitation was imposed for two reasons, i.e. firstly, where horn lengths were available but the age of the animals unknown, alternative ageing criteria could be used to determine the age of animals in this age-group with a reasonable degree of accuracy while this was not possible in the case of post-mature individuals; and secondly, the importance of horn length for age determination is limited to the immature stages and more specifically, to age classes under 12 months.

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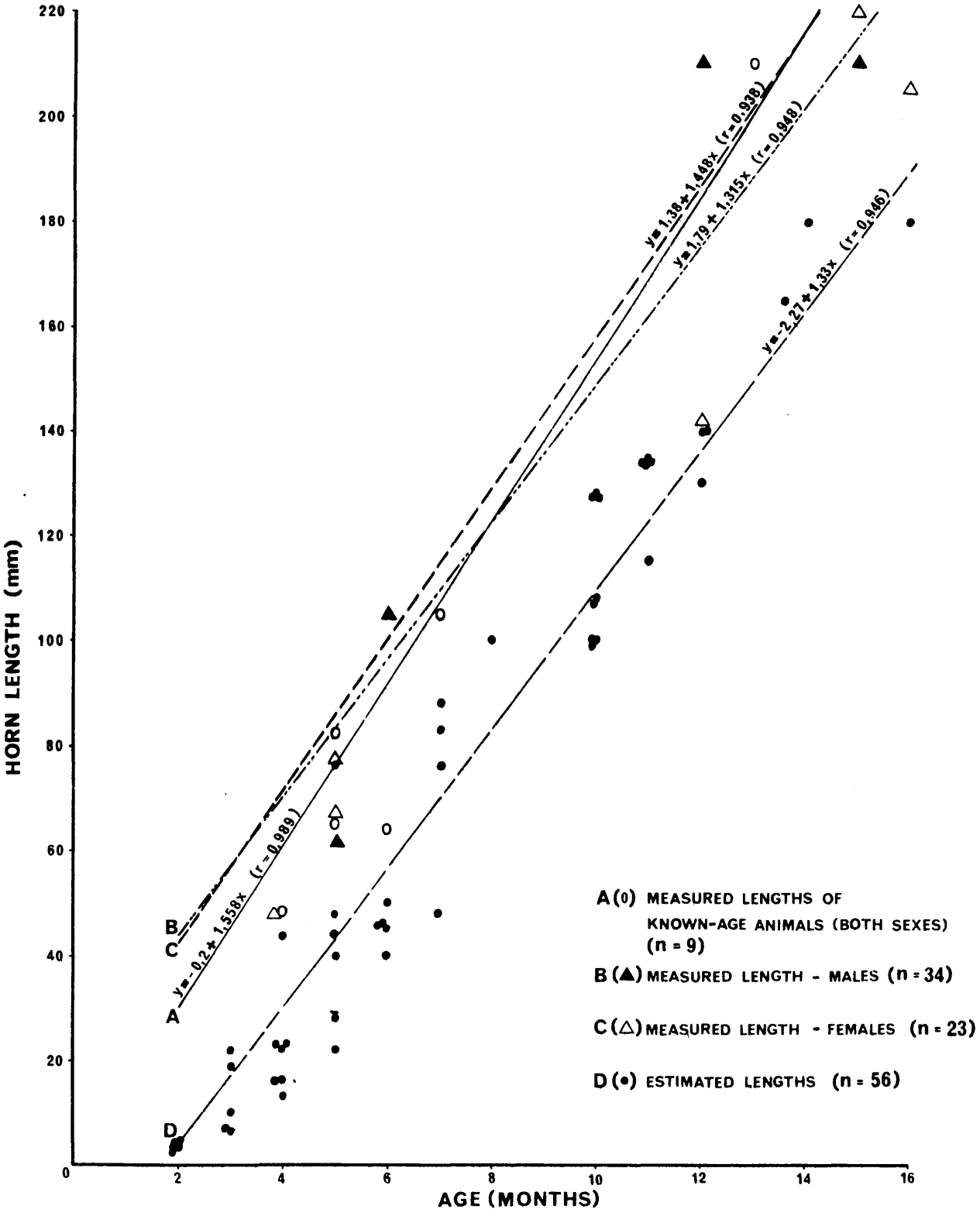

Figure 19 : Correlation of horn length with age in roan antelope up to the age of 16 months, from horn lengths obtained in the Kruger National Park, South Africa and the National Museum, Bulawayo, Rhodesia. The correlations are derived from horn lengths of animals up to the age of 36 months while only those falling within the age group 0 to 16 months have been plotted.

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Age determination by means of horn growth characteristics in immatures

The correlation between horn length and age as obtained by all the criteria applied, indicate that horn length could form a convenient basis for age determination, at least in the immature and sub-adult stages to the age of 30 to 36 months. However, as horn length becomes superfluous as a means of age determination beyond the age of 12 months, due to other more readily applied field methods, the use of this criterion to age roan in the field is suggested only for animals under 12 months of age (Table 2) although it may be practically useful up to the age of 16 months (Fig. 19).

By comparing the different regressions in Fig. 19 it is immediately apparent that all the methods employed where actual measurements were available, indicate a close correlation with one another. The major differences between these regressions are in the youngest age classes, up to four months, and in the older age categories, above 13 to 14 months. It is believed that these differences are mainly due to the fact that sampling was not evenly distributed throughout the whole range of age distribution. For regression A (horn lengths of known-age animals) five of the 10 animals measured fell within the four to seven month age bracket while the rest were all older than 12 months. Conversely, the regressions plotted for females (B) and males (C) relied heavily on a preponderance of animals above the age of 12 months (of the males only two of the 34 were under 12 months and of the females, four).

In all the samples horn lengths of immatures between two and three months were, with a single exception, entirely lacking. It is therefore suggested that in using the regressions for age determination, A be considered for animals between four and seven months of age, especially as there is not much difference in the lengths of male and female horns during this stage. From seven to 16 months regression B and C are recommended for females and males respectively.

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Table 2 : Age classes for roan antelope calves, 0 to 12 months of age, on the basis of horn length in the Kruger National Park, South Africa.

AGE		HORN LENGTH (mm)	
Class	Months	Estimated	Measured
I	0 - 2	Horns first appear 5-6 weeks. Clearly visible at two months.	5 - 10
II	3 - 5	5 - 80	10 - 70
III	6 - 9	80 - 140	60 - 140
IV	8 - 12	140 - 190	130 - 180

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It is noteworthy that regression D (i.e. estimates of horn length) runs almost parallel to the other regressions but indicates an under-estimate of the true length of horns. Under-estimating horn lengths of roan may be influenced by especially two factors, i.e. the exceptionally long ears of the roan may tend to make the horns appear shorter than they actually are and the hairy covering concealing the base of the horns may be confusing and lead to under-estimates. In spite of the under-estimates by different observers, the error is remarkably constant and therefore validates this method as a rough and readily applicable field method for determining the age of immature roan.

Horn rings

Between the age of 10 to 12 months the first of a series of annular rings appears on the horns. In a sample of eight known-age calves the first ring became apparent at 11, 10-11, 11, 12, 10-11, 11, 10-11 and 11 months of age respectively. The first one or two, and occasionally even the third, "rings" are merely ridges on the anterior surface of the horns which, with increase in age become less discernible until at the age of three years the first and sometimes the second ridges are hardly visible at all in the field. After the second or third ridge, the first complete ring, a distinctive bulging band encircling the horn, is formed.

During the second and third year the rings appear from the base of the horns at regular intervals and are clearly distinguishable from one another by marked depressions between the successive rings. During the fourth year the rings are still clearly visible though they become less well defined and by the fifth year follow one another with hardly any intermittent depressions. From the fourth year the counting of rings under field conditions becomes impractical. With increasing age the basal area of the horns becomes almost flat-surfaced with little or no indication of rings.

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In Table 3 and Fig. 20 data on horn ring formation in relation to age are presented. From these data it is apparent that ring formation continues at a constant rate of eight rings per annum for at least two years, i.e. the second and third years of life. With the appearance of the first ridge at the age of 11 months an animal at the age of 23 months would therefore have approximately eight rings and approximately 16 at the age of 35 months. With four rings developing every six months, horn rings could therefore form a convenient basis for determining the age of roan in their second and third years.

The high correlation coefficient (r = 0,991) and low standard deviation of 0,6561 endorses the reliability of this method though the following possible sources of error must be pointed out:

(i) The appearance of the first ridge usually occurs in the eleventh month but may also develop in the tenth or twelfth month thus resulting in a margin of error of $\pm$ one month.

(ii) The ridges that precede the actual rings become less conspicuous with increasing age and may be overlooked when applying this method in the field though the margin of error is not believed to exceed an under-estimate of two months.

(iii) As with all biological material, individual peculiarities are occasionally present, e.g. deformed horns or poorly developed rings. In one particular cow one horn had normal rings while the other had no rings whatsoever. Animals with malformed horns or poorly developed rings are, however, exceptional and easily noticeable.

During the second year the horns continue growing out as straight spikes although a slight backward curvature may be observed from the 18th to 20th month. At the age of two years the horns are approximately 360 mm long in males and 330 to 340 mm in females with seven to eight distinct rings in both sexes.

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Table 3 : Number of horn rings between the age of 10 and 37 months in roan antelope in the Kruger National Park, South Africa.

NO.OF HORN RINGS	AGE (IN MONTHS) AND SEX OF ANIMALS IN SAMPLE															
	♀*	♂*	♂*	♀*	♂*	♀*	♀*	♀*	♀*	♂*	♂*	♂*	♂	♀	♀	♀
1	11					10	11		11-12	11			11-12			
2	12	14	14	14	14		12	13	13							
3	14	16		16	16	15-16	15	15		15				15-16		
4						16-17				17	17					
5					19		18	18							18	
6					20			20	20				21			
7					22	20		21		19						21
8													23-24	24		
9							23						25			
10													26	26		
11												28	28	28		
12												29	29	27		
13													31	31		
14					33								33	33	29	30
15																33
16								32					37	35	34	

*Known-age animals, age of other animals in the sample determined by means of alternative ageing criteria.

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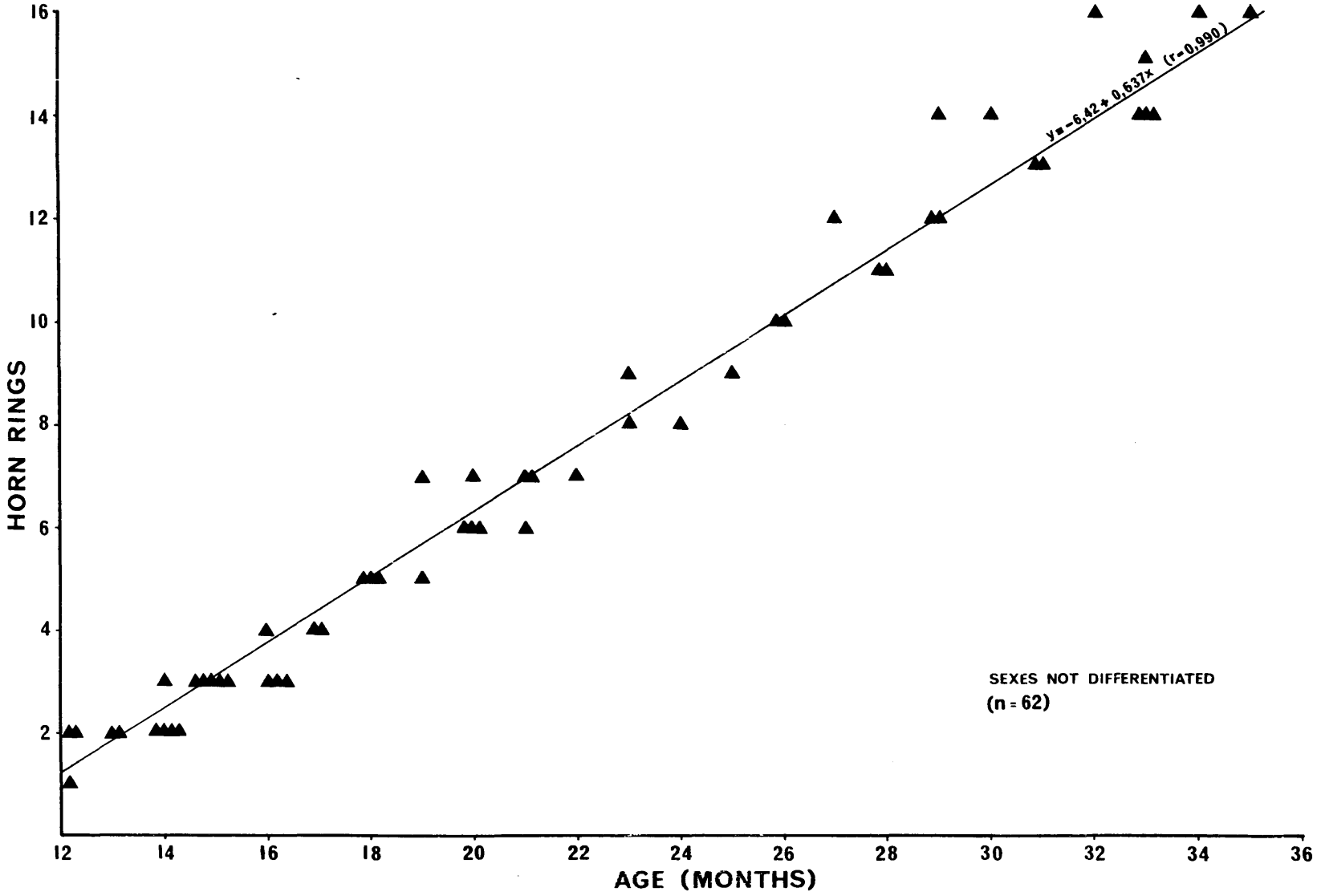

Figure 20 : Correlation of horn rings with age in roan antelope between the age of 12 and 36 months as determined from data obtained in the Kruger National Park, South Africa and the National Museum, Bulawayo, Rhodesia.

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During the third year the curvature of the horns becomes more pronounced and at the end of the third year the horns have clearly taken on the characteristic scimitar-shape of those of adult roan antelope. At the end of the third year the horns are approximately 520 mm long in males and approximately 490 mm in females with 15 to 17 rings in both sexes.

During the fourth and fifth years the rings become less well defined and the rate of growth of the horns gradually diminishes until they reach a maximum length from 520 mm to 700 mm. The maximum length is probably attained by the end of the fifth or sixth year. In a sample of 30 males over three years of age, the average horn length was 618 mm and for 19 females in the same age group it was 538 mm .

Though horn length and horn rings are not suggested for age determination in adult animals, the less well-defined rings at the base of the horns, which result in an almost smooth surface in older animals, may however be used to differentiate between young adults, adults and old animals.

Young adults in their fourth and fifth years have ill-defined rings at the base of the horns. Although individual rings are easily distinguishable at close range they follow tightly on one another and are therefore difficult to count under field conditions. These ill-defined rings follow on the 16 to 17 rings at the end of the third year, to reach a total of 25 to 30 at the end of the fifth year.

In older animals the base of the horn becomes completely smooth-surfaced without any clearly discernible rings. The height of the smooth base appears to be closely related to age and this phenomenon is confirmed by comparing it with the other age criteria. The fact that the smooth base does not commence at the same stage in all individuals tends to limit its reliability in age determination and for adults the following age groups are suggested:

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1. Young adults: Including all animals with 16 to 17 rings to a smooth horn base 30 mm broad.
2. Adults: Animals with a smooth horn base ranging from 30 to 100 mm .
3. Old adults: Individuals with a smooth horn base exceeding 100 mm .

A number of rather poorly defined ridges may be discernible on the surface of the smooth base and similar ridges on the horns of other antelopes have been suggested as additional aides in determining the age of the animals (Simpson 1971). These annulations have not been taken into consideration in the present study primarily because no known-age adult animals were available in the sample to determine the reliability of the method. Additionally, the ridges are poorly defined in most cases so that an accurate count is difficult to obtain, and finally, because either measuring or - under field conditions - estimating the height of the horn base presents a more feasible approach.

Age determination by means of horn rings.

Though horn length can be used as a criterion for ageing roan between 12 and 36 months, the appearance of the conspicuous annular horn rings provide additional criteria which not only relieve the observer of estimating horn lengths (which become less reliable with increase in horn length) but provide a readily applicable method with greater reliability. Age classes for sub-adult animals based on horn rings are presented in Table 4.

On the basis of horn development at least three additional age classes amongst adult animals may be differentiated as outlined in Table 4.

TEETH

Ageing criteria based on tooth development and the sequence of eruption are well known for a wide variety of mammals. In roan the replacement of the deciduous teeth follows the same general pattern as that of most bovids and can conveniently be used for ageing animals up to the age of three years. Once the full complement of permanent teeth has been acquired, additional ageing criteria may be deduced from the degree of wear.

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Table 4 : Age classes determined on the basis of horn rings and horn growth characteristics in roan antelope in the Kruger National Park, South Africa, and the skull collection of the National Museum, Bulawayo, Rhodesia.

	AGE	HORN RINGS AND/OR HORN CHARACTERISTICS
Class	Months	
IV	10 - 12	1 - 2 ridges on anterior surface of horns
V	13 - 14	2 - 3 including ridges
VI	15 - 18	4 - 5
VII	19 - 24	6 - 9
VIII	25 - 30	10 - 13
IX	31 - 36	14 - 17
X	c. 4-5 years	Young adults: Horns with full backward curvature. Rings at basal area of horns follow tightly on one another but clearly distinguishable and a smooth horn base up to 30 mm .
XI	c. 6-10 years	Adults: Horn shape as above. Basal areas of horns without clearly distinguishable rings and largely flat-surfaced. Smooth basal area 40-100 mm broad.
XII	Older than c. 10 years.	Old adults: Basal areas of horns smooth surfaced, appear worn and exceed 100 mm in height.

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Most of the data presented here were obtained from the skull collection of the National Museum in Bulawayo, Rhodesia. Additional data on tooth phenomena were collected during capture operations in the Kruger National Park and in the Waterberg district of the Transvaal as well as from odd skulls which were salvaged from predators during the course of the study. Unfortunately only a limited number of known-age skulls were available to determine the validity of the various age classes based on eruption sequences. However, by applying all available data on ageing criteria (e.g. horn growth and development) it was possible to identify a number of age classes as reflected by tooth replacement and to ascribe a specific age to each class.

The tooth formula of the roan antelope conforms to that of most bovids and consists of:

Maxilla :	Incisors: 000	Canine: 0	Premolars: 0234	Molars: 123
Mandible :	Incisors: 123	Canine: 1	Premolars: 0234	Molars: 123

Of these the incisors, canines and premolars are deciduous and are replaced in the course of the first three years of life while the molars are represented by a single permanent set.

Tooth characteristics useful for age determination

Tooth replacement

At birth all the deciduous incisors and canines are fully erupted with the premolars in various stages of eruption. At this age the first signs of the first molar tooth also become apparent in the skull with the tooth just starting to emerge through its bone casing in both the maxilla and mandible. By the age of four to five weeks all the deciduous incisiform, caniniform and premolariform teeth are fully erupted. This position prevails until the third to fourth month of age when the anterior cusp of molar 1 starts to appear in the lower jaw. At this stage molar 1 of the maxilla is only just emerging from its bone casing. Apparently the eruption of molar 1 extends over a period of months and in a six to eight month old animal the anterior cusp of molar 1 of the maxilla had just

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erupted while molar 1 of the lower jaw was almost completely erupted.

At the age of one year molar 1 is fully erupted in both upper and lower jaws while molar 2 is just breaking through its mandibular bone casing. No sign is as yet evident of molar 2 in the maxilla.

The eruption of molar 2 in the lower jaw commences between the 14th and 15th months of age. Simultaneously molar 2 of the upper jaw is in the process of breaking through the bone casing of the maxilla. Full eruption of molar 2 in upper and lower jaws is usually achieved by the 19th or 20th month.

By the age of 28 months molar 3 first makes its appearance in the lower jaw with the eruption of the anterior cusp. Towards the 33rd to 34th month of age all the molars have erupted and are in use.

In the eruption process the mandibular molars clearly precede the corresponding molars of the maxilla and are usually already at the point of erupting before their counterparts of the upper jaw have fully broken through the bone casing.

The first deciduous teeth to be replaced are the incisiform teeth. The eruption of incisor 1 usually takes place between the 20th and 24th month. During the 28th month incisor 2 appears after which incisor 3 and the permanent canine follow rapidly on one another. By the end of the 34th month most of the individuals have their full complement of permanent incisors and canines.

Considerable overlap is evident during the period of rapid replacement (i.e. 28th to 34th month) with some animals having replaced all their deciduous incisors and canines by 31 or 32 months of age while in others they are still erupting. It has also been noted that in some individuals the eruption of the corresponding incisors on either side of the jaw are not necessarily synchronised, with incisor 1 or 2 replaced on the one side, and incisor 3 and even the canine already replaced on the other.

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All the premolars are replaced almost simultaneously and are the last of the permanent teeth to come into use. By the time the last molar has erupted the deciduous premolars are usually reduced by wear to mere caps covering the emerging permanent premolars which come into use shortly after the eruption of molar 3, i.e. between the 35th and 36th month.

Tooth-wear categories

Figure 21 illustrates the full complement of permanent teeth shortly after the replacement of the last set of deciduous teeth, i.e. the premolars. In the following discussion and in Fig. 21 tooth nomenclature follows that of Flower and Lydekker (1891) and Spinage (1973).

Although tooth attrition phenomena have customarily been applied to the permanent teeth in determining age categories (Spinage 1967, Simpson 1973) there does not seem to be any reason why the same phenomenon could not be applied to the deciduous incisors and premolars to augment the age categories in immature and sub-adult animals. The following age classes based on tooth wear are suggested for roan antelope:

Immatures: 0 to 12 months

At birth the incisiform and caniniform teeth are practically fully erupted while the premolariform teeth are in various stages of eruption. By the age of four to five weeks all the deciduous teeth are in place. Although some nibbling of grasses takes place from the second or third week, the full eruption of the milk teeth roughly coincides with the commencement of more serious grazing. At this stage there is obviously no apparent wear on any of the teeth. During the period in which the eruption of molar 1 takes place, only light wear becomes evident on the incisors and premolars. By the end of the first year the following features may be mentioned with regard to tooth wear (Fig. 22a):

Mandible: Deciduous incisors 1, 2 and 3 and canine 1 retain much the

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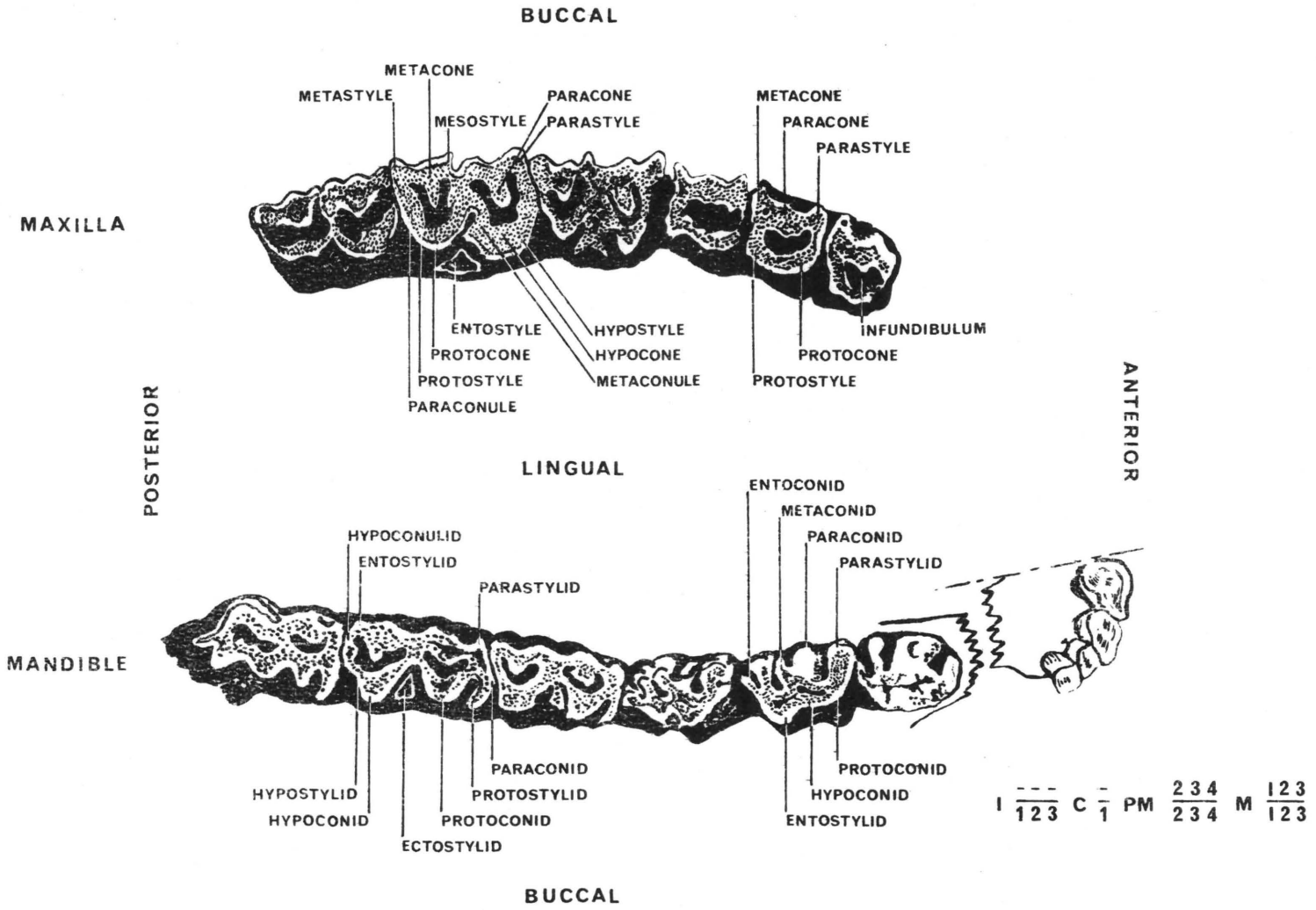

Figure 21 : Full complement of permanent teeth of the roan antelope immediately after the eruption of the permanent premolars at age 36 to 38 months. Nomenclature follows Flower and Lydekker (1891) and Spinage (1973).

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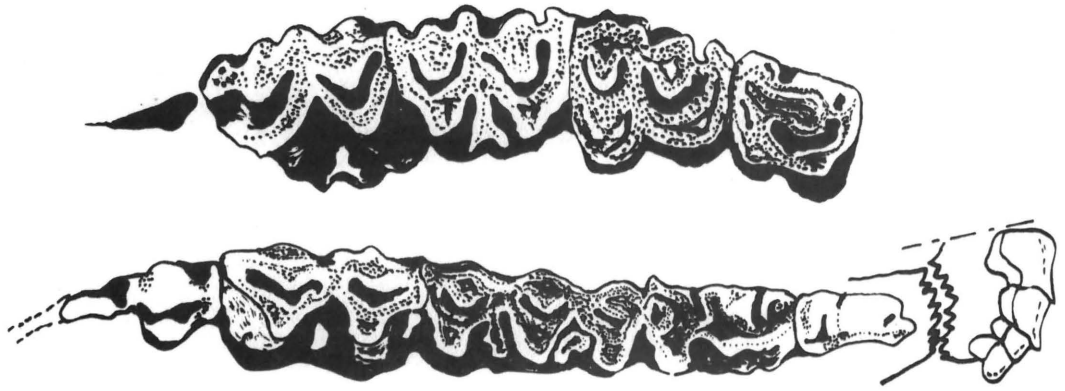
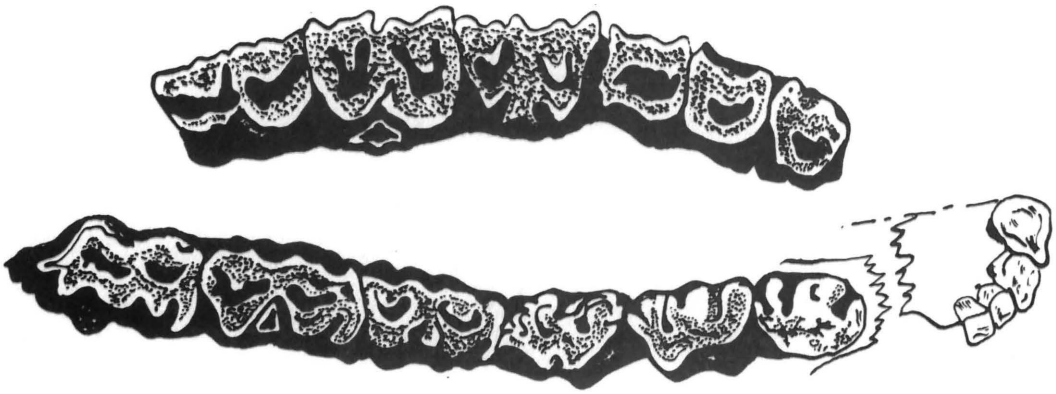


a immature

b sub adult



A YOUNG ADULT

Figure 22 : Stages in the tooth attrition of roan antelope representative of relative age classes. Data obtained from the Kruger National Park, South Africa and the skull collection of the National Museum, Bulawayo, Rhodesia.

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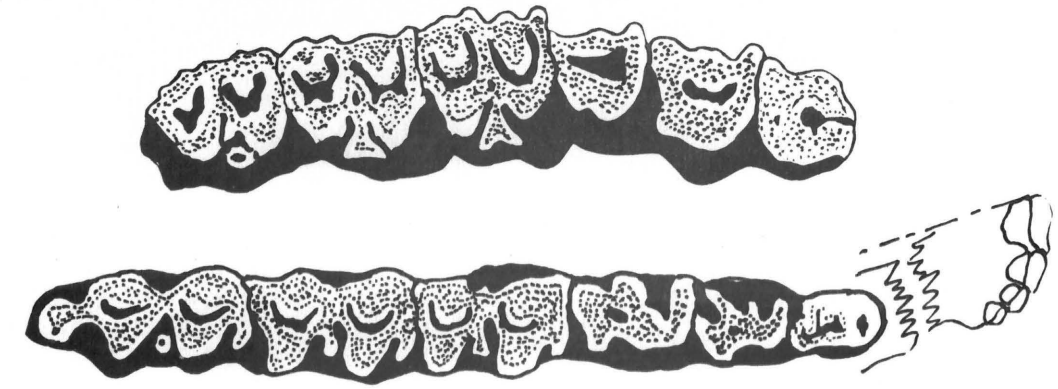
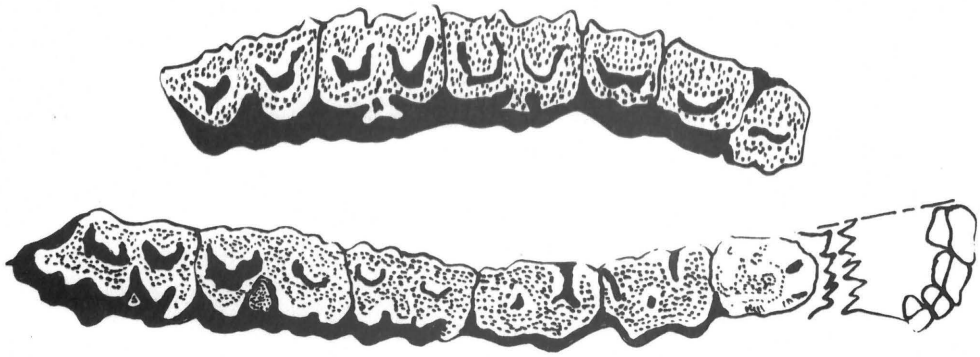
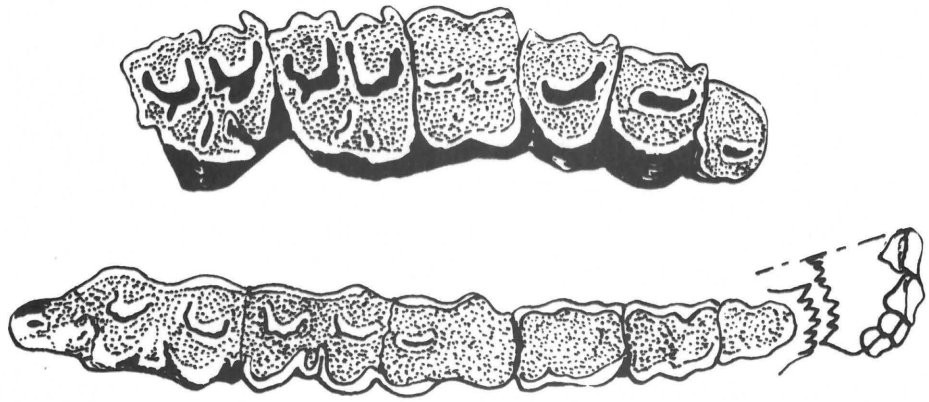


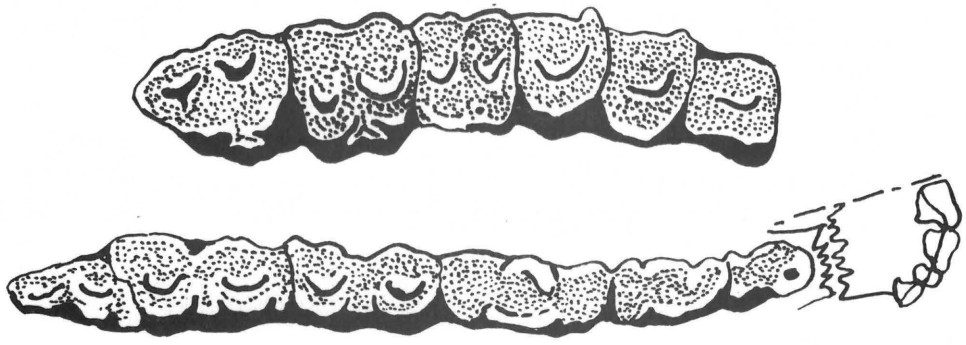
B ADULT



C ADULT



D OLD ADULT



E VERY OLD ADULT

Figure 22 (cont.) : Stages in the tooth sttrition of roan antelope representative of relative age classes. Data obtained from the Kruger National Park, South Africa and the skull collection of the National Museum, Bulawayo, Rhodesia.

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same size and shape as at birth with a slight flattening of the anterior edges due to wear; premolar 2 intact as erupted with no apparent wear, premolar 3 light wear on the anterior surface (protoconid) with heavier but still light wear on the posterior areas (metaconid, entoconid and entostylid), premolar 4 with light wear apparent on all surface areas, infundibulae well defined and clearly horseshoe shaped; molar 1 with no wear and the proto- and ectostylids floating, i.e. seemingly detached units of the tooth from a dorsal point of view, molar 2 meta- and protoconids just breaking through mandibular bone casing.

Maxilla: Light wear only on premolar 2 while premolar 3 and 4 indicate general but light wear, infundibulae conspicuous and in premolar 4 the entostyle is clearly attached to the main body of the tooth (metaconule); molar 1 no wear and entostyle apex floating, molar 2 not yet emerging from bone casing but crevices in maxillary bone indicate its position.

Sub-adults: 13 to 20 months

The limit of this phase was chosen to coincide with the full emergence of the maxillary molar 2.

Considerable attrition and consequently changes in the general shape of the premolars takes place during this stage and at its conclusion wear for both incisors and premolars may be regarded as moderate or even heavy moderate (Fig. 22b). With the appearance of molar 2 in the maxilla the general tooth charactersitics are:

Mandible: All incisors reduced in size and dorsal surfaces more flattened and oval-shaped than in immatures; premolar 2 still showing the least wear though apex of the protoconid worn and exhibiting flattened surface as also the ento- and metaconid sections, the entire dorsal surface of premolar 3 largely flattened with clear incision between meta- and entoconid sections or incision only apparent as small infundibulum

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following fusion of the meta- and entoconids; the two infundibulae of the previous stage having disappeared altogether; attrition of premolar 4 similar to that of premolar 3 with the dorsal surface flattened and the three infundibulae in various stages of disappearing. All the premolars are more rectangular in shape than in immatures. Molar 1 clearly showing light wear with the fusion of the proto- and ectostylids to the main body of the tooth; infundibulae (two) well defined as well as the incision between the ectostylid and the protoconid; slight wear is apparent on anterior surfaces of molar 2, with the fusion of the protostylid to the protoconid, ectostylid apex floating, infundibulae well defined, proto- and metaconid of molar 3 breaking through mandibular bone casing.

Maxilla: Moderate to heavy wear apparent on all premolars. The basic shape and pattern of these teeth unchanged although the apposition surfaces flattened and the infundibulae considerably reduced; molar 1 also showing light wear with ento-style clearly attached to the metaconule, infundibulae well defined; molar 2 without any apparent wear, entostyle apex floating; no signs of molar 3 emerging from maxilla casing.

Sub-adults: 21 to 35 months

At the conclusion of this stage the full complement of permanent teeth are in use.

Before being replaced the incisors are worn close to the gums and have flattened oval or rounded surfaces. The permanent incisors are similar in shape to their deciduous counterparts and by the end of this stage there is no visible wear. Other changes include:

Mandible: In the latter half of this period the heavy wear of the premolars is evidenced by large flattened apposition surfaces and the loss of all infundibulae with the single exception of that of premolar 2.

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By the 33rd month the premolars are reduced to mere 'caps' loosely fitting over the emerging permanent set; molar 1 does not differ from that of the previous stage and wear is light, infundibulae probably more horseshoe-shaped; light wear becomes apparent on cusps of molar 2, ectostylid apex still floating; molar 3 recently erupted and showing only very light wear on anterior cusps, proto- and ectostylids floating.

Maxilla: Compared to the 13 to 20 month age group, the premolars show progressive loss of infundibulae and consequently more flattened dorsal surfaces - this is especially true of premolar 2 while premolar 3 and 4 do not necessarily differ much from those in the preceeding stage; molar 1 appears identical to that of the previous stage with light wear; molar 2 has no apparent wear, apex of entostyle floating; molar 3 just or not quite fully erupted and consequently no wear.

Young adults

This phase commences with the acquisition of the full complement of permanent teeth, i.e. with no visible wear of the incisors and premolars and only light wear on molar 1 and 2 and none on molar 3.

During this stage the changes taking place in the respective teeth include the following:

Mandible: The incisors gradually lose their sharp-edged appearance and at the end of the phase exhibit a slightly flattened anterior surface; the protoconid apex of premolar 2 gradually wears off to form a flattened surface and the incision between the paraconid and metaconid is deep and well defined; premolars 3 and 4 have very much the same appearance and by the end of the phase the meta- and entoconid sections have merged resulting in a clear round infundibulum on the main surface of the tooth; molars 1 and 2 also show a fair amount of wear with the fusion of the

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ecto- and protostylids to the main body of the tooth; in molar 3 the protostylid is clearly fused with the paraconid while the apex of the ectostylid is clearly rounded off but is not attached to the tooth.

Maxilla: No notable changes take place in the premolars other than a gradual broadening of the contact areas with a corresponding reduction in the size of the infundibulae. In molar 1 the entostyle has fused with the metaconule while in molar 2 the fusion is not quite completed by the conclusion of this phase. In molar 3 the apex of the entostyle is slightly worn but is still separate from the body of the tooth. Otherwise little change has taken place in the molars, and contact areas reveal light wear only (Fig. 22A).

Adults

This phase covers most of the adult life-span and changes taking place include the following:

Mandible: The incisors progressively show more and more wear with the dorsal surfaces becoming flattened and eventually clearly round in shape.

In premolar 2 the apposition surfaces are flattened and enlarged as the tooth wears down; in premolars 3 and 4 the round infundibulum resulting from the fusion of the meta- and entoconids during the previous stage becomes more isolated in the centre of the tooth as the surfaces around it become broader from wear. With progressive wear the incision between the para- and metaconid becomes less conspicuous until it eventually disappears almost entirely. In the process the round infundibulum disappears, the changes resulting in a large flattened surface with the teeth becoming clearly square in shape.

In the molars the flattened apposition surfaces increase considerably

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with a corresponding decrease in the infundibulae and at the conclusion of the phase the infundibulae of molars 1 and 2 are in various stages of disappearing. As with the premolars the molars are clearly more rectangular.

Maxilla: With the attrition of the paracone, the metacone and parastyle extremities are less pronounced and the infundibulae become reduced in size until the anterior tip separates to form a small isolated infundibulum. The same changes noted for the mandibular molars also apply to the maxillary molars (Fig. 22B and C).

Old adults

During this phase the teeth are mostly worn down to the neck of the tooth. In the mandible the incisors are reduced to short pegs with round dorsal surfaces while the premolars have flat surfaces without any infundibulae and with a pronounced square shape. In molar 1 the surface is flattened with the loss of the infundibulum in the anterior half of the tooth while only vestiges of the infundibulum are apparent in the posterior half. In molars 2 and 3 the infundibulae are mostly retained although considerably reduced but still horseshoe-shaped, the remaining dorsal surfaces exhibiting large flat apposition surfaces. In the maxilla much the same position is apparent as in the mandible, with the premolars reduced to square, flat-surfaced teeth with or without vestiges of the infundibulae being retained. This also applies to molar 1 while molars 2 and 3 retain their horseshoe-shaped infundibulae and, until the last stages, also two small lingual infundibulae resulting from the fusion of the distal portion of the entostyle with the proto- and hypocone (Fig. 22D and E).

Age classes derived from tooth characteristics

In Table 5, six age classes are suggested for roan on the basis of tooth eruption and attrition characteristics.

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Table 5 : Tooth wear and eruption sequences as age indicators in roan antelope as determined from skulls collected in the Kruger National Park, South Africa, and the skull collection of the National Museum, Bulawayo, Rhodesia.

AGE		TOOTH CHARACTERISTICS
Class	Months	
I	0 - 12	Incisiform and canine teeth erupted (from birth) and show light wear only in the later stages of this age group. Premolars: All premolars are apparently erupted a few weeks after birth with premolars 3 and 4 already surfacing at birth. Wear: Light.
II	16 - 18	Incisors and canines: Moderate wear. Premolars: All deciduous premolars in use. Wear: Moderate. Molars: Molar 1 light wear, Molar 2 starting to erupt.
III	19 - 28	Incisors and canines: All deciduous teeth start showing heavy wear and first permanent incisor appears. Premolars: All deciduous, moderate to heavy wear. Molars: Molar 2 erupted, wear light on both.
IV	29 - 30	Incisors and canines: Second deciduous incisor replaced. Deciduous incisors and canine remaining largely reduced due to heavy wear. Premolars: No replacement, all deciduous, heavy wear. Molars: First two in use, third beginning to erupt.
V	31 - 33	Incisors and canine: Full complement of permanent incisors erupted and in some cases the deciduous canine has also been replaced, and no apparent wear. Premolars: No replacement, all deciduous, very heavy wear. Molars: Third molar erupting.
VI	34 - 36	Premolars: Fully erupted. Tooth characteristics for other permanent teeth as for age class IV.

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Cementum annulations

The small sample of six teeth tested for cementum layers all proved to be positive with clearly visible layers. Because of the extremely small size of the sample, the inspection of cementum layers was not intended to reveal definite age classes. The lack of known-age animals would also have invalidated any such attempts.

The main objective, however, was to indicate whether these layers are in fact recognisable in roan teeth and whether this technique is worthwhile pursuing for age determination in post-mature animals. The results, as outlined in Table 6, are certainly encouraging. Further investigation is, however, necessary to determine whether the layers can be correlated with age and, if affirmative, the degree of reliability afforded by the method.

It has been pointed out elsewhere in this chapter that age criteria based on material collected from dead animals (e.g. eye lenses and teeth) could have some practical value although in rarer species, such as the roan, criteria derived from live animals are considered more important. In the case of the roan, the tooth cementum layers can possibly be useful in determining the longevity of cows under natural conditions which would yield important information on their reproductive life-span. Other than for this purpose, this method seems rather impractical and superfluous in the light of other more readily applicable methods.

SHEDDING OF THE NEONATE COAT

Roan calves are born with the same basic colour pattern as the adult animals. At birth the overall body colour of the neonate coat varies from a light to rich rufous brown which differs markedly from the roan (or greyish-brown) coat of the older animals. The major part of the body is a uniform rusty brown colour which is slightly darker on the back and lighter (almostyellow-brown) under the abdomen.

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Table 6 : Cementum layers of mandibular molar 1 of roan antelope and the relative age of the animals as determined from six teeth received from the National Museum, Bulawayo, Rhodesia.

TOOTH NUMBER	TOOTH WEAR	CEMENTUM LAYERS	RELATIVE AGE CLASS
1	Light	2 - 3	Young adult
2	Moderate	3	Adult
3	Moderate	5 - 6	Adult
4	Moderate	7 - 8	Adult
5	Heavy	9	Old adult
6	Heavy	9 - 11	Old adult

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The facial markings clearly reveal the characteristic "mask" of the adult animals although the colour patterns are less contrasting than in the latter; the entire area on the forehead down to the dorsal bridge of the muzzle just below the level of the eyes, the ears and the posterior areas of the cheeks are all rufous brown. The lower third of the muzzle, extending laterally and ventrally to below the eyes, is dark brown with a mixture of black and rusty brown hairs. The areas around the nose, under the chin and the two semi-circles in front of the eyes are off-white.

The legs are rufous brown but much darker than the rest of the body. The tail is dark brown dorsally and merges into black on the ventral surface.

The neonate coat is shed between the second and fourth month after birth and progresses according to a fixed pattern. Ten calves were observed to determine the pattern and time lapse in the replacement of the neonate coat.

The first obvious signs of replacemement occur along a dorso-lateral line of the neck, immediately below the mane. From this starting point the process expands ventrally down the neck and posterially towards the shoulders, thence over the rib-cage and down to the abdomen, simultaneously spreading towards the back and finally also reaching the hind-quarters.

The hair replacement of the head and legs proved difficult to observe under field conditions and are therefore omitted although it was apparent that the legs were the last to lose their birth coat.

The first signs of replacement in the neck region were observed at the age of two weeks in one calf while in six other calves it only became apparent between five and eight weeks. Once the process has commenced it spreads quite rapidly and reaches the shoulders at approximately eight to ten weeks of age, while the final stages, i.e. the hindquarters, are reached four to six weeks later. In the majority of cases replacement was considered complete between the 15th and 17th week, thus covering a period of approximately

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six to eight weeks. Table 7 illustrates the sequences in the replacement of the neonate coat. There is a correlation (r = 0,858) between age and the shedding of the neonate coat. The replacement of the birth coat is completed during the fourth month after which the young calf resembles the adults. A calf in which the process has not been completed would therefore fall within age classes I and II, as derived from horn growth characteristics, and on completion into age class III (Tables 2 and 7). Almost the entire process takes place during the age of two to four months and the various phases in the replacement would therefore indicate an animal in age class II.

DISCUSSION

Data on the age and sex ratio of a population provide the raw material for the calculation of life tables and for computerised population simulation studies. Information derived from these life tables and simulation models include the annual recruitment rate necessary to maintain a population, the effect of culling operations and/or predation at different exploitation levels and the effect of various management practices on populations. The importance of reliable age determination criteria for a better understanding of the population dynamics of species has been pointed out by, e.g. Quick (1960), Hewer (1964), Child (1964), Mitchell (1965), Simpson (1966), Fairall (1969) and Smuts (1972).

Understandably, the need for reliable ageing criteria has been emphasised for animals which are exploited on a large scale for commercial or other reasons. This has led to the availability of considerable sources of study material for analysis and has resulted in the development of various methods for determining the age of different species.

In the case of the larger mammals, age criteria are largely based on phenomena related to the teeth, e.g. tooth wear, replacement and anatomical structure, eye lensemass or various body measurements. The application of such methods obviously implies that animals that are to be classified either

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Table 7 : Sequences in the replacement of the neonate pelage in known-age roan antelope calves in the Kruger National Park, South Africa. Ages are given in weeks and blank squares indicate that no observations were made.

SEX	DATE OF BIRTH	AGE (WEEKS) AND SEQUENCES IN THE SHEDDING OF THE NEONATE COAT				
		Age at commencement	Neck complete reaching shoulder	Over rib-cage, spreading to stomach and back	Over hind-quarters	Complete
♀	6. 2.68			11-12		16-17
♂,♂,♀	10, 14 & 16. 5.69		12-13			16-17
♀	2. 8.69	2	5	8	11-12	13-14
♂	29. 9.69	7-8	8-9			
♀	2. 7.68			12-13		18
♀	12. 9.68	9	10-11		12	14-15
♀	11.11.68	8-9	10-11			16-17
♂	28.11.68	7-8	8-9			13-14
	16. 5.70	6	7-8	11-12	14	

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have to be dead or, at best, immobilised. In spite of any measure of accuracy which such methods may provide, their application is clearly seriously curtailed.

In wildlife management it is becoming increasingly important to analyse not only abundant species populations but also the less numerous associated species. The problems of studying these populations are self-evident and to obtain the data required for a population analysis the scientist is often largely (or entirely) dependent on live animals. From this point of view a method(s) based on the morphological characteristics of the animal would have distinct advantages. If such a method conforms to the basic requirements of accuracy and reliability, it would provide a means of assessing the age structure of a population whenever required, e.g. either seasonally or annually, and would further have the advantage of allowing rapid surveys on live animals before and after the commencement of management practices to evaluate the effects of such operations.

Due to the scarcity of roan antelope in the Kruger Park, criteria in the current study were almost exclusively limited to external morphological characteristics and the validity of these methods are best evaluated in the light of other acknowledged and proven methods.

On the basis of horn growth and development, four distinct age classes can be differentiated in roan between 0 and 12 months old (Table 2). Additionally, the shedding of the neonate coat is a further aid in the first two age classes. Distinction between age classes I and II is clear enough to avoid any overlap while maximum overlap of plus and minus one month between later age classes may be expected.

A total of five convenient age classes have been suggested for animals ranging in age from 13 to 36 months (Table 4, V-IX). Horn rings are quite distinctive and easily counted with a pair of binoculars in the field and allow for an accuracy of plus and minus one month. In addition to the horn rings,

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phenomena related to tooth eruption and wear could also be used for determining age classes.

Due to the regularity of the horn ring development (eight per annum) age classes between 11 and 36 months may be distinguished as convenience or circumstances necessitate. It is therefore clear that up to the age of 36 months at least nine and, if necessary, more age classes with a reasonable degree of accuracy may be determined.

In the adult stages the three age classes, i.e. young adults, adults and old adults, are quite readily distinguishable on the basis of horn differences around the basal areas, though it is also true that these broad categories are largely subjective and without any definite age limits.

A number of studies in which horn development has been related to age have been undertaken on various African antelopes. Although the demarcation of individual age classes vary, most offer some practical means for age determination. In the greater kudu Simpson (1966) found that it was possible to age the horn-bearing males, to within three months, up to the two-year-old stage. In all, he has suggested seven age classes based on horn development, i.e. four for immatures (up to 30 months) and three for adults.

More recently Simpson (1971, 1972) has drawn attention to the formation of growth checks, i.e. definite annulations on the surface of the horns, in post-mature horns to determine age in adult animals. In the greater kudu and bushbuck (Tragelaphus scriptus) horn growth checks corresponded closely to age classes determined by cementum layer counts of the teeth. This enabled Simpson (1972) to allocate definite age limits to his previously (1966) suggested age classes of young, middle-aged and old adults.

Spinage (1967) found that he could reliably determine the age of horn-bearing male defassa waterbuck (Kobus defassa ugandae) on the basis of horn length and horn annulations for the first three years, after which these criteria

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became unreliable due to too much variation. Similar results have been obtained for tsessebe, and Huntley (1973) described five age classes for animals up to 18 months of age by using horn shape and development.

In the African buffalo, Pienaar (1969a) found that the horns attained their adult form by the age of four years and was able to distinguish between nine age classes ranging from calves to very old individuals. Talbot and Talbot (1963) were able to identify seven age classes on the basis of the horn characteristics for blue wildebeest in East Africa.

Other observers who have used horn growth as a criterion for age determination include Child (1964) for impala (three age classes), Kerr and Roth (1970) for eland (four age classes), Mitchell (1965) for Lichtenstein's hartebeest (three age classes), Rautenbach (1970) for springbuck (Antidorcas marsupialis) (five age classes), Rowe-Rowe and Mentis (1972) for nyala (Tragelaphus angasi) (five age classes), and Walther (1972) who used horns in addition to other morphological features to determine eight age classes for Thomson's gazelle (Gazella thomsoni).

Tooth eruption and wear have been widely used to determine the age of ungulates, with the former generally giving good results during the replacement phases. Among the larger African antelopes, Kerr and Roth (1970) showed that the first permanent tooth (molar) in eland appeared between six to nine months of age, and was fully erupted by the age of 10 to 14 months. The first incisor appeared at 22 to 23 months while the second molar was erupting. From this stage on the replacement sequences accelerated and the incisors, canines and molars were replaced by the age of 32 to 35 months. The permanent premolars all erupted between 36 to 40 months of age. From these results he could identify 10 age classes up to 40 months of age. Tooth wear in later stages could be used as rough indicators of age, but were too unreliable to define precise age classes.

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Other African ungulates in which tooth eruption has been used with similar results to those described above, include blue wildebeest (Talbot and Talbot 1963, Braack 1973), kudu and bushbuck (Simpson 1966, 1973), buffalo (Pienaar 1969), defassa waterbuck (Spinage 1967), nyala (Vincent, Hitchens, Bigalke and Bass 1968), springbok (Rautenbach 1970) and tsessebe (Grobler 1973, Huntley 1973).

For roan it has been illustrated that tooth wear categories may be used as additional age determination criteria in immature animals although their application is limited to broad and pooorly defined age classes. In adult animals, by using the characteristic features of the morphological structure of the teeth (e.g. styles and stylids, infundibulae and shape) and the relative amount of attrition, three broad age classes could be differentiated.

Using a similar approach, Quimby and Goab (1957) isolated five tooth characters in the mandibular dentition of the elk (Cervus canadensis) by which year-classes in adult animals could be identified. However, they pointed out that age classes based on characters indicative of wear, have certain limitations and that inaccuracies increase with an increase in age.

Various other authors have also correlated tooth wear with age (Spinage 1967, Rautenbach 1971, Simpson 1973). Spinage (1973) noted that "attrition of the permanent teeth provides the most ready means of estimating ages of adult animals".

By using tooth wear classes for ageing white-tailed deer (Odocoileus virginianus) Gilbert and Stolt (1970) could achieve only 58,4 per cent agreement between these age classes and those determined by cementum layers. Spinage (1973) mentioned several other authors (Keiss 1969, Erickson, Anderson, Medin and Bowden 1970, Kerwin and Mitchell 1971, Lockard 1972) who obtained results varying between 50 and 80 per cent when comparing the results derived from the same methods. The conclusion drawn by these authors is that the visual assessment

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of age by means of wear classes does not yield reliable results. However, Spinage (1967) initially obtained only 38 per cent agreement but increased the agreement to 76 per cent by enlarging his age classes with ± one year in the case of the defassa waterbuck.

Gilbert and Stolt (1970) found that errors arose from over-estimating the age of animals in the younger age classes and under-estimating those in older age classes. On the other hand, Kerwin and Mitchell (1971) noted errors directly opposite to those of Gilbert and Stolt (1970). Spinage (1973) ascribed the errors found by the latter authors to tooth attrition which could be expected to follow a negative exponential rate of decay, thereby concluding that "rapid rate of wear in the young age classes makes them look older, whilst flattening of the curve in the older classes makes then difficult to separate from younger ones."

The major source of error appears to be the general attempt to designate wear classes to too narrowly defined age classes, e.g. year intervals. In the age classes suggested for roan on the basis of tooth wear, such errors may therefore be expected to be largely eliminated. Confusion may still arise in marginal cases as differentiation between the age classes is not absolutely rigid. However, faulty classifications could not possibly be a serious problem, considering the broadness of the classes. Similarly, for the same reason, variable rates of wear would not be expected to impede the usefulness of the three defined age classes.

Another method which has been helpful in determining the age of mammals is the number of cementum layers of the permanent teeth. This method proved highly successful for various species of seals (Pinnipedia), e.g. elephant seal (Mirounga leonina) (Laws 1952) and fur seal (Callorhynus ursinus) (Kenyon and Scheffer 1954).

This method has subsequently also been applied to African ungulates

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with varying degrees of success. Simpson (1972) quoted various authors who found that the reliability of age determination by means of cementum layers decreased in the older age categories. In comparing the annual horn growth checks with the "twinned" cementum layers (Simpson 1972) he found that there was a high degree of correlation between the two methods (r = 0,995) despite the fact that there was disparity between the two methods in the older age categories. In the defassa waterbuck, Spinage (1967) also found this method valuable in the ageing of older animals while Braack (1973) has indicated its usefulness in blue wildebeest and Smuts (1972) has applied it with satisfactory results to zebra in the Kruger National Park. The accuracy of this method is generally believed to be within one year and its advantage is that it enables the age determination of animals with a long life-span beyond the attainment of maturity.

The presence of cementum layers in the teeth of roan antelope and the indications of increasing numbers with an increase in age, could possibly also prove to be a useful method in determining the age of post-mature animals.

This short review of the applicability of generally used ageing criteria should suffice to draw attention to what is really required of ageing techniques:

i) Distinction between clearly defined age classes, with as little overlap as possible, should be ensured,

ii) sufficient age classes should be identifiable to allow the compilation of life tables and population simulation models,

iii) repeated age assessments of a sufficiently large sample of a population at regular intervals should be possible, and yet avoid time-consuming and arduous laboratory work,

iv) the application of ageing techniques should not be confined to research staff only but should be elementary enough for use by untrained staff

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and should allow for the collection of a uniform set of data by different observers,

v) from (iii) and (iv) it may be deduced that it would be preferable not to have to rely on dead animals for material; this would have the further advantage of allowing an assessment of a population before any radical measures, such as cropping, commence, and

vi) alternative methods for ageing remains from predator kills or other die-offs should be available.

Evaluated in the light of the above-mentioned requirements, it may be concluded that the ageing criteria suggested for roan antelope meet these requirements adequately. The reliability with which individual age classes up to early adulthood may be identified, compare favourably with any of the other methods currently in use. Age class identification based on horn development characteristics provide an elementary means of determining the age structure of free roaming wild animals from the ground, air or from photographs. Tooth replacement phenomena provide a less reliable though workable alternative for ageing animals up to 36 to 40 months of age where the horns are not available (as may happen in the case of remains from predator kills).

Beyond the age of three years the three age classes suggested for roan are based on relative age (i.e. young adults, adults and old adults) with only a vague indication of actual age. This does not imply a serious handicap although it is unfortunate in at lease two respects for this species, i.e.

(i) young roan males are evicted from the nursery herds at the age of 2 to $2\frac{1}{2}$ years (Joubert 1970, 1974a) and it would be important to know at what age these males attain full reproductive status by becoming herd bulls and how long they can maintain this status, and

(ii) it does not enable the determination of the reproductive and physiological life-spans of cows under natural conditions.

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CONCLUSIONS

The ageing criteria suggested for roan suit all the requirements seen from a practical wildlife management point of view and provide sufficient data for the calculation of the population's vital statistics. From this approach it may therefore also be concluded that methods based on eye lense mass or the counting of cementum layers, which entail laboratory processing of material, are largely superfluous and only of limited practical value.

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CHAPTER 4 : POPULATION ATTRIBUTES

INTRODUCTION

The inherent biological characteristics of any animal population are centred around the rate of recruitment to the population and the factors suppressing or otherwise influencing the increase in numbers. It stands to reason that the uncontained increase of a population could only eventually lead to its own destruction, on the one hand, and, on the other, that an imbalance of mortality over recruitment would inevitably result in its final extinction.

The relationship between increase and mortality is of such a complex nature that it is seldom, if ever, fully understood. However, for any understanding of an animal population at all, it is a prerequisite to know at least the reproductive potential of the population and evaluate its performance in terms of existing circumstances. In this respect, the concept of wildlife management which is essentially the manipulation of animal numbers, has been enforced upon most nature conservation agencies due to the confinement of large numbers of different species in areas of limited size.

This situation is particularly frustrating as the factors governing animal numbers are often poorly understood and under the same set of circumstances wildlife managers frequently have to contend with species at either extreme of the numerical scale, i.e. those which have increased to the point of self-destruction and those of which the numbers have remained so low as to cause grave concern about their future safety. In most conservation areas management programmes have already been initiated to curtail the unlimited increase of some species while every effort is made to encourage the increase of others.

Clearly, increase is not only a function of reproduction, as is evidenced by species with a poorer reproductive potential being numerically

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dominant over others with a higher potential, but must rather be evaluated in the light of the degree to which the new-born of a species can overcome the critical stages before being recruited to the adult segment of the population. The roan antelope is a good example; in its size class there is no other African antelope with a higher reproductive potential, yet, in the Kruger Park and in most other areas where it occurs, the population asymptote is reached at a level well below that of most other species. In this, and subsequent chapters, the various causes responsible for this phenomenon will be investigated.

REPRODUCTION

Methods

No systematic culling of roan could be undertaken to determine their reproductive status and consequently the collecting of data on this aspect was limited to field observations of live animals. This did not prove to be a serious handicap other than that it did not allow detailed physiological study of the reproductive process.

However, the basic - and from a management point of view, important - information could be derived from observations on known-age animals which were individually marked. Record was kept of courtship behaviour and mating activity (Joubert 1970) and subsequent births. The history of a number of cows was also documented to determine calving intervals.

Results and discussion

Joubert (1970) and Estes (In prep.) have discussed the courtship and mating rituals of roan in some detail. As the collection of data on reproduction was almost entirely dependent on observations of live animals, the various phases in the courtship displays, such as "Flehmen", "Laufschlag" and "mating-whirl-around", played an important role in drawing attention to reproductive activity.

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The shy and secretive habits of cows immediately before and after birth often made it difficult to determine whether a cow had actually given birth or not. Fortunately, behavioural patterns again were useful in determining, with a reasonable degree of certainty if, and when a cow had calved.

Reproductive data on females

Age at sexual maturity

In the case of six known-age cows born in the 1,6 kilometre square enclosure at Nwashitsumbe, the youngest age at first birth was 32 months (two cows). The other cows gave birth to their first calves at the age of 33 months (two), 34 months (one) and 34 to 35 months (one). Of four additional cows, of which the exact ages were not known but could be derived by other means, two gave birth between 32 and 33 months of age, one at 38 months and the fourth at 41 months. It would therefore appear that the majority of roan cows have their first calf between 32 and 34 months of age.

For the Percy Fyfe Nature Reserve in the northern Transvaal, Huntley (1971a) gave the age at first parturition for a roan cow as three years. Estes (In prep.) stated that "females mate for the first time as two-year-olds". In the Hanover Zoo, Germany, a cow gave birth (probably the first birth of a roan calf in a zoological garden) to her first calf at the age of about 43 months (Dittrich 1969). However, this is not really a reliable record of the age at first parturition as the cow and a young bull of the same age were introduced to the zoo when 23 months old and the belated birth probably resulted from the incapability of the young bull or initial adaptations to captivity. The three references cited here are all that are available on age at first parturition of roan cows but in general they substantiate the findings of the present study.

Although the sample is too small to permit reliable quantitative conclusions it is sufficient to suggest that the majority of roan cows conceive for the first time between 23 and 25 months of age (gestation period nine months)

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and have their first calf between the age of 32 and 34 months.

Gestation period

The gestation period was considered to be the time lapse between the last observed mating and the day the calf was born. It has already been shown (Joubert 1970) that actual copulation takes place over a period of approximately 24 to 36 hours so that any observed mating could in fact be taken as the conception date and would not affect the calculation of the gestation period by more than one day either way. The same margin of error could be expected with the determination of the birth date as on only two occasions could the exact time of birth be determined. These margins of error are so small that they are probably absorbed in the natural variation of the gestation periods recorded and are therefore regarded as of no importance at all.

A total of five gestation periods could be determined with the accuracy described above and these ranged between 276 and 287 days, the five periods being 276-278, 278, 285-286, and 287 days respectively.

For two births in the Hanover Zoo, Dittrich (1972) recorded gestation periods of 268 and 280 days. Wilhelm (1933, In: Kenneth and Ritchie 1953) gave the gestation period as 270 days. Various other authors have made reference to a gestation period of nine or ten months (Stevenson-Hamilton 1912, Rode 1943, In: Asdell 1964). All the available records indicate a gestation period of roughly nine to nine-and-a-half months.

Calving intervals

There is no post-partum anoestrus and roan cows normally enter their first oestrus cycle from two to four weeks following parturition. If conception takes place during this cycle a cow could therefore have a calf every 294 to 308 days (280 days average gestation plus 14 to 28 days before next conception). In 11 recorded cases one cow had four consecutive calves with time intervals between births of 296, 305 and 301 days. In three other cows of which the birth

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dates of three consecutive calves for each cow were obtained, the intercalving periods were 317-318 and 318 days, 307-308 and 333 days and 324 and 317 days respectively. Intercalving periods of two additional cows were 338 and 337-339 days. The mean intercalving interval is therefore 317 days with a range of 296 to 339 days.

In a further nine observations, in which the actual birth dates of two successive calves could not be obtained, the time interval is expressed to the nearest month. Of these, ten months elapsed between calves in six cases and 11 months in another three. If the months were converted to days it would mean that the calving intervals in all these observations fell within approximately 300 to 340 days.

The most important fact emanating from these data is obviously the implication that roan cows do not follow the general pattern of one calf per annum as in the case of most - if not all - other medium to large antelopes in the Kruger Park. In actual fact, roan could gain a calf on all strictly annual breeders in every five-year cycle. It would also suggest that there is no definite mating and, consequently, calving season (see: Calving season). The only other large antelope in the Kruger Park to approach this reproductive potential appears to be the waterbuck (Fairall 1968). In East Africa the Uganda defassa waterbuck also has a breeding cycle similar to that of the roan (Spinage 1969, 1970).

Conception rate

The original nucleus of ten roan that were introduced into the Nwashitsumbe enclosure during July, 1967 included four adult cows and three heifers (estimated ages 21, 18 and 15 months respectively). Of the four adult cows one was obviously an old animal, two were adult (i.e. "middle-aged") and one was a young cow which had apparently not calved before. The case history of each cow was carefully followed until they all succumbed in an anthrax

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epizootic in September to October, 1970.

During the period of 39 months that they were kept under observation one adult cow gave birth to four calves while the other three (old, adult and young adult) each gave birth to three calves.

Of the three heifers originally introduced, one had her first parturition during July, 1968 and subsequently gave birth to two more calves, the other two each had their first calf in May, 1969 and each also had another calf before dying of anthrax.

It will be noted therefore, that not one cow skipped a pregnancy and a conception rate of 100 per cent was maintained throughout the period of observation.

During August, 1971 three young adult cows were again released into the enclosure. Two of these cows gave birth during November of the same year and the third during February, 1972. By the end of April, 1974, i.e. after a period of 32 months, the three cows had each had three calves while the two that calved first were again near full term in their fourth pregnancies. Obviously, all three cows were pregnant when introduced into the enclosure but since then have regularly calved at 10 to 11 month intervals. The same applied to known-age youngsters born in the enclosure and amongst nine adult cows (of which one had her first calf in March/April, 1972, another in April, 1972, a third in November/December, 1972 and the fourth and fifth in January/February, 1973) a total of 19 calves were born in the period under consideration. Under the conditions of semi-captivity the 16 cows observed during the two periods mentioned above, gave birth with unfailing regularity.

Dittrich (1972) in referring to animals in captivity under zoological garden conditions, stated that "not every mating results in pregnancy and often a number of oestrus periods have to follow each other at intervals of two to four weeks." By taking the maximum gestation period recorded (287 days) and

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adding 28 days as the conclusion of the post-partum oestrus cycle, it would be expected that if conception takes place during this first oestrus cycle the next calf would be born within a maximum of 315 days of the previous one.

The mean intercalving period is 317 days, thus indicating that a proportion of births fall wide of the maximum interval. It may therefore be assumed that conception does not always take place during the first oestrus cycle following parturition. It is uncertain how soon the subsequent oestrus cycles follow on one another but are approximately the same as that following birth, i.e. two to four weeks. If this were the case, calving intervals would not be expected to exceed 343 days (315 plus 28) if conception took place during the second oestrus cycle. As the maximum calving interval recorded during this study was 339 days it may be concluded that all the cows fell pregnant within the first two post-partum oestrus cycles.

Unfortunately detailed observations could not be made on free-roaming animals and it would probably be erroneous to assume a 100 per cent conception rate throughout an entire population. On the other hand, observations on the age structure of herds would also indicate a high calving rate. Although subjective, due to the lack of supporting evidence, it is nevertheless believed that the conception rate in the adult population is close to 100 per cent and at least as good as, or better than, in most other antelope species.

Reproductive life-span

Very little is known of the longevity of the roan antelope and as one of the largest African antelopes, even the 14 years recorded in the Pretoria Zoological Gardens (Flower 1931) seems an under-representation of its potential physiological life-span. This is especially so if the recorded longevity of its next of kin is taken into consideration. Flower (1931) recorded a sable antelope still alive after 16 years and 8 months and a species of the genus Oryx attaining an age of 18 years. The potential physiological longevity of the roan could

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therefore also be expected to be of the order of 16 to 18 years.

However, there is good reason to assume that their ecological longevity would be slightly less. No reliable methods for determining the age of fully adult roan are available but from all outward appearances (especially horn development and the degree of wear on the teeth) the oldest cow released into the Nwashitsumbe enclosure was estimated to be between 10 and 12 years old. This cow lived on - and produced three calves - for a further three years in the enclosure before dying of anthrax. Two cows of approximately seven to eight years of age at the time of capture also eventually died of anthrax after a further three years in the enclosure. Although these animals spent their last three years in the protection of the enclosure there was nothing to suggest that they were weakened or "nearing their end" and all three maintained the same calving rate as the younger animals until the time of death. If 12 years were accepted as the ecological longevity of the roan, and, considering the available evidence of sustained breeding activity into old age, the reproductive life-span of a roan cow is in the region of nine years. With the first parturition taking place at the age of 33 months and mean calving intervals of 317 days it would further suggest that each cow is physiologically capable of producing 10,65 calves in her reproductively active life.

No data on senility could be obtained from free-roaming animals and the sample of cows which were kept under close observation - all of which were prolific breeders - is too small to draw any definite conclusions.

Calving Season

The mere fact that roan cows enter an oestrus cycle shortly after parturition, resulting in a calving interval of 10 to 11 months, would indicate that calves are born throughout the year with no definite breeding season.

In Table 8 and 9 the number of births for the different months are presented as recorded in the roan enclosure. By ageing immatures in "free-roaming'

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Table 8 : Monthly percentage distribution of roan antelope births for the period October 1967 to March 1974 in the Kruger National Park, South Africa.

MONTH	NWASHITSUMBE ROAN ENCLOSURE		FREE-ROAMING HERDS, LEBOMBO FLATS		TOTAL	
	Births	Percentage	Births	Percentage	Births	Percentage
January	6	11,76	9	9,00	15	9,94
February	9	17,65	8	8,00	17	11,26
March	3	5,88	11	11,00	14	9,27
April	7	13,73	12	12,00	19	12,58
May	5	9,80	10	10,00	15	9,94
June	1	1,98	10	10,00	11	7,28
July	4	7,85	4	4,00	8	5,30
August	5	9,80	5	5,00	10	6,62
September	4	7,85	7	7,00	11	7,28
October	0	-	4	4,00	4	2,65
November	6	11,76	5	5,00	11	7,28
December	1	1,96	15	15,00	16	10,60
TOTAL	51	100,00	100	100,00	151	100,00

Table 9 : Wet (October to March) and dry (April to September) season births of roan antelope for the period October 1967 to March 1974 in the Kruger National Park, South Africa.

AREA	WET SEASON (October - March)		DRY SEASON (April - September)	
	Births	Percentage	Births	Percentage
Nwashitsumbe roan enclosure	25	49,02	26	50,98
Free-roaming herds, Lebombo Flats	52	52,00	48	48,00
T O T A L	77	50,99	74	49,01

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herds, their approximate month of birth could be calculated and the distribution of these births is also indicated in Tables 8 and 9. The percentage distribution of births is given in Table 8 and from these data it is clear that births are widely distributed throughout the year with no clearly defined calving season.

Although it could probably be shown, statistically, that the number of births differ significantly from one month to the other (e.g. nine in February and only one in June in the Nwashitsumbe enclosure or 15 in December and four in July for free-living herds) these differences are probably largely due to the small sample size and are not regarded as a reflection of a differential calving rate from one month to the other. However, although no definite calving peak can be distinguished for any particular time of the year, there does seem to be somewhat of a lull during the late dry season, i.e. June-July to September-October, but if the year is divided into its two natural seasons, i.e. the wet or rainy season extending from October to March and the dry winter season from April to September, the data in Table 9 reveal no seasonal differences in the rate of calving (Chi^2 = 0,059; P > 0,05; d.f. = 1).

Working on a smaller sample of 41 births, Joubert (1970) had previously determined a 46,34 per cent birth rate for the wet season and 53,66 per cent for the dry season. Even these figures are of the same magnitude as those derived from the much larger sample in the present study (Table 9). The 41 births previously recorded, are incorporated in Tables 8 and 9.

Fairall (1968) could draw no definite conclusions regarding the breeding season for roan in the Kruger Park on the basis of data collected during an earlier study but stated that "the results seem to indicate more calves being dropped during the late autumn and winter months". In Zambia, Ansell (1960) was also unable to define an exact calving season although departmental records indicated most births between April and August. Both authors, however, concede the lack of sufficient data for the rainy season

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and regard their data as inconclusive.

Asdell (1946) stated that there was no fixed breeding season but that roan births in central and southern Africa were mostly from August to February with January and February the important months in the south, while Stevenson-Hamilton (1947) was of the opinion that most calves were born " ... from about the third week in January to the end of February".

Wilhelm (1933) stated that the calving season in South West Africa commenced in August.

Blower (1961) and Child and Wilson (1964) could define no particular calving season for east Africa and central southern Africa, respectively, and Verheyen (1951, In: Ansell 1960) was also of the opinion that roan calved throughout the year but with a possible peak from February to May in the Upemba National Park, Zaïre.

Reproductive data on males

Amongst roan bulls, participation in reproduction is strongly influenced by the social organisation of the roan. Numerous authors have mentioned the fact that one adult bull only characteristically accompanies a nursery herd and Joubert (1970, 1974a) has described the eviction process of young males from the nursery herds.

Young roan males are tolerated in the nursery herds up to their third year during which the herd bull actively drives them out. During their sojourn in the herd these young males have no part in reproduction, and the eviction process, which is normally initiated when the young males are 24 to 30 months old, is believed to coincide with their achieving sexual maturity.

Once evicted from the nursery herds, the males associate in all-male bachelor groups from whence they graduate as mature herd bulls at the age of approximately five to six years, i.e. when they have become intolerant towards other bulls and are capable of competing for their own nursery herds. Under

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normal circumstances it is therefore clear that bulls attain physiological sexual maturity at least two to three or more years before they are in a position to reproduce. Active participation of the bulls in reproduction is therefore strongly influenced by the social organisation of the roan.

In the Percy Fyfe Nature Reserve, South Africa, a young bull mated successfully for the first time at the age of 33 months despite the availability of oestrus females when he was 25, 28 and 29 months old and the absence of competing bulls (Huntley 1971a).

The first successful mating of a young bull in the Nwashitsumbe enclosure of the Kruger Park took place when the bull was 31 to 32 months old despite the opportunity of mating from the age of 27 to 28 months. In two young males from the enclosure active spermatogenesis was found in one at the age of 26 to 27 months while it was absent in the other at the age of 18 months. Estes (In prep.) has given the age of sexual maturity in roan males as two years.

The successful copulations of the two young bulls mentioned above, both just over 30 months of age, tend to endorse the deduction that the eviction process coincides with the attainment of sexual maturity. On the other hand, a few males of two years and slightly younger have also on occasion been seen with bachelor groups. It is doubtful whether these youngsters had in fact attained sexual maturity and it was thought that with the presence of a bachelor group near a herd, the younger males more readily joined them to seek refuge from the harassments of the herd bull. The age-determined relationships among young males may also play a role in this respect (Joubert 1970).

POPULATION STRUCTURE

The most difficult aspect of this entire study was obtaining reliable data on the population structure of roan. This was primarily because roan herds frequently break up into sub-groups (Joubert 1970). When encountering a

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herd it was therefore not always clear whether it represented the whole herd or only part of it. The composition of the sub-groups are also influenced by the bonds between immatures of the same age-group which are apparently stronger than the bonds between a cow and her offspring (Joubert 1970). This was all too obvious in sub-groups where the number of young far outnumbered the adult cows and were therefore clearly sub-groups. However, these sub-groups were more acceptable than those where adult cows were in excess of the youngsters and it was often difficult to decide whether this was due to mortality or the fragmentation of the herd.

The formation of sub-groups is only temporary and only by observing a herd over a fairly long period could its strength be determined. Apparently some herds were also more prone to subdivision than others. Joubert (1970) has indicated that competition for the leadership of a herd becomes more severe where there are a number of old cows in the same herd and that such competition is probably responsible for the fragmentation.

Sex ratio

Calves

The sex ratio of 34 roan calves born between July 1967 and May 1974 in the enclosure at Nwashitsumbe was 16 males to 18 females or a ratio of 1,125 females per male and of 32 calves under six months old amongst free-living herds 15 males to 17 females or 1,133 females per male. The ratio for the total number of calves would therefore be 31 males to 35 females or 1,129 females per male.

Of the 18 calves born in the enclosure prior to the anthrax epizootic, i.e. between July 1967 and August 1970, eight were males and 10 females, thus 1,250 females per male and of the 16 born between August, 1971 and May 1974 eight were males and eight females.

The sex ratio derived from calves up to six months of age relied on the assumption that there was no differential mortality among the sexes during

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this period. However, the ratio obtained for free-living animals tallies closely with that obtained in the enclosure and there is therefore no reason to believe that the ratio presented is not a true reflection of the sex ratio at birth.

Although the sex ratio at birth is slightly in favour of females it does not differ from parity (Chi^2 = 0,243; $P > 0,05$; d.f. = 1). However, it must be borne in mind that statistically the sample is still too small to draw any definite conclusions.

Yearlings

Amongst yearlings, i.e. animals between the age of 13 and 24 months, a total of 49 in the nursery herds were sexed. Of these, 19 were young males and 30 heifers, with a sex ratio of 1,578 females per male.

As the eviction of young males from the nursery herds occasionally takes place before the age of two years the decline in the male segment may, at least partially, be ascribed to this process. It was found that of 22 bulls in bachelor groups six (27,27 per cent) were under 24 months of age. These six yearling males, added to those of the nursery herds, give a corrected sex ratio of 25 males to 30 females or 1,20 females per male for this age class. Statistically there is no deviation from parity (Chi^2 = 0,454; $P > 0,05$; d.f. = 1) although the sample (n = 55) is once again too small to draw any definite conclusions. There may, in fact, be some indication of a differential loss of more males than females.

By subdividing the yearling class into the age groups 12 to 18 months and 19 to 24 months it was found that of the 19 yearling males, 11 fell within the first group and eight in the second, a decline of 27,27 per cent. This tends to substantiate the conclusion that the decline of yearling males in the nursery herds can be ascribed to eviction and not necessarily mortality, as eviction would affect the older group of yearlings rather than the younger.

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Child, Robbel and Hepburn (1972) and Joubert (In prep.) have drawn attention to the dangers of sampling populations, for age and sex ratio determination, in which there is a segregation of the sexes. Bachelor groups are normally much more unsettled than nursery herds and therefore much less likely to remain in an area for a prolonged period. Furthermore, these groups are denied their favoured habitats which are occupied by breeding herds and therefore withdraw to peripheral areas. The likelihood of locating bachelor groups while sampling such populations is consequently less than for the nursery herds and this may be a further explanation for the discrepancies between the sexes. However, there is no statistically significant difference between the sex ratios of calves and yearlings and in spite of the small samples the conclusion must be drawn that there is no sex differential mortality during the first two years of life.

Adults

Because cows calve for the first time in their third year and the young bulls are ousted from the nursery herds to form bachelor groups, all animals older than two years were considered adults. The adult segment of the population may therefore be divided into three definite categories, i.e. nursery herds, lone mature bulls and bachelor groups.

The overall ratio of females per male in all these groups for the period 1968 to 1970 was 1,94 or 54 males to 105 females. For the three years under consideration the ratios were 1,70 ; 2,73 and 1,80 females per male, respectively.

Similarly, the mean ratio of adult cows per herd bull in the breeding herds was 5,25 and for the three respective years 5,57; 5,00 and 5,14.

Omitting the figures for 1969, as bachelor groups were under-represented for that year, probably due to inadequate sampling, the mean ratio of bulls detached from the nursery herds (i.e. lone bulls and bachelors) per herd

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bull was 2,07 (2,29 for 1968 and 1,86 for 1970). On the other hand, the ratio of males in bachelor groups per lone bull in the non-breeding segment was 2,22 (3,00 for 1969 and 1,60 for 1970).

Assuming that the female segment remains constant in the population as reflected by the birth rates, the ratio of 1,20 females per male amongst the yearlings would imply a decline of 5,92 per cent males in this age class. Although at least a portion of this decline could be ascribed to sampling bias, there is also the possibility of a slight sex-differentiated mortality affecting the evicted yearling males although such mortality would be too small to reveal statistically significant results.

In the adult segment the sex ratio indicates a decline of 38,15 per cent males over females as compared with the yearling age class. The total loss of males over females from birth to adulthood is therefore 41,81 per cent or a ratio of 1,72 males per female.

Although the sample of predator kills and other causes of mortality will necessarily be small for such a limited and widely dispersed population, the sample of 11 carcasses collected over a period of six years, of which eight were males and three females, may at least give some indication of the ratio in which the sexes succumb to predation. From these data it would appear that males are more vulnerable than females with a mortality ratio of 2,63 males per female. The mortality sex ratio corresponds somewhat to the differential decline of the sexes from birth to adulthood (2,63 and 1,72 males per female, respectively) and the loss of males in the adult segment of the population may therefore be largely attributed to higher mortality amongst the males (see mortality factors).

Age structure

The age structure of the breeding segment, i.e. nursery herds with the exclusion of bachelor groups and lone bulls, for four consecutive years is given in Table 10.

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Table 10 : Percentage age structure of the breeding segment (excluding lone bulls and bachelor groups) of the roan antelope population in the Kruger National Park, South Africa, for the period 1968 to 1971.

YEAR	SAMPLE SIZE	PERCENTAGE COMPOSITION OF AGE GROUPS IN THE BREEDING SEGMENT OF ROAN ANTELOPE			
		0 - 12 months	13 - 18 months	19 - 24 months	25 months
1968	62	11,29	9,68	4,84	74,19
1969	67	28,36	11,94	5,97	53,73
1970	95	27,37	14,73	12,63	45,26
1971	62	22,58	16,13	12,90	48,39
MEAN		22,40	13,12	9,09	55,39

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In addition to the data in Table 10 an aerial census during July, 1973 of the area north of the Shingwidzi River revealed a total of 21 calves under the age of one year out of a total of 71 animals in the breeding herds, or 29,58 per cent. The corresponding figures for the same area in 1974 were 27 calves (or 23,28 per cent) af a total of 106 animals.

A similar survey of the area to the south of the Shingwidzi River during June, 1974 gave a total of 23,21 per cent calves in the breeding segment (n = 56).

In relation to the total population, including bachelors and lone bulls, young calves made up 9,09 per cent (1969), 24,07 per cent (1970), 25,61 per cent (1973) and 20,00 per cent (1974) of the population.

The ratio of adult cows to calves under the age of one year was 5,51 adult cows per calf in 1968, 1,58 (1969), 1,38 (1970) and 1,71 for 1971, with an overall mean of 2,55 adult cows per calf. With an average calving interval of 317 days and therefore a reproductive potential of six calves in every five-year cycle per adult female in a continuously breeding population and disregarding senescence, it would be expected that one-fifth (or 20 per cent) of the adult cows would give birth twice in one year. Were there no calf mortality and if the reproductive potential of each of the adult cows were realised, a ratio of 0,83 cows per calf could therefore be expected. Deviation from the expected ratio would give some indication of the loss of calves due to mortality. Consequently, a ratio of 2,55 cows per calf would reflect an average calf mortality of the order of 67,5 per cent for the period 1968 to 1971, with mortality in the four respective years being 85 per cent (1968/'69), 47,5 per cent (1969/'70), 40,0 per cent (1970/'71) and 51,7 per cent (1971/'72).

The exceptionally low calf percentage recorded for 1968 may partially be due to an under-representation of this age class in the population as reflectd by the proportion of yearlings in 1970. The proportion of 13 to 18 and 19 to 24

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month age class actually represent the previous years' 0 to 12 month age class and by this criterion it would seem that the 0 to 12 month calf segment for 1968 should in fact have been slightly higher. However, the proportion of yearlings in the 1968 sample reflects a similar poor calf crop for 1967.

This position clearly improved from 1969 onwards and, indeed, all indications pointed to an expansion in the roan population and even in spite of a setback in 1970, due to an anthrax epizootic, a favourable calving rate was maintained.

From a study of the population trends of roan antelope in the Kruger Park it appears that their numbers have fluctuated considerably through the years but this phenomenon will be discussed in greater detail in a later section. The possibility therefore exists that this study was initiated at a time when the population had reached a numerical low followed by an upward trend.

The data in Table 10 further indicate that mortality is largely restricted to animals in their first year of life. In fact, from field observations the most vulnerable period for roan calves appears to be the first six weeks after birth during which period the calf remains concealed and does not accompany the herd. Once the calf emerges from concealment and joins the herd, mortality decreases abruptly and the chances of survival conversely increase. Of the first 22 calves born in the Nwashitsumbe enclosure, six (27,27 per cent) died within the first six weeks of life and also represented the entire calf loss before the anthrax epizootic. This is in close agreement with Spinage (1970) who found in the defassa waterbuck that "once a calf had survived the first month or so of life it had a good chance of continued survival during the first year".

The discrepancy between percentages in the 13 to 18 month and 19 to 24 month age classes should not be interpreted as a result of mortality alone

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but also as a reflection of the eviction of young males from the nursery herds. The decline between these two age groups was 50 per cent for 1968 and 1969, 14,26 per cent for 1970 and 20,02 per cent for 1971 (mean: 33,57 per cent). It has already been shown that 27,27 per cent of the males in bachelor groups consist of yearling males so that the decline between these two age classes could in part be ascribed to a substantial loss of males from the 19 to 24 month age class due to eviction from the nursery herds. For the period 1968 to 1971 it was actually found that males constituted only 37,5 per cent (nine out of 24 animals) of this group.

If, therefore, males contributed 38 (37,5) per cent towards the 19 to 24 month age class and assuming a 1:1 ratio amongst the 13 to 18 month olds, the annual recruitment of females to the adult segment of the population would have been in the region of 7,84 per cent in 1968, 9,67 per cent in 1969, 15,20 per cent in 1970 and 16,07 per cent in 1971. An average annual recruitment rate of 12,20 per cent cows to the breeding segment may therefore be expected if mortality amongst yearling heifers is not taken into account.

With a mean adult female component in the population of 41,66 per cent (50,65; 41,67; 33,33 and 40,98 per cent for 1968, 1969, 1970 and 1971, respectively) and a total population of approximately 260 animals this would imply an annual recruitment of 13 cows (12,2 per cent of 108 cows in the adult segment). However, this recruitment is based on an assumption that could hardly be expected to hold true under natural conditions, i.e. no mortality in the yearling age class.

Applying the data presented earlier, 108 cows could be expected to give birth to 127 calves annually. With an initial sex ratio of 1,13 females per male, 68 of these calves would be heifers, but with a mortality rate of 67,5 per cent within the first few weeks only 22 of these heifers could be expected to survive their first two months of life. With the assumed absence

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of mortality in their second year and only 13 being recruited to the adult segment in their third year, this would reflect a further 13,24 per cent (or 40,9 per cent of those surviving their first two months) mortality during the remainder of their first year, thus indicating a total mortality rate of 80,74 per cent of the expected calf crop within the first 12 months of life.

If survival is further reduced by five to eight per cent mortality amongst yearling heifers, which, however subjective, does not seem unreasonable, it would in effect mean the loss of one more yearling heifer with the result that annual recruitment is reduced to approximately 12 young cows. Likewise, with a yearling ratio of 1,20 females per male the number of yearling males recruited to the adult segment would number approximately 10. However, with an overall adult ratio of 1,94 females per male this would mean that only about five males effectively become part of the adult component of the population. An average overall adult increase of the Kruger Park population of some 16 to 17 animals annually may therefore be expected, i.e. if adult mortality is disregarded.

The calculations given here are based on the average performance of the population over a four-year period and as a point of interest, the calculated annual increase for the poorest and best of the four years may be of some significance. In both cases the data are based on an adult female component of 108 cows. For 1968 the calf crop was found to be only 11,29 per cent of the breeding population. Early mortality was estimated to be 85 per cent thus leaving only 10 of the expected 68 female calves. With a recruitment rate of 9,67 per cent and yearling mortality of approximately five to eight per cent this would give an effective recruitment of only nine young cows to the adult segment. On the other hand 1971 had a recruitment rate of 16,07 per cent which would have meant an increase of about 15 to 16 cows.

In spite of the high initial mortality, annual recruitment to the

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population would appear to be sufficient to sustain a growing population. Actual growth, however, would again be dependent on the rate of mortality in the adult segment of the population. A reliable assessment of the extent of such mortality in a small and widely dispersed population would obviously present a formidable and almost impossible task. This is further complicated by the small samples from which basic information must be derived and could therefore shed some doubt on the validity of the conclusions drawn from them. However, the following aspects pertaining to decimating factors may be considered:

MORTALITY FACTORS

Decimation of roan populations by the various factors affecting mortality appear to affect this species in three different stages, i.e. a high initial mortality amongst young calves which is sex independent, an increased mortality amongst males coinciding with their eviction from the nursery herds and finally, in the fully adult segment where males continue to suffer higher losses than the females. The general causes of mortality include the following:

Predation

In analysing the kills ascribed to predation for the periods 1st January, 1936 to 31st December, 1946 and 1st January, 1954 to 31st December, 1966, i.e. a total period of 22 years, Pienaar (1969[b]) found that roan antelope were mainly preyed upon by four predators, i.e. lion (Panthera leo), leopard (P. pardus), cheetah (Acinonyx jubatus) and wild dog (Lycaon pictus). This list could almost certainly be extended to include spotted hyaena (Crocuta crocuta) and, in the case of young calves, also black-backed jackal (Canis mesomelas) and possibly even pythons (Python sebae) and the martial eagle (Polemaetus bellicosus). Certainly, all these predators would be quite capable of preying upon roan calves and there is every reason to believe that they would do so if the opportunity presented itself.

However, of the roan kills on record since 1936, the lion clearly

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emerges as the most important predator of this species and for the periods under consideration lions were responsible for 86,57 per cent of the kills recorded, wild dog for 8,89 per cent, leopard for 2,22 per cent and cheetah for 1,11 per cent out of a total of 90 recorded kills. In the northern areas where roan occur in the Park, they made up a total of 1,11 per cent of the lion's diet, 0,04 per cent of the leopard's, 0,45 per cent of the wild dog's and 0,16 per cent of the cheetah's (calculated from data presented by Pienaar 1969).

From these data it would appear that roan constitute only a minute proportion of the total kills of their major predators. Caution must, however, be exercised in the interpretation of such results and the following considerations should be borne in mind: The areas mainly inhabited by roan have, until recently, been poorly patrolled so that the carcasses actually recorded make up only a small percentage of those taken by predators. Furthermore, the attention of scout patrols is mainly drawn to kills by the presence of vultures, so that a significant proportion of kills, especially young animals, go undetected due to rapid clearance of remains either by the predators themselves or the vultures.

Both factors mentioned above are equally applicable to other wildlife species inhabiting the same areas. However, of major importance in respect of the roan is their habit of avoiding large concentrations of other species and withdrawing to the more remote areas of their habitats. This would further complicate the detection of carcasses although the frequency of kills in such areas may be counteracted by the fact that predators are also more concentrated in areas of large aggregations of prey species.

These various factors are impossible to relate in terms of actual numbers or the extent of predation on roan but by any standards the recording of kills is believed to be only a fraction of the total number actually taken. The 90 roan kills recorded over the 22-year period would indicate a recovery of 4,09 carcasses per annum. In a population of approximately 260 animals this

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would mean roughly 1,6 per cent known mortality due to predation.

Of the 13 carcasses collected over a seven-year period between 1966 and 1973 only three (23,08 per cent) were classified as "immatures". This would again point to the bias favouring the recovery of adult animals (as carnivores and vultures would tend to concentrate around a large carcass for a longer period) while immatures are more easily overlooked. If this small sample could suffice to give an indication of the ratio of adult to immature kills recovered by patrols (1 adult: 0,3 immatures) it would mean that of the 1,6 per cent kills reported annually roughly 70 per cent consist of adults.

To attempt to evaluate what percentage of the annual kills are actually reported, would at best result in a guess, but assuming that between 10 and 30 per cent of the adult roan kills are recovered, it would amount to a loss of between 4 and 12 per cent of the adult segment, or, in more practical terms, of between seven (6,6) and 20 (19,8) adults a year (calculated from a population of 260 animals of which 62,76 per cent, i.e. 163, are adults consisting of lone bulls, bachelors and adults in nursery herds).

With an adult sex ratio of 1,94 females per male and a mortality ratio of 1,72 males per female it would indicate an annual mortality rate of between five and 13 males as opposed to two to seven adult cows.

Relying on the rather subjective criterion of "field experience", these figures appear to be quite reasonable for what could be expected under natural conditions and, if accepted, would reflect a nett annual gain to the adult female segment of the population of four to nine cows (average annual recruitment of 11 cows minus mortality).

Eleven of the 13 roan killed by predators between 1966 and 1973 could be sexed and of these eight were males and three females, giving a mortality ratio due to predation of 2,63 males per female. Predation may therefore be considered as one of the major contributing factors in the decline of the

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male segment in relation to that of the females.

This is not a phenomenon peculiar to roan antelope, and various authors have shown a differential sex mortality favouring the survival of females in a wide variety of prey species. Mitchell, Shenton and Uys (1965) found that in various species males were killed in excess of females and this has also been pointed out by Estes and Goddard (1967) who found that lone territorial males were especially vulnerable. In the Gorongosa National Park, Tello (In prep.) also found a high preponderance of males of various prey populations in the recorded kills of lions and this same phenomenon in the Kruger Park led Pienaar (1969) to conclude that "differential predation on the sexes may in fact be the most important factor responsible for the disproportionate sex ratio which is apparent in the adult segment of the populations of the majority of prey species".

In comparison with the 2,63 males per female kill ratio among roan, Pienaar (1969) found that the ratio for waterbuck, kudu, impala and wildebeest were 2,32; 2,22; 2,38 and 2,08 males per female respectively.

The vulnerability of males to predation commences with the eviction of the young bulls from the breeding herds and the most likely explanation must be sought in their loss of the wariness of adult cows. The adult cows are undoubtedly the individuals most sensitive to threatening danger (Joubert 1970) and in their absence the young bachelor males are almost certainly placed at a disadvantage. Simultaneously, the evicted males are displaced from the most favoured areas and either inhabit peripheral areas or roam from one area to another to avoid the harassment of herd bulls. In this way they could also be placed in a more vulnerable position with regard to predators, than in the protective company of the herd.

It may also be argued that the herd bulls themselves are more vulnerable to predation than other herd members due to their habit of taking up the rear

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position when the herd takes flight. It may therefore be concluded that throughout their adult life after eviction from the breeding herds, the bulls are destined to bear the brunt of predation.

Intraspecific fighting

Roan antelope are not strictly regarded as territorial according to the definition of the term but exhibit many characteristics of a territorial species, with herds occupying fixed areas, i.e. activity zones, which are largely exclusive to adjoining herds, while each herd is also accompanied by a single dominant male (Joubert 1970, 1974a). This social system gives rise to intra-specific conflicts between the males at at least two important stages in the life cycle, i.e. at the age of two years onwards when young bulls are evicted from the nursery herds and again in the fully adult stage in competition for a breeding herd or in the defence of such a herd.

Fighting is highly ritualised and especially in the eviction process bodily contact between the herd bull and ousted youngster is rarely achieved. The disruption caused by this process and the loss of the protective qualities of the breeding herd render the young males more vulnerable to decimating factors and results in a higher mortality rate among such males.

Among the older bulls, fighting, which primarily consists of ritualised displaying and eventually develops into a head-on pushing duel, may be fierce. However, apart from broken horns or other superficial wounds, especially in the face and ear regions, no cases of serious bodily harm or fatalities due to intra-specific fights were recorded during this study.

That fighting could, however, have fatal results is quite possible, with an even greater possibility that wounds inflicted during such fights could render one of the contestants more vulnerable to some other form of death, e.g. predation. However, although intraspecific fighting amongst males could indirectly lead to some losses, deaths directly attributable to fighting must be

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limited to the absolute minimum. In this respect it must be considered significant that even in the confined space of the Nwashitsumbe enclosure, no deaths occurred as a result of fighting despite high intensity fighting between the herd bull and competing bachelors.

Deaths due to intraspecific fighting would obviously lead to a higher rate of mortality amongst the males and would therefore tend to accentuate the sex differential mortality ratio as reflected by predation.

Natural hazards and accidents

Extreme weather conditions may on occasion place such a stress on a population that some individuals succumb. Sporadic prolonged droughts have been known to cause considerable die-offs amongst large concentrations of animals on depleted habitats, e.g. wildebeest (Child 1972). However, despite a number of critically dry years during the present study - notably the 1970/'71 season - no mortalities due to such conditions were observed amongst roan.

During a series of particularly dry years in the Kruger Park during the 1920's it was reported that several of the herbivores, notably sable and waterbuck, had been badly affected but that roan had suffered considerably less under the circumstances (Stevenson-Hamilton 1929).

Quite a frequent occurrence under the reigning weather pattern in southern Africa is an abrupt drop in temperature accompanied by light showers of rain during late spring or even early summer (October and November). These sudden changes in the weather have been known to cause light to quite severe die-offs in various animal populations. It is the general contention that individuals weakened by the long dry winters and - especially in those species with a calving season in early summer - females with close to full-term foetuses are the first to succumb.

In the Kruger Park the populations generally affected by these sudden drops in temperature include impala, kudu, bushbuck and buffalo, while tsessebe

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have also been known to die. In the Kyle National Park, Rhodesia, Ferrar and Kerr (1971) described large-scale die-offs among reedbuck (Redunca arundinum).

In the Nwashitsumbe enclosure three roan antelope died during such a cold spell in 1971 although no deaths were recorded amongst free-roaming animals. It is probably reasonable to expect that some individuals die during these periods although the extent of mortality could certainly not be high in spite of an almost annual occurrence of such sudden drops in the temperature.

Child (1972) found that wildebeest males suffered more mortalities than females under severe conditions of starvation and lack of water but not enough is known of the sex and age distribution of deaths occurring during cold spells to suspect the same mortality tendencies as those reported by Child (1972).

During the current study period no other forms of mortality were noted which could be ascribed to some form of accident. It is almost certain that at least occasional deaths may occur due to snake bite or due to leg or other injuries sustained during wild bouts of running (e.g. during the eviction process) but no evidence to support such an assumption could be obtained.

With roan calves being born throughout the year it could also be expected that wild bush fires during the dry season could constitute a serious threat to the lives of calves during their concealment period. Once again, the effect of such fires is virtually impossible to determine with any degree of accuracy.

Disease

Roan antelope are plagued by a number of diseases which may be responsible for widespread mortalities in the population. The various diseases affecting this species undoubtedly represent the major single decimating factor and together with other inherent population regulatory factors have certainly played an important role in limiting or retarding population growth in the Kruger Park.

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From the frequency of deaths the immature and sub-adult age classes ranging from three months to two years appear to be the least susceptible to disease, with deaths largely occurring in young calves and adult animals. Diseases most prevalent and causing the severest mortalities include the following:-

Calves

Cytauxzoonosis

During July 1973 a total of 12 sub-adult roan (ranging between one and three years old) were transferred from Rhodesia to the Kruger Park and released into an enclosure in the Pretoriuskop area. During their period of adaptation the animals lost condition considerably and were found to be covered with lice of the genus Linognathus. During this period five animals died, all from a Theileria-like blood parasite strongly resembling the genus Cytauxzoon (De Vos pers. comm.). The infestation with lice and the subsequent death due to the cytauxzoonosis are believed to have been conditions arising from the severe stress to which the animals were subjected.

Thus far cytauxzoonosis has manifested itself as a condition of young calves with distinct decimating potential. In the Percy Fyfe Nature Reserve, situated in the Sour Bushveld regions in the northern Transvaal and consisting of atypical and/or inferior roan habitat, Wilson, Bartsch, Bigalke and Thomas (1974) found a mortality rate of 57 per cent amongst roan, of which 80 per cent occurred within the first 12 weeks after birth. Cytauxzoonosis was confirmed as the cause of death in at least two of the roan calves. Wilson et al. (1974) came to the conclusion that "the high mortality rate in roan and sable calves under 12 weeks of age may indicate that cytauxzoonosis and babesiosis (isolated in sable calves only) play a role in limiting their propogation". The disease was also found to cause the death of a large percentage of the calf crop of the tsessebe population from the same reserve (Basson pers. comm., In: De Vos and Lambrechts 1971).

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In the Nwashitsumbe enclosure of the Kruger Park a fairly steady mortality rate of the order of 25 per cent was observed amongst young calves. Of the first 22 calves born in the enclosure, six (27,3 per cent) died within their first month, with the third week of life apparently the most critical.

As the animals in the enclosure were under semi-natural conditions and death occurred in the period during which the calves conceal themselves for most of the day (Joubert 1970), the remains of dead calves were invariably only found at a stage when they were worthless for determining the cause of death. However, predation was ruled out and the remains strongly suggested that they had succumbed to some undetermined disease. In one young calf which died at the age of three weeks, a preliminary diagnosis suggested that it had died of cytauxzoonosis, complicated by navel ill and further indications of chlamydiosis (Imes and De Vos pers. comm.).

In mature (adult) wild mammals only sporadic cases of cytauxzoonosis have thus far been encountered in the duiker (Sylvicapra grimmia) (Neitz and Thomas 1948, Neitz 1957), eland (Martin and Brocklesby 1960, Brocklesby 1962, Neitz 1964) and giraffe (McCully, Keep and Basson 1970). A doubtful record in the reticulated giraffe (G.c. reticulata) has also been listed (Brocklesby and Vidler 1965). The extremely common occurrence of piroplasms in the red blood cells of wild animals have also led Neitz (1964) to suggest that many, if not all, may eventually be identified as Cytauxzoon species.

The examination of randomly selected blood smears from free ranging wild animals, inter alia roan antelope, from the Kruger Park has also revealed a high percentage of small piroplasms indicative of Cytauxzoon spp. (De Vos pers. comm.). It is therefore conjectured that cytauxzoonosis occurs enzootically in the Kruger Park and that calves contract the disease at a young age.

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Mycotic dermatitis

During a period of exceptionally high rainfall and rank grass conditions a severe skin disease, mycotic dermatitis, caused by the actinomycete Dermatophilus congolensis resulted in the death of a number of sable calves in the Nwashitsumbe enclosure. Both roan and sable calves were affected and it is believed that only the timely capture and treatment of the roan and surviving sable calves saved them from death. Only young calves under the age of four months were clinically affected

Although a common disease amongst domestic stock, mycotic dermatitis has hitherto been unknown amongst southern African wildlife species and could possibly have broken out in the enclosure due to the specific climatic and environmental conditions, in addition to the unnaturally high concentrations of the two species (De Vos and Imes pers. comm.). This disease could consequently not be regarded as a decimating factor of any magnitude under free-ranging populations of roan and has, as yet, not been reported from individuals of either species outside the enclosure.

Adults

Anthrax

The severest mortalities recorded amongst adult and, to a lesser extent, immature roan in the Kruger Park may be ascribed to the bacterial disease anthrax, caused by Bacillus anthracis. A wide variety of mammals are affected by the disease although the degree of susceptibility differs from one to the other (Pienaar 1960, 1961).

Since this blood parasite was first identified amongst wildlife in the Kruger Park in 1959, three large-scale outbreaks have occurred in 1959, 1960 and 1970. All these epizootics were confined to the northern districts of the Park and the most susceptible antelopes proved to be kudu and roan antelope. In each case the outbreaks coincided with the extremely dry conditions experienced after a long dry winter season and outbreaks rapidly spread

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from their focal points to adjoining areas.

The spores of the anthrax bacteria are known to survive for 40 years or more (Umeno, Notaba and Teramoto 1938) and consequently the outbreaks were believed to be the result of either osteophagia and/or feeding on contaminated grazing, especially in depressions, with the subsequent dispersion of the disease through contamination of waterholes by scavengers, such as vultures which are relatively immune to anthrax. Due to the limited water supplies during such outbreaks, the bacteria are transmitted to large numbers of game animals concentrated around the available watering points with a consequently rapid spread of the disease.

Suppressive measures during outbreaks included the burning of carcasses and combustible plant material where carcasses had been found. In addition, waterholes were also treated with bacteriocidal chemicals (quaternary ammonium compounds) to destroy the source of infection. Despite the effect that such measures may have had in containing and eliminating the anthrax, they were insufficient to prevent widespread mortality amongst the particularly susceptible roan antelope.

During the 1959 outbreak six roan carcasses were found, 41 in 1960 (Pienaar 1960, 1961) and during the 1970 epidemic a total of 23 among free-roaming roan herds and 15 in the Nwashitsumbe enclosure.

During the most recent outbreak (1970) a helicopter was used in addition to vehicle patrols to locate carcasses and yet many were initially overlooked and only located after days of intensive patrolling. From this point of view the figures for carcasses actually found must be regarded as the absolute minimum and especially for the two earlier epidemics the losses could have been considerably higher.

Deaths due to anthrax were largely, but not exclusively, confined to adult animals. In the Nwashitsumbe enclosure 15 of the 27 roan died with the

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12 survivors all being immature, and in an adjacent herd that also suffered heavy mortalities, all eight survivors were also immature.

Of the carcasses recovered during the 1959 and 1960 epizootics the two sexes were virtually equally represented (1959: three males, two females, one unidentified: 1960: 18 males, 20 females, three unidentified) while females outnumbered males in 1970 (11 males, 26 females). With a preponderance of females in the adult segment (1,94 females per male) a large number of female carcasses could be expected from such a die-off although the deaths in the 1959 and 1960 samples would reflect a disproportionately high number of males succumbing to the disease. However, there does not seem to be any feasible explanation for a sex differential mortality rate as the disease is particularly quick-acting and affects all individuals, irrespective of physical condition.

Accepting the figures given above as the minimum number of deaths during each respective epizootic, the total number of deaths for the 11-year period from 1959 to 1970 amount to 70 (28 males, 38 females and four unidentified) - excluding the 15 that had died in the enclosure. The bearing of mortality of this magnitude on a small population is self-evident. Taking into account normal predation the calculated annual recruitment rate of females to the breeding segment is of the order of four to nine cows. With an average annual recruitment of approximately seven cows it would imply that for the 11-year period under consideration, population growth was limited to six years only with the recruitment of the remaining five years being eliminated by anthrax. It may therefore be concluded that this disease is one of the major, and certainly the most violent, decimators of the Kruger Park roan population.

The lack of earlier reports of widespread die-offs of game animals in the anthrax endemic areas of the Kruger Park can hardly be accepted as evidence that such epizootics did not take place. It must be pointed out that the anthrax endemic northern areas of the Park cover many thousand square

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kilometres and, prior to 1960, were poorly provided with both conservation officers and negotiable patrol roads.

The patrolling of the entire area of some 4 800 km^2 was the responsibility of four rangers and their meagre staff of scouts. As these areas have, furthermore, always been relatively sparsely populated by wildlife it is only feasible to accept that even fairly extensive die-offs could have gone unnoticed.

More important, however, was the ignorance of the authorities regarding the effects which game diseases may have on animal populations which probably led to the misinterpretation of the cause(s) of death where carcasses were found in the field, e.g. where scavengers had already fed on a carcass the cause of death would almost certainly have been ascribed to predation, or in the case of a carcass without any external wounds death would most likely have been passed off as exceptional (e.g. snake bite or complications while giving birth) with no further concern or veterinary investigation into the actual cause of death.

Entries in the pioneer rangers' diaries of deaths attributed to menial causes, such as fighting, often accompanied descriptions of the carcasses which strongly indicated a more serious cause of death, and many were even clearly symptomatic of anthrax. As early as November 1923, Ranger Ledeboer of Letaba described how he had come upon the carcass of a waterbuck bull and on dissecting it, found the "... liver, spleen, etc. badly swollen and bloody". Without any refernce to external wounds he nevertheless came to the conclusion that the animal must have died from fighting. Similarly, the death of a waterbuck cow with the remains of her young calf nearby during February 1924, was ascribed to complications during birth. On 26th May 1924 Ranger Ledeboer found another dead waterbuck bull but merely stated that he " ... could not find out what it died from" (Ledeboer 1924).

Some years earlier, Stevenson-Hamilton (1913), stated that "during the drought this year, Major Fraser (Warden of the Shingwidzi Game Reserve)

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found that a considerable number of waterbuck were dying from some unexplained cause. The circumstances appeared very similar to those attending the mortality amongst the kudu in the Zoutpansberg district a year or two ago. Being apprehensive that there might be some disease present which would spread, blood-smears were taken, but rendered a negative result". After the negative results with the blood-smears, local inhabitants were ordered to burn all carcasses and almost simultaneously the dying stopped. The inevitable conclusion was drawn that the animals had been poisoned. This prompted Stevenson-Hamilton (1913) to remark: "I think in the event of any recurrence of anything of the sort in the future ... , that the deaths safely be put down to this cause (poisoning), since there is no known epidemic disease which arises spontaneously among wild animals ... ". The merits of the deductions in this case are beside the point (although highly suspect at their best) but would almost certainly have contributed toward an ignorant attitude in any further such outbreaks. However, in 1938, Stevenson-Hamilton (1939a) outlined steep declines in various wildlife populations (among others, reedbuck, waterbuck and blue wildebeest) at various stages in the history of the Park. These declines were ascribed to unknown pathological conditions as the possibility of predation and poaching as decimating factors were ruled out.

Another of the early pioneers to the Lowveld, Mr. Pias Memeda of Mapai in Mocambique, recalled that in the mid-1930's a few head of his cattle in the Pafuri area died for no apparent reason. After a few more deaths he reported his losses to the Portuguese veterinary authorities but before they arrived his total herd of about 80 head of cattle had succumbed - within approximately a week. Once the entire herd had died the matter was called off without any further investigations into the cause of death (Pias Memeda pers. comm.).

No proof exists to suggest that the cattle at Pafuri or the deaths described by Ledeboer were, in fact, caused by anthrax although the symptoms

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described and the patterns of mortality all strongly point to anthrax as a possible cause of death.

Without pushing this issue beyond reasonable limits it does, however, seem feasible that anthrax had been endemic in the northern areas of the Kruger Park for many years prior to the 1959 outbreak. Unfortunately its influence on the roan antelope population prior to 1959 will always remain a point for speculation although it may explain the apparently contradictory assessments of the population trends of this antelope over the years.

Rinderpest

Rinderpest is a highly contagious viral disease and has been responsible for the death of literally millions of head of cattle and a wide variety of wild animals (Stevenson-Hamilton 1947, Simon 1963). It is a "recognized cause of epizootics and panzootics in wildlife populations" (De Vos and Lambrechts 1971), and Spinage (1962) has ascribed the anomalies in the distribution of certain ungulate species to the effects of rinderpest epizootics.

The most notorious rinderpest panzootic raged through Africa in the late nineties of the previous century. Beginning in Ethiopia in the north it rapidly spread throughout most of the subcontinent southwards until it finally reached South Africa. It left in its wake millions of dead animals, domestic and wild, and in many arees it all but exterminated some of the more susceptible species, e.g. buffalo (Stevenson-Hamilton 1939a, 1947, Simon 1963, Stewart 1964).

Although the roan antelope is mentioned only low down in the list of susceptible animals (Simon 1963, Stewart 1964) it was nevertheless regarded as "one of the antelopes reputed to have suffered most severely from rinderpest" (Simon 1963). Special reference is seldom made regarding the extent of mortalities amongst roan and this may possibly be attributed to the fact that roan are generally sparsely distributed and losses would consequently be more difficult to ascertain while widespread mortalities amongst the more abundant animal

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populations would tend to be more dramatic.

Spinage (1962) indicated that "the specific susceptability of wild ungulates to rinderpest seems to vary considerably at different times and in different localities". In this respect, it was stated that severe mortalities occurred amongst 'susceptable species' during an outbreak in the southern Ruampara District of Uganda but that roan were immune to the disease and therefore suffered no ill-effects (Anon 1936).

Since the scourge of 1890 to 1903 rinderpest is not known to have recurred in the Kruger Park and has therefore had no effect on the local roan population for at least the last 70-odd years, and no records could be traced to confirm whether the roan had, in fact, suffered from this disease in the Kruger Park during the earlier panzootic. Stevenson-Hamilton (1939a) remarked that "all horned ruminants which possess a hairy rhinarium, such as sable, roan, tsessebe, blue wildebeest and impala ... seem to have been little, if at all, affected by the disease".

THE NUMERICAL STATUS OF THE ROAN ANTELOPE POPULATION IN THE KRUGER NATIONAL PARK

No reliable figures are available on the roan population for the area now comprising the Kruger Park during the period prior to the proclamation of the area as a game sanctuary. The roan's occurrence in the Transvaal Lowveld is noted by several of the early hunter pioneers but apart from the broadest terms in referring to their abundance, little else is presented to give any indication of the species' numerical status in the wildlife community.

From the memoirs of Glynn (1926) it may be deduced that the roan, together with tsessebe and eland, were quite common in the Pretoriuskop-Legogote area during the latter half of the nineteenth century. He recalled that " ... eland roans, sable antelope, zebras ... were to be found all over that country".

By the turn of the century Sclater (1900) wrote that roan were still to be found in the eastern districts of the Transvaal, although only rarely.

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Haagner (1920) also referred to the roan as being rare in general, in the area south of Rhodesia, " ... though still found in the Eastern Transvaal". Rendall (1895, In: Du Plessis 1969) stated that there were still a few in the Olifants River vicinity.

Other authors (cf. Bryden 1899, Chapman 1900, Shortridge 1934) merely noted the existence of roan in the eastern areas of the Transvaal without giving any indication of their status.

The first actual attempt to evaluate the numerical status of the various game species of the Lowveld was given by Stevenson-Hamilton in his annual reports for 1903 of the Singwitsi (Shingwidzi) and Sabi Game Reserves, respectively. His assessments confirm the rarity of the roan and, in fact, he believed that it had been exterminated in both reserves, but for two individuals seen along the Crocodile River which were believed to have been immigrants from Mocambique.

For the Shingwidzi Game Reserve information gathered from the local native inhabitants indicated that roan were known from that area " ... but they had seen none for a long time". In the Sabi Game Reserve to the south, including much of the country referred to by Glynn (1926) roan were believed to be non-existent although they were still fairly numerous in the adjoining areas of Mocambique (Stevenson-Hamilton 1903).

In 1903 Stevenson-Hamilton (1903) summarised the situation pertaining to roan as follows: "This antelope is now extremely rare in the Transvaal, and should be specially protected". Their precarious position was ascribed to hunting.

From 1905 a favourable upward trend for most animal populations was reported and by 1911 the roan was found to be increasing well with numerous small herds about. A further increase was reported for 1912, despite two successive years of drought. For the first time some form of census," ... founded on average numbers with regard to mileage ... ", was attempted and although this amounted to little more than an estimate the total number of roan in the Sabi

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Game Reserve was believed to be 300 and roughly half of this total (150) in the Shingwidzi Game Reserve. The figure for the latter reserve was later regarded as an under-estimate by the then warden, Maj. Fraser (Stevenson-Hamilton 1913).

The Warden's Annual Report for 1913 stated that " ... roan antelope are now spread over all the country south of the Sabi in ... the western section (Pretoriuskop-Legogote). They keep to the more or less open country under the foothills of the (Drakens)berg. Their increase from very small numbers twelve years ago has been most encouraging. They are also met with in small troops west of the Imbabate (Timbavati) River, ... as far as the western boundary of the Park". In 1915 the number of roan in the Sabi Game Reserve was estimated at 300, and 500 for the Shingwidzi Game Reserve (Stevenson-Hamilton 1915).

In the Annual Report for 1925, Stevenson-Hamilton (1925) stated that he may have under-estimated the number of animals in his 1912 calcuations and that in the period to 1925 the various populations had again " ... increased at least fourfold". However, prior to the proclamation of the Kruger National Park a considerable portion of the western areas of the old Sabi Game Reserve was excised in 1923, including the most favourable roan habitas (Fig. 23). Within the new boundaries roan were still found in the vicinity of Pretoriuskop but were seldom encountered east of the Selati Railway line.

For the Shingwidzi Game Reserve it was reported that roan " ... exist in considerable numbers north of the Olifants to the Limpopo river" (Stevenson-Hamilton 1925).

Subsequent to 1925 a number of serious drought years followed one another (1926 to 1928) and by 1929 it was reported that the sable antelope population had been badly affected. However, Stevenson-Hamilton (1929) noted that "roan have always been scarce but I do not think they suffered relatively to the more numerous sable".

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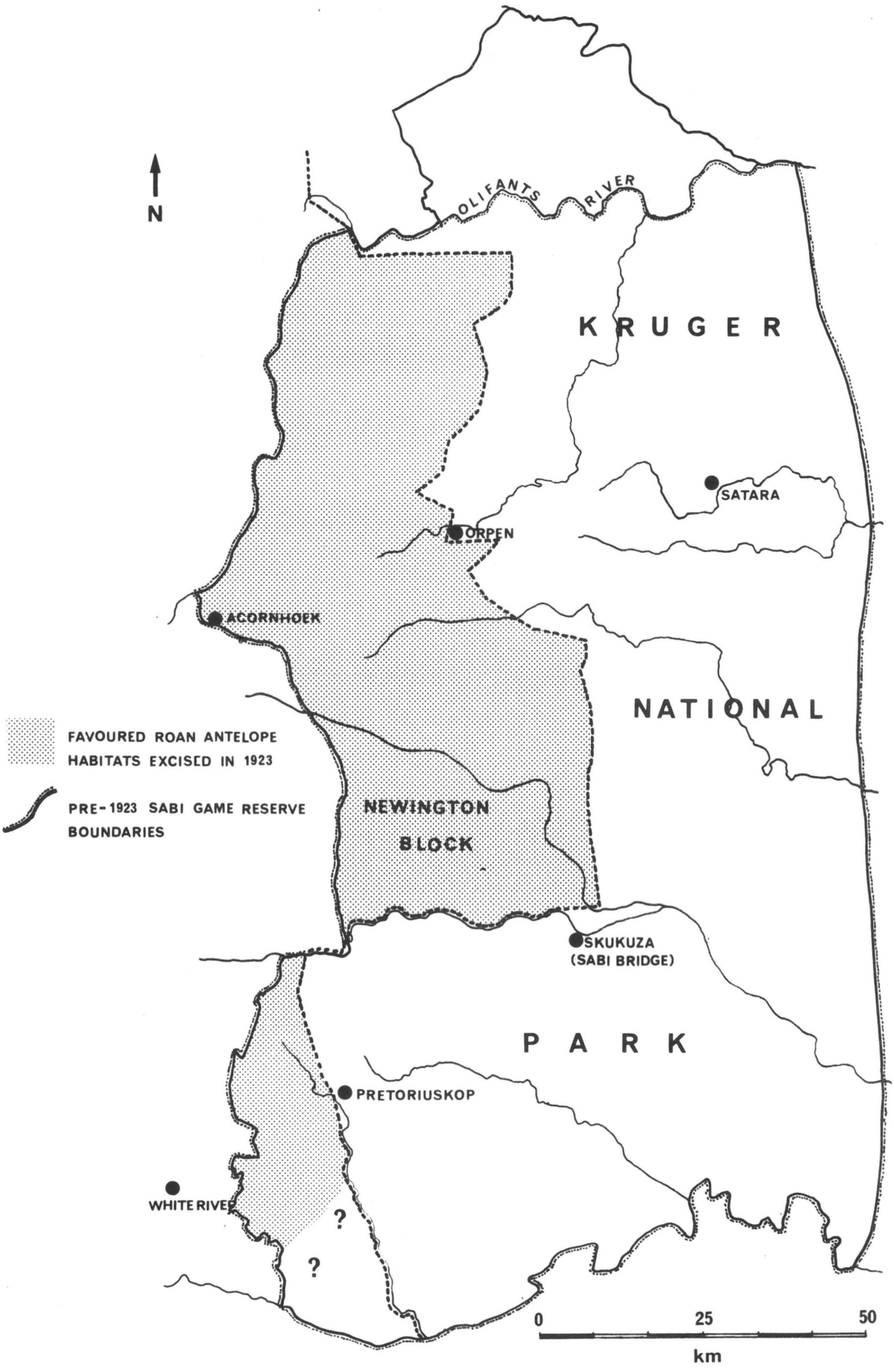

Figure 23 : Map indicating the boundaries of the Sabi Game Reserve, South Africa and the areas of favourable roan habitats excised in 1923.

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Roan were reported to be numerous in the Punda Milia and Letaba districts during 1931, and also in the Tsendi-Shingwidzi region in 1933. Recognizing the fact that animal populations fluctuate in numbers in response to changing environmental and associated factors, the Warden in 1937 suggested that the roan, together with sable and warthog, were experiencing a decline in their populations (Stevenson-Hamilton 1937).

In his Annual Report for 1939, Stevenson-Hamilton (1939b) referred to sable, roan, tsessebe and waterbuck in the Newington area as "once exceedingly numerous but now fast disappearing" due to hunting.

"North of the Olifants River roan appear to be on the increase and are frequently seen in considerable groups" (Stevenson-Hamilton 1940).

In 1944 the Warden reported that "... the position of roan antelope north of the Olifants River continues to be favourable and the same may be said for tsessebe. Neither of these species existed in more than quite small numbers south of the Olifants River in the present Kruger National Park, though in the areas west in what was once part of the Sabi Game Reserve, they both were fairly numerous" (Stevenson-Hamilton 1944).

Again, in the 1946 Annual Report (Sandenbergh 1946), roan were reported to be "numerous" in the northern areas while "some" were near Tshokwane and only two in the Pretoriuskop area. In the next year, 1947, a herd of 14 was seen near Ship Mountain (Pretoriuskop area) with the conclusion that " ... it appears that this species is on the increase" (Sandenbergh 1947).

In 1948 the following assessment was made of the roan population: "The roan position seems to have deteriorated and all herds seen are on an average made up of smaller numbers than last year. Added to this, herds are less frequently seen" (Sandenbergh 1948). Seven roan were reported from Pretoriuskop during the course of 1948. Similar impressions were also reflected in the 1949 Annual Report: " ... I do not think that these animals are nearly

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numerous enough considering the favourable grazing and other conditions in the Park. In the southern part of the Park the species has without doubt diminished; in the northern areas they seem to be just holding their own" (Sandenbergh 1949).

During 1950 the tide again seemed to turn as "there appeared to have been an increase" in the numbers of roan in the northern areas although their position in the southern districts remained "static" (Sandenbergh 1950).

During the period 1951 to 1954 the overall position remained unchanged and in 1955 - only the second time since 1912 - the status of the roan population was expressed in terms of actual numbers. Relying almost entirely on road counts the Biologist (Anon 1955) estimated the total number in the Park between 450 and 550 with 22 south of the Sabi River, 20 between the Sabi and Olifants rivers and 400 to 500 north of the latter. This position probably reflected what has hitherto been referred to as "scarce" or "rare" in the southern districts and "favourable" or "numerous" in the northern areas. These conditions remained fairly constant at least until the end of the fifties with no steep fluctuations either way.

During 1959 the first recorded anthrax epidemic plagued the roan population of the north-eastern Lebombo Flats and was followed by a second in the mid-winter months of 1960. These two epidemics caused a severe setback and in the Annual Report of 1961/'62 the population total in the northern districts was estimated at no more than 180 to 200 (Pienaar 1961/'62).

After this setback the population again increased and in 1963 the roan numbers were estimated to be 200 to 220 in the northern areas, 31 in the Central District (between the Olifants and Sabi rivers) and 35 south of the latter (Pienaar 1963).

Further favourable increases were recorded in the mid-sixties and in the Annual Report for 1966/'67 the total for the southern area was estimated at 50, while the position in the northern area was considered favourable. Only in

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the Central District all indications were that the small population (approximately 30 in 1963) that had been holding its own for many years along the western border, had eventually collapsed and been completely exterminated within the Park boundaries. This was believed to have been caused primarily by the fencing of the western boundary which cut them off from their traditional watering points. The only roan still known to exist in the Central District were a few in the Nkuane-area of the Lebombo Mountain Range adjoining Mocambique (Pienaar 1966/'67).

In the late 1960's it was reported that a definite upward trend had become obvious in the roan population and that their total number could well have surpassed the 250 mark. At the same time the population in the Pretoriuskop area was estimated at no less than 25 (Pienaar 1968/'69).

Censusing of big game populations by means of extensive ground counts in addition to an annual aerial census commenced in 1968. This method was a great improvement on the monthly road-strip counts used previously. Although this method is not without its sources of error, it has proved useful and is regarded as the most reliable form of censusing yet applied in the Park. Basically the method consists of intensive and extensive road-strip counting of an area on consecutive days until a stable composition of the animal community is obtained. The contribution of each population toward the composition of the community is expressed as a percentage. By obtaining an accurate figure for one or two of the animal populations in an area and by replacing its relative contribution towards the community, as derived from the differential counts, with the actual population size, the numerical status of the other populations could therefore also be calculated, e.g. if tsessebe constitute 15 per cent of an animal community and their population is known to be 50, the total number of waterbuck, constituting 18 per cent, will be 18/15 x 50 = 60. By applying this method, the numerical status of the Park's roan antelope population for the period 1968 to 1973 was calculated and the results are presented in Table 11.

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Table 11 : Calculated number of roan antelope in the Kruger National Park, South Africa, by applying five differential road counts and five aerial censuses.

AREA	RELATIVE DENSITY (PERCENTAGE) OF ROAN ANTELOPE AS DERIVED FROM DIFFERENTIAL ROAD COUNTS					TOTAL COUNTED DURING AERIAL CENSUS					ESTIMATED TOTAL BY APPLYING ALL RELEVANT INFORMATION				
	1968	1969	1970	1971	1973	1968	1969	1970	1971	1973	1968	1969	1970	1971	1973
Pretoriuskop	0,24	0,19	0,06	0,06	0,07	25	0	0	0	5	30	25	30	30	30
Letaba	0,08	0,32	0,14	0,02	0,03	21	1	4	0	0	25	25	25	22	20
Mooiplaas	1,77	1,22	2,51	1,31	1,90	75	52	52	44	19	75	75	75	70	85
Mahlangene	0,26	0,25	0,25	0,30	0,17	10	5	0	0	0	15	15	15	26	20
Shangoni	0,09	0,22	0,50	0,07	0,16	19	0	0	2	8	20	25	25	27	35
Shingwidzi	0,75	0,41	1,96	1,96	1,24	28	7	48	15	51	45	35	65	65	83
Punda Milia	0,57	0,48	1,17	0,44	0,13	48	1	23	4	28	48	48	15	20	30
WHOLE PARK	-	-	-	-	-	226	66	127	65	111	258	248	250	260	308

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Subsequent to the anthrax epizootic of 1970 the roan on the north-eastern Lebombo Flats to the north of the Shingwidzi River are immunized annually against this disease (De Vos et al 1973). This has led to the most intensive counts of roan antelope on the far north-eastern flats as it is important that all roan herds in the area are immunized. Herds are located by flying tight predetermined strips with a fixed-wing Cessna 206 at low levels. This has proved highly successful and this form of flying has recently also been adapted to aerial censusing with most encouraging results.

The results obtained from both innoculation operations and censusing in this way are presented in Table 12. The innoculation counts include the area between the Shingwidzi River in the south, the Punda Milia-Pafuri tourist road in the north, the Mphongolo River in the west and the Park's eastern boundary (Fig. 1). In the 1974 count the area between the Letaba River (south), Tsendi River (west), Shingwidzi River (north) and the eastern boundary is also included. The roan of these two areas together represent at least 75 per cent of the total roan population in the Park. The figures undoubtedly represent the most reliable counts of roan antelope yet obtained for the Park and probably come as close to a total count of roan on the north-eastern Lebombo Flats as could reasonably be expected. From the totals presented in Table 12 it is clear that the prime roan habitats to the north of the Letaba River have a total roan population of at least 188 animals. It is accepted that a number of roan were inevitably overlooked during the counts, so that - taking ground patrol observations of roan herds into account - the true population would in all probability number roughly 200, or even slightly more.

During a similar survey of the area around Pretoriuskop in 1974, a total of 17 roan were counted. This almost certainly represents an under-count and the true figure is probably around 25, once again basing the correction on observations of roan herds during ground patrols.

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Table 12 : Aerial counts of roan antelope for the north-eastern Lebombo Flats, Kruger National Park, South Africa, as obtained from anthrax innoculation operations and aerial censusing for the period 1971 to 1974.

YEAR	NORTH-EASTERN LEBOMBO FLATS		TOTAL
	North of Shingwidzi River	South of Shingwidzi River	
1971	56	*	56
1972	86	*	86
1973	82	*	82
1974	123	65	188

*area not counted

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The only other significant roan herds in the Park are widely scattered in the Combretum apiculatum - Colophospermum mopane communities along the western side of the Park, including Letaba, Mahlangene, Shangoni and Pund Milia sections (Fig. 24). In total, these animals would not exceed 40 to 50 with only two or three (but not more than five) stragglers left in the Nkuane region of the Central District. This therefore amounts to a total population in the Kruger Park of between 260 and 280 animals.

To attempt any deductions on the performance of the roan population through the years on the basis of the available data presented here would hardly amount to anything more than guesswork. The following aspects are, however, of interest:

South of the Olifants River

It is clear from the earliest reports that the western areas of the old Sabi Game Reserve, i.e. the foothills of the Drakensberg Mountains, included the prime roan habitats for that reserve and consequently harboured the bulk of the southern population. These areas included the tract of land from Legogote in the west to Pretoriuskop and Newington in the east. Roan were clearly all but "rare" in these whereabouts and were invariably referred to as "numerous", "exceedingly numerous" and estimated to be at least 300 strong in 1912 (Stevenson-Hamilton 1912).

After the excision of the western half of the Sabi Game Reserve in 1923, all but the extreme eastern limits of the favoured roan habitats still fell within the new Transvaal Game Reserve and later Kruger National Park.

After the proclamation of the Kruger National Park in 1926 the entire roan population south of the Olifants River was limited to three isolated pockets, i.e. two small sub-populations, each consisting of approximately 25 to 35 animals, in the neighbourhood of Pretoriuskop and in the Batavia-Shiyanamane-Swartkops area along the western boundary and a smaller sub-population - probably never

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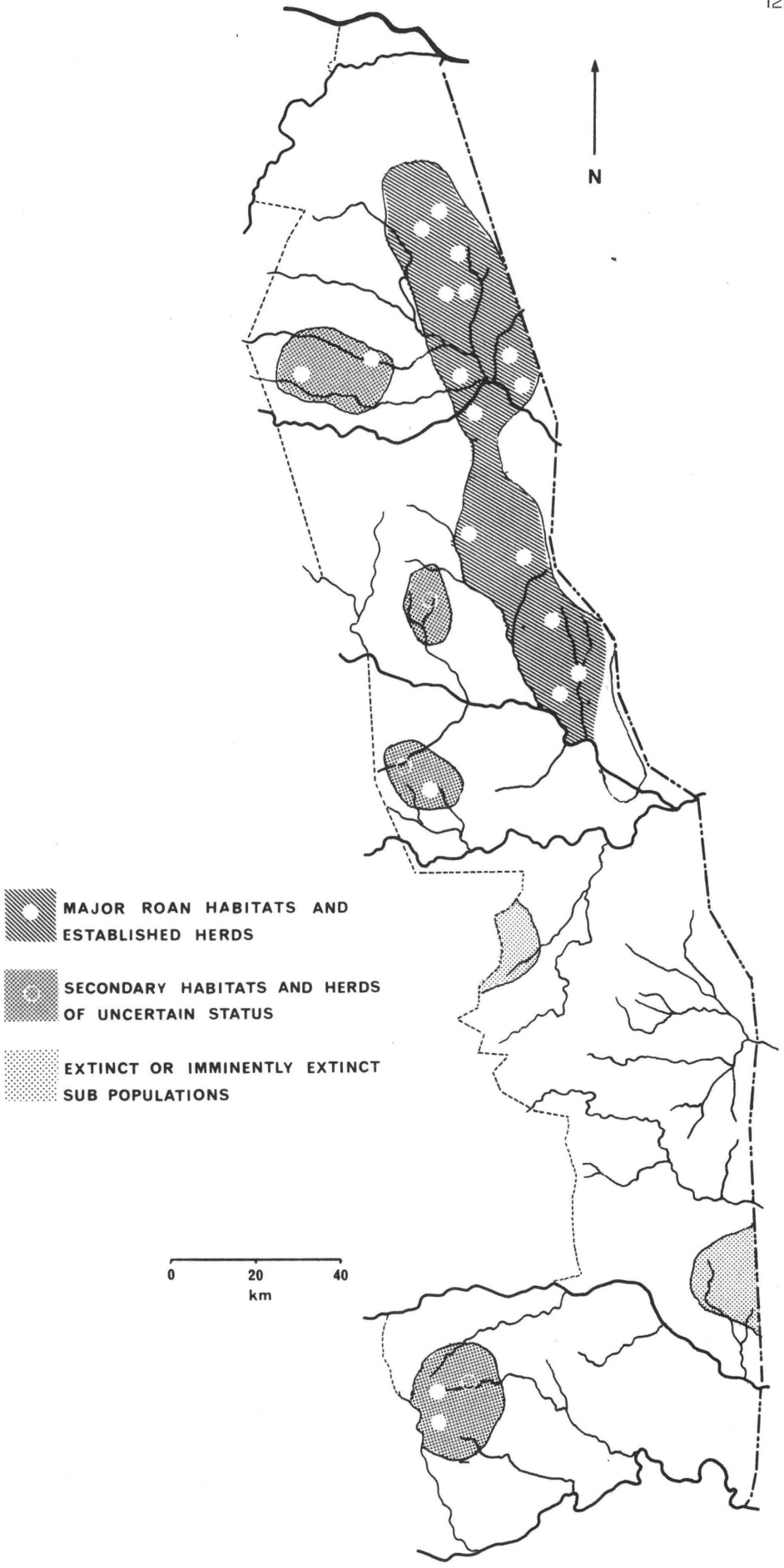

Figure 24 : The present distribution of roan antelope in the Kruger National Park, South Africa with an indication of two areas in which roan have become extinct since 1965.

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more than 15 to 20 - in the Nkuane area slong the eastern boundary. These sub-populations held their own for many years, apparently never really increasing or decreasing. It was only in the early 1960's, with the erection of a game-proof fence along the western boundary, that the roan in the Batavia-Shiyanamane-Swartkops area suffered a setback which eventually led to their extinction.

The small group around Nkuane appears to be suffering the same fate and in recent years the only sightings have been of one or two old bulls.

The assessments of the Pretoriuskop sub-population have remained remarkably constant at approximately 25 over the years, in spite of reports suggesting increases in numbers and/or expansion of their range. The most important deduction from the meagre information available on the Pretoriuskop sub-population is its apparent inability to increase its numbers. Whatever the limiting factor(s), it does not seem unreasonable to assume that the limiting effects have been operative for at least the last 20 to 30 years as no significant increase in the population could be illustrated since the excision of the area to the west of Pretoriuskop.

North of the Olifants River

Since the proclamation of the Kruger National Park with the exclusion of the once prolific population in the western areas of the old Sabi Game Reserve, the bulk of the Park's roan population has been limited to the extensive Lebombo Flats to the north of the Letaba River.

Assessments of this sub-population through the years followed a similar pattern to those of the isolated sub-populations south of the Olifants River. In broad and vague terms this sub-population was alternatively referred to as increasing, decreasing or static. It is impossible to formulate any idea of the actual numerical status of the roan during this period and assessments were probably largely based on the frequency with which the different herds were observed during patrols.

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However inconsistent such estimates may have been, the overall impression gained from the observations of the early pioneers is one of a fluctuating population with periods during which the roan numbers increased and again obviously declined. With only the 1912 estimate of 150 for this area to rely on for the period prior to 1955 and the more systematic census figures since the latter date, it would appear that the population has remained fairly static for the past 60-odd years. With an asymptote of between 150 and 300 animals the fluctuations in the population indicated by the early rangers could very well have coincided with anthrax epizootics or other severely decimating factors. In addition, the population trends seem to indicate a stable population as determined by habitat availability (see Chapter 6).

CONCLUSIONS

From the available data on the reproductive potential of the roan and the high conception and birth rate, the conclusion must be drawn that factors limiting population growth should rather be sought in post-natal stages than in reproductive deficiencies. The fact that the roan antelope represents the only continuously breeding population amongst the larger antelopes in the Kruger National Park, and with a gestation period of similar duration to that of most other herbivores in its size category, the roan could justly be considered the most prolific breeder of all the larger antelopes.

The severest mortality amongst roan appears to occur in the first two months of life. In spite of the high initial mortality, the age and sex structure of the population indicates a healthy population which should ensure a steady, albeit slow, increase.

In terms of population performance the most harmful decimation occurs in the adult stages during periodic anthrax epizootics. Adult animals are more susceptible to this disease than the immatures and during such epizootics the breeding segment, i.e. adult females, have been known to suffer severe setbacks.

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In an enclosed population limited to relatively few animals, the nett annual recruitment to the breeding segment would be correspondingly small with the result that a single anthrax outbreak could eliminate the increase of many years within a few weeks.

Although predation takes its toll from all segments of the population, the annual recruitment to the adult segment is nevertheless satisfactory. It may therefore be implied that the present rate of predation of immatures may retard, but does not adversely affect population growth. Amongst the adults mortality of the males is almost twice that of females so that the breeding segment of the population is largely unaffected by predation. However, in a small population the loss of even a few females annually may have an effect on population growth.

It is known that any particular habitat has its maximum stocking rate in terms of the number of each animal population which it can sustain. The factors involved in regulating the population numbers are not always clearly understood. Some of these will be dealt with in subsequent chapters though the conclusion may be drawn here that the roan population has reached its asymptote in the available habitats of the Kruger Park and an overall increase in the population should preferably be sought in providing more suitable habitats, thereby alleviating the major cause affecting population growth.

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CHAPTER 5 : FOOD PREFERENCES AND REQUIREMENTS

INTRODUCTION

The well-being of an animal population is dependent on numerous different factors which may affect it in one way or another. Potentially retarding or decimating factors such as endo- and ectoparasites, disease, excessive predation and factors affecting reproduction pose a constant threat to most natural populations. In spite of the attendance of so many diverse factors, their decimating effects under normal circumstances are frequently negligible and even advantageous to the population by eliminating the weaker individuals. Such conditions normally exist where populations are well adapted to their environment.

Where one or more of the decimating factors reaches epidemic proportions it could almost invariably be regarded as symptomatic of a corresponding deterioration in environmental conditions affecting the adaptability of the animal. An equilibrium between the habitat and the requirements of an ungulate population is therefore an important prerequisite for the successful management of the population in a particular area.

It is also true, however, that the habitat of an animal comprises not only its 'living quarters' but also its source of nourishment. From this point of view a study of the food preferences of an animal would not only enable an evaluation of the suitability of a particular habitat for that animal but would further enable the wildlife manager to assess an area in terms of the co-inhabitability of a number of different animal populations. Intensive utilization of a restricted food resource by two or more animal populations would inevitably lead to severe competition between the animals involved with possible disastrous results for the less competent populations, or even the entire community. Eventually the food resource itself and consequently the entire habitat may suffer. The importance of a thorough knowledge of the feeding preference of an animal is therefore essential for its management.

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As one of the rare large antelopes in the Kruger Park, an investigation into the feeding habits of the roan antelope to determine whether its existing food resources are sufficient, and also to assess the degree of competition from numerically stronger animal populations for the same resources, was deemed especially important.

DEFINITIONS OF SELECTED TERMS

Grazing selection: This indicates the number of tussocks of a particular grass species which were grazed relative to the total number of tussocks of all grass species utilized. Grazing selection values are expressed as percentages (e.g. if 500 grass tussocks had been grazed to which Themeda triandra contributed 100 the grazing selection for T. triandra would be 20 per cent).

Grazing preference ratings: Grazing selection expressed in terms of availability. Availability was determined by basal cover, relative density and production of grasses.

Basal cover: As described and defined by Tidmarsh and Havenga (1955).

Relative density: The total number of tussocks of a grass species expressed as a percentage of the total number of tussocks of all grass species.

Frequency: The number of sampling sites in which a species occurred as a percentage of the total number of sampling sites.

Production: The calculated mass of all above-ground parts of individual grass species, including dead and live material, expressed as kg/ha .

Short grasslands: Mean height of grasses 150 mm or shorter.

Medium tall grasslands: Mean height of grasses taller than 150 mm to 1,5 m.

Tall grasslands: Mean height of grasses taller than 1,5 m .

MATERIAL AND METHODS

Direct observations on actively grazing animals were made from a Land Rover by using a pair of 10 X 50 mm Halina binoculars or a 40 X 60 mm Hensoldt

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Wetzlar telescope. Notes were made on the plant species utilized and also the parts of the plants taken.

In the roan antelope enclosure at Nwashitsumbe, roan were the only antelope initially introduced into the paddock and, apart from a few steenbok (Raphicerus campestris) and a single reedbuck ewe, were the only animals in the camp until a herd of sable antelope were introduced at a later stage. Steenbok feed almost exclusively on herbs (Huntley 1972, Cohen pers. comm.) so that most of the grasses found grazed were eaten by the roan.

In determining the number of times the various grass species were grazed, the following method was used in the enclosure: The herd was observed for some time during periods of peak grazing activity and a few landmarks (e.g. dead and/or easily identified trees and rocks) selected in the areas of concentrated grazing. Once the herd had moved away, the author and an assistant, who was well acquainted with the plants of the area, walked a few paces abreast from one side of the grazed area to the other and counted all the grass tussocks which had been grazed, noting the species and the number of each species which had been utilized.

For grass species where the individual tussocks could easily be separated from one another counting was straightforward but for creepers and those which grow in dense stands (e.g. Schmidtia pappophoroides and Cenchrus ciliaris) the concept of an individual plant was often ill-defined and made accurate and reliable counting difficult. In such cases one mouthful of grass taken by the animal could have included parts from two or more "tussocks". A completely satisfactory solution to this problem could not be found but to avoid overcounting of such species, two or more rooted plants of which the leaves and stems were closely integrated, were counted as one. Grazing activity in such stands was also more difficult to determine than in stands with loose individual tussocks and the results could therefore have favoured the latter.

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The degree of utilization was not taken into consideration and the results therefore do not reflect the bulk of intake although this would be implied for the heavily grazed species.

The application of this method for determining grazing selection in areas where other herbivores were present, further proved to be confusing as it could not always be determined beyond doubt that roan had, in fact, utilized the different plant species and not any of the other grazers.

Methods to determine various aspects of grass composition were confined to 16 sampling sites in the roan enclosure. Each site measured 100 metres square and the 16 sites were selected to include almost all the variations of the grass composition in the enclosure. Sampling methods applied to these plots included (a) the wheelpoint method of Tidmarsh and Havenga (1955) for determining basal cover and (b) tussock counts within a steel ring with a total area of 0,831 m^2 for the determination of the relative density and frequency of the grass species represented in the enclosure and for determining the production of the different species (Brown 1954). These methods were applied as follows:

(a) Wheelpoint method: This method was applied as outlined by Tidmarsh and Havenga (1955). Litter and herbs were not recorded. Two points 1,4 m apart, were taken on each rotation of the wheel using directly opposite spokes.

A total of 1 000 points were recorded per sampling site by recording 100 points along each of ten parallel lines, 10 m apart and each 140 m long (points 1,4 m apart). For this survey, the individual sites were therefore 90 X 140 m square.

(b) Relative density and frequency: The selection of sampling areas for the steel ring was achieved by determining 10 parallel lines, 10 m apart and each 100 m long, for each sampling site. As each line was 100 m long numbered cards ranging from one to 100 were placed into a container. The

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number of each card represented the distance, in metres, from either side of the lines and by drawing a number from the container the distance from the start of the line to the sampling area could be determined. In this way a random distribution of sampling areas was ensured.

In each sampling area the number of tussocks of each grass species was recorded. Tussocks with one half or more of their basal area falling within the ring were counted as individuals and the results from the ten sampling areas pooled for each sampling site. From these data the relative density and frequency of grass species could be calculated for each sampling site.

Production: Using the same ring and sampling areas as for the determination of relative density and frequency, all grasses within the ring were clipped as close to the ground as possible and the material of each species placed separately into paper packets. All grass parts within the circumference of the ring were clipped.

The material was kept in the packets for three months until it was properly air-dried before its mass, together with the packets, was determined on a Mettler electrical balance.

A sample of 20 packets, representing material of all the more abundant grass species and over a wide mass range, was then extracted and placed in an oven at 102°C for 45 hours, to ensure that no moisture was retained, before determining the dry mass. The mass of all the packets and their contents in the sample were determined immediately after being removed from the oven and of these ten were then placed in a dessicator. Once they had properly cooled off their mass was again recorded. Finally, the dry mass of the empty paper packets was determined and subtracted from the total mass of the packets plus dry material to obtain the mass of the grass material alone.

It was found that there was a mean mass increase of 0,98 gm (range 0,7 to

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1,3 gm) from the 'hot mass' after removal from the oven to the cooled dessicated mass. In further calculations this mass difference was taken as 1,0 gm . After determining the absolute dry mass of the grass material from the sample, it was found that the mass had decreased by an average of 2,4 gm (range 2,2 to 2,7 gm) per 25 gm from air-dried to absolute dry mass and was then applied to the entire sample to determine the dry mass/ha of the material (Table 13 and 14).

The various survey methods applied, further enabled the differentiation between three plant communities based on grass composition in the Nwashitsumbe enclosure. . By plotting the daily movements of the roan in the enclosure the relative time spent by the herd in the different communities could also be determined.

RESULTS AND DISCUSSION

Although roan are partially browsers, the bulk of their diet consists of a variety of grasses and they may therefore be considered as predominantly grazers. Consequently, attention was largely focussed on their grazing habits in an effort to determine whether they showed any definite partiality to certain selected species or not. The following results were obtained:

Grazing selection

Surveys to determine the selection of grasses in the feeding behaviour of roan were done during three different periods of the year, i.e. late summer to early autumn (March - April), mid-winter (July) and late winter to spring (August - October).

Similar surveys during early to mid-summer (November - February) when grasses were actively growing proved difficult and misleading as it was not always possible to determine which tussocks had been grazed. Individual plant identification also proved to be a problem during this period, especially before

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Table 13 : Determination of the dry mass (gram) and mean decrease in mass from air-dried to absolute dry mass (per 25 gm) of a sample of 10 packets of grass material, representing six grass species, from the Nwashitsumbe roan antelope enclosure, Kruger National Park, South Africa.

SPECIES	MASS			
	Air-dried	Absolute dry mass	Decrease	Decrease/25 gms*
Themeda triandra	123,8	113,1	10,7	2,2
Themeda triandra	183,3	166,4	16,9	2,3
Cenchrus ciliaris	163,8	146,0	17,8	2,7
Cenchrus ciliaris	100,0	90,8	9,2	2,3
Heteropogon contortus	264,4	237,7	26,7	2,5
Heteropogon contortus	201,4	183,0	18,4	2,3
Panicum coloratum	249,1	223,2	25,9	2,6
Digitaria pentzii	131,0	118,3	12,7	2,4
Digitaria pentzii	154,6	140,6	14,0	2,3
Eragrostis superba	130,2	116,3	13,9	2,7
		Mean decrease/25 gms :		2,4

*Decrease/25 gms of grass material determined as a convenient measure to illustrate the decrease in mass from air-dried to absolute dry mass of grasses in the sample.

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Table 14 : Example of the calculation of the absolute dry mass (kg) of grasses per hectare in the Nwashitsumbe roan antelope enclosure, Kruger National Park, South Africa. Sampling site 1 given as an example.

SPECIES	AIR-DRIED MASS	DECREASE 2,4gm/25 gm	DRY MASS PLUS PACKETS	MASS OF PACKETS	ABSOLUTE DRY MASS OF GRASS MATERIAL
Themeda triandra	1 287,2	122,4	1 164,8	101,5	1 063,3
Panicum coloratum	3 078,2	295,2	2 783,0	203,0	2 580,0
Cenchrus ciliaris	266,6	26,4	240,2	43,5	196,7
Heteropogon contortus	255,7	21,6	204,1	29,0	175,1
Eragrostis superba	308,4	28,8	279,6	87,0	192,6
Urochloa mosambicensis	97,5	9,6	87,9	29,0	58,9
Aristida spp.	90,0	9,6	80,4	29,0	51,4
Digitaria pentzii	47,3	4,8	42,5	14,5	28,0
Enneapogon cenchroides	25,8	2,4	23,4	14,5	8,9
		Total dry mass of grasses for Site No.1 : 4 354,9			

Total area sampled : 8,31 square metres, therefore, total dry mass of grasses/hectare: $\frac{10\ 000}{8,31} \times \frac{4\ 354,9}{1\ 000}$ kg

= 5 240,6 kg.

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the inflorescences of the grasses were produced. During March-April most grasses had reached maturity with a corresponding drop in active growth and consequently grazed tussocks were more readily identified. The results for this season of the year are presented in Table 15 and Fig. 25.

In spite of the apparent discrepancies in the result of the March - April surveys it is important that Heteropogon contortus and Themeda triandra comprised more than 70 per cent of the grasses utilized on both occasions while Digitaria pentzii featured prominently during the March survey. Conditions which may have influenced grazing selection during this time will be dealt with later in this section.

The results presented in Table 16 and Fig. 25 reflect the mid-winter grazing selection of grasses by the roan in the Nwashitsumbe enclosure. The importance of Themeda triandra as a preferred food plant is once again emphasised while the grazing selection of both Schmidtia pappophoroides and Panicum coloratum increased considerably as compared with the March - April surveys. Conversely Heteropogon contortus and Digitaria pentzii showed a sharp decline and each contributed only slightly more than 3 per cent towards the grazing selection.

The latter half of the dry winter season and spring (before the first rains) represents the most crucial period of the year to grazers in terms of competition for the more palatable grass species. The availability and/or nutritional value of the food plants decrease as the dry season progresses, as evidenced by a loss of condition of the herbivores. This period therefore largely determines the ability of a herbivorous species to adapt to a particular environment and surveys were consequently concentrated to the months immediately preceding the first rains. Table 17 and Fig. 25 reflects the results of the grazing selection of grasses by roan for this period. In Table 18 and Fig. 25 the pooled results for the period March to October are given. For the late dry season and spring (August - October) the results presented in Table 17 indicate a strong grazing

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Table 15 : Utilization and grazing selection (percentage utilization) of grasses by roan antelope during late summer and early autumn (March - April) in the Nwashitsumbe roan enclosure, Kruger National Park, South Africa.

SPECIES UTILIZED	MARCH		APRIL		POOLED RESULTS	
	No.of grass tussocks utilized	Grazing selection (per cent)	No.of grass tussocks utilized	Grazing selection (per cent)	No.of grass tussocks utilized	Grazing selection (per cent)
Heteropogon contortus	17	5,63	440	54,32	457	41,10
Themeda triandra	198	65,56	190	23,46	388	34,89
Digitaria pentzii	66	21,85	15	1,85	81	7,28
Panicum coloratum	5	1,66	62	7,65	67	6,03
Cenchrus ciliaris	15	4,97	45	5,56	60	5,40
Schmidtia pappophoroides	-	-	44	5,43	44	3,96
Urochloa mosambicensis	-	-	14	1,73	14	1,26
Sorghum versicolor	1	0,33	-	-	1	0,08
TOTAL	302	100,00	810	100,00	1 112	100,00

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Legend:

Late Summer - Early Autumn

A. Heteropogon contortus
B. Themeda triandra
C. Digitaria pentzii
D. Panicum coloratum
E. Cenchrus ciliaris
F. Schmidtia pappophoroides
G. Urochloa mosambicensis
H. Sorghum versicolor

Mid-Winter

A. Themeda triandra
B. Schmidtia pappophoroides
C. Panicum coloratum
D. Digitaria pentzii
E. Heteropogon contortus
F. Cenchrus ciliaris
G. Eragrostis superba
H. Aristida spp.

Late Winter - Spring

A. Themeda triandra
B. Schmidtia pappophoroides
C. Setaria woodii
D. Panicum coloratum
E. Heteropogon contortus
F. Cenchrus ciliaris
G. Sporobolus sp.
H. Urochloa mosambicensis
I. Digitaria pentzii
J. Eragrostis superba
K. Enneapogon cenchroides
L. Sporobolus robustus
M. Andropogon sp.
N. Fingerhuthia africana
O. Chloris sp.
P. Ischaemum brachyatherum
Q. Aristida spp.

Figure 25 : The relative grazing selection of grasses by roan antelope in the roan antelope enclosure, Nwashitsumbe, Kruger National Park, South Africa.

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Table 16 : Utilization and grazing selection (percentage utilization) of grasses by roan antelope during mid-winter (July) in the Nwashitsumbe roan enclosure, Kruger National Park, South Africa.

SPECIES UTILIZED	JULY	
	No.of grass tussocks utilized	Grazing selection (per cent)
Themeda triandra	663	54,66
Schmidtia pappophoroides	282	23,25
Panicum coloratum	167	13,77
Digitaria pentzii	39	3,22
Heteropogon contortus	38	3,13
Cenchrus ciliaris	17	1,40
Eragrostis superba	6	0,49
Aristida spp.	1	0,08
T O T A L	1 213	100,00

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Table 17 : Utilization and grazing selection (percentage utilization) of grasses by roan antelope during late winter and spring (August - October) in the Nwashitsumbe roan enclosure, Kruger National Park, South Africa.

SPECIES UTILIZED	AUGUST		SEPTEMBER		OCTOBER		POOLED RESULTS	
	No. of grass tussocks utilized	Grazing selection (per cent)	No. of grass tussocks utilized	Grazing selection (per cent)	No. of grass tussocks utilized	Grazing selection (per cent)	No. of grass tussocks utilized	Grazing selection (per cent)
Themeda triandra	57	10,48	644	28,28	303	44,69	1 004	28,69
Schmidtia pappophoroides	118	21,69	165	7,25	175	25,52	456	13,03
Setaria woodii	-	-	366	16,07	-	-	366	10,46
Panicum coloratum	42	7,72	258	11,33	14	2,06	314	8,97
Heteropogon contortus	104	19,12	121	5,31	71	10,47	296	8,46
Cenchrus ciliaris	122	22,43	94	4,13	52	7,67	268	7,66
Sporobolus sp.	-	-	239	10,50	-	-	239	6,84
Urochloa mosambicensis	-	-	174	7,64	1	0,15	175	5,00
Digitaria pentzii	86	15,81	78	3,43	9	1,33	173	4,94
Eragrostis superba	10	1,84	57	2,50	53	7,82	120	3,43
Enneapogon cenchroides	3	0,55	41	1,80	2	0,29	46	1,32
Sporobolus robustus	-	-	33	1,46	-	-	33	0,95
Andropogon shirensis	-	-	3	0,13	-	-	3	0,09
Fingerhuthia africana	2	0,37	-	-	-	-	2	0,05
Chloris sp.	-	-	2	0,09	-	-	2	0,05
Ischaemum brachyatherum	-	-	1	0,04	-	-	1	0,03
Aristida sp.	-	-	1	0,04	-	-	1	0,03
T O T A L	544	100,00	2 277	100,00	678	100,00	3 499	100,00

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Table 18 : Pooled utilization and grazing selection (percentage utilization) of grasses by roan antelope from March to October in the Nwashitsumbe roan antelope enclosure, Kruger National Park, South Africa.

SPECIES UTILIZED	GRASS TUSSOCKS UTILIZED	GRAZING SELECTION (PER CENT)
Themeda triandra	2 055	35,29
Heteropogon contortus	791	13,58
Schmidtia pappophoroides	782	13,43
Panicum coloratum	548	9,41
Setaria woodii	366	6,28
Cenchrus ciliaris	345	5,92
Digitaria pentzii	293	5,03
Sporobolus spp.	239	4,10
Urochloa mosambicensis	189	3,25
Eragrostis superba	126	2,16
Enneapogon cenchroides	46	0,79
Sporobolus robustus	33	0,57
Andropogon sp.	3	0,05
Aristida spp.	2	0,03
Chloris sp.	2	0,03
Fingerhuthia africana	2	0,03
Ischaemum brachyatherum	1	0,02
Sorghum versicolor	1	0,02
T O T A L	5 824	100,00

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selection in favour of especially Themeda triandra, Schmidtia pappophoroides, Panicum coloratum, Heteropogon contortus and, in addition, Setaria woodii and Cenchrus ciliaris.

The results given for the three months in Table 17 represent data collected at different times during those months and in habitats differing in grass composition. Although this gives an overall picture of grazing selection, the significance of the results can only be tested realistically against the natural composition of the vegetation. To achieve this the point of departure was therefore to compare actual utilization with availability. To determine availability the relative density, basal cover and standing crop of all grass species were used as criteria.

In Table 19 and Fig. 26 the relative density and frequency of the grasses in the Nwashitsumbe enclosure are given. These criteria merely give some indication of the relative numbers of individual plants and their distribution but as grass species vary greatly in growth form and size, this information alone would only be of limited value as a criterion of availability. To augment these results, the basal cover and relative basal cover of each species was also determined and the results are presented in Table 20 and Fig. 26.

As a further measure for determining the degree of grazing selection, the relative production of the various grass species was also calculated and the results are presented in Table 21 and Fig. 26.

The March - April grazing selection of grasses by roan is illustrated in Table 15 and Fig. 25. From these results it is apparent that selection was strongly in favour of Themeda triandra during March, 1969 (65,56 per cent) followed by Digitaria pentzii (21,85 per cent). These two species alone accounted for 87,41 per cent of the diet of the roan and the only other grasses grazed to any extent were Heteropogon contortus (5,63 per cent) and Cenchrus ciliaris (4,97 per cent). It was noted that in spite of the abundance of species such as Cenchrus

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Table **19**: The relative density (R.D.) and frequency (F.) of grass species in the Nwashitsumbe **roan antelope** enclosure, Kruger National Park, South Africa.

SPECIES	SAMPLE SITE																														MEAN FOR ALL SAMPLING SITES	
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16			
	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.	R.D.	F.
Schmidtia pappophoroides	0,56	10	27,27	50	35,19	90	27,37	70	6,75	30	26,19	60	47,62	90	65,93	100	**52,85**	100	42,58	80	26,02	70	-	-	52,08	70	36,44	50	28,69	60	35,62	60	31,94	61,88
Panicum coloratum	27,78	100	19,48	80	29,61	90	21,53	50	13,50	60	23,33	90	14,29	60	7,04	60	**4,56**	20	4,69	20	4,09	70	32,52	90	2,88	40	2,54	20	3,69	20	7,53	50	13,69	57,50
Digitaria pentzii	9,44	10	-	-	0,86	10	12,04	40	8,86	30	15,71	30	-	-	7,41	30	**25,86**	60	25,78	60	39,78	60	9,20	30	18,85	20	-	-	15,98	30	20,55	30	13,15	27,5
Themeda triandra	22,22	60	22,08	60	13,73	30	10,95	40	30,38	70	5,24	50	6,49	40	6,67	30	**1,52**	10	1,56	10	-	-	-	-	1,28	20	4,66	30	2,05	10	10,62	60	8,72	32,5
Aristida spp.	25,00	20	9,09	30	0,43	10	9,12	20	12,24	40	14,76	40	7,36	30	4,44	10	-	-	-	-	9,29	60	-	-	0,96	20	5,51	20	13,52	30	8,56	30	7,52	22,50
Heteropogon contortus	1,11	20	3,90	20	18,03	30	9,12	50	16,88	50	0,48	10	-	-	1,85	20	**5,70**	30	8,20	20	7,06	70	-	-	14,06	90	3,81	30	17,62	40	4,45	10	7,02	30,63
Sorghum vesicolor	-	-	2,60	20	-	-	4,01	40	7,17	40	9,52	30	13,42	60	1,11	10	**3,42**	50	-	-	9,29	90	6,75	20	0,64	10	2,12	20	1,64	30	7,53	30	4,33	28,13
Cenchrus ciliaris	3,89	30	2,60	10	1,71	10	-	-	-	-	-	-	6,49	30	4,44	10	**0,38**	10	12,89	50	-	-	-	-	7,99	50	13,14	30	0,82	10	3,77	30	3,63	16,88
Setaria woodii	-	-	1,30	10	-	-	0,36	10	-	-	0,48	10	-	-	-	-	**0,38**	10	-	-	-	-	12,27	70	-	-	25,42	70	1,23	20	-	-	2,59	12,50
Chloris sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33,74	10	-	-	-	-	-	-	-	-	2,11	0,63
Urochloa mossambicensis	1,67	20	-	-	-	-	1,46	10	0,42	10	2,86	20	0,43	10	1,11	10	**0,38**	10	1,17	20	4,09	20	4,91	20	1,28	40	6,36	30	6,56	60	-	-	2,04	17,50
Eragrostis superba	6,11	60	0,65	10	0,43	10	2,55	30	0,42	10	-	-	3,90	20	-	-	-	-	3,13	20	-	-	-	-	-	-	-	-	1,64	20	0,34	10	1,20	11,88
Enneapogon cenchroides	1,67	10	10,39	10	-	-	1,46	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,68	10	0,89	2,50
Bothriochloa insculpta	-	-	0,65	10	-	-	-	-	0,84	10	0,48	10	-	-	-	-	**4,94**	10	-	-	-	-	-	-	-	-	-	-	6,56	10	-	-	0,84	3,13
Andropogon shirensis	-	-	-	-	-	-	-	-	2,53	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,16	0,63
Tragus berteronianus	0,56	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,34	10	0,06	1,25
Sporobolus sp.	-	-	-	-	-	-	-	-	-	-	0,95	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,06	0,63
Ischaemum brachyatherum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,61	10	-	-	-	-	-	-	-	-	0,04	0,63
Panicum maximum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,37	10	-	-	-	-	-	-	-	-	-	-	0,02	0,63

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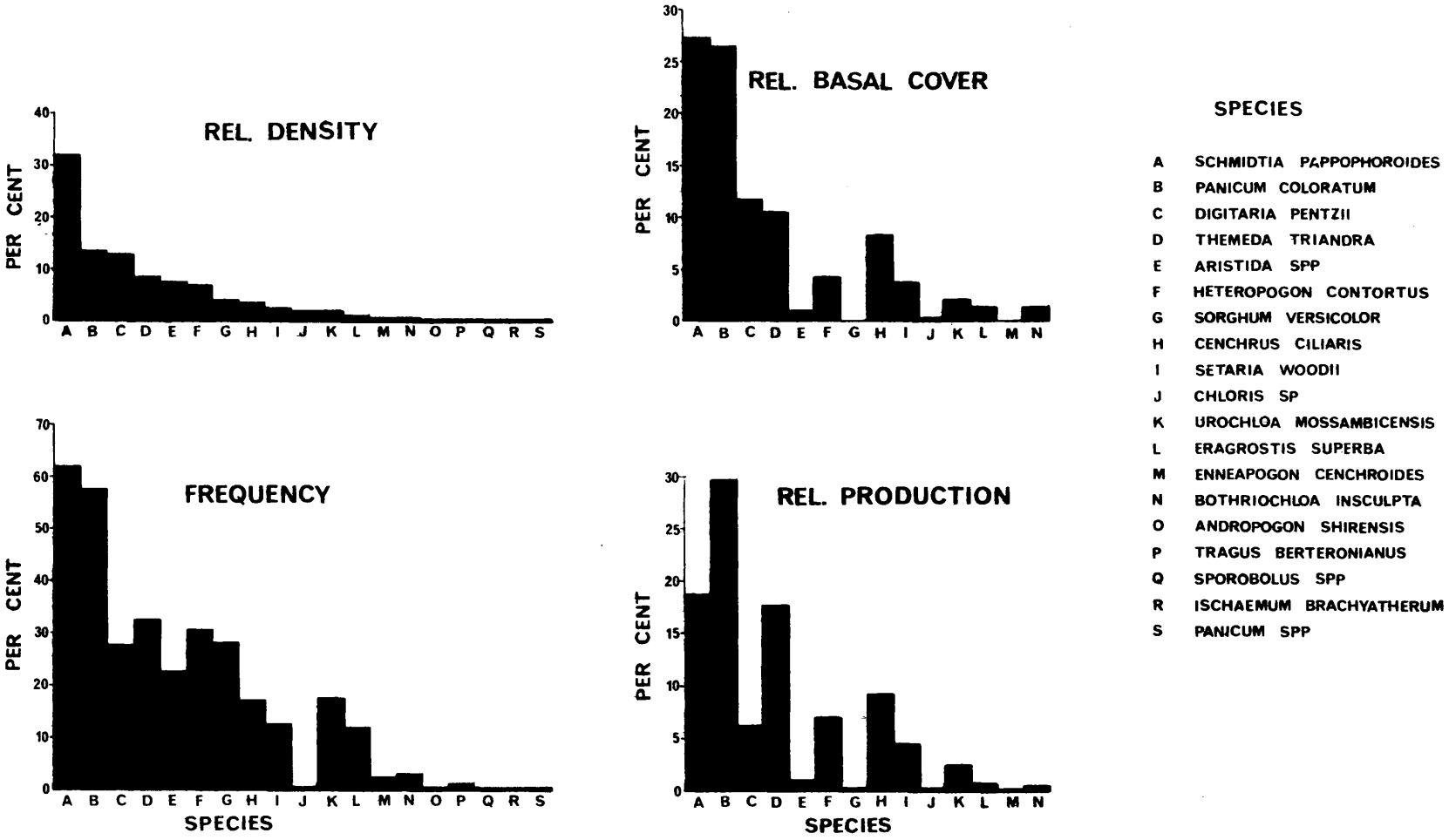

Figure 26 : The relative density, frequency, relative basal cover and relative production of grasses in the Nwashitsumbe enclosure, Kruger National Park, South Africa.

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Table **20**: Basal cover (B.C) and relative basal cover (R.B.C) of grasses in the Nwashitsumbe roan antelope enclosure, Kruger National Park, South Africa.

SPECIES	SAMPLING SITE																														MEAN FOR ALL SAMPLING SITES	
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16			
	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.	B.C	R.B.C.
Themeda triandra	1,1	22,45	1,8	24,0	0,5	7,46	1,0	14,08	0,7	10,45	0,6	11,11	0,6	8,57	1,6	17,2	0,1	1,43	-	-	0,2	4,55	0,1	1,85	0,1	1,27	0,6	11,11	1,8	31,00	0,2	3,28	0,69	10,62
Panicum coloratum	0,4	8,16	2,5	33,33	4,1	61,19	2,1	29,58	3,6	53,37	3,0	55,56	2,2	31,43	1,3	13,98	0,6	8,57	0,5	6,49	0,7	15,91	3,0	55,56	1,0	12,65	0,3	5,56	0,8	13,79	1,5	24,59	1,73	26,62
Schmidtia pappophoroides	1,7	34,69	0,9	12,0	0,8	11,95	1,9	26,76	0,9	13,43	0,8	14,81	2,6	37,14	4,8	51,61	2,3	32,86	2,5	32,47	0,9	20,45	-	-	3,4	43,04	1,7	31,48	1,1	18,97	2,2	36,07	1,78	27,38
Cenchrus ciliaris	0,5	10,2	0,5	6,67	0,1	1,49	-	-	0,3	4,48	0,2	3,7	0,7	10,0	0,2	2,15	4,7	24,29	1,2	15,58	0,4	9,09	-	-	1,8	22,77	0,2	3,7	0,4	6,9	0,5	8,19	0,54	8,31
Eragrostis superba	0,3	6,12	0,2	2,67	0,1	1,49	-	-	-	-	-	-	0,1	1,43	0,2	2,15	0,1	1,43	-	-	-	-	-	-	0,2	2,53	-	-	0,2	3,45	-	-	0,09	1,38
Heteropogon contortus	0,1	2,04	0,5	6,67	0,4	5,97	0,8	11,27	0,1	1,49	-	-	0,2	2,86	0,3	3,23	0,6	8,57	0,3	3,9	-	-	-	-	0,8	10,13	0,2	3,7	-	-	0,1	1,64	0,28	4,31
Bothriochloa insculpta	0,3	6,12	0,1	1,33	-	-	-	-	-	-	-	-	-	-	0,3	3,23	0,1	1,43	0,2	2,6	0,2	4,55	-	-	-	-	-	-	0,1	1,72	0,2	3,28	0,09	1,38
Digitaria pentzii	0,2	4,08	0,7	9,34	0,4	5,97	1,0	14,08	1,0	14,93	0,4	4,71	-	-	0,6	6,45	1,3	18,57	2,4	31,16	1,8	40,91	0,1	1,85	0,3	3,8	0,1	1,86	0,8	13,79	1,2	19,67	0,77	11,85
Aristida spp.	0,1	2,05	0,1	1,33	0,3	4,48	-	-	-	-	-	-	0,5	7,14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,1	1,64	0,07	1,08
Fingerhuthia africana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,3	3,9	-	-	-	-	0,1	1,27	-	-	-	-	-	-	0,03	0,46
Urochloa mosambicensis	0,1	2,05	0,1	1,33	-	-	-	-	-	-	0,2	3,7	-	-	-	-	0,2	2,85	0,1	1,3	0,1	2,27	0,5	9,26	0,1	1,27	0,2	3,7	0,6	10,34	-	-	0,14	2,15
Panicum maximum	0,1	20,4	0,1	1,33	-	-	-	-	0,1	1,49	0,1	1,85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,03	0,46
Sporobolus sp.	-	-	-	-	-	-	0,2	2,82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloris sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,2	3,70	-	-	-	-	-	-	-	-	0,01	0,15
Setaria woodii	-	-	-	-	-	-	-	-	-	-	0,1	1,85	-	-	-	-	-	-	0,1	1,3	-	-	1,5	27,78	0,1	1,27	2,1	38,89	-	-	-	-	0,24	3,69
Other (e.g.Tragus berteronianus, Sorghum versicolor	-	-	-	-	-	-	0,1	1,41	-	-	-	-	0,1	1,43	-	-	-	-	0,1	1,3	0,1	2,27	-	-	-	-	-	-	-	-	0,1	1,64	0,03	0,46
Total basal cover	4,9	100,0	7,5	100,0	6,7	100,0	7,1	100,0	6,7	100,0	5,4	100,00	7,0	100,0	9,3	100,0	7,0	100,01	7,7	100,0	4,4	100,0	5,4	100,0	7,9	100,0	5,4	100,0	5,8	100,0	6,1	100,0	6,5	100,0

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le 21: Standing crop (C, kg/hectare) and relative production (R.P.) of grass species on 15 sampling sites in the Nwashitsumbe roan antelope enclosure, Kruger National Park, South Africa

PECIES	SAMPLING SITE																												MEAN FOR ALL SAMPLING SITES	
	1		2		4		5		6		7		8		9		10		11		12		13		14		15		16			
	CROP C.	Relat. R.P.	C	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.	C.	R.P.
emeda iandra	1 279,54	24,42	1 616,73	44,39	1 229,00	23,12	1 338,15	41,34	673,04	19,68	584,12	12,56	798,32	20,89	-	-	140,67	3,77	-	-	-	-	147,29	3,51	593,86	12,55	743,20	16,56	1 609,03	35,51	716,86	17,71
teropogon ntortus	210,71	4,02	100,12	2,75	436,34	8,21	593,62	18,34	8,42	0,25	-	-	140,43	3,67	197,95	6,1	417,21	11,17	565,22	17,39	-	-	851,87	20,31	278,82	5,89	330,08	7,35	136,82	3,02	284,51	7,03
nicum loratum	3 104,69	59,24	1 425,87	39,15	2 354,87	44,30	974,01	30,09	1 786,76	52,24	878,22	18,88	1 065,58	27,88	327,44	10,1	683,75	18,3	282,43	8,69	1 935,50	56,23	315,88	7,53	94,46	2,0	2 188,09	48,75	684,36	15,1	1 206,79	29,82
gitaria ntzii	33,69	0,64	-	-	141,76	2,67	118,17	3,65	304,45	8,90	-	-	9,15	0,24	839,83	25,9	746,33	19,98	851,75	26,21	28,28	0,82	259,33	6,18	-	-	10,11	0,23	414,68	9,15	250,50	6,19
hmidtia ppophoroides	-	-	358,84	9,85	771,96	14,52	46,33	1,43	467,27	13,66	1 266,07	27,22	1 213,96	31,77	1 399,40	43,16	989,05	26,47	851,87	26,22	-	-	489,05	35,5	850,18	17,97	651,62	14,52	1 092,54	24,11	763,21	18,86
nchrus liaris	236,70	4,52	-	-	-	-	-	-	-	-	1 712,15	36,81	393,38	10,29	24,43	0,75	602,53	16,13	-	-	-	-	028,16	24,51	578,34	12,22	535,26	11,93	542,60	11,97	376,90	9,31
ochloa ssambicensis	70,88	1,35	-	-	1,20	0,02	1,56	0,05	60,41	1,77	-	-	184,72	4,83	28,16	0,87	140,07	3.75	425,15	13,08	84,60	2,46	99,04	2,36	450,42	9,52	-	-	-	-	103,08	2,55
taria ndii	-	-	38,39	1,85	80,51	1,51	-	-	24,43	0,71	-	-	-	-	75,69	2,33	-	-	118,77	3,66	791,94	23,01	-	-	1 610,71	34,05	-	-	-	-	182,70	4,51
egrostis perba	231,77	4,42	31,17	0,86	114,32	2,15	124,79	3,86	-	-	155,60	3,34	-	-	-	-	16,61	0,44	-	-	-	-	-	-	-	-	7,22	0,16	12,15	0,27	30,79	0,76
rghum rsicolor	-	-	10,95	0,3	6,74	0,13	22,50	0,7	31,65	0,93	-	-	3,01	0,08	3,25	0,1	-	-	93,26	2,87	3,73	0,12	0,60	0,01	2,41	0,05	-	-	22,26	0,49	13,36	0,33
istida spp.	61,85	1,18	34,78	0,95	162,33	3,05	17,57	0,54	63,78	1,86	55,72	1,2	13,00	0,34	-	-	-	-	60,89	1,87	-	-	3,37	0,08	15,04	0,32	22,50	0,5	16,61	0,37	35,16	0,87
neapogon nchroides	10,71	0,20	3,73	0,1	16,25	0,31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,60	0,01	2,09	0,05
thriochloa sculpta	-	-	21,66	0,59	-	-	-	-	-	-	-	-	-	-	346,57	10,69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24,54	0,61
nicum ximum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	360,89	10,48	-	-	256,68	5,43	-	-	-	-	41,17	1,02
loris sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	195,55	5,68	-	-	-	-	-	-	-	-	13,04	0,32
chaemum acnyatherum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36,70	1,07	-	-	-	-	-	-	-	-	2,45	0,06
loris rgata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
tal	5 240,54	99,99	3 642,24	99,99	5 315,28	99,99	3 336,70	100,00	3 420,21	100,00	4 651,88	100,01	3 821,55	99,99	3 242,72	100,00	3 736,22	100,01	3 249,34	99,99	3 442,19	99,87	194,59	99,99	4 730,92	100,00	4 488,08	100,00	4 531,65	100,00	4 047,15	100,00

ata for sampling site No. 3 not available.

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ciliaris, Schmidtia pappophoroides and Panicum coloratum in the enclosure (Tables 19, 20 and 21) they were apparently largely or even completely ignored. At the time of the survey grass growth was extremely rank and although the grasses had already reached maturity and were in full seed the leaves and stems were still green.

A survey during April, 1970 revealed that Heteropogon contortus was actively sought by roan and made up 54,32 per cent of the grasses utilized. Although Themeda triandra was less heavily grazed at this time, it still made up a substantial 23,46 per cent of the diet. Compared with March, Panicum coloratum showed an increase in grazing selection from 1,66 to 7,65 per cent in April while the utilization of Digitaria pentzii decreased from 21,75 to 1,85 per cent. The 5,56 per cent utilization of Cenchrus ciliaris showed no dramatic change from the 4,97 per cent recorded for March. Although low on the preference list, Schmidtia pappophoroides and Urochloa mosambicensis, merit attention. Neither of the two species were recorded during March but made up 5,43 per cent and 1,73 per cent respectively of all the tussocks grazed during April. General conditions during the survey were drier than normally expected for this time of the year with most grasses matured and dry, and only the stems of perennials, such as Cenchrus ciliaris, still retained some greenness. The overall impression was that Themeda triandra and Heteropogon contortus were actively sought by the roan while other grasses were only taken incidentally.

A mid-winter survey was made during July, 1970 after 25 mm of rain had fallen during June. Despite a slight green flush in the vegetation, the grasses were generally dry with only a few green shoots. Themeda triandra was once again the predominantly utilized species and made up 54,66 per cent of all the tussocks of the various species grazed. The increased utilization of Schmidtia pappophoroides, as evidenced in the April survey, continued and comprised 23,25 per cent of the total number of grass tussocks grazed while Heteropogon contortus (3,13

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per cent) and Cenchrus ciliaris (1,4 per cent) were low on the list, with Digitaria pentzii showing a slight increase from the April survey. It was noticed that the dry, moribund tussocks of Heteropogon contortus seemed to be avoided, as well as those of Digitaria pentzii.

The pooled results of the late winter and spring period (August, September, October) indicated a distinct grazing selection in favour of Themeda triandra although the heavier utilization of a wider variety of other grasses was also revealed. During the August (1968 and 1969) surveys Cenchrus ciliaris (22,43 per cent), Schmidtia pappophoroides (21,69 per cent), Heteropogon contortus (19,12 per cent) and Digitaria pentzii (15,81 per cent) features prominently with Themeda triandra (10,48 per cent) with no clearly defined preferences.

During September (1968 and 1969) Themeda triandra rose to 28,28 per cent and after it was observed that the roan herd was spending some time in the relatively small area covered by the vlei in the enclosure, it was found that they were grazing heavily on Setaria woodii (16,07 per cent) and a Sporobolus sp. (10,5 per cent) - both grasses largely confined to seasonally inundated depressions. Other species which were less heavily grazed but still well represented in the diet of the roan included Panicum coloratum (11,33 per cent), Urochloa mosambicensis (7,64 per cent), Schmidtia pappophoroides (7,25 per cent) and Heteropogon contortus (5,31 per cent).

From a survey under the extremely dry conditions of October, 1968, Themeda triandra (44,69 per cent) again clearly emerged as the most favoured species with Schmidtia pappophoroides (25,52 per cent) also well utilized. Other important species during this period were Heteropogon contortus (10,47 per cent), Cenchrus ciliaris (7,67 per cent) and, to a lesser extent, Panicum coloratum (2,06 per cent).

From Tables 15, 16, 17 and 18 it is obvious that Themeda triandra is the all-important grass species in the diet of the roan. From mid to late winter

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and spring, before the onset of the wet season, Schmidtia pappophoroides becomes increasingly important. While the importance of these two species is emphasised due to their prominence in the grazing selection of roan, all the grass species referred to in Table 22 contributed substantially towards the total number of utilized tussocks and are therefore not merely regarded as supplementary to Themeda triandra and Schmidtia pappophoroides but as important constituents in the diet of the roan.

To draw any meaningful conclusions on the selection of food plants from the results discussed so far, it must, however, be borne in mind that selection would be subject to the general composition of the vegetation and the availability of the various grass species. It could, in fact, be expected that grazing selection would to some extent reflect the composition of the vegetation in which the survey was done - especially in so-called "sweet grass veld" where the palatability of the various grasses remains fairly good throughout the year (Scott 1955).

To evaluate 'selection' it would therefore be important to compare grazing selection with actual availability. With such an approach it would be possible to illustrate that although the utilization of a certain species may be poorly represented in the grazing selection, its intake may in fact be high in comparison to its availability. In an attempt to establish a more objective basis for determining the partiality of roan for a particular food species, a preference rating was calculated for each species by applying the following formula:

$$\text{Preference rating} = \frac{\text{grazing selection}'}{\text{availability}},$$

where availability is represented by relative density, relative basal cover and relative production of the vegetation. Further reference to preference ratings in the text will follow the sequence of ratings determined in terms of relative density, relative basal cover and relative production, respectively.

Although all three criteria may be helpful in determining the degree

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Table 22 : Grass species contributing 75 per cent, or more, of the diet of the roan antelope, from March to October, as determined by relative grazing selection in the Nwashitsumbe roan enclosure, Kruger National Park, South Africa.

SPECIES	MARCH	APRIL	JULY	AUGUST	SEPTEMBER	OCTOBER	POOLED
Themeda triandra	65,56	23,46	54,66	-	28,28	44,69	35,29
Hetropogon contortus	-	54,32	-	19,12	-	-	13,58
Schmidtia pappophoroides	-	-	23,25	21,69	7,25	25,52	13,43
Panicum coloratum	-	-	-	-	11,33	-	9,41
Digitaria pentzii	21,85	-	-	15,81	-	-	-
Cenchrus ciliaris	-	-	-	22,43	-	-	-
Setaria woodii	-	-	-	-	16,07	-	6,28
Sporobolus spp.	-	-	-	-	10,5	-	-
Urochloa mosambicensis	-	-	-	-	7,64	-	-
Eragrostis superba	-	-	-	-	-	7,82	-
T O T A L	87,41	77,78	77,91	79,05	81,07	78,03	77,99
NUMBER OF SPECIES	2	2	2	4	6	3	5

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of selection it should not necessarily be accepted that the importance of the three criteria is equal. In determining preference ratings based on relative density, a direct comparison is made of tussocks grazed to those "available" in the field. The relative density of the grass species does not take into consideration the size of each individual plant and as species vary markedly in individual plant size, several tussocks of one species may be found in the same surface area covered by a single tussock of another species. It must also be pointed out that numerous tussocks growing in a dense stand give rise to difficulties in counting the individual tussocks grazed and this criterion is therefore considered the least reliable of the three.

Preference ratings based on basal cover eliminate some of the problems encountered with the former criterion. At least the determination of basal cover is objective and gives a good idea of the actual area covered by the different species on the ground. Unfortunately it gives no indication of the growth form of the species and a plant with a large basal area is still not necessarily the one with the most edible parts available for grazers.

The production, or standing crop, of the various grass species is regarded as the most reliable criterion of availability. Production is a reflection of the total amount of edible material available to grazers and as such it eliminates the major objections limiting the usefulness of either relative density or basal cover as criteria of availability.

In determining grazing selection, note was only made of the number of tussocks which had been grazed by roan while disregarding the actual amount of intake, in terms of mass, from the tussocks of the different species. Attempts to determine the mass intake of forage from the grass species utilized, proved futile due to the low grazing pressure in the enclosure. A more precise knowledge of the mass intake of material from the various grass species would have yielded a more reliable evaluation of preference ratings based on production although,

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in spite of this handicap, the present approach is considered adequate.

In Table 23 the preference ratings for the various surveys are given. A few interesting phenomena emerge from these results and the following points are worth mentioning:

For March the preference ratings derived from all three sources confirm the selection of Themeda triandra and Digitaria pentzii as obtained from direct grazing selection counts, with hardly any selection for Panicum coloratum. However, on the basis of the preference rating derived from relative density there is some indication of a higher selection for Cenchrus ciliaris than for Heteropogon contortus in spite of the fact that the latter had a higher grazing selection than the former. On the other hand, preference ratings based on relative basal cover and relative production again favoured Heteropogon contortus and as both these criteria are considered superior to the first, it is accepted that selection was in favour of this species and not vice-versa.

During April the two predominantly grazed grasses, Heteropogon contortus and Themeda triandra retained their positions as determined by grazing selection. Although Panicum coloratum rated third highest of the utilized species, all the preference ratings indicate that it was poorly selected and dropped well below Cenchrus ciliaris and Urochloa mosambicensis. It is noteworthy that in spite of a grazing selection ratio of 1 : 0,3 in favour of Cenchrus ciliaris over Urochloa mosambicensis, the preference ratings derived from relative basal cover and relative production showed a higher selection for the latter. In this respect Urochloa mosambicensis was also favoured above Schmidtia pappophoroides, which was grazed to the same extent as Cenchrus ciliaris. Cenchrus ciliaris and Schmidtia pappophoroides were grazed in a ratio of 1 : 0,98 but the ratios of the preference ratings were 1 : 0,11; 1 : 0,3 and 1 : 0,48 in favour of Cenchrus ciliaris thus indicating a considerably higher degree of selectivity for this species. Another interesting aspect is that although Schmidtia pappophoroides

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Table **23**: Preference ratings of grass species utilized by roan antelope as derived from the relative density, relative basal cover and relative production of grasses in the roan antelope enclosure, Nwashitsumbe, Kruger National Park, South Africa.

SPECIES	MARCH				APRIL				JULY				AUGUST				SEPTEMBER				OCTOBER				MARCH TO OCTOBER			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Themeda triandra	65,56	7,52	6,17	3,70	23,46	2,69	2,21	1,32	54,66	6,27	5,15	3,09	10,48	1,20	0,99	0,59	28,28	3,24	2,66	1,60	44,69	5,13	4,21	2,52	35,29	4,05	3,32	1,99
Heteropogon contortus	5,63	0,80	1,31	0,80	54,32	7,74	12,60	7,73	3,13	0,45	0,73	0,45	19,12	2,72	4,44	2,72	5,31	0,76	1,23	0,76	10,47	1,49	2,43	1,53	13,58	1,93	3,15	1,93
Cenchrus ciliaris	4,97	1,37	0,60	0,53	5,58	1,53	0,67	0,60	1,40	0,39	0,17	0,15	22,43	6,18	2,70	2,42	4,31	1,19	0,52	0,46	7,67	2,11	0,92	0,82	5,92	1,63	0,71	0,64
Schmidtia pappophoroides	-	-	-	-	5,43	0,17	0,20	0,29	23,25	0,73	0,85	1,23	21,69	0,68	0,79	1,15	7,25	0,23	0,26	0,38	25,52	0,80	0,93	1,35	13,53	0,42	0,49	0,71
Digitaria pentzii	21,85	1,66	1,84	3,53	1,85	0,14	0,16	0,30	3,22	0,24	0,27	0,52	15,81	1,20	1,33	2,55	3,43	0,26	0,29	0,55	1,33	0,10	0,11	0,21	5,03	0,38	0,42	0,81
Panicum coloratum	1,66	0,42	0,06	0,06	7,65	0,56	0,29	0,26	13,77	1,01	0,52	0,46	7,72	0,56	0,29	0,26	11,33	0,83	0,43	0,38	2,06	0,15	0,08	0,07	9,41	0,69	0,35	0,32
Eragrostis superba	-	-	-	-	1,73	1,44	1,25	2,28	0,49	0,41	0,36	0,64	1,84	1,53	1,33	2,42	2,50	2,08	1,81	3,29	7,82	6,52	5,67	10,29	2,16	1,80	1,57	2,84
Urochloa mosambicensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,64	3,75	3,55	3,00	0,15	0,07	0,07	0,06	3,25	1,59	1,51	1,27
Enneapogon cenchroides	-	-	-	-	-	-	-	-	-	-	-	-	0,55	0,62	-	11,00	1,80	2,02		36,00	0,29	0,33		5,80	0,79	0,89		1,58
Setaria woodii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16,07	6,20	4,35	3,56	-	-	-	-	6,28	2,42	1,70	1,39
Sporobolus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,50	-	-	-	-	-	-	-	4,10	-	-	-
Sporobolus robustus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,45	-	-	-	-	-	-	-	0,57	-	-	-
Aristida spp.	-	-	-	-	-	-	-	-	0,05	0,01	0,05	0,06	-	-	-	-	0,04	0,01	0,04	0,05	-	-	-	-	0,03	-	0,03	0,03
Ischaemum brachyatherum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,04	-	-	0,67	-	-	-	-	0,02	-	-	0,33
Chloris sp,.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,08	-	0,35	-	-	-	-	-	0,03	-	0,13	-
Fingerhuthia africana	-	-	-	-	-	-	-	-	-	-	-	-	0,37	-	1,16	-	-	-	-	-	-	-	-	-	0,03	-	0,09	-
Andropogon shirensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,13	-	-	-	-	-	-	-	0,05	-	-	-
Sorghum versicolor	0,33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,02	-	-	0,06
Bothriochloa insculpta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 = grazing selection

2 = preference rating determined from relative density of grasses

3 = preference rating determined from relative basal cover of grasses

4 = preference rating determined from relative production of grasses

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was grazed more heavily than Digitaria pentzii (1 : 0,34) selection was almost the same for the two species (1 : 0,82; 1 : 0,80 and 1 : 1,03 respectively).

Based on preference ratings the order of selectivity for roan during April would therefore be: Heteropogon contortus, Themeda triandra, Urochloa mosambicensis, Cenchrus ciliaris, and, with little difference, Panicum coloratum, Schmidtia pappophoroides and Digitaria pentzii (Table 23).

From an analysis of the mid-winter (July) data, selection for Themeda triandra surpassed all other species. For the other species utilized there is no definite order of preference and although the preference rating for Schmidtia pappophoroides had increased to place it second to Themeda triandra, the increase in selection was nowhere in relation to the 23,25 per cent utilized (Table 23).

Despite a grazing selection ratio of 1 : 0,23 between Panicum coloratum and Heteropogon contortus the choice between the two as grazing plants did not differ much (preference ratings 1 : 0,45; 1 : 1,40 and 1 : 0,98 respectively). Eragrostis superba maintained a favourable position and in spite of only 0,49 per cent recorded utilization, it still revealed a higher preference rating than both Digitaria pentzii and Cenchrus ciliaris with 3,22 per cent and 1,4 per cent utilization, respectively. Both Digitaria pentzii and Cenchrus ciliaris were low on the preference list and although this does not reflect a change of position for Digitaria pentzii it does represent a sharp decline for Cenchrus ciliaris.

In order of declining importance, selection, as based on preference ratings, favoured the following species during mid-winter: Themeda triandra, Schmidtia pappophoroides, Heteropogon contortus, Panicum coloratum, Eragrostis superba, Digitaria pentzii and Cenchrus ciliaris (Table 23).

In the August surveys the most favoured species was Heteropogon contortus (although it only had a 19,12 per cent grazing selection) and was followed by Cenchrus ciliaris, Digitaria pentzii and Eragrostis superba. The selection of Eragrostis superba as a favoured food plant was again confirmed as the grazing

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selection ratio of Digitaria pentzii to Eragrostis superba was only 1 : 0,12 though the preference ratings indicate a ratio of 1 : 1,28; 1 : 1 and 1 : 0,95 respectively.

Themeda triandra dropped somewhat as a preferred species but still maintained a favourable position and was almost on a par with Schmidtia pappophoroides in spite of a grazing selection of 21,69 per cent to 10,48 per cent in favour of the latter (preference ratings 1 : 1,76; 1 : 1,23 and 1 : 0,51 respectively). This again left Panicum coloratum well in arrear of the other more commonly grazed species.

Enneapogon cenchroides is not a well-represented species in the Nwashitsumbe enclosure and only accounted for 0,89 per cent in the relative density counts, with a total mean production of 2,09 kg/ha or 0,05 per cent of the mean total production of all grasses. In the determination of basal cover this species was not recorded at all. However, during August its grazing selection amounted to 0,55 per cent and gave it the highest preference rating, based on relative production, of all species. This leaves no doubt that it is a highly selected species but due to its limited occurrence in the enclosure it would not merit inclusion in the determination of the relative preferences of the more common grasses in the roan's diet. Enneapogon cenchroides will, however, be taken into consideration again later in this discussion when evaluating the different species making up the diet of the roan antelope.

Preference ratings indicate that the important grasses for roan during August include Heteropogon contortus, Cenchrus ciliaris, Digitaria pentzii, Eragrostis superba, Themeda triandra and Schmidtia pappophoroides, with Enneapogon cenchroides high on the priority list but playing an inferior role in the diet due to its limited availability in the Nwashitsumbe enclosure.

During September, usually the most severe month for grazers due to increasing ambient temperatures and the end of the dry season, two grasses which

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had been inconspicuous in the diet throughout the dry period, became prominent through high preference ratings if not actual intake. Setaria woodii has a patchy distribution in the enclosure as evidenced by the fact that it was recorded in only five of the 16 sampling sites during the recording of basal cover and in seven during production determinations. Although it is locally abundant in depressions, its overall relative density only amounted to 2,59 per cent (Table 19), relative basal cover 3,69 per cent (Table 20) and relative production 4,51 per cent (Table 21) of all species. With a grazing frequency of 16,07 per cent the preference rating of Setaria woodii is well above all other species, indicating a high selection value. The same arguments also apply to Urochloa mosambicensis (total relative density 2,04 per cent, relative basal cover 2,15 per cent, relative basal cover 2,15 per cent and relative production 2,55 per cent). Although it had a grazing selection of only 7,64 per cent it had a higher selection value than Themeda triandra as determined by all preference rating criteria.

As in August, Enneapogon cenchroides again proved to be a highly favoured species and, based on production, had the exceedingly high preference rating of 36,00.

Themeda triandra and Eragrostis superba were once again well represented in September and although preference ratings derived from relative density and basal cover favoured Themeda triandra, production-wise Eragrostis superba had a higher preference rating than the former. With a grazing selection ratio of 1 : 0,09 between Themeda triandra and Eragrostis superba, the corresponding preference ratios were 1 : 0,64; 1 : 0,68 and 1 : 2,06. The importance of Heteropogon contortus as a favoured food plant was re-affirmed, followed by Cenchrus ciliaris. There was, however, little differece between Panicum coloratum, Digitaria pentzii and Schmidtia pappophoroides.

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During particularly dry conditions, e.g. late in October, 1968, the preference ratings for Eragrostis superba reached their peak with values of 6,52, 5,67 and 10,29 for the three criteria respectively (Table 23). Themeda triandra, followed by Heteropogon contortus, maintained its position as one of the most important grasses in the roan's diet, especially if it is taken into consideration that this species contributed 44,69 per cent to the grazing selection.

Although the ratio of the grazing selection between Heteropogon contortus and Schmidtia pappophoroides was of the order of 1 : 2,44, the preference rating ratios were 1 : 0,54; 1 : 0,38 and 1 : 0,88 respectively. Cenchrus ciliaris followed closely on Schmidtia pappophoroides as a favoured species while it is probably significant that the preference ratings for Digitaria pentzii were the lowest recorded throughout the period from March to October and those for Panicum coloratum also dropped to well below their normal and were lower only during March. During this period Enneapogon cenchroides remained one of the highly selected species.

Lumping all the data collected from March to October, the following food plants were found to be the most important for roan in the Nwashitsumbe enclosure on the basis of preference: The two most preferred species were obviously Eragrostis superba and Themeda triandra and under prevailing conditions in the enclosure Themeda triandra is the most important single food item in the diet of the roan antelope. Of almost equal importance is Heteropogon contortus which is nearly on a par with Themeda triandra (preference rating ratios 1 : 0,48; 1 : 0,95 and 1 : 0,97) and has a grazing selection value of 1 : 0,16 in comparison with Eragrostis superba.

There does not appear to be much difference in the partiality of roan for either Schmidtia pappophoroides, Digitaria pentzii or Cenchrus ciliaris as deduced from their preference ratings, though these species are grazed in a ratio of 1 : 0,37 : 0,44. In spite of a relatively high grazing selection (9,41 per cent)

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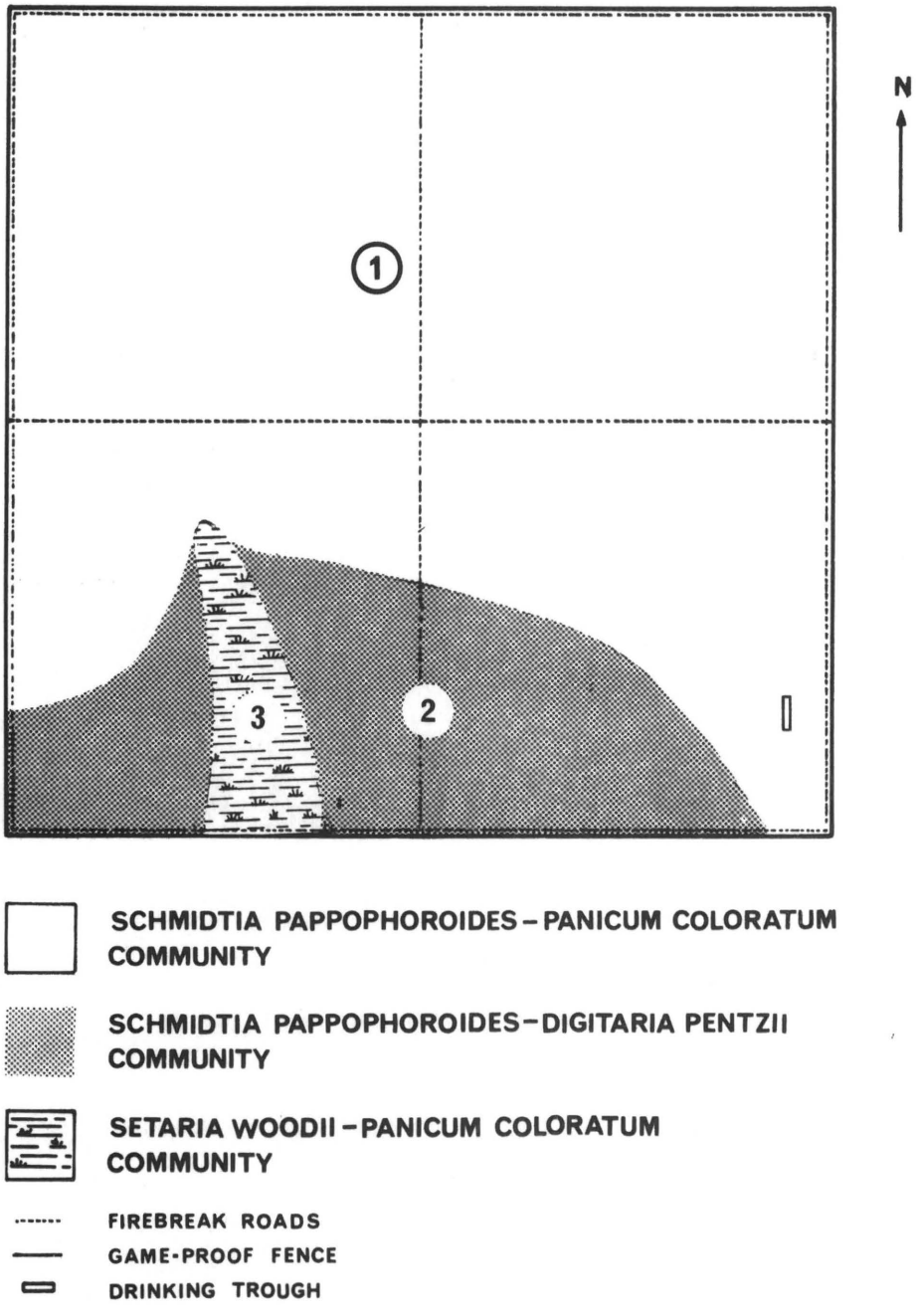

Figure 27 : A map of the roan antelope enclosure, Nwashitsumbe, Kruger National Park, South Africa indicating the three major grass communities.

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closure and also incorporates large areas of the southern half. In total it comprises approximately 72 per cent of the grazing area. Within this community small patches representative of the two other zones also occur but they are of such small and local nature that it was not considered important to regard them as separate entities.

The second largest community (Schmidtia pappophoroides - Digitaria pentzii Community, Fig. 27) comprises roughly 20 per cent of the enclosure and is characterised by species such as Schmidtia pappophoroides, Digitaria pentzii, Cenchrus ciliaris and Heteropogon contortus. Other important grasses are Panicum coloratum, Sorghum versicolor, Urochloa mosambicensis, Setaria woodii, Themeda triandra and Eragrostis superba. This community is represented by two areas situated on the southern side of the enclosure on either side of a vlei.

The third community (Setaria woodii - Panicum coloratum Community, Fig. 27) occurs in depressions with heavy and poorly drained soils. This community is represented in the upper reaches of one of the minor tributaries of the Stangene River which falls within the enclosure on its southern side and forms a shallow grass-covered depression. This community is characterised by Setaria woodii with Panicum coloratum, Digitaria pentzii, Cenchrus ciliaris and Schmidtia pappophoroides important associated species. Other important grasses include Sporobolus robustus, Sporobolus sp., Sorghum versicolor and Ischaemum brachyatherum. This community is also represented in other depressions in the enclosure which act as water catchment areas during the rainy season but are too small to be taken into account here. In total, this community comprises approximately 8 per cent of the area in the enclosure.

During observations of the roan herd, record was kept of their movements and the different areas they utilized throughout the year. To differentiate between the seasons, the period April to the end of September was considered to represent the dry or winter months while the period October to the end of March

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represented the wet or summer months.

From a direct comparison of the year-round utilization of the three areas it could be expected that the Schmidtia pappophoroides - Panicum coloratum Community would reflect the heaviest utilization as it represents by far the largest zone. It was, in fact, found that 64,7 per cent of all grazing was concentrated in this community as compared with the 20,4 per cent in the Schmidtia pappophoroides - Digitaria pentzii Community and the 15,0 per cent in the Setaria woodii - Panicum coloratum Community. The corresponding figures for the wet season were 74,4 per cent, 12,1 per cent and 13,6 per cent and for the dry season 57,3 per cent, 26,4 per cent and 16,1 per cent, respectively.

It would be incorrect to assume that habitat selection in herbivores was solely dependent on the food plants available although this aspect must obviously play an important role. To evaluate the selection of roan for the three different communities it would therefore be more realistic to compare the utilization figures on a common basis, i.e. utilization per unit area. By accepting this point of view, it is found that the corresponding figures are then 7,2 per cent, 8,2 per cent and 15,0 per cent on a year-round basis while it is 8,3 per cent, 4,8 per cent and 13,6 per cent for the wet season and 6,4 per cent, 10,6 per cent and 16,1 per cent during the dry season. On this basis it is obvious that the "vlei" area (Setaria woodii - Panicum coloratum Community) provided the most preferred grazing during both seasons although it was more heavily grazed during the dry months.

It is also important to note the increased utilization of the Schmidtia pappophoroides - Digitaria pentzii Community during the dry season which corresponds with the marked increase in the utilization of Cenchrus ciliaris, Digitaria pentzii, Heteropogon contortus and Schmidtia pappophoroides during the late dry season and prior to the first rains.

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Although these observations largely confirm the results obtained from determining grazing preferences, it must however, be pointed out that the actual time spent by the roan in each vegetation zone could not be determined. A note was merely made each time the herd was located in a particular community. It therefore implies that the herd may have moved through one community and into an adjoining one and, although grazing in both communities, may have spent more time in the one than the other. The total time spent in each community could therefore have had an influence on the determination of the selection of the animals for a particular area although this is not believed to have affected the results in any significant way.

Grazing habits and species utilization

In conformity with most other grazers, roan in the Kruger Park have two definite peaks of grazing activity during the day, i.e. during early morning and again during late afternoon. It is not known to what extent they graze during the night but at sunrise most animals are found lying down or just starting to graze. Grazing activity lasts two to four hours after which it declines and by 10h00 it has usually ceased. In free roaming herds morning grazing is also concluded between 10h00 and 11h00. In the enclosure the herd frequently drank around midday (12h00 to 13h00) and this was usually accompanied by a short grazing period of 1,0 to 1,5 hours.

During hot days roan often rest until 16h30 or 17h00 before starting to graze. Grazing activity then normally continues until dusk. Afternoon grazing sessions rarely commence before 16h00. During the day total grazing time usually varied between five and seven hours.

When grazing, a roan herd fans out with the individuals furthest from one another often as far as 150 to 200 m apart, usually creating the impression of little coherence amongst the members of a herd.

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Roan antelope may be considered delicate feeders and customarily feed on the higher parts of their food plants, to a height of approximately 80 mm from the ground, therefore largely utilizing leaves and stems well above ground level. Green shoots may, however, also be taken at 20 to 30 mm above ground though roan are in no way close 'croppers' such as wildebeest or zebra. Roan are therefore well adapted to grass stands of medium height (150 mm to 1,5 m or taller) and even dependent on such stands for their well-being.

Utilization of preferred grass species

Themeda triandra Relative basal cover: 10,62 per cent

Relative density 8,72 per cent and frequency 32,5 per cent.

Relative production: 17,71 per cent.

Preference ratings: 4,05; 3,32; 1,99.

Themeda triandra is a perennial which attains a height of 500 mm to 1,0 m in the enclosure. The tussocks have a moderate crop of leaves and it is obviously one of the "sweet" grasses which maintains a high degree of palatability throughout the year, as evidenced by the high degree of utilization and selection by roan.

During the summer months the upper parts of the plants, including both leaves and stems, even of mature plants, are well grazed down to a height of roughly 70 to 100 mm above ground level. During the dry months it is the most important single food item in the diet of the roan antelope with an overall grazing selection of 35,29 per cent for this period. In one particularly dry spell it was observed that especially the smaller tussocks were grazed down to about 50 mm .

Heteropogon contortus Relative basal cover: 4,31 per cent.

Relative density 7,02 per cent and frequency 30,36 per cent.

Relative production: 7,03 per cent.

Preference ratings: 1,93; 3,15; 1,93.

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A perennial grass with tussocks not unlike the smaller tufts of Themeda triandra. It retains some 'greenness' to late summer or early autumn (March - April) and attains a height of approximately 500 to 700 mm with moderate leaf production.

When green it is one of the roan's highly favoured food plants and although its palatability diminishes when it reaches maturity, it still represents one of the best utilized plants during the dry months with an overall grazing selection of 13,68 per cent for the latter period. Green plants are usually grazed down to a height of 50 to 80 mm and leaves and stems are utilized.

Schmidtia pappophoroides Relative basal cover: 27,38 per cent.

Relative density 31,94 per cent and frequency 61,88 per cent.

Relative production: 18,86 per cent

Preference ratings: 0,42; 0,49; 0,71.

Although one of the less conspicuous grasses and often physiognomically obscured by the more robust species, Schmidtia pappophoroides is nevertheless by far the most common species in terms of abundance and distribution. It is a stoloniferous perennial and reaches its highest density in the Schmidtia pappophoroides - Digitaria pentzii Community. Due to its stoloniferous nature individual tussocks are difficult to define, production of edible parts is moderate and it generally attains a height of 300 to 500 mm .

Both leaves and stems are grazed during wet and dry climatic conditions but from field observations, and confirmed by the preference ratings, its palatability is of a low order and it is generally ignored when other more acceptable grasses are available. In spite of this, however, it plays an important role in the overall diet of the roan and especially during the winter (dry) months it constitutes 13,4 per cent in the grazing selection. Generally only the top parts of the plants are cropped.

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Panicum coloratum Relative basal cover: 26,62 per cent.

Relative density 13,69 per cent and frequency 57,5 per cent.

Relative production: 29,82 per cent.

Preference ratings: 0,69; 0,35; 0,32.

A large robust perennial with a wide distribution in the enclosure. Based on its composition and physiognomy it is one of the most important grasses in the enclosure. It reaches a height of 1,0 to 1,5 m with well developed tussocks and a high production of edible parts. It remains green well into the dry season.

During the wet season the leaves and stems are well grazed although the roan normally do not concentrate on one plant and graze it down but select a few leaves and/or stems and then move off to the next one.

During the dry season its palatability diminishes although green shoots, where available, are still selected. In spite of its abundance it has a winter grazing selection of only 9,4 per cent and the preference ratings indicate that it is not high on the priority list as a food plant. These figures could, however, be somewhat misleading as the tussocks are large and individual plants are not as numerous as those of most associated species. This would tend to lead to under-estimating its role as a food plant by the criteria used to determine grazing preferences, although field observations confirm that it is readily taken but by no means one of the preferred species.

Cenchrus ciliaris Relative basal cover: 8,31 per cent

Relative density 3,63 per cent and frequency 16,88 per cent.

Relative production: 9,3 per cent.

Preference ratings: 1,63; 0,71; 0,64.

A stoloniferous perennial, growing in clumps of varying size (up to 4,0 m in diameter) and is well distributed throughout the enclosure but common only in the southern areas. It varies in height from about 500 mm to 1,0 m and production is moderate.

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It retains some 'greenness' until late autumn and readily gives a green flush after out-of-season rain showers.

Leaves and stems are grazed alike and characteristically only the tops are cropped away. Cenchrus ciliaris is readily taken during the growing season (summer) and during the winter months it has a grazing selection of 5,9 per cent which, with regard to availability, constitutes a reasonably substantial proportion of the roan's diet.

Setaria woodii Relative basal cover: 3,69 per cent.
Relative density 2,59 per cent and frequency 12,5 per cent.
Relative production: 4,51 per cent.
Preference ratings: 2,42; 1,7; 1,39.

Setaria woodii is a tall perennial (1,0 to 1,8 m) and grows on heavy black and poorly drained soils (turf) of basaltic origin found in vleis and depressions. Due to its habitat it is largely restricted to a few well-defined areas in the enclosure. The individual plants are fairly large in size and leaf production is moderate to high. Growing in moist areas it remains green until late into the dry season.

It is well grazed during the summer months when both leaves and stems are taken. During the late winter months it is an important food plant for the roan and in spite of its restricted occurrence in the enclosure, it contributed 6,32 per cent to the grazing selection. Preference ratings also indicate that it is a highly favoured species that apparently retains its palatability throughout the year.

Digitaria pentzii Relative basal cover: 11,85 per cent.
Relative density 13,15 per cent and frequency 27,5 per cent.
Relative production: 6,1 per cent.
Preference ratings: 0,38; 0,42; 0,81

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Digitaria pentzii is a stoloniferous perennial and the tussocks are often spaced closely together to form dense, patchy stands. Although it may attain a height of 1,0 m or more the major part of the tuft is approximately 150 mm high and is therefore rather inconspicuous amongst other more robust grasses. It is distributed over a wide area in the enclosure and constitutes an important component of the grass stratum.

This species is relished when it is young and green but apparently loses much of its attraction once the plants have matured and dried. It represents 5,0 per cent of the dry season grazing selection although the preference ratings indicate a relatively low selection for this species. It must, nevertheless, still be regarded as one of the major constituents in the roan's diet and seems to play its most important role during late summer and autumn.

The seven grass species discussed above represent the major compositional elements in the grass stratum of the enclosure. All these species are grazed and form, in varying degrees of importance, the bulk of the intake of the roan. The relatively high consumption of some of these grasses is believed to be directly attributable to the quantity available to the animals.

On the other hand there were also several species present which were poorly represented but were highly selected as indicated by their preference ratings. It would therefore imply that in areas where they are more abundant they could form an important part of the roan's diet. Grasses falling into this category include the following:

Eragrostis superba Relative basal cover: 1,38 per cent.
Relative density 1,2 per cent and frequency 11,88 per cent.
Relative production: 0,76 per cent.
Preference ratings: 1,80; 1,57; 2,84.

Eragrostis superba is a sparsely distributed perennial with well

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developed tufts and moderate production, and retains its "greenness" well into the dry season.

During the summer leaves and hard stems are taken by roan. It is one of the highly preferred species during the dry months and whenever available it is heavily grazed. It made up a mere 2,2 per cent of all plants grazed by the roan although the preference rating based on relative production placed it at the top of preferred species.

Urochloa mosambicensis Relative basal cover: 2,15 per cent.
Relative density 2,04 per cent and frequency 17,5 per cent
Relative production: 2,55 per cent.
Preference ratings: 1,59; 1,51; 1,27

Another of the less numerous perennials, Urochloa mosambicensis normally attains a height of 500 to 800 mm with a moderate production of edible parts. This species plays an important role in disturbed grasslands on the rich loam to clay soils of the Lebombo Flats in the Kruger Park.

Leaves and stems were taken during the summer months but on a limited scale only. Incidental feeding by roan on Urochloa mosambicensis continued to mid-winter when utilization started increasing and in late winter it emerged as one of the important species with 7,6 per cent utilization. In spite of its scarcity in the enclosure the overall grazing selection for the period March to October was 3,3 per cent, resulting in very favourable preference ratings.

Enneapogon cenchroides Relative basal cover: not recorded.
Relative density 0,89 per cent and frequency 2,5 per cent.
Relative production: 0,05 per cent.
Preference ratings: 0,89 (relative density);
1,58 (relative production)

Enneapogon cenchroides is an annual of disturbed veld or areas with stony and skeletal soils. Production is moderate to low and plants are normally

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400 to 700 mm high. This species is very limited in the enclosure and was not recorded during the determination of basal cover.

In spite of its scarcity, the extent to which it was grazed, where present, during the dry season and especially late winter, pointed to the fact that it is highly palatable to roan and, similar to Urochloa mosambicensis and Eragrostis superba, might have played an important role in the diet of the roan were it more abundant.

Sporobolus sp.

This grass (Sporobolus sp. cf. S. schlechteri) occurs locally on the edges of depressions and is found in only one isolated patch in the enclosure and was consequently hardly recorded (relative density 0,06 per cent; frequency 0,63 per cent). However, during late winter it contributed a substantial 10,5 per cent to the grazing selection.

It is a fairly common grass associated with the vlei-fringes outside the enclosure and may therefore also be an important constituent of the roan's winter fodder. The same arguments may apply to Ischaemum brachyatherum which is poorly represented in the enclosure but more abundant in vlei areas outside. It was grazed to some extent by roan during the dry season but in too small quantities to allow any conclusions regarding its palatability.

Other grasses which were utilized by roan in limited quantities in the enclosure included Sporobolus robustus, Aristida spp., Fingerhuthia africana, Chloris sp., Andropogon shirensis and Sorghum versicolor. Bothriochloa insculpta occurred in small patches but was apparently avoided altogether..

Food plants other than grasses

Merremia palmata (Fam. Convolvulaceae)

Merremia palmata is a creeper and is particularly abundant in the enclosure, intertwining with grasses and shrubs, and especially abundant along the

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fence. The leaves and stems remain green well into or throughout the dry season.

Roan were seen feeding on the creeper during January, March, April, May, August, September and October. The roan often selected it from mopane shrubs and during the dry season were often observed "browsing" it from the enclosure fence.

Dalbergia melanoxylon (Fam. Papilionaceae)

This robust shrub or small tree is partial to heavy soils and in disturbed areas it is one of the notorious "bush encroachers". It is a deciduous tree which retains its leaves well into the dry season.

Browsing of the leaves and young shoots by roan has been observed during the wet season and, during the dry season when the grasses are mature, roan readily browse on the remaining green leaves. Dalbergia melanoxylon is actively selected by roan during the dry season as evidenced by the animals feeding from one plant to the next. Utilization of this species was observed during January, February, May, July and November.

Lonchocarpus capassa (Fam. Papilionaceae)

Lonchocarpus capassa may be referred to as semi-deciduous due to the fact that it retains its leaves almost throughout the dry season. Both tree and low shrub forms occur in the Kruger Park.

Most browsing of this species occurs during late winter, spring and early summer (August, September, October and November). During these periods browsing is heavy and on one occasion a roan cow was seen to denude a 1,8 m high shrub almost totally of its leaves.

A single observation was noted of browsing - during April - on each of the following: Indigofera sp. (Papilionaceae), Albizia harveyi (Mimosaceae) and Dichrostachys cinerea (Mimosaceae). Two records of roan browsing Grewia sp.

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cf. G. kwebensis (Tiliaceae) during February and July were also made.

Grass composition of roan antelope habitats in the Kruger National Park

The results discussed in the previous section were all obtained from the roan antelope enclosure at Nwashitsumbe. During the period of observation the herd of roan were the only grazers in the 634 ha enclosure (with the exception of a single reedbuck) and therefore provided favourable opportunities for assessing their feeding preferences. Furthermore, with the initial selection of an area for the enclosure all efforts were made to select an area which represented true roan habitat.

The final decision to select the Nwashitsumbe area for the roan enclosure was influenced by the fact that it had long been known as a favoured roan area while at the same time it represented the main features of the vast Colophospermum mopane Shrub Savanna north of the Letaba River on the north-eastern Lebombo Flats. This habitat, extending from the Letaba River in the south to the rugged, hilly terrain between Punda Milia and Pafuri in the north, and flanked by the Lebombo Mountains in the east and a transition to the mixed Combretum apiculatum - Colophospermum mopane communities in the west (Van der Schijff 1957, Pienaar 1963), has proved to be the main stronghold of the roan in the Kruger Park with more than 75 per cent of the population occurring within its limits. It is true that there are minor variations of a local nature affecting plant composition and structure (Pienaar 1963) but on the whole the vegetation is remarkably homogeneous and the Nwashitsumbe enclosure can reasonably be assumed to be a fair representation of this plant community. An extensive survey of the woody vegetation of this habitat largely verifies this assumption (see Chapter 6) though, as yet, no meaningful sampling of the grass stratum has been made.

The study of plant communities in the Kruger Park was originally initiated by Van der Schijff (1957, 1959, 1961 and 1968). According to this

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author the entire Colophospermum mopane Shrub Savanna may be considered as exclusively "sweet" grazing, with the dominant grass species being Panicum coloratum, Bothriochloa insculpta, Urochloa rhodesiensis (U. mosambicensis), Digitaria spp., Heteropogon contortus, Schmidtia bulbosa (S. pappophoroides), Setaria woodii, Themeda triandra, Eragrostis rigidior, Aristida graciliflora and Enneapogon cenchroides. Dominants were determined by using the point quadrat method and therefore selected according to the basal cover of each species. One thousand points were recorded in each of four sites, i.e. Tsendi, Nshawu, Mooiplaas and Dzombo, distributed throughout the Colophospermum mopane Shrub Savanna (Van der Schijff 1957). Of these, only the Nshawu and Dzombo sampling sites fell within the typical roan habitat of the mopane shrub savanna, while the other two were located too far west and are more representative of the transitional zone from the Colophospermum mopane Shrub Savanna in the east to the mixed Combretum apiculatum - Colophospermum mopane communities in the west. Unfortunately the results of the individual sampling sites were not recorded separately by Van der Schijff (1957) and though the lumped results may reflect the composition of the grass stratum of the Colophospermum mopane Shrub Savanna as a whole, they cannot be considered entirely representative of the areas occupied by roan in particular.

During 1957/'58 Pienaar and Barkhuizen undertook a second survey of the area, applying the same method as Van der Schijff (1957), i.e. the point quadrat method, but on a more extensive scale than the surveys of Van der Schijff (1957). The same sampling sites as those surveyed by Van der Schijff (1957) were used with a total of 12 000 points per site. As the data for each site were recorded separately, the results obtained in the Colophospermum mopane Shrub Savanna proper, thus representing more optimal roan habitat, could roughly be compared with those obtained at Nwashitsumbe. The results of the various surveys are presented in Table 24.

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Table 24 : The relative basal cover of the more important grass species of the Colophospermum mopane Shrub Savanna of the north-eastern Lebombo Flats, Kruger National Park, South Africa.

SPECIES	RELATIVE BASAL COVER		
	A	B	NWASHITSUMBE
Panicum coloratum	25,00	23,05	26,95
Bothriochloa insculpta	16,79	20,86	1,40
Urochloa mosambicensis	8,93	1,94	2,18
Digitaria spp.	8,57	8,11	11,99
Eragrostis spp.	7,14	1,18	1,40
Heteropogon contortus	6,79	6,64	4,36
Schmidtia pappophoroides	5,71	9,77	27,73
Setaria woodii	5,00	4,39	3,74
Themeda triandra	4,64	8,50	10,75
Aristida spp.	4,29	-	1,09
Enneapogon cenchroides	3,93	4,73	-
Cenchrus ciliaris	3,21	10,83	8,41
	100,00	100,00	100,00

Footnote:

A : From Van der Schijff (1957) (Point quadrat method)

B : From Pienaar and Barkhuizen (1957/'58) (Point quadrat method)

Nwashitsumbe: Wheel-point method, current study.

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The similarities between the more important grass species in the areas surveyed are obvious from the results presented in Table 24. Considering the results of the three surveys, it may therefore be concluded that the most important constituent species in these areas are Panicum coloratum, Schmidtia pappophoroides, Themeda triandra, Cenchrus ciliaris, Heteropogon contortus, Digitaria spp., Bothriochloa insculpta and Setaria woodii. Many associated grass species are also present, notably Eragrostis spp., Urochloa mosambicensis, Enneapogon cenchroides, Panicum maximum, Aristida spp., Sporobolus robustus, Sporobolus schlechteri, Fingerhuthia africana, Ischaemum brachyatherum, Tricholaena monachne, Cymbopogon excavatus, Andropogon gayanus, Sorghum versicolor, Sorghum verticilliflorum, Tragus berteronianus, Rhynchelytrum repens and Pogonarthria squarrosa.

Pienaar (1963) differentiated between two main wildlife habitats in the vast Colophospermum mopane Shrub Savanna of the north-eastern Lebombo Flats, i.e. (i) grassland plains and 'dambos' and (ii) mopane scrub and tree savanna. Although variations occur in these two habitat types, they are both so well-defined that a further fragmentation into smaller units would be superfluous (cf. Chapter 6).

The grassland plains and 'dambos' are represented by broad grass-covered depressions forming the drainage systems of the larger seasonal rivers and resemble the typical 'dambos' (or 'mulolas') characteristic of the Brachystegia woodlands of central Africa. The most common grasses of these areas are Sporobolus robustus, Sporobolus schlechteri, Setaria woodii, Ischaemum brachyatherum, Sorghum versicolor, Sorghum verticilliflorum, Cenchrus ciliaris, Bothriochloa glabra, Cynodon dactylon and Themeda triandra (Pienaar 1963). It was pointed out in an earlier section that the small area represented by this sub-type in the roan enclosure formed an important source of food for the roan throughout the year but especially during the dry winter months.

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The largest single habitat of the north-eastern Lebombo Flats is represented by the 'mopane scrub and tree savanna'. Pienaar (1963) mentioned Panicum coloratum, Themeda triandra and Cenchrus ciliaris as the major grass species with associated species such as Digitaria spp., Bothriochloa insculpta, Urochloa mosambicensis, Heteropogon contortus, Schmidtia pappophoroides, Setaria woodii, Eragrostis spp., Aristida spp., Enneapogon cenchroides, Panicum maximum, Fingerhuthia africana, Cymbopogon excavatus and Ischaemum brachyatherum.

Mention has been made of the two sites, Tsendi and Mooiplaas, which are not truely representative of the Lebombo Flats. Although these areas cannot be considered true roan habitat they are marginal to the Lebombo Flats and in both areas, but especially Tsendi, roan have frequently been observed to graze at the actual sampling sites. According to the surveys of Pienaar and Barkhuizen (1957/'58) the most abundant species in these areas are Bothriochloa insculpta Digitaria eriantha, Enneapogon cenchroides, Cenchrus ciliaris and Heteropogon contortus (relative densities 50,93 per cent, 13,52 per cent, 12,82 per cent, 6,18 per cent and 5,01 per cent respectively).

Bothriochloa insculpta certainly has no attraction for roan as a food plant but the high incidence of Enneapogon cenchroides, Digitaria eriantha and Heteropogon contortus may be regarded as significant. During a mid-summer (January, 1969) count of grasses grazed in the Malopanyane area - adjacent to the Tsendi area, but on the flats - the grazing selection was: Digitaria sp. 47,62 per cent, Panicum coloratum 23,81 per cent, Heteropogon contortus 7,62 per cent and Themeda triandra 4,76 per cent. Other grasses grazed were Enneapogon cenchroides, Brachiaria sp., Fingerhuthia africana, Cenchrus ciliaris, Urochloa mosambicensis, Sorghum versicolor and Aristida spp.

Although the Malopanyane area is not directly comparable with the Tsendi survey site, both these areas fall within the activity zone of the roan herd occupying that area. The high intake of Digitaria sp., Panicum coloratum and Heteropogon contortus may explain the roan's utilization of the Tsendi area

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during the wet season. In the discussion of the preference ratings of the different grass species utilized by roan, it was pointed out that in spite of the low incidence of Enneapogon cenchroides at Nwashitsumbe it was actively selected, especially during late winter. The high availability of this species in the Tsendi area could therefore play an important role during the winter months, together with other favoured dry season species such as Cenchrus ciliaris, Digitaria sp. and Heteropogon contortus.

Although the majority of the roan in the Kruger Park are concentrated on the north-eastern Lebombo Flats, small sub-populations are also found in other areas of widely differing vegetational composition. One of the main sub-populations, numbering between 25 and 35 roan still lingers on in the Pretoriuskop area in the south of the Park. This small remnant population is mainly centred to the south and south-east of the Pretoriuskop Rest Camp (Chapter 4) where they occur over a fairly extensive area and little is known of their feeding habits and preferences.

The areas inhabited by this sub-population represent a number of different habitats which may be divided into two main communities, i.e. (i) Large-leaved Deciduous Woodland with tall grass and (ii) various communities of predominantly Combretum spp. (Van der Schijff 1957, 1959). Pienaar (1963) identified the following wildlife habitats corresponding to Van der Schijff's categories: (i) tall grass savanna woodland and tree savanna, (ii) mixed Combretum spp. savanna woodland, (iii) mixed Combretum spp. - Acacia spp. tree savanna with interspersed (iv) bush- or forest-clad mountains or rocky outcrops. The soils are mainly of granitic origin and range from sandy to sandy-loam with the main grass species being Hyperthelia dissoluta, Eléonurus argenteus, Hyparrhenia filipendula, Diheteropogon amplectens, Schizachyrium sanguineum, Loudetia simplex, Digitaria pentzii and Setaria flabellata. A wide range of associated species are also present, including Panicum maximum, Panicum coloratum, Eragrostis spp.,

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Microchloa caffra, Sporobolus spp., Trachypogon spicatus, Pogonarthria squarrosa, Perotis patens, Aristida spp., Brachiaria spp., Schmidtia pappophoroides, Themeda triandra, Trichoneura grandiglumis, Tricholaena monachne and Eustachys mutica. The main feature of the grass stratum is the physiognomically tall aspect of the grasses.

Van der Schijff (1957) gave the main dominants for the Large-leaved Deciduous Woodland as Elionurus argenteus (18,2 per cent - percentages indicate relative basal cover), Hyperthelia dissoluta (13,6 per cent), Heteropogon contortus (8,2 per cent), Diheteropogon amplectens (8,2 per cent), Schizachyrium sanguineum (7,4 per cent), Pogonarthria squarrosa (6,4 per cent) and Panicum maximum (4,9 per cent). In the adjoining mixed Combretum spp. - Terminalia sericea Community, the dominant grasses were found to be Digitaria spp. (25,2 per cent), Setaria flabellata (15,2 per cent), Panicum maximum (12,6 per cent) Schmidtia pappophoroides (10,4 per cent), Heteropogon contortus (6,8 per cent), Trichoneura grandiglumis (4,9 per cent), Loudetia simplex (4,2 per cent) and Diheteropogon amplectens (3,9 per cent).

In a third major sub-group inhabited by roan, i.e. the mixed Combretum zeyheri - Combretum apiculatum Community, the most abundant grasses included Digitaria spp. (40,0 per cent), Aristida spp. (14,7 per cent), Panicum maximum (14,7 per cent), Michrochloa caffra (10,7 per cent) and Heteropogon contortus (2,7 per cent) (Van der Schijff 1957).

The results of subsequent surveys of these plant communities by Pienaar and Barkhuizen (1957/'58) and Gertenbach, Nel and Potgieter (pers. comm.) largely confirm the sequence of representation as given by Van der Schijff (1957) (Table 25).

In spite of the physiognomically dominant tall grasses which are normally avoided by grazers in the mature stages, Van Wyk (1971) noted that " ... palatable species such as Setaria flabellata, Heteropogon contortus,

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Table 25 : Relative basal cover of the more important grasses of roan antelope habitats in the south-western section (Pretoriuskop area) of the Kruger National Park, South Africa.

SPECIES	RELATIVE BASAL COVER					
	Large-leafed deciduous woodland			Mixed Combretum associates		
	A	B	C	A	B	C
Eleionurus argenteus	18,2	10,3	15,7	-	-	1,0
Hyperthelia dissoluta	13,6	18,8	7,3	0,2	-	1,0
Heteropogon contortus	8,2	5,9	8,2	4,7	8,8	7,1
Diheteropogon amplectens	8,2	6,1	2,7	1,9	2,6	-
Schizachyrium sanguineum	7,4	7,3	2,2	-	-	-
Pogonarthria squarrosa	6,4	2,2	4,7	1,3	-	9,8
Panicum maximum	4,9	4,6	5,8	13,7	10,4	5,3
Sporobolus spp.	3,3		6,5	0,5	-	2,0
Loudetia simplex	2,1	9,0	7,8	2,1	-	7,5
Hyparrhenia filipendula	2,3	2,2	3,4	-	-	-
Digitaria spp.	1,5		7,7	32,6	22,4	10,5
Brachiaria spp.	0,3		0,4	2,6	6,9	10,7
Setaria spp.	0,5		9,9	7,6	14,3	11,8
Schmidtia pappophoroides	-	-	1,9	5,2	9,9	15,3
Eragrostis spp.				1,9	2,8	3,7
Themeda triandra				0,3	1,9	1,5

A. Van der Schijff 1957. (Point quadrat method)

B. Pienaar and Barkhuizen 1957/'58 (Point quadrat method)

C. Gertenbach, Nel and Potgieter 1972/'73 (Wheel-point method).

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Digitaria spp. and a number of Eragrostis spp. are also abundant and even dominant in some areas. Panicum maximum forms dense and almost homogeneous stands under trees." It is therefore clear that palatable species - many of which are highly favoured by roan - are well represented in this community, despite the tag of "sour" veld (Van Wyk 1971). This is particularly true of the mixed Combretum spp. associations where palatable species such as Digitaria spp., Setaria spp. (notably Setaria flabellata), Panicum maximum, Heteropogon contortus, Brachiaria spp., and Schmidtia pappophoroides are especially abundant and represent the dominant species. In some areas with heavier clay soils (e.g. dolerite intrusions) even Themeda triandra is abundant.

Although the availability of preferred food species would inevitably play an important role in the habitat selection of any herbivorous species, the distribution of roan in the Kruger Park cannot be explained on the basis of food plants alone. Many hitherto unoccupied areas and areas where roan have become extinct, still maintain a favourable food source and the conclusion must therefore be drawn that the food source is only one of a number of factors determining habitat selection. Other factors involved will be discussed in the next chapter.

Miscellaneous records of the feeding behaviour of roan antelope

Kruger National Park

Van der Schijff (1957, 1959) recorded roan utilizing Themeda triandra and Digitaria spp. and the dry and green leaves of Colophospermum mopane and Grewia spp. During the present study no evidence could be found of roan browsing the leaves of Colophospermum mopane and on occasions when it had appeared that the roan were utilizing this species, closer inspection revealed that they were in fact selecting either the creeper, Merremia palmata, or grazing grasses, notably Panicum coloratum and Panicum maximum, growing around the bases of the shrubs.

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Jungius (1971a) noted that roan grazed heavily on Cenchrus ciliaris, Chloris gayana and Panicum coloratum during August, September and December, with moderate utilization of Digitaria pentzii during December and Sporobolus robustus during September.

Pienaar (1964[3]) described the roan's feeding habits as "selective grazing and some browsing."

Northern Transvaal (Waterberg).

Identifiable contents from the rumen of a roan that died during a capture operation in the Waterberg district in the northern Transvaal, revealed that it had browsed on the leaves of Diplorhynchus condylocarpon and Pseudolachnostylis maprouneifolia. Other rumen contents included numerous pieces of the skull of a tortoise, Geochelone pardalis. Subsequent analyses of the mineral composition of the bones of roan from this area revealed a severe deficiency of calcium and phosphates (De Vos pers. comm.).

Roan in the Waterberg area occur on private farmlands and inhabit the plateaus of the Waterberg Mountains. Major species in the grass stratum include Schizachyrium sanguineum, Eragrostis spp., Perotis patens, Loudetia sp., Aristida spp., Andropogon shirensis, Sporobolus sp., Rhynchelytrum repens, Digitaria sp., Chloris sp., Cynodon dactylon, Bothriochloa sp. and Eleusine indica.

Rhodesia and Zambia

Child and Wilson (1964) found that the stomach contents of 38 roan from the Chipangali and Kalichero areas in Zambia and the Magupande area of Rhodesia contained over 90 per cent grasses but also recorded the leaves of Diplorhynchus mossambicensis (D. condylocarpon) and Capparis tomentosa. In addition the pods of Acacia spp. and Piliostigma thonningii and the fruits of Diospyros kirkii, Diospyros mespiliformis and Pseudolachnostylis maprouneifolia could be identified.

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In the Wankie National Park roan were found to graze heavily on Heteropogon contortus (Anderson In litt.).

In the Sehubu Tribal Trustlands to the south of Wankie National Park the grazing activity of roan during the winter months (June - July) was largely concentrated in large open grasslands surrounded by Colophospermum mopane Woodland. The physiognomic dominants in the 1,5 m tall grasslands were Andropogon sp., Setaria inceps and Bothriochloa sp. Grasses available in the adjoining Colophospermum mopane Woodland included Enteropogon sp., Sporobolus sp., Chloris sp., Aristida spp., Eragrostis spp. and Pogonarthria squarrosa.

In the Kafue National Park, Zambia, the following browse species have been recorded for roan: Pods of Piliostigma thonningii, fruit and leaves of Dalbergia glandulosa, Acacia sieberana, pods and seeds of Schwartzia madagascariensis, fruits of Combretum mossambicense, Diplorhynchus condylocarpon, Capparis tomentosa, Erythrophleum africanum, Hibiscus sp., Achyranthes aspera, Eninia harmsiana, Justicia heterocarpa, Mpamoa sp., Popowia obovata and Premna senensis (Ansell In litt.).

Visual records of grasses utilized by roan in the Kafue National Park are Andropogon gayanus, Andropogon shirensis, Brachiaria brizantha, Brachiaria deflexa, Brachiaria sp., Chloris gayana, Chloris virgata, Cynodon dactylon, Digitaria diagonalis, Digitaria gazensis, Digitaria milanjiana, Diheteropogon amplectens, Echinochloa holubi, Echinochloa pyramidalis, Echinochloa sp., Eleonurus argenteus, Elymandra grallata, Eragrostis sp., Hyparrhenia spp., Hyperthelia dissoluta, Loudetia simplex, Loudetia sp., Oryza barthii, Panicum maximum, Panicum merker, Panicum sp., Piptostachya inamolua, Rothboellia exaltata, Schizachyrium sanguineum, Setaria sphacelata, Setaria sp., Sporobolus sp., Sporobolus pyramidalis Themeda triandra, Trachypogon spicatus, Tristachya superba and Vossia sp. (Ansell In litt.).

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For the Luangwa Valley the following food plants have been recorded for roan: Grasses: Setaria sp., Andropogon gayanus, non-grasses: Combretum sp. and Disperma sp. (Ansell In litt.).

Critchley (In litt.) of the Blue Lagoon Ranch in Zambia noted that the most preferred food plant of the roan during the dry season was Echinochloa stagnina. On the Blue Lagoon Ranch roan moved freely from high ground (plateau) to low-lying flats although spending most of the year on the flats where the most common grasses are Echinochloa pyramidalis, Echinochloa stagnina, Vossia cuspidata, Oryza barthii and Leersia sp. Other grasses available to roan are: (i) on "dambo" edges: Panicum coloratum, Setaria avetlae, Setaria sphacelata and Chloris gayana and (ii) on the highland area: Hyparrhenia filipendula, Cynodon dactylon, Digitaria milanjiana, Brachiaria brizantha, Heteropogon contortus and Cymbopogon excavatus.

Angola

Roan occur throughout a major portion of Angola and the population of some 2 000 animals in the Quicama National Park probably represents one of the largest single populations of the roan. The Quicama National Park comprises at least 13 distinct habitats, ranging from dense thickets to open grassland. Although no information is available on the roan's specific food plants by far the largest concentration of roan inhabit the extensive Eragrostis superba - Eragrostis fasciculatis Savanna. Major grass species in this habitat are Eragrostis superba and Eragrostis fasciculatis with well represented associated species such as Heteropogon contortus, Tricholaena monachne, Digitaria milanjiana, Schmidtia pappophoroides and Rhynchelytrum sp. Several shallow depressions occur in these grasslands and contain water during the rainy season. Common grasses in these depressions are Echinochloa sp., Sporobolus robustus and Bothriochloa sp.

Adjoining areas in which roan are also abundant include (i) the Schizachyrium sanguineum Savanna with common grasses such as Schizachyrium

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sanguineum, Digitaria milanjiana, Digitaria monodactyla, Pogonarthria squarrosa, Tricholaena monachne, Eragrostis spp., Aristida spp., Hyparrhenia rufa and Heteropogon contortus, and (ii) the Setaria welwitschii Grassland in which Setaria welwitschii forms large and almost homogeneous stands. Associated species include Sporobolus robustus, Bothriochloa radicans and Dicanthium papillosum (Teixeira, de Matos and De Sousa 1967).

In the Bicuar National Park in south-central Angola, roan are commonly found in the shallow grass-covered drainage lines dissecting the surrounding heavily wooded areas. Common grasses in these "dambos" or "mulolas" are Loudetia superba, Pogonarthria squarrosa, Hyparrhenia sp., Tristachya sp., Eragrostis spp., Sporobolus sp., Schizachyrium sanguineum and on heavier clay soils also Themeda triandra and Heteropogon contortus.

Malawi

One of the significant populations of roan still to be found in Malawi inhabits the Nyika Plateau of the Malawi National Park. Altitudinally it ranges from about 1 067 m to 2 134 m above sea level. The roan are generally encountered in the open grasslands of the plateau and only go down to the lower-lying woodlands for a short time during the height of the dry season (Lemon 1964).

The major grass species constituting the grasslands include Exotheca abyssinica and Loudetia simplex as the dominants with important sub-dominants such as Andropogon shirensis, Danthonia sp., Eleonurus argenteus, Hyparrhenia cymbaria, Rendlia altera, Themeda triandra and Trachypogon spicatus. Other associated grass species include Eragrostis spp., Festuca spp., Digitaria sp., Agrostis spp., Aristida spp., Panicum spp., Pennisetum spp., Monocymbium ceresiiforme, Koeleria cristata and other high altitude grasses (Lemon 1964). Child and Wilson (1964) refer to observations of roan on the Nyika Plateau grazing on an Equisetum sp. with their heads submerged in 600 mm deep water in a pool.

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Uganda

According to Ross (In litt.) roan in the Kidepo Valley National Park, in the extreme north-east of Uganda, are customarily found at elevations ranging from 1 219 m to 1 829 m . Not much is known of their feeding habits but in the areas most frequented by the roan the following grasses are abundant: Hyparrhenia spp., Themeda triandra, Andropogon sp., Brachiaria sp., Eragrostis sp., Bothriochloa sp., Setaria sp., Loudetia sp., Sporobolus festivus, Panicum massaiens and Barberia longissima.

Nigeria

In the Borgu Game Reserve roan are mainly found where the grass component consists of predominantly Andropogon sp., Loudetia spp., and Hyparrhenia spp. (G.S. Child In litt.). In the Yankari Game Reserve roan are reported to feed on a wide variety of both annual and perennial grasses and also heavily browse the legume Mimosa pigra (Henshaw In litt.).

Significance of the grass stratum as a food resource and component of the habitat of roan antelope.

However inconclusive these notes on the food plants of roan may be, they nevertheless reflect the knowledge available on the food selection of one of the most widespread of all artiodactyls of the Sub-Saharan region of the African continent. They also shed some light on the wide adaptability of the roan to food resources vastly differing in species composition. This would tend to suggest that the food resource as such cannot be considered the sole explanation for the presence of the roan in any particular environment and again reflects the complexity of factors determining the suitability, or otherwise, of an environment for the species.

It is therefore also true that the various factors contributing toward the 'habitat' of a species cannot easily be isolated from one another and must preferably be regarded in a wide context. In this respect it may be considered

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that roan could very well adapt to any area with a varied and well developed grass stratum provided the structural (physiognomic) features of the vegetation as a whole are acceptable (Chapter 6).

Considering the food resource alone it would appear that notwithstanding the grass composition, at least two factors may be of crucial importance in determining the acceptability of an area to roan, i.e. (i) the condition of the grass stratum and (ii) competition for selected food plants by different grazers.

Condition of the grass stratum

In the Kruger Park roan do not exhibit any predilection for short grass areas and, in fact, are customarily found in medium to tall grass areas. Of particular importance is the fact that all areas inhabited by stabilized herds, i.e. herds with fixed activity zones, represent areas in which the grass stratum is compiled of predominantly perennial species. This phenomenon has also been observed in other areas where roan occur, i.e. Angola and Rhodesia.

From the description of the composition of the grass stratum of areas inhabited by roan throughout their range of distribution this would also seem to be the case in almost all areas where roan are still to be found in any numbers. Roan antelope may therefore be considered a species of open grasslands or savanna where the grass stratum is represented by a healthy stand of perennial species.

Competition for selected food plants

Competition for a particular food source may be evidenced in various ways, e.g. the depletion of favoured palatable species in an area by a numerically strong and nomadic species before they move off to another area, thus rendering the former area unsuitable to the more sedentary species. This was dramatically illustrated in the Tsavo National Park where Napier Bax and Sheldrick (1963) observed that "the rhinoceros, having a permanent browsing territory, was dependent on areas near permanent water, which were the very parts which suffered

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most devastation by elephant. Elephant, however, could forage much further afield or even move out of the area altogether ... ".

Conversely, competition may take the form of interspecific competition for the same parts of the food plants (cf. Sinclair 1974). The phenonemon of different species utilizing different parts of the same food plant or of a variety of species utilizing the various strata of the same habitat has the obvious advantage of eliminating direct interspecific competition and has led to the widespread propagation in favour of game farming in marginal areas unsuitable for sustaining domestic stock (cf. Dassman 1964). Indeed, Vesey-Fitzgerald (1960, 1965) has indicated the advantages of a mosaic of grassland types (tall and short grass areas) for different species and also illustrated the utilization of the same grassland by a number of different species by the exploitation of different growth stages. Essentially, it must therefore be emphasised that the utilization of the same habitat by different animal species - even though they may be dependent on the same food source - does not necessarily imply interspecific 'competition' but rather an economic exploitation of the available food resource.

On the other hand, Sinclair (1974) has shown that where two species are dependent on the same parts of the favoured food plants, competition may lead to a reduction in the size of one or both of the populations. In this way he estimated that a buffalo population was depressed by 18,5 per cent of their potential population in their dry season habitats due to competition for grass leaves by wildebeest. Field (1970) also came to the conclusion that "direct competition may only be initiated when vital components of the sward are depleted."

The co-existence of different herbivores and their selection for specific food plants and/or particular parts of the selected plant species has been dealt with in some detail by Stewart (1967), Field (1968 a and b, 1970, 1972),

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Gwynne and Bell (1968), Bell (1970, 1971) Field and Laws (1970), Casebeer and Koss (1970), Sinclair and Gwynne (1972) and Sinclair (1974).

In the Kruger Park the larger herbivores most commonly associated with roan in their favoured habitats include eland, reedbuck, zebra, tsessebe, blue wildebeest, kudu, buffalo, elephant and sable antelope. Of these eland and kudu are predominantly browsers and therefore do not compete for the same food source as roan. Elephant utilize grass species fairly extensively, tsessebe are almost exclusively grazers but preferably inhabit short grass areas while buffalo range extensively in savannas with a medium to tall grass stratum, sable antelope are almost exclusively grazers but normally inhabit more thickly wooded savanna than roan.

Zebra and wildebeest are highly gregarious species preferring close cropped grasslands or open savannas although the former species is quite capable of utilizing fairly tall grass swards.

Of the animal species normally occupying the same habitats as roan, competition from eland and reedbuck can almost be ruled out completely. Eland are predominantly browsers but also take a varying amount of grasses (Lemon 1964, Pellew 1967, Littlejohn 1968, Van Zyl 1965, Kerr, Wilson and Roth 1970). Even though they may utilize the same species, or even the same parts as roan, and in spite of the fact that they often form large herds of 30 or more, their highly nomadic habits in the Kruger Park ensure that they seldom remain in one area long enough to constitute a threat to the food resources. Being an animal well adapted to a wide variety of different habitat types, the eland furthermore only occupies favoured roan habitats for part of the year - in the Kruger Park normally late in the dry season. In unrestricted areas with a variety of different habitats direct interspecific competition between roan and eland is almost certain to be restricted to the minimum.

Although the diet of the reedbuck consists overwhelmingly of grasses

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(Jungius 1971 a and b) and in spite of the fact that 'dambos' - which are equally important to roan - are their favoured habitats, the reedbuck's social system in which small groups consisting of solitary animals or small family units dispersed throughout their preferred areas, largely eliminate the danger of population increases to the point where they could make serious inroads into the available food resource or be a serious threat to associated species (Jungius 1971 a and b).

Kudu are almost exclusively browsers which associate in small groups seldom exceeding 10 to 12 individuals and do not customarily inhabit the typical habitats of roan. Kudu therefore constitute even less of a threat to the food resources of the roan than either eland or reedbuck.

Tsessebe are highly territorial and in the Kruger Park bulls maintain the same territories for several years. Harem groups are each confined to the territory of a particular bull (Joubert 1972). These territories are almost invariably in the neighbourhood of permanent waterholes where the tsessebe preferably utilize short grass areas for grazing. As the normal activity zones of roan reach far beyond the radius of these territories from the watering points, tsessebe could neither be considered a threat to roan in any way.

The open grasslands or lightly wooded savanna types favoured by roan are not normally utilized to any great extent by elephants. The large breeding herds of elephant in the Kruger Park are mainly restricted to heavily wooded savanna or woodlands while those elephants which may compete with roan are almost without exception either lone bulls or bachelor groups. In spite of the elephant's diet which consists largely - up to 90 per cent - of grasses (Buss 1961, Napier Bax and Sheldrick 1963, Pienaar 1966, Laws, Parker and Johnstone 1970) the daily intake of the few bulls that occupy the roan habitats is not considered a threat to the food resource of the roan. In fact, it has been found that large numbers of elephant can actually be instrumental in transforming heavily wooded areas to lightly wooded savannas to the advantage of the open plains-loving species, e.g.

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the creation of open savanna areas in the Tsavo National Park with the subsequent increase of species such as zebra, oryx and hartebeest (Napier Bax and Sheldrick 1963).

Buffalo utilize much the same medium to tall grasslands as roan but due to their nomadic habits apply an ideal form of natural "rotational grazing" (Pienaar 1969a). Neither are they restricted to a particular habit-type but utilize widely differing vegetation types with equal partiality. Pienaar (1961) described the grazing habits of the buffalo as "coarse grazing and some browsing. Young and old grass grazed equally well." Pienaar (1969a) also stated that the " ... grazing habits of buffalo actually complement the requirements of species with more restricted feeding habits and others which shun old or tall grassland such as tsessebe, wildebeest, zebra, among others, in that additional grazing range suitable to the selective requirements of these animals is opened up in the wake of buffalo herds".

Similar grazing sequences were described for the Rukwa Valley where elephant and buffalo grazed and trampled tall grass areas to a stage more acceptable to herbivores that normally avoid tall grass (Vesey-Fitzgerald 1965).

In a broad sense it may therefore be deduced that buffalo are capable of initiating a form of faunistic succession similar - and even corresponding - to vegetational succession. This may be assumed to take the form of buffalo 'opening' new range in tall grass areas to animals such as zebra which are "close grazers" but not intolerant to medium tall grass swards (Smuts 1972). Once the latter has grazed the new area sufficiently and created short grass conditions, wildebeest can move in and, due to their partiality for short grass areas, keep the grasses grazed to the ground. With sufficiently heavy grazing pressure by the wildebeest and zebra, it could eventually lead to the 'over-utilization' of the area to the extent that retrogressive vegetational succession is initiated with an increase of annual grasses, forbs and woody growth. Taken

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to its logical consequence, the increase of woody species (so-called bush encroachment) renders the habitat less suitable for wildebeest but can be exploited by browsers such as impala and kudu. Thus, the reverse process to the destruction of woody thickets by elephants and the creation of open savanna, as witnessed in the Tsavo National Park (Napier Bax and Sheldrick 1963), may result.

As it will be indicated that zebra and wildebeest are the only two species which really constitute a direct threat to roan as regards their food source in the Kruger Park, it logically follows that an uncontained build-up of the buffalo population in roan habitats could initiate a process that would not only be detrimental to the roan population but would also be most difficult to reverse. The conclusions to be drawn are that buffalo, per se, do not constitute a threat to the food resource of roan but could be instrumental in such competition by paving the way for grazers which could compete with roan.

Of the herbivores occupying the same habitat as roan, zebra and wildebeest are the only close-to-ground grazers. In times of prolonged drought zebra are even known to dig out roots and succulent bulbs and rhizomes with their hooves (Pienaar 1963). Zebra and wildebeest are attracted to short grass areas but whereas wildebeest are largely confined to such areas, zebra also readily utilize medium to tall grasslands (Smuts 1972).

Once inroads have been made into tall grass areas and they have been grazed and trampled, concentrations of zebra and wildebeest persistently remain on these areas and effectively keep the grass short. Expansion of the short grass areas is easily accomplished by zebra grazing into the tall grass on the fringes with the wildebeest following in their wake. An increase in the numbers of these species would inevitably also lead to the denudation of progressively larger areas and with sustained grazing eventually result in the deterioration of the habitat and consequent retrogressive plant succession.

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The habit of roan to select medium to tall grass areas and their avoidance of over-utilized short grass areas may be ascribed to a number of different factors of which their particular feeding habits may be one of the most important. Roan have frequently been referred to as 'selective' or 'delicate' grazers (Pienaar 1963). However, they have already been shown to utilize a wide variety of grasses and although a few favoured species make up the bulk of their diet, this phenomenon is probably true of most grazers. Moreover, the same grass species may be important for a number of different grazers with availability playing the major role in selection (Casebeer and Koss 1970). Considerable overlap in the utilization of food plants by a number of different herbivores in East Africa, especially towards the end of the dry season, has also been reported by Stewart (1967).

The utilization of the same food plants by different animals does not in itself imply competition for those food plants. However, to evaluate the sources of possible competition between roan and other herbivores occupying the same range, the manner in which roan utilize the food resource should be taken into consideration.

Roan customarily feed on the top parts of their favoured food plants and normally do not graze lower than approximately 80 mm from the ground. During droughts, however, roan have been observed to feed close to the ground and they are also attracted to the green flush on newly burned veld so that they are at least capable of close grazing. The top parts of grasses being the select source of nutrition for the roan it would therefore be logical to assume that the favoured parts of their food plants are denied them where grazers such as wildebeest and zebra persistently keep the grass sward closely cropped. The conclusion is therefore that with an increase in the population of zebra and wildebeest competition for the food resource may arise that could lead to a situation favouring both zebra and wildebeest but intolerable for roan.

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This may further explain why certain grass species of the lower successional growth stages, i.e. of disturbed areas (e.g. Enneapogon cenchroides, Urochloa mosambicensis), may have a high selection value for roan though roan are frequently absent from the areas in which they are more abundant. Disturbances resulting in retrogressive succession imply heavy or over-utilization of the pasture and therefore create conditions to which roan are unable to adapt.

An interesting phenomenon in the Kruger Park is the almost total absence of impala in typical roan habitats. In spite of the impala's super-abundance in many areas throughout the Kruger Park its absence in roan habitats is a reflection of the selection of medium to tall grass swards by the latter. Conversely, an invasion of impala into such areas would almost certainly signify a disturbance in the habitat that would favour the increase of more woody growth - most likely initiated by animals such as zebra and wildebeest.

CONCLUSIONS

1. The methods in general use for determining food preferences almost invariably rely on the comparison of the utilization of food plants in relation to their availability. To obtain this objective many different methodshave been applied: Stewart (1967) and Field (1972) determined the preferred food species of ungulates by identifying grasses from their epidermis in the faeces of the animals and relating their relative abundance in the faeces to the composition of the natural vegetation on the basis of bulk (production). By guiding tame animals along a predetermined route Field (1970) could determine the "preference percentages" by expressing the total number of times a food plant was taken as a percentage of the total number of times it was available. Variations of these two methods are most commonly applied to wild herbivores as most of the more sophisticated methods, e.g. fistulas and/or exclosure plots, are frequently impractical in the field.

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In the present study three different criteria for determining availability were employed and the result of each compared. The method of obtaining information on the food plants taken, i.e. by counting the tussocks which had been grazed, may have its inherent shortcomings but is considered as reliable as any of the other methods in use. It may therefore be concluded that the preference ratings for the different grass species in this study probably reflect the natural selection of those species by roan as determined by either availability or palatability.

2. From an analysis of the food plants utilized by roan it is clear that a few species make up the bulk of their diet although they feed on a wide variety of grasses. It is also noteworthy that those species which play a major role in the diet do not necessarily have the highest preference ratings, therefore suggesting that availability plays an important role in food selection. Although little is known of the feeding habits of roan in other areas, the vegetational composition of the habitats frequented by roan would further indicate that the roan is quite capable of adapting to a wide variety of grassland and/or open savanna situations. The most outstanding factor seems to be a selection for medium to tall grass stands.

3. Browse plays only a minor role in the diet of the roan and it is doubtful whether it contributes even five per cent of the total intake.

4. Due to the fact that roan are capable of utilizing a wide variety of grass species, competition from other herbivores is not regarded important in terms of the specific species utilized but rather the parts of those plants favoured by roan. Roan are not customarily close grazers and all available evidence suggests that they are highly sensitive to continuously close-cropped and over-grazed areas. Of all the information derived from their feeding habits this is the most important single aspect which would require careful and continued consideration in their management. This is especially important under circumstances which could favour the increase of close grazers such as wildebeest

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CHAPTER 6 : HABITAT SELECTION AND PREFERENCES

INTRODUCTION

The close association of wild animals with particular features in their environment is a universal phenomenon by which each animal may be classified as, among others, an open plains, savanna, woodland or forest species according to its preferences. Indeed, the predilection of an animal for a particular habitat type is of such prime importance that almost any animal study would be incomplete without at least some reference to its preferred habitats.

Since the time when the association of an animal with a particular habitat was merely mentioned as a point of interest by the early hunters and travellers, the concept of the habitat has today emerged as one of the major cornerstones in wildlife management. By definition a habitat comprises "the dwelling place of a species or of a community including all of the operative factors, except competition, that influence the plants (or organisms) themselves" (Yapp 1922, In: Braun-Blanquet 1932). It is therefore clear that the term habitat signifies a diverse and complex combination of factors which provide an organism with a "dwelling place".

In its general application in terms of the larger animals the habitat more specifically refers to the vegetational composition, both floristically and structurally, of the area as the ultimate product of the various factors involved, among others climate and soil. Vegetation also represents the most variable of the components constituting a habitat and its stability is readily influenced by utilization. It is this dynamic nature of the vegetation and the manipulation of changes to suit the needs of different animals which is posing one of the greatest challenges to wildlife ecologists. Restricted conservation areas harbouring a variety of animals with diversified habitat preferences necessitate a delicate balance between herbivores and the species and structural composition of their respective habitats.

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METHODS

Quantitative data on the structural and compositional aspects of roan and sable antelope habitats were collected by using a combination of two acknowledged botanical surveying methods and adapting them to provide the information required. Sampling sites were not restricted to roan habitats only but were extended to include sable habitats. This was done with two objectives in mind:

a) Roan and sable are congeneric antelopes and are similar in their general ecology and behaviour (Joubert 1970, Grobler 1973). One of the few differences between roan and sable is evidenced by their habitat preferences. Roan are generally associated with more extensive open grasslands with scattered trees and shrubs, i.e. open savanna, while sable characteristically prefer denser savanna. However, sable avoid thickets and forests and the difference in the selection of habitats by roan and sable lies primarily in the degree of "openness" so that their habitats frequently overlap. Consequently they are also known to occur sympatrically in many areas.

By sampling the habitats of roan and sable an attempt could therefore be made to isolate the salient factors operative in determining their ecological separation.

b) By comparing two relatively similar habitats it was hoped that the factors distinguishing between the two would be more readily recognisable and would therefore eliminate confusion with less important factors.

In 13 different areas 280 sampling sites were selected throughout the ranges of roan and sable in the Kruger Park. Of these, 140 sampling sites were representative of roan habitats and 140 of sable habitats. Data were collected by using the following methods:

(i) A method for providing data on the "density" of a vegetation type by means of measuring the obstruction to vision was described by Wight (1938, In: ~~De Vos and~~ Mosby 1963).

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In the description of the method by Wight (op. cit.) it is reported that the results reflect the density of the vegetation, i.e. density in terms of obstruction to vision. However, as the term "density" is more applicable to specific numbers, its use in this context is misleading and it has therefore been substituted by "visibility" which, in effect, implies the measure of cover provided by the vegetation at different height levels.

In its original form this method involved a board, 1,8 m (six feet) long with each 0,3 m (one foot) marked off and numbered from one to six, starting at the bottom. In its application the board is held upright in the vegetation to be measured and at a distance of 20 m (66 feet) from the observer. The numbers which are not obscured by the vegetation are recorded and from the total of these numbers an indication of the visibility within the vegetation is gained. Completely open vegetation would therefore have a value of 21 (1+2+3+4+5+6) while the denser the vegetation becomes, the lower the value will be. Thus a value of 0 would indicate that the entire board had been obscured.

It is clear that this method was devised solely to measure the physical structure of the habitat and that in its original form the interpretation of a set of values could have led to misleading conclusions (see discussion). In an attempt to iron out the more obvious deficiencies of the method and to adapt it to measure the stratification of the vegetation (as determined by visibility) the following procedures were adhered to:

A board, 4 m by 0,3 m, and divided into eight 0,5 m units was used. Readings were taken at a distance of 25 m and a unit was considered obscured if vegetation covered at least 25 per cent of it. A record was kept of the individual units that were obscured at each sampling site. In this way a more detailed record could be kept of the structure of the vegetation at different height levels.

At each sampling site a total of ten readings was taken, i.e. five

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at 25 m intervals, starting 5,0 m from the road and proceeding perpendicularly away from it and five in a parallel line 30 m from the first, back to the road (Fig. 28C). The number of sampling sites varied with the importance of the area being sampled but was never less than ten, giving a total of at least 100 readings.

Sampling sites were selected in the following way: The habitats to be sampled were predetermined on the basis of the frequency with which either roan or sable were encountered in the areas. Roads traversing the most favoured areas of the two antelopes were travelled and sampling sites, commencing at a predetermined reading on the odometer of a vehicle, were selected at 0,5 km intervals as indicated by the odometer of the vehicle. Recordings were made alternatively on the left and right hand side of the road. In this way any subjective considerations in the choice of a sampling site were eliminated (Fig. 28B). At the actual site sampling was done directly alongside the vehicle, starting 5,0 m from the side of the road.

(ii) The second part of this method, which was applied simultaneously with the first, consisted of measuring the distances between trees and shrubs and the recording of various measurements of individual trees and shrubs. Differentiation between trees and shrubs was subjective and merely relied on height, i.e. woody growth forms, either single- or multi-stemmed, 2,0 m and lower were regarded as shrubs and those over 2,0 m high as trees.

At each sampling site the tree or shrub (1,0 m or higher) nearest the vehicle was taken as the starting point. From the first tree or shrub the distance to the next nearest tree or shrub was taken and this procedure was repeated until the distances between the first 30 trees and/or shrubs had been recorded (Fig. 28C). The species of each tree or shrub selected was recorded.

In determining the nearest neighbour to a specific tree or shrub, measurements were not taken along any predetermined transect or at any particular angle in relation to the previous tree or shrub. The area covered in measuring

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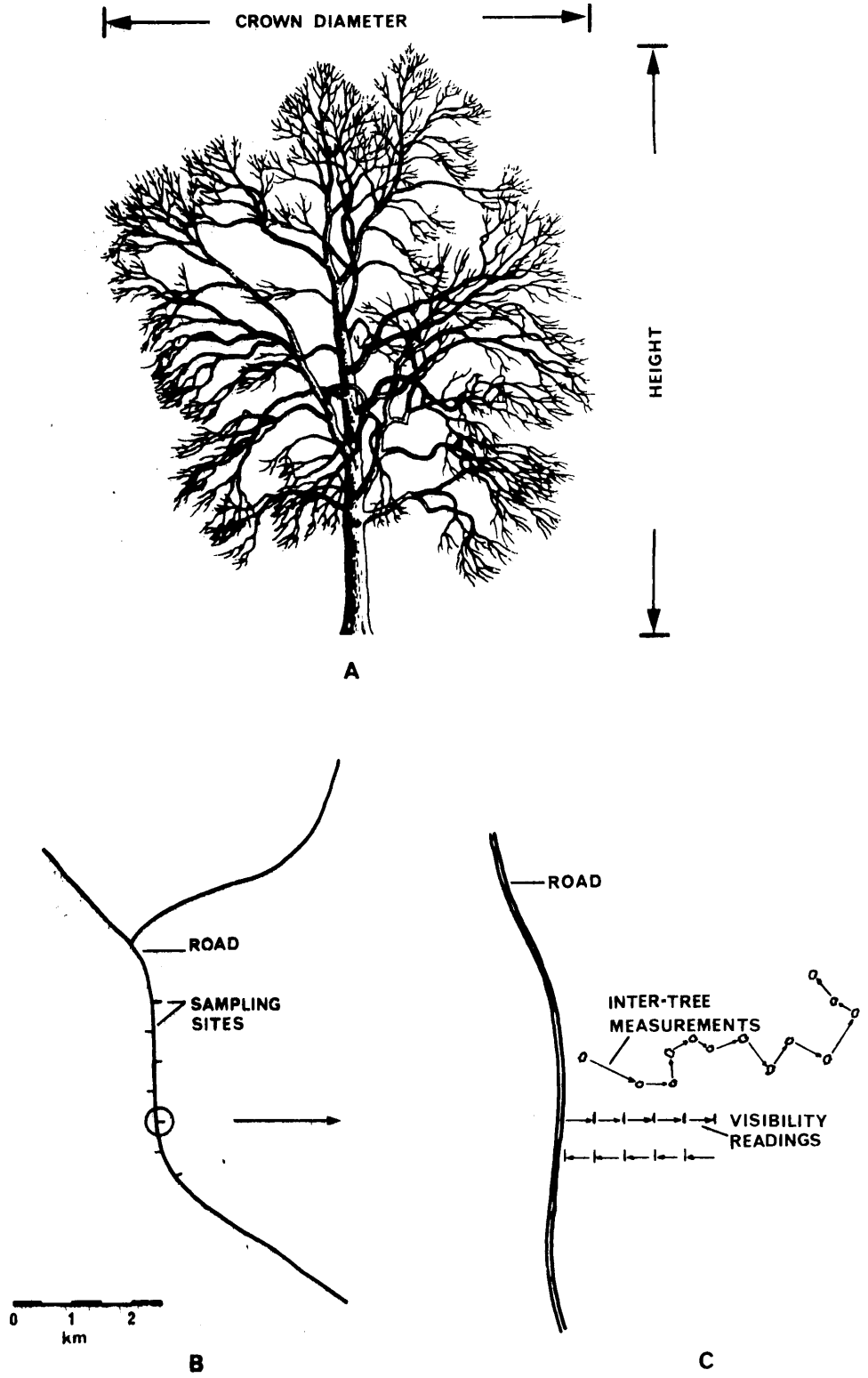

Figure 28 : Schematic representation of methods applied for evaluating roan antelope and sable antelope habitats in the Kruger National Park, South Africa. Individual tree measurements are indicated in A, the selection of sampling sites, at 0,5 km intervals, in B, and inter-tree distances and visibility readings in C.

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the distance between the first 30 trees and/or shrubs varied considerably, depending upon the denseness or openness of the vegetation.

Measurements of the selected trees and shrubs included stem and crown diameter and height (Fig. 28A). In the case of single-stemmed trees, stem diameter was determined at a height of one metre from the ground. Stem diameters of shrub were taken according to the growth form and height of the shrub. In coppice growth forms, the diameter of the stems forming the base of the plant was recorded. Calipers were used to obtain measurements. Crown diameters were measured by means of a measuring tape and represented the largest diameter of the crown. Tree heights were obtained by using a five metre rod, marked in 0,5 m units, and the maximum height of each tree or shrub was recorded. For the purpose of this survey only shrubs one metre, or more, in height were recorded.

The determination of sampling sites was the same as that for the visibility readings. Sampling sites varied between 10 and 30, therefore providing from 300 to 900 readings per area sampled.

The approach used in this survey obviously originated from the many methods which have already been described in which the distances between trees play an important role (cf. Clark and Evans 1954, Cottam and Curtis 1956).

RESULTS AND DISCUSSION

The objective of the application of the combined method was to illustrate the differences, if any, in the structure and composition of roan and sable antelope habitats and to isolate the salient factors determining habitat selection. From the distribution of roan and sable in the Kruger Park, the following areas were regarded as representative of their habitat preferences and were accordingly surveyed (Fig. 29):

1. Mestel - Shabin:

   Sable Antelope

   30 sampling sites

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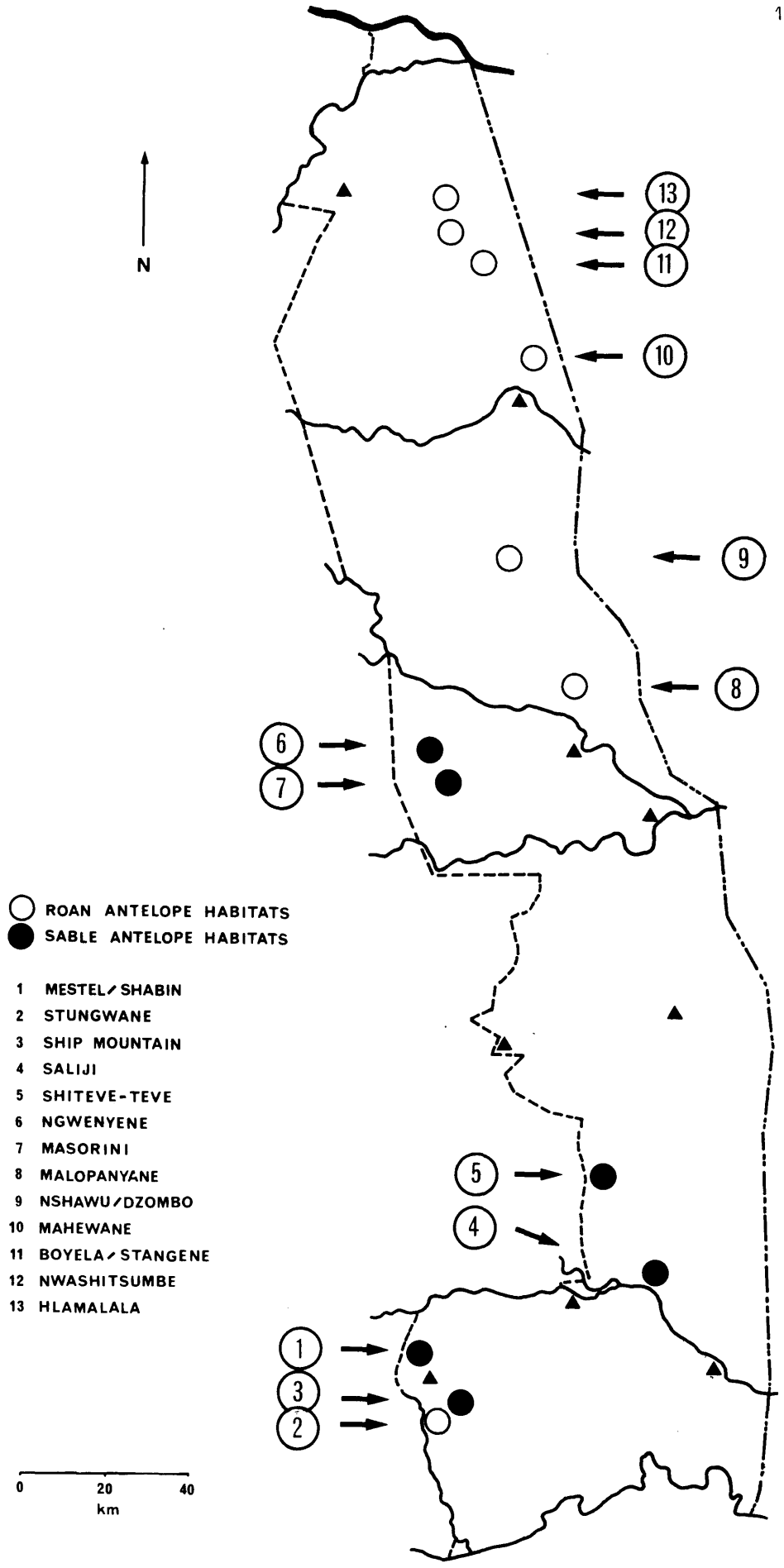

Figure 29 : Map indicating localities surveyed as roan antelope and sable antelope habitats in the Kruger National Park, South Africa.

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2. Stungwane:

   Roan and sable antelope

   20 sampling sites

3. Ship Mountain:

   Sable antelope

   10 sampling sites

4. Saliji:

   Sable antelope

   20 sampling sites

5. Shiteve-teve:

   Sable antelope

   30 sampling sites

6. Ngwenyene:

   Sable antelope

   30 sampling sites

7. Masorini:

   Sable antelope

   20 sampling sites

8. Malopanyane:

   Roan antelope

   20 sampling sites

9. Nshawu - Dzombo:

   Roan antelope

   30 sampling sites

10. Mahewane:

    Roan antelope

    10 sampling sites

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11. Boyela - Stangene:

    Roan antelope

    20 sampling sites

12. Nwashitsumbe roan antelope enclosure (henceforth referred to as Nwashitsumbe)

    Roan antelope

    20 sampling sites

13. Hlamalala:

    Roan antelope

    20 sampling sites

Visibility (i.e. obstruction to vision)

To isolate and differentiate between typical roan and sable habitats a linear regression (Snedecor 1965) was applied which indicated a high degree of correlation between the visibility values and the height intervals of the habitats sampled (Tables 26 and 27). To apply the regression, y-values were taken as the values of the different height intervals while x-values (1 to 8) were allocated to the eight half-metre height intervals. The positions of the various habitats were plotted by distributing the values of coefficient "a" (intercept coefficient) along the x-axis and coefficient "b" along the y-axis (Table 27 and Fig. 30 and 31) (Snedecor 1965, Robinson pers. comm.).

The results obtained by applying this analysis indicated that the most favoured roan habitats included Malopanyane, Boyela - Stangene (Fig. 32C), Hlamalala and Nwashitsumbe (Fig. 30 and 31) while the choice sable habitats were Ngwenyene (Fig. 34B), Masorini (Fig. 34C), Shiteve-teve and Saliji (Fig. 30 and 31). With respect to roan the four areas indicated also represent the areas which have always been known as their favoured habitats. The isolation of these four areas is therefore in accordance with the observed preferences of the roan. The same applies to the isolation of the sable habitats, i.e. the Ngwenyene and Masorini areas represent two of the most favoured areas of the sable while they

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Table 26 : Summary of the percentage obstruction to vision at various height intervals as determined by means of the visibility board in seven roan antelope and six sable antelope habitats in the Kruger National Park, South Africa.

A. ROAN ANTELOPE HABITATS.

LOCALITY	NO. OF SITES	PERCENTAGE OBSTRUCTION AT DIFFERENT HEIGHT INTERVALS (m)								MEAN OBSTRUCTION (PER CENT)
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0	
Stungwane	20	100,0	42,7	22,0	16,0	14,7	15,3	16,7	18,7	30,76
Malopanyane	20	94,5	43,0	17,0	5,5	4,0	1,5	1,5	1,5	21,06
Nshawu-Dzombo	30	100,0	51,0	25,0	9,7	8,0	5,0	4,7	4,3	25,96
Mahewane	10	99,0	62,0	35,0	14,0	1,30	11,0	8,0	6,0	31,00
Boyela-Stangene	20	100,0	34,5	13,5	7,0	5,0	3,5	3,0	2,5	21,12
Hlamalala	20	100,0	56,0	36,5	13,5	7,0	4,0	3,0	3,0	27,87
Nwashitsumbe	20	99,5	41,5	20,0	15,0	9,0	7,5	6,5	5,0	25,50
Total	140	693,0	330,7	169,0	80,7	60,7	47,8	43,4	41,0	
Mean		99,0	47,2	24,1	11,5	8,7	6,8	6,2	5,9	26,18

B. SABLE ANTELOPE HABITATS

LOCALITY	NO. OF SITES	PERCENTAGE OBSTRUCTION AT DIFFERENT HEIGHT INTERVALS (m)								MEAN OBSTRUCTION (PER CENT)
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0	
Mestel-Shabin	30	100,0	68,0	41,3	30,0	27,0	26,0	29,7	31,3	44,16
Ship Mountain	10	100,0	51,0	37,0	36,0	37,0	36,0	34,0	31,0	45,25
Saliji	20	99,5	46,5	38,0	39,5	39,5	38,5	36,0	36,5	46,75
Shiteve-teve	30	100,0	47,0	43,3	39,7	38,3	37,7	34,3	32,0	46,53
Ngwenyene	30	100,0	71,0	63,0	59,3	54,3	51,3	43,0	36,3	59,73
Masorini	20	100,0	76,0	65,0	61,0	56,5	48,0	42,5	39,0	61,00
Total	140	599,5	359,5	287,6	265,5	252,6	237,5	219,5	206,1	
Mean		99,9	59,9	47,9	44,3	42,1	39,6	36,6	34,4	50,57

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Table 27 : Linear regression (i) and logarithmic transformation (ii) of roan and sable habitats based on visibility readings as obtained in the Kruger National Park, South Africa.

LOCALITY		r	coeff.b.	coeff.a.	S.D. x	$\bar{x}$	S.D. y	$\bar{y}$
Mestel-Shabin	(i)	-0,7954	- 8,5869	82,8035	2,4494	4,5	26,4409	44,1625
	(ii)	-0,93	- 0,65	4,53	0,70	1,32	0,49	3,66
Stungwane	(i)	-0,7134	- 8,5773	69,3607	2,4494	4,5	29,4506	30,7625
	(ii)	-0,91	- 0,87	4,32	0,70	1,32	0,67	3,17
Ship Mountain	(i)	-0,7261	- 6,7857	75,7857	2,4494	4,5	22,8894	45,2500
	(ii)	-0,92	- 0,49	4,39	0,70	1,32	0,37	3,73
Saliji	(i)	-0,6624	- 5,8571	72,8571	2,4494	4,5	21,6580	46,5000
	(ii)	-0,86	- 0,42	4,33	0,70	1,32	0,34	3,77
Shiteve-teve	(i)	-0,8682	- 5,7916	89,6250	2,4494	4,5	16,3389	63,5625
	(ii)	-0,98	- 0,31	4,31	0,70	1,32	0,22	4,12
Mgwenyene	(i)	-0,9313	- 7,4523	93,3107	2,4494	4,5	19,5993	59,7750
	(ii)	-0,97	- 0,42	4,61	0,70	1,32	0,30	4,04
Masorini	(i)	-0,9515	- 7,7380	95,8214	2,4494	4,5	19,9194	61,0000
	(ii)	-0,98	- 0,45	4,64	0,70	1,32	0,31	4,06
Malopanyane	(i)	-0,8037	-10,7916	69,6250	2,4494	4,5	32,8899	21,0625
	(ii)	-0,97	- 2,25	4,91	0,70	1,32	1,61	1,93
Nshawu-Dzombo	(i)	-0,8277	-11,4654	77,5571	2,4494	4,5	33,9269	25,9625
	(ii)	-0,98	- 1,16	4,80	0,70	1,32	1,99	2,59
Mahewane	(i)	-0,8701	-11,8333	84,2499	2,4494	4,5	33,3123	31,0000
	(ii)	-0,98	- 1,40	4,82	0,70	1,32	1,00	2,96
Boyela-Stangene	(i)	-0,7567	-10,3809	67,8392	2,4494	5,5	33,6024	21,1250
	(ii)	-0,99	- 1,84	4,64	0,70	1,32	1,30	2,19
Hlamala	(i)	-0,8666	-12,2940	82,5607	2,4494	4,5	34,7485	27,2375
	(ii)	-0,97	- 1,89	5,03	0,70	1,32	1,36	2,52
Nwashitsumbe	(i)	-0,7973	-10,4761	72,6428	2,4494	4,5	32,1825	25,5000
	(ii)	-0,99	- 1,45	4,64	0,70	1,32	1,02	2,21

Where:

r = correlation coefficient
coeff.b. = slope coefficient
coeff.a. = intercept coefficient
$\bar{x}$ = mean of values ascribed to height intervals
$\bar{y}$ = mean of visibility values (see Appendix 3)

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ROAN ANTELOPE HABITATS

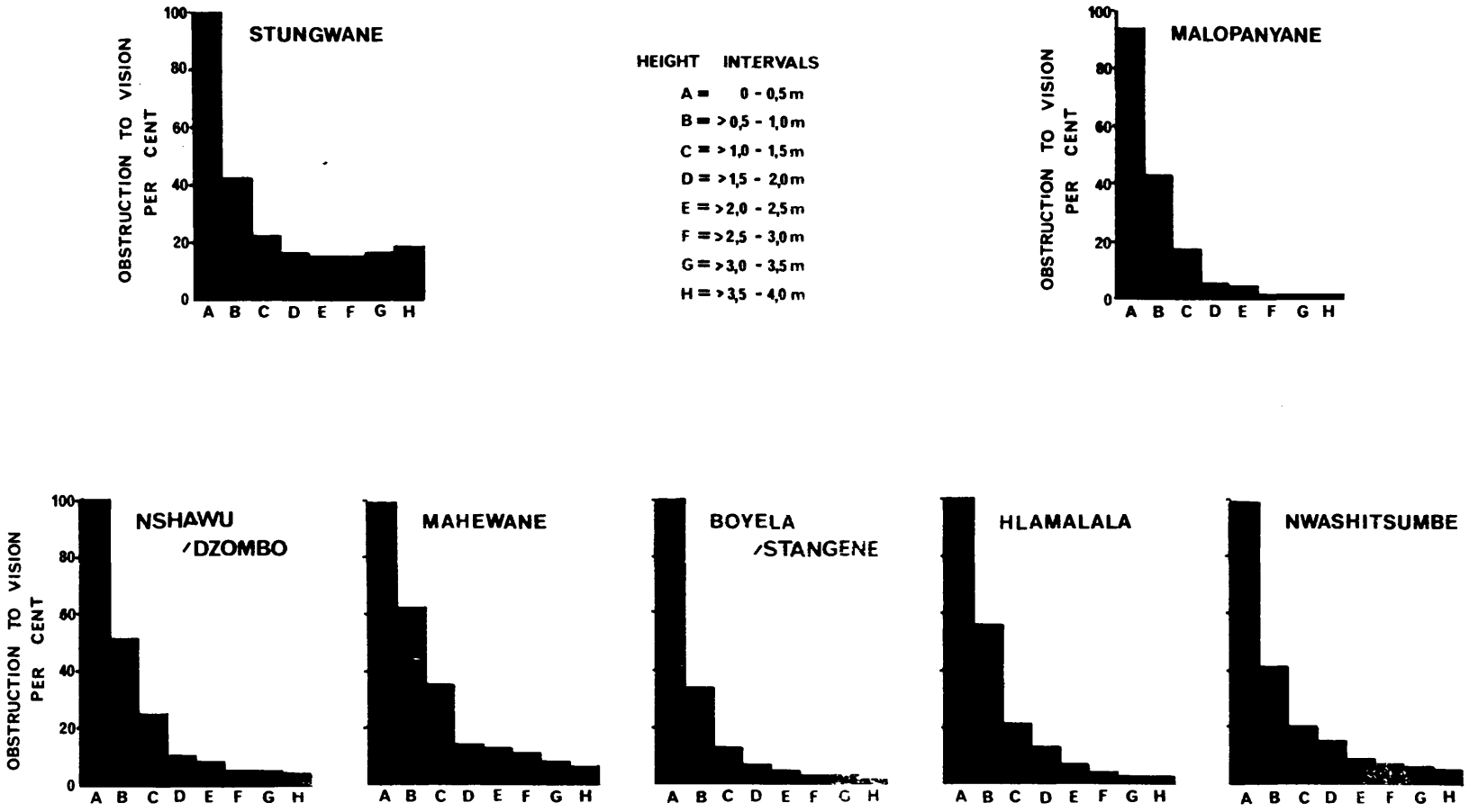

Figure 35 : Percentage obstruction to vision at eight height intervals as determined by means of a visibility board in roan antelope habitats in the Kruger National Park, South Africa.

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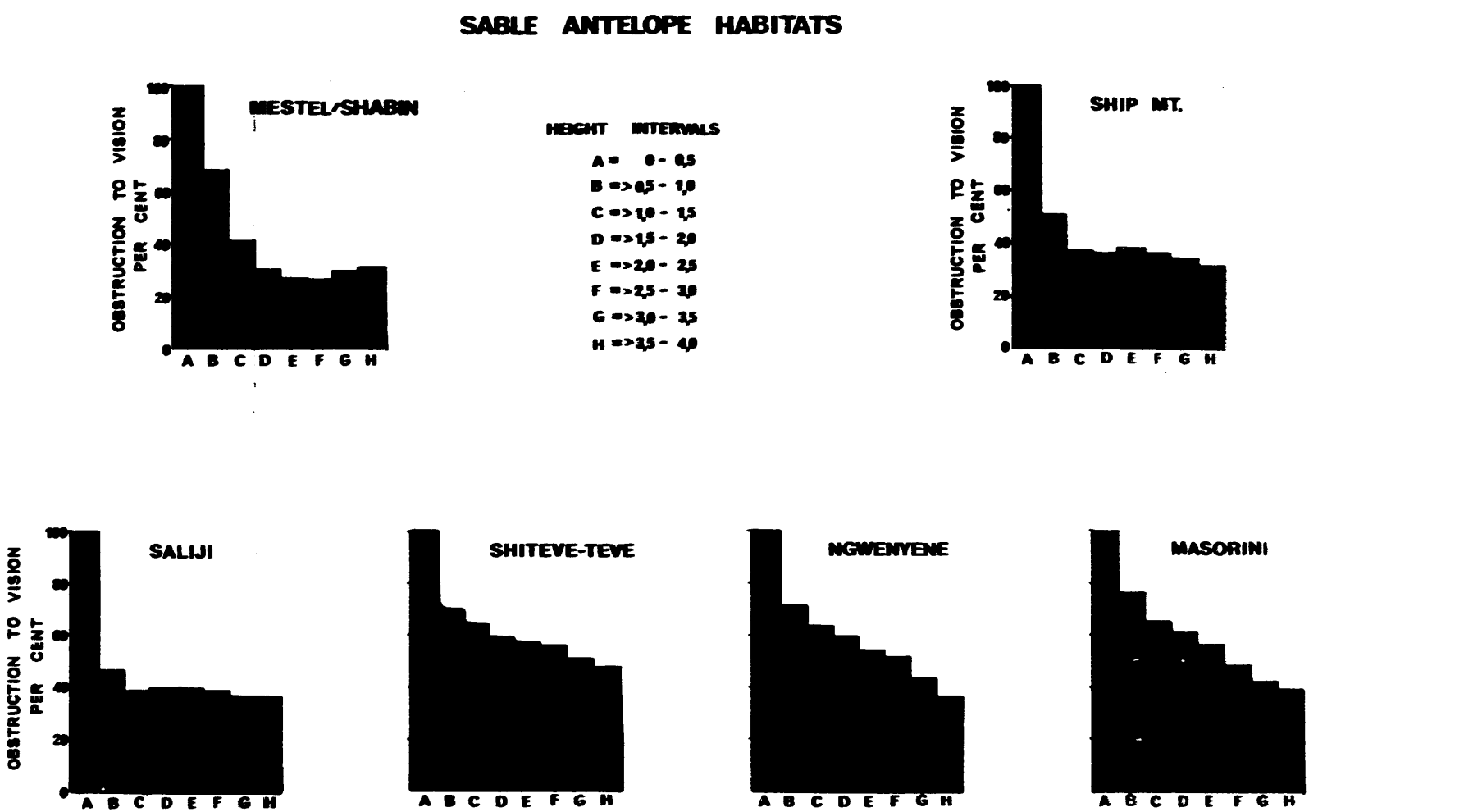

Figure 36 : Percentage obstruction to vision at eight height intervals as determined by means of a visibility board in sable antelope habitats in the Kruger National Park, South Africa.

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least differences between the various habitats are to be found in the two basal height intervals (i.e. 0 to 0,5 m and > 0,5 to 1,0 m) up to the height of 1,0 m (Table 26, Fig. 35 and 36).

In the 0 to 1,0 m height interval the vegetation largely comprises grass species and the smaller shrubs, and as roan and sable have a distinct predilection for medium to tall grass stands in either open grasslands or savanna's, their requirements would not be expected to differ in this stratum.

It must, however, be noted that the range of values is not constant throughout the basal 1,5 m but a breakdown into the three 0,5 m height intervals, i.e. 0 to 0,5 m, > 0,5 to 1,0 m and > 1,0 to 1,5 m, reveal that although the basal (0 to 0,5 m) height interval had a value of almost 100 per cent, the value dropped by roughly half in the next height interval (> 0,5 to 1,0 m) with a further decline in the third (> 1,0 to 1,5 m) (Table 26, Fig. 35 and 36).

In the higher strata - representative of the tree and shrub components of the vegetation - the differences in the values of the roan habitats ranged from four to six times less than those of the sable habitats. This clearly reflects a considerable difference in the volume of woody growth between the two types of habitats. These differences are all the more obvious when the visibility values of the select roan and sable habits, i.e. Malopanyane and Boyela-Stangene for roan and Ngwenyene and Masorini for sable, are compared with one another. The values of the latter reveal habitats with a substantially higher production of woody plants than the former, with the mean difference of the values in the respective height intervals being 2,75 per cent (0 to 0,5 m), 34,75 per cent (>0,5 to 1,0 m), 48,75 per cent (>1,0 to 1,5 m), 53,9 per cent (>1,5 to 2,0 m), 50,9 per cent (>2,0 to 2,5 m), 47,15 per cent (>2,5 to 3,0 m), 40,5 per cent (>3,0 to 3,5 m) and 35,65 per cent (>3,5 to 4,0 m). It could be argued that the uniformity of the roan habitats could be ascribed to the fact that they mostly represent the same plant community, i.e. Colophospermum mopane

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Shrub Savanna. However, the single areas representing roan habitat in otherwise predominantly sable surroundings, i.e. Stungwane, clearly revealed a much higher association with the other roan habitats than those of sable while the two sable habitats sampled within predominantly Colophospermum mopane savanna (Ngwenyere and Masorini) could obviously be differentiated from the roan habitats on the basis of visibility in the different height intervals (Table 26, Fig. 35 and 36).

Visibility is a criterion essentially related to plant growth forms and as such it could be expected to be a good measure of the physiognomy of a habitat, irrespective of the species composition. This has adequately been illustrated by the uniformity of the widely differing plant communities represented by especially the sable habitats, as well as the close resemblance of the Stungwane area to other roan habitats.

In any deciduous plant community the values of the different height intervals would also vary from one season to the other, so that measurements of this character should be limited to the periods of maximum plant production, i.e. when plants are in full leaf.

Supplementary data pertaining to vegetation stratification and composition

To augment the results pertaining to the stratification of the vegetation as determined by visibility, the second part of the method employed, i.e. the determination of the distances between trees and/or shrubs and the measurements of individual trees and shrubs, allowed for further analysis of the habitat in terms of its structure. It also proved suitable for extracting the main species composition of the different habitat types. From a structural point of view the most important information derived from these data involve:

i) Mean distance between trees and shrubs,

ii) Mean height of trees and shrubs and their grouping into height classes,

iii) Mean crown diameter,

iv) Determination of the major species in the various vegetation communities.

The relevant data pertaining to these criteria appear in Table 28.

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Table 28 : Summarized data of various measurements of trees and shrubs in seven roan antelope and six sable antelope habitats in the Kruger National Park, South Africa.

A. ROAN ANTELOPE HABITATS

LOCALITY	NO. OF SITES	MEAN DISTANCE BETWEEN TREES/SHRUBS (m)	MEAN CROWN DIAMETER(m)	MEAN HEIGHT (m)	MEAN NO. OF TREES AND SHRUBS IN HEIGHT INTERVALS			
					1-2 m	>2-3m	>3-4m	> 4m
Stungwane	20	3,0	2,0	2,4	20,4	4,6	1,4	3,7
Malopanyane	20	3,2	2,3	1,6	26,9	2,6	0,5	0,2
Nshawu-Dzombo	30	3,5	2,0	1,8	24,0	4,6	0,9	0,4
Mahewane	10	2,9	1,9	1,8	25,6	3,4	0,1	0,9
Boyela-Stangene	20	4,1	1,5	1,6	26,9	3,0	0,3	0,4
Hlamalala	20	3,3	1,8	1,7	25,3	3,6	1,0	0,3
Nwashitsumbe	20	3,5	1,9	1,8	26,1	1,7	0,7	0,5
Mean values	140	3,4	1,9	1,8	25,0	3,4	0,7	1,0

B. SABLE ANTELOPE HABITATS

LOCALITY	NO. OF SITES	MEAN DISTANCE BETWEEN TREES/SHRUBS (m)	MEAN CROWN DIAMETER(m)	MEAN HEIGHT (m)	MEAN NO. OF TREES AND SHRUBS IN HEIGHT INTERVALS			
					1-2m	>2-3m	>3-4m	>4m
Mestel-Shabin	30	5,1	3,4	3,3	11,5	7,3	3,9	7,4
Ship Mountain	10	4,1	3,5	3,8	13,3	4,4	1,9	10,4
Saliji	20	3,8	3,2	3,3	14,7	5,6	2,4	7,5
Shiteve-teve	30	3,4	2,6	2,6	16,1	8,0	2,3	3,6
Nqwenyene	30	2,4	2,2	2,3	18,4	7,5	2,2	1,9
Masorini	20	2,8	2,3	2,2	18,7	7,2	2,5	1,7
Mean values	140	3,6	2,9	2,9	15,5	6,7	2,5	5,4

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To further allow an evaluation of the degree of uniformity, within the roan and sable habitats, of the various criteria measured, t-tests (Snedecor 1965) were applied and each of the thirteen areas sampled compared with one another individually. This was done in the hope of identifying those factors common to both roan and sable habitats which could then be assumed to be of no or little importance in differentiating between the two types of habitats, on the one hand, and on the other, those factors which are mainly responsible for habitat differences and could therefore be considered the salient factors in determining the suitability of an area for either roan or sable.

In the application of the t-tests the following procedure was followed: The means of the various measurements in each sampling site were obtained and regarded as the raw material from which the standard deviation (S.D.) and other calculations were made. The number of sampling sites in each area varied between 10 and 30.

This is obviously a deviation from the normal procedure in the application of this statistical test which would necessarily also affect the accuracy of the results. The major discrepancy appears to be caused by the fact that the means do not reflect the full range of distribution around the mean in the sample and would therefore result in a smaller S.D. which would again affect further calculations. The net result would therefore tend to make the test more sensitive and indicate a significant difference between areas which may, in fact, not differ significantly. Significance was determined at the $P>0,05$ level. The greater sensitivity of the test would not have any adverse effects on the results obtained but would rather accentuate the isolation of the points of difference. The results are presented in Figure 37 and 38.

It must, however, be pointed out that the results obtained from these tests cannot be accepted as absolutely reliable in determining the degree of differentiation between the habitats for the criteria tested but do provide a good indication thereof.

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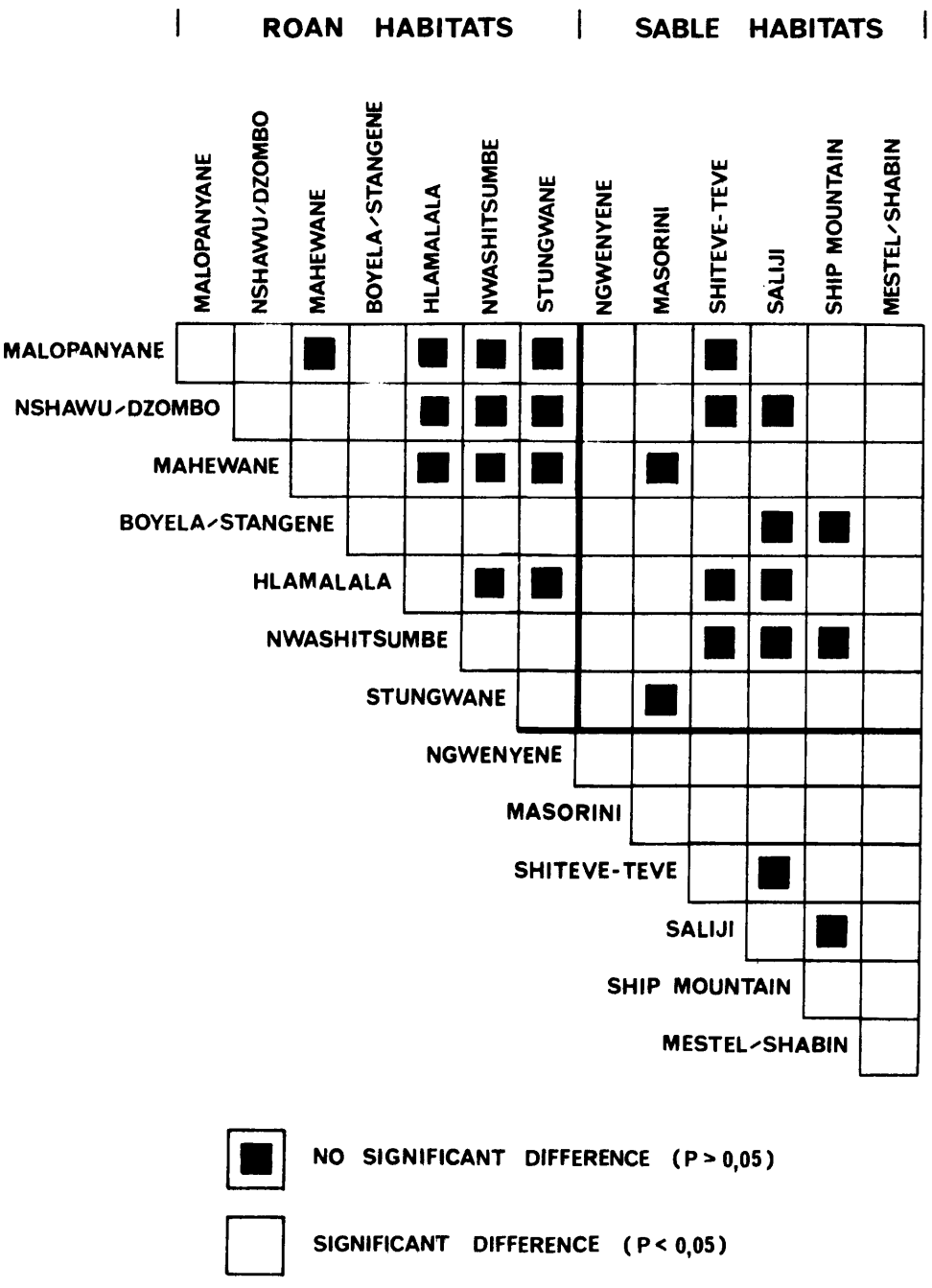

Figure 37 : Degree of differentiation between roan antelope and sable antelope habitats as determined by means of t-tests on the basis of the mean distance between trees and shrubs, Kruger National Park, South Africa.

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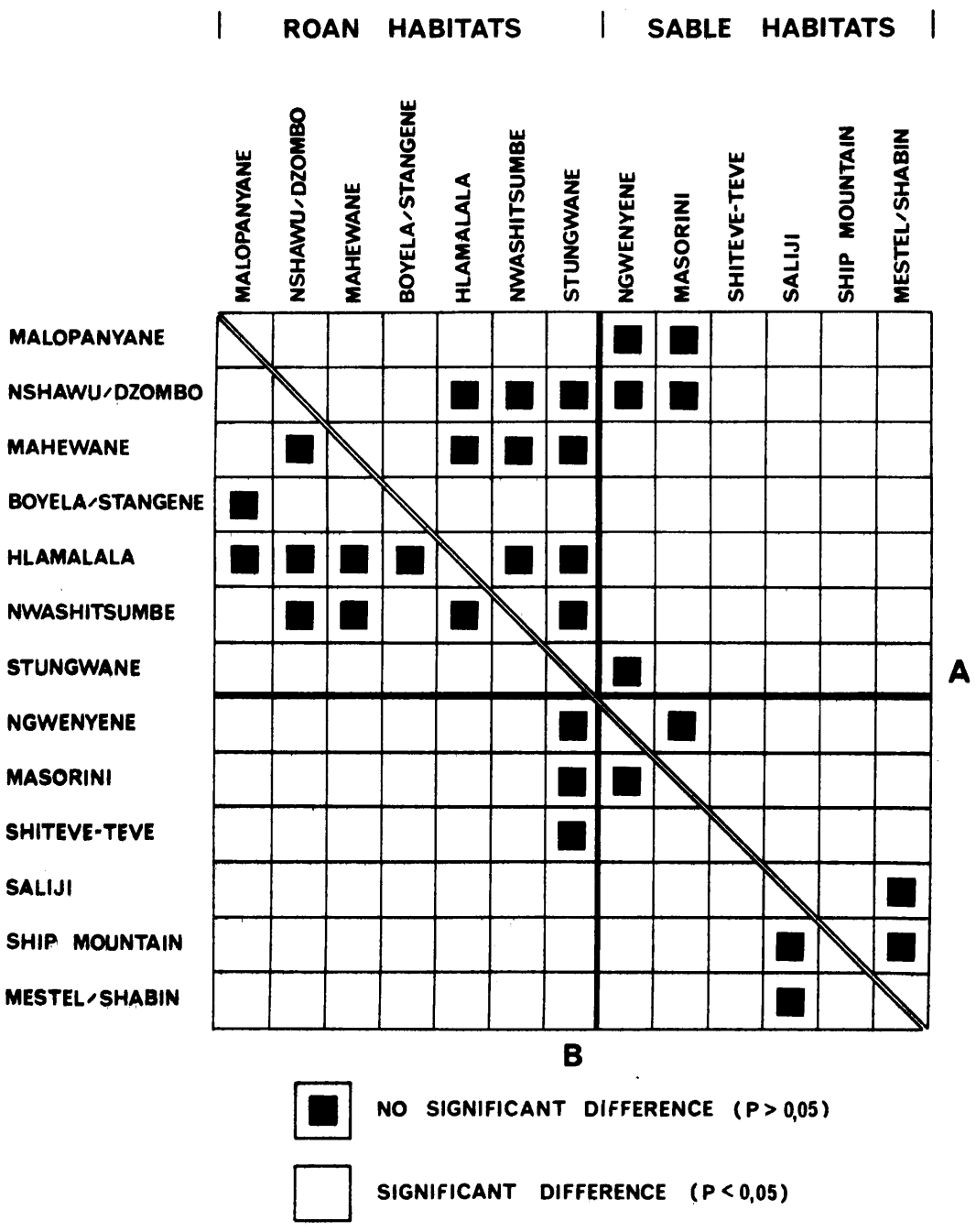

Figure 38 : Degree of differentiation between roan antelope and sable antelope habitats as determined by means of t-tests on the basis of (A) mean crown diameter and (B) mean height of trees and shrubs in the Kruger National Park, South Africa.

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To augment these results an F-test and t-test (Snedecor 1965) was also applied to the mean values of the distances between trees, crown diameter and tree height (Tables 29 and 30).

In addition, the relative variability of the habitat factors examined in roan and sable habitats is expressed by the coefficient of variation (C.V.) in Table 31 (Snedecor 1965).

Mean distance between trees and shrubs

In spite of the differences in the stratification of trees and shrubs between the various areas sampled, the mean distance between woody growth forms 1,0 m and higher showed only slight differences between roan and sable habitats The overall mean for roan habitats was 3,4 m and that for sable habitats 3,6 m (Table 28).

Statistically both the t-tests and the F-test revealed that the distances between trees in roan and sable habitats did not reveal any significant differences (Tables 29 and 30, Fig. 37). This measurement could therefore not be applied, in general terms, to distinguish between such habitats. It is also important to note that even among the select roan and sable habitats there was considerable overlap which would further tend to invalidate this criterion for differentiation between the two types of habitats (Fig. 37).

The mean distance between trees and shrubs could be interpreted as a reflection of the density of the vegetation. Although the data collected in this survey does not facilitate the calculation of numbers of trees and shrubs per unit area, the lack of statistical evidence to suggest significant differences in the mean distance between trees and shrubs for roan and sable habitats tends to indicate that the density of these growth forms for the two types of habitats are of the same order. The inference could therefore also be made that the growth forms of the component species of a plant community are probably more important in differentiating between wildlife habitats than the mere numbers of plants per unit area.

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Table 29 : Results of an F-test applied to the mean distance between trees, mean crown diamter of trees and the mean height of trees in roan and sable habitats in the Kruger National Park, South Africa.

A. ROAN ANTELOPE HABITATS

PARAMETER	F-VALUE	DEGREES FREEDOM	CRITICAL VALUES	
			5 per cent	1 per cent
Mean distance between trees/shrubs	3,341	6 ; 133	2,16	2,96
Mean crown diameter of trees/shrubs	4,340	6 ; 133	2,16	2,96
Mean height of trees/shrubs	10,823	6 ; 133	2,16	2,96

B. SABLE ANTELOPE HABITATS

PARAMETER	F-VALUE	DEGREES FREEDOM	CRITICAL VALUES	
			5 per cent	1 per cent
Mean distance between trees/shrubs	20,356	5 ; 134	2,28	3,17
Mean crown diameter of trees/shrubs	10,459	5 ; 134	2,28	3,17
Mean height of trees/shrubs	13,214	5 ; 134	2,28	3,17

Table 30 : Results of a t-test to compare the mean distance between trees, mean crown diameter of trees and the mean height of trees between roan and sable habitats in the Kruger National Park, South Africa.

PARAMETER	t-VALUE	DEGREES FREEDOM	CRITICAL VALUES	
			5 per cent	1 per cent
Mean distance between trees/shrubs	- 1,273	278	1,96	2,58
Mean crown distance of trees/shrubs	- 9,514	278	1,96	2,58
Mean height of trees/shrubs	-11,534	278	1,96	2,58

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Table 31 : Mean ($\bar{x}$), standard deviation (S.D.) and per cent coefficient of variation (C.V.) for the various parameters measured in seven roan antelope and six sable antelope habitats in the Kruger National Park, South Africa.

PARAMETER	ROAN HABITATS			SABLE HABITATS		
	$\bar{x}$ (m)	S.D.	C.V.	$\bar{x}$ (m)	S.D.	C.V.
Distance between trees	3,40	0,93	27,36	3,59	1,45	40,38
Crown diameters of trees/shrubs	1,92	0,54	28,12	2,80	0,95	33,92
Mean tree/shrub height	1,80	0,43	23,88	2,79	0,93	33,33
Trees/shrubs in height classes						
1,0 - 2,0 m	24,88	4,62	18,56	15,57	6,12	39,30
> 2,0 - 3,0 m	3,58	3,38	94,41	7,01	3,55	50,64
> 3,0 - 4,0 m	0,74	1,16	156,75	2,59	2,28	88,03
> 4,0 m	1,00	1,94	194,00	4,82	4,70	97,51

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Tree and shrub height classes

The stratification of vegetation could obviously also be obtained by grouping trees and shrubs into height classes. Such grouping could be expected to render similar results as those derived from the determination of visibility and canopy cover (page 213) as the three criteria are complementary functions of one another.

The mean tree height for all height classes in roan habitats was 1,8 m while that of sable habitats was 2,9 m (Table 28). However, a great deal of heterogeneity was found within roan and sable habitats on the basis of mean tree height, though the degree of heterogeneity was greater within sable habitats than within those of roan (Table 29, Fig. 38B). In spite of this heterogeneity it was also found that the differences between the mean tree height of roan habitats, on the one hand, and that of sable habitats, on the other, were significant at the one per cent level (Table 34).

Each of the four height classes (i.e. 1,0 to 2,0 m, > 2,0 to 3,0 m, > 3,0 to 4,0 m and > 4,0 m) compared with one another revealed a clear distinction between the two habitat types and only in the > 2,0 to 3,0 m height class were there similarities between the roan habitats and two sable areas i.e. Saliji and Ship Mountain (Fig. 39 and 40). Of the four height classes, the number of trees and shrubs in roan habitats exceeded those in sable habitats only in the 1,0 to 2,0 m height interval but were considerably fewer in all the higher categories.

As in the case of visibility and canopy cover these results again indicate the highest concentration of woody plants in the lowest height classes with a rapid decline in the upper height classes in roan habitats. While this tendency is also apparent in the sable habitats it is not as pronounced as in the roan habitats (Fig. 41).

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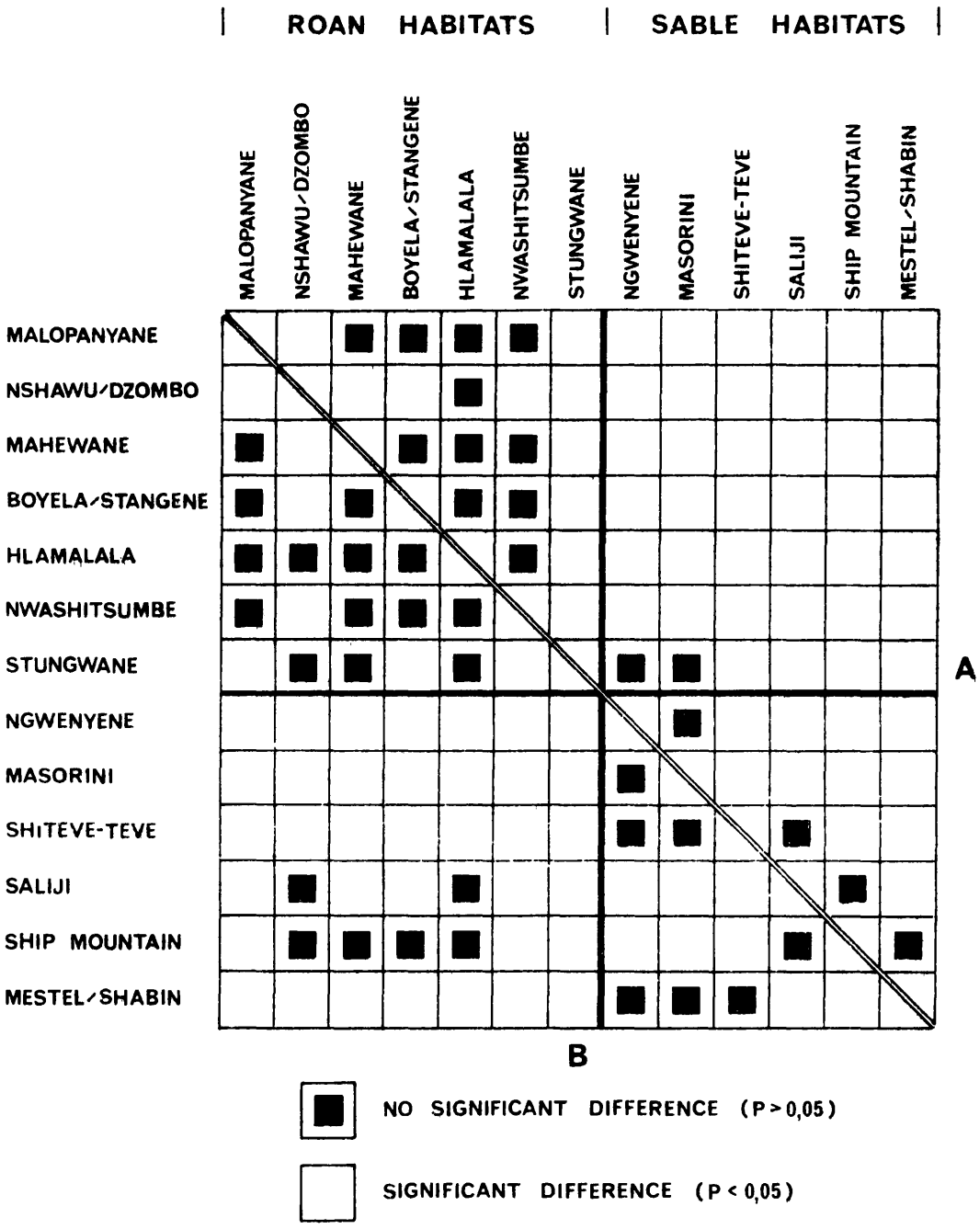

Figure 39 : Degree of differentiation between roan antelope and sable antelope habitats as determined by means of t-tests on the basis of (A) the number of trees in the height interval 1,0 to 2,0 m and (B) the number of trees in the height interval >2,0 to 3,0 m in the Kruger National Park, South Africa.

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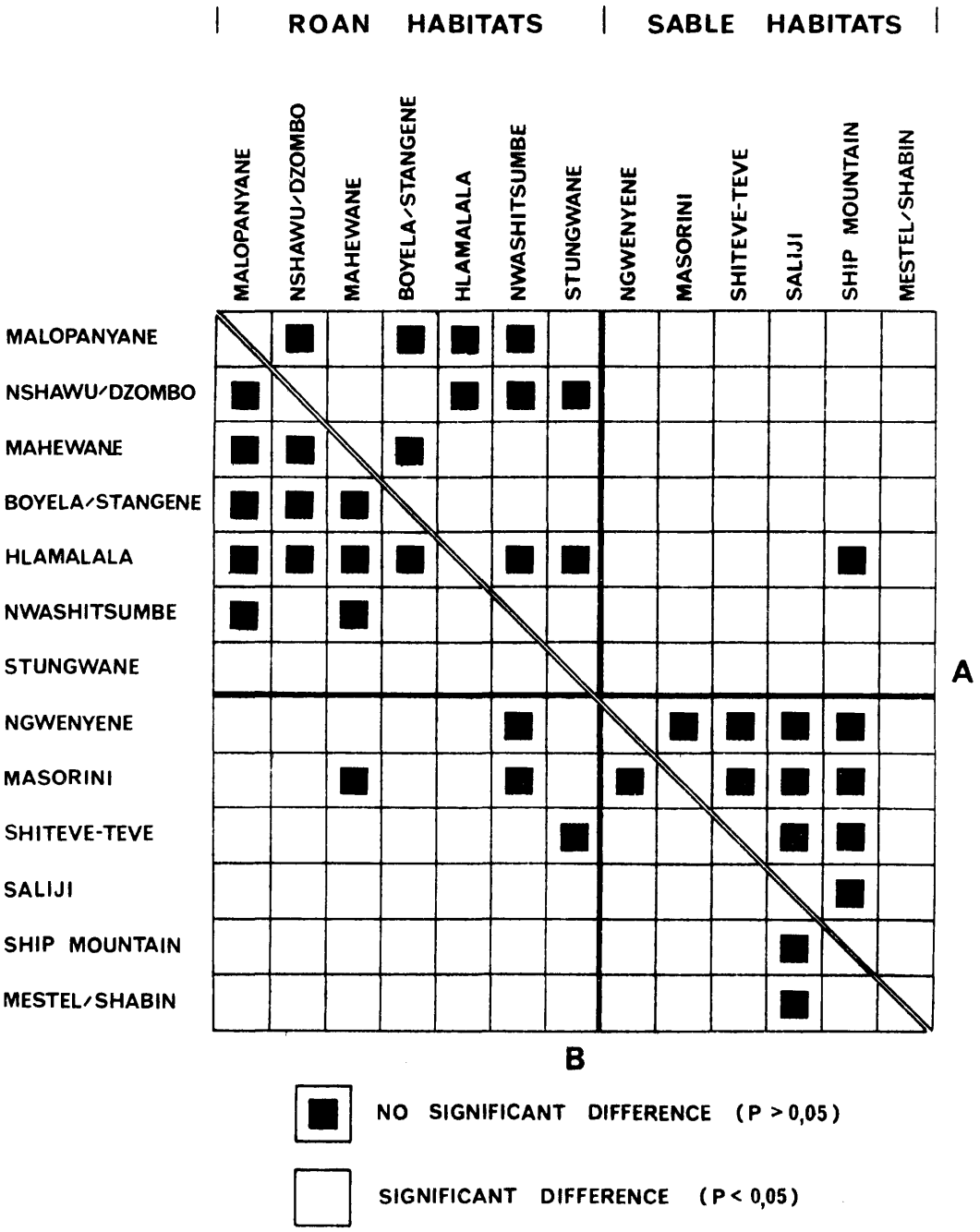

Figure 40 : Degree of differentiation between roan antelope and sable antelope habitats as determined by means of t-tests on the basis of (A) the number of trees in the height interval > 3,0 to 4,0 m and (B) the number of trees in the height interval > 4,0 m in the Kruger National Park, South Africa.

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Canopy cover

By assuming that the crowns of trees and shrubs are circular in shape the total relative canopy cover of each of the major species was calculated for the various height classes. This is considered an important criterion in the structure of the vegetation and the results are given in Table 32, Fig. 42 and Appendix 5.

A large degree of differentiation was obtained by considering the mean crown diameter of the trees and shrubs representative of the different areas sampled. Although the t-tests indicated some uniformity within the roan habitats (Fig. 38A), both the t-tests and F-tests (Table 29) indicated that there was a fair amount of heterogeneity within the roan and sable habitats but with significant differences between the two types of habitats (Table 30).

It would therefore appear that the mean crown diameter is more closely related to plant communities with the same species composition, or at least similar types of growth forms than mere density of woody plants. It's use as an expression of the structure of the vegetation is therefore limited when applied as the mean of all the trees and shrubs, irrespective of the species or height classes.

However, by grouping the trees and shrubs into height classes and converting crown diameters into canopy cover (Table 32 and Appendix 5) a more realistic representation of the structural features of the vegetation may be obtained (Fig. 42). With the same number of sampling sites in each of the two habitat types the denser aspects of the sable areas are once again clearly illustrated by the total relative canopy cover of all species, i.e. 59,61 per cent, as compared to the 40,39 per cent of roan habitats (Appendix 5).

The major differences must, however, be sought in the stratification of the vegetation where 60,09 per cent of the total canopy cover of roan habitats is confined to the 1,0 to 2,0 m height class as compared to the 12,7 per

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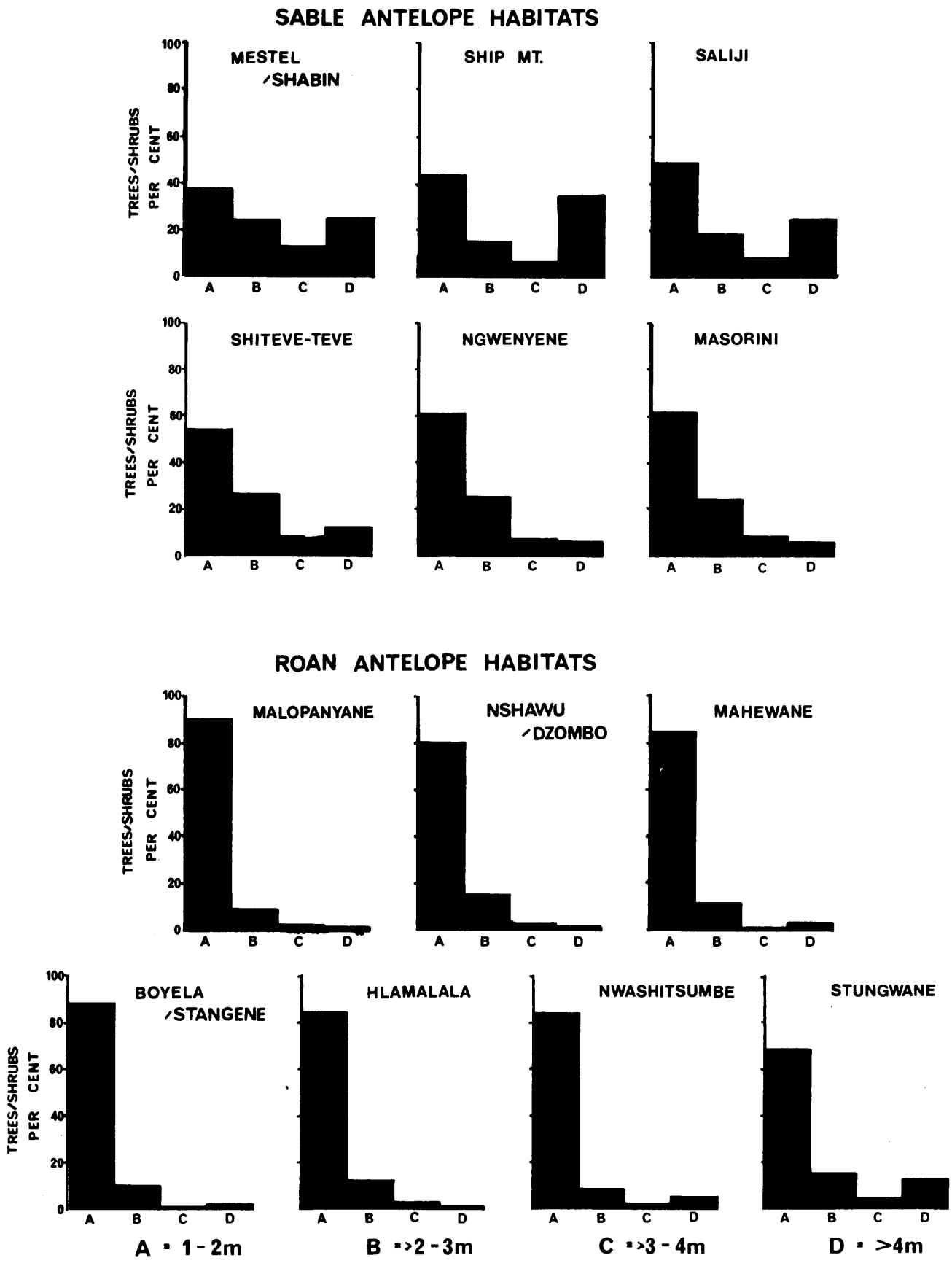

Figure 41 : The relative abundance of trees and shrubs in four height intervals, i.e. 1,0 to 2,0 m (A), > 2,0 to 3,0 m (B), > 3,0 to 4,0 (C) and > 4,0 m (D), in roan antelope and sable antelope habitats in the Kruger National Park, South Africa.

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Table 32 : Summarized relative canopy cover of trees and shrubs in four height intervals in roan and sable habitats in the Kruger National Park, South Africa.

A. ROAN ANTELOPE HABITATS

LOCALITY	RELATIVE CANOPY COVER IN HEIGHT INTERVALS				RELATIVE CANOPY COVER FOR ALL HEIGHT INTERVALS
	1,0 to 2,0 m	>2,0 to 3,0 m	>3,0 to 4,0 m	>4,0 m	
Malopanyane	86,34	12,01	1,64	0	20,23
Nshawu-Dzombo	69,01	20,94	6,83	3,23	17,37
Mahewane	53,93	16,52	13,19	16,36	8,88
Boyela-Stangene	59,49	31,97	3,54	5,00	10,45
Hlamalala	70,21	16,41	12,57	0,81	12,86
Nwashitsumbe	53,70	16,96	4,95	24,39	15,87
Stungwane	14,17	14,99	12,51	58,04	14,34
Relative canopy cover of habitats	60,09	17,82	7,26	14,83	100,00

B. SABLE ANTELOPE HABITATS

LOCALITY	RELATIVE CANOPY COVER IN HEIGHT INTERVALS				RELATIVE CANOPY COVER FOR ALL HEIGHT INTERVALS
	1,0 to 2,0 m	>2,0 to 3,0 m	>3,0 to 4,0 m	>4,0 m	
Mestel-Shabin	6,04	11,76	20,39	61,80	22,36
Ship Mountain	3,25	5,22	3,60	87,93	14,55
Saliji	7,25	10,59	10,98	70,91	20,63
Shiteve-teve	18,99	28,23	18,47	34,32	16,42
Masorini	22,44	32,27	21,88	23,41	10,76
Ngwenyene	24,80	25,89	22,67	26,64	15,28
Relative canopy cover of habitats	12,70	17,64	16,20	53,46	100,00

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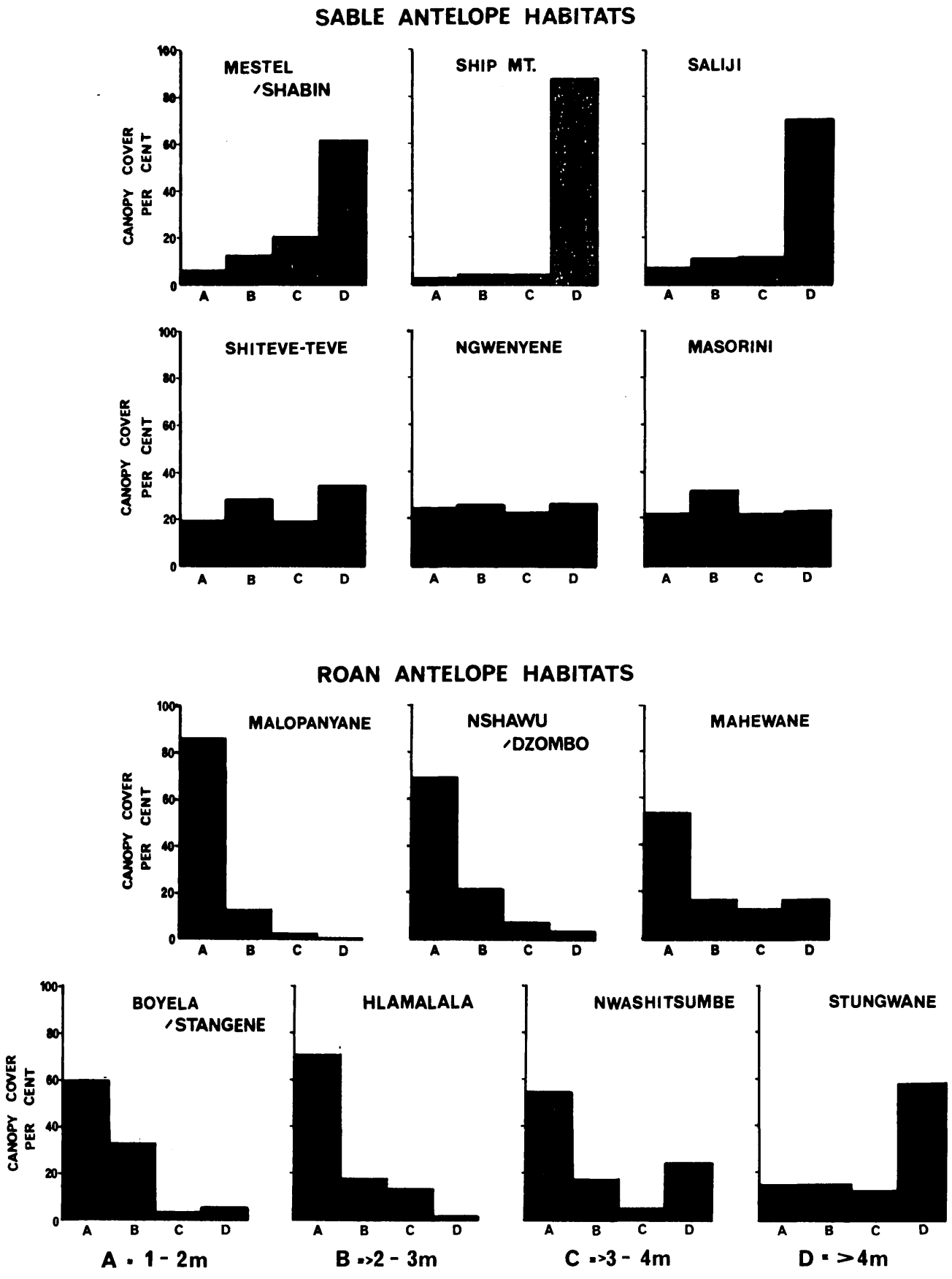

Figure 42 : The relative canopy cover of trees and shrubs in four height intervals, i.e. 1,0 to 2,0 m (A), > 2,0 to 3,0 m (B), > 3,0 to 4,0 m (C) and > 4,0 m (D), in roan antelope and sable antelope habitats in the Kruger National, Park South Africa.

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cent of the sable habitats. There is no difference in the >2,0 to 3,0 m height class (roan 17,82 per cent and sable 17,64 per cent) but in the next two classes (>3,0 to 4,0 m and >4,0 m) there is a sharp decline in the percentage canopy of roan habitats while canopy cover reaches its peak (53,46 per cent) in the case of the sable habitats (Table 32).

These results strongly resemble those obtained by means of visibility calculations with the exception of the >2,0 to 3,0 m height class. Both sets of data suggest that roan are tolerant towards a relatively high vegetation cover up to the 1,0 to 2,0 m level and that the critical criteria in yielding a habitat acceptable or unacceptable to roan must be situated in the degree of cover in the upper height classes with the most critical intervals ranging from >2,0 to 4,0 m .

From the data in Appendix 5 it may also be deduced that although a particular species may be numerically the most abundant in a plant community (i.e. have the highest density) its ecologically functional features, i.e. its significance in a habitat, can only be ascertained by a detailed account of its growth form. For example, in the Mestel-Shabin area Dichrostachys cinerea was found to numerically the most abundant species although in canopy cover its prominence is only reflected in the >2,0 to 3,0 m and >3,0 to 4,0 m height classes while in the >4,0 m group it is exceeded by Terminalia sericea and Sclerocarya caffra (Appendix 5). Where the cover provided by the vegetation plays a more important role in habitat selection than mere species composition, and where the degree of cover becomes a critical factor in a particular stratum, or strata, it would naturally imply that those plant species which contribute the major portion of the cover in those strata are ecologically (or physiognomically) the most important, regardless of their numerical status in the plant communities.

In the case of roan antelope it has been indicated that plant cover in the strata from 1,5 m upwards is an important factor in determining the

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acceptability of the habitat and the most important strata are believed to be between 1,5 m and 4 m . In the open savannas inhabited by the roan, it is doubtful whether trees exceeding 4,0 m in height contribute much in the line of cover which would render the habitat unacceptable. To what extent the density of shrubs in the lower strata or trees in the top strata may increase before rendering the habitat unacceptable, is not exactly known. However, it has been observed that roan largely avoid areas with low shrub thickets and also woodlands with closed canopies. In both cases it is believed that the availability of open stands of medium to tall grasses play a deciding role in the acceptability for roan (see feeding habits) and that where the development of the grass stratum is inhibited by an increase in tree and/or shrub density, the suitability of the habitat for roan will also be affected.

In all the areas surveyed the spatial distribution of woody growth forms provided sufficient space for the development of healthy grass stands. Furthermore, there is statistical evidence that the mean distance between trees and shrubs does not differ significantly between roan and sable habitats which would suggest that the density of woody growth forms in the two types of habitats is of the same order. Major points of difference between roan and sable habitats may, however, be found in the degree of cover in especially the strata above 1,5 m . In both the determination of visibility (Table 26) and relative canopy cover (Table 32) it is obvious that the total cover in these strata in roan habitats is considerably less than that for sable habitats. Again, the critical level is difficult to determine but as most of the roan habitats in the Kruger Park are considered marginal rather than optimal (see later discussion), the threshold between acceptable and unacceptable is believed to be reflected by the results for the roan habitats surveyed. Any increase in the plant cover of these strata could therefore be detrimental to the roan.

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Vegetation composition

Although the data collected were intended primarily to reflect the structural aspects of the habitats and were, therefore, not approached from a purely botanical survey point of view, they nevertheless yielded sufficient information for the determination of the major trees and shrubs in the composition of the various communities. The most important species were determined by merely considering the total number of individuals (above 1,0 m) in relation to the total number sampled (Appendix 6).

In their spatial distribution some tree and shrub species tend to clump while others are more evenly distributed throughout the habitat. This phenomenon is clearly illustrated by considering the frequency of each species, i.e. the number of sampling sites in which the species was encountered in relation to the total number of sampling sites for each area. While only the major species are listed in Appendix 6, the degree of heterogeneity of each area sampled, together with the compositional and distributional frequency status of each species, are further illustrated in Fig. 43 to 47.

APPROACH TO HABITAT STUDIES

Although numerous references to habitat types ascribed to specific animals are cited in the literature, the general approach has been of a subjective nature, merely referring to habitats in broad and often poorly defined terms, such as grasslands, savannas, thickets, woodlands and forests. Tinley (1966b and 1969) has provided detailed definitions for these various categories, based on the physiognomical features of the vegetation. More detailed analyses of wildlife habitats are surprisingly few for such an important aspect of wildlife studies. References to vegetation composition and descriptions of the general physiognomic aspects thereof are distinctly of greater value than the terminology referred to above, though this still does not allow direct comparisons of one area with another.

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Legend:

Boyela-Stangene

A. Colophospermum mopane
B. Combretum imberbe
C. Dalbergia melanoxylon
D. Acacia nigrescens
E. Lonchocarpus capassa
F. Dichrostachys cinerea
G. Grewia spp.
H. Ormocarpum trichocarpum
I. Acacia gerrardii

Hlamalala

A. Colophospermum mopane
B. Dalbergia melanoxylon
C. Lonchocarpus capassa
D. Acacia nigrescens
E. Dichrostachys cinerea
F. Combretum imberbe
G. Grewia spp.
H. Ehretia spp.
I. Acacia gerrardii

Nwashitsumbe

A. Colophospermum mopane
B. Combretum imberbe
C. Lonchocarpus capassa
D. Pterocarpus rotundifolius
E. Ozoroa paniculosa
F. Dalbergia melanoxylon
G. Grewia spp.
H. Sclerocarya caffra
I. Dichrostachys cinerea
J. Albizia harveyi

Figure 44 : The relative abundance (composition) and frequency distribution of the major trees and shrubs in three roan antelope habitats, i.e. Boyela-Stangene, Hlamalala and Nwashitsumbe, in the Kruger National Park, South Africa.

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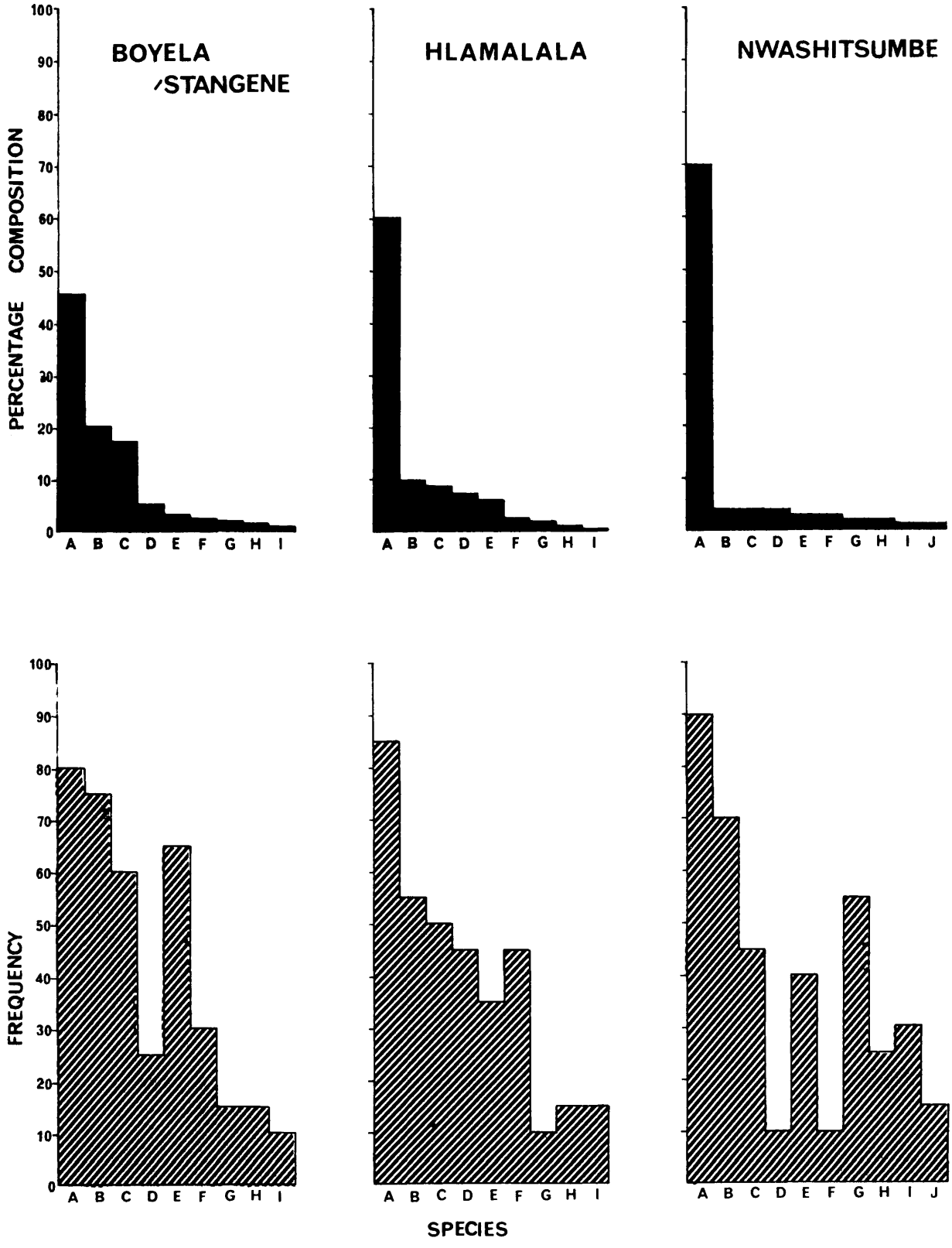

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Legend:

Mestel -Shabin

A. Dichrostachys cinerea
B. Terminalia sericea
C. Sclerocarya caffra
D. Annona senegalensis
E. Rhus spp.
F. Combretum molle
G. Maytenus heterophylla
H. Combretum colinum
I. Maytenus senegalensis
J. Parinari curatellifolia
K. Acacia gerrardii
L. Lonchocarpus capassa
M. Ximenia caffra.
N. Euclea schimperi
O. Diospyros mespiliformis
P. Dalbergia melanoxylon
Q. Grewia spp.
R. Strychnos madagaskariensis
S. Acacia caffra
T. Faurea saligna
V. Dombeya rotundifolia
W. Antidesma venosum
Y. Euclea divinorum
Z. Pavetta schumanniana
a. Zeromphis obovata
b. Piliostigma thonningii

Ship Mountain

A. Combretum apiculatum
B. Acacia nigrescens
C. Acacia exuviales
D. Dichrostachys cinerea
E. Combretum hereroense
F. Acacia gerrardii
G. Bolusanthus speciosus
H. Terminalia sericea
I. Combretum zeyheri
J. Sclerocarya caffra
K. Maytenus heterophylla
L. Strychnos madagaskariensis
M. Pterocarpus rotundifolius
N. Grewia spp.
O. Ozoroa reticulata
P. Dombeya rotundifolius
Q. Euclea divinorum
R. Ziziphus mucronata
S. Acacia caffra
T. Combretum imberbe
V. Ormocarpum trichocarpum
W. Dalbergia melanoxylon

Figure 45 : The relative abundance (composition) and frequency distribution of the major trees and shrubs in two sable antelope habitats, i.e. Mestel-Shabin and Ship Mountain in the Kruger National Park, South Africa.

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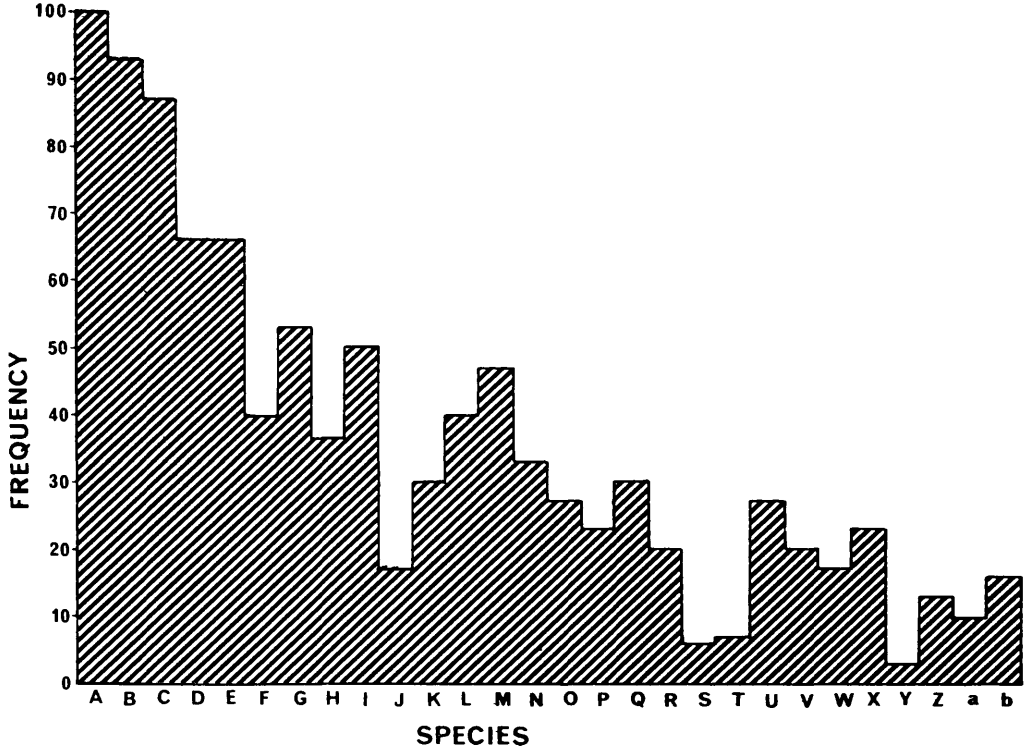

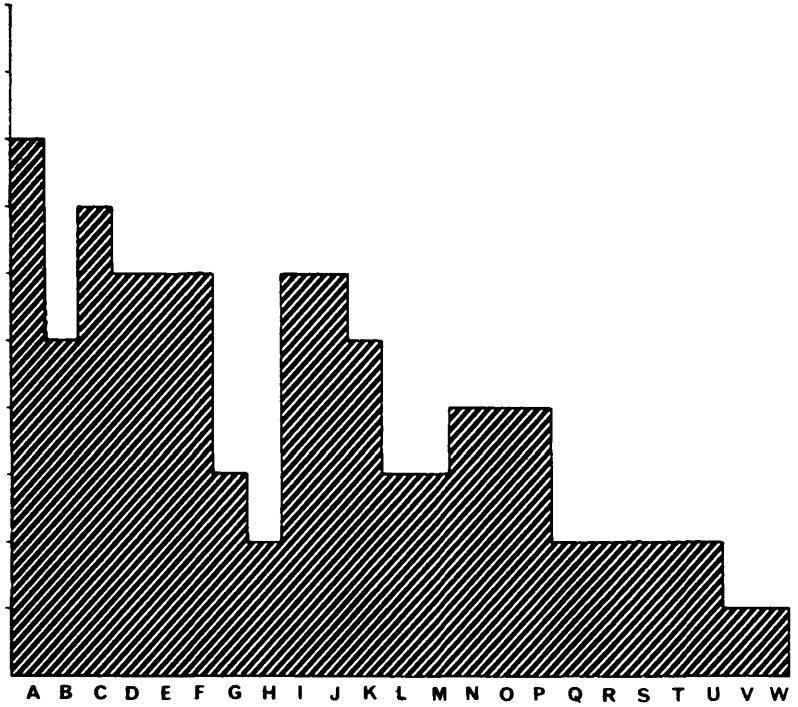

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Legend:

	Saliji	Shiteve-teve
A.	Albizia harveyi	Albizia harveyi
B.	Combretum apiculatum	Dichrostachys cinerea
C.	Dalbergia melanoxylon	Pterocarpus rotundifolius
D.	Dichrostachys cinerea	Acacia nigrescens
E.	Acacia welwitschii	Maytenus heterophylla
F.	Combretum zeyheri	Acacia gerrardii
G.	Acacia exuvialis	Combretum hereroense
H.	Albizia evansii	Dalbergia melanoxylon
I.	Euclea divinorum	Combretum zeyheri
J.	Acacia nigrescens	Combretum apiculatum
K.	Acacia gerrardii	Combretum imberbe
L.	Combretum hereroense	Maytenus senegalensis
M.	Lannea stuhlmanni	Terminalia sericea
N.	Sclerocarya caffra	Euclea divinorum
O.	Lonchocarpus capassa	Cassia petersiana
P.	Grewia spp.	Securinega virosa
Q.	Strychnos madagaskariensis	Cissus spp.
R.	Rhus sp.	Lonchocarpus capassa
S.	Cissus spp.	Sclerocarya caffra
T.	Securinega virosa	Peltophorum africanum
U.	Terminalia sericea	Grewia spp.
V.	Ormocarpum trichocarpum	Lannea stuhlmanni
W.	Maytenus heterophylla	Albizia evansii
X.	Pappea capensis	Ziziphus mucronata
Y.	Combretum imberbe	
Z.	Cassia abbreviata	
a.	Ximenia africana	

Fig. 46 : The relative abundance (composition) and frequency distribution of the major trees and shrubs in two sable antelope habitats, i.e. Saliji and Shiteve-teve in the Kruger National Park, South Africa.

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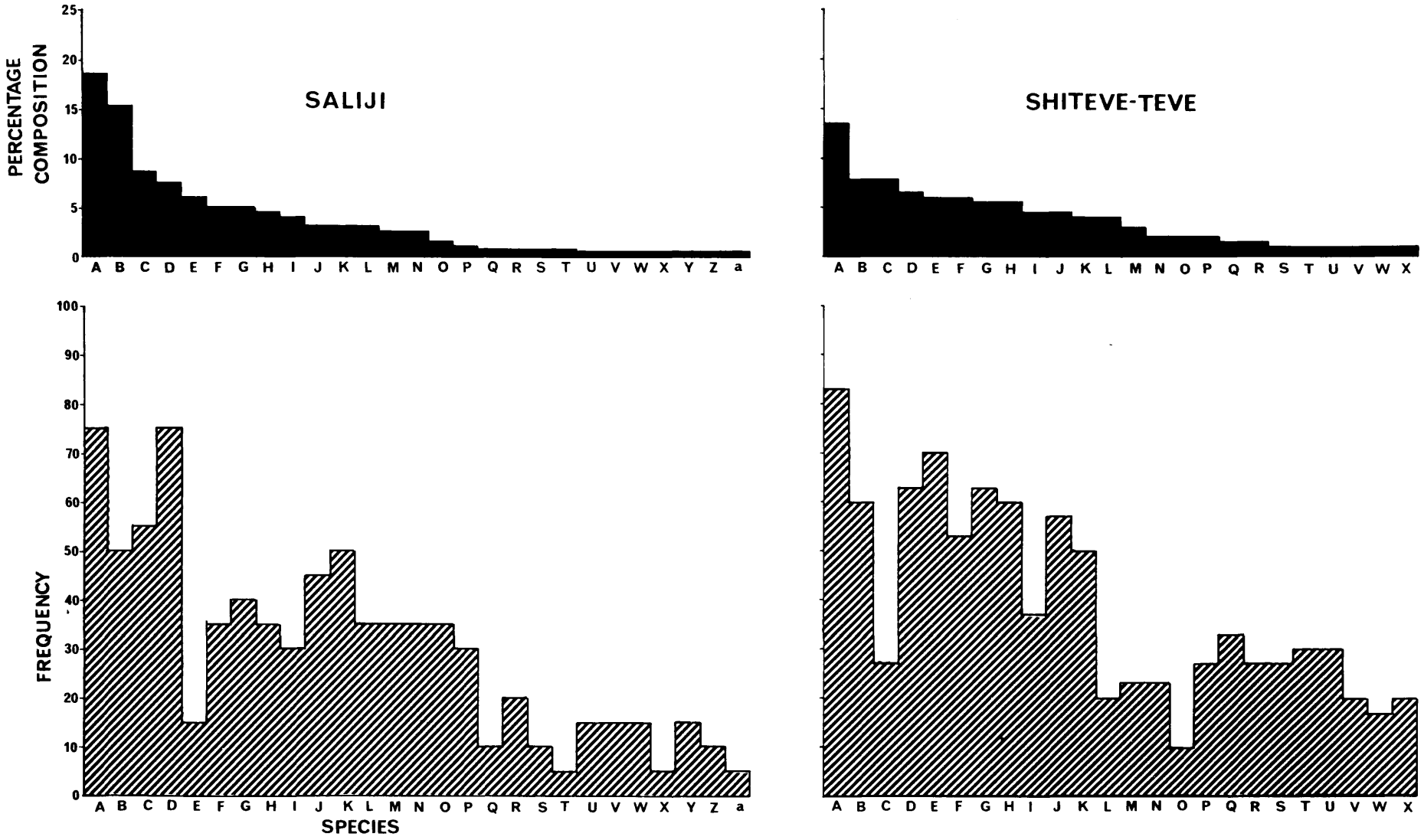

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Legend:

	Ngwenyene	Masorini
A.	Colophospermum mopane	Colophospermum mopane
B.	Combretum apiculatum	Combretum apiculatum
C.	Acacia nigrescens	Dichrostachys cinerea
D.	Cissus lonicerifolius	Terminalia sericea
E.	Dichrostachys cinerea	Cissus sp.
F.	Grewia spp.	Acacia nigrescens
G.	Terminalia sericea	Combretum hereroense
H.	Commiphora mollis	Mundulea sericea
I.	Acacia exuviales	Albizia harveyi
J.	Dalbergia melanoxylon	Maerua spp.
K.	Lannea stuhlmanni	Grewia spp.
L.	Ozoroa insignis	Lannea stuhlmanni
M.	Commiphora africana	Ozoroa insignis
N.	Albizia harveyi	Dalbergia melanoxylon
O.	Combretum hereroense	Strychnos madagaskariensis
P.	Lonchocarpus capassa	Securinega virosa
Q.	Sclerocarya caffra	Bolusanthus speciosus
R.	Securinega virosa	Rhus sp.
S.	Commiphora pyracanthoides	Acacia exuviales
T.	Euclea divinorum	Ziziphus mucronata
U.	Ziziphus mucronata	Euclea divinorum
V.	Maerua parvifolia	Ximenia caffra
W.	Peltophorum africanum	Rhigozum mossambicensis
X.	Combretum mosambicensis	Z. Combretum imberbe

Fig. 47 : The relative abundance (composition) and frequency distribution of the major trees and shrubs in two sable antelope habitats, i.e. Ngwenyene and Masorini in the Kruger National Park, South Africa.

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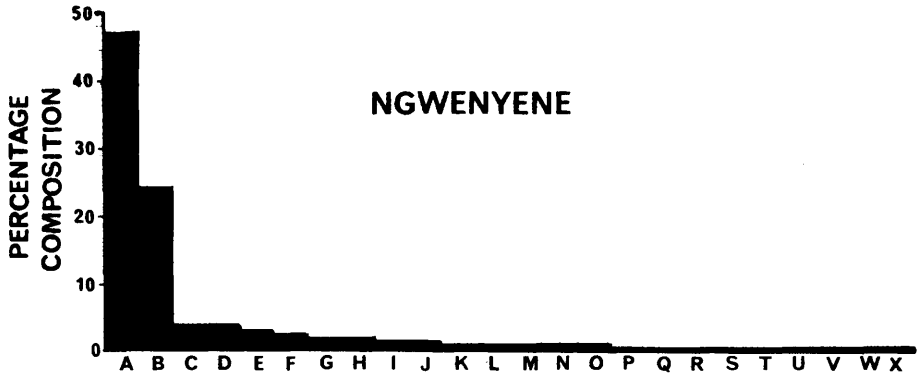

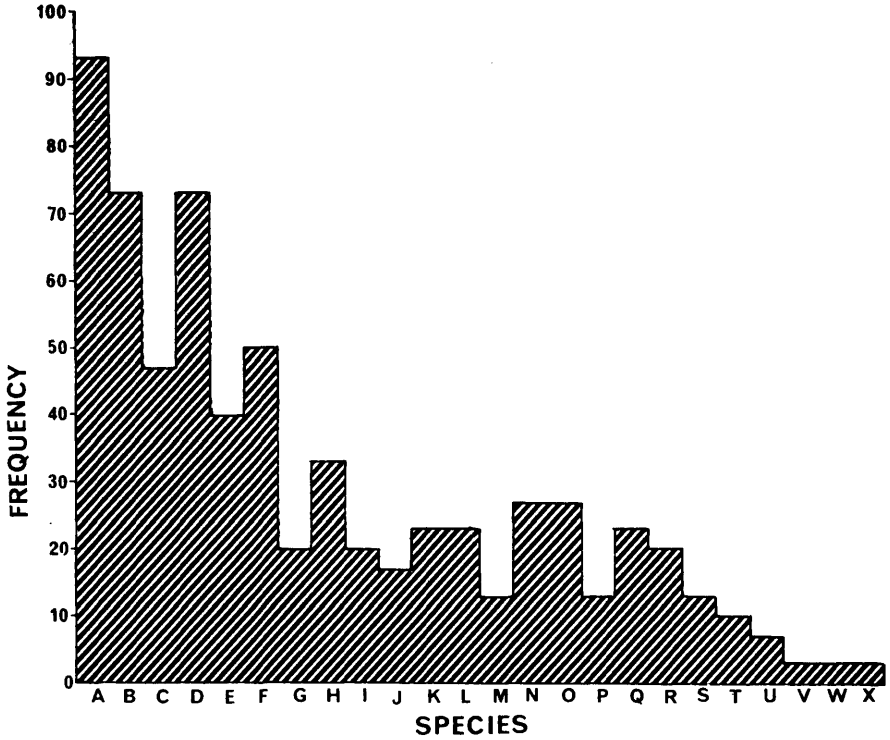

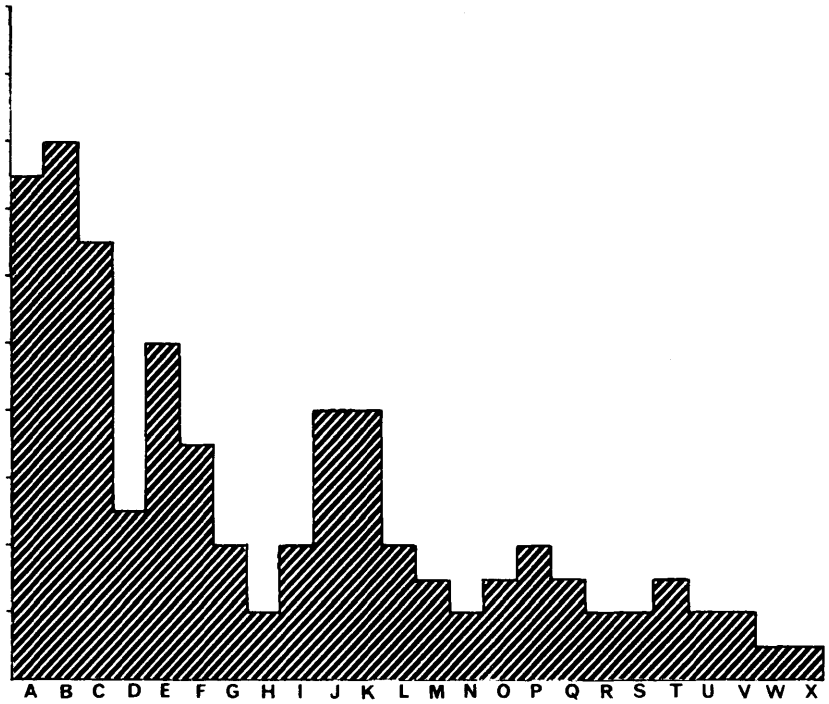

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References to wildlife habitats have mainly been included in ecological studies to indicate the association of different animals with specific habitats (cf. Fraser Darling 1960, Grzimek and Grzimek 1960, Talbot and Talbot 1963, Pienaar 1966 and 1974, Field and Laws 1970).

In the Tarangire National Park of Tanzania, Lamprey (1963) illustrated the ecological separation of 14 different ungulates on the basis of habitat selection throughout or at different times of the year while Vesey-Fitzgerald (1960) drew attention to the successional utilization of the same habitat by different herbivores in accordance with the stage of growth or degree of utilization of the vegetation. In many of these studies the factors determining habitat preferences - based on the relative height of especially the grass stratum of the vegetation or the availability of food plants - have been pointed out.

In a more recent study Hirst (1975) made a detailed analysis of the habitats in a small area of the Timbavati Game Reserve in South Africa and recorded 25 different aspects of the habitat which were later correlated with the amount of utilization by various ungulates and the habitat preferences of each was determined by means of principle component analyses. In this way the factors affecting the habitat preferences of the different ungulates could be isolated. In the Kyle National Park, Rhodesia, Ferrar and Walker (1974) adopted a similar approach in determining the relationships between herbivores and their preferred habitats.

In the present study the emphasis has been on the vegetative aspects of roan and sable habitats with the major objective of isolating those factors which may be decisive in determining the acceptability of an area for roan.

General discussion of roan habitats

The habitats occupied by roan have frequently been described as open or lightly wooded savanna, wooded grasslands or grass plains (Pienaar 1963, Smithers 1966, Dorst and Dandelot 1970). However subjective these terms may be,

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and irrespective of their exact interpretation, they all accentuate essentially one major feature in roan habitats, i.e. their openness. The roan must therefore be regarded as one of the characteristic antelopes of lightly wooded or open grassland savannas. The distribution of the species (Chapter 2) also indicates a wide range throughout most of the Northern and Southern Savanna zones, with the exception of the eastern areas of the Southern Savanna (Ansell 1971

During the course of this study roan were observed in three different areas in addition to the Kruger Park, i.e. the Quicama and Bicuar national parks of Angola and the Tjolotjo Tribal Trustlands, south of the Wankie National Park in Rhodesia. Although no detailed surveys of these habitats were undertaken, a brief description will suffice to indicate their main features.

Angola

In the Quicama National Park roan mainly occupied three different plant communities, i.e. open Eragrostis superba - Eragrostis fascicularis Savanna with a sparse covering of trees and shrubs, Schizachyrium sanguineum Savanna with a heavier covering of woody plants and Setaria welwitschii Grassland almost devoid of any trees or shrubs. In plant composition the major dominants in the Eragrostis superba - Eragrostis fascicularis Savanna were Eragrostis superba, Eragrostis fascicularis, Heteropogon contortus and Digitaria milanjiana while the tree and shrub strata included, among others, Adansonia digitata, Hyphaene guineense, Euphorbia conspicua, Commiphora spp., Carissa edulis and Strychnos spinosa. This habitat carried the highest density of roan and consisted of vast areas of open grasslands widely interspersed with clumps of Hyphaene guineense or other trees and shrubs (Fig. 32A).

The most homogeneous community was the Setaria welwitschii Grassland. This tall robust grass entirely dominated the physiognomy and composition of the community. In the lower-lying areas other species such as Sporobolus robustus and Bothriochloa sp. were also common. Trees and shrubs were almost

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entirely absent but for the occasional Maerua angolensis, Capparis subglabra and a few others.

From a tree and shrub point of view the Schizachyrium sanguineum Savanna was the most heavily wooded area although it could still fall within the category of open wooded savanna. In tree and shrub density it varied from fairly open, lightly wooded to relatively thickly wooded savanna. A wide variety of grasses formed the grass stratum, including tall grasses, i.e. grasses exceeding 1,5 m in height, such as Hyparrhenia rufa and Schizachyrium sanguineum. The ascending shrub and tree strata were composed of many of the species occurring in the Eragrostis superba - Eragrostis fascicularis Savanna and, in addition, Combretum psidioides, Combretum zeyheri, Sterculia sp., Boscia sp. and a variety of others.

The density of roan in the three communities was calculated by dividing the number of roan seen by the total distance travelled through each community and resulted in 1,17 roan per kilometre in the Eragrostis superba - Eragrostis fasicularis Savanna, 0,34 roan per kilometre in the Setaria welwitschii Grassland and 0,03 roan per kilometre in the Schizachyrium sanguineum Savanna. These figures clearly accentuate the roan's preference for open, lightly wooded savanna areas. The greater abundance of roan in the Eragrostis superba - Eragrostis fascicularis Savanna compared to the Setaria welwitschii Grassland could possibly be ascribed to the superiority of the food source in the former (this is a subjective impression gained from observations and may be erroneous) and the fact that the latter was largely distributed over the rugged inclines of the escarpment of the Cuando River Flood Plain.

In the Bicuar National Park the major part of the vegetation consisted of vast Brachystegia speciformis - Julbernardia paniculata Woodland, dissected by numerous shallow and broad drainage lines. The drainage lines were more than a kilometre broad in many areas and covered by dense grass stands, thereby creating

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open grasslands in otherwise thick woodland. These grass-covered drainage lines are a characteristic feature of the expanses of Brachystegia spp. woodlands extending over great parts of central southern Africa and are commonly referred to as "dambos" or "mulolas". Typical Brachystegia spp., woodlands have closed canopies but are fairly open in the lower strata and although roan have been observed in the more open areas of such woodlands, their main concentration areas are the grasslands of the "dambos". The ecotones between the open grasslands and the woodlands are utilized for resting while the main part of the roan's habitat falls within the grasslands.

Rhodesia

In the Sehubu area of the Tjolotjo Tribal Trustlands immediately south of the Wankie National Park in Rhodesia, much the same situation prevails as described for the Bicuar National Park. In many areas the otherwise thick stands of Colophospermum mopane Woodland are interrupted by large shallow depressions with heavy soils which maintain tall grasslands with an almost total absence of trees and shrubs. Once again, these open grasslands together with the ecotone with the adjoining woodlands, form the major part of the habitat of the roan in the area (Fig. 32B).

The roan population of the Quicama National Park, numbering approximately 2 000 (Joubert 1969, Huntley 1971[b]), probably represents one of the largest concentrations of the roan in Africa. Among the factors that have contributed to the roan's success in the area, optimal habitat conditions may unquestionably be regarded as one of prime importance. Similarly, the population of an estimated 300 in the Bicuar National Park occupy a total area amounting to no more than approximately 20 per cent of the areas considered to be reasonable roan habitat in the Kruger Park.

In Chapter 4 the various known limiting factors affecting the population growth of roan in the Kruger Park have been analysed. Although factors such as disease play the most important role as a decimating factor (in both the above-

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mentioned areas the limiting factors are unknown and predation is negligible due to very small carnivore populations) the percentage composition of the three populations compare favourably with one another. Calves under one year of age comprised 24,27 per cent in the Quicama National Park, 27,35 per cent in the Bicuar National Park and 22,40 per cent in the Kruger National Park (mean for 4 years) while two- and three-year-olds contributed 25,1 per cent (Quicama), 29,91 per cent (Bicuar) and 22,21 per cent (Kruger) towards the populations. In spite of the fact that the Kruger Park population is slightly lower in both categories there is no evidence to suggest that mortality factors are responsible for the low population level. One of the main causes for the low population level may, however, be the lack of sufficient suitable habitat.

All the available evidence on the past and present distribution of roan indicate that the Kruger Park population falls within the fringes of the extreme south-eastern range of the roan. This fact alone does not prove that the situation was brought about by the lack of suitable habitat although it could certainly be interpreted as a strong indication thereof. There is every reason to believe that the primary areas occupied by roan in the Quicama and Bicuar national parks represent optimum roan habitats and if this assumption were accepted, there is also sufficient evidence to indicate that optimum roan habitats in the Kruger Park are restricted to almost insignificantly small and isolated patches while the majority of the areas regarded as even reasonable roan habitats are only secondary or marginal in quality.

Unfortunately any comparisons of the areas to determine the differences must be subjective although the most obvious differences are in the lower shrub strata. In the areas sampled within the Kruger Park it has been shown that the height interval between 1,5 m and 4,0 m is the most critical in determining the suitability of an area for roan while shrub growth in the lower (grass) stratum is less decisive in habitat selection by roan. However, the one conspicuous difference between the Quicama and Bicuar habitats

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and that of the Kruger Park is the almost complete absence of a dense shrub layer in the former two areas. It may therefore be deduced that while roan are obviously tolerant towards low shrub growth they are nevertheless sensitive to it and it should therefore be considered inhibitory to the full exploitation of the habitat in the Kruger Park. It should also be borne in mind that the critical higher shrub strata arise from the lower shrub layer so that remedial management projects should be directed at the reduction or elimination of the shrub layer to ensure more suitable habitats (see Chapter 7).

Distribution and availability of suitable roan habitats in the Kruger National Park.

The areas in which roan still occur naturally in the Kruger Park may be subdivided into three geographical areas which may be differentiated from one another on the basis of topography, substrate and vegetation, i.e. the extensive, slightly undulating flats of the north-eastern sector of the Park stretching from the Letaba River in the south to the foothills of the Punda Milia mountain ranges in the north, the western complement of the area north of the Letaba River, ranging from broken hilly country to gently undulating country dissected by numerous well defined seasonal river courses, and a similar though more restricted tract of country in the south-western part of the Park in the neighbourhood of Pretoriuskop (cf. Pienaar 1963).

The north-eastern Lebombo Flats

Of the total roan population of the Kruger Park approximately 75 to 80 per cent of the animals are concentrated within this zone and therefore renders it the most important single habitat type for the roan within the Park. The southern and northern extremes of the flats have been outlined above while the eastern boundary is formed by the Lebombo Mountain Range and the western boundary by the Tsendi, Mphongolo and Shisha rivers.

The substrate in this zone consists predominantly of heavy clay soils

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of a black colour derived from basalt (Van der Schijff 1957, Van Wyk 1972). The depth of the basaltic soils varies considerably and may exceed 1,0 m . Over extensive areas the underlying formation consists of a deep and impervious layer of calcareous rock.

The physiognomy of the vegetation varies greatly throughout the region although compositionally it is characterised by the preponderance of Colophospermum mopane (Van der Schijff 1957, Pienaar 1963, Van Wyk 1972).

Pienaar (1963) distinguished between two major wildlife habitats in this area and designated them as "grassland plains and 'dambos', and mopane scrub and tree savanna". The major part of the north-eastern Lebombo Flats consists of the low shrub growth form of Colophospermum mopane which occurs in varying densities interspersed with trees and with only limited areas of relatively open grasslands and 'dambos'. The Malopanyane, Nshawu-Dzombo, Mahewane, Boyela-Stangene, Hlamalala and Nwashitsumbe surveys are all representative of this area, and Fig. 43 and 44 and Appendix 6 all clearly illustrate the high occurrence of Colophospermum mopane shrubs in these habitats.

An important feature of the north-eastern Lebombo Flats is the occurrence of a number of open tree savanna areas where the knobthorn Acacia nigrescens is locally the most abundant species in the almost total absence of Colophospermum mopane. Two especially important Acacia nigrescens plains are found in the Nwashitsumbe-Stangene-Boyela area in the northern half of the flats and in the Tihongonyene-Nshawu region to the south. In all aspects these Acacia nigrescens plains are more representative of the roan habitat than the Colophospermum mopane areas and this is evidenced by the fact that the highest roan density is found in the former (and more extensive) of the two areas.

The total north-eastern Lebombo Flats area comprises some 2 800 km^2 with 12 to 15 established roan activity zones, i.e. roughly between 180 and 230 km^2 per activity zone. Known activity zones of roan were estimated to range between

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60 and 100 km^2 (Joubert 1970, 1974a) so that the area could well be expected to include anywhere between 28 and 46 activity zones if fully utilized. However, of the total area it has already been indicated that the grass-covered drainage systems are the most favoured parts of the roan habitats and if these, together with the areas where roan are known to occur, are taken into account, it materialises that roan inhabit only approximately 1 400 km^2 of the area, i.e. 93 to 116 km^2 per roan herd. This is clearly more in keeping with the known size-range of the activity zones.

If, however, only the "dambos" and their immediate environs and the Acacia nigrescens plains were considered, it is found that the nearest approximation to true roan habitat in the Kruger Park comprises only about 300 km^2. This figure may be regarded as further confirmation of the earlier conclusion that the major proportion of what is considered good roan habitat in the Park is in fact, only secondary or marginal in comparison with optimum habitats. It may therefore be argued that quite apart from the extensive areas devoid of roan, their occupation of significant proportions of their present range may be a result of population pressure and the lack of more suitable areas. This is certainly also the impression gained by observing roan herds in such areas as the upper reaches of the Gadzingwe River, Shipandi, Nkokodzi - Joao and even in the Mahewane area.

It is also especially noteworthy that in the area immediately north of the Nkulumbene River southwards to the Shingwidzi River, sable antelope outnumber roan by 55 to 20, as determined during 1973 and 1974. This area includes the Mahewane and Gadzingwe areas and is clearly more suitable for sable than for roan. Conversely, in more favourable roan areas north of the Nkulumbene River, roan are by far in the majority.

In Chapter 4 the effects of anthrax epizootics in limiting roan population growth have been illustrated and due to, or in spite of, these epizootics it has also been pointed out that the northern roan population appears to have

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maintained its asymptote at plus or minus 300 animals since at least reasonable record of the population has been kept. Although various factors may have been instrumental in bringing about this situation the effect of limited habitat may certainly not be overlooked. It is unfortunate that animal-habitat relationships are, as yet, still poorly understood although varying densities of animal populations have frequently been aligned to variations in the availability of the food resource, competition with other animals with similar food or habitat requirements, predation and self-limiting social behaviour (cf. Errington 1956, Calhoun 1962, Wynne-Edwards 1964). The regulatory function fulfilled by the habitat is obviously of such a complex nature that the correct interpretation of cause and effect is often blurred by confusion. In the case of the roan the limiting factors are generally ascribed to disease, predation and lack of sufficient watering points, and management projects have been devised to counteract these as the causes rather than as the symptomatic manifestations resulting from population pressure due to a lack of suitable habitat.

The general conclusion arrived at for the north-eastern Lebombo Flats habitats is that the roan population has already overflowed into sub-marginal habitats and that the lack of suitable habitats should therefore be regarded as the primary population regulatory mechanism affecting its growth (cf. Chapter 7). However, even under the present circumstances the elimination of the "effects" could be expected to result in the expansion of the population and although many of the areas still unoccupied may be regarded as sub-optimal, greater population pressure should nevertheless result in the establishment of activity zones within their confines.

The north-western mixed Combretum apiculatum - Colophospermum mopane communities

These communities cover a considerable area from the Letaba River in the south to the neighbourhood of Punda Milia in the north. On the eastern side they are flanked by the Lebombo Flats and on the western side they eventually

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merge into mixed Combretum spp. communities beyond the western limits of the Kruger Park (Van der Schijff 1957). However, since the erection of a game-proof fence on the western boundary of the Park, the western limits of this habitat-type are formed by an arbitrary line cutting through the mixed Combretum apiculatum - Colophospermum mopane communities.

Topographically the area is characterised by a gently undulating landscape with numerous seasonal rivers. The soils are mainly derived from archaic granite, which manifests itself in outcrops of small inselbers composed of a number of large boulders, and range from patches of deep sand to shallow skeletal soils on the higher ground and clayloam soils in the depressions. A number of dolerite intrusions are also present and give rise to heavy dark soils resembling those of the Lebombo Flats (Van der Schijff 1957, Van Wyk 1972).

Botanically the area is considerably more diverse than its eastern counterpart with Combretum apiculatum and Colophospermum mopane the two most abundant species. On the sandy patches Terminalia sericea is prominent. A variety of other associated shrubs and trees are also present (Van der Schijff 1957, Pienaar 1963, Van Wyk 1972). Physiognomically the area is more representative of sable antelope habitats than those of roan with dense shrub and tree strata above 1,0 to 2,0 m in height. Of the habitats surveyed, Masorini and Ngwenyene (Tables 27 and 28, Fig. 34B and C) are representative of this area.

A few herds of roan are known to occur within this habitat type in spite of the fact that it could, with the exception of a few limited areas, be considered atypical of true roan areas and almost certainly be classified as sub-marginal.

It is therefore not surprising that apart from a number of lone roan bulls or bachelor groups, only four and possibly five nursery herds are known from this area which covers well over 4 000 km^2. Even though two or three hitherto unknown smaller herds may occur in this zone, the extremely small population

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size would still be a reflection of the uninhabitability of the area for roan. The small isolated areas in which roan are able to establish their activity zones could therefore only serve to absorb the overflow from neighbouring areas with a high population pressure.

The south-western Large-leaved Deciduous Woodland

The third area in which roan still occur naturally is situated in the south-western region of the Park, extending from the Malelane Mountain Range in the south to the Paben and Sabi rivers in the north, and from the fenced western boundary (along the Nsikazi River) eastwards to the verge of the denser mixed Combretum spp. and Acacia spp. communities demarcating the drop into the Sabi River basin. Altitudinally this area is higher than the two previous areas (Chapter 1) with a correspondingly higher annual rainfall (Table 1). Topographically and in soil characteristics the area is comparable to the north-western zone described previously with differences in soil colour and texture being ascribed to the higher precipitation. In general features it is also more hilly and undulating than the north-western zone (Van der Schijff 1957, Pienaar 1963, Van Wyk 1972).

Vegetationally, this area differs quite significantly from the north-western area with a much larger variety of trees and shrubs, of which Dichrostachys cinerea, Terminalia sericea, Parinari curatellifolia and Sclerocarya caffra are conspicuous in addition to a large variety of others (Van der Schijff 1957, 1958, Pienaar 1963, Van Wyk 1972). It is further also characterised by its tall grasses of which Hyperthelia dissoluta is the most conspicuous. A major proportion of this habitat is formed by a large dolerite intrusion which originates just south of Ship Mountain and runs from south to north through the area (Fig. 2). The heavy dark clay to clay-loam soil derived from the dolerite sustains a considerably more open-aspect type of vegetation and in some areas results in fairly large and relatively open savanna plains. The structural features of the vegetation

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are represented in the surveys of the Mestel-Shabin, Stungwane and Ship Mountain areas (Tables 26 and 28).

Of the three areas surveyed in this zone only Stungwane is considered to be typical of the habitats frequented by roan as it represents the area in which roan are most frequently encountered. Although Stungwane is in itself regarded as marginal for roan, a study of Figures 35, 41 and 42, in which the various features of the habitats are compared with one another, reveals several similarities with the more typical roan habitats whereas it differs markedly from the surrounding areas - including Mestel-Shabin and Ship Mountain.

An estimated population of 25 to 35 roan still inhabit this area and represent the last survivors of a once flourishing population reported for these south-western regions. However, as pointed out in Chapter 4, this south-western sub-population should rather be regarded as the extreme eastern fragment of the erstwhile population since the available records indicate that the range of this population once extended to the west of Pretoriuskop (to the foothills of the Drakensberg Mountain Range) and that the majority of these animals were lost with the excision of the area from the Sabi Game Reserve in 1923.

The remaining area available for roan in the vicinity of Pretoriuskop must therefore be regarded as an insignificantly small part of their once favoured habitats. Although the remaining area as a whole can only be classified as sub-optimum habitat, a number of superficially quite suitable areas are still available for roan occupation. Their absence in the entire area north of Pretoriuskop to the Paben and Sabi rivers and also in the more eastern open savanna plains of the dolerite intrusion, is difficult to explain. Habitat-wise these areas appear to conform to the requirements of the roan as both are physiognomically open savanna areas with a well developed grass stratum. Other largely uninhabited and apparently suitable areas for roan include the more lightly wooded regions on the gentle slopes of and depressions between the hills south of Ship Mountain.

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The small population of roan in this zone has been holding its own for several years without any apparent expansion in either range or numbers. In this respect it is similar to both the northern sub-populations and once again the conclusions must be drawn that the losses counterbalance the increase in numbers. Whatever the reasons may be for the stagnancy in the numbers and the difficulties in defining cause and effect, no management programme aimed at increasing the populations could possibly render any long-term solution or improvement without due consideration of the basic and essential habit requirements of the species.

Areas where roan antelope have become extinct in recent years

In addition to the areas mentioned above, roan antelope also occurred in two other areas of the Kruger Park where they have either become extinct, as in the Shiyanamane-Swartkops area along the western boundary, or where extinction is inevitable, as in the Muntshe-Nkuane area on the eastern boundary.

Shiyanamane-Swartkops area

It is of interest that the Shiyanamane area to the north of Kingfisher-spruit refers to a seasonal river and that it is also the local Shangane name for the roan antelope. Roan were never known to be common in this area and were represented by a few odd groups, probably never totalling more than 25 to 35 animals. In the pre-1960 period these roan freely crossed the Park's western boundary to the adjoining game farms in their normal daily and seasonal activities. After the erection of the game-proof fence along the western boundary in 1961/'62, at least part of their normal haunts were cut off and the already declining population eventually ceased to exist towards 1965/'66 (Chapter 4).

The topography, soils and vegetation of this area are typical of the western plant communities of the Park, floristically consisting of either Combretum spp. or mixed Combretum apiculatum - Colophospermum mopane communities and are typical of the habitats surveyed at Shiteve-teve, Masorini and Ngwenyene

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(Tables 26 and 28). The area also falls within the extreme southern extensions in the distribution of Colophospermum mopane. Very little of the early history of the roan population was documented for this area apart from the rather vague statement by Kirby (1939) that they occurred from the vicinity of Mariepskop and along the Olifants River. It would therefore appear that this area represented the extreme eastern limits in the distribution of the roan and on the basis of the present-day habitats the area could decidedly be classified as sub-marginal for roan.

Although the hazards created by the erection of the western boundary fence and the loss of part of the roan's former range may have largely or directly contributed to the eventual extinction of the roan in this area, there can be little doubt that the unsuitability of the habitat available to them within the Park would also have exerted a detrimental influence on the few remaining herds, thereby exaggerating the other limiting factors and hastening the roan's disappearance

Muntshe-Nkuane area

The last signs of this once small remnant population are still evidenced by the occasional sighting of one or two lone bulls which are believed to be the last stragglers. The area once frequented by the few small groups is the undulating plateau of the Lebombo Mountain Range. The soils are mainly of riolytic origin and are generally poor or skeletal (Pienaar 1963) while the vegetation somewhat resembles that of the western areas of the Park and may be defined as mixed Combretum apiculatum - Pterocarpus rotundifolius Savanna (Van der Schijff 1957, Pienaar 1963, Van Wyk 1972).

If anything, the vegetation differs physiognomically from the western communities by being more open in the higher shrub and small tree strata. In this respect this habitat should be more acceptable to roan than those in the western areas though it could still not be regarded as favourable. An interesting phenomenon is that roan never seemed to have established themselves on the open

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flats at the foot of the Lebombo Mountain which in all respects could be regarded as far superior habitat than the plateaus. A possible explanation for this apparent anomaly is the fact that the plains form one of the main winter (dry) season concentration areas of many thousands of wildebeest and zebra. During these annual concentrations - in normal years commencing towards the end of March and continuing until the first substantial spring rains - the grass stratum of the open savannas is trampled and grazed to the ground, thereby eliminating from the habitat one of the basic, and critical, essentials of favoured roan habitats.

In assessing cause and effect in the downward trend of both these populations, the role of sub-optimum habitats cannot be overlooked as even the effects of the direct causes of mortality such as the erection of the western boundary fence, predation or disease, are undoubtedly largely determined and/or modified by existing habitat conditions. The roan's habit of occupying fixed activity zones (Joubert 1970a, 1974) would also have aggravated the negative affects of the habitat and in the Mara region of Kenya, Fraser Darling (1960) also came to the conclusion that the roan's " ... habit of staying in one locality renders it liable to complete extinction".

CONCLUSIONS

The results of roan habitat analyses have clearly illustrated that the areas surveyed as roan habitats have much in common but differ physiognomically and structurally from the savanna habitats of sable in the Kruger Park. As with other more favourable roan areas (cf. Angola, Rhodesia) the conclusion must be drawn that optimum roan habitats must include a well developed grass stratum with sparsely distributed trees (i.e. open savanna). Roan are more tolerant towards the lower (1,5 m) strata of shrub growth while the cover and density of the intermediate strata (1,5 to 4,0 m) play an important role in rendering a habitat either acceptable or unacceptable to roan. Due to the

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relatively high proportion of shrubs in all these strata in the Kruger Park roan habitats, they are considered to be sub-optimum and only of marginal quality.

This conclusion is borne out by the low densities of roan in these habitats and the indications that population pressure is evident even in the most favoured habitats. It has already been shown (Chapter 5) that the grass component of the habitats is sufficient to meet the requirements of the roan so that the reduction or elimination of a major part of the shrub layer would be the obvious course to take in creating more favourable habitat conditions.

In conclusion it may be stated that the isolation of the salient factors affecting the preferences of different animals for particular habitats will yield the maximum results in determining herbivore-habitat relationships essential for the successful management of a complex community of different animals. In this respect several authors have demonstrated the changes which elephant may cause to habitats with consequences beneficial to some animals and detrimental to others (cf. Glover 1963, Napier Bax and Sheldrick 1963, Lamprey, ~~1968,~~ Glover, Turner and Bell 1967, Agnew 1968, Laws, Parker and Johnstone 1970) The changes wrought by elephant invariably include the opening of woodlands and thickets and are therefore spectacular and easily observed. However, the grazing succession referred to in Chapter 5 is not only applicable in terms of the food requirements of the various ungulates (cf. Vesey-Fitzgerald 1960, 1965, 1969) but should actually be interpreted as physiognomic changes in the habitat, thereby rendering it more or less suitable for the different ungulates utilizing the range. The mere height of grass may therefore be a critical factor affecting the habitat preferences of different grazers and in Chapter 5 it was implied that heavily grazed short grass areas would impose a stress upon roan as the habitat would then be less suitable. The conditions of the grass stratum may therefore be as critical as the density of the shrub strata in determining the quality of roan habitats.

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CHAPTER 7 : MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

INTRODUCTION

The ultimate objective in a study of this nature is obviously to determine those factors which should receive careful consideration for the successful management of the animal involved. Factors such as the population dynamics, feeding behaviour and habitat requirements of the roan have already been dealt with in the preceding chapters. As further background it may be well to recapitulate some of the more important behavioural characteristics of the roan of which cognisance should also be taken. These aspects have been dealt with in more detail in Joubert (1970).

MOTHER-YOUNG RELATIONSHIPS

A few days prior to giving birth a roan cow leaves the herd and gives birth to her calf in the seclusion of suitable cover. Suitable cover may represent a stand of tall grass lightly interspersed with shrubs and trees. For the first few days following parturition the cow remains within a few hundred metres of her calf which curls up in a patch of cover and remains concealed for most of the day. It is only attended by the mother at intervals between late afternoon and early morning.

After approximately one week the mother rejoins the herd and, while the calf remains concealed until the age of six weeks, the mother may move a kilometre or more away from her calf. During daylight the calf is only nursed in the early morning and late afternoon (and probably once or twice at night). It is important, however, that for the first six weeks following birth the young calf remains entirely on its own during the day while the mother may be several hundred metres away.

Young roan calves are also markedly weaker at birth than the young of those herbivores which follow their mothers almost from birth, e.g. wildebeest,

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impala and zebra. In fact, for approximately the first two weeks of life the young roan calf does not even attempt to flee when disturbed and relies entirely on concealment for its safety. Even after this initial period it will run only short distances before again taking refuge beneath a shrub or in a dense stand of grass.

It is therefore also important to note that roan calves are born throughout the year which would imply that a percentage of the young are dropped when cover is at its minimum during the dry winter months.

From these brief notes it should be obvious that young roan calves have no defence against the onslaughts of most of the larger carnivores and are therefore dependent on sufficient cover for protection during their first six weeks of life. The implications of calf vulnerability and survival will receive further attention in the course of this discussion.

SOCIAL ORGANISATION AND SPATIAL DISTRIBUTION OF HERDS

A further point of interest is the social organisation of the roan into nursery herds accompanied by a single adult bull which inhabit exclusive activity zones. For all practical purposes the activity zones are similar to the better-known territories in which the entire herd occupies a territory and the distinction was merely formulated to avoid confusion in purely ethological terms (Joubert 1970, 1974a).

Roan antelope herds in the Kruger Park occupy activity zones ranging from 60 to 100 km^2 in size and are dispersed in a mosaic pattern. The boundaries of the various activity zones are largely non-overlapping.

It has also been shown that individual roan herds are organised as "closed units" through the intolerance of herd bulls towards other adult bulls and a dominance hierarchy amongst the females. This implies that the assimilation of other roan into existing herds is inhibited (Joubert 1970, 1974a).

This system of exclusive activity zones therefore has the important

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implication that once the available habitat is occupied the "surplus" animals (i.e. evicted males and new herds formed through fragmentation of existing herds) would be compelled to withdraw to sub-optimum habitats where they are subjected to the hazards normally operative under such conditions.

The size of the activity zones could also be expected to vary with the suitability of the habitats which would again influence the density of animals per unit area. However, even under the most optimum conditions, such as in the Quicama National Park in Angola, the roan's social system would preclude the high densities attained by the more gregarious species, e.g. wildebeest and buffalo. The nett result of the particular spatial and social organisation of the roan would therefore be sparsely distributed herds averaging six to 20 animals in favoured habitats.

Before commencing discussions on management programmes it is important to review some of the general management policies already initiated and under way in the Kruger National Park and the principles on which they are formulated. A review of these policies is considered important for a better understanding of the present situation and the objectives determining the course of management in the Kruger Park.

PRESENT MANAGEMENT POLICIES APPLYING TO PLANT AND ANIMAL COMMUNITIES IN THE KRUGER NATIONAL PARK

Zonal differentiation

The major objective of conservation in the South African national parks is to maintain and preserve the diversity of species in both the plant and animal communities representative of the respective areas.

In its faunal variety and especially with regard to the diversity amongst the larger mammals, the Kruger National Park must certainly rank as one of the world's unique wildlife areas. A total of eight different carnivores ranging in size from the black-backed jackal (Canis mesomelas) and therefore

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excluding all the smaller felines, occurs in the Kruger Park while herbivores, ranging in size from the suni, Neotragus moschatus, are represented by a total of 28 species and subspecies (Appendix 1).

The occurrence of such a wide variety of the larger mammals in a single national park may be ascribed to the equally diversified habitat types within the Kruger Park. Van der Schijff (1957, 1958) differentiated six major vegetation types in the Kruger Park while Pienaar (1963) further subdivided the area into 15 broad wildlife habitats, ranging from thickets and dense woodlands to open "dambos" and grasslands. All the larger mammals occurring in the Kruger Park are therefore not randomly distributed throughout the area but are arranged in recognisable communities as determined by their particular habitat preferences. Of the carnivores and herbivores some are inherently more tolerant of a wide range of habitat types, while others are strictly confined to limited areas suited to their particular requirements.

Diversity, therefore, being the greatest asset of the Kruger Park and responsible for the occurrence of natural units or communities of associated plant and animal life, it is only logical that any management programme should take thorough cognisance of these communities to ensure their protection and perpetuation. For this reason the policy has been adopted to identify each community and to manage it on its own merits to the optimum benefit of the wildlife involved. However, the tolerance of the various animals for different habitats must also be taken into consideration and management priorities should therefore be adapted to provide optimum conditions for those confined to a particular habitat with less emphasis on the associated wider-ranging group. With due consideration of all these factors the Kruger Park has provisionally been divided into seven major regions.

It must be pointed out, however, that each of these regions can be subdivided into more concise units (Fig. 48) although for the purpose of this

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1. The northern sandveld protected zone

   a. Limpopo-Levubu botanical, bird and rare animal priority area
   b. Nyandu sandveld botanical priority area
   c. Punda Milia sandveld and wildernis area

2. The north-eastern Lebombo Flats

   a. Colophospermum mopane Woodland and elephant priority area
   b. Roan antelope and eland priority area
   c. North-eastern Lebombo Flats diverse wildlife community area (e.g. roan antelope, sable antelope, eland, tsessebe, reedbuck, buffalo, zebra, wildebeest)
   d. Lebombo Mountain wildlife communities
   e. Lebombo Mountain botanical priority area

3. The north-western mixed Combretum apiculatum - Colophospermum mopane communities

   a. Elephant priority area
   b. North-western diverse wildlife communities
   c. Rare antelope priority area (sable antelope, eland, tsessebe and waterbuck)
   d. Hippopotamus and waterbuck priority area

4. and 5. The western mixed Combretum spp communities and the south-eastern Lebombo Flats

   a. Rare antelope priority area (sable antelope, tsessebe)
   b. Hippopotamus and waterbuck priority area and incorporated wildernis area
   c. South-eastern Lebombo Flats diverse wildlife communities (e.g. zebra, wildebeest, impala, giraffe, warthog)
   d. Western diverse wildlife communities (e.g. sable antelope, zebra, wildebeest, kudu, waterbuck, giraffe, tsessebe)
   e. Acacia welwitschii - Albizia evansii botanical priority area
   f. Lebombo Mountain botanical priority area
   g. Pumbe sandveld communities
   h. Lebombo Mountain diverse wildlife communities and incorporated wildernis area

6. Pretoriuskop and Malelane rare animal priority areas

   a. Rare antelope priority area (e.g. sable antelope, reedbuck, oribi)
   b. Roan antelope priority area
   c. Pterocarpus angolensis botanical priority area
   d. Malelane botanical and rare antelope (e.g. mountain reedbuck) priority area

7. Mixed woodlands of the Sabi and Crocodile river drainage zone

   a. Diverse wildlife communities and incorporated black rhinoceros priority area
   b. White rhinoceros priority area
   c. Diverse wildlife communities

Figure 48 : A simplified map of the zonal differentiation of the Kruger National Park, South Africa for management purposes

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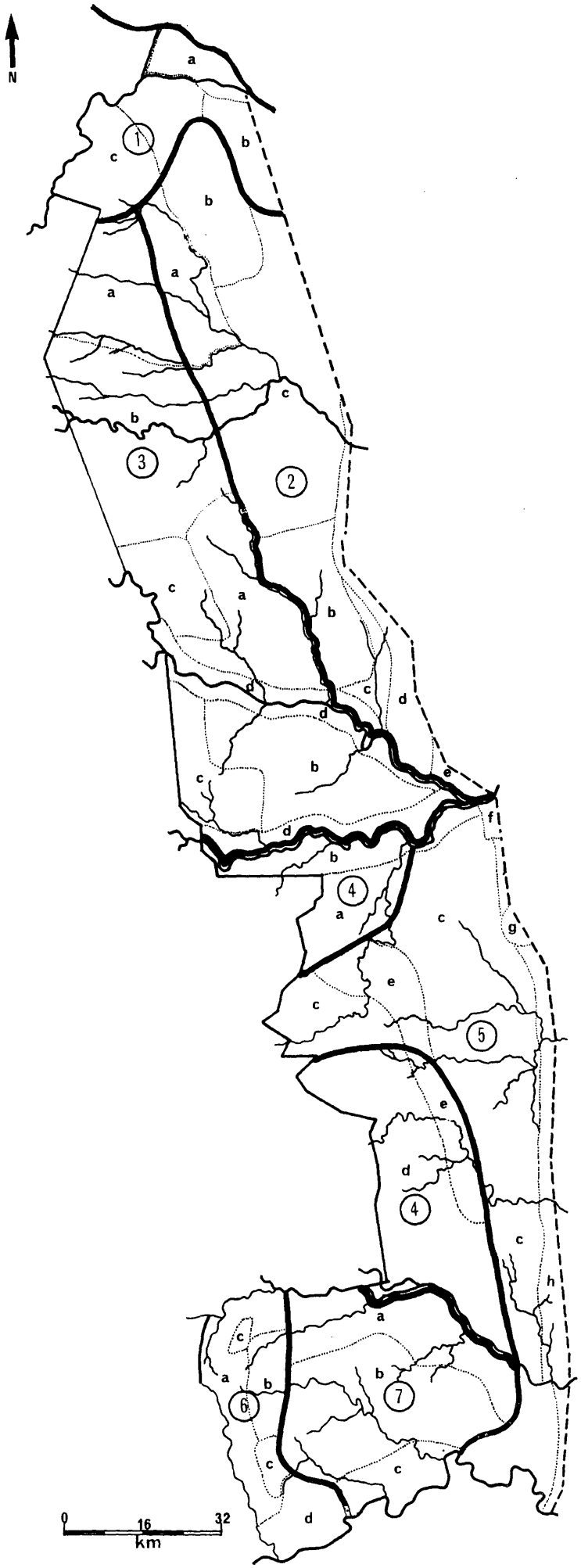

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discussion a more detailed account of each region is not considered important, except where such detail is relevant to the management strategies suggested with regard to roan. The major regions include the following (cf. Joubert 1974b):

Northern sandveld protected zone

This zone comprises the extreme northern area of the Kruger Park (Fig. 48-1) including the sandy, mountainous regions around Punda Milia to the Levubu River, the low-lying flood plains of the Limpopo and Levubu river basin in the Pafuri area, and the Nyandu sandveld communities to the south.

The area is especially prized for its rich variety of plants, especially a number of species with more tropical affinities (Van der Schijff 1957, Pienaar 1963). Animals occurring in this zone include elephant, buffalo, nyala, bushbuck, reedbuck, waterbuck, kudu, eland, sable antelope, impala, zebra, warthog, and a few of the smaller antelopes. This area represents the major stronghold of the nyala and in spite of the wide variety of animals only elephant, buffalo, kudu and, to a lesser degree, impala can be considered common while it is of no importance to roan antelope.

The north-eastern Lebombo Flats

The geographical limits and botanical composition of the area have been given in some detail in Chapters 5 and 6.

This area (Fig. 48-2) contains the bulk of the Kruger Park's roan antelope population (Chapter 4) and, in addition, the following associated herbivores are common: Zebra, wildebeest, tsessebe, eland, sable antelope, reedbuck, kudu, elephant, buffalo and steenbok.

The north-western mixed Combretum apiculatum - Colophospermum mopane communities

Although the western areas north of the Olifants River represent, with minor local variations, one large habitat, the emphasis on the management of its fauna necessitates its subdivision into a number of different zones (Fig. 48-3). The major animals occurring within this area include elephant, buffalo, zebra,

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kudu, sable antelope, waterbuck, eland, and, to a lesser extent, tsessebe, giraffe and roan.

The western mixed Combretum spp. communities and the south-eastern Lebombo Flats

The entire area between the Sabi and Olifants rivers can be managed as two separate entities, i.e. the western and eastern halves (Fig. 48 - 4 and 5) with a rather arbitrary division along the ecotone of the western mixed Combretum spp. communities and the eastern open plains and Acacia nigrescens - Sclerocarya caffra Savanna.

The western half is similar in general appearance to the western areas north of the Olifants River and although it largely contains the same fauna, their numerical relationships differ markedly. Wildebeest, zebra, impala, kudu, giraffe and elephant are common, with scattered herds of sable antelope and tsessebe while eland do not occur in this area. Animals which receive special attention in this area are primarily wildebeest and zebra in their selected areas, and giraffe, sable antelope, waterbuck, kudu and tsessebe in their favoured haunts.

The south-eastern Lebombo Flats extend from the Olifants River southwards to the Sabi River and from there southwards to the Crocodile River. Although this area is subdivided by the Sabi River into two more-or-less distinct units the ecological features are the same for both areas.

As this vast habitat has not previously been discussed, it is appropriate to elaborate on its composition in slightly more detail than for the previous areas. Topographically and in soil characteristics it is comparable to the Lebombo Flats in the north-eastern sector of the Park. The area is generally flat and slightly undulating and is dissected by a number of sharply defined seasonal watercourses, mostly originating in the higher western areas. The lack of the broad, grass-covered, shallow drainage systems of its northern counterpart is one of the major differences between the two areas. The soils are mainly derived from basalt and are of the same dark colour and heavy clay texture as those in the north-eastern districts.

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The botanical composition of the two areas differs in the total absence of Colophospermum mopane in the southern area. Here the major species in the tree stratum are Acacia nigrescens and Sclerocarya caffra while a variety of other Acacia spp. and Combretum spp., together with various shrubs and smaller trees, occur in association with the dominants (Van der Schijff 1957, 1958, Pienaar 1965, Van Wyk 1972a and 1972b). In some areas this savanna also extends well into the western half in the vicinity of the Orpen Rest Camp. Major perennial grasses are Themeda triandra, Panicum maximum, Setaria sphacelata, Digitaria spp. and Bothriochloa insculpta. In the absence of heavy grazing pressure the area supports a lush medium to tall grass stand similar to that of the north-eastern Lebombo Flats.

Physiognomically the southern and northern flats have much in common and like its northern counterpart, the southern plains may also be classified as open savanna. From a physiognomic point of view the south-eastern Lebombo Flats would undoubtedly provide much more suitable roan habitats than any of the presently occupied roan habitats in the western areas of the Kruger Park. The factors believed to prevent the establishment of roan herds in this area will be dealt with later in this chapter.

The numerically dominant herbivores are wildebeest and zebra with impala particularly numerous in some areas. Other associated animals include kudu, buffalo, waterbuck, giraffe, elephant and to a lesser extent reedbuck, sable antelope and tsessebe. This area is well known for its large concentrations of wildebeest and zebra which follow rhythmic seasonal migrations over its entire length (Smuts 1972, 1974, Braack 1973) and management priorities are directed at maintaining both these populations at their optimum level.

Pretoriuskop and Malelane rare animal priority areas

The area is situated in the south-western extreme of the Park (Fig. 48-6) including the Malelane Mountain Range and the Large-leaved Deciduous Woodland of

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Pretoriuskop. The topography and vegetation of this area have been discussed in some detail in Chapters 5 and 6.

A large variety of animals occur in the diversity of habitats represented in the area, but are mostly sparsely distributed. This area represents one of the major strongholds of the sable antelope and white rhinoceros (Ceratotherium simum) in the Kruger Park but also supports other rarer antelope such as roan, reedbuck, mountain reedbuck, and oribi. Other more commonly associated animals include kudu, zebra, buffalo, impala, giraffe and wildebeest.

The importance of this area is accentuated due to the occurrence of several of the less numerous animals in the Kruger Park and, in addition to their management, the management objectives for the area include the re-establishment of eland and tsessebe which were once quite common in the vicinity but have become extinct in recent years (Glynn 1926, Pienaar 1963).

Mixed woodlands of the Sabi and Crocodile river drainage zone

The final area covers those portions of the area south of the Sabi River not included in the previous zones (Fig. 48-7) and includes large portions of the relief areas of the Sabi and Crocodile rivers.

The predominantly granitic soils support mixed Combretum spp. communities on the higher ground while the vegetation merges into thick stands dominated by Acacia spp. in the lower-lying areas. Animals favouring these habitats include elephant, buffalo, kudu, giraffe, bushbuck, impala and, in the more open areas, white rhinoceros and sable antelope. The black rhinoceros (Diceros bicornis) has also recently been re-introduced to this area.

Water provision

From the memoirs and reports of the early pioneers and rangers the number of natural springs and permanent waterholes in the Kruger Park appear to have diminished quite considerably over the years (cf. Crous 1929 to 1935, Botha 1930 to 1938). In latter years even the flow in the once perennial rivers

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has dwindled to the point where rivers such as the Letaba and Levubu can no longer be considered truely perennial as they frequently stop running during the dry months.

Apart from the larger and more stable rivers, e.g. the Sabi, Olifants, Crocodile and to a lesser extent the Letaba and Levubu rivers, natural waterholes with surface water are limited to a few isolated springs and waterholes in the larger seasonal rivers during even moderately dry years.

In addition to the natural water resources, artificial watering points have been created by means of boreholes and windmills and the building of dams in the seasonal rivers. The provision of additional watering points proceeded through the years and was only retarded by lack of funds. Through the prolonged drought which commenced in 1960/'61 and only terminated in 1971/'72, the urgent need of even more water resources was pleaded. In the early 1970's this programme gained momentum by the acquisition of substantial state subsidies and in the last four years dams and boreholes have mushroomed throughout the Kruger Park.

The inadvertent provision of water in some areas, especially the summer grazing areas of the large concentrations of wildebeest and zebra, resulted in the build-up of large numbers of animals around such waterholes throughout the year and eventually led to the serious over-utilization and eventual retrogression of the habitats in the surrounding areas. These experiences have resulted in the adoption of the principle of only stabilizing once permanent waterholes and preventing them from drying up. To achieve this objective large concrete dams and weirs are being erected in the larger perennial rivers and are further augmented by earthen dams in the seasonal rivers. In the case of windmills it may be argued that full control can be exerted over the water supply as the waterhole can easily be closed down should circumstances require it.

Obviously, the artificial provision of water in an area could have a profound effect on the animals inhabiting the area and these possible changes will be discussed in subsequent sections.

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Population reductions

The artificial reduction of the more numerous animal populations is commonly justified on the basis of animal-plant relationships and, in the case of the Kruger Park, with due consideration of the available water resources. Such an approach has long been recognised in farming practices and is based on the so-called "carrying capacity" of the food source in relation to the utilizers.

Where one or two animal populations, especially those with similar habitat and food prequirements, are concerned, the conventional concept of "carrying capacity" could possibly still hold true in wildlife management. However, in a community consisting of a large variety of animal populations such an approach would be an over-simplification of a much more complex situation which involves, among others, the following: Under favourable conditions some animals have the ability of unlimited population increase to the point of destroying their own habitats which would have a profound effect not only on the animal itself but also on associated animals; in other animals their own social organisation inhibits population increase beyond a certain density; different animals utilizing the same food plants often feed on different parts of the plants, which could result in either complementary or competitive feeding, and finally, carrying capacity in wildlife populations is not only a function of the food source but of the total environment, including the water resources.

From this brief account of the factors affecting the "carrying capacity" of different animal populations, it must be deduced that the important considerations in deciding upon reduction schemes not only include the potential of the food source and its ability to sustain heavy grazing pressure, but even more especially the optimum densities of the animals to be reduced, their particular habitat requirements and tolerances, as well as those of associated animals. Finally, a clear understanding of the management objectives of a particular area is imperative.

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Habitat manipulation

It is an irrefutable fact that optimum habitat conditions are fundamental in determining the success of wildlife populations. The diversity of animal life in the Kruger Park (Appendix 1) has already been ascribed to the diversity of available habitats. To maintain healthy wildlife populations it is therefore a prerequisite to understand the requirements of each animal and manage the environment accordingly. This obviously implies a thorough understanding of plant-substrate relationships, the impact of veld burning and animal utilization at different levels of intensity, and the associated progressive and retrogressive successional stages of the vegetation.

According to the interim policy on veld burning in the Kruger Park the major portion of the area is subjected to a triennial burn while minor areas, due either to their unique floristic composition or poor coverage resulting from skeletal soils or over-utilization, are only burned as and when circumstances demand it. The relatively small areas of tall grass around Pretoriuskop are subjected to a biennial burn (Brynard 1964, Van Wyk 1972a).

Supplementary management policies

Additional management policies which are operative in the Kruger Park and which will be referred to in subsequent sections include the re-introduction of animals which had become extinct or the re-establishement of others in areas from which they have become extinct, the erection of game-proof enclosures to serve as breeding camps for less numerous animals and from which the animals may be released into resettlement areas, the elimination of contagious diseases such as anthrax by means of mass innoculation, and predator control (Joubert 1974b).

THE MANAGEMENT OF THE ROAN ANTELOPE IN THE KRUGER NATIONAL PARK: DISCUSSION AND RECOMMENDATIONS

Having outlined the various management procedures hitherto adopted in the Park, the following aspects emerge as specifically important in the management of the roan antelope:

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The north-eastern Lebombo Flats

From previous discussions (Chapters 4, 5 and 6) there can be no doubt that this area is most suited to the requirements of the roan, hence the highest concentration of roan within its confines.

From a habitat point of view it has also been shown (Chapter 6) that only limited areas approach optimum roan habitat conditions, so that the highest priority in any management programme should therefore include efforts to provide more areas suitable for occupation by roan. As such, the prerequisites would be to create more extensive areas of open savanna. To achieve a more uniform occupation of the areas potentially suited to the roan it would be imperative to relieve them of the inhibitory effects of dense stands of especially Colophospermum mopane shrub.

Various experiments are currently underway to obtain the most effective way to combat the hardy Colophospermum mopane shrub (Van Wyk, Gertenbach and Potgieter pers. comm.) and once this is achieved the following application is recommended: The eradication of all shrubs up to 3,0 m in height from the Acacia nigrescens plains and intervening areas in the Hlamalala-Nwashitsumbe-Boyela and Mooiplaas-Tihongonyene areas (Fig. 49).

Further eradication of all shrubs should initially be concentrated in and along the five main grass-covered drainage lines, i.e. Hlamalala, Nwashitsumbe, Boyela, Nshawu and Malopanyane. Significant increases in favoured grasslands could be achieved by clearing lanes, 1,0 km broad, of all shrubs on either side of these depressions. There are no valid reasons why the ecotone between the depressions and the adjoining savannas should not be cleared in these areas while it could be expected to render distinct beneficial results to herbivores such as the roan, tsessebe, reedbuck and eland.

The above-mentioned recommendations are suggested to improve the already

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Figure 49 : A map of the northern areas of the Kruger National Park, South Africa indicating the major localities and watering points relevant to the management of the roan antelope.

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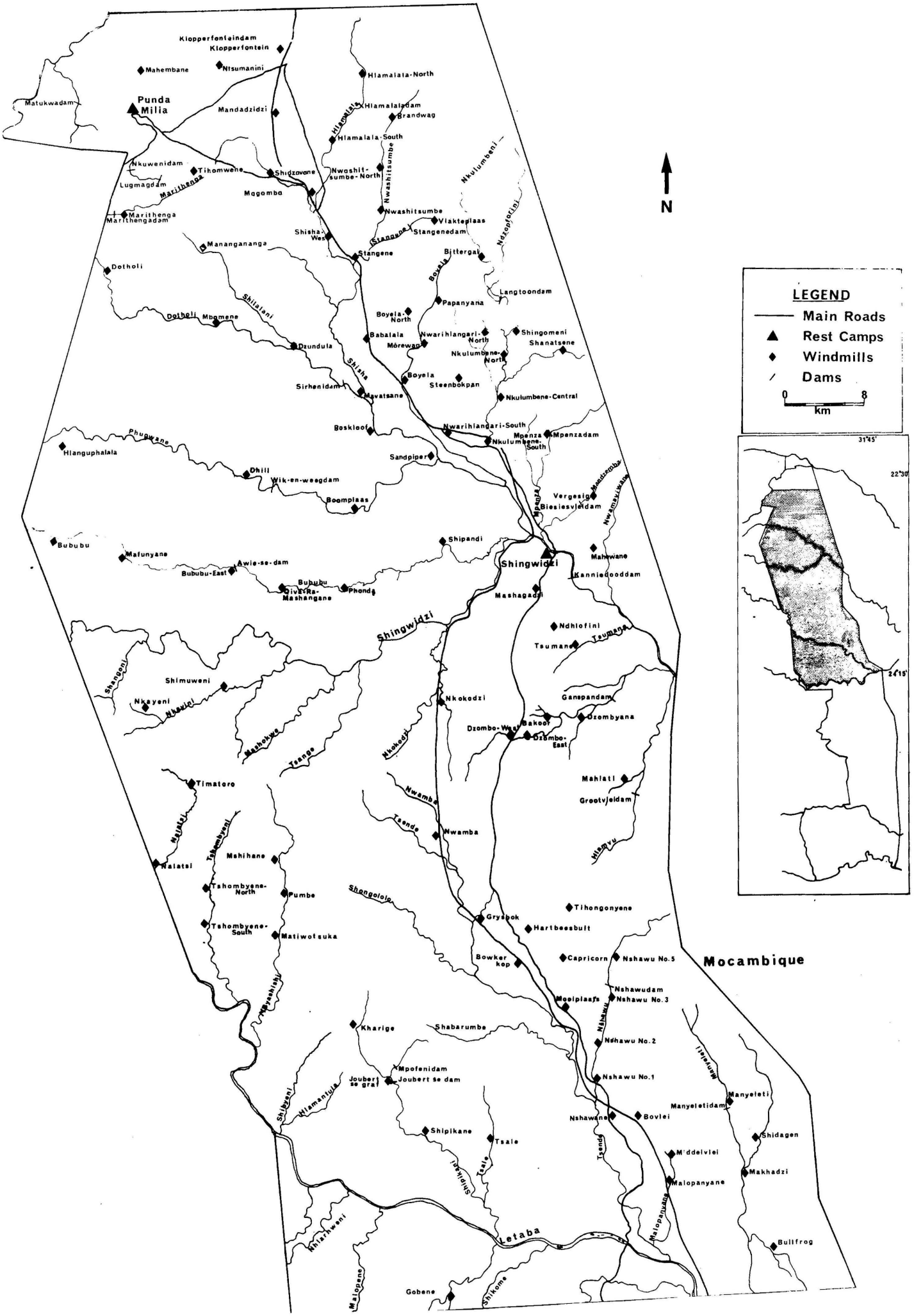

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more favourable roan areas while the following are suggested to make the less suitable areas more habitable: In the large blocks presently covered by a more-or-less homogeneous stand of Colophospermum mopane shrub and small trees, open savannas should be created by clearing a number of patches of not less than four square kilometres in size of all shrubs and inter-connecting these clearings by similarly cleared lanes, 0,5 km broad. These clearings should be planned in accordance with existing grass-covered depressions or pans, and the tributaries of the larger drainage systems. Initial shrub clearing operations should be limited to those areas already inhabited by roan and would therefore include all blocks between the Nkulumbene River and Mandadzidzi as well as the blocks from Tihongonyene to the Tsendi and Letaba rivers (Fig. 49).

Once these priorities have been met, the marginal areas along the upper reaches of the Tsendi River, the area north of Tihongonyene to the Shingwidzi River and north of the latter to the Nkulumbene River should be treated in a similar way.

Simultaneous with the improvement of each area according to its priority, all shrubs in a redius of at least 0,5 km around existing waterholes should be cleared. The area between the Shingwidzi River and Mpenza Dam is the least suitable for roan and clearings should be planned to give maximum benefit to the two or three herds of roan within their activity zones while preserving the general features favouring the population of sable antelope in the area.

The main objective of the suggested shrub clearings is to provide additional open savanna areas for the roan without affecting the general features of the present habitat in any detrimental way. Furthermore, these openings are not expected to jeopardise the co-existence of the associated animals in any manner and could also be to the advantage of other plains-loving animals such as tsessebe, eland, zebra, wildebeest and ostriches.

The clearing of shrubs would also promote a policy aimed at the

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maintenance and protection of healthy swards of medium to tall grasses. Open savanna habitats have already been shown to be the ultimate form of optimum roan habitats and are essential to the roan both as a source of food and cover, the latter especially during the period of concealment of young calves.

For the protection of the grass stratum of the savannas it would be essential to avoid at least two potential hazards, i.e. prolonged heavy or over-utilization by associated herbivores and the interrelated build-up of concentrations of animals around artificial watering points. In Chapter 5 the grazing succession of the various herbivores occupying the same range as the roan was discussed and the conclusion was drawn that those most likely to compete with roan for their food source included buffalo, zebra and wildebeest. This conclusion was derived from the fact that roan are essentially delicate feeders which utilize the higher parts of their favoured grass species to a height of c. 80 mm above the ground. Competition may therefore arise with large herds of buffalo grazing and trampling the medium and tall grasses and thereby paving the way for the influx of zebra and wildebeest.

Both zebra and wildebeest constitute a more direct threat to the roan than buffalo as high concentrations of either or both tend to remain in an area (wildebeest more so than zebra) and graze the grass to the ground. In this way severe competition may arise which would be to the detriment of the more sensitive and less competitive roan antelope.

Earlier in this chapter reference was made to the open savanna aspects of the south-eastern Lebombo Flats, which closely resemble those of the north, and the apparent inability of roan to establish activity zones in this area. Without attempting an over-simplification of the issue it may, however, be pointed out that the south-eastern Lebombo Flats have, from the earliest recorded times, been the main concentration area of immense concentrations of wildebeest and zebra (Stevenson-Hamilton 1925). If not the sole reason, the large concentrations

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of these two populations and their regular denudation of the area would doubtlessly have contributed in no small way to the absence of roan on these flats.

From the arguments presented above at least one important aspect in wildlife management arises, i.e. to avoid detrimental competition with roan it would be imperative to maintain a balance between the roan, on the one hand, and wildebeest and zebra, on the other, where these animals occupy the same range. It also stands to reason that the food source alone cannot be regarded as a reliable criterion for determining the numbers of different herbivores that could be sustained by a particular habitat. In this respect the delicate feeding behaviour of roan could therefore necessitate the artificial reduction of wildebeest and zebra populations long before they have endangered their own food source. In the southern areas on the other hand, where the objective is to provide optimum conditions for zebra and wildebeest, it would therefore not be strange to find that the numbers of these populations would be several times that of their northern habitats before population reductions are deemed necessary.

In an area managed for roan, the balance between the roan and other competing herbivores, e.g. buffalo, zebra and wildebeest, would obviously be rather delicate and could easily be upset by any variable factor such as weather conditions. To be dogmatic in determining the exact numbers of each population to ensure such a balance would be pointless at this stage as much more information is required. Both wildebeest and zebra have shown a steady increase over the last six years (1968 to 1974), as determined by annual aerial and/or ground censusing, in the three game ranger sections incorporating the north-eastern Lebombo Flats, i.e. Mooiplaas, Shingwidzi and Punda Milia. During this period wildebeest increased by 46,6 per cent on Mooiplaas Section and 37,5 per cent and 16,6 per cent on Shingwidzi and Punda Milia sections, respectively. Similar increases in the zebra populations for the three sections were 50,0 per cent, 33,3 per cent and 17,6 per cent respectively. The derived total wildebeest

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population for the north-eastern Lebombo Flats is 600 and that of zebra 2 300 (Table 33).

No culling operations have been undertaken on either of the two populations in this area and an interim policy on the management of these populations can only be advocated after taking water provision and distribution into consideration as an additional and complementary factor.

In recent years a series of earthen dams and boreholes have been established in the area to supplement the rather poor natural supply of drinking water. In 1970 there were five medium-sized earthen dams spread over the length of the flats of which only two (Manyeleti and Hlamvu) could retain sufficient supplies of water through even a moderately dry year. In addition to these dams the area was also provided with 32 windmills and drinking troughs. Since 1970 these water resources have been expanded and at present include 46 windmills and nine dams. Of the dams, three have been completed in the last two years and their influence on wildlife populations has yet to be determined.

It is interesting to note that the largest increases in both zebra and wildebeest numbers occurred on Mooiplaas Section and, particularly in the case of zebra, the largest concentrations are found in the surroundings of the oldest dam of any consequence, i.e. Manyeleti. On the north-eastern Lebombo Flats other large concentrations of wildebeest and zebra are also found around the Mpenza and Hlamalala dams. One of the largest concentrations of wildebeest in the northern areas of the Kruger Park is also known from the Tihongonyene-Mooiplaas complex while zebra, especially, have increased their numbers remarkably rapidly around the relatively new Nshawu Dam. Other watering points favoured by zebra and/or wildebeest include Malopanyane, Nwatimofu, Hlamvu-Mahlati, the Dzombo windmills, Dzombyana, Tsumane, Ndlofine, Nwarihlangari-north, Boyela, Nwashitsumbe, Hlamalala and Mandadzidzi (Fig. 49).

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Table 33 : Aerial census figures (A) and derived totals (B), as obtained from ground censusses and the monthly reports of game rangers, of the more important herbivore populations of the north-eastern Lebombo Flats of the Kruger National Park, South Africa for 1974.

ANIMAL	NUMBER OF ANIMALS				TOTAL	
	Letaba River to Shingwidzi River		Shingwidzi River to Mandadzidi			
	A	B	A	B	A	B
Elephant	200-400	(variable)	50-150	(variable)	250-550	(variable)
Buffalo	1 387	1 387	359	359	1 746	1 746
Zebra	1 700	1 800	407	500	2 107	2 300
Wildebeest	369	450	102	150	471	600
Roan antelope	65	70	123	130	188	200
Sable antelope	11	25	55	60	66	85
Tsessebe	231	250	81	110	312	360
Eland	28	35	82	82	110	117

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In studying this position analytically, it is found that roan are mostly dependent on the waterholes of Hlamalala-south, the Nwashitsumbes, Boyelas, Nshawu windmills and Malopanyane. Although environmental factors also play a role it is nevertheless noteworthy that roan are almost entirely absent, but for sporadic appearances, from zebra and wildebeest concentration areas such as Hlamalala Dam and Hlamalala-north windmill, Nwarihlangari-north, Mpenza, Ndlofine, Tsumane and Mooiplaas. However, if it is taken into consideration that the area to the north of the Shingwidzi River accommodates less than half the wildebeest and zebra populations found in the area between the Letaba and Shingwidzi rivers and that exactly the opposite is true of the roan population, the latter's absence from the main concentration area must be ascribed to more than mere coincidence.

Throughout this thesis the investigations into the various aspects of the ecology of the roan have repeatedly pointed to one important phenomenon, i.e. the apparent wariness of the roan of large concentrations of other animals. This avoidance of large concentrations of herbivores is clearly a function of the socio-ecological needs of the roan and should therefore be considered in their management. From this point of view it is imperative that measures should be taken to alleviate roan of the detrimental effects of competition with animal populations co-inhabiting their range and the following measures are proposed:

While there are definite indications that the zebra population of especially Mooiplaas Section has reached the threshold of tolerable interspecific relationships with regard to the roan, as evidenced by increasing concentrations of the former around the available water resources during the dry season, it is recommended that the zebra population be maintained at its present level as an interim measure. The removal of the annual increase should be concentrated in the area from Tihongonyene-Mooiplaas southwards to Malopanyane and Makhadzi, and be confined to the immediate surroundings of Malopanyane, Manyeleti, Nwatimofu and Mooiplaas. Arbitrary as this measure may be, it should be approached on an experi-

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mental basis with careful record being kept on the reaction of the roan population and other less numerous associated animals (cf. Smuts 1974).

In the more northern regions of this area, i.e. Mahlati, Hlamvu, Dzombyana, Tsumane and Ndlofine (Fig. 49) it does not seem advisable either that the zebra population should increase beyond its present level. The presence of zebra in numbers sufficient to create restricted short grass areas without inducing retrogressive succession could in fact be beneficial to tsessebe which are particularly partial to short grass areas in the immediate neighbourhood of permanent watering points. The areas mentioned above are less suitable to roan but well occupied by tsessebe and it is therefore recommended that the status quo of the zebra population be maintained for these areas.

To the north of the Shingwidzi River the area south of Mpenza Dam may be managed on similar lines to that of the Ndlofine-Hlamvu area with no further increases in the wildebeest and zebra populations recommended.

North of Mpenza Dam the total population of zebra in this area may be tolerated although it would be desirable to discourage even their present use of the Boyela and Nwashitsumbe windmills. Unfortunately, however, the segments of the zebra and wildebeest populations concentrating around individual watering points are unstable and considerable movement from one waterhole to the next takes place (Smuts 1972). This would of course complicate the management of both zebra and wildebeest and even though some restricted areas do exist where a fair build-up in their numbers could be tolerated, there is no way of ensuring that they would remain in these areas and preventing especially zebra from entering the more vulnerable roan areas at will. However, the north-eastern flats have been allocated to the management of some of the rare animals such as roan, tsessebe, eland and sable, and there is no other option but to reduce and control the competitive and more numerous ones by artificial means.

The only feasible alternative to culling operations would be to close

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down all but a few selected artificial watering points. There can be no doubt that the steady incline in the zebra and wildebeest populations on the north-eastern Lebombo Flats in recent years can, to a large extent, be ascribed to the increased water supplies. Even at the present level of water provision and the increases in the two respective populations it is quite conceivable that, in the absence of reduction schemes, both zebra and wildebeest could increase within the foreseeable future to the level attained on the south-eastern Lebombo Flats and thereby render the northern areas unacceptable to roan and, to a large extent, also tsessebe.

It has frequently been observed that herds of roan (and sable) withdraw into remote and waterless areas away from other wildlife concentrations. In many such cases watering points have actually been provided in these waterless areas for the benefit of the roan or sable herds. If it were agreed that these herds withdrew into such areas to avoid over-crowded conditions, it is only logical that if such a watering point were to serve its intended function all the animals which have the tendency to remain sedentary around a waterhole and build up in numbers should be removed.

This entire argument has led to but one of two alternatives: Either the artificial watering points - especially the larger dams - must go or the stabilization of the zebra and wildebeest populations has become imperative. However, having accepted the management of wildlife populations as inevitable in the Kruger Park, and the provision of watering points as essential in the management of these populations, the following management strategies, in addition to those already proposed, are suggested:

That any build-up of zebra numbers around the recently constructed Langtoon Dam be discouraged. This area has the potential to become a favoured roan habitat as it lies on the fringes of an open Acacia nigrescens tree savanna and any competition from associated herbivores with roan or tsessebe should be avoided.

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All zebra and wildebeest attempting to colonise the series of new watering points should be eliminated. These watering points include Brandwag, Vlakteplaats, Bittergal, Morewag, Steenbokpan, Bakoor, Hartbeesbult, Capricorn, Bovlei and Middelvlei (Fig. 49). This recommendation may well be considered impractical but would imply that any reductions to be made should be concentrated around them, in addition to those given priority in the sections above.

It is proposed that no further watering points be provided on the north-eastern Lebombo Flats and that the effects of those already in existence be given attention to determine their desirability in terms of the reaction of the various herbivores inhabiting the area. The nomadic habits of buffalo pose no threat to either roan or any of the other rarer antelopes and the policy of maintaining them at their present level by removing the annual increase, is endorsed.

Supplementary management practices, such as predator control, are not considered essential under present conditions although the increase in the zebra and wildebeest populations would almost certainly have led to a corresponding increase in those predators, especially lion, preying on the larger herbivores. It would therefore be imperative to continually re-evaluate the position once culling operations have been introduced and should the necessity arise, the rarer prey animals should be relieved of excessive predator pressure.

The current procedure of mass innoculation of roan against anthrax has, after four years, revealed no detrimental effects regarding the stability of herds and/or their activity zones. Until such time that innoculation can be achieved by less disturbing means, there is no apparent reason why the present form of innoculation by means of darting (De Vos *et al.* 1973) should not continue. According to De Vos (*pers. comm.*), anthrax is most prevalent under conditions of over-utilization of the range and associated high animal densities. This is in accordance with the recorded outbreaks in the Kruger Park which have all occurred

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during periods of severe drought. The alleviation of large concentrations of other herbivores in the favoured roan habitats, as proposed, may therefore further assist in diminishing the severity of such epizootics during unfavourable spells.

The north-western mixed Combretum apiculatum - Colophospermum mopane communities

In previous discussions (Chapter 6) it has clearly been indicated that this area in its entirety is regarded as poor or sub-optimal and even marginal roan habitat. Its potential for development as an area for less numerous antelopes should rather be exploited for sable antelope and eland than for the plains-loving roan and tsessebe.

However, the local areas in which roan are able to establish activity zones could play a valuable role in relieving the eastern areas (i.e. the Lebombo Flats) of excessive population pressure. Any attempts at providing more suitable areas for colonisation should therefore be confined, at least in the initial stages, to the ecotonal zone between the western and eastern habitat types. In this respect the areas between Dzundwene Mountain and the Mphongolo River, along the Bububе River and the upper reaches of the Tsendi River could play an important role in providing additional roan habitats (Fig. 49).

Within the mixed Combretum apiculatum - Colophospermum mopane habitats there are also numerous areas where the generally relatively dense savanna woodland is replaced by lightly wooded open savanna. This is especially true of the vegetation of the dolerite intrusions. Any form of management for roan should therefore include these areas as priority zones. With this in mind the following areas may be developed, albeit on a limited scale, for colonisation by roan: In addition to those already mentioned, the catchment zone of the Nalatsi, Tshombyeni, Mbyashishi and Shipikani rivers. The large elephant populations within the elephant sanctuaries in this zone could, in time, also possibly contribute towards the opening of some areas which should favour roan.

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Attempts at augmenting the present roan population with transfers of roan from other areas are definitely not recommended. At this stage the only feasible attempts to accommodate more roan in the area are believed to be efforts in providing more suitable range.

The south-western Large-leaved Deciduous Woodland

In general, the arguments forwarded for the western mixed Combretum apiculatum - Colophospermum mopane habitats of the north are also applicable to this area. There are, however, a few important differences of which the most notable is the availability of larger areas of more suitable habitat that may be exploited for roan. These areas were dealt with in Chapter 6 and include the region north of Pretoriuskop to the Sabi River and eastwards to the dolerite intrusion running in a north-south direction from south of Ship Mountain and crossing over Shitlave to east of the confluence of the Mtshawu and Sabi rivers.

Management proposals for this area include the clearing of shrubs under 3,0 m tall from the presently occupied roan habitats and those intended for future colonisation.

In a few localities of the Kruger Park roan and sable antelope occur sympatrically although it has been illustrated that there is a clear differentiation between optimum roan and sable habitats (Chapter 6). The well-established and wide-ranging occurrence of sable in the above-mentioned area suggests - and was confirmed by the habitat surveys - that it is more suited for sable than for roan (cf. Mestel-Shabin habitat surveys). Caution should therefore be exercised in any future developments of the area that efforts to encourage one rare antelope do not jeopardise the stability of another. Such wide-ranging alterations to the habitat seem rather unlikely and immediate aims should be to develop those habitats most likely to suit the requirements of roan, i.e. the area encompassed by the dolerite intrusion and extending from Matupa to Ship Mountain.

In an attempt to augment the small roan population still existing to the

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south of Pretoriuskop an enclosure was erected (Hlangwine camp) into which a small breeding nucleus of roan was released in 1973. It is hoped that the breeding group in the enclosure will rapidly increase its numbers in the absence of most natural limiting factors and that the surplus animals may be captured from time to time and be released into the surrounding areas. The success of such an operation would naturally depend on the ability of the animals to find suitable areas in which to establish their activity zones after their release. The most suitable habitats, as pointed out above, are on the dolerite intrusion and especially the area between Shitlave and Ship Mountain and the open savanna plains south of Matupa. It is therefore recommended that all future releases from the enclosure be done in these areas and that the roan disperse from them as their needs dictate. It would also be in the best interests of the animals that they be kept in a temporary paddock prior to being released until they have formed fixed hierarchical bonds and thereby also a coherent unit (herd).

An experimental reduction of predators in part of the area under consideration commenced during 1974 and should this experiment yield good results with respect to the survival rate of the prey populations of rare antelopes, the elimination of predators from the area in which roan from the Hlangwine enclosure will be released, must precede such operations. To enable a herd to establish itself in an activity zone, predator control measures should also be continued for at least three months after releasing a herd to avoid predator influxes from adjoining areas.

The water resources of this area are considered adequate and except for the proposed windmill and dam along the fringes of the Matupa plains, further extensions of watering points are not necessary.

Other areas

The extinction of the roan populations from the Kingfisherspruit and Nkuane-Mnondozi areas in recent years resulted from conditions still prevailing

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in these areas. Although the ultimate cause of the roan's extinction in the Kingfisherspruit region has been attributed to the western boundary fence and in the latter region to excessive poaching and predation (Pienaar pers. comm.) both areas represent sub-optimum roan habitats, especially the former, and re-establishment attempts in either would be senseless until such time as the more acceptable habitats mentioned above have been consolidated and the objectives achieved.

SUGGESTIONS FOR FUTURE RESEARCH

In spite of the knowledge thus far obtained on the general ecology and behaviour of the roan antelope there are obviously several unknown factors which still require urgent attention, especially with regard to such contentious issues as the reduction of associated animal populations in roan habitats. Further detailed investigations into the following aspects are considered of major importance.

i) Animal - habitat relationships and the development of rapid, dependable methods by which to measure habitats should receive urgent attention. This is the one aspect on which most of the management strategies in the Kruger Park is based but which is, as yet, still poorly understood.

Studies of this nature should be approached with the objective of determining those factors to which the various animals are most sensitive and therefore exert the most influence on their well-being. This is especially true of the less numerous animals as their low numbers almost invariably reflect habitat conditions.

Such studies would also yield information on the sources of competition between animals (where combined with food preference studies), the co-habitability of different animals and could further be used to determine balanced numerical relationships of one population to another under set habitat conditions.

ii) Fire as a factor instrumental in maintaining, or creating, open savannas should be used to its best advantage in the northern, and other, areas of the Park.

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Factors such as its effect on the palatable ("sweet") grasses of the north-eastern flats, inhibitory effects on the growth and regeneration of especially Colophospermum mopane shrubs, and the most advantageous frequency of application, should be determined. Results to clarify some of these aspects have already been obtained through prolonged research efforts (Van Wyk pers. comm.). These results should be analysed to form the basis of the recommended burning regime.

A burning policy with the object of achieving the separation of animals should also be investigated, e.g. a longer inter-burning frequency in the favoured roan areas, to maintain medium to tall grass conditions, and more frequent burns to create, albeit temporary, short grass conditions to attract animals such as zebra and wildebeest to areas where they will not be in direct competition with roan.

iii) All the environments currently occupied by roan have been provided with numerous additional watering points in recent years. The reaction of the various animal populations to these new water resources should receive careful attention to avoid the proliferation of one or two populations at the cost of others.

iv) With the fencing of the eastern boundary of the Kruger Park - which should be completed in the course of 1976 - the movements of especially elephant, zebra and eland to the adjoining areas of Mocambique will be curtailed. New ecological patterns regarding the seasonal movements and concentration areas of these animals may be expected and it would therefore be imperative to study their influences on the rarer animals from the earliest stages.

v) Limiting factors and the interpretation of cause and effect phenomena need further investigation in both roan and other rare animals. The effects of factors such as predation and disease on population growth, and whether of a primary or secondary nature, need more detailed analysis.

In conclusion then, wildlife management has become a generally accepted concept in modern-day conservation. The need for man to regulate the

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course of animal populations and their environmnent has largely arisen from the fact that conservation areas are fringed with ever-encroaching human civilisation and the consequent loss of freedom of the animal populations to evacuate an area in favour of a more favourable one. Under such circumstances it has become inevitable that wildlife be subjected, to a greater or lesser degree, to artificial, man-induced management projects.

However, it should at all times be the object to manage ecosystems with the minimum of interference. In this respect it may be well to heed the warning of one of the great South African pioneers in wildlife management, Col. J. Stevenson-Hamilton (1947) who wrote that " ... it is so easy to misunderstand the factors governing the actions and reactions of wild creatures living under natural conditions. Man, today, has such absolute power over the existences of other creatures of the earth, that any action taken as the result of inaccurate observations, or faulty deduction, may not only cause irreparable mischief, but may defeat the very interests which it is intended to serve".

May our actions reflect our responsibility.

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SUMMARY

The results of the second part of a six-year study of the roan antelope, Hippotragus equinus equinus (Desmarest, 1804), are presented in this paper. The research was conducted in the Kruger National Park which is situated in the north-eastern Transvaal Lowveld of the Republic of South Africa.

A review of the taxonomic status of the species is given with notes on the six recognised subspecies and their distribution. There is considerable overlap and intergrading of the various subspecies; furthermore, subpsecies differentiation is superficial and the species is consequently in need of a more thorough taxonomic revision.

Research into the past and present distribution of the roan has revealed that the species still - as in the past - occurs throughout most of the Southern and Northern Savanna zones. In spite of its wide distribution, detailed information of even the present distribution is poorly documented for large areas of the sub-continent. All evidence suggests that the roan has never been a numerically important species in most wildlife communities, although represented in most of the savanna associations. Two major areas of relatively high densities occur in the central regions of Africa, i.e. from the west coast of Angola eastwards into Zambia, and the area south of Lake Tchad to the northern boundary of the Central African Republic. Roan are well represented in a large number of national parks and other wildlife sanctuaries, though, in general, their numbers have dwindled and they have become extinct over vast areas of their former range.

Due to the importance of determining the age structure of populations in ecological studies, on the one hand, and the limited populations of roan in most areas, on the other, the need for morphological criteria in age determination has been emphasised. Horn growth characteristics have proved to be the most suitable for the roan in this respect. Between the ages of two to 12 months age determination may be achieved by horn length in relation to age. In the

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age-group 12 to 36 months the development of successive conspicuous horn annulations renders a readily applicable field method for age determination. In young calves the shedding of the neonate pelage provides additional data for age determination. The sequence of tooth eruption conforms to that of most other bovids and may be used for age determination. Tooth wear categories of deciduous, but more especially the permanent teeth, provide additional criteria for age determination in both immature and adult animals. Clearly defined cementum layers in the teeth could also provide a means of determining age but need further investigation.

Reproductively the roan antelope has one of the highest potentials of all the larger antelopes. Females conceive for the first time at the age of 22 to 24 months, and give birth to their first calf at the age of 31 to 33 months. There is no post partum anoestrus and cows may conceive again three weeks after parturition. If unsuccessful, conception almost invariably takes place during the second post partum oestrus cycle, three weeks after the first. This results in a mean intercalving period of 317 days. A roan cow may, therefore, give birth to six calves in every five-year cycle. The reproductive lifespan is believed to be 10 to 12 years.

Mortality amongst calves is high during the first six weeks following birth and may be as high as 80 per cent. The first six weeks of life coincides with the period of concealment of the young calf and although it is vulnerable to a wide array of predators during this period, the major decimating factor is thought to be disease. Mortality diminishes rapidly after this period. During the immature stages there is no sex differential mortality. After the expulsion of males from the nursery herds mortality amongst the males supercedes that of females by two to one. Adult roan antelope are especially vulnerable to anthrax and heavy losses have been incurred during repeated epizootics.

From a review of the past history of the Kruger National Park roan

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population it appears that the fluctuations reported periodically since the turn of the century reflect those of a stable population in balance with its environment

The diet of the roan consists largely, but not exclusively, of grasses. In its grazing habits the species is fairly catholic and intake largely reflects availability. However, preference ratings, based on selection as opposed to availability during the dry periods of the year, suggest the selection of a few favoured grass species.

Roan utilize the upper parts of the leaves, stems and inflorescences of grasses and do not normally graze close to the ground. They are therefore also characteristically found in medium to tall grasslands or open savanna areas and avoid overgrazed or otherwise denuded areas. They are consequently sensitive to competition by large concentrations of especially those species which graze close to the ground e.g. wildebeest and zebra.

To determine the habitat requirements of roan, botanical surveys were undertaken to isolate the important physiognomic aspects of favoured roan habitats. Factors such as the stratification, relative density and relative cover of the woody vegetation were determined. Results indicate that roan are sensitive to trees and shrubs in especially the 1,5 to 4,0 m height classes. The north-eastern flats adjoining the Lebombo Mountain Range represent the major habitat for roan in the Kruger National Park. This area may, however, be subdivided into a number of regions in relation to the specific requirements of roan and it was found that only limited areas actually conform to optimum roan habitat. All the areas representing favourable roan habitats are presently occupied.

With due consideration of the social behaviour and ecological requirements of the roan, management recommendations have been proposed with the objective of stabilising the present sub-populations of roan in the Kruger National Park by providing more optimal habitats and alleviating the negative effects of adverse competition from associated animal species. Proposals for future research on aspects that may influence the successful management of the roan are also suggested.

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OPSOMMING

Die resultate van die tweede deel van 'n ses-jaar studie van die bastergemsbok, Hippotragus equinus equinus (Desmarest, 1804), word in hierdie proefskrif saamgevat. Die navorsing is in die Nasionale Krugerwildtuin, geleë in die Transvaalse Laeveld van die Republiek van Suid-Afrika, onderneem.

'n Oorsig van die taksonomiese status van die spesie word gegee met verwysing na die ses erkende subspesies en hulle verspreiding. Aansienlike oorvleueling en integrasie van die onderskeie subspesies kom voor en die differensiasie tussen subspesies is verder baie oppervlakkig. Gevolglik is 'n intensiewe hersiening van die taksonomiese aspekte van die spesies noodsaaklik.

Navorsing aangaande die eertydse en huidige verspreiding van die bastergemsbok dui daarop dat die spesie nog steeds in die grootste deel van die Noordelike en Suidelike Savanna sones voorkom. Ongeag die wye verspreiding van hierdie spesie is daar egter groot dele in hulle huidige verspreidingsgebied waaroor daar baie min inligting beskikbaar is. Alle gegewens dui daarop dat die bastergemsbok nooit 'n numeries belangrike spesie in meeste wildgemeenskappe was nie, ondanks hulle aanwesigheid in meeste van die savanna gemeenskappe. Twee gebiede met relatiewe hoë digthede is in die sentrale dele van Afrika geleë, d.i. vanaf die weskus van Angola ooswaarts tot in Zambië en suid van Tshadmeer tot by die noordelike grens van die Sentraal Afrikaanse Republiek. Bastergemsbokke is goed verteenwoordig in 'n groot aantal nasionale parke en ander wildreservate maar oor die algemeen het hulle getalle gedaal en hulle het selfs uit groot dele van hulle eertydse verspreidingsgebiede verdwyn.

Weens die belangrikheid van die ouderdomstruktuur van wildbevolkings in ekologiese studies, aan die een kant, en die beperkte getal bastergemsbokke in meeste gebiede, aan die anderkant, is daar klem gelê op die behoefte aan 'n metode waarin van morfologiese eienskappe vir ouderdomsbepalings gebruik gemaak kan word. In hierdie verband het horingontwikkeling die mees suksesvolle geblyk

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te wees. In die twee tot 12 maande ouderdomsgroep kan ouderdomme vasgestel word deur horinglengte. In die ouderdomsgroep 12 tot 36 maande bied die opvallende opeenvolgende horingringe 'n gerieflike metode van ouderdomsbepaling onder veld-toestande. Onder jong kalfies bied die vervanging van die geboortehaarkleed 'n bykomende ouderdomskriterium. Die volgorde van tandwisseling is in ooreenstemming met dié van die meeste Bovidae en kan vir ouderdomsbepalings aangewend word. Tandslytasieklasse van wisseltande en meer bepaaldelik die permanente gebit, bied addisionele kriteria vir die ouderdomsbepaling van onvolwasse en volwasse diere. Goedgedefinieerde sementum lae in die tande mag ook moontlikhede vir ouderdomsbepalings inhou maar vereis verdere navorsing.

Die reproduksie potensiaal van die bastergemsbok is van die hoogste onder die groter antiloopsoorte. Koeie word vir die eerste keer op 22 tot 24 maande gedek en gee op 31 tot 33 maande ouderdom geboorte aan hulle eerste kalwers. Daar is geen post partum anestrus nie en koeie mag drie weke na 'n geboorte weer gedek word. Indien bevrugting nie met die eerste estrus siklus plaasvind nie, vind dit feitlik sonder uitsondering tydens die tweede siklus, drie weke na die eerste, plaas. Dit het 'n gemiddelde tussenkalf periode van 317 dae tot gevolg. 'n Bastergemsbokkoei is dus in staat om in elke vyf-jaar siklus aan ses kalwers geboorte te gee. Die reproduktiewe lewensduur word op 10 tot 12 jaar gereken.

Mortaliteit onder kalwers is veral hoog in die eerste ses weke na geboorte en mag tot 80 persent wees. Dié tydperk verteenwoordig ook die verstekingsperiode van die jong kalf en hoewel kalwers dan meer aan verprooiing deur 'n groot verskeidenheid roofdiere blootgestel is, word die grootste verliese aan siektes gewyt. Na hierdie periode neem mortaliteit vinnig af. In die onvolwasse segmente is daar geen geslagsgedifferensieerde mortaliteit nie hoewel die verliese onder bulle die van koeie met twee teen een oorskrei na die jong bulle die teeltroppe verlaat het. Miltsiekte het reeds hoë bastergemsbok verliese in opeen-

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volgende epidemies in die Nasionale Krugerwildtuin tot gevolg gehad. Veral die volwasse diere is besonder kwesbaar . Uit 'n oorsig van die bastergemsbokbevolking van die Nasionale Krugerwildtuin blyk dit dat die fluktuasies wat periodiek sedert die begin van die eeu gerapporteer is, verteenwoordigend is van 'n stabiele bevolking in ewewig met sy omgewing.

Die dieet van die bastergemsbok bestaan grootliks, maar nie uitsluitlik nie, uit grasse. Die spesie benut 'n wye verskeidenheid grasspesies hoewel die beskikbaarheid van voedselplante die verbruik daarvan bepaal. Voorkeurbepalings, gebaseer op benutting in verhouding tot beskikbaarheid, dui egter daarop dat sekere grassoorte bo ander geselekteer word.

Bastergemsbokke benut gewoonlik die hoërliggende blare, stingels en bloeiwyses van grasse en wei normaalweg nie tot op grondvlak nie. Hulle kom gevolglik ook gewoonlik in middelmatig tot lang grasveld, of savanna-gebiede, voor en vermy oorbeweide of andersins kaal gebiede. Hulle is derhalwe gevoelig vir kompetisie in die vorm van groot konsentrasies ander wild, en veral kortgras beweiers bv. wildebeeste en kwaggas.

Om die habitatsvereistes van bastergemsbokke vas te stel, is botaniese opnames onderneem om die belangrike fisiognomiese faktore in hulle voorkeurhabitatte te bepaal. Faktore soos die stratifikasie, relatiewe digtheid en relatiewe bedekking van houtagtige plante is vasgestel. Dit blyk dat bastergemsbokke gevoelig is vir bome en struike in veral die 1,5 tot 4,0m hoogteklas. Die noordoostelike Lebombo Vlakte verteenwoordig die vernaamste bastergemsbokhabitat in die Nasionale Krugerwildtuin. Hierdie gebied mag egter in 'n aantal subgebiede onderverdeel word na gelang van die spesifieke behoeftes van die bastergemsbok en daar is gevind dat slegs beperkte streke voldoen aan die optimum vereistes. Alle beskikbare, geskikte bastergemsbokgebiede word tans deur hierdie diere benut.

Met inagneming van die sosiale gedrag en ekologiese behoeftes van die bastergemsbok is bestuursaanbevelings gedoen om die huidige bevolkings in die

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Nasionale Krugerwildtuin te stabiliseer deur meer optimale habitatte beskikbaar te stel en hulle teen nadelige kompetisie deur geassosieerde spesies te beskerm. Voorstelle vir verdere navorsing oor aspekte wat die suksesvolle bestuur van die bastergemsbok mag beïnvloed, word aan die hand gedoen.

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Appendix 1 : The larger mammal taxa and their respective population estimates for 1973/74, as derived from ground and aerial censusing, in the Kruger National Park, South Africa. Nomenclature according to Ansell (1971).

Herbivores	Population Totals	Remarks
Family: Elephantidae Loxodonta africana (African elephant)	7 702	Subjected to annual culling
Family: Rhinocerotidae Diceros bicornis (Black rhinoceros)	± 30	Re-introduced in 1971 after becoming extinct
Ceratotherium simum (White rhinoceros)	500	Re-introduced in 1961 after becoming extinct
Family: Equidae Equus burchelli antiquorum (Burchell's zebra)	13 800	Culling operations discontinued (1972) after decline in population of Central District.
Family: Suidae Potamochoerus porcus (Bushpig)	Probably less than 300	Rare, but fairly common locally.
Phacochoerus aethiopicus (Warthog)	± 2 700	
Family: Hippopotamidae Hippopotamus amphibius (Hippopotamus)	2 321	Locally over abundant, culling operations in Letaba, Olifants and Crocodile rivers.
Family: Giraffidae Giraffa camelopardalis (Giraffe)	4 125	
Family: Bovidae Cephalophus natalensis (Red duiker)	Very rare	25 introduced in 1972 from neighbouring areas to augment K.N.P. population
Sylvicapra grimmia (Grey Duiker)	Probably more than 800	
Raphicerus campestris (Steenbok)	Probably more than 4 000	
R. sharpei (Sharpe's steenbok)	Probably less than 800	

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Herbivores	Population Totals	Remarks
Family: Bovidae		
Neotragus moschatus (Livingston's suni)	Extremely rare	
Ourebia ourebi (Oribi)	± 150	Re-introduced into south-western area in 1972.
Oreotragus oreotragus (Klipspringer)	More than 1 000	
Redunca arundinum (Reedbuck)	± 1 500	
Redunca fulvorufula (Mountain reedbuck)	± 200	148 introduced to augment small local population (1974).
Kobus allipsiprymnus (Waterbuck)	3 100	
Aepyceros melampus (Impala)	154 000	Culling operations in specified areas.
Hippotragus equinus (Roan antelope)	280	
H. niger (Sable antelope)	1 200	
Damaliscus lunatus lunatus (Tsessebe)	600	
Connochaetes taurinus (Blue wildebeest)	7 400	Culling discontinued (1972) after population decline in Central district.
Tragelaphus scriptus (Bushbuck)	Probably more than 700-800	
T. angasi (Nyala)	Probably more than 600	
Strepsiceros strepsiceros (Kudu)	7 200	
Taurotragus oryx (Eland)	340	
Syncerus caffer (Buffalo)	23 172	Subjected to culling operations.

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LARGER CARNIVORES

Family: Canidae		
Canis mesomelas (Black-backed jackal)	Probably more than 1 500	
C. adustus (Side-striped jackal)	In the region of 300	
Lycaon pictus (Cape wild dog)	± 400	
Family: Hyaenidae		
Crocuta crocuta (Spotted hyaena)	Probably more than 2 500	Considered locally over-abundant.
Hyaena brunnea (Brown Hyaena)	Very rare	
Family: Felidae		
Acinonyx jubatus (Cheetah)	Less than 300	
Panthera pardus (Leopard)	± 700	
Panthera leo (Lion)	± 1 500	Considered locally over-abundant.

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Appendix 2 : Tooth eruption and attrition, skull characteristics and horn development of roan antelope from the Kruger National Park (K.N.P.) and the Percy Fyfe Nature Reserve (P.F.N.R.), South Africa, and the skull collection of the National Museum, Bulawayo, Rhodesia (R).

IMMATURES

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RING	MAND. LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
1. ?	P.F.N.R.	-	-	16,0	20,3	m m m m		- e e		- - -		3 days*	Premolar 2: broken through bone case
2. ?	? (R)	Not emerged	-	19,8	25,4	m m m m		e m m		- - -		3-4 wks.	Premolars: Max: all erupted. Mand. 3-4 erupted; 2 erupting
3. ?	? (R)	Just emerging	-	19,5	26,8	m m m m		m m m		- - -		5 weeks	Mol. 1: Ant. cusps just breaking through casing.
4. ♀	Shapi (R)	0,5 - 0,7	-	22,0	28,1	m m m m		m m m		- - -		6-7 wks.	Mol. 1: Breaking through bone casing.
5. ?	? (R)	Bone core: 2,0 Horn: ± 3,0	-	23,3	31,2	m m m m		m m m		- - -		3	Mol. 1: Max: just breaking through casing. Mand: Very near to erupting.
6. ?	? (R)	?	-	24,1	31,4	m m m m		m m m		e - -		3-4	Mol.1: Max.: Breaking through casing. Mand: Ant. cusps just emerging
7. ?	? (R)	3,9	-	24,3	31,5	m m m m		m m m		- - -		4	Mol.1: Max: breaking through casing.Mand. Very near to erupting
8. ?	? (R)	Bone core: 3,0 Horn: +4,0-5,0	-	25,2	33,4	m m m m		m m m		e - -		4	Mol.1: Just surfacing (ant.cusp)in mand.+ max.

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IMMATURES

NO. & SEX	LOCALITY	HORN LENGTH (cm)		MAND. LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
9. ♀	K.N.P.	4,8	-	-	-	m m m m		m m m		?		4*	
10. ♀	K.N.P.	6,4	-	-	-	m m m m		m m m		?		5*	
11. ♂	K.N.P.	6,2	-	-	-	m m m m		m m m		?		5*	
12. ♀	K.N.P.	7,6	-	-	-	m m m m		m m m		?		5*	
13. ♂	K.N.P.	10,5	-	-	-	m m m m		m m m		?		6*	
14. ?	? (R)	11,0	-	26,1	33,6	m m m m		m m m		e - -		6-8	Mol. 1: Max.Ant.cusp erupted. Mand.: Ant & post. cusps erupted.
15. ♂	K.N.P.	21,0	-	-	-	m m m m		m m m		?		12*	
16. ♂	K.N.P.	19,1	1	-	-	m m m m		m m m		?		11-12*	
17. ♀	Tjollotjo	14,0	1	25,8	33,0	m m m m	(L)	m m m	(N)	1 - -		11-12	Mol 2: Max: Not yet breaking casing. Mand: Breaking through casing.

SUB-ADULTS

1. ♂	K.N.P.	27,3	2	-	-	m m m m		m m m				16*	
2. ♀	Tjollotjo (R)	?	3	26,2	33,0	m m m m	(L)	m m m	(N)	1 - -		14-16	Mol 2: Not yet breaking casing. Mand: Breaking through casing
3. ♂	Ft. Jameson (R)	21,0	3	29,3	38,5	m m m m	(L)	m m m	(L)	1 - -		14-16	Mol 2: Max: Breaking through casing.Mand: Ant. cusps just erupting

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SUB-ADULTS

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RINGS	MAND. LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
4. ♂	K.N.P.	27,6	3	-	-	m m m m	(L)	m m m		?		16*	
5. ♂	K.N.P.	?	3	-	-	P m m m		m m m		?		16*	
6. ♀	K.N.P.	22,2	3	-	-	m m m m		m m m		?		14-16	
7. ♂	Chipingali (R)	25,8	4	32,0	42,4	m m m m	M-H	m m m	L	1 - -		16-17	Mol 2: Max: Ant.cusp probably just emerging Mand: Ant. & post. cusps erupted
8. ?	? (R)	24,3	4	31,1	40,0	m m m m	M	m m m	L	1 e -		16-17	Mol 2: Max: Ant. cusp erupted. Mand.: Ant & post cusps erupted.
9. ?	? (R)	25,4	4	30,4	40,5	m m m m		m m m		1 e -		16-17	Mol 2: As above
10. ♂	K.N.P.	27,8	4	31,1	38,6	P m m m		m m m	M	1,3,-		17*	Mol 3: Max. Not through casing. Mand: Just breaking through casing.
11. ♀	P.F.N.R.	24,8	4	31,3	38,2	m m m m	M-H	m m m	M-H	1 e -		16-17	Mol 2: Max: Ant. cusps erupted. Mand. Ant and post. cusps erupted.
12. ♀	P.F.N.R.	20,5	4	29,2	36,2	m m m m	M-H	m m m	M	1 e e		16-17	Mol 2: Max. & Mand: Through casing but not erupted.
13. ♂	Chipingali (R)	16,0	5	31,4	41,1	m m m m	M-H	m m m	L-M	1,2,-		18-19	Mol 2: Max: Ant cusps erupted. Mand.Fully erupted.
14. ♂	Chipingali (R)	31,3	5	31,5	40,0	m m m m	M-H	m m m	L-M	1,2,-		18-19	Mol 2: Just fully erupted in max.

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SUB-ADULTS

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RINGS	MAND LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
15. ♂	? (R)	25,6	5	-	42,9	m m m m	M-H	m m m	M	1,2,-		18-19	
16. ♀	Ft. Jameson (R)	27,7	5	31,2	41,0	m m m m		m m m	L-M	1,2,-		18-19	Mol.2: Max: Ant. cusp only.Mand.Just fully erupted.
17. ♂	? (R)	31,0	5	31,9	41,8	m m m m		m m m	M	1 e -		18-19	Mol.2: Max: Ant. cusp only. Mand: Ant & post cusps erupted.
18. ♀	K.N.P.	29,2	5	-	-	m m m m		m m m		?		18-19	
19. ♂	Tjollotjo (R)	26,0	5	-	-	m m m m		m m m		?		18-19	
20. ♀	Tjollotjo (R)	34,7	6	29,8	?	m m m m	M-H	m m m		1,2,-		20-21	Mol.3: Max: Breaking through casing
21. ♂	Ft. Jameson (R)	27,2	6	30,1	38,8	m m m m		m m m		1,2,-		20-21	Mol. 2: Max: Ant cusp about to erupt. Mand. Just erupted.
22. ♂	? (R)	27,8	6	32,7	41,2	P m m m	(H)	m m m	M	1,2,-		20-21	
23. ♂	Chipingali (R)	34,4	6	-	41,8	m m m m	H	m m m	M	1,2,-		20-21	
24. ♀	K.N.P.	32,0	7-8	-	-								
25. ♀	W. Nicholson (R)	28,8	7	33,4	42,7	e m m m	H	m m m	M	1,2,-		21-22	
26. ?	Mapani (R)	38,2	7	-	-	?		m m m	M-H	1,2,-		21-22	
27. ♀	K.N.P.	33,0	7	-	-							21-22	
28. ♀	Tjollotjo (R)	35,5	7	-	-	m m m m		m m m		?		21-22	
29. ♀	Tjollotjo (R)	34,0	8	-	-	m m m m		m m m		?		22-23	
30. ♂	Chipingali (R)	33,6	8	33,6	42,1	3 m m m		m m m	M-H	1,2.-		22-23	Mol.3: Max: Not through casing.Mand.Through casing

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SUB-ADULTS

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RINGS	MAND LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
31. ♂	? (R)	52,0	9	29,3	39,1							23-25	
32. ♂	K.N.P.	39,3	11	33,2	40,3	P e m m		m m m	M-H	1,2,-		28*	Mol.3: Max. Just breaking through casing. Mand. Ant. cusp erupting
33. ♂	K.N.P.	38,0	11	-	-	P m m m		m m m		?		28	
34. ♀	Lutembwe (R)	30,0	11	32,0	40,4	P e m m		m m m	H	1,2		28	Mol. 3: Max: Not through casing. Mand: Broken through casing
35. ♀	Tjollotjo (R)		12	-	-	P P m m		m m m		?		29	
36. ♂	Ft. Jameson (R)	41,0	12	34,7	44,9	P m m m		m m m	H	1,2,e		29	Mol. 3: Max. Through casing but not erupting. Mand.: Ant.cusp erupted.
37. ♂	Msandileriv. (R)	46,5	12	34,6	44,3	P P P P		P P e		1,2,3		29	Premolars: 2+3 erupted; 4 lifting milk tooth
38. ♀	P.F.N.R.	30,5	12	31,7	39,2	P P m m		m m m	H	1,2,e		29	Mol. 3: Max: Ant cusp erupted. Mand: Ant & post cusps erupted.
39. ♂	K.N.P.	41,2	11-12	33,1	42,1	P P P e		m m m	H	1,2,e		29	Mol.3: Max: just through bone casing. Mand. just erupted.
40. ♀	P.F.N.R.	41,3	12	-	-	P m m m		m m m		?		29	
41. ♀	K.N.P.	38,9	13	33,4	41,0	P P P P		m m m	H-M	1,2,e		30-31	Mol.3: Max: Ant. cusp about to erupt.Mand.Ant & post cusps erupted.

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SUB-ADULTS

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RINGS	MAND LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
42. ♂	? (R)	49,0	13	33,5	43,8	P P P P		m m m	H	1,2,3		30-31	Premolars: Not erupted, but being lifted.
43. ♀	K.N.P.	41,5	13	-	-	P P P P		?		?		30-31	
44. ♂	K.N.P.	57,3	13	-	-	P P P P		?		?		30-31	
45. ♀	Tjollotjo (R)	48,3	13	-	-	P P P m		-		-		30-31	
46. ♀	Tjollotjo (R)	44,0	13	-	-	P P m m		-		-		30-31	
47. ♂	K.N.P.	48,5	14	-	-	P P P m						33*	
48. ♂	? (R)	43,0	14	-	-	?		m m m	H	1,2		32-33	Mol.3: Max.: Broken through casing
49. ♂	Kali-Kali (R)	55,3	14	34,0	44,2	P P P P		P P P		1,2,3		32-33	Premolars: Max:Replacing 3 erupted but not 2+4. Replacing almost simultaneous Mand. All just replaced.
50. ♂	Ft. Jameson (R)	49,8	14	35,5	45,5	P P P P		m m m	H	1,2,3		32-33	Mol.3: Recent replacement
51. ♂	? (R)	50,5	14	-	44,1	?		e e e		1,2,e		32-33	Premolars: Max.all simultaneously rising (almost erupted) beneath worn milk premolars Mol.3: Ant.cusp erupted; post cusp just emerging.
52. ♂	K.N.P.	54,6	15	-	-	P P P P		?		?		34-36	
53. ♂	Livingstone (R)	47,0	15	32,3	44,2	P m m m	H	m m m	H	I,II,e		34-36	

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SUB-ADULTS

NO. & SEX	LOCALITY	HORN LENGTH (cm)	RINGS	MAND. LENGTH (cm)	SKULL LENGTH (cm)	INCISOR	WEAR	PREMOLARS	WEAR	MOLARS	WEAR	AGE (MONTHS)	REMARKS
54. ♂	Kasukambale (R)	?	?	34,3	45,8	P P P e		e e e		1,2,3		34-36	Premolars: Not erupted but being lifted (almost erupted).
55. ♂	Chipingale (R)	54,3	16	36,4	45,8	P P P P		e e e		1,2,3		34-36	Premolars: Max. all recently erupted. Mand close to erupted but still lifting milk set.
56. ♂	Tjollotjo (R)	46,3	15-16	-	45,7	P P P P	N	P P P	N	1,2,3	N	34,36	All permanent, recently replaced and no wear.
57. ♂	?	53,3	17	35,1	46,5	P P P P	N	P P P	N	1,2,3	N		
58. ♂	Chipingale (R)	59,8	17	35,0	44,1	P P P P	N	P P P	N	1,2,3	N		

YOUNG ADULTS

NO. & SEX	LOCALITY	HORN LENGTH	RINGS	MAND.LENGTH	SKULL LENGTH	TOOTH WEAR		
						Incisor	Premolars	Molars
1. ♂	? (R)	53,5	18	34,1	43,4	N	N	N
2. ♂	K.N.P.	64,5	19	-	-	N	N	N
3. ♀	? (R)	52,5	20	34,9	44,3	N	N	N
4. ♂	W.Nicholson (R)	54,0	20	36,6	45,1	L	N-L	N
5. ♂	K.N.P.	56,5	20	-	-	?	?	?
6. ♂	K.N.P.	57,7	21	35,6	45,2	N	N	N
7. ♂	Nagupande (R)	63,7	22	36,4	46,1	N	N	N

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YOUNG ADULTS

NO. & SEX	LOCALITY	HORN LENGTH	RINGS	MAND.LENGTH	SKULL LENGTH	TOOTH WEAR		
						Incisor	Premolars	Molars
8. ♀	Tjollotjo (R)	49,2	22	34,1	44,2	L	N-L	N
9. ♂	? (R)	69,8	22	36,8	-	L	L	N-L
10. ♂	K.N.P.	72,0	22	-	-	?	?	?
11. ♀	K.N.P.	52,1	22	-	-	?	?	?
12. ♀	Manzila (R)	48,0	23-24	33,0	-	L	L	N-L

ADULTS

NO. & SEX	LOCALITY	HORN LENGTH	RINGS	MAND.LENGTH	SKULL LENGTH	TOOTH WEAR		
						Incisor	Premolars	Molars
1. ♀	Ft. Jameson (R)	52,7	1,0(24)	-	-	L	L	N-L
2. ♂	? (R)	64,0	1,5(26)	34,7	45,9	L	L	L
3. ♀	? (R)	47,7	2,5(24)	34,4	42,7	L-M	L-M	L
4. ♀	Chipingali (R)	57,8	3,5(28)	37,1	47,1	M	L-M	L
5. ♂	? (R)	70,7	4,0(24)	36,4	46,3	L	L	N
6. ♀	Ft. Jameson (R)	52,0	4,0(23)	36,0	45,7	M-H	M	L
7. ♀	Chipingali (R)	47,2	4,5(17)	35,5	44,8	M	M	L
8. ♀	? (R)	56,0	5,0(18)	-	43,7	M	M-H	L
9. ♀	? (R)	54,5	5,0(20)	37,8	46,3	L	L	L
10. ♂	Kalomo Zam (R)	54,0	5,0(20)	-	-	M	M	L

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ADULTS

NO. & SEX	LOCALITY	HORN LENGTH	RINGS	MAND.LENGTH	SKULL LENGTH	TOOTH WEAR		
						Incisor	Premolars	Molars
11. ♂	? (R)	63,0	5,0(23)	-	45,7	M-H	M-H	L
12. ♂	? (R)	64,3	5,0(21)	35,6	45,8	M	M-H	M
13. ♀	Ghona-re-Zhou (R)	50,6	5,5(16)	36,6	45,2	M-H	M	L
14. ♂	? (R)	64,8	5,5(26)	35,4	44,4	H	M-H	M
15. ♂	? (R)	64,2	5,5(27)	-	44,1	M	L-M	L
16. ♂	Chipingali (R)	70,4	6,0(25)	33,8	43,9	M-H	M	L-M
17. ♂	Lundi. (R)	62,5	6,0(27)	34,8	43,5	M	L-M	L
18. ♂	? (R)	70,4	6,0(24)	-	46,3	M	M	L
19. ♂	Latete (R)	60,5	6,5(23)	37,9	47,2	M-H	M	L-M
20. ♂	? (R)	71,5	6,5(23)	-	44,5	M-H	M	M
21. ♀	Ft. Jameson (R)	58,0	7,0(24)	35,0	43,8	M-H	M	M
22. ♂	Livingstone (R)	69,0	7,5(26)	37,8	45,5	H	M-H	M
23. ♂	Ft. Jameson (R)	60,3	8,0(23)	36,2	45,6	H	H	M-H
24. ♀	Ft. Jameson (R)	55,8	8,0(25)	36,1	46,5	H	H	H
25. ♂	? (R)	59,9	8,0(17)	34,2	44,7	M	L-M	L
26. ♀	Ndola (R)	47,9	9,0(20)	35,7	43,5	H	M	L-M
27. ♂	? (R)	60,5	10(?)	35,5	46,9	H	H	H

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OLD ADULTS

NO.& SEX	LOCALITY	HORN LENGTH	RINGS	MAND.LENGTH	SKULL LENGTH	TOOTH WEAR		
						Incisor	Premolars	Molars
1. ♂	Nuanetsi (R)	64,6	12,0(21)	36,1	46,0	H	M-H	M-H
2. ♀	? (R)	62,4	12,0(23)	36,1	46,1	H	H	H
3. ♀	Ft.Jameson (R)	62,0	12,0(23)	35,3	44,2	H	H	H
4. ♀	? (R)	57,0	13,0(?)	-	-	H	H	H
5. ♀	? (R)	64,0	14,0(27)	36,9	47,0	H	H	H

Footnote:

HORN RINGS: For adults and old adults figure before brackets represents height of smooth horn base (see text) and figure in brackets the number of horn rings above smooth base.

MANDIBULAR LENGTH: Condyle crest to mandibular extreme

SKULL LENGTH: Lambdoid crest to premaxilla extreme

TEETH: m = deciduous tooth
e = erupting
P = permanent

TOOTH WEAR: N= none
L = light
M = moderate
H = heavy

*Known-age animals

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Appendix 3 : Obstruction to vision by vegetation as measured with a visibility board in 13 areas representing roan and sable habitats in the Kruger National Park, South Africa.

Locality : Meestel/Shabin
(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS (m)							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
1	35,0	10	9	4	2	3	3	3	3
2	17,8	10	9	3	1	-	-	1	2
3	20,5	10	9	4	1	-	-	2	2
4	22,7	10	8	5	1	2	2	1	1
5	16,7	10	8	6	2	-	-	-	1
6	27,5	10	5	3	1	2	3	2	3
7	25,5	10	10	5	4	2	1	1	1
8	24,4	10	8	4	2	1	1	2	2
9	50,8	10	7	5	5	5	4	5	5
10	30,0	10	8	7	5	1	1	2	2
11	16,3	10	7	4	2	-	-	1	1
12	24,4	10	10	10	5	-	-	-	1
13	26,4	10	9	4	2	4	2	1	1
14	42,2	10	9	4	4	4	4	4	3
15	51,9	10	8	6	4	4	4	6	5
16	36,4	10	3	2	3	2	2	5	5
17	6,1	10	3	2	-	-	-	-	-
18	12,8	10	5	1	1	1	1	-	1
19	25,8	10	8	3	3	2	1	2	2
20	10,3	10	3	2	1	1	1	-	-
21	30,3	10	4	2	3	2	3	3	3
22	32,5	10	4	3	3	3	3	3	3
23	17,8	10	3	1	1	1	1	2	2
24	39,4	10	9	3	1	2	4	5	4
25	38,8	10	10	9	3	3	3	2	3
26	65,0	10	4	4	7	7	6	7	7
27	41,7	10	5	3	3	5	4	4	4
28	86,1	10	5	6	7	8	9	10	10
29	64,4	10	6	2	5	7	6	7	8
30	85,0	10	8	7	8	9	9	8	9
MEAN	34,1	300	204	124	90	81	78	89	94

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STUNGWANE
(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
31	28,0	10	5	4	3	3	2	2	2
32	23,0	10	5	2	2	3	2	2	1
33	33,6	10	8	5	4	3	2	3	2
34	10,8	10	4	4	1	1	-	-	-
35	16,6	10	6	4	2	1	1	1	-
36	56,6								
37	36,1								
38	30,0								
39	36,9								
40	7,7								
41	11,9	10	3	1	-	-	-	1	1
42	18,8	10	3	1	1	2	2	1	2
43	13,6	10	3	1	1	1	1	1	1
44	4,7	10	-	1	1	-	-	-	-
45	11,9	10	2	-	-	-	1	1	2
46	19,2	10	8	3	2	1	1	1	1
47	23,0	10	5	1	2	2	2	2	2
48	24,7	10	4	2	1	1	3	2	3
49	41,7	10	2	2	2	3	4	5	6
50	31,4	10	6	2	2	1	2	3	5
MEAN	24,1	150	64	33	24	22	23	25	28

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SHIP MOUNTAIN
(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
51	27,0	10	2	-	2	2	2	3	4
52	50,9	10	7	5	4	5	4	5	5
53	71,9	10	6	8	7	8	8	7	6
54	52,8	10	8	7	8	6	5	5	2
55	26,4	10	6	3	2	2	2	2	2
56	6,9	10	1	-	-	-	1	1	-
57	8,3	10	1	1	1	1	1	-	-
58	13,9	10	6	2	1	1	1	-	-
59	38,9	10	6	3	4	3	3	4	4
60	80,6	10	8	8	7	9	9	7	8
MEAN	37,8	100	51	37	36	37	36	34	31

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SALIJI
(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
61	42,8	10	4	4	4	5	4	3	5
62	74,4	10	9	9	8	10	8	5	6
63	41,0	10	6	4	5	3	3	4	4
64	49,4	10	2	2	5	5	5	5	6
65	5,6	10	1	1	-	1	-	-	-
66	36,7	10	4	3	3	3	3	4	4
67	76,4	10	8	8	8	8	8	7	7
68	80,3	10	6	6	7	8	9	9	8
69	3,3	10	1	-	-	-	-	-	-
70	30,3	10	5	2	3	3	3	2	3
71	59,4	10	6	6	6	6	5	6	6
72	72,5	10	8	9	9	7	8	7	5
73	39,2	10	8	5	5	5	3	3	2
74	31,7	10	7	6	5	2	2	2	2
75	10,5	10	4	4	2	-	-	-	-
76	28,0	10	4	2	1	2	3	3	3
77	47,8	9	6	3	4	4	5	5	5
78	10,5	10	1	-	-	1	1	1	1
79	14,7	10	1	-	1	2	2	1	1
80	43,9	10	2	2	3	4	5	5	5
MEAN	40,0	199	93	76	79	79	77	72	73

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SHITEVE-TEVE

(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
81	34,8	10	4	6	4	5	3	2	2
82	2,8	10	-	-	-	-	-	-	-
83	28,9	10	6	6	3	2	2	2	2
84	51,1	10	6	4	5	5	5	5	5
85	81,4	10	9	8	9	8	9	9	6
86	39,2	10	3	3	3	4	4	4	4
87	8,0	10	3	2	1	1	-	-	-
88	77,2	10	9	8	9	6	8	8	7
89	12,8	10	3	2	2	2	1	-	-
90	64,4	10	9	7	7	8	8	5	4
91	77,2	10	10	9	10	10	8	5	6
92	14,7	10	1	-	-	1	1	2	2
93	37,2	10	5	4	4	3	3	3	4
94	38,3	10	4	4	5	4	4	3	2
95	46,4	10	7	5	4	5	4	4	4
96	11,7	10	4	3	1	1	1	-	-
97	21,4	10	5	3	2	3	3	1	-
98	26,1	10	4	3	1	3	3	2	2
99	5,3	10	3	1	-	-	-	-	-
100	49,2	10	3	4	6	3	6	6	4
101	62,2	10	5	5	5	6	7	7	6
102	43,0	10	5	5	3	4	2	4	6
103	35,9	10	4	4	4	4	3	3	3
104	62,2	10	6	6	7	6	6	6	6
105	36,4	10	6	6	3	2	4	3	3
106	52,5	10	7	7	6	5	6	5	3
107	23,9	10	1	2	2	2	2	2	3
108	58,0	10	3	7	7	6	4	6	6
109	31,9	10	3	3	3	3	3	3	3
110	31,9	10	3	3	3	3	3	3	3
MEAN	38,9	200	141	130	119	115	113	103	96

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NGWENYENE

(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
111	36,1	10	7	5	5	3	3	2	3
112	29,2	10	7	7	4	2	2	2	1
113	33,9	10	7	4	3	4	4	2	2
114	49,7	10	7	7	6	6	6	4	2
115	30,5	10	5	4	4	4	2	2	2
116	63,3	10	6	7	8	7	6	6	5
117	53,0	10	7	8	8	6	5	4	2
118	43,3	10	6	6	5	4	4	4	3
119	37,8	10	2	2	3	4	4	4	4
120	55,3	10	8	7	8	8	6	4	2
121	25,3	10	6	3	2	2	2	2	2
122	58,3	10	9	9	9	8	6	5	1
123	57,8	10	8	7	7	6	6	5	4
124	60,0	10	8	7	8	7	7	4	4
125	59,4	10	9	7	7	7	7	4	4
126	64,2	10	9	9	9	7	5	5	5
127	53,6	10	8	8	7	5	5	4	4
128	41,9	10	8	8	7	5	3	2	2
129	69,4	10	8	7	6	6	6	7	8
130	45,0	10	8	4	4	5	5	1	2
131	69,2	10	9	7	7	8	7	6	6
132	56,7	10	5	4	4	6	6	6	6
133	50,8	10	6	5	6	6	7	6	1
134	48,6	10	5	4	5	5	5	4	5
135	49,1	10	5	4	3	3	6	6	5
136	63,3	10	9	9	7	7	6	6	4
137	55,3	10	9	8	8	5	5	4	4
138	76,9	10	10	10	8	8	8	7	6
139	54,2	10	7	7	4	4	4	6	6
140	51,9	10	5	5	6	5	6	5	4
MEAN	51,1	300	213	189	178	163	154	129	109

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MASORINI

(Sable antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
141	51,4	10	7	6	6	6	5	5	3
142	44,4	10	5	6	6	6	4	4	2
143	72,5	10	8	8	8	8	7	7	6
144	73,3	10	9	7	6	8	7	7	7
145	42,2	10	10	8	7	3	3	3	2
146	66,4	10	9	8	8	7	5	6	6
147	50,8	10	7	4	5	6	5	5	4
148	34,2	10	8	6	4	3	3	2	2
149	47,5	10	7	7	6	5	4	3	4
150	51,9	10	8	7	7	5	6	4	3
151	66,4	10	9	9	7	9	6	5	5
152	28,0	10	6	5	3	2	2	2	2
153	38,9	10	4	4	4	5	4	3	3
154	56,1	10	10	8	5	5	6	5	4
155	22,2	10	5	3	4	2	2	1	1
156	73,0	10	10	9	9	9	7	5	6
157	48,6	10	7	6	6	5	4	4	4
158	61,7	10	8	6	7	6	5	6	6
159	51,7	10	7	7	7	6	5	3	4
160	58,3	10	8	6	7	7	6	5	4
MEAN	51,9	200	152	130	122	113	96	85	78

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MALOPANYANE

(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
161	6,9	10	5	-	-	1	-	-	-
162	5,5	10	5	-	-	-	-	-	-
163	19,2	10	4	4	2	2	1	1	1
164	2,8	8	1	-	-	-	-	-	-
165	7,8	10	6	2	-	-	-	-	-
166	4,7	9	4	-	-	-	-	-	-
167	16,9	10	3	3	2	1	1	1	1
168	3,3	10	1	-	-	-	-	-	-
169	11,1	10	9	4	-	-	-	-	-
170	6,1	9	5	1	-	-	-	-	-
171	6,9	9	5	2	-	-	-	-	-
172	13,3	10	7	5	1	1	-	-	-
173	8,0	10	5	3	-	-	-	-	-
174	3,6	9	2	-	-	-	-	-	-
175	2,8	6	2	-	-	-	-	-	-
176	16,9	10	7	5	3	2	-	-	-
177	4,7	9	4	-	-	-	-	-	-
178	4,4	10	3	-	-	-	-	-	-
179	12,5	10	5	2	1	-	-	1	1
180	12,2	10	3	3	2	1	1	-	-
MEAN	8,6	189	86	34	11	8	3	3	3

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NSHAWU-DZOMBO

(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
181	11,9	10	6	4	1	1	-	-	-
182	15,3	10	6	3	1	1	-	1	1
183	8,9	10	8	2	-	-	-	-	-
184	9,4	10	6	4	-	-	-	-	-
185	26,9	10	9	9	4	4	1	-	-
186	10,5	10	8	4	-	-	-	-	-
187	17,8	10	6	4	1	1	1	1	1
188	14,7	10	8	4	1	1	1	-	-
189	4,7	10	2	1	-	-	-	-	-
190	16,9	10	7	5	1	1	1	1	-
191	18,1	10	6	4	3	3	1	-	-
192	17,2	10	4	2	1	1	1	1	2
193	9,7	10	6	3	1	-	-	-	-
194	12,8	10	4	3	2	1	1	-	-
195	2,8	10	-	-	-	-	-	-	-
196	4,7	10	2	-	-	-	-	-	-
197	10,0	10	8	2	1	-	-	-	-
198	6,7	10	6	-	-	-	-	-	-
199	6,7	10	7	-	-	-	-	-	-
200	9,2	10	8	1	1	-	-	-	-
201	12,5	10	3	1	-	1	1	1	1
202	12,8	10	4	3	1	-	-	1	1
203	8,6	10	3	2	1	1	-	-	-
204	21,1	10	4	2	2	2	2	2	1
205	13,9	10	2	2	1	1	1	1	1
206	30,5	10	6	3	3	2	2	3	3
207	13,9	10	2	2	1	1	1	1	1
208	5,3	10	3	1	-	-	-	-	-
209	7,2	10	5	2	-	-	-	-	-
210	17,5	10	4	2	2	2	1	1	1
MEAN	12,5	300	153	75	29	24	15	14	13

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MAHEWANE

(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
211	18,9	10	8	4	1	1	1	1	1
212	26,1	10	9	7	2	2	2	1	1
213	12,2	10	4	1	1	1	1	-	1
214	27,8	10	7	5	2	2	1	1	-
215	8,3	10	7	2	-	-	-	-	-
216	6,9	9	3	2	1	-	-	-	-
217	27,5	10	4	4	3	3	2	2	2
218	15,3	10	7	3	1	1	1	1	-
219	9,7	10	8	3	-	-	-	-	-
220	27,5	10	5	4	3	3	3	2	1
MEAN	17,2	99	62	35	14	13	11	8	6

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HLAMALALA

(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
231	17,2	10	9	7	2	1	-	-	-
232	21,1	10	7	6	2	1	1	1	1
233	9,1	10	7	3	-	-	-	-	-
234	18,9	10	5	3	2	2	1	1	1
235	4,4	10	3	-	-	-	-	-	-
236	5,2	10	3	1	-	-	-	-	-
237	8,9	10	5	1	1	1	-	-	-
238	11,9	10	4	1	1	1	1	1	-
239	9,4	10	4	4	1	-	-	-	-
240	6,4	10	5	1	-	-	-	-	-
241	15,3	10	6	2	1	1	1	1	1
242	15,0	10	8	5	2	1	-	-	-
243	17,5	10	5	5	3	2	1	-	-
244	11,1	10	7	4	1	-	-	-	-
245	11,7	10	8	4	1	-	-	-	-
246	8,0	10	5	3	-	-	-	-	-
247	7,2	10	3	2	1	-	-	-	-
248	17,2	10	8	5	4	1	-	-	-
249	23,0	10	6	5	3	1	1	1	2
250	18,3	10	4	1	2	2	2	1	1
MEAN	12,8	200	112	63	27	14	8	6	6

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ROAN ANTELOPE ENCLOSURE, NWASHITSUMBE

(Roan antelope)

SITE NO.	OBSTRUCTION TO VISION (per cent)	HEIGHT INTERVALS							
		0-0,5	>0,5-1,0	>1,0-1,5	>1,5-2,0	>2,0-2,5	>2,5-3,0	>3,0-3,5	>3,5-4,0
261	3,9	10	2	-	-	-	-	-	-
262	15,3	10	2	1	1	1	1	1	2
263	12,8	10	3	2	2	2	1	-	-
264	16,7	10	8	4	1	1	1	1	-
265	6,4	10	3	1	1	-	-	-	-
266	22,2	10	-	1	2	2	2	3	2
267	25,8	10	5	3	3	2	2	2	2
268	5,8	10	4	1	-	-	-	-	-
269	23,0	10	7	3	2	3	2	1	1
270	5,5	10	5	-	-	-	-	-	-
271	16,4	10	3	3	2	1	1	1	1
272	16,1	10	4	2	2	1	1	1	1
273	12,2	10	5	3	1	1	1	-	-
274	9,7	10	4	3	2	-	-	-	-
275	10,5	10	9	2	1	-	-	-	-
276	40,3	10	8	8	7	4	3	3	1
277	3,9	10	2	-	-	-	-	-	-
278	5,8	10	2	1	1	-	-	-	-
279	4,2	9	3	-	-	-	-	-	-
280	8,9	10	4	2	2	-	-	-	-
MEAN	13,3	199	83	40	30	18	15	13	10

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Appendix 4 : Field data pertaining to tree and shrub surveys in 13 areas representative of roan and sable antelope habitats in the Kruger National Park, South Africa.

MESTEL - SHABIN

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	>4m
1	3,8	21	0,15	70,0	2,6	2,8	16	6	3	5
2	3,6	20	0,08	66,7	2,3	2,3	20	6	1	3
3	7,1	21	0,18	70,0	4,2	4,0	5	9	6	10
4	7,6	18	0,16	60,0	3,5	3,9	8	7	5	10
5	7,9	20	0,13	66,7	4,6	4,4	2	13	5	10
6	5,3	16	0,07	53,3	3,7	3,8	8	6	7	9
7	4,8	14	0,08	46,7	3,4	3,1	9	13	3	5
8	6,5	17	0,11	56,7	2,7	3,0	16	4	1	9
9	5,2	16	0,11	53,3	3,0	3,0	10	11	4	5
10	4,7	19	0,10	63,3	2,2	2,5	16	8	4	2
11	5,2	16	0,11	53,3	3,2	3,3	11	6	6	7
12	7,4	12	0,14	40,0	4,3	3,9	13	3	3	11
13	3,6	17	0,10	56,7	3,1	3,6	7	6	10	7
14	3,4	13	0,07	43,3	4,0	3,0	13	7	2	8
15	6,9	14	0,10	46,7	4,0	3,5	12	5	3	10
16	5,2	18	0,16	60,0	3,7	3,5	10	9	1	10
17	4,4	20	0,08	66,7	2,8	2,9	14	9	2	5
18	5,4	17	0,10	56,7	3,7	3,3	7	13	6	4
19	4,7	17	0,09	56,7	4,9	4,0	4	10	9	7
20	8,4	20	0,10	66,7	2,9	2,8	12	13	1	4
21	5,9	20	0,10	66,7	3,4	3,8	12	8	1	9
22	3,8	9	0,04	30,0	2,3	2,1	23	3	1	3
23	5,5	9	0,11	30,0	4,2	4,0	12	2	4	12
24	3,9	21	0,08	70,0	2,6	2,7	18	4	4	4
25	6,4	16	0,14		3,4	3,7	12	4	4	10
26	2,7	18	0,06	60,0	2,5	2,3	22	5	-	3
27	3,7	11	0,07	40,0	4,1	3,7	4	10	8	8
28	3,6	17	0,10	56,7	4,5	4,8	6	1	3	20
29	2,6	17	0,05	56,7	3,0	2,8	14	7	2	7
30	3,7	13	0,05	43,3	3,5	3,2	10	10	4	6
Total	-	-	-	-	-	-	346	218	113	223
Mean	5,1	16,6	0,10	53,6	3,4	3,3	11,5	7,3	3,9	7,4

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STUNGWANE

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	>4m
31	3,1	19	0,10	63,3	3,2	2,9	8	13	5	4
32	2,1	8	0,07	26,7	1,5	1,9	24	6	0	0
33	3,1	6	0,08	20,0	2,1	2,8	22	1	0	7
34	1,9	11	0,06	36,7	0,9	1,6	25	4	0	1
35	2,0	4	0,05	13,3	1,7	2,2	22	4	1	3
36	2,4	8	0,08	26,7	2,5	2,3	14	13	2	1
37	3,2	15	0,05	50,0	2,2	2,3	22	5	1	2
38	4,3	11	0,05	36,7	3,5	3,3	14	4	3	8
39	2,1	13	0,04	43,3	1,2	1,6	24	6	0	0
40	1,9	19	0,04	63,3	1,1	1,5	28	2	0	0
41	3,6	10	0,07	33,3	1,3	2,3	24	0	2	4
42	3,2	15	0,07	50,0	2,1	2,5	20	5	1	4
43	3,9	13	0,08	43,3	2,3	2,4	20	5	1	4
44	5,5	7	0,10	23,3	1,7	2,0	21	7	0	2
45	2,9	7	0,17	23,3	2,0	2,4	25	2	0	3
46	4,5	14	0,06	46,7	2,3	2,7	22	3	-	5
47	3,3	17	0,10	56,7	2,9	3,5	12	4	2	12
48	3,3	16	0,06	53,3	2,6	2,9	16	3	5	6
49	2,5	20	0,07	66,7	1,9	2,5	17	4	3	6
50	1,6	16	0,02	53,3	1,1	1,6	28	0	1	1
Total	-	-	-	-	-	-	408	92	27	73
Mean	3,0	14,5	0,07	41,5	2,0	2,4	20,4	4,6	1,4	3,7

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SHIP MOUNTAIN

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
51	4,6	11	0,08	36,7	3,5	3,4	15	4	1	10
52	3,2	7	0,04	23,3	3,2	3,0	14	6	5	5
53	2,8	13	0,06	43,3	3,2	3,1	13	8	2	7
54	2,4	7	0,05	23,3	2,7	2,8	28	6	0	6
55	3,9	9	0,08	30,0	2,2	2,7	20	5	1	4
56	6,0	15	0,23	50,0	3,2	4,4	15	1	2	12
57	6,4	17	0,23	56,7	4,3	5,7	8	1	2	19
58	5,1	16	0,24	53,3	5,5	6,1	7	1	0	22
59	4,2	6	0,05	20,0	4,4	4,0	6	5	6	13
60	2,4	13	0,05	43,3	2,6	2,8	17	7	0	6
Total	-	-	-	-	-	-	133	44	19	104
Mean	4,1	11,4	0,11	38,0	3,5	3,8	13,3	4,4	1,9	10,4

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SALITJI

SITE NO	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
61	2,8	10	0,04	33,3	2,3	2,6	18	3	5	4
62	3,0	10	0,08	33,3	3,7	4,0	7	7	3	13
63	2,8	10	0,07	33,3	3,3	3,4	15	4	2	9
64	2,7	11	0,05	36,7	1,6	1,9	23	6	0	1
65	2,8	11	0,05	36,7	1,5	1,6	26	4	0	0
66	2,4	10	0,06	33,3	2,1	2,3	19	7	1	3
67	5,3	6	0,11	20,0	5,4	5,0	4	6	3	17
68	3,4	11	0,12	36,7	4,8	5,0	8	3	3	16
69	5,3	9	0,08	30,0	2,6	2,5	17	9	0	4
70	4,2	6	0,10	20,0	3,2	3,0	19	3	1	7
71	3,7	16	0,13	53,3	3,5	4,0	11	4	4	11
72	2,8	13	0,08	43,3	2,4	2,6	11	10	7	2
73	2,3	10	0,06	33,3	1,7	1,8	20	10	0	0
74	2,1	13	0,03	43,3	1,9	1,9	14	16	0	0
75	2,2	19	0,04	63,3	1,2	1,4	30	0	0	0
76	5,1	8	0,25	26,7	5,4	5,4	6	5	2	17
77	6,2	6	0,14	20,0	4,8	3,8	12	4	3	11
78	7,3	13	0,22	43,3	4,1	4,0	11	3	5	11
79	5,5	10	0,17	33,3	3,8	3,8	11	5	5	9
80	4,6	5	0,15	16,7	4,6	5,0	11	2	3	14
Total	-	-	-	-	-	-	293	111	47	149
Mean	3,8	10,4	0,10	34,5	3,2	3,3	14,7	5,6	2,4	7,5

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SHITEVE-TEVE

SITE NO	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
81	4,9	6	0,09	20,0	2,0	1,9	21	8	0	1
82	3,4	9	0,08	30,0	1,6	1,6	22	7	1	0
83	2,8	5	0,08	16,7	1,5	1,7	28	1	0	1
84	3,4	5	0,13	16,7	3,6	3,0	15	8	1	6
85	3,0	4	0,04	13,3	2,6	2,3	15	11	3	1
86	6,0	2	0,19	6,7	5,7	3,6	7	7	8	8
87	2,6	11	0,07	36,7	2,2	2,5	9	18	2	1
88	2,9	5	0,06	16,7	2,4	2,3	18	9	0	3
89	3,4	6	0,05	20,0	1,4	1,9	17	12	1	0
90	3,3	8	0,07	26,7	3,1	3,2	8	11	4	6
91	2,4	1	0,10	3,3	2,5	2,2	21	6	2	1
92	3,6	7	0,17	23,3	3,2	2,9	14	8	1	7
93	3,7	14	0,09	46,7	2,8	3,0	7	13	5	5
94	2,7	13	0,06	43,3	1,8	1,9	20	9	0	1
95	3,9	7	0,08	23,3	3,6	4,3	10	8	1	11
96	3,4	4	0,04	13,3	2,3	2,1	26	3	0	1
97	2,7	1	0,02	3,3	2,8	1,6	28	2	0	0
98	3,4	2	0,06	6,7	2,7	1,6	27	0	3	0
99	2,9	7	0,04	23,3	2,5	2,1	19	9	2	0
100	3,2	11	0,11	36,7	2,1	2,9	15	2	5	8
101	3,6	8	0,10	26,7	3,1	3,4	7	9	7	7
102	2,5	4	0,02	13,3	2,3	2,4	17	9	1	3
103	3,3	4	0,05	13,3	2,3	2,7	14	8	4	4
104	4,8	11	0,06	36,7	3,4	3,0	12	11	1	6
105	3,1	14	0,06	46,7	2,7	3,3	8	14	2	6
106	2,0	17	0,06	56,7	2,7	2,1	19	8	2	1
107	4,3	15	0,03	50,0	1,4	1,8	23	6	0	1
108	3,0	10	0,09	33,3	1,6	2,5	18	7	1	4
109	4,1	8	0,16	26,7	3,4	3,7	8	11	4	7
110	4,9	5	0,25	16,7	3,3	3,8	10	4	7	9
Total	-	-	-	-	-	-	483	239	68	109
Mean	3,4	7,5	0,08	24,9	2,6	2,6	16,1	8,0	2,3	3,6

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NGWENYENE

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
111	1,6	11	0,06	36,7	1,8	1,9	21	8	0	1
112	2,6	7	0,04	23,3	2,0	2,0	19	10	1	0
113	3,0	12	0,06	40,0	2,2	2,4	14	13	2	1
114	2,9	8	0,08	26,7	2,9	2,6	12	11	4	3
115	2,7	7	0,07	23,3	2,7	2,4	16	6	6	2
116	2,5	9	0,06	30,0	2,3	2,4	15	11	2	2
117	3,0	6	0,06	20,0	2,5	2,7	11	11	4	4
118	2,9	6	0,06	20,0	2,1	2,3	14	12	4	0
119	2,2	5	0,05	16,7	1,8	1,9	20	10	0	0
120	2,3	2	0,11	6,7	2,1	2,0	23	2	3	2
121	3,0	5	0,09	16,7	2,3	2,1	20	6	3	1
122	3,2	13	0,05	43,3	1,9	2,0	22	6	1	1
123	2,1	5	0,08	16,7	1,9	2,0	21	7	1	1
124	1,8	3	0,09	10,0	1,9	1,6	26	4	0	0
125	2,3	6	0,05	20,0	1,7	1,9	23	6	0	1
126	2,4	7	0,05	23,3	2,0	2,2	18	9	2	1
127	2,3	8	0,06	26,7	2,3	2,2	15	14	1	0
128	2,2	4	0,05	13,3	1,7	1,5	29	1	0	0
129	2,3	9	0,06	30,0	2,7	2,9	10	10	8	2
130	2,8	7	0,06	23,3	2,1	2,3	20	6	1	3
131	2,5	6	0,10	20,0	2,8	3,1	16	5	3	6
132	2,2	7	0,06	23,3	2,0	2,1	24	3	2	1
133	2,7	1	0,03	3,3	3,3	3,0	14	8	1	7
134	2,3	1	0,20	3,3	2,5	2,6	16	3	7	4
135	2,7	5	0,05	16,7	2,5	2,4	17	5	5	3
136	2,4	8	0,05	26,7	2,7	2,6	16	9	3	2
137	2,0	7	0,05	23,3	2,1	2,6	19	8	1	2
138	1,5	8	0,05	26,7	1,5	2,3	17	10	1	2
139	1,6	6	0,04	20,0	1,3	1,3	26	4	0	0
140	2,8	6	0,14	20,0	2,4	2,6	18	8	0	4
Total	-	-	-	-	-	-	552	226	66	46
Mean	2,4	6,5	0,07	21,7	2,2	2,3	18,4	7,5	2,2	1,9

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MASORINI

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
141	2,6	3	0,10	6,7	2,3	2,1	19	7	2	2
142	2,9	4	0,12	13,3	2,5	2,6	11	11	7	1
143	2,6	4	0,06	13,3	3,4	2,9	13	7	3	7
144	2,6	3	0,02	10,0	2,5	2,1	22	5	1	2
145	2,4	6	0,05	20,0	2,2	2,1	21	4	4	1
146	3,2	8	0,06	26,7	2,3	2,0	19	8	3	-
147	3,0	1	0,03	3,3	3,1	2,9	12	7	4	7
148	2,0	3	0,03	10,0	2,1	1,7	24	6	-	-
149	2,3	5	0,07	16,7	2,1	1,9	23	4	2	1
150	3,1	4	0,08	13,3	2,8	2,5	18	5	3	4
151	3,2	4	0,02	13,2	2,2	2,2	17	7	5	1
152	3,3	3	0,07	10,0	2,1	1,9	24	4	2	-
153	3,7	6	0,07	20,0	2,2	2,4	12	14	3	1
154	1,8	2	0,03	6,7	1,7	1,8	24	6	-	-
155	3,2	6	0,05	20,0	2,8	2,5	12	12	5	1
156	3,0	6	0,07	20,0	1,6	2,1	21	6	2	1
157	2,3	5	0,04	16,7	2,2	2,1	21	7	1	1
158	2,1	1	0,05	3,3	1,9	1,8	25	5	-	-
159	2,4	8	0,06	26,7	2,2	2,4	13	14	1	2
160	3,2	9	0,04	30,0	1,9	1,8	22	5	1	2
Total	-	-	-	-	-	-	373	144	49	34
Mean	2,8	4,5	0,06	15,0	2,3	2,2	18,7	7,2	2,5	1,70

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MALOPANYANE

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
161	3,2	1	0,01	3,3	2,1	1,3	30	0	0	0
162	2,7	0			2,5	1,5	29	1	0	0
163	3,4	0			2,3	1,4	30	0	0	0
164	5,2	0			2,5	1,6	28	2	0	0
165	2,7	0			2,2	1,5	30	0	0	0
166	3,3	0			1,7	1,2	29	0	1	0
167	3,0	3	0,16	10,0	2,2	2,1	20	7	3	0
168	3,9	0			2,3	1,3	30	0	0	0
169	2,6	0			1,9	1,2	29	1	0	0
170	3,1	0			1,7	1,3	29	1	0	0
171	3,1	0			3,1	1,6	29	1	0	0
172	3,1	0			2,4	1,2	29	1	0	0
173	2,9	0			2,3	1,4	30	0	0	0
174	3,4	1	0,20	3,3	2,3	1,6	26	3	1	0
175	4,0	1	0,10	3,3	2,6	2,2	19	8	1	2
176	3,3	0			2,7	2,1	19	9	1	1
177	3,2	0			3,0	1,4	29	1	0	0
178	2,9	0			2,4	1,7	26	4	0	0
179	2,4	8	0,04	26,7	1,7	1,5	28	2	0	0
180	3,4	0			2,1	2,0	18	10	2	0
Total	-	-	-	-	-	-	537	51	9	3
Mean	3,2	0,7	0,03	2,3	2,3	1,6	26,9	2,6	0,5	0,2

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NSHAWU - DZOMBO

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
181	2,1	1	0,07	3,3	1,7	1,5	27	3	0	0
182	4,1	2	0,02	6,7	1,9	1,8	20	10	0	0
183	4,1	0			2,7	1,8	26	4	0	0
184	3,3	1	0,03	3,3	2,5	1,8	23	7	0	0
185	3,0	0			2,5	1,7	24	6	0	0
186	3,1	0			2,9	1,9	21	8	1	0
187	3,3	1	0,02	3,3	2,6	1,6	29	1	0	0
188	3,3	0			2,9	1,7	29	1	0	0
189	3,1	0			2,5	1,5	26	4	0	0
190	2,7	0			1,8	1,7	26	4	0	0
191	3,1	2	0,06	6,7	2,1	1,8	23	7	0	0
192	4,1	7	0,13	23,3	2,7	2,0	21	6	3	0
193	4,1	1	0,02	3,3	2,1	1,8	22	6	2	0
194	5,1	3	0,08	10,0	2,4	1,7	25	4	1	0
195	5,3	8	0,11	26,7	1,3	1,8	20	10	0	0
196	4,8	9	0,11	30,0	1,7	2,1	19	7	3	1
197	2,1	2	0,02	6,7	0,9	1,2	30	0	0	0
198	3,6	4	0,09	13,3	1,6	1,5	28	1	1	0
199	2,4	3	0,03	10,0	0,8	1,4	30	0	0	0
200	4,0	2	0,13	6,7	1,8	1,7	26	4	0	0
201	3,3	5	0,07	16,7	1,2	1,7	25	1	3	1
202	3,2	7	0,11	23,3	1,9	2,0	22	4	1	3
203	4,1	4	0,21	13,3	2,4	2,1	21	6	1	2
204	3,8	5	0,07	16,7	2,0	2,1	22	4	1	3
205	2,8	0			2,2	2,0	20	10	0	0
206	2,5	3	0,06	10,0	2,3	2,3	17	8	5	0
207	2,8	5	0,12	16,7	1,8	2,0	21	5	3	1
208	3,7	3	0,01	10,0	1,0	1,3	29	1	0	0
209	3,8	3	0,02	10,0	1,6	1,8	23	5	2	0
210	3,5	3	0,04	10,0	1,4	1,8	26	2	1	1
Total	-	-	-	-	-	-	721	139	28	12
Mean	3,5	2,8	0,08	9,3	2,0	1,8	24,0	4,6	0,9	0,4

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MAHEWANE

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
211	2,3	0			1,7	1,6	27	3	0	0
212	1,8	0			1,8	1,6	26	4	0	0
213	4,3	8	0,19	26,7	2,2	2,6	19	5	0	6
214	2,5	1	0,02	3,3	1,7	1,6	27	3	0	0
215	2,8	3	0,20	10,0	2,3	1,9	25	2	1	2
216	4,5	0			1,8	1,9	25	4	0	1
217	3,2	0			2,3	1,7	27	3	0	0
218	2,1	0			1,6	1,6	29	1	0	0
219	2,2	0			1,8	1,6	27	3	0	0
220	2,8	0			2,0	1,9	24	6	0	0
Total	-	-	-	-	-	-	256	34	1	9
Mean	2,9	1,2	0,04	4,0	1,9	1,8	25,6	3,4	0,1	0,9

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BOYELA - STANGENE

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
221	2,7	9	0,04	30,0	0,8	1,4	28	0	2	0
222	5,1	9	0,15	30,0	1,1	1,7	22	7	0	1
223	4,3	11	0,10	36,7	1,5	2,0	21	7	0	2
224	2,4	4	0,05	13,3	1,5	1,6	27	2	0	1
225	3,2	0			1,5	1,5	29	1	0	0
226	5,5	3	0,02	10,0	1,1	1,4	28	2	0	0
227	4,1	3	0,03	10,0	1,5	1,4	30	0	0	0
228	7,1	5	0,17	16,7	1,4	1,9	24	4	0	2
229	3,0	2	0,02	6,7	0,8	1,4	29	1	0	0
230	3,3	1	0,30	3,3	1,7	1,5	28	1	1	0
251	5,4	2	0,06	6,5	1,2	1,5	28	2	1	0
252	5,3	1	0,25	3,2	1,7	1,4	30	1	0	0
253	5,6	0			2,3	1,7	28	3	0	0
254	3,6	0			2,3	1,7	28	3	0	0
255	3,3	0			1,9	1,8	26	5	0	0
256	2,4	0			1,6	1,4	31	0	0	0
257	4,9	1	0,06	3,2	1,5	1,7	23	7	1	0
258	3,9	10	0,10	32,3	1,2	1,9	26	3	0	2
259	3,6	0			2,5	1,9	22	9	0	0
260	2,7	0			1,6	1,5	29	2	0	0
Total	-	-	-	-	-	-	537	60	5	8
Mean	4,1	3,1	0,07	10,1	1,5	1,6	26,9	3,0	0,3	0,4

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HLAMALALA

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
231	3,0	1	0,02	3,3	2,2	1,7	28	2	0	0
232	2,7	1	0,02	3,3	1,7	1,5	30	0	0	0
233	3,9	0			2,1	1,6	30	0	0	0
234	4,1	1	0,02	3,3	2,6	1,9	23	2	4	1
235	3,4	1	0,04	3,3	0,9	1,2	30	0	0	0
236	4,5	1	0,10	3,3	1,4	1,6	28	0	2	0
237	3,6	1	0,04	3,3	1,4	1,6	24	6	0	0
238	3,3	11	0,06	36,7	1,3	1,7	25	3	2	0
239	3,5	0			1,6	1,5	30	0	0	0
240	3,3	2	0,03	6,7	1,6	1,6	27	3	0	0
241	3,0	1	0,07	3,3	1,8	1,9	24	4	0	2
242	3,2	2	0,07	6,7	1,7	1,6	24	5	1	0
243	2,7	0			1,7	1,6	28	2	0	0
244	2,7	3	0,02	10,0	1,2	1,6	26	3	1	0
245	2,8	0			2,0	1,5	30	0	0	0
246	4,8	6	0,11	20,0	2,0	2,1	22	2	4	2
247	2,5	0			1,7	1,4	28	2	0	0
248	3,9	0			2,8	2,5	4	23	3	0
249	3,2	0			2,2	2,3	16	12	2	0
250	2,7	1	0,02	3,2	1,5	1,6	28	2	1	0
Total	-	-	-	-	-	-	505	71	20	5
Mean	3,3	1,6	0,03	5,3	1,8	1,7	25,3	3,6	1,0	0,3

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ROAN ANTELOPE ENCLOSURE, NWASHITSUME

SITE NO.	MEAN DISTANCE BETWEEN TREES (m)	NO. OF SINGLE STEMMED TREES	MEAN STEM DIAMETER (m)	PERCENTAGE SINGLE STEMMED TREES	MEAN CROWN DIAMETER (m)	MEAN HEIGHT (m)	TREES AND SHRUBS HEIGHT CLASSES			
							1-2m	>2-3m	>3-4m	> 4m
261	5,3	6	0,16	19,4	1,9	2,5	23	1	1	6
262	5,1	8	0,14	25,8	2,5	3,1	22	2	0	7
263	3,6	2	0,25	6,5	2,2	2,2	25	3	1	2
264	3,3	2	0,06	6,5	2,1	1,6	27	3	1	0
265	3,4	0			1,8	1,5	30	0	0	1
266	3,5	1	0,18	3,2	2,5	2,6	21	5	1	4
267	2,8	0			1,8	1,6	27	3	0	1
268	2,6	1	0,02	3,2	1,5	1,4	28	2	1	0
269	3,9	0			2,0	1,7	27	1	2	1
270	2,9	0			1,3	1,2	31	0	0	0
271	3,2	0			1,9	1,8	24	4	3	0
272	3,5	0			2,2	1,8	24	6	1	0
273	4,9	3	0,20	9,7	2,0	1,9	24	5	0	2
274	4,0	0			2,0	2,0	20	9	1	1
275	3,0	0			2,0	2,0	27	2	1	1
276	2,6	4	0,15	12,9	1,8	1,8	25	4	1	1
277	3,7	3	0,08	9,7	1,3	1,6	29	0	0	2
278	3,5	1	0,26	3,2	1,9	1,7	27	3	0	1
279	2,5	0			1,3	1,3	30	1	0	0
280	2,4	1	0,02	3,2	1,8	1,5	31	0	0	0
Total	-	-	-	-	-	-	522	54	14	30
Mean	3,5	1,6	0,08	5,2	1,9	1,8	26,1	2,7	0,7	1,5

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Appendix 5 : Crown cover and relative crown cover of trees and shrubs in four different height intervals in roan and sable habitats in the Kruger National Park, South Africa, as obtained during January/February 1972.

(1a) = No in sample 1-2 m; (1b) = 2-3 m; (1c) = 3-4 m; (1d) = 4 m .
(2) = Mean crown diameter (m)
(3) = Total crown cover (m^2)
(4) = Relative crown cover for specific height interval
(5) = Relative crown cover for all height intervals

A. Roan antelope habitats

Malopanyane	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	504	2,3	2 094,6	98,51	87,52	42	2,9	277,5	93,81	11,59	3	3,0	21,2	52,35	0,89	-	-	-	-	-	2 393,3
Lonchocarpus capassa	4	1,0	3,1	0,15	11,36	1	2,5	4,9	1,66	17,95	2	3,3	19,3	47,65	70,70	-	-	-	-	-	27,3
Combretum imberbe	7	1,3	9,3	0,44	56,71	1	3,0	7,1	2,40	43,29	-	-	-	-	-	-	-	-	-	-	16,4
Others	17	1,2	19,2	0,90	75,29	2	2,0	6,3	2,13	24,71	-	-	-	-	-	-	-	-	-	-	25,5
Total			2 126,2	100,00	86,34			295,8	100,00	12,01			40,5	100,00	1,64						2 462,5
Nshawu/Dzombo	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	363	2,1	1 257,8	86,23	70,08	153	2,6	397,8	89,88	22,16	30	3,1	93,0	64,45	5,18	11	4,2	46,2	67,74	2,57	1 794,8
Dalbergia melanoxylon	79	0,7	55,3	3,79	100,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55,3
Acacia nigrescens	28	0,9	25,2	1,73	27,51	16	1,5	24,0	5,42	26,20	11	2,2	24,2	16,77	26,42	7	2,6	18,2	26,69	19,87	91,6
Combretum imberbe	22	1,4	30,8	2,11	48,97	9	1,7	15,3	3,46	24,32	5	2,6	13,0	9,01	20,67	2	1,9	3,8	5,57	6,04	62,9
Others	114	1,0	89,6	6,14	82,05	7	1,0	5,5	1,24	5,04	2	3,0	14,1	9,77	12,91	-	-	-	-	-	109,2
Total			1 458,7	100,00	69,01			442,6	100,00	20,94			144,3	100,00	6,83			68,2	100,00	3,23	2 113,8
Mahewane	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	187	1,9	530,3	90,98	51,88	28	2,8	172,5	96,64	16,88	6	5,5	142,6	100,00	13,95	9	5,2	176,8	100,00	17,30	1 022,2
Dalbergia melanoxylon	15	0,9	9,5	1,63	100,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,5
Dichrostachys cinerea	14	1,3	18,6	3,19	100,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18,6
Combretum imberbe	5	1,1	4,8	0,82	72,73	1	1,5	1,8	1,01	27,27	-	-	-	-	-	-	-	-	-	-	6,6
Acacia nigrescens	4	1,2	4,5	0,77	56,96	3	1,2	3,4	1,90	43,04	-	-	-	-	-	-	-	-	-	-	7,9
Others	16	1,1	15,2	2,61	95,00	1	1,0	0,8	0,45	5,00	-	-	-	-	-	-	-	-	-	-	16,0
Total			582,9	100,00	53,93			178,5	100,00	16,52			142,6	100,00	13,19			176,8	100,00	16,36	1 080,8

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Boyela/Stangene	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	206	1.9	584,2	77,23	61,08	57	2,8	351,1	86,37	36.71	3	3,3	21,2	47,11	2.22	-	-	-	-	-	956,5
Combretum imberbe	83	1,1	78,9	10,43	43,45	18	1,2	20,4	5,02	11,23	8	1,7	18,7	41,56	10,30	9	3,0	63,6	100,00	35,02	181,6
Dalbergia melanoxylon	95	0,7	33.5	4,43	80,72	6	1,3	8,0	1,97	19,28	-	-	-	-	-	-	-	-	-	-	41,5
Acacia nigrescens	19	0,9	12,1	1,60	30,79	11	1,6	22,1	5,44	56,23	2	1,8	5,1	11,33	12,98	-	-	-	-	-	39,3
Others	75	0,9	47,7	6,31	90,68	1	2,5	4,9	1,21	9,32	-	-	-	-	-	-	-	-	-	-	52,6
Total			756,4	100,00	59,49			406,5	100,01	31,97			45,0	100,00	3,54			63,6	100,00	5,00	1 271,5
Hlamalala	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	295	2,0	926,9	84,38	72,06	72	1,8	183,3	71,41	14,25	14	3,8	176,0	89,48	13,68	-	-	-	-	-	1 286,2
Dalbergia melanoxylon	54	0,7	19,1	1,74	75,20	2	2,0	6,3	2,45	24,80	-	-	-	-	-	-	-	-	-	-	25,4
Lonchocarpus capassa	16	2,0	50,3	4,58	71,96	4	2,5	19,6	7,64	28,04	-	-	-	-	-	-	-	-	-	-	69,9
Acacia nigrescens	32	1,2	36,2	3,30	61,15	3	2,0	9,4	3,66	15,88	3	2,4	13,6	6,91	22,97	-	-	-	-	-	59,2
Dichrostachys cinerea	29	1,3	38,5	3,50	54,69	6	2,6	31,9	12,43	45,31	-	-	-	-	-	-	-	-	-	-	70,4
Others	35	1,0	27,5	2,50	51,50	4	1,4	6,2	2,42	11,61	1	3,0	7,1	3,61	13,30	1	4,0	12,6	100,00	23,60	53,4
Total			1 098,5	100,00	70,21			256,7	100,01	16,41			196,7	100,00	12,57			12,6	100,00	0,81	1 564,5
Roan enclosure, Nwashitsumbe	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	363	1,8	924,2	89,11	69,23	59	2,4	267,0	81,50	20,00	13	2,8	80,1	83,70	6,00	9	3,1	63,6	13,50	4,76	1 334,9
Combretum imberbe	6	1,3	8,0	0,77	9,88	6	1,6	12,1	3,69	14,94	1	2,0	3,1	3,24	3,83	6	3,4	57,8	12,27	71,36	81,0
Lonchocarpus capassa	18	0,9	11,4	1,10	73,55	2	0,8	1,0	0,31	6,45	-	-	-	-	-	1	2,0	3,1	0,66	20,00	15,5
Pterocarpus rotundifolius	17	1,7	38,6	3,72	51,60	8	2,4	36,2	11,05	48,40	-	-	-	-	-	-	-	-	-	-	74,8
Others	70	1,0	55,0	5,30	12,93	4	1,9	11,3	3,45	2,66	3	2,3	12,5	13,06	2,94	9	7,1	346,5	73,57	81,47	425,3
Total			1 037,2	100,00	53,70			327,6	100,00	16,96			95,7	100,00	4,95			471,0	100,00	24,39	1 931,5
Stungwane	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Dichrostachys cinerea	110	1,0	86,1	34,11	33,39	39	1,7	88,6	33,87	34,35	9	3,0	63,6	29,15	24,66	1	5,0	19,6	1,94	7,60	257,9
Terminalia sericea	56	1,0	43,8	17,35	5,77	19	1,4	29,3	11,20	3,86	11	2,4	49,8	22,82	6,56	40	4,7	636,4	62,84	83,81	759,3
Acacia exuviales	73	0,8	36,7	14,54	72,53	9	1,4	13,9	5,31	27,47	-	-	-	-	-	-	-	-	-	-	50,6
Combretum hereroense	27	1,3	35,9	14,22	17,62	18	1,8	45,8	17,51	22,48	5	4,5	79,6	36,48	39,08	6	3,1	42,4	4,19	20,81	203,7
Acacia gerrardii	12	1,1	11,4	4,52	7,87	14	1,7	40,9	15,63	28,25	4	2,1	13,9	6,37	9,60	4	5,0	78,6	7,76	54,28	144,8
Others	49	1,0	38,5	15,25	11,72	19	1,7	43,1	16,48	13,12	4	1,9	11,3	5,18	3,44	12	5,2	235,7	23,27	71,73	328,6
Total			252,4	99,99	14,17			261,6	100,00	14,99			218,2	100,00	12,51			1 012,7	100,00	58,04	1 744,9

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B. Sable antelope habitats

Mestel/Shabin	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Dichrostachys cinerea	56	1,0	44,0	18,12	4,13	67	2,3	278,5	58,94	26,23	52	3,3	500,5	61,10	47,14	19	4,7	238,8	9,62	22,49	1 061,8
Terminalia sericea	75	1,1	71,3	29,37	6,71	46	1,4	70,8	14,98	6,67	27	2,2	102,7	12,54	9,67	65	4,0	817,1	32,92	76,95	1 061,9
Sclerocarya caffra	10	1,1	9,5	3,91	1,39	6	1,8	15,3	3,24	2,23	3	2,0	9,4	1,15	1,37	23	6,1	650,6	26,21	95,01	684,8
Annona senegalensis	23	1,3	30,5	12,56	29,84	8	2,3	33,2	7,03	32,49	4	3,3	38,5	4,70	37,67	-	-	-	-	-	102,2
Rhus spp.	9	1,5	15,9	6,55	89,83	1	1,5	1,8	0,38	10,17	-	-	-	-	-	-	-	-	-	-	17,7
Combretum molle	14	0,9	8,9	3,67	15,56	9	1,5	15,9	3,37	27,80	5	2,4	22,6	2,76	39,51	2	2,5	9,8	0,39	17,13	57,2
Others	66	1,1	62,8	25,86	6,09	37	1,4	57,0	12,06	5,53	22	2,9	145,4	17,75	14,10	39	4,9	766,1	30,86	74,28	1 031,3
Total			242,8	100,04	6,04			472,5	100,00	11,76			819,1	100,00	20,39			2 482,4	100,00	61,80	4 016,9
Ship Mountain	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Combretum apiculatum	17	0,9	10,8	12,74	1,81	12	1,5	21,2	15,54	3,56	7	2,2	26,6	28,27	4,46	19	5,9	537,4	23,39	90,17	596,0
Acacia nigrescens	2	0,4	0,3	0,35	0,02	1	1,5	1,8	1,32	0,14	1	1,0	0,8	0,85	0,06	40	6,5	1 327,8	57,80	99,78	1 330,7
Acacia exuviales	13	0,8	6,5	7,67	27,31	13	1,3	17,3	12,68	72,69	-	-	-	-	-	-	-	-	-	-	23,8
Dichrostachys cinerea	8	1,5	14,1	16,63	33,49	11	1,8	28,0	20,53	66,51	-	-	-	-	-	-	-	-	-	-	42,1
Combretum hereroensis	12	1,4	18,5	21,82	25,14	5	1,8	12,7	9,31	17,26	1	2,0	3,1	3,29	4,21	2	5,0	39,3	1,71	53,40	73,6
Others	44	1,0	34,6	40,80	6,33	16	2,1	55,4	40,62	10,14	9	3,2	63,6	67,59	11,64	20	5,2	392,9	17,10	71,89	546,5
Total			84,8	100,00	3,25			136,4	100,00	5,22			94,1	100,00	3,60			2 297,4	100,00	87,93	2 612,7
Saliji	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Albizia harveyi	73	1,2	82,6	29,66	18,68	32	2,2	121,7	31,02	27,52	8	2,8	49,3	12,12	11,15	15	4,2	188,6	7,18	42,65	442,2
Combretum apiculatum	29	1,0	22,8	8,19	3,55	14	1,7	31,8	8,11	4,96	8	3,2	56,6	13,91	8,82	27	5,1	530,4	20,19	82,67	641,6
Dalbergia melanoxylon	34	1,3	45,2	16,23	28,27	12	2,0	37,7	9,61	23,58	5	3,3	48,1	11,82	30,08	3	3,3	28,9	1,10	18,07	159,9
Dichrostachys cinerea	13	1,1	12,4	4,45	5,94	23	2,0	72,3	18,43	34,64	7	4,4	111,4	27,38	53,38	1	4,0	12,6	0,48	6,04	208,7
Others	75	1,4	115,5	41,47	5,13	41	2,0	128,8	32,83	5,72	20	3,1	141,4	34,76	6,28	66	5,8	1 866,9	71,06	82,88	2 252,6
Total			278,5	100,00	7,52			392,3	100,00	10,59			406,8	99,99	10,98			2 627,4	100,01	70,91	3 705,0

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Shiteve-teve	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Albizia harveyi	76	1,0	59,7	10,66	29,76	37	1,5	65,4	7,85	32,60	1	4,0	12,6	2,31	6,28	5	4,0	62,9	6,21	31,36	200,6
Dichrostachys cinerea	16	1,0	12,6	2,25	6,04	45	2,0	141,4	16,98	67,75	4	2,9	26,4	4,84	12,65	1	6,0	28,3	2,80	13,56	208,7
Pterocarpus rotundifolius	42	2,7	240,6	42,95	61,84	21	3,1	148,5	17,84	38,16	-	-	-	-	-	-	-	-	-	-	389,1
Acacia nigrescens	16	1,1	15,2	2,71	5,21	23	1,6	46,3	5,56	15,88	5	2,8	30,8	5,65	10,57	6	6,6	199,2	19,68	68,34	291,5
Maytenus heterophylla	14	1,1	13,3	2,37	16,46	17	1,7	38,6	4,64	47,77	3	3,7	28,9	5,30	35,77	-	-	-	-	-	80,8
Acacia gerrardii	10	0,8	5,0	0,89	2,44	15	1,9	42,5	5,10	20,73	9	2,7	51,6	9,47	25,17	11	3,6	105,9	10,46	51,66	205,0
Others	161	1,3	213,8	38,16	13,58	92	2,2	349,9	42,02	22,23	41	3,3	394,6	72,42	25,07	49	4,1	616,0	60,85	39,14	1 574,0
Total			560,2	99,99	18,99			832,6	99,99	28,23			544,9	99,99	18,47			1 012,3	100,00	34,32	2 949,7

Ngwenyene	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	218	1,7	495,1	72,77	38,27	127	1,9	360,2	50,72	27,84	26	3,2	183,8	29,55	14,21	16	4,4	254,6	24,83	19,68	1 293,7
Combretum apiculatum	44	1,2	49,8	7,32	4,86	78	2,0	245,1	34,51	23,91	47	3,1	332,3	53,42	32,42	25	4,3	397,8	54,42	38,81	1 025,0
Others	102	1,3	135,5	19,91	31,89	37	1,9	104,9	14,77	24,69	11	3,3	105,9	17,02	24,92	4	5,0	78,6	10,75	18,50	424,9
Total			680,4	100,00	24,80			710,2	100,00	25,89			622,0	99,99	22,67			731,0	100,00	26,64	2 743,6

Masorini	(1a)	(2)	(3)	(4)	(5)	(1b)	(2)	(3)	(4)	(5)	(1c)	(2)	(3)	(4)	(5)	(1d)	(2)	(3)	(4)	(5)	Total crown cover for all height intervals
Colophospermum mopane	132	1,6	265,5	61,20	33,96	62	2,4	280,6	44,99	35,89	12	3,0	84,9	20,08	10,86	12	4,2	150,9	33,34	19,30	781,9
Combretum apiculatum	41	1,2	46,4	10,70	5,60	57	2,2	216,8	34,76	26,18	39	3,1	275,8	65,22	33,31	23	4,1	289,1	63,88	34,91	828,1
Dichrostachys cinerea	12	1,1	11,4	2,63	23,55	9	1,8	22,9	3,67	47,31	2	3,0	14,1	3,33	29,13	-	-	-	-	-	48,4
Terminalia sericea	2	1,0	1,6	0,37	2,45	12	2,6	63,7	10,21	97,55	-	-	-	-	-	-	-	-	-	-	65,3
Others	82	1,3	108,9	25,10	52,03	14	1,9	39,7	6,37	18,97	5	3,4	48,1	11,37	22,98	1	4,0	12,6	2,78	6,02	209,3
Total			433,8	100,00	22,44			623,7	100,00	32,27			422,9	100,00	21,88			452,6	100,00	23,41	1 933,0

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Appendix 6 : Most abundant trees and shrubs and their frequency distribution in roan and sable habitats in the Kruger National Park, South Africa. Number of sampling sites in brackets after locality.

A. ROAN ANTELOPE HABITATS

1. MALOPANYANE (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	615	556	90,41	100,0
Combretum imberbe		13	2,11	30,0
Ehretia rigida		6	0,98	15,0
Dichrostachys cinerea		4	0,65	20,0
Percentage compostion of most abundant species :			94,15	

2. NSHAWU - DZOMBO (30)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	935	587	62,78	93,33
Dalbergia melanoxylon		83	8,88	33,33
Acacia nigrescens		72	7,70	46,67
Combretum imberbe		43	4,60	53,33
Dichrostachys cinerea		40	4,28	26,67
Percentage composition of most abundant species:			88,24	

3. MAHEWANE (10)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	310	232	74,84	100,0
Dalbergia melanoxylon		17	5,48	40,0
Dichrostachys cinerea		14	4,52	30,0
Combretum imberbe		12	3,87	40,0
Acacia nigrescens		9	2,90	40,0
Percentage composition of most abundant species:			91,61	

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4. BOYELA - STANGENE (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	624	278	44,55	80,0
Combretum imberbe		123	19,71	75,0
Dalbergia melanoxylon		108	17,31	60,0
Acacia nigrescens		31	4,97	25,0
Lonchocarpus capassa		21	3,37	65,0
Dichrostachys cinerea		16	2,56	30,0
Percentage composition of most abundant species:			92,47	

5. HLAMALALA (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	612	369	60,29	85,0
Dalbergia melanoxylon		58	9,48	55,0
Lonchocarpus capassa		52	8,50	50,0
Acacia nigrescens		44	8,19	45,0
Dichrostachys cinerea		39	6,37	35,0
Combretum imberbe		15	2,45	45,0
Percentage composition of most abundant species:			94,28	

6. ROAN ANTELOPE ENCLOSURE, NWASHITSUME (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	647	455	70,32	90,0
Combretum imberbe		27	4,17	70,0
Lonchocarpus capassa		27	4,17	45,0
Pterocarpus rotundifolius		19	2,94	40,0
Ozoroa paniculosa		19	2,94	40,0
Dalbergia melanoxylon		18	2,78	10,0
Grewia spp.		15	2,32	55,0
Percentage composition of most abundant species:			90,87	

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7. STUNGWANE (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Dichrostachys cinerea	676	180	26,63	90,0
Terminalia sericea		154	22,78	70,0
Acacia excuvialis		92	13,61	45,0
Combretum hereroense		72	10,65	45,0
Acacia gerardii		41	6,07	40,0
Percentage composition of most abundant species:			79,74	

B. SABLE ANTELOPE HABITATS

1. MESTEL - SHABIN

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Dichrostachys cinerea	1 321	314	23,77	100,00
Terminalia sericea		294	22,26	93,33
Sclerocaryea caffra		101	7,65	86,67
Annona senegalensis		90	6,81	66,67
Rhus spp.		59	4,47	66,67
Combretum molle		56	4,24	40,0
Maytenus heterophylla		35	2,65	53,33
Percentage composition of most abundant species:			71,85	

2. SHIP MOUNTAIN

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Combretum apiculatum	367	80	21,80	80,0
Acacia nigrescens		48	13,08	50,0
A. exuvialis		34	9,26	70,0
Dichrostachys cinerea		32	8,72	60,0
Combretum hereroense		24	6,54	60,0
Acacia gerrardii		21	5,72	60,0
Bolusanthus speciosus		21	5,72	30,0
Terminalia sericea		21	5,72	20,0
Percentage composition of most abundant species:			76,56	

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3. SALIJI (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Albizia harveyi	725	136	18,70	75,0
Combretum apiculatum		111	15,31	50,0
Dalbergia melanoxylon		63	8,69	55,0
Dichrostachys cinerea		54	7,45	75,0
Acacia welwitschii		43	5,93	15,0
Combretum zeyheri		37	5,10	35,0
Acacia exuvialis		36	4,97	40,0
Albizia evansii		32	4,41	35,0
Euclea divinorum		31	4,28	30,0
Percentage composition of most abundant species:			74,84	

4. SHITEVE-TEVE (30)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Albizia harveyi	1 128	153	13,56	83,33
Dichrostachys cinerea		88	7,80	60,0
Pterocarpus rotundi-folius		88	7,80	26,67
Acacia nigrescens		74	6,56	63,33
Maytenus heterophylla		70	6,21	70,0
Acacia gerrardii		65	5,76	53,33
Combretum hereroense		62	5,50	63,33
Dalbergia melanoxylon		61	5,41	60,0
Combretum zeyheri		51	4,52	36,67
Combretum apiculatum		49	4,34	56,67
C. imberbe		47	4,17	50,0
Percentage composition of most abundan t species:			71,63	

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5. MASORINI (20)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	673	244	36,26	75,0
Combretum apiculatum		202	30,01	80,0
Dichrostachys cinerea		29	4,31	65,0
Terminalia sericea		24	3,51	25,0
Cissus spp.		18	2,67	50,0
Acacia nigrescens		16	2,38	35,0
Combretum hereroense		16	2,38	20,0
Percentage composition of most abundant species:			81,52	

6. NGWENYENE (30)

SPECIES	TOTAL NO. OF TREES/SHRUBS IN SAMPLE	TOTAL NO. OF INDIVIDUALS	PERCENTAGE COMPOSITION	FREQUENCY
Colophospermum mopane	673	244	36,26	75,0
Combretum apiculatum		202	30,01	80,0
Dichrostachys cinerea		29	4,31	65,0
Terminalia sericea		24	3,51	25,0
Cissus spp.		18	2,67	50,0
Acacia nigrescens		16	2,38	35,0
Combretum hereroense		16	2,38	20,0
Percentage composition of most abundant species:			81,52	

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