EUGENE JOUBERT

AN ECOLOGICAL STUDY OF THE BLACK RHINOCEROS *Diceros bicornis* Linn. 1758 IN SOUTH WEST AFRICA

UNIVERSITY OF PRETORIA

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AN ECOLOGICAL STUDY OF THE BLACK RHINOCEROS *Diceros bicornis* LINN. 1758 IN SOUTH WEST AFRICA.

by

EUGENE JOUBERT.

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PRETORIA.
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Dedicated gratefully to my
Mother and Father.

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CHAPTER : I

INTRODUCTION.

1.1 General.

At the London Convention of 1933 the Union of South Africa (since 1961 the Republic of South Africa) pledged on behalf of the Administration of South West Africa to ensure the conservation of all indigenous animals and plants in South West Africa. Although the treaty has become obsolete in the meantime, conservation initiated at the time is still being carried out by the Department of Nature Conservation and Tourism in South West Africa.

Most of the larger mammals in South West Africa are protected by law, which makes it illegal to hunt without official permission and/or permits. Enforcement of these game laws were made extremely difficult however by the vastness of the country and, in earlier times, by the continuous opening up of new areas for settlement. This fact and certain other limiting factors caused the number of black rhinos to dwindle away and during the last two decades their preservation became an urgent problem.

Black rhino occur in isolated localities in the north western corner of South West Africa. The South

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West African Administration, through the Department of Nature Conservation, thought it wise to translocate as many as possible of these extremely valuable animals to the Etosha National Park, where measures could be taken to safeguard their existence.

To ensure the success of this venture two delegates from the South West African Department of Nature Conservation and Tourism were sent to Natal. They were to study the methods refined by the Natal Parks Board to immobilize and translocate rhino. In South West Africa a research project was launched. The main objects of the project was to obtain detailed information regarding status, distribution, life requirements, limiting factors and to advise on a future conservation policy to ensure the survival of black rhinos in South West Africa.

It was decided by Mr. B. de la Bat, Director of Nature Conservation and Tourism, South West Africa, that a representative area where this study could be carried out should be chosen to serve as base. Otjovasandu, in the western portion of the Etosha National Park, was subsequently chosen. This happened to be fortunate as it turned out that the biggest concentration of the remnant black rhino population was in this area. The rest of the

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Kaokoveld and all the other distribution areas could also easily be reached from there.

Work on the research project started in June, 1966. Several problems were encountered in the study area, the most arduous being the fact that due to the small number of rhino, only 17 in approximately 270 square miles and the difficult terrain, it was extremely difficult to locate the animals. During the early months of the study, three weeks sometimes passed without a single animal being observed, apart from those seen at night at the different waterholes. Although the situation improved as the area became better known it still remained one of the most serious handicaps.

1.2 Acknowledgements.

I wish to express my sincere gratitude to my father for awakening my interest in nature and to professor F.C. Eloff who cultivated and directed these interests into the correct channels. Also for his negotiations in getting me to South West Africa, and constant guidance thereafter. To Mr. B. de la Bat Director of Nature Conservation and Tourism, for his advice and criticism and under whose direction the work took place.

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I am also very much indebted to Mr. C.G. Coetzee for his guidance on the section dealing with the taxonomic status of the black rhinoceros, and for critically reading through the manuscript. Mr. W. Giess, of the Herbarium, Windhoek, is thanked for his invaluable assistance in identifying all the plants collected during the study and for reading through the section on vegetation.

To the Administration of South West Africa I wish to express my greatest appreciation for having arranged a study visit to the Natal Game Parks. Also to Dr. Zigalke and Messrs. J. Vincent and P. Kitchens for their informative talks as well as the hospitality extended to me.

I wish to extend grateful appreciation to the following persons; Mr. G.A. Roux and J.J. van Zyl who analysed the soil samples collected in the study area, Dr. van Wyk and his geologists, Mr. J. Jooste, his wife and the successive Native Commissioners at Chopoho and their staff, Mr. and Mrs. Tromp, Ken Tinley for encouragement, Warrant Officer B. Holthauzen, Mr. C. Rocher and his Game rangers for assistance in various ways especially Mr. P. van der Westhuizen, Dr. Scherz and Mr. F. Gaerdes for invaluable information, Mrs. Scherz for the use of photo no.6, and

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Mr. W.P.S. Joubert for printing the rest of the photos.

I am very much obliged to the Administration of South West Africa for permission to use the information gathered during this study for a M. Sc. (Wildlife management) thesis.

And finally my deepest gratitude to my wife who shared constant hardships during the study and who typed this manuscript more times than I would care to remember.

1.3 Nomenclature.

The existing nomenclature on black rhinoceroses can broadly be grouped into three different stages. Prior to 1900 the taxonomic aspects received most, if not all, of the attention as publications by the following authors show, viz. Blumenbach (1803), Smith (1836), Schinz (1845), Gray (1867), Drummond (1867), Gray (1873), Flower (1876) and Selous (1881).

The second stage covers more or less the first half of this century. During this period a flood of publications appeared, which usually included descriptions on the "habits" of black rhinos by "sportsmen", hunters, Game Wardens and amateur naturalists. Some of

the better known include the following :
Kirby (1899), Sclater (1900), Fischer (1914), Lydekker (1911), (1926), Roosevelt (1915), Stevenson - Hamilton (1912), (1917), (1947), Fitzsimons (1920), Roosevelt and Heller (1922), Steinhardt (1924), Percival (1924), Pitman (1934), Potter and Mitchell (1947), Stott (1950), Mackenzie (1950), Hutchinson and Ripley (1954), Owen (1956), Ripley (1958), Ritchie (1963) and Guggisberg (1966).

During this period the taxonomic position of the black rhino still received sporadic attention. Zukowsky (1922), Shortridge (1934), Allen (1939), Roberts (1951), Ellerman, Morrison - Scott and Hayman (1953), Deraniyagala (1953), Thenius (1955), Cave (1962), Meester, Davies and Coetzee (1964), Zukowsky (1965) and Ansell (1967).

The second and third stages overlap to some extent. The third stage is characterised by the amount of serious research being done on rhino, the black rhinoceros in particular. The latter stage was partially initiated by the large number of publications which appeared during the late fifties and brought to world attention the status of the family Rhinocerotidae. They all reported on the low number of rhino everywhere in the world.

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Grzimek (1958), (1961), Swynnerton (1959), Sandeman (1959), Gee (1959), Talbot (1960), Daubercies (1960), Blancou (1961), Lithglow (1961), Feely (1962), Sutherst (1964), Guggisberg (1966), and Schaurte (1967).

Contributions on black rhino research have appeared by the following authors :
Cave (1959), Greed (1960), Schulz and Kluge (1960), Schultz (1961), Aschaffenburg et al (1961), Harthoorn (1962), Cave (1962), Cave and Aumonier (1962), Ryder (1962), Parsons and Sheldrick (1964), Round (1964), Cave (1964), Lamprey (1964), Howard (1964), Bligh and Harthoorn (1964), Glover and Sheldrick (1964), Young (1965), Foster (1965), Brocklesby and Vidler (1965), King and Carter (1965), Klingel and Klingel (1966), Goddard (1967).

1.4 Procedure and Methods.

Taxonomy : During the study 18 black rhino skulls were collected throughout the north western sector of South West Africa. From these skulls the following measurements were taken (see fig. 1).

a/a :- Length of the skull between the premaxilla to the posterior extention of the occipital bone.
b/b :- Length of the skull between the premaxilla to the posterior edge of the condylus.

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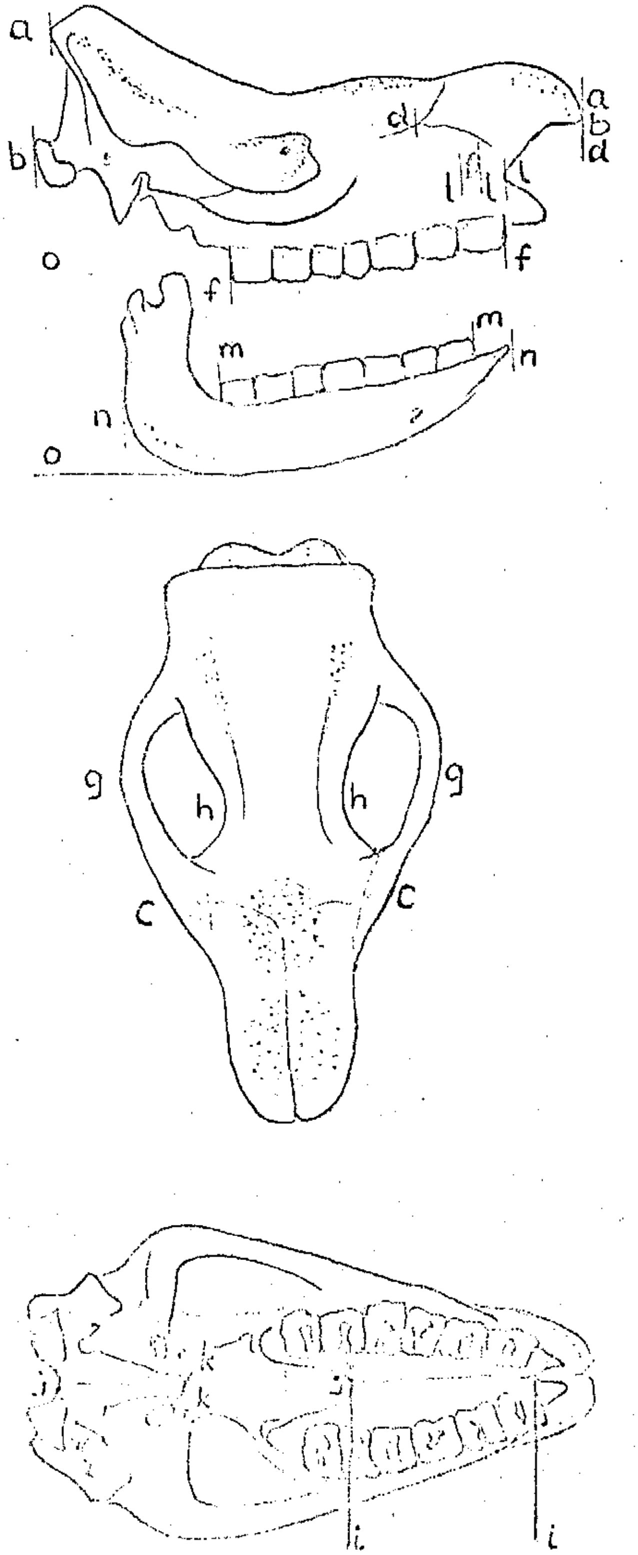
FIGURE : 1.

LATERAL, DORSAL AND VENTRAL VIEWS OF RHINO SKULL, SHOWING POINTS BETWEEN WHICH MEASUREMENTS WERE TAKEN.



c/c :- Width at the anterior edge of the orbital.

d/d :- Length of the nasals medially from the posterior to the anterior edges.

e/e :- Extreme width of nasals.

f/f :- Length of upper toothrow from anterior edge of the first premolar to posterior edge of the last molar.

g/g :- Greatest zygomatic width.

h/h :- Narrowest width of the post orbital constriction.

i/i :- Palatine length between foramen palatinum and choane.

j/j :- Length from the posterior edge of the palatines at choane to the basioccipital at foramen magnum.

k/k :- Interpterygoid width.

l/l :- Distance between the anterior orbital foramen and the sub-nasal immargination when measured from :

l/l ant :- anterior edge of the anterior orbital foramen and

l/l post :- posterior edge of the anterior orbital foramen.

m/m :- Length of lower toothrow from the anterior edge of the premolar to the posterior edge of the last molar.

n/n :- Greatest length of the lower jaw from the anterior edge of the symphysis to the posterior edge of the angular process.

o/o :- The greatest height of the lower jaw.

These measurements were taken with a steel slide-caliper and a calibrated steel tape. The measurements are given in centimeters except for those given in appendix 3.

During an visit to Natal 20 skulls representing a sample from the Hluhluwe and Umfolozi black rhino population were also measured by the author. The measurements taken from the Natal and South West Africa samples were then statistically analysed.

Status : To determine the status of the black rhinoceros in South West Africa the following method was used. A census was carried out during October, November and December 1966. This is the driest and hottest time of the year and during this time the rhino tend to drink every night. Every known waterhole in the Kaokoveld and western Etosha National Park was visited in turn. If any indication could be found of it being frequented by rhino camp was pitched about a mile or more distant. Two or three nights were spent at every waterhole, all depending on circumstances. During daytime reconnaissance was carried out in the vicinity looking for tracks, frequency and size of dung heaps and the amount of

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vegetation that showed browsing by rhino.

By using this method one had to make two assumptions.

1. That all the waterholes are known. Everyone aquainted with the arid parts of South West Africa knows how important a role water plays in the existence of man and animal. One can thus safely presume that all the permanent waterholes are known especially those in the populated part north of the Hoanib River. A very good military map, showing all the waterholes, was also used extensively.

2. That a rhino uses only one waterhole. During the drier part of the year the distances between perennial waterholes are considerable. In areas where waterholes were located nearer to each other, precautious were taken, eg. more time was spent in the area.

Information was gathered from the police stations at Kamanjab, Outjo, Otjiwarongo and Welwitchia to determine on which farms rhinos occurred. These farms were visited during March 1967 to complete the census.

Soils of the study area : Twelve localities were chosen in the study area, distributed in the various superficially - different types of soil.
Profile pits were dug as deep as possible up to a

maximum depth of 6 feet. A profile was drawn and samples taken from every different layer of soil. These samples were subseqently analysed at the Soil research laboratories at Neudamm.

Vegetation of the study area : Most of the plants in the study area were collected and identified in the Herbarium at Windhoek. In this way a herbarium of local plants was built up at Otjovasandu.

The vegetation at the Otjovasandu study area was divided, with the aid of aerial photos and general knowledge of the vegetation in the area, into nine different plant associations. To characterise each plant association, quarter method surveys (Curtis and Cottam, 1962), were carried out in five plant associations and two wheelpoint surveys (Tidmarsh and Havenga, 1955), in two other plant associations. No botanical surveys were carried out in the Commiphora - Sterculia and Catophractes alexandri - Acacia nebrowni associations.

Quarter method : 25 points (8+8+9) were chosen on three predetermined compass lines. Each point was chosen by pacing 50 yards along the transect line. At each point, the space around the point was divided into four quarters, with the compass line of traverse as one bisect

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and another line at 90° angle to this through the point as the other. Within each quarter, the nearest tree above a height of 6 foot to the point was chosen, its distance from the point, its basal area, its height, the diameter of its crown, and its species determined. The nearest shrub (below a height of six feet) in each quarter, its distance from the point and its species were also determined.

Wheelpoint method : Each wheelpoint survey consisted of 2000 points, counting every second time the selected spoke touched. Twenty transects, of 200 points each, were done on predetermined compass lines approximately 100 yards apart. The various definitions of strikes given by Tidmarsh and Havenga were closely followed.

In the valley community the transects were laid out diagonally across the valley.

Habitat preferences : To determine the horizontal density of vegetation in the various home ranges of rhino in the study area a cover "density board" (Wildlife Investigational Techniques, 1965), was used. A board, 5 inches wide and 6 feet in height, was marked off in feet and numbered from 1 to 6. The assistant places the density board in the cover to be measured and the observer reads the figures which were unobscured by

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by cover at a distance of 66 feet (one chain). (See photo 1). If there is no cover, the reading is 21 (1,2,3,4,5 and 6 added together); if the cover completely obscures the entire board the reading would be 0.

Six transects were marked out, each with 25 points. Measurements were taken during March and October to determine the rainy season and dry season horizontal densities.

Food species and preferences : Food plants utilized by rhino were collected throughout the period of study. The food plants were usually collected by following a rhino's tracks and noting which species were utilized or by direct observation.

To determine preference, surveys were carried out in the various home ranges. The survey would start at any random point along a predetermined compass line. The first shrub or tree along this line would be inspected to see whether it had been browsed by rhino or not and the result noted. The amount of twigs browsed, the number of twigs that were browsed and were now dead and the general condition of the plant were also noted. Whenever the least doubt existed as to whether the particular shrub or tree was browsed by rhino or not, it was completely ignored. The next shrub or plant

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within 45° on either side of the transect line would then be inspected. This would continue until 100 plants of each species were inspected.

<u>Behaviour and living habits</u> : When the study commenced the study area was traversed on foot and by vehicle to become familiar with the area. Several of the hills were chosen as reconnaissance points and were extensively used. A map of the study area was also compiled with the aid of aerial photographs.

To locate the animals as early as possible, position on one of the reconnaissance points was always taken up at sunrise or shortly thereafter. If no rhino could be located with the aid of binoculars during the first hour, position would be changed to the second and third reconnaissance points. If rhino were encountered during botanical surveys etc. the survey would be stopped and the rhino kept under observation for the rest of the day. Rhino were always kept under observation from the time they were first observed until it became too dark for further observations. A strict record was kept of the time and all activities during the observation period.

A photo index was built up of all the individuals in the area. All particulars were also noted on a

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roneod sheet viz. shape of horn, approximate size of horn in relation to ears, the state of the ears and size of calf in relation to the female.

<u>Influence of weather</u> : Temperature data were obtained by the use of a maximum and minimum thermometer. The readings were taken every morning at 0800 hours.

Rainfall was measured by a standard rain-gauge issued by the Weather Bureau. The rain-gauge was read every morning at 0800 hours to measure the previous day's precipitation.

Relative humidity data was obtained by the use of a whirling hygrometer which gave quick and accurate readings. The relative humidity was recorded three times daily viz. at 0800, 1200 and 1600 hours together with the amount of cloudcover and the wind movement.

The intensity of wind movement was recorded according to the Beaufort scale of wind force. The direction of movement was also recorded.

CHAPTER : II

THE ANIMAL.

2.1 Evolution.

The early history of the rhinoceros can be traced from the Eocene age, sixty million years ago. It was represented during Tertiary times by a large number of species, including the largest of all land mammals ever to have lived. The several lines of the rhinoceros were evolving parallel with one another making their past history difficult to interpret. They were numerous in most continental regions during late Cenozoic times, but became extinct during the Pliocene age in North America. Various lines died out in Eurasia during the same period. In the Pleistocene age more lines died out and today they are represented by only five living species. These living monuments occur in Java, Sumatra, India and Africa.

Hyrachyus, the earliest rhinoceros, was closely related to Hyracotherium, oldest known ancestor of the horses. It was slenderly built, adapted for running, with four toes on its forefeet. More recent members of this genus had only three toes on all feet and occurred over the whole of the northern hemisphere. They developed small horns, but their main weapons remained the second incisors of the lower jaws, which became enlarged into tusks. The genus became extinct during the middle Pliocene.

Baluchitherium was the largest of the rhinoceroses. Its skull measured five feet in length. Standing sixteen to eighteen feet at the shoulder, with a length of twenty-eight feet it exceeded the mammoth in size. These animals lived during Oligocene and early Miocene times.

Another branch of rhino evolution during the Eocene were aquatic or semi-aquatic types. This branch is known as the amynodonts and was represented in the upper Eocene by Amynodon which originated in North America and spread to Asia, and in the Oligocene by Metamynodon.

The central stock of the rhinoceros evolution was represented by Caenopus during the Oligocene. One of the Caenopenes from the lower Pliocene, Teleoceras fossiger, stood four feet high at the shoulders, had a girth of nine feet two inches and a lenght of ten feet. From this point the later rhinoceroses evolved in several directions. Their adaptive radiation included a general increase in size, the development of broad three-toed feet for supporting the heavy body, the molarization of premolars, the lengthening of crowns in the molars and the development of horns on the skull. (Colbert 1961).

A forest belt extended across most of Europe and India during the upper Pleistocene. Most of the Dicerorhinus occurred within this forest zone. Evidence indicates that the rhinos that moved into the open habitats offered by plains, developed faster evolutionary speaking, than those that remained in the forest zone. Dicerorhinus sumatrensis, the only remaining species of this group is the smallest and most primitive rhino alive today.

During the transition from Miocene to Pliocene some double-horned rhino moved into Africa. Having lost their cutting teeth, they had lower jaws which were shortened and the premaxillary bones in the upper jaws were also reduced. The horns now became important as weapons, which caused the strengthening of the nasal

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bones supporting the anterior horn. One group also developed a pointed prehensile lip for browsing, while the other group acquired broad grazing lips as well as long-crowned molars (Mostly after Colbert (1961) and Guggisberg (1966), the latter quoting Harper (1945) and Osborn (1923).

Interesting facts came to light during escavations at Hopefield (Hooier and Singer 1960). The general age of the Hopefield fauna is considered to be early upper Pleistocene. Most of the upper Pleistocene mammals still have their living counterparts today. Neither the white nor the black rhinoceros from Hopefield appears to be distinct from the forms now living. The only way the extinct black rhinoceros form is distinquisable from the living form is a tendency to be larger. This is an indication of its evolutionary stability.

2.2 Taxonomy.

Order : Perissodactyla.
Family : Rhinocerotidae.
Genus : Diceros Gray, 1821.

DICEROS BICORNIS Linnaeus, 1758.

1758. Rhinoceros bicornis Linnaeus, Syst. Nat. 10th ed. 1:56. "India", but Cape of Good Hope according to Thomas (1911:144).

1803. Rhinoceros africanus Blumenbach, Man. Hist. Nat. 1:156, Cape of Good Hope.

1836. Rhinoceros keitloa A. Smith, Rept. Exped. Expl. Central Afr., 44. "Country north and south of Kurrichaine" (Marico district, western Transvaal).

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1837. Rhinoceros ketloa A. Smith, Cat. S. Afr. Mus. 7 "180 miles N.E. of Lattakoo".

1842. Rhinoceros bicornis Var. B. Rhinoceros gordoni Lesson, Nouv. Tabl. Règne Anim. Mamm. 155, nom. nud.

1845. Rhinoceros niger Schinz, Synops. Mamm. 2:335. Chuntop near Mt. Mitchell, Kuiseb district, South-West Africa (Shortridge, 1934, Mamm. S.W. Africa, 1:412, footnote).

1845. Rhinoceros camperi Schinz, loc. cit. Cape of Good Hope.

1898. Rhinoceros bicornis capensis Trouessart, Cat. Mamm. Viv. Foss. 757. Cape of Good Hope.

1922. Opsiceros occidentalis Zukowsky, Arch. Naturgesch. 88A, 7:162. Kaokoveld-Cunene region, northern South-West Africa.

1947. Diceros bicornis punyana Potter & Mitchell, Field, 190:385. Hluhluwe Game Reserve, Zululand, Natal.

Discribed forms from South West Africa are the following:

1758. Rhinoceros bicornis Linnaeus, Syst. Nat. 10th ed. 1:56. "India", but Cape of Good Hope according to Thomas (1911:144).

1845. Rhinoceros niger Schinz, Synops Mamm. 2:335. Chuntop, near Mt. Mitchell, Kuiseb district, South-West Africa (Shortridge, 1934, Mamm. S.W. Africa, 1:412, footnote).

1922. Opsiceros occidentalis Zukowsky, Arch. Naturgesch. 88A, 7:162. Kaokoveld - Cunene region, northern South West Africa.

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1934. Diceros bicornis Shortridge, Mamm. S.W. Africa, 1:412 South-West Africa.

2.2.1 Comments on Taxonomy.

Captain Alexander travelled through South West Africa during 1836 and 1837. (See Distribution and Status). In his 'Travels in the Interior of South Africa' he published a description of black rhinoceros he came across at Chuntop near Mount Mitchell. According to Alexander these animals were well over six foot tall. Their horns were mounted loosely on the forehead and while browsing the animals would strike the horns against each other causing a clacking noise. Whenever the animal became alarmed the two horns would stiffen, and the animal would be ready to defend himself. Schinz (1845) in his monograph, 'Synopsis Mammalium' named a species Rhinoceros niger after Capt. Alexander's description, which is also listed in Gray (1867)

In his publication 'On some Cranial and Dental Characteristies of the existing Species of rhinoceros' Flower (1876) omitted the species Rhinoceros niger probably due to a lack of material.

In 1922 Zukowsky described a species, Opsiceros occidentalis from the northern Kaokoveld. The general distribution of this animal was published in 1924. According to Zukowsky they occurred in isolated localities as far south as the lower Ugab River.

The distribution pattern of the black rhinoceros in South West Africa before 1900 is discussed under the heading Distribution and Status. They occurred along the western side of South West Africa mainly in the escarpment zone. According to Alexander's map Mt. Mitchell is situated at the present-day Naukluft

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Mountains. Zoogeographically Mt. Mitchell and the Kaokoveld belongs to the same entity. No ecological barriers eg. mountain ranges or perennial rivers, exist between these two localities to stop any gene flow. If it is further taken into consideration that Rhinoceros niger was only based on a description in a travelogue and not on any actual measurements the existence of two species of black rhinoceros in South West Africa seems to be a very remote possibility.

The question as to whether the black rhinoceros occurring in South West Africa should have subspecific status or not, is still a debatable point. This uncertainty is mainly due to a lack of sufficient material available to workers.

Shortridge (1934), regarded it as unlikely that Opsiceros occidentalis Zukowsky (1922), would be distinguishable from the typical Diceros bicornis. Even if this would be the case it still would be a synonym of Rhinoceros niger Schinz (1845), which would antedate it.

Roberts (1952), and Allen (1939), both regarded Rhinoceros niger and Opsiceros occidentalis as synonyms of Diceros bicornis bicornis Linn.

In 1965 Zukowsky published his revision on the genus Diceros. In this he recognises both Diceros bicornis niger Schinz (1845), and Diceros bicornis occidentalis Zukowsky (1922). In this work he also acknowledged the existence of Diceros bicornis keitloa A. Smith (1836). The latter form has first been shown by Selous (1881), to be a synonym of Diceros bicornis, a view held by most workers thereafter. Smith described this species from north of the present day Kuruman and the map published by Zukowsky shows the locality to be in the upper reaches of the Limpopo drainage system.

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In the Kaokoveld however, at least two animals are known to exist (Photo 3) which would satisfy some of the external characteristics described by Smith (1836) for Rhinoceros keitloa viz. " ... the two horns are of equal, or nearly equal length" (page 2).

Hopwood (1939), and Ansell (1967), both accepted the possibility of the existence of a separate subspecies in Angola based on skull characteristies which would then also include the South West African form. Hopwood however did not name the subspecies due to insufficient material. Ansell suggested the name Diceros bicornis niger Schinz (1845).

The validity of a subspecies in South West Africa (and Southern Angola) is therefore still in question.

2.2.2 Analysis of cranial measurements.

The black rhinoceros occurring in Zululand are regarded by most recent workers as Diceros bicornis bicornis, viz. Shortridge (1934), Allen (1939), Roberts (1957), Ellerman et al., (1953), Meester, Davis and Coetzee (1964), and Ansell (1967).

No evidence could be found of sexual dimorphism in the skulls of the black rhinoceros. Foster (1965), did extensive work on this aspect and was equally unsuccessful. Sexual dimorphism in the skulls does not seem to exist and was therefore disregarded as a factor which might have an influence on any statistical conclusions regarding this study.

During the study eighteen black rhino skulls were collected in localities to the north of the Ugab River, South West Africa. Measurements were also taken of twenty skulls obtained from the collection at the

Hluhluwe Game Reserve, Natal, and were used as a comparison.

All these measurements are given in Appendix I. The calculated figures are shown in table 1.

The South West Africa skulls are on the average larger than the Natal skulls, with two exepticns viz. mean interpterygoid width and lacrimal length from the anterior edge of the foramen. The latter two means are smaller in the South West African black rhinoceros' skulls.

To determine whether the difference in measurements between the two rhino samples were statistically significant the standard error of the difference between the two groups of means was calculated. The following formula was used (Mayr, Linsley and Usinger, 1953).

$$SE_d = \sqrt{(SE_{m1})^2 + (SE_{m2})^2}$$

where SE_d = Standard error of the difference

SE_{m1} = Standard error of means of first group of measurements (South West Africa).

SE_{m2} = Standard error of means of second group of measurements (Natal).

The results obtained can be seen in table 1. The difference between the different arithmetic means is over three times the SE_d in almost all the measurements - thus statistically significant. Only the anterior orbital widths show no significant difference.

The various skull measurements were then subjected to Mayr, Linsley and Usinger's (1953), interpretation of the "75 per cent rule" parameter. They suggest the acceptance as a standard of subspecific separation that 75 per cent of population A be different from 97 per cent of population B. This would then mean that

TABLE : 1

A COMPARATIVE ANALYSIS OF DICEROS BICORNIS SKULL MEASUREMENTS OBTAINED FROM A SOUTH WEST AFRICA AND A NATAL POPULATION.

		a/a	b/b	c/c	d/d
Sample size n.	S.W.A.	16	17	20	9
	Natal	20	20	20	20
Mean.	S.W.A.	58.6	52.9	21.6	18.9
	Natal	51.7	48.3	20.3	17.3
Variance.	S.W.A.	6.43	10.82	1.72	0.91
	Natal	14.99	18.32	2.90	1.376
Standard deviation.	S.W.A.	2.537	3.289	1.31	0.953
	Natal	3.871	4.28	1.702	1.117
Difference means.		6.9	4.6	1.3	1.6
Standard error	S.W.A.	.634	.798	.308	.317
	Natal	.27	.95	.380	.762
Standard error of the difference.		.687	1.24	.487	.409
SEdx3		2.061	3.72	1.461	1.227
Coefficient of difference. (Mayr *et al.*, 1953)		1.064	0.606	0.431	0.772

TABLE : 1 continued.

		e/e	f/f	g/g	h/h	i/i	j/j
n.	S.W.A.	9	16	17	20	15	16
	Natal	20	20	20	20	20	20
Mean.	S.W.A.	16.4	27.0	33.0	11.5	19.7	29.6
	Natal	14.8	24.8	30.6	10.3	17.9	27.4
Variance.	S.W.A.	1.23	1.18	1.62	0.35	1.25	2.30
	Natal	2.16	7.68	5.31	0.58	2.54	2.92
SD.	S.W.A.	1.109	1.08	1.27	0.59	1.118	1.516
	Natal	1.469	2.771	2.304	0.761	1.593	1.708
Dif. m.		1.6	2.2	2.4	1.2	1.8	2.2
SE.	S.W.A.	.350	.263	.300	.139	.288	.379
	Natal	.328	.619	.515	.170	.344	.382
SEd.		.467	.672	.595	.107	.448	.538
SEdx3.		1.401	2.016	1.785	.327	1.344	1.614
CD.		0.620	0.597	0.671	0.888	0.663	0.682

a/a : Greatest length Condylo-Nasal length.
b/b : Greatest length Occipito-Nasal.
c/c : Anterior orbital.
d/d : Nasal length.
e/e : Nasal width.
f/f : Length upper tooth row.
g/g : Zygomatic.
h/h : Post. orbital constriction.

TABLE : 1 continued.

		k/k	1/1 post.	1/1 ant.	m/m	n/n	o/o
n.	S.W.A.	14	17	18	9	9	9
	Natal	20	20	20	20	20	20
Mean.	S.W.A.	6.7	4.1	1.6	26.6	45.8	24.5
	Natal	7.0	4.0	1.8	24.9	41.9	22.1
Variance.	S.W.A.	0.37	0.18	0.06	0.88	0.66	1.38
	Natal	0.52	0.29	0.10	4.22	6.03	2.59
SD.	S.W.A.	0.608	0.424	.2449	0.938	0.812	1.174
	Natal	.228	.1702	.100	2.05	2.455	1.609
Dif. m.		.3	.1	.2	1.7	3.9	2.4
SE.	S.W.A.	0.16	.102	.057	.31	.27	.391
	Natal	.051	.038	.022	.459	.549	.359
SEd.		.028	.0014	.0032	.553	.609	.530
SEdx3		.084	.0042	.0096	1.659	1.827	1.590
CD.		0.358	0.168	0.581	0.568	1.193	0.862

i/i : Palatine length.
k/k : Interplerygoid width.
1/1 Ant : Lacrimal length from anterior edge of foramen.
n/n : Greatest length lower jaw.

j/j : Post. edge Palatine - basilar length
1/1 post : Lacrimal length from post edge of foramen.
m/m : Length of lower tooth row.
o/o : Greatest height of lower jaw.

about 90 per cent of the individuals of A are different from about 90 per cent of the individuals of B.

In calculating the coefficient of difference (C.D.) the following formula was used :

$$C.D. = \frac{M_B - M_A}{SD_A + SD_B}$$

The value which corresponds to the standard of subspecific difference (75 per cent A from 97 per cent B) = 2.56/2 = 1.28. Then, if the C.D. exceeds 1.28, it seems probable that it will be advisable to separate the two populations subspecifically. At this value about 90 per cent of A is different from about 90 per cent of B.

The following results were obtained using this procedure. (Table 2). Only seven of the measurements show a magnitude of joint nonoverlap of more than 75 per cent; greatest skull length has a joint nonoverlap of more than 85 per cent and greatest length of the lower jaw has a joint nonoverlap of more than 88 per cent. This indicates that no subspecies difference exist.

To determine the correlation between greatest skull length and palatine length the following formula was used :

$$r = \frac{y - \frac{xy}{n}}{\sqrt{\left(x^2 - \frac{(x)^2}{n}\right)\left(y^2 - \frac{(xy)^2}{n}\right)}}$$

The following r values were found for the two populations

S.W.A. r = 0.544 and NATAL r = 0.788.

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TABLE : 2.

PERCENTAGE JOINT NONOVERLAP OF PARTIALLY OVERLAPPING SKULL MEASUREMENTS OF BLACK RHINO POPULATIONS IN SOUTH WEST AFRICA AND NATAL ASSOCIATED WITH VALUES OF COEFFICIENT OF DIFFERENCE (C.D.).

Measurement.	C.D.	Joint nonoverlap per cent.
(Conventional level of sub-specific difference)	1.28	90)
Greatest length of lower jaw	1.193	more than 88
Greatest skull length (condylo nasal)	1.064	more than 85
Post orbital constriction	.988	more than 80
Height of lower jaw	.862	more than 80
Nasal length	.772	more than 75
Length from post palatine to basilar	.682	more than 75
Zygomatic width	.671	nearly 75

All the other measurements were below this level.

These values show that there does exist a correlation between the total length of the skull and the length of the platine. This correlation seems to be more marked in the S.W.A. population. To determine whether the statistical r values differ significantly they were then subjected to the t test.

S.W.A. $r = 0.544$ $n = 13$ NATAL $r = 0.788$ $n = 20$

	n	r	z	$\frac{1}{n-3}$
S.W.A.(n_1)	13	.544	.61	0.1
NATAL.(n_2)	20	.788	1.065	0.05
			0.455	$\frac{1}{n-3}$ =0.15

$$S_{z1} - Z_2 = \frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}$$
$$= 0.387$$

$$t = \frac{Z_1 - Z_2}{S_{z1} - Z_2}$$
$$= \frac{.455}{.387}$$
$$= 1.18$$
$$t^{\infty}.05 = 1.96 > 1.18$$

This shows that the values of r do not differ significantly.

The coefficients of regression between greatest skull length and the length of the palatine were also determined. This method is discussed by Bailey (1959). The basic observation are in pairs of associated observations, represented by x and y (For x and y values see appendix 3). The following factors are determined for each sample : n, x, y, x^2, y^2 and xy.

The following quantities are now calculated to give the estimated variances and estimated co-variance

$$Sx^2 = x^2 - \frac{(x)^2}{n}$$

$$Sy^2 = y^2 - \frac{(y)^2}{n}$$

$$c = xy - \frac{xy}{n}$$

where Sx^2 = estimated variance
Sy^2 = estimated variance
c = estimated co-variance

The true regression line for the regression of y on x is given by :

$$y = a + bx$$

where a = observed frequency
b = estimated regression coefficient.

The true regression coefficient b is determined by :

$$b = \frac{c}{Sx^2}$$

and the constant a by :

$$a = y - bx$$

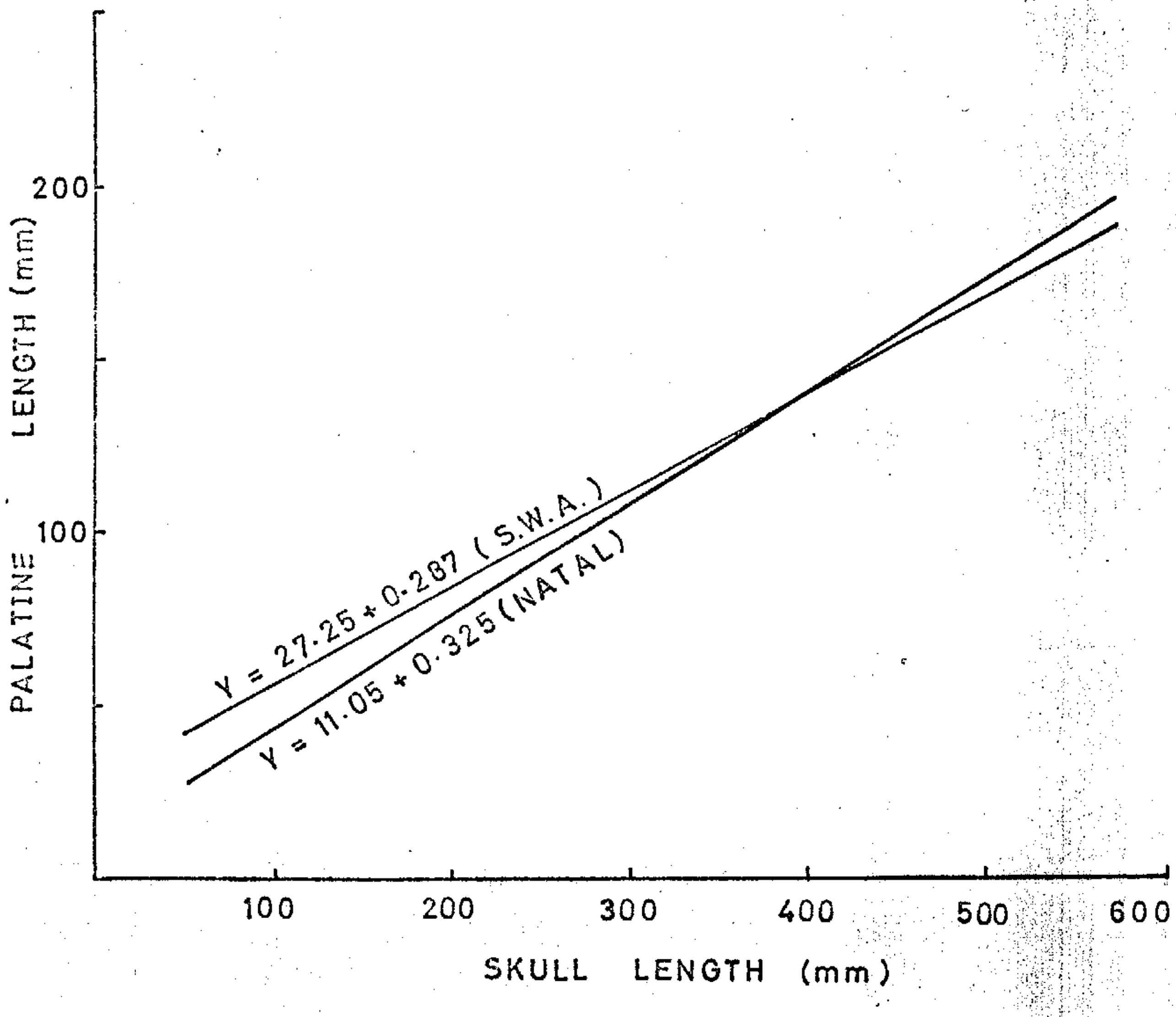
The regression lines of greatest skull length to the length of the palatine are shown in figure 2. These represent both the black rhinoceros population in South West Africa and that occurring in Natal.

2.2.3 Conclusions.

Rhinoceros niger Schinz, Synopsis Mamm., 2:335, 1845
Opsiceros ocidentalis Zukowsky, Arch. f. Naturgesch., 88 ; sect. A, pt. 7, p. 162,1922.

FIG. 2.

REGRESSION LINES OF GREATEST SKULL LENGTH TO PALATINE LENGTH FOR A SOUTH WEST AFRICAN SAMPLE AND A NATAL SAMPLE OF BLACK RHINOCEROS.



As shown earlier only the description of occidentalis Zukowsky (1922), is adequate enough for further consideration allthough it is antedated niger Schinz (1845). In his original description Zukowsky describes the skull of Opsiceros occidentalis as follows:

"Schädel : Verhältnismagzig breiter und kürzer als bei O. bicornis"

As seen under the previous heading, the mean of the greatest skull length of the South West African specimens exceeds that of Natal with 6.9 cms. However this characteristic also shows a joint nonoverlap of more than 85 per cent, close to the conventional level of subspecific difference. The mean width of the skull at the zygomatic arch is also larger (2.4 cm) in the South West African population.

Taking the skull measurements as base it can be reasoned that in the South West African specimens the animals should on the average be larger than those animals occuring in the Natal population. In his description of Opsiceros occidentalis Zukowsky (1922), however, describes the animal as follows :

"Allgemeine Kennzeichen : Viel kleiner als O. bicornis und verwandte Formen".

According then to the abovementioned it seem that Zukowsky's claim for a spec. nov. and even a distinct subspecies for South West Africa is groundless.

That the tendency exists in the South West African black rhinoceros population to differ from the Natal population is clearly illustrated in figure 2. This tendency however, is shown by the 75 per cent parameter to be still below the conventional level of

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subspecific difference. The black rhinoceros population in South West Africa and that occurring in Natal are thus below the conventional level of subspecific distinctness.

Diceros bicornis niger Schinz (1845 and
Diceros bicornis occidentalis Zukowsky (1922)
are therefore synonymous to
Diceros bicornis bicornis Linn 1758 .

2.3 General characteristics.

2.3.1 External body measurements.

Only the measurements of three adult animals could be obtained during the study. These measurements are given in table 3, together with other measurements from, Ellerman et al. (1953) and Roberts (1952).

2.3.2 Structure of rhinoceros horn.

Ryder (1962), did microscopical examinations of whole mounts in glycerine and of individual filaments. Although he denied the view that horn filaments were homologous to hairs, he came to the conclusion that one could not escape their similarity. This is partly due to the similarity of dermal papillae of the epidermis to those of hair follicles, and there is no doubt of an evolutionary association between them.

2.3.3 Sense perception.

The ears of black rhino are in constant motion even while sleeping. Whenever alarmed the ears are cocked in the direction from which they expect danger. To determine the acuteness of their hearing a "Jock" alarm clock, manufactured in Scotland, was used. Experiments were carried out on a captured animal in a boma. The animal became agitated whenever it heard the

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TABLE : 3

DICEROS BICORNIS - EXTERNAL BODY MEASUREMENTS.+

Locality/ Source	Sex	Height	h+b	Tail	h.f.	Ear	Ant. Horn	Post Horn	girth
Kaokoveld	o	1638	3632	635	660	-	610	457	2311
Kaokoveld	♀	1524	3048	559	-	267	368	280	2387
Kaokoveld	o	1524	3416	686	622	216	483	305	-
Kirkby	o	-	4064	686	-	-	-	-	-
Kirby	o	-	3963	635	-	-	-	-	-
Kirby	o	-	3658	610	-	-	-	-	-
Jackson	♀	-	3048	610	-	-	-	-	-
Neumann	o	-	3683	610	-	-	-	-	-
Neumann	o	-	3048	610	-	-	-	-	-
Roosevelt	o	-	2743	610	-	-	-	-	-
Roosevelt	o	-	3734	762	-	235	-	-	-
Roosevelt	♀	-	2442	673	-	216	-	-	-
Zululand (Roberts).	o	1440	2964	158	330	165	-	-	-

alarm clock ringing. It showed this agitation whenever the alarm clock was rung closer than 129 feet to the boma.

No method could be devised to measure eyesight and smelling abilities of black rhinos. Personal experience leads to the assumption that eyesight is poor and that the sense of smell is acutely developed. In the study area it was once possible to approach a female and calf with a one ton truck to within fifty-two yards. Both animals were lying down at the time and a strong wind was blowing. Although they got up from time to time they never spared the vehicle a second glance. During the late afternoon the wind calmed down and small eddies started moving about. Suddenly both animals jumped up and came charging at the vehicle and veered off at about five yards.
On another occasion a male (MB3) was observed moving in the direction of the road crossing the home range, B3. He crossed the road forty yards in front of the vehicle without being aware of its presence. When the horn was sounded he immediately turned around and charged up to five yards of the vehicle before turning around.

In both instances mentioned above the impression was created that the animals wanted to have closer look at the offending object after firstly smelling it and secondly hearing it. Rhino might be able however to detect movement at greater distances.

The following experiences illustrate the smelling ability of black rhinos. The author and his Herero assistant were once sitting on a low hill trying to locate rhino. No rhino could be observed with the aid of binoculars. The assistant then lit his pipe and about a minute or two afterwards a rhino female and calf broke cover approximately 600 yards away and ran off.

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A slight wind blew from the author and his assistant in the direction from which the animals broke cover.

On the 11th January 1968 the male and female in home range H2 were kept under observation. As they passed a rainwater pan the male wallowed and lingered a while. The female and calf in the meantime moved on. After some time the male seemed to realize that he was alone and made short frantic rushes in every direction, although the female was still only 70 yards off. He then apparently picked up her scent and followed the spoor exactly like a dog.

2.3.4 Temperament.

The temperament of black rhino shows such a wide individual variation that nothing definite can be said. On the average however the following were found in South West Africa :

(a) That females with small calves tend to charge more often than males.
(see 8.4 Parental care).

(b) That if the animal becomes aware of one's presence by smelling, it is bound to run away.

(c) If the rhino however, hears a suspicious noise, it is bound to charge closer. It may stop short with a snort, then turn around and leave the area (as in most of the cases) or it may press home with the attack. The latter was observed three times, in all three instances by females with small calves.

CHAPTER : III.

DISTRIBUTION AND STATUS IN SOUTH WEST AFRICA.

To determine the past distribution and status of the black rhinoceros in South West Africa the following sources were used to a large extent to obtain information. All available records and old reports on expedition through South West Africa were consulted. In comparison with the rest of Southern Africa, South West Africa is covered remarkably well by journals and official reports of early expeditions. Rhino engravings and/or paintings, and also excavation sites where rhino remains were found were also used. Regarding the more recent distribution and status a direct census was carried out and numerous interviews were held with old inhabitants and settlers in certain areas. With all this evidence in hand a more or less complete picture of the past and present distribution of the black rhinoceros was obtained.

3.1 Past distribution.

3.1.1 Distribution before 1900.

During July 1761 Ryk Tulbagh sent a party of volunteers on a scientific expedition to explore the country north of the Orange River. They reached Warmbad on the 5th October and moved on to the Lion River. The banks were well-wooded, they reported, apart from rhino, also giraffe, buffalo, zebra, quagga, kudu, eland, hartebeest and wildebeest (Vedder 1938). This is the earliest record in literature of the occurrence of rhinoceroses in South West Africa.

In 1791 Willem van Reenen set out on a hunting and exploration expedition and travelled into South West Africa. He reached Swartmodder (Keetmanshoop) in November 1791. After crossing the Fish River his party had difficulty in crossing a waterless stretch of country. At the Leber River they shot rhino, giraffe and buffalo as food for the party. They travelled for a period of nine months and during this time shot 65 rhino, 6 giraffe and large numbers of other game.

The Dutch Government despatched the MEERMIN from Cape Town to the South West African coast in 1793 to forestall occupation by foreign powers. A landing party went on shore on the 23rd January, 1793. They saw great numbers of animals in the Swakop River. Animals recorded by them were elephant, rhino, gemsbok and springbok (Vedder 1938).

In his "An expedition of Discovery into the interior of Africa" J.E. Alexander (1838) described his journey from Cape Town, across the Orange River, along the Fish River and down the Kuiseb River to Walvis Bay, returning past present-day Windhoek. His party left Cape Town on the 8th September, 1836. He came across his first rhino at Kopumnaas,or "Bulls Mouth Pass". He reached this mountainous terrain after crossing the "Kei Kaap or Great Flat". According to his map the "Bull's Mouth Pass" is situated north of the 24th Latitude - possibly in the region of the present-day Naukluft mountains and with little doubt the present-day "Büllsport".

During his travels Alexander came across a few Bushmen (near the abovementioned Bull's Mouth Pass) and he records the following :

"I asked him what was that of all other things he wished for in the world - was it plenty of wives, of children, of cattle, of sheep, of clothes, or a good hut ? and he (the Bushman) answered, the rhinoceros, and to get it easily !"

By now more and more travellers and missionaries travelled and settled in South West Africa. When Hugo Hahn travelled from Otjikango down the Swakop River to Walvis Bay in 1847 a rhino crossed his path. During 1850 Rath explored the north bank of the Swakop River as far north as the Erongo Mountains where he was repeatedly molested by rhinoceroses (Vedder 1938). During this time a missionary at Rooibank used the skin of a black rhinoceros, shot in the nearby Kuiseb River, as a door.

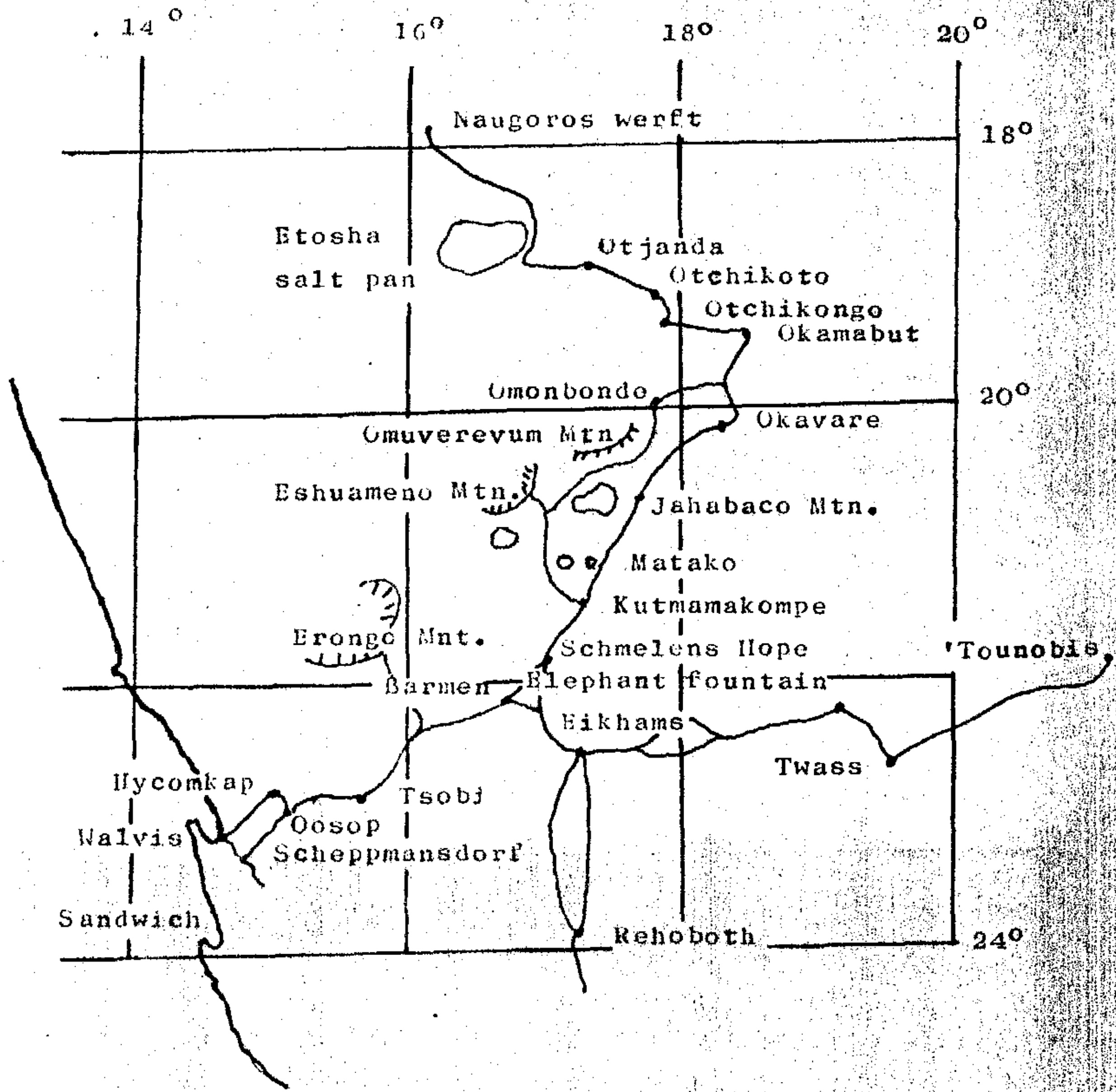
Francis Galton and Andersson travelled extensively in South West Africa during 1850 and 1851. (See map 1) The results were published during 1889. They set out from Walvis Bay during September 1850, travelling along the Swakop River. Galton records that there was not a sign of game apart from tracks several days old and mostly of buffaloes. After visiting Ovamboland, travelling past the Etosha Pan, they reached Elephant Fountain in August 1851. At Elephant Fountain (the present day Gobabis) he records that the inhabitants :

"... talk familiarly of the rhinoceros as an everyday kind of game ... I had not yet seen a single rhinoceros" (almost a year after they set out from Walvis Bay !!!) "One was shot by Andersson when they went down to the bay (Walvis Bay), but I was then not present."

From Elephant Fountain they travelled over Twass to 'Tounobis'. Two days journeying brought them to a picturesque gorge in the ridge (along which they were

MAP 1.

THE TRAVELS OF F. GALTON AND ANDERSON (1850-1851) IN SOUTH WEST AFRICA.



travelling) which led down to the plain, and in which was a succession of small springs :

> "Rhino skulls were lying in every direction, but strangely enough not a single spoor could be seen. The whole of that night did Saul and I watch without seeing anything but a jackal. Saul had told us that the rhinoceros would begin trooping in at nightfall, and that we should continue firing at them till daybreak, and I had believed him. Forty were killed here about a month since. I could not doubt it, for I counted in a small place upwards of twenty heads; but I suppose that a vast number were also wounded, and that the whole game fairly scared from the place."

These animals were apparently shot by Witbooi's Hottentots who roamed through these regions.

On the 28th September, they reached a waterhole and saw a dozen fresh tracks of elephant and a few of rhino at the waterhole. That night Galton "bagged" his first rhino, and also a lion, a hyena and a wildebeest. On reaching 'Tounobis they erected hides and shot a number of rhino as they came to water. Galton did not record how many but added :

> "The Hottentots shot away a great many bullets at rhinoceroses and did, I daresay, a great deal of mischief. They bagged but very few, compared to the number they fired at; the others most likely lingered on for a few days, and then lay down and died elsewhere."

Dr. Scherz (pers. com.) made a thorough survey of the rock engravings and paintings in South West

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Africa. Most of the engravings portray animal figures, and in a few cases rhinos are also delineated. Although the possibility exists that the artists may have moved long distance after observing an animal and before engraving it, it is usually considered that the artists tended to engrave animals seen in the immediate vicinity.

Dr. Scherz found rhino engravings south of Bethanie on the farm Rooipunt, 157. There are engravings to the south-east of Luderitz on Aar 16, Geelperdhoek 76 and Swartpunt 74. On Aar there are three rhinos engraved on rock. The rhino engraved on Geelperdhoek is more than three feet high. The engravings on Geelperdhoek and Swartpunt are the most southern engravings of rhino known in South West Africa. Some other rhino engravings occur on several farms (E.g. Die Valle 226, Hauzerus 229) in the Haukluft area to the west of Mariental. The rhino engravings at Spitzkoppe, near Usakos were reported for the first time early in the nineteenth century. On the western side of the Brandberg some rhinos are also delineated on rock. On Harmonie 97, along the Ugab River, numerous rhino engravings occur. Further north the only known rhino engravings are situated at Twyfelfontein and some others a few miles south of Sesfontein at Sossos in the Kaokoveld. The latter are the most northern rhino engravings known.

Towards the east rhino engravings were found on the farm Ivanhoe 92, south of Gobabis. Dr. Scherz mentioned that no rhino engravings occurs to the east of an imaginary line that may be drawn from Tsumeb and Otavi to Okahandja.

Old remains of rhino skulls and/or parts of skeletons were also found (Mr. de la Bat, _pers. com._) viz. in the Fish River, Kuiseb River, Swakop River and near Omaruru, Windhoek and Gobabis.

A little way south-east of Lüderitz in the Namib a set of rhino footprints is encasted in a limestone layer. At Grullental a rhino skeleton, completely fosilized, was found. Carbon C_{14} dating method showed the fossil to be ± 10,000 years old.

To determine the distribution pattern of black rhinoceros in South West Africa before 1900 the following, fully independent, factors may be used as a basis. They are :

(a) Distribution pattern of rhino rock engravings and/or paintings.

(b) Localities where early hunters/explorers came across rhino.

(c) Localities where the remains of rhino skeletons were found during excavations.

It may be argued that the engravings/paintings only show the distribution of the artists and suitable rocks and this may be true to a certain extent. The localities, however, where early hunters/explorers came across rhino, and also the localities where remains of rhinos were found during excavations show a clear correlation with the localities of rhino engravings/ paintings (See map 2). The abovementioned factors taken by themselves seem slender and will always leave room for a degree of inaccuracy or doubt. The three taken together however, lessens inaccuracy or doubt to a point of insignificance.

No permanent rhino populations occur today on the drier side of the 100 mm. isohyet, and this may be considered an ecological barrier. It may therefore be assumed that in the era before 1900, the black rhinoceros was distributed from the Kunene River in the north, down to the Orange River in the south, and extended westwards to the eastern boundary of the Namib desert. They may have entered the Namib desert down river courses during the rainy season as is the case at present in the Kaokoveld and Western Etosha National Park.

The distribution pattern on the inland plateau, to the east is much more vague. They occurred to the south-east as far as natural vegetation (for food and cover) and available surface water allowed. As rhinos are partial to acacia thorn country, it is doubtful if they ever occurred in the sandveld areas in the eastern portions of South West Africa except in limited numbers. They did occur, however, south of the Angola border in the Kungveld. The main factor hampering their distribution in sandveld areas was, as mentioned earlier, the lack of surface water. They may have occurred down the east flowing omurambas viz. Omuramba Omatako, Otjosondjou, Eiseb, Epukiro, Rietfontein and probably the Black and White Nossob during good rainfall years.

Their distribution pattern in South West Africa during the 19th century must have looked more or less as follows: one arm reaching north-west from Outjo to the Kaokoveld and Kunene River, and the other arm stretching to the east past the present day Gobabis. Isolated localities existed in the Kungveld and Okavango. The rest of the distribution reached south past Windhoek along the 16th Longitude to the Orange river. If they ever did occur north of the Etosha pan on the Ovamboland plains, it must have been the first area in the South West Africa where they were wiped out by man.

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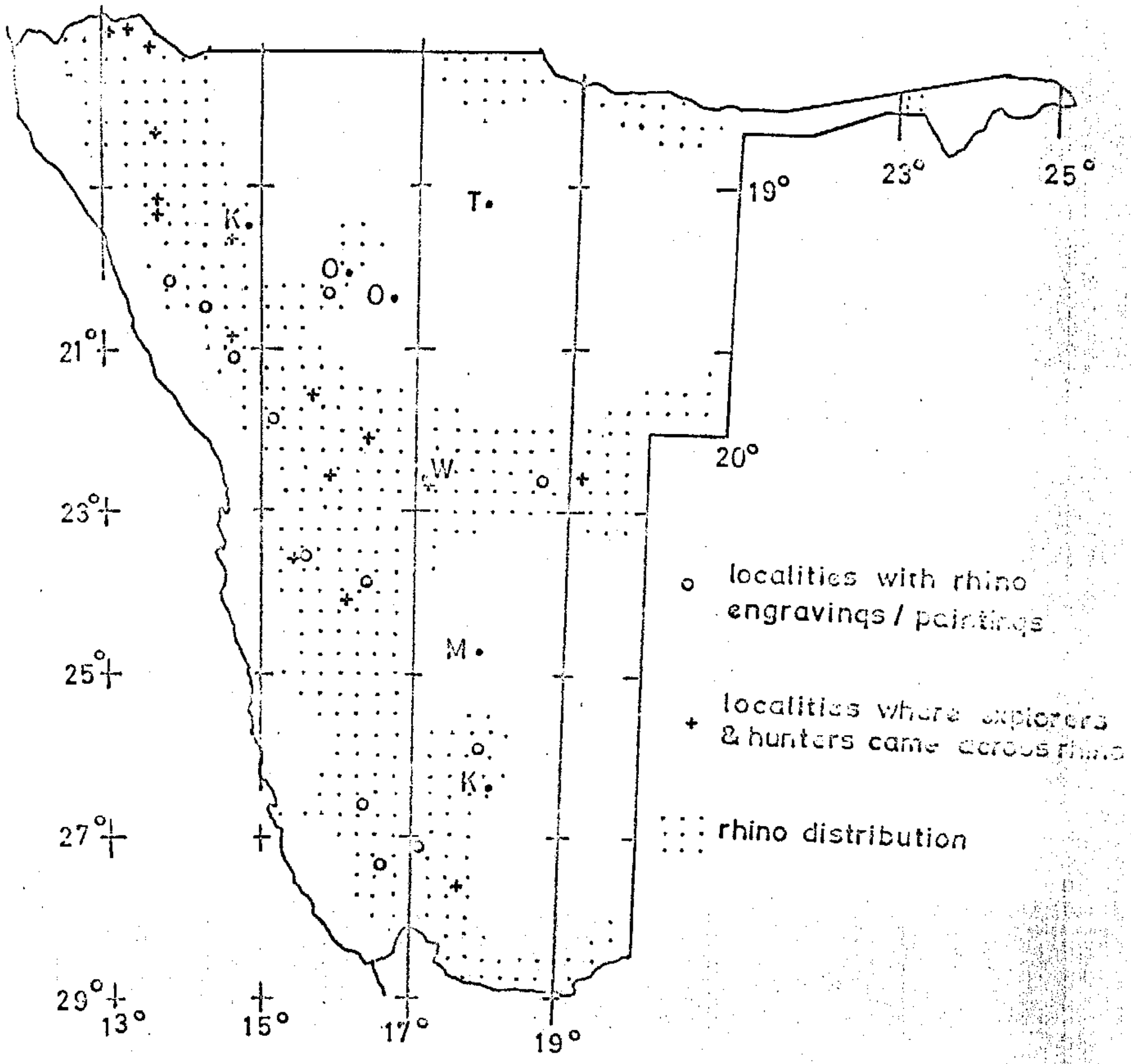
MAP 2.

DISTRIBUTION OF BLACK RHINOCEROS IN SOUTH WEST AFRICA CIRCA 1850.



According to the old Heikum Bushman, now resident at Okaukuejo, no rhino were ever known to them or their fathers to have occurred in their old hunting grounds to the near west and south of the Etosha pan. Galton, Andersson and also Hugo Hahn travelled in this region without reporting the presence of rhino. The rhino that frequent the waterholes at Grünewald and Gobaub in the Etosha National Park are apparently more recent arrivals from the south and south-west, probably from the Ugab drainage system.

The pressure of man was then felt in the south as the armed bands of Hottentots and Griquas swept across the Orange River during the second half of the 18th century. By the end of the 19th century the black rhinoceros must have neared total extermination in the southern parts of South West Africa.

3.1.2. <u>Distribution after 1900.</u>

As can be deduced from the above, the distribution pattern of black rhinoceros started changing long before the turn of the century. After 1900 the changing distribution pattern to the north of Windhoek gathered momentum as new areas were opened for settlement and during a period of thirty years it shrank to include only the Kaokoveld and a few localities in the mountains north of the 28th Latitude.

References available on the distribution of rhino after 1900 are the following :
Fischer recorded in 1904 the presence of rhino at Warmquelle and Sesfontein in the Kaokoveld. The presence of rhino near Usakos is also discussed. Steinhardt (1924) wrote that during 1915 to 1919 rhino still occurred in the lower Ugab River and sometimes moved as far as Outjo

They were also reported from the Huab River and the Hoanib River. Various other localities in the Kaokoveld are also mentioned. In 1916 Mattenklodt shot a rhino on the northern bank of the Okavango River in southern Angola. Wilhelm (1931) reported that they did not occur on the southern bank of the Okavango River but that there still were some left near the Kwando River. Shortridge (1934)reported that they occurred from about the latitude of Kaoko-Otavi (Northern Kaokoveld) northwards and that during the rainy season, while surface water was available, afew wandered as far south as the northern and north-western parts of the Outjo district. He recorded rhino tracks near Kamanjab.

Bearing the present distribution pattern in mind, one feels that the black rhinoceros was much more widely distributed in the north-western area of South West Africa during this period than implied by the abovementioned authors. This lack of information can be attributed to the lack of roads and the resulting large inaccessible areas and also to the lack of communications at the time.

Mr. Fritz Gaerdes of Okahandja (Pers. comm. 1967) supplied invaluable information regarding the past distribution of the black rhinoceros in northern South West Africa. Information was also gathered from farmers who originally settled on farms in the Welwitchia and Kamanjab areas in 1948. Information from these sources indicates that rhino were distributed as far south as the 22nd Latitude. They occurred in the Brongo Mountains between Omaruru and Usakos, and to the west on the edges of the Okombahe and Otjihorongo Reserves. They also occurred in the upper reaches of the Ugab River as far east as Outjo. From the middle reaches of the Ugab River in a north-westerly direction past Welwitchia, Fransfontein and Kamanjab they were more or less evenly distributed as far north as the Kunene River. A few also occurred south of the Etosha pan at Grünewald and Gobaub.

3.2 Present distribution.

The present distribution pattern of the black rhinoceros in South West Africa was fairly accurately established from a survey which was carried out during October, November and December, 1966 and during March, 1967. The results obtained during this survey indicate that the black rhinoceros has at present a limited distribution. It occurs only in the most inaccessible, mountainous areas of the escarpment transition belt; the exception being the Etosha National Park. (See map 3).

The present distribution in South West Africa can be divided into the following distribution areas :-

3.2.1 The area north of the Hoanib River -

(a) Northern concentration.
(b) Western concentration.
(c) Southern concentration.

3.2.2 The area within the Etosha National Park.

(a) Western portion.
(b) Eastern portion.

3.2.3 Farms along the Huab- and Ugab Rivers.

(a) Farms within the Odendaal area.
(b) Farms outside the Odendaal area.

3.2.4 Elsewhere in South West Africa.

3.2.1 The area north of the Hoanib River.

The distribution of the rhino in the Kaokoveld correlates for the greater part with the distribution of the OvaHimba and OvaTjimba population groups. The rhino and the OvaHimba and OvaTjimba occur on the escarpment area within the 2,000 and 4,000 foot contours. The reasons why the rhino population follows this distribution pattern may be the following :-

1. The extremely broken country within the escarpment zone offers a certain degree of protection against man.

2. The OvaHimba and OvaTjimba, with whom they share this area are nomadic and seldom live around permanent waterholes - thus ensuring the rhino free access to the water. The Herero on the plateau usually live at the waterholes.

3. The vegetative cover of this area includes most of the qualifying aspects preferred by rhino, viz. -

cover and preferred food plants.

The rhino is not evenly distributed through this area but occurs in three more or less isolated patches.

(a) <u>Northern concentration.</u>

This concentration area lies mostly within the upper reaches of the Hoarusib River, with isolated occurrences along the Kunene River in the Baynes and Zebra Mountains. As far as is known, no rhinos utilize the water of the Kunene River between the Ruacana Falls and the Epupa Falls. Individuals within the Baynes Mountains may do so, however. The individuals that utilize the waterhole at Ombombo-Ovambo sometimes wander into western Ovamboland. Permanent waterholes utilized by rhino are the following :
Enduva, Otjipembae, Otjitanga, Epembe, Otjirekeha,

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Okauzuma, Otjiwero, Ekoto, Ongongo, Otjiu, Kaoko-Otavi, Omeamo, Otjijenjenesa and Ombombo-Ovambo. Some of these waterholes may dry up in years drier than the average.

(b) Western concentration.

The western concentration lies in an area around Orupembe. This area lies for the greater part in the sub-desert region. The rhino here are isolated and this area used to be regarded as the safest for them in the Kaokoveld. During the last few years OvaHimba pastoralists moved in and settled in the area. This area lacks the dense vegetative cover and broken country of the other two concentration areas in the Kaokoveld - placing this rhino population in danger of being wiped out. Permanent waterholes used here are Orupembe, Sanitatas, to the east across the mountains, Otjitambi (which may dry up in years drier than the average) and Okonjombo. To the west of Orupembe lies Ombarundu which may also dry up in dry years.

(c) Southern concentration.

This concentration lies in the middle stretch of the Hoarusib River between the waterholes Purros and Otjikondawironko. Other waterholes utilized within this area are Omanje, Kotjidenta, Maruru and Otjakakawa. All the latter waterholes are likely to dry up in years drier than the average.

3.2.2 The area within the Etosha National Park.

(a) Western portion.

This distribution area extends from the Atlantic coast, between the Ugab and Hoanib Rivers, east to the 15th Longitude. The greater part of the remnant rhino population in South West Africa is found here,

with the largest concentration in the vicinity of Otjovasandu. To the east it only occurs as far as the Okawao waterhole. Westward its distribution pattern closely follows the distribution of permanent waterholes and the broken escarpment area.
Permanent or semipermanent waterholes frequented by rhino in the Hoanib drainage system are the following : Otjihuruotwatwa, Kowares, Omborongbonga, Renosterfontein, Otjovasandu, Kaross, Omborongbonga, Gaimaiss, Numas, Kamakams, Urukamses, Kamikukous, Chungab and Mudorib. In the Unjab drainage system the following are frequented: Agab, Zebraquelle, Nadas, Urunendes, Kaus, Dabeeb, Gemsbokquelle. In the Koichab River Springbokwasser, and another small waterhole about ten miles higher up in the river are used.

(b) Eastern portion.

This portion includes the rest of Etosha National Park east of the 15th Longitude. In this area only a few rhino occur in isolated localities; they are the following : Grünewald, Gobaub and sometimes Okaukuejo and Ombika.

3.2.3 Farms along the Huab and Ugab Rivers.

(a) Farms within the Odendaal area.

Farms situated to the west of Grootberg along the Etosha National Park boundary are not fenced in and movements by rhino in and out of the E.N.P. on to these farms occur. In some localities rhino home ranges extend onto the farms. The farms referred to above are Palmwag 715, Juriesdraai 709, Rooiplaat 710, Wêreldsend 715, and Driefontein 716. Other farms in the Odendaal area where rhino occur are the following : Naauwpoort 511, Rushof 509, Versteende Woud 485. The

same group of rhino frequents these three farms. Rhino also occur on Twyfelfontein 534, and along the lower Ugab and sometimes wander into the Bantu reserves on the southern bank. During 1967 a rhino was reported from Uis Mine. Farms higher up along the Ugab River where rhino occur are the following :
Leeuwhoek 411, and Zebraskop 410. In the upper reaches of the Huab River rhino occur at Kakatswa - Onguati 236. The most southern locality where rhino occur in South West Africa is near the Brongo Mountains on the farms Brongorus 166, Omandumba-West, and on Libertas 68, near Omaruru. A rhino used to frequent Otjimbingwe, on the Swakop River but no record could be found of its whereabouts during the last two years.

(b) Farms outside the Odendaal area.

The Ugab and Huab Rivers cut through several mountain ranges on their way down towards the Atlantic ocean. Farms situated in these mountainous localities harbour a few rhino usually in the most inaccesable corners. Although movement does occur up and down the drainage lines, it is usually resticted due to wirefences.

In the upper reaches of the Ugab River, near Outjo, the following farms are visited by rhino :
Petersburg 151, Ombakaha 150, Follie 147, Iris 145, and Okaura 140. Lower down this river farms harbouring rhino are Minorca 71, Hankow 78, Landeck 77, and Saturn 103. In the upper reaches of the Huab River rhino frequent the following farms : Garubib 188, and Bhobib 209.

3.2.4 Elsewhere in South West Africa.

There are no other localities in South West Africa where there are resident populations of rhino. Four black rhino were found in the Western Caprivi (Tinley pers. com. 1966). They are not residents and apparently wander along the Kwando River crossing the Angola and Botswana borders. Rhino sometimes cross the Angola border to enter the north-eastern sector of Ovamboland. Since the border has been fenced in they are very seldom recorded from this area.

3.3 Status

3.3.1. Past status.

Not one reference could be found in all the available literature giving an estimate of the total black rhinoceros population in South West Africa before 1900. After 1900 a few tentative estimates can be found in the literature. All these estimates, however, refer only to the nothern regions. As previously mentioned no real census was ever carried out prior to 1966.

Even before the interference of man the larger part of the rhino population must have occurred in the northern areas of South West Africa; the most obvious reason for this being the higher rainfall in this area resulting in more food, cover and availability of water throughout the year. Although black rhinos once occurred as far south as the Orange River they never attained large numbers in these regions owing to the relatively lower carrying capacity for this species. The reasons why they were wiped out in the south are shortly the following :

(a) Low population numbers.
(b) Lack of sufficient vegetation cover over large areas.

(c) This area was the first in South West Africa to be invaded by men armed with firearms.

That there were still a few left in the southern regions during the first few years after 1900 can only be considered a miracle. J.A. Meyer (pers. com. 1968) relates that he heard from an old Witbooi Hottentot that after a skirmish with German troops during 1904 at Swartmodder (the present-day Keetmanshoop) they fled into the mountain ranges next to the Fish River. After a few days of nearly continuous moving they camped one night in a ravine. During the night a rhino charged through the camp causing them to think that they were being attacked by the German troops.

From various other sources (eg. Dr. Schertz and Mr. P.G.L. van Blerk, pers. com.) it was learned that during the twenties and thirties rhino horns were much valued in these southern areas for honing knives. Rhino horn was at that time already unobtainable and farmers who did possess pieces usually had obtained them years before. One may assume with some safety that the black rhinoceros in these southern regions was exterminated around the turn of the century.

With regard to the regions to the north of the 23rd Latitude the following records were found in literature :-

Hugo Hahn (1843) saw several rhino tracks crossing the road between Windhoek and Okahandja. Andersson shot one rhino in the Swakop River near Walvis Bay in 1850. During 1850 Rath came across a fair number in the Erongo Mountains. Galton and Andersson found a concentration of rhino east of Gobabis in 1851. Hartmann travelled through

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the Kaokoveld in 1900 and came across elephant herds with more than a 100 animals in a herd, large numbers of rhino, hippo (in the Kunene River), giraffe and antelope. In the northern Kaokoveld, "Dorslandtrekkers" from Humpata in Angola frequently crossed the Kunene River to poach elephant. J. van Molkte (1943) compiled a comprehensive work on the hunting adventures of these "Dorslandtrekkers". Most of his information he gathered from the living members of this group of pioneers who moved back to South West Africa during 1928. The most concentrated hunting apparently took place during the years from 1898 to about 1908, under the leadership of Jan Harm Robbertse. The hunting season lasted from about June until November every year, and although they concentrated on elephant, rhino were also shot as they received about R15 for each. During these ten years they shot between 150-200 rhino viz. about 15 to 20 per year. It seems therefore that even at this stage the largest concentration of black rhinoceros was in the Kaokoveld.

Steinhardt (1924) visited this area during 1915 to 1919 and recorded that rhinos were sporadically distributed in the southern Kaokoveld but were more numerous towards the Kunene River. Along the Kunene River there appeared to be one to every kilometer of river. (This is the area where rhino were hunted by Robbertse and his men). In 1923 Manning estimated that there were 50 black rhinos in the Kaokoveld. In 1934 Shortridge estimated 40 to 80 animals between the lower Ugab and Kunene Rivers. Haerlen (1939) reports only that rhinos occur between the lower Ugab and Kunene but are everywhere rather scarce.

After the completion of the black rhinoceros census during 1966 information was obtained that

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rhinos were much more numerous up to 1948, especially between the lower Ugab and Hoanib Rivers, than implied by Manning and Shortridge. As already mentioned this could be attributed to the lack of roads, to there being no white inhabitants apart from those of the police station at Kamanjab and also to the poor communications, at the time, in this area.

According to farmers who originally settled to the north of the lower Ugab River in 1948, there were many rhinos in this area but they were not abundant. A farmer, looking back, said that in those years one of their first actions had been to hunt rhino systematically on their farms; the reason for this being that the Bantu who had to look after their herds and flocks refused to do so if they knew that there were rhinos on the farm. On two farms (Minorca 71, and Persianer 105) the remains of six skulls and/or skeletons were found. On several more farms, especially in the Grootberg area, one or two remnants of skulls and/or skeletons were found. On several other farms skulls were known to be lying around but could not be found. Most of this information was obtained from neighbours or from tenants who recently leased the farms from the Administration of South West Africa after the original owners had moved away and information was only seldom volunteered by the owners themselves.

Taking into account -

(a) the 1966 figure of 90 (See par. 3.3.2 on Present status)

(b) the fact that rhinos are known to be slow breeders

(c) the undoubtedly large numbers shot on these newly settled farms from 1948 onwards, one can only reach the conclusion that the black rhinoceros must have been much more numerous at the time than the maximum of 80 estimated in 1934. A figure of about 200-250 for the whole of South West Africa would have been more accurate. Even so one wonders whether the black rhinoceros population ever reached very high numbers in South West Africa.

3.3.2 Present status.

The figures mentioned below are those obtained during the black rhinoceros census carried out during 1966. No adjustments were made for any changes in number that must have occurred during the time lapse since the census was carried out. Seven known births of black rhino calves in South West Africa were recorded afterwards. During 1967 and the first half of 1968 six rhinos were killed in the Kaokoveld and two were shot in the upper reaches of the Unjab River by unknown white poachers. Three other animals died during trials to translocate them to the Etosha National Park.

Black rhinos counted during this census numbered 90. These animals are distributed as follows :

25 ... North of the Hoanib River.
48 ... In the Etosha National Park (including those animals on farms adjoining the Park along the west in the Unjab drainage system, and 8 in the eastern portion of Etosha National Park - Starke and van der Westhuizen - pers. com.).
7 ... On other farms in the Odendaal area.

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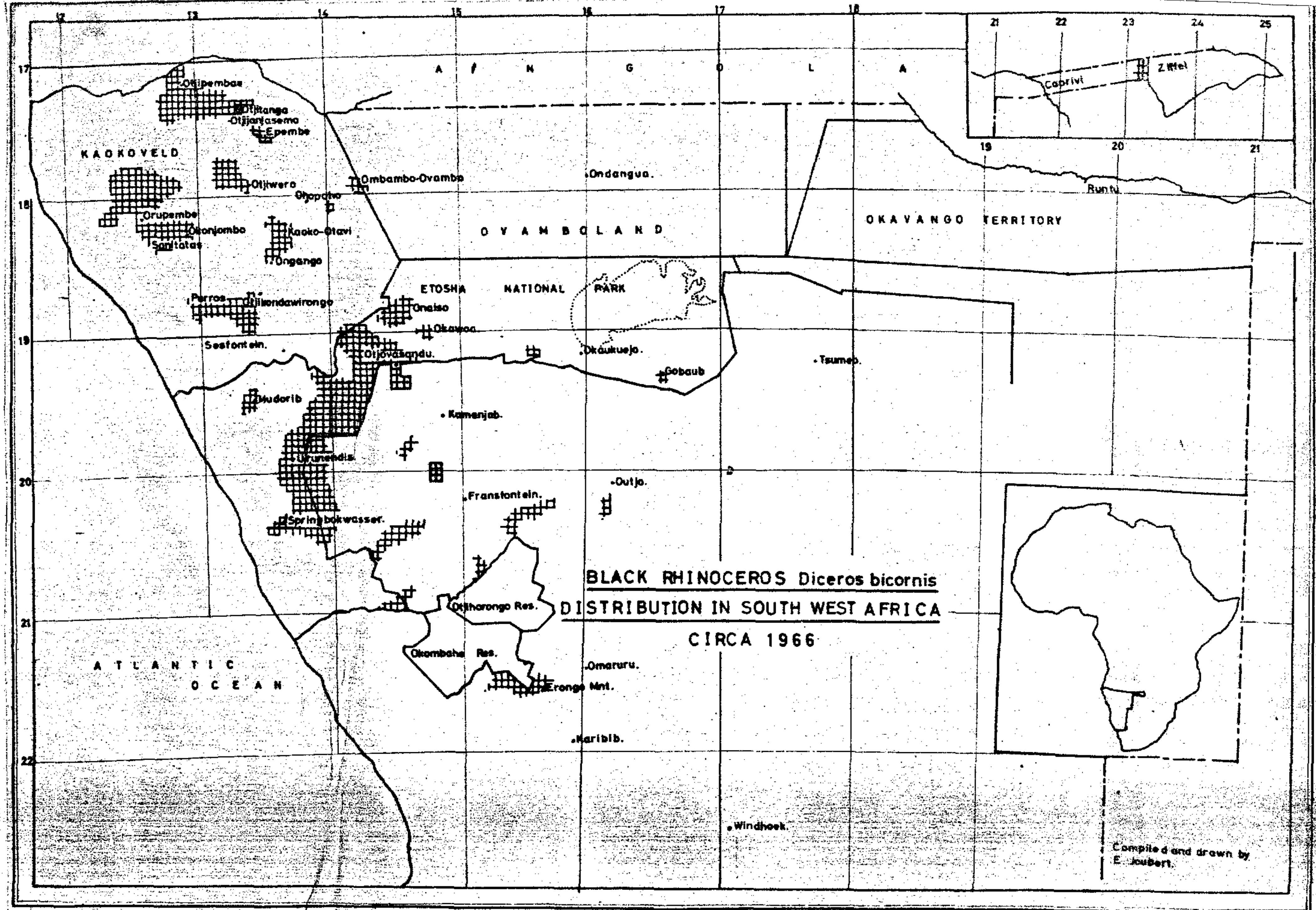
10 ... On the farms outside the Odendaal area.

Looking at these figures one might be lulled into a false sense of security. These figures should, however, be analysed against the background of the proposals made by the Odendaal Commission. The rhino population then shows the following distribution :

72% of the rhino population occurs in Bantu areas or proposed Bantu areas.
11% on privately owned farms.
17% within the proposed boundaries of the Etosha National Park.


BLACK RHINOCEROS Diceros bicornis
DISTRIBUTION IN SOUTH WEST AFRICA
CIRCA 1966
A N G O L A
KAOKOVELD
OVAMBOLAND
OKAVANGO TERRITORY
ETOSHA NATIONAL PARK
ATLANTIC OCEAN
Caprivi
Zipfel
Runtu
Otjipembas
Otjitanga
Otjijanjasemo
Epembe
Otjiwero
Ombambo-Ovambo
Ohopoho
Ondangua.
Orupembe
Okonjombo
Sanitatas
Kaoko-Otavi
Ongango
Perros
Otjikondawirongo
Sesfontein.
Onaiso
Okawao.
Otjovasandu.
Okaukuejo.
Gobaub
Tsumeb.
Mudorib
Kamanjab.
Outjo.
Franstontein.
Springbokwasser.
Otjiharongo Res.
Okombahe Res.
Omaruru.
Erongo Mnt.
Karibib.
Windhoek.
Compiled and drawn by
E. Joubert.

CHAPTER : IV

THE KAOKOVELD : A BRIEF REVIEW.

4.1 Physiography.

The Kaokoveld is situated in the north- western corner of South West Africa. Zoogeographically it is bounded by the Namib desert in the west, the Kunene River in the north and the inland plateau (Ovamboland)border) in the east. Shortridge (1934) gives the southern border as being the Ugab River. Strictly speaking, however, this is not true as some Kaokoveld elements viz. mopane and also certain mammal species (C.G. Coetzee pers. com.1968) occur as far south as the Erongo Mountains.

Politically speaking the Kaokoveld is bounded by the Hoanib River and the Etosha National Park in the south, Ovamboland in the east, the Atlantic coast in the west and the Kunene River in the north. The Kunene River is the only perennial river having its headwaters in the Angola highlands with its high rainfall. This river also forms the border with Angola. The Kaokoveld approximately falls between the Latitudes 17°S and 19° 15'S and Longitudes 11° 50'E and 14° 30'E. It covers an area of approximately 22,650 sq. miles, with a population density of .45/sq. mile.

The area north of the Ugab River and to the west of Kamanjab is still known as 'Kaokoveld' by the farmers who settled in this area. Although this is zoogeographically true, the name was never officially accepted, and in this paper, this area, as well as the Etosha National Park to the west and south-west of Otjovasandu will be excluded in any discussion of the Kaokoveld unless otherwise stated.

Physiographically the Kaokoveld and the western Etosha National Park may be divided into the following regions :

(a) The coastal desert in the west.

(b) The escarpment.

(c) The plateau to the east.

The desert is known as the Namib. It stretches along the Atlantic coast and is about sixty miles wide. Sand dunes occur only in the immediate proximity of the coast. Large areas consist of pediplains and, towards the east, Inselbergs. These areas are traversed by several river courses. The vegetation is sparse and for the greater part the ground surface is bare. Welwitschia mirabilis occur on the pediplains, but most of the other vegetation is limited to the dry river courses. Near the coast one finds Acanthosicyos horrida (Narras). The following also occur :

Zygophyllum stapfii; Z. clavatum;
Salsola nollothensis; S. aphylla;
Ectadium vingatum var. rotundifolium;
Merremia Multisecta.

If this part receives rain the grass-cover is formed chiefly by :

Stipagrostis species, viz. S. ramulosa and S. subacaulis.

The escarpment is no true escarpment as found on the south-eastern side of the subcontinent, but rather a mountainous transition belt. For the sake of brevity this area will be referred to as escarpment in this paper. The mountains are generally formed by folded

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Hoaib and Damara sediments that rise above the surrounding granites and gneiss which have been more severely w weathered and eroded. The vegetation on the escarpment is denser and of a much more complex and varied nature. A few plants occurring in the Kaokoveld are typical; some of them are :

Acacia robynsiana;	A. montis-ustii;
Commiphora wildii;	Euphorbia guerichiana;
Combretum wattii;	Rhigozum virgatum;
Commiphora anaiardifolia;	C. multijuga;
Adenolobus garripensis;	A. pechuelii.

In the rivers one finds Acacia albida and A. giraffae, the latter only in the Hoanib River. Colophospermum mopane form large trees in the rivers while elsewhere the growth is usually stunted. In localities where surface water appears in the riverbeds Tamarix usnoide and Salvadora persica form large communities. Aristida damarensis and Eragrostis spinosa are found in the riverbeds. Near waterholes Cynodon dactylon and Odyssea paucinervis occur. In some localities on alluvial soils in valley floors Acacia tortilis forms the dominant tree growth, such as around Sesfontein and Warmquelle. The vegetation on the mountain sides usually consists of Acacia, Combretum and Commiphora species. Succulents also form an important part of the vegetation to the west in the sub-desert region.

The inland plateau forms part of the great African plateau. It reaches its highest elevations, ranging between 4,000 - 6,000 feet, along the western rim. This forms the watershed between the catchment areas of the rivers draining into the Atlantic Ocean and the endoreic basin of the Etosha Pan. The inland plateau is a featureless plain covered by calcareous sand, gravel and secondary surface limestone. Rubble calcrete sometimes forms pronounced ridges. The soil is never more than a few feet deep. The vegetation is mostly grass, shrub and scattered mopane trees forming a typical shrub savanna. The vegetation will be discussed in greater detail later in the paper.

The country is exceedingly dry. The vegetative cover is poor and the sparse grass-cover insufficient to retard the flow of occasional rainwater. When it does rain the run-off is therefore considerable. The broken formations collect rainwater and lead it underground feeding perennial springs and waterholes. Some of these have never been known to dry up.

4.2 Distribution and effects of man.

4.2.1 Distribution of man.

The inhabitants of the Kaokoveld to the north of the Hoanib River may be divided into five main culture groups. They are the pastoralists, Herero, OvaHimba and OvaTjimba groups, who have a mutual language and more or less the same culture; the fourth and fifth culture groups being those of the Bergdama and Nama. The latter groups are encountered in the south around Sesfontein. They seldom own more than a few goats and are mainly dependent on the produce which they cultivate at these fountains. The produce consists mainly of maize, corn and tobacco; the latter has an important exchange value.

The Herero are found on the plateau to the east of the territory. They are not nomadic, and tend to congregate with their stock at permanent waterholes. They are not in the habit of digging for water. At these waterholes (e.g. Kaoko-Otavi and Oruwanjae) they

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cultivate irrigated crops, mainly maize and corn, to a very limited extent, usually only to satisfy their own needs. In these areas there are signs of denudation owing to overstocking. The Department of Bantu Affairs and Development is constantly sinking new boreholes to relieve this position. During the dry season they send their herds to grazing grounds, while they themselves stay at the waterholes.

The OvaHimba and OvaTjimba are found mainly on the mountainous escarpment areas. In contrast to the Herero they are nomadic. The former move about with their cattle and live in temporary huts, built with branches and smeared with cow dung, on the grazing ground and never near the water. They water their stock once a day. As it gets drier they move further away in search of new pastures and if necessary water their herds only every second day. This gives the wildlife a chance to utilize the water, usually at night.

The OvaTjimba lives in the Baynes Mountains in the northern Kaokoveld. Their mode of life comprises mainly of a hunter-gatherer economy (Mac Calman and Grobbelaar, 1965).

4.2.2 Effects of man.

Man has an adverse effect on the wildlife in the Kaokoveld. The influence may briefly be listed as follows :

4.2.2.1 Water.

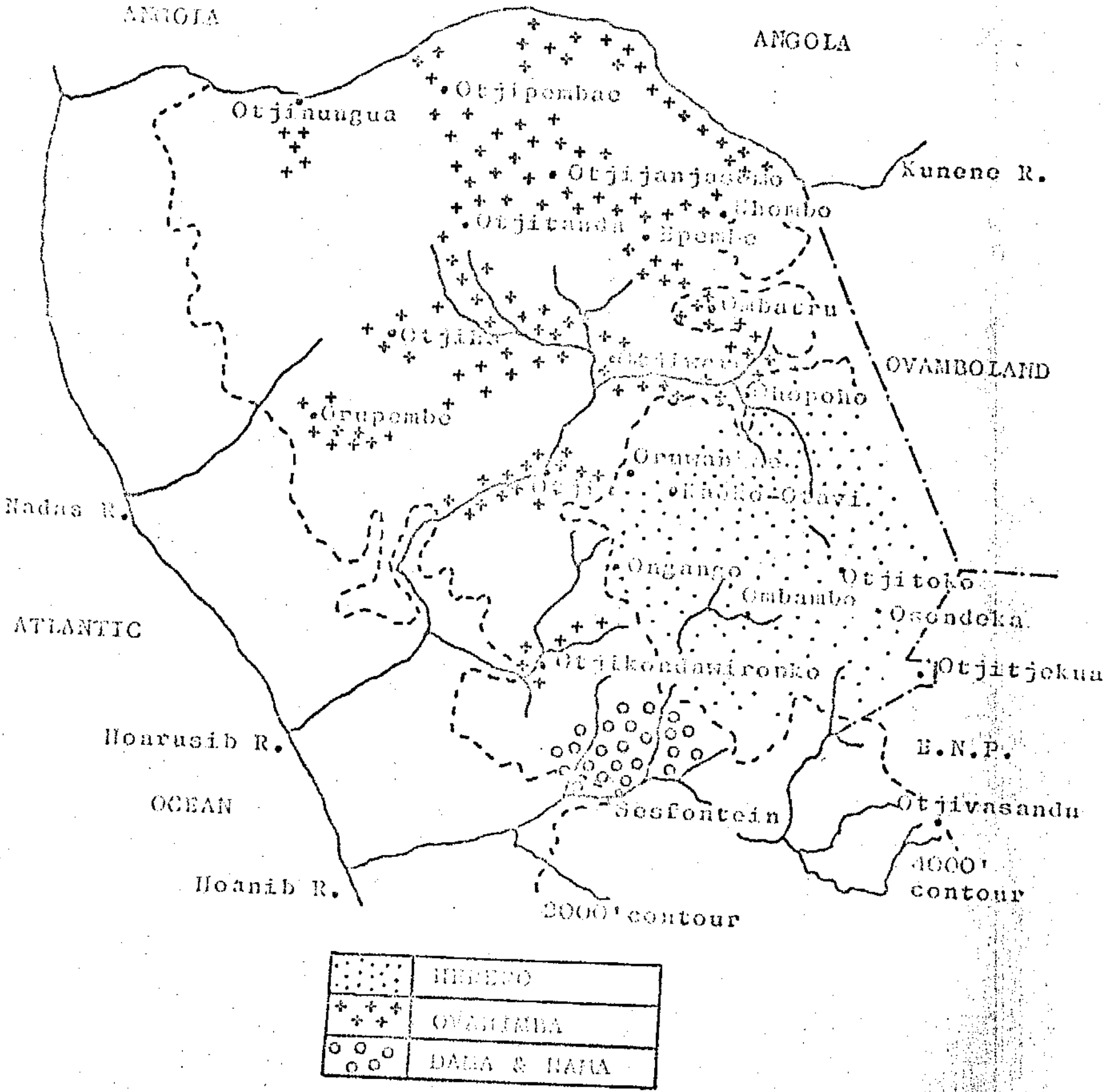
4.2.2.2 Incorporation of new areas.

4.2.2.3. Competition with livestock.

4.2.2.3. Hunting pressure.

MAP 4.

DISTRIBUTION OF BANTU POPULATION IN THE KAOKOVELD, SOUTH WEST AFRICA.



4.2.2.1 Water

The availability of water to rhino is one of the most important single aspects in their fight for survival. In the Kaokoveld with its limited waterholes this importance is magnified. The permanent waterholes on the plateau are mainly unavailable for the rhino. Apart from the concentration of Herero around the waterholes, these waterholes are usually fenced in by the Herero with impenetrable thornbush. Kaoko-Otavi however is an exception. This very strong spring drains into a large open dam which is used by rhino, other game and occasionally elephant. At Ovambo-Obombo the terrain is unsuitable for any agricultural projects.

On the escarpment the situation changes. The terrain is extremely broken and the waterholes are usually situated in rocky ravines. The OvaHimba very seldom try to cultivate crops at these localities. Some of the permanent waterholes on the escarpment grow very weak during the dry season. With the increase in stock these waterholes then sometimes fail to yield enough water for both game and stock. During the height of the dry season the OvaHimba nightly build fires at these waterholes and burn animal bones in them. The smell of the burning bones keeps the game away, and allows the small depressions at the waterholes to fill up with this precious liquid.

4.2.2.2 Incorporation of new areas.

As previously noted new boreholes are constantly being sunk in the Kaokoveld. As soon as the water installations at the new waterholes are completed the pastoralists move in with their stock. In some instances this is virgin area and has either never before been utilized by man or only to a limited extent. The implication of this is clear. Rhinos which may inhabit this area as part of their rainy season home range or which use a distant waterhole, immediately come into contact with man, with all the usual implications, and later on as denudation takes place, also in competition with his livestock.

4.2.2.3 Competition with livestock.

Apart from the competition with livestock for water as already discussed, rhino are also faced with competition with livestock for food. As the success and social status of the Kaokoveld pastoralists is measured by the amount of stock they own, they are not in the habit of selling livestock. The result is that the number of livestock increases yearly. The rhino are thus forced into competition with goats, easpecially during the dry season. Although this competition is not serious at present, mostly owing to the reduced numbers of rhino, it may become important in the near furture.

Rhino are also forced more and more into a competition for living space by livestock. When cattle graze in the home range of a rhinoceros, and the rhino should for example, charge through the herd it usually means the end of the rhinoceros.

4.2.2.4 Hunting pressure.

Apart from the large number of illegal rifles in the Kaokoveld there are more then seventy firearms officially issued to local chiefs and headmen of kraals. These firearms are a token of prestige and the chiefs are supposed to protect their crops and livestock against animal marauders. Those rifles are, however, also used indiscriminately for hunting purposes.

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Although no proof has been found that rhino are being hunted systematically they are shot whenever the opportunity arises. The horns are usually sold or exchanged across the Angolan border for liquor. The horns are also used to a limited extent to make snuff-boxes and other bric-à-brac. (See photo 10 and 11).

An incident worth repeating is the following :

While working in the sub-desert region with a base camp at Otjikondawironko during October, 1967, it was learned that a Bantu woman had been seriously injured by a rhino the previous day. According to the messenger there was some doubt as to whether she would live. The following morning, the author, accompanied by a large number of Bantu, paid a visit to the kraal where this women lived. Reaching the kraal, about five miles from the road, the author found the old woman basking in the sun. Her leg was scratched and one elbow slightly swollen. Apparently she had been on her way during the late afternoon looking for missing goats when the rhino cow and calf had 'charged' her. She had thrown herself under a Terminalia prunioides shrub and luckily escaped serious injuries. At this kraal there were gathered about fifteen men, some armed with rifles, on their way to hunt these animals. The chances are that those two unfortunate animals are not alive today.

TABLE : 4

POPULATION NUMBERS IN THE KAOKOVELD,
SOUTH WEST AFRICA (1964).+

Herero	4,085
OvaHimba	7,280
OvaTjimba groups	2,600++
Bergdama	425
Nama	115
Total	14,505

+Figures from the annual report of the Native Commissioner, Ohopoho 1964.

++OvaTjimba groups consist of the pastoralists Herero-Tjimba and HimbaTjimba, and the stone working hunter-gatherer group TjimbaTjimba. (B.J. Grobbelaar, pers. com. 1968)

TABLE : 5

FIGURES ON DOMESTIC ANIMALS (DEC. 1964).+
IN THE KAOKOVELD, SOUTH WEST AFRICA.

Cattle	87,000	Sheep	81,000
Horses	1,500	Goats	125,000
Donkeys	12,000	Total	206,000
Mules	500		
Total	101,000		

10 Sheep equal one cattle unit.
Total cattle units : 121,600.

+figures from the annual report of the Native Commissioner, Ohopoho 1964.

CHAPTER : V.

THE STUDY AREA.

5.1 Topography.

The study area was situated just south of the 19th Latitude at Otjovasandu. It is bound in the south by the old Etosha Game Reserve boundary, in the east by a dolomite ridge, in the north by the Sesfontein road and in the west by an imaginary line connecting the waterholes Renosterfontein, Omborongbonga and Kowares. This area covered about 270 square miles. In regard to the physiography of the Kaokoveld the study area was situated on the transition between the escarpment and the inland plateau. Two of the three Kaokoveld physiographic regions thus occurred in the study area. The dolomite ridges forming the eastern boundary of the study area formed a third component. Physiographically the study area then consisted of the following :

5.1.1 The edge of the escarpment.

5.1.2 The plateau.

5.1.3 The eastern dolomite ridges.

5.1.1 The escarpment.

The western edge of the plateau is marked by the 4,000 feet contour line. (See map 5). From here the country falls away to the west to form an extremely dissected landscape. In this part a well developed, eshorheic drainage system forms the headwaters of the Hoanib River catchment area just below the 4,000 feet contour. Some of these seasonal streams form wide valleys with ill-defined drainage lines. The four perennial waterholes serving this areas are situated in these stream beds. The stream beds are sand-filled and the water rises to the surface where there are natural transverse barriers - Renostervlei and Omborongbonga. At Otjovasandu the sub-surface channel is narrowed by impervious rock side walls sufficiently to dam the subterranean water so that it appears on the surface.

5.1.2 The plateau.

Apart from a few hills the plateau is mostly flat with a gentle slope towards the east. Its highest elevations are the Landskrone ridge in the north-western area and a few ridges along the western and southern edges. Some of these were extensively used as reconnaissance points during the study.

The inland plateau is endoreicly drained into the Etosha Pan. Owing to the dolomite ridges in the east this catchment area is cut off from the larger system. A poorly developed local endoreic system replaces it. The smaller system consists of a number of interlaced omurambas (drainage lines) which drain into pans formed in depressions along the eastern side of the plateau. Sometimes the water collects in depressions along the omuramba bed itself. Numerous little pans are formed in this way all over the study area. Their influence on the behaviour of the black rhinoceros during the rainy season appears to be remarkable.

Besides the natural waterholes the only permanent water available is supplied by a windmill in the south-eastern portion of the plateau.

5.1.3 The eastern dolomite ridges.

These ridges run from the south-eastern corner of the study area in a north-westerly direction. They never exceed altitudes of more than two or three hundred feet above the surrounding plateau. They are not persistent throughout their length but leave a series of openings through which animal movements take place. They cannot therefore be regarded as an ecological barrier. The dry sandveld to the east is a much more effective barrier for animal (apart from elephant) movements.

5.2 Geology of the study area.

The study area is underlain by granite and gneiss of Archean age, followed by sediments and volcanics belonging to the Khoabendus Formation and Outjo Facies of the Damara System of pre-Cambrian age. The physical characteristics of these rocks and their different behaviour under weathering and erosion exercised a very important geomorphological influence on the evolution of the landscape, which resulted in the already mentioned physiographic features, which are characteristic of the study area.

5.2.1 The Archean Basement.

It is represented in the study area by granite, gneiss and granitised metasediments and metavolcanics belonging to the Huab Formation.

5.2.2 Khoabendus Formation.

It rests unconformably over the gneiss and granite of the basement by means of a locally developed basal conglomerate. This formation consists of shale, limestone, quartzite, acid volcanics and granite. The quartzite is white and very hard. In the southern portion of the study area several of the ridges are formed by this white metaquartzite. The fragments of

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this rock are scattered on the surface along the southern slopes of the escarpment. In the vicinity of Otjovasandu it is reported to contain a small amount of gold (Martin, 1964).

Greenish phyllites and bands of dolomite overlie the quartzite in the area to the north of Otjovasandu.

5.2.3 Damara System.

(a) The Nosib Series : It consists of a very thick sequence of feldspatic quartzite which always weathers pink. Thin bands of shale and limestone are interbedded within the quartzite. Characteristically it sometimes consists of a conglomerate of pebbles, mostly quartz and quartzite. This formation is more than 4,000 feet thick at the Hundskop Mountains. It also forms the Landskrone ridge in the study area.

(b) The Otavi Series : The lower dolomite stage : The lowest members of this stage consist mainly of dolomite and dark blue-black magnesiac limestone. At places they appear interbedded with shale, sandstone and quartzite. Upper dolomite stage : The basal portion is composed of tillite which may include some iron ore. This is followed by limestone and occasionally by dolomite breccia. A thick sequence of light-grey, well-bedded dolomite closes this stratographic succession. (Mainly after Martin, 1964).

5.3 Soils.

Recent deposits cover most of the abovementioned geological formations, especially on the plateau and valley floors. Only on the slopes of the escarpment and on the hills is the vegetation influenced by the older geological formations. Different climates procure different types of soils having characteristic chemical and

<u>TABLE</u> : 6

THE GEOLOGICAL FORMATIONS IN THE STUDY AREA,
AT OTJOVASANDU, SOUTH WEST AFRICA.

Sand, Gravel, Calcrete, Soils etc.			Kalahari beds.	Recent Tertiary
Dolomite shale. Limestone Tillite	Upper dolomite	Otavi series	Damarasystem.	Late Pre- cambrain
Dolomite, Limestone Shale, graywacke	Lower dolomite			
Quartzite Shale Conglomerate		Nosib series		
Shale, limestone Quartzite, Acid volcanics			Khoabendus for- mation and Kaross volcanics	Pre-cambrian
Granite, granodiorite Gneiss.			Archaen System Basement.	

physical properties. Arid climate such as in the study area, can therefore produce only desert or semi-desert types of soil and corresponding vegetations.

The soils tend to be shallow, alkaline, high in water soluble salts, poor in phosphates and nitrogen content (See appendix 5).

5.3.1 Kalahari-like red sand.

The Etosha basin forms part of the greater Kalahari Basin (Wellington, 1955). The Kalahari-like sand may have been windblown or redeposited through water action in the present localities. The greatest part of the study area is covered by this redeposited material. The sand is usually reddish and fine-grained. In some localities the colour of the sand is changed to grey or lighter by the influence of vegetation and/or bleaching. According to du Toit (1954) the Kalahari sand consists chiefly of quartz fragments together with feldspar, chalcendony and chert. Heavy minerals include ilmenite and magnetite.

The natural vegetation is formed by a tree and shrub savanna. The average depth of the sand (2 profile pits) is two feet overlying sheet calcrete. The sand is usually alkaline (See fig.3). On the eastern side of the study area some dunes are formed. These are usually covered by *Terminalia prunioides* trees and riddled with animal burrows - especially mice.

Characteristically large numbers of termite mounds (with the resulting antbear holes) are scattered throughout the Kalahari-like sand. In the study area some of these termite mounds are of a greyish, clayey soil. This indicates that the sand is a more recent deposit on an older and deeper layer of soil.

5.3.2 Granitic coarse red sand.

This sand occurs along the western edge of the plateau. It is formed on granite parent material. The grains are coarser than those of the Kalahari-like sand. Limestone occurs in a few isolated patches. The soil is usually acid, getting more so the deeper one goes (See fig. 4). The sand layer on top of the granite is never more than about two feet thick - this explains the absence of termite mounds and animal burrows. The natural vegetative cover is formed by combretums and mopanes with the dominant grass being Stipagrostis uniplumis.

5.3.3 Surface limestone and calcrete rubble.

Surface limestone covers large areas on the plateau especially where underlain by dolomite. This surface limestone is formed in the following manner : rainwater percolates downward and dissolves underlying limestone; this solution then rises by capillary action to the surface and while drying deposits as sheets of calcrete on the surface or just underneath. In fig. 5 calcrete nodules may be seen in the overlying soil layer. In some areas the sheet calcrete has been broken by root action forming loose calcrete rubble. This may form ridges giving the terrain an undulating appearance. The vegetation on these calcrete ridges is usually dominated by Catophractes alexandri and to a lesser extent by A. nebrownii and Sesamothamnus querichii.

5.3.4 Alluvial soils.

The alluvial soils occur in the broad valleys where the seasonal streams open out. The soils are

FIG.3. PROFILE PIT (No.1) IN KALAHARI LIKE SAND.

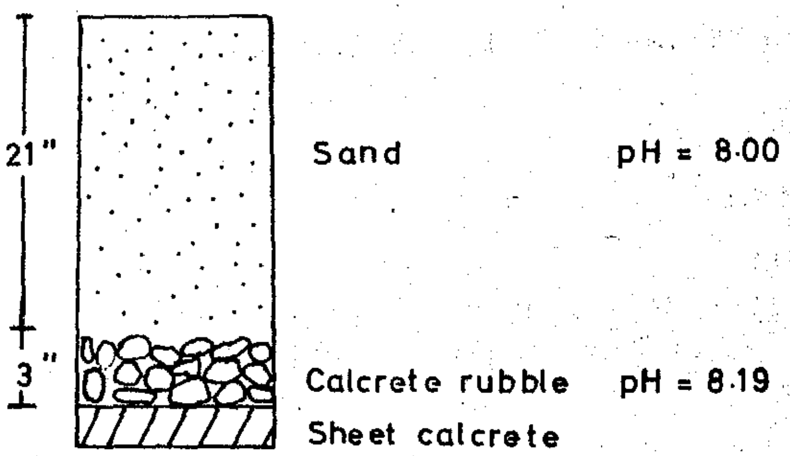


FIG.4 PROFILE PIT (No.3) IN GRANITIC SAND.

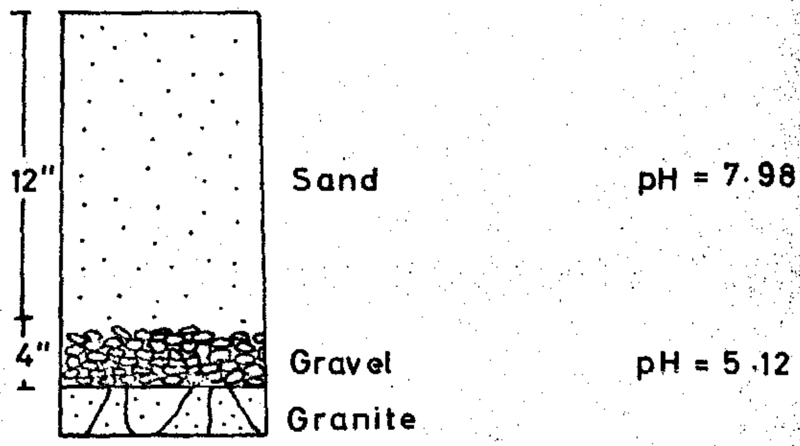
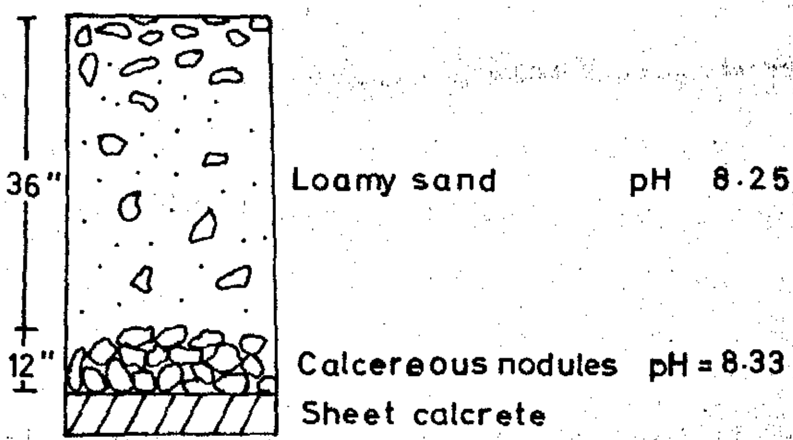


FIG.5 PROFILE PIT (No.7) IN SURFACE LIMESTONE



fairly deep loam, sandy clay loam to sandy loam, dark grey to brown depending on the degree of humus impregnation. The sub-soil often contains calcareous nodules passing into beds of limestone. Out of three profile pits dug, calcrete sheets were found in one at 54 inches (See fig. 6) In profile pit no.10 a layer of quartzite gravel was found at 34" inches. The soils are alkaline (See fig. 6).

The soils have a low permeability. The surface often becomes quite loose when dry, especially with trampling. With heavy traffic the powdery dust is sometimes up to 18 inches deep. These soils will be sensitive to trampling as a result of overgrazing, etc. Because of the depth of the soils the best tree growth in the study is found here. Tree mopane,

Acacia tortilis, Acacia giraffae
Acacia hebeclada

occur.

5.3.5. Sceletal soils.

These soils are usually found on the ridges of exposed escarpment areas and are formed by weathered parent material. It is seldom more than a few inches deep. (See fig. 7) Vegetation however finds adequate roothold in the crevices of the much-weathered surface rock from which there is comparatively little run-off. The vegetative cover is usually a Commiphera-Sterculia association. On the less pronounced slopes, with a deeper soil layer, a Colophospermum mopane, Acacia reficiens and a Terminalia prunioides association with a karroid shrub layer occur.

5.3.6 Claylike soils in the depressions.

These depressions are found in scattered

FIG. 6 PROFILE PIT (No. 8) IN ALLUVIAL SOIL.

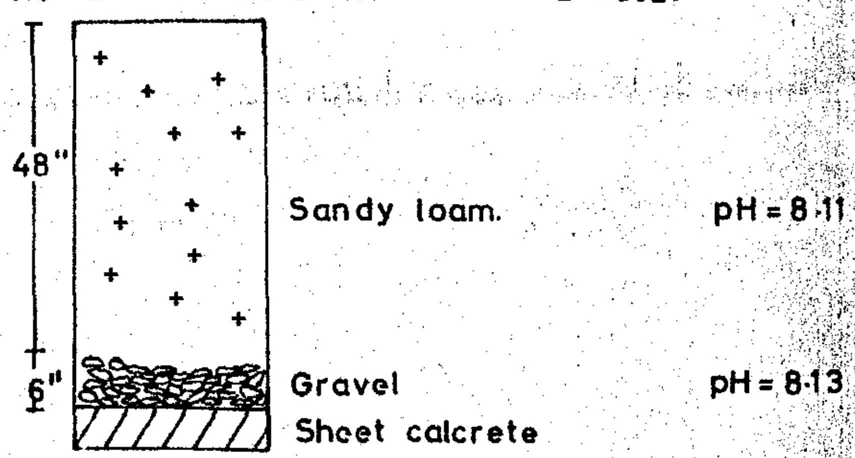


FIG. 7 PROFILE PIT (No.11) IN SKELETAL SOIL.

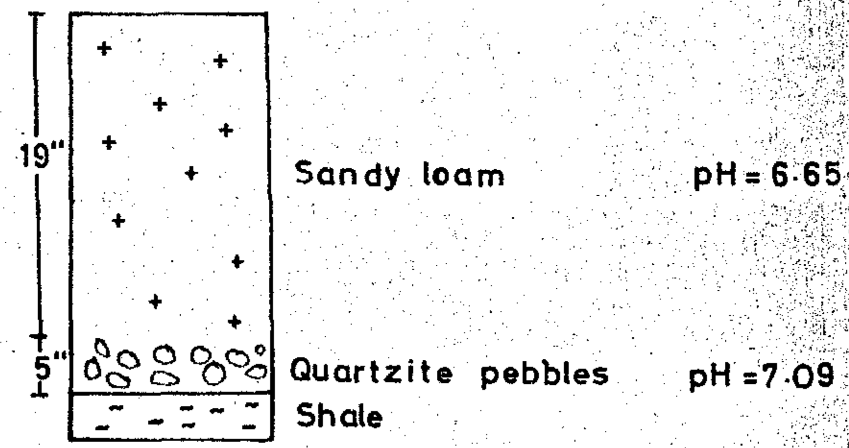
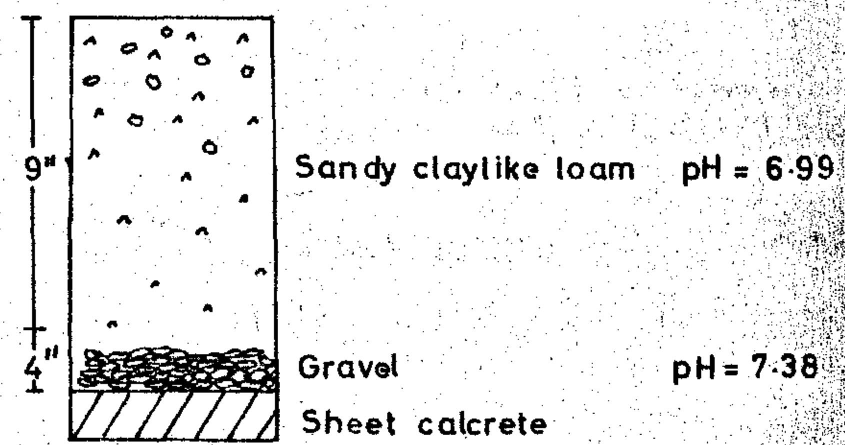
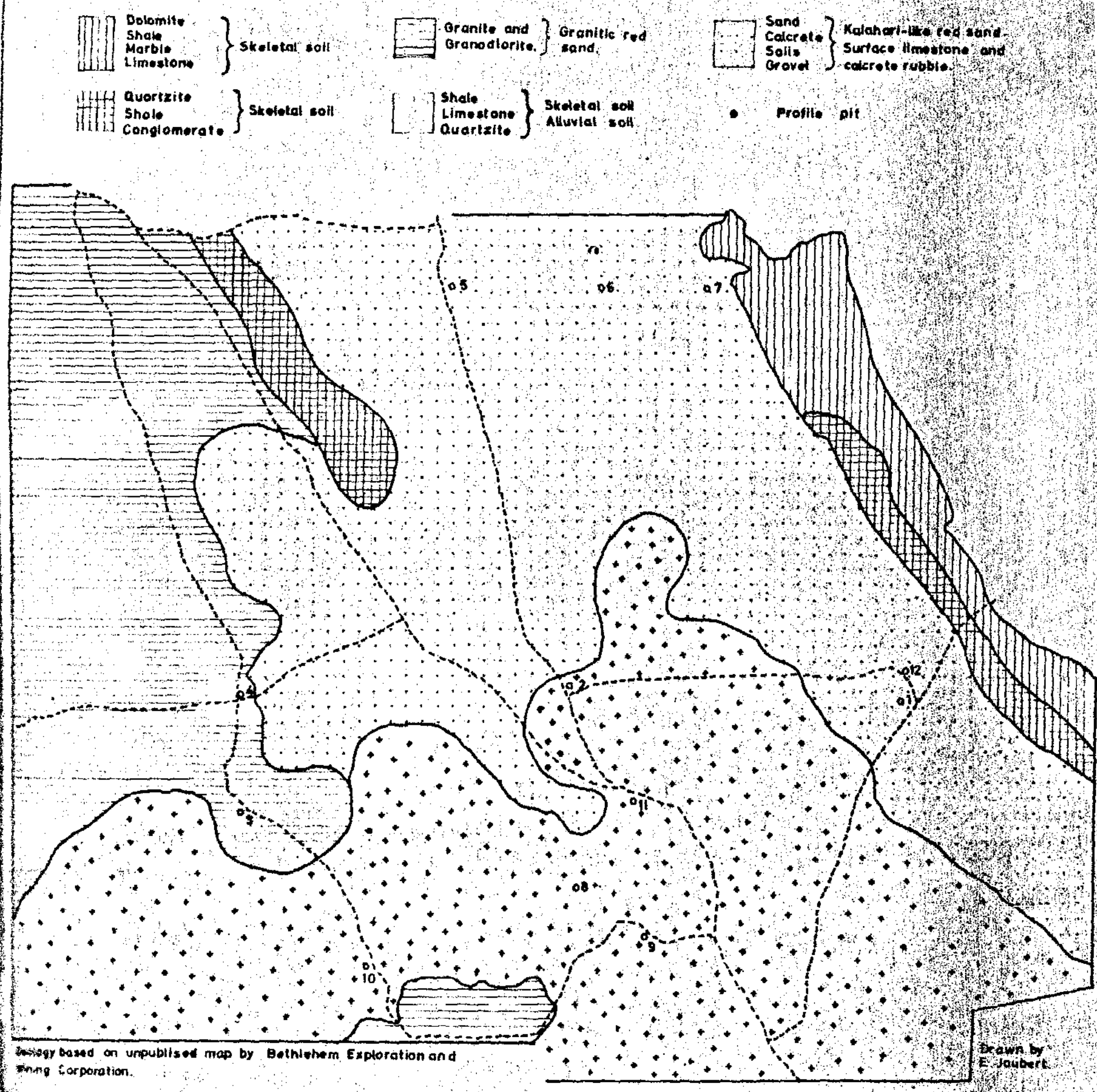


FIG. 8 PROFILE PIT (No.12) IN CLAYLIKE SOIL.



GENERALISED GEOLOGY AND SOIL TYPES IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA



localities on the plateau but are more notable along the eastern side. The soil is usually only about five to fifteen inches deep over sheet calcrete. Nodular calcrete, up to twelve inches in diameter, is often found on the surface of these little pans. The soil is alkaline and dark grey in colour (See fig. 8).

The surface is fine-grained and baked hard when dry. In the more frequented pans the mud is trampled while drying and hardened in this way. In some of the larger pans the surface has a table-top appearance covered with *Sporobulus* and *Enneapogon* grasses. The trees consist of *Combretum imberbe*, *Ziziphus mucronata* and on the edges, tall mopanes.

5.4 Vegetation.

Stocker (1964) suggested that the term savanna should not only be limited to a park landscape with grassland and single trees, but instead, it should be used collectively for forest-, parkland - and grassland vegetation of tropical climates with pronounced dry periods, because these vegetational types are generally conditioned by edaphic factors. Stocker distinguished between moist savanna; dry savanna - with grass and slender trees; and thorny savanna - with low grass and thorny succulent small trees and bushes.

The Kaokoveld lies within the 0-300 mm. isohyets. This arid climate therefore produces, as already mentioned, only desert or semi-desert types of soil and corresponding vegetation. The vegetation of the Kaokoveld can be divided into two main components :

Arid savanna and
Desert and sub-desert.

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The study area falls within the arid savanna, larger and more important of the two components. According to the presence and distribution of the plants in the study area, two of the five physiographic components of a savanna that were recognized by Hopkins, occur within the study area viz. :

tree savanna.
shrub savanna.

In the study area it was found that the latter two occur in a combined form in some localities. They both however, also occur in the study area as pure physiographic units. It was possible to sub-divide the physiographic components of the study area vegetation into several smaller communities.

5.4.1 Tree savanna on sand.

5.4.1.1 *Colophospermum mopane* tree savanna on granitic sand.

5.4.2 Tree and shrub savanna on Kalahari-like sand, granitic sand and alkaline soils.

5.4.2.1 *Colophospermum mopane* - *Acacia reficiens* - *Terminalia prunioides* association.

5.4.2.2 *Colophospermum mopane* - *Terminalia prunioides* *Combretum apiculatum* association.

5.4.2.3 *Combretum apiculatum* - *Colophospermum mopane* association.

5.4.3 Shrub savanna on calcrete rubble and alkaline soils.

5.4.3.1 *Colophospermum mopane* - *Catophractus alexandri* shrub savanna.

5.4.3.2 *Catophractus alexandri* - *Acacia nebrownii* association.

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5.4.3.3 <u>Sesamothamnus guerichii</u> association.

5.4.4 Valley community on alluvial soils.

5.4.5 <u>Commiphora</u> - <u>Sterculia</u> association on rocky outcrops.

The terms used are modified after Hopkins (1965) and Tinley (1966). Tree savanna :- Stands of trees not forming a dense canopy, the crowns being spaced from touching, in aggregations, to more than twice their own crown diameter apart. The ground layer is formed dominantly by grass with shrub in scattered localities. Tree and shrub savanna :- Trees are scattered, with shrub and grasses forming the dominant vegetative cover. Shrub savanna :- When trees are absent and herbs and grasses form, apart from shrub, important components of the vegetative cover.

5.4.1 <u>Tree savanna on sand.</u>

5.4.1.1 <u>Colophospermum mopane tree savanna on granitic sand.</u>

Only a small fraction of the study area is covered by a true tree savanna. This is in the western section of the study area on secondary deposited granitic sand on valley alluvial soils. The tree canopy is formed mainly by <u>Colophospermum mopane</u> trees, with a relative density of 58 per cent. Although some of the mopane trees reach heights of up to 30 feet, the average height is 19 feet.

Although mopane is deciduous, it never loses all its leaves completely except after heavy frost. New leaves are usually formed from about August during the spring flush. They flower from about February to March. In the study area mopane trees are sometimes defoliated

TABLE : 7

SPECIES COMPOSITION AND DIFFERENTIATION OF THE TREE LAYER IN THE *COLOPHOSPERMUM MOPANE* TREE SAVANNA.

Species.	Average distance from point (feet).	Average height of trees (feet).	Average diameter of crown (feet).	Average circumference of trunks (inches).
Colophospermum mopane	33.4	19.0	12.8	27.4
Combretum apiculatum	19.7	12.1	9.7	27.6
Boscia albitrunca	45.5	19.0	9.0	24.5
Terminalia prunioides	28.5	20.0	21.0	32.0

TABLE : 7 continued.

Species.	No. of points of occurance.	No. of trees.	Total basal area (square inches).	Relative frequency (F) %	Relative density (D) %	Relative dominance (Do) %	Importance value (F+D+O).
Colophospermum mopane	21	58	5048.32	52.5	58.0	62.3	172.8
Combretum apiculatum	10	20	1676.40	25.0	20.0	20.6	65.5
Boscia albitrunca	5	12	573.48	12.5	12.0	7.1	31.6
Terminalia prunioides	4	10	813.00	10.0	10.0	10.0	30.0
Total	40	100	8111.20	100.0	100.0	100.0	300.0

Average distance : 31.6 feet
Trees per acre : 42.7
Average basal area per tree : 81.11 sq. inch.
Basal area per acre : 2563 sq. inch.

in patches by the mopane "worm" - Gonimbrasia belina and to a lesser extent, the thorn tree emperor moth G. maja. This defoliation usually occurs in patches during the summer months (January - February). The defoliated mopane trees then usually have a second leaf growth soon after, from March to May.

The mopane "worm" is protein rich and is gathered by the Ovambos as a delicacy. The inhabitants of the Kaokoveld, apart from the small hunter gatherer TjimbaTjimba group (D. Grobbelaar pers. com. 1968), however do not eat the caterpillars. A zebra (Equus burchelli) was once observed in the study area picking the caterpillars from shrub mopane and apparently eating them. Centipedes also feed to a large extent on these caterpillars.

Another component of the tree canopy is Combretum apiculatum. This is the only locality in the area where they have a tree growth form with an average height of 12 feet. An occasional tall Boscia albitrunca and Terminalia prunioides also contributes to the tree canopy.

On the average the variety of shrub in this vegetation type is poor (See table 8), the most prominent being shrub mopane. In the ecotones of this tree savanna, and in localities where the tree canopy has been destroyed by elephant, one finds an encroachment by shrub savanna elements; apart from shrub mopane also Combretum apiculatum and Catophractes alexandri. Other shrubs which occur throughout this community are :-

Monechma genistifolium	Montinia caryophyllacea
Croton subgratissimus	Rhigozum brevispinosum
Commiphora pyracanthoides	

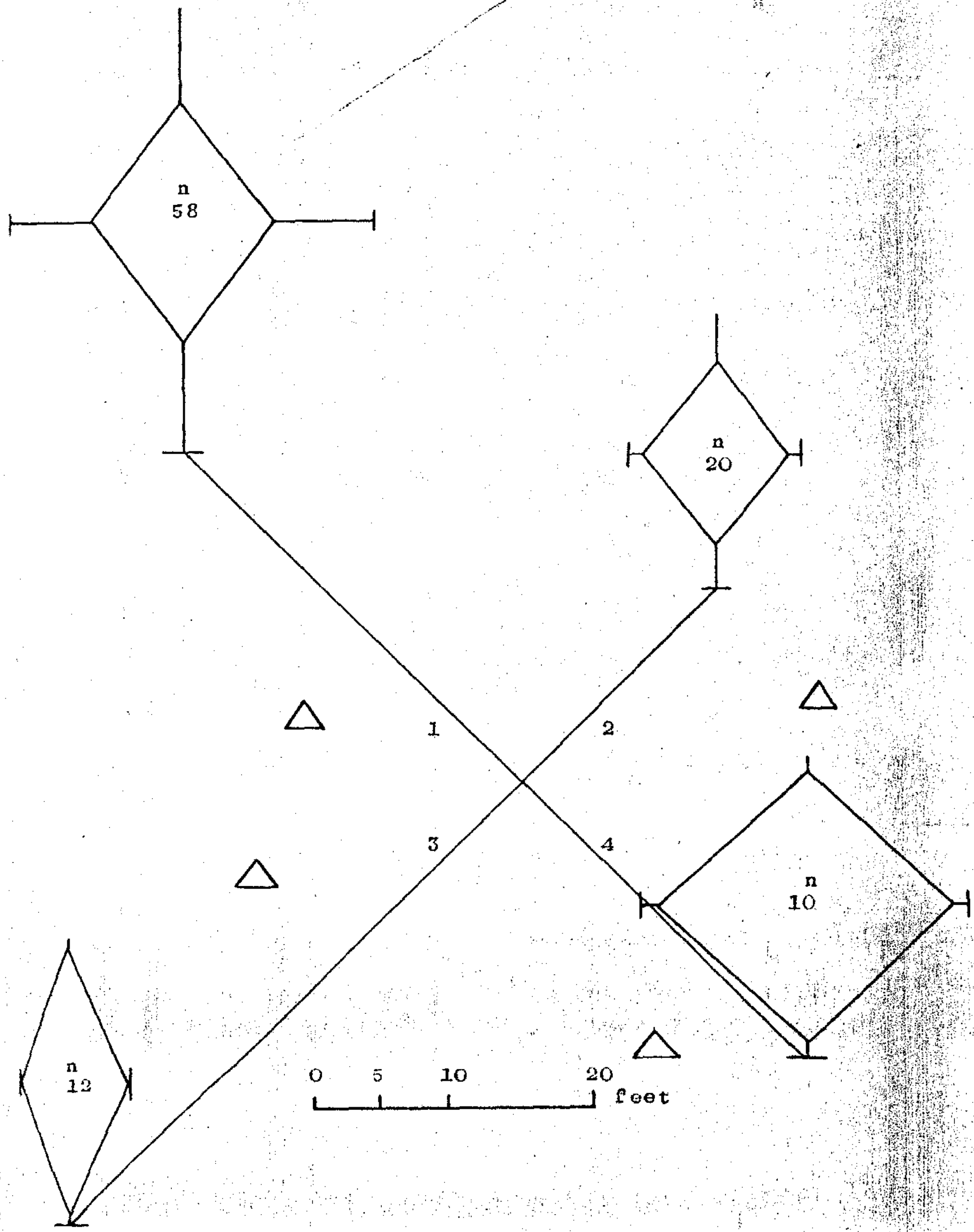
TABLE : 8

SPECIES COMPOSITION OF THE MORE COMMON SHRUBS
IN THE COLOPHOSPERMUM MOPANE TREE SAVANNA.

Species.	Average distance from point (feet).	No of points of occurrance.	No of plants.	Relative frequency %	Relative density %.
Colophospermum mopane	11.7	23	45	34.4	45
Combretum apiculatum	21.6	11	11	16.4	11
Monechma genistifolium	20.0	7	9	10.4	9
Montinia caryophyllacea	20.0	6	9	8.9	9
Catophractes alexandri	17.0	6	8	8.9	8
Commiphora pyracanthoides	18.0	5	6	7.4	6
Croton subgratissimus	6.0	4	5	5.9	5
Rhigozum brevispinosum	21.3	3	4	4.4	4
Pechuel-loeschea reubnitziae	14.0	2	3	2.9	3

FIGURE : 9

MEAN AND MAXIMUM HEIGHT AND WIDTH OF CROWN AND MEAN DISTANCE FROM THE POINT FOR THE FOUR DOMINANT TREE SPECIES IN THE COLOPHOSPERMUM MOPANE TREE SAVANNA.



Tree species.	Shrub species.
Colophospermum mopane.	Colophospermum mopane.
Combretum apiculatum.	Combretum apiculatum.
Boscia albitrunca.	Monechma genistifolium.
Terminalia prunioides.	Montinia caryophyllacea.

In the sandy washes Pechuel-Loeschea leubnitziae forms dense stands.

The grass cover is dominantly formed by:
Stipagrostis uniplumis, Aristida meridionalis
Schmidtia kalahariensis

5.4.2 Tree and shrub (thorn scrub) savanna on Kalahari-like sand, granitic sand, and alkaline soils.

This physiographic component forms one of the major vegetative cover types found in the Kaokoveld between the 100 mm and 300 mm isohyets. It also carries the richest mammal and bird life of the region.

5.4.2.1 Colophospermum mopane, Acacia reficiens and Terminalia prunioides association.

This vegetation type covers a large portion of the study area along the escarpment on to the edge of the plateau. It also covers the hills on the plateau in the study area. Throughout the rest of the Kaokoveld and the Etosha National Park to the west of Otjovasandu it contributes a major portion of the vegetative cover. It is also the most preferred vegetative cover for black rhinoceros, mainly due to the great of variety of food-plants and protection offered.

This vegetation type may also be called the tall shrub savanna, especially in areas where the soil deepens. This community can be divided into three strata, viz. a tree canopy, a shrub layer, and a ground layer.

The tree canopy is formed by tall, usually single boled mopanes, especially on the edges of little depressions or omurambas where rainwater collects during the rainy season. Boscia albitrunca, Maerua schinzii and an occasional *Combretum imberbe* and *Ziziphus mucronata* also contribute to the canopy. This stratum is between fifteen to twenty five feet high. In areas where the soil is not very deep viz. the hills in the escarpment zone, this stratum is sometimes absent.

The second stratum is formed by a great variety of shrub. These shrubs are usually multistemmed and between six to fifteen feet high. The dominant components of this second stratum are *Colophospermum mopane*, *Acacia reficiens* and *Terminalia prunioides*, from which this community's name is derived. *A. reficiens* is a shrub and is sometimes parasitized by *Loranthus elegantisimus*.

Some other shrubs which also occur are :

Acacia mellifera ssp. *detinens*	*A. nilotica*
A. erubescens	*A. senegal* var. *rostrata*
Cordia gharaf	*Albizzia anthelmintica*
Dichrostachys glomerata	*Croton subgratissimus*
Croton gratissimus	*Adenolobus garipensis*

Combretum apiculatum also form a part of this stratum in some areas of the study area, especially in the ecotones to the west but are very seldom present in large numbers. On the rocky hills in the western portion *Acacia ataxacantha* is sometimes found. At a few waterholes *Combretum wattii* is also present in small numbers. *Sesamothamnus guerichii* and *Catophractes alexandri* is represented by a few individuals only.

The ground layer is formed by a great variety of shrubs, herbs and grasses, especially in areas where the tall shrub layer opens out on the plateau. The more important shrubs are represented by :

Grewia bicolor	*Grewia villosa*
Grewia tenax	*Grewia flavescens*

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Mundulea sericea — Boscia foetida
Maerua parvifolia — Montinia caryophyllacea
Amphiasma merenskyanum — Gossypium triphyllum
Otoptera burchellii — Lycium boscifolium
Barleria senensis — Justica odora
Helinus integrifolius — Veronia cineracens
Asparagus denudatus — Lantana dinteri
Triaspis nelsonii var. austro-occidentalis.

Young plants of Acacia species and Terminalia prunioides occur in large humbers. In areas where the ground is more alkaline Catophractes alexandri and karroid shrub occur, represented by the following species:

Monechma genistifolium — Petalidium engleranum
Leucosphaera bainesii — Leucas pechuelii

M. genistifolium seems to have a large range throughout the study area.

Herbs are also woll represented in this community, the more common being :

Blepharis obmitratra — Aptosimum angustifolium
Plectranthus hereroensis — Geigeria spp.
Dicoma tomentosa — Cleome diandra
Tribulus terrestris — Cleome suffruticosa
Barteria lanceolate — Petalidium coccineum
Hibiscus caesius — Hibiscus micranthus

The grasses that occur are mainly :

Stipagrostis hirtigluma — Stipagrostis uniplumis
Aristida rhiniochloa — Heteropogon contortus

onto the hills Anthephora schinzii

Triraphis ramosissima — Tragus racemosus

Rhynchelytrum ssp. into the omurambas Bothriochloa radicans and Urochloa brachuyura. Other shrubs and herbs common in omurambas are Lycium trothae

TABLE : 9

SPECIES COMPOSITION AND DIFFERENTIATION OF THE TALL SHRUB LAYER IN THE *COLOPHOSPERMUM MOPANE*, *ACACIA REFICIENS* AND *TERMINALIA PRUNIOIDES* ASSOCIATION.

Species.	Average distance from point (feet).	Average height of trees (feet).	Average diameter of crown (feet).	Average circumference of trunks (inches).
Acacia reficiens	30.1	8.5	13.6	44.7
Colophospermum mopane	19.7	8.0	8.9	16.5
Terminalia prunioides	28.3	14.2	15.3	37.0
Acacia mellifera spp. detinens	19.4	9.8	12.6	32.2
Boscia foetida	36.7	7.2	6.2	27.0
Combretum apiculatum	18.0	9.0	9.0	12.0
Boscia albitrunca	12.0	16.2	16.0	27.1
Croton species	9.0	8.1	3.2	12.0
Sesamothamnus guerichii	21.0	9.0	4.0	22.1

TABLE : 9 continued.

Species.	No. of points of occurance.	No. of trees.	Total basal area (square inches).	Relative frequency (F) %.	Relative density (D) %.	Relative dominance (Do) %	Importance value (F+D+O).
Acacia reficiens	20	29	6094.06	27.7	29	51.99	108.69
Colophospermum mopane	16	27	1035.72	22.2	27	8.38	58.03
Terminalia prunioides	16	23	2975.74	22.2	23	25.36	70.56
Acacia mellifera spp. detinens	8	9	996.03	11.1	9	8.49	28.59
Boscia foetida	5	5	424.95	6.9	5	3.62	15.52
Combretum apiculatum	2	2	116.02	2.7	2	.96	4.79
Boscia albitrunca	2	2	26.02	2.7	2	.02	4.72
Croton species	2	2	22.92	2.7	2	.01	4.71
Sesamothamnus guerichii	1	1	38.51	1.3	1	.03	2.33
Total	72	100	11729.97	99.5	100	98.31	297.94

Average distance : 21.5 feet
Trees per acre : 94.23
Average basal area per tree : 117.29 sq. inches.
Basal area per acre : 11020 sq. inches.

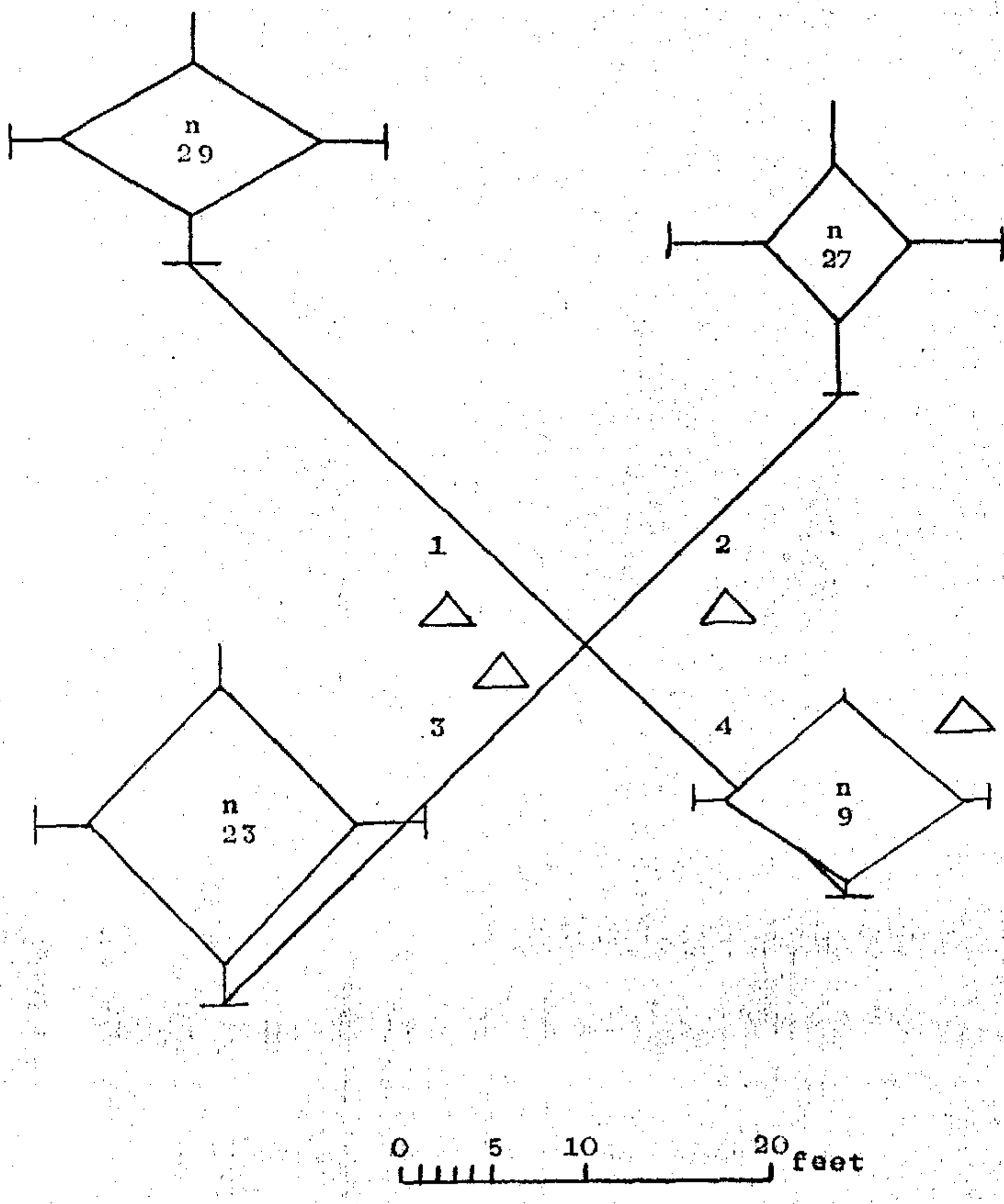
TABLE : 10.

SPECIES COMPOSITION OF THE MORE COMMON SHRUBS IN THE COLOPHOSPERMUM MOPANE, ACACIA REFICIENS, TERMINALIA PRUNIOIDES ASSOCIATION.

Species.	Average distance from point (feet).	No. of points of occurance.	No. of plants.	Relative frequency %.	Relative density %.
Petalidium englerianum	7.4	13	21	16.9	21
Colophospermum mopane	8.3	12	16	15.5	16
Monechma genistifolium	4.0	6	11	7.8	11
Grewia species	20.5	7	8	9.1	8
Croton species	11.6	5	6	6.5	6
Boscia foetida	7.2	5	6	6.5	6
Acacia reficiens	7.0	4	5	5.1	5
Terminalia prunioides	12.0	4	4	5.1	4
Dichrostachys glomerata	6.0	3	3	3.9	3
Montinia caryophyllacea	4.0	3	3	3.9	3
Catophractes alexandri	21.5	2	3	2.6	3
Acacia ataxacantha	42.0	3	3	3.9	3
Gossypum triphyllum	12.0	2	3	2.6	3
Acacia mellifera ssp. detinens	16.0	3	3	3.9	3
Combretum apiculatum	27.0	2	2	2.6	2
Acacia erubescens	6.0	2	2	2.6	2
Phyllogeiton discolor	9.0	1	1	1.3	1

FIGURE : 10

MEAN AND MAXIMUM HEIGHT AND WIDTH OF CROWN AND MEAN DISTANCE FROM THE POINT FOR THE FOUR DOMINANT TREE SPECIES IN THE <u>COLOPHOSPERMUM MOPANE</u>, <u>ACACIA REFICIENS</u>, AND <u>TERMINALIA PRUNIOIDES</u> ASSOCIATION.



Tree species.

Acacia reficiens.
Colophospermum mopane.
Terminalia prunioides.
Acacia mellifera species detinens

Shrub species.

Petalidium englerianum.
Colophospermum mopane.
Monechma genistifolium.
Grewia species.

Petalidium coccineum the cyperaceae eg. C. fulgens; Justicia platysepala and the creepers Rhynchosia ssp. and Ipomoea arachnosperma.

5.4.2.2 The Colophospermum mopane, Terminalia prunioides and Combretum apiculatum association.

This association is found on the coarse granitic sand and in the western part of the study area. The vegetation composition is very much the same as the former community. It mainly differs in that Combretum apiculatum replaces Acacia reficiens which is completely absent from this community. The former, together with Terminalia prunioides are the dominant species.

Two other species quite common in this community, but which only seldom occur in the former are Commiphora pyracanthoides, which is also present in a large number of seedlings and Sesamothamnus guerichii. The latter usually occurs more to the eastern side of the community in the ecotone with the neighbouring community where the soil is more alkaline.

The Colophospermum mopane are usually present in the form of trees between fifteen to twenty five feet high. The Terminalia prunioides is also usually taller than in the former community and may reach heights of twenty feet. Combretum apiculatum never reaches heights of more than ten feet but forms a dense growth in patches. Catophractes alexandri occur in scattered localities throughout the community. Boscia albitrunca occurs but B. foetida is absent.

The variety and number of shrubs in this association is noticeably less than in the previous plant association.

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Monechma genistifolium
Montinia caryophyllacea
Croton spp.
and young plants of
Terminalia prunioides
Mundulea sericea
Grewia spp.
Catophractes alexandri
Commiphora pyracanthoides
Combretum apiculatum
and shrub mopane constitute the sole members of this layer.

The more common herbs are :

Cleome diandra
Heliotropium giessii
Barleria lanceolata
Helichrysum tomentosulum
Hibiscus micranthus
Justicia platysepala
Cleome elegantisima
Heliotropium ovalifolium
Nelsia quadrangula
Veronia poskeana
Neorautaneria amboensis
Lantana dinteri
Triapis nelsonii var. austro-occidentalis

A wide variety of grasses occur, the following which are the more conspicious :

Anthephora schinzii
Stipagrostis uniplumis
Rhynchelytrum villosum
Aristida meridionalis
Pogonarthria fleckii
Aristida rhiniochloa
Schmidtia kalahariensis and some Enneapogon species

5.4.2.3 Combretum apiculatum - Colophospermum mopane association.

This association occurs along the eastern side of the Landskrone ridge and south of the Sesfontein road. The sand is about two to three feet deep and the surface is nearly always loose - hampering movement. In some localities it may be more compact with pebbles and stone, usually metaquartzite, lying on the surface. This area is riddled with antbear holes.

TABLE : 11.

THE SPECIES COMPOSITION AND DIFFERENTIATION OF THE TREE LAYER IN THE COLOPHOSPERMUM MOPANE, TERMINALIA PRUNIOIDES, COMBRETUM APICULATUM ASSOCIATION.

Species.	Average distance from point (feet).	Average height of trees (feet).	Average diameter of crown (feet).	Average circumference of trunks (inches).
Combretum apiculatum	20.1	9.7	8.1	25.2
Terminalia prunioides	18.1	13.5	12.9	38.6
Colophospermum mopane	21.3	13.6	11.5	27.6
Sesamothamnus guerichii	31.5	14.3	11.1	107.6
Commiphora pyracanthoides	21.3	14.3	7.6	22.3
Boscia albitrunca	36.0	15.0	5.0	21.0

TABLE : 11 continued.

Species.	No. of points of accurrance.	No. of trees.	Total basal area (square inches).	Relative frequency (F) %	Relative density (D) %.	Relative dominance (Do) %	Importance value (F+D+O).
Combretum apiculatum	19	37	2311.39	30.1	37	17.9	85.0
Terminalia prunioides	19	31	4361.51	30.1	31	33.9	95.0
Colophospermum mopane	15	21	1193.15	23.8	21	9.2	54.0
Sesamothamnus guerichii	5	6	4872.95	7.9	6	37.8	51.7
Commiphora pyracanthoides	3	3	121.36	4.7	3	.9	8.6
Boscia albitrunca	2	2	18.16	3.2	2	.1	5.3
Total	63	100	12878.52	99.8	100	99.8	299.6

Average distance : 24.7 feet.
Trees per acre : 71.39
Average basal area per tree: 128.78 square inches.
Basal area per acre : 9064 square inches.

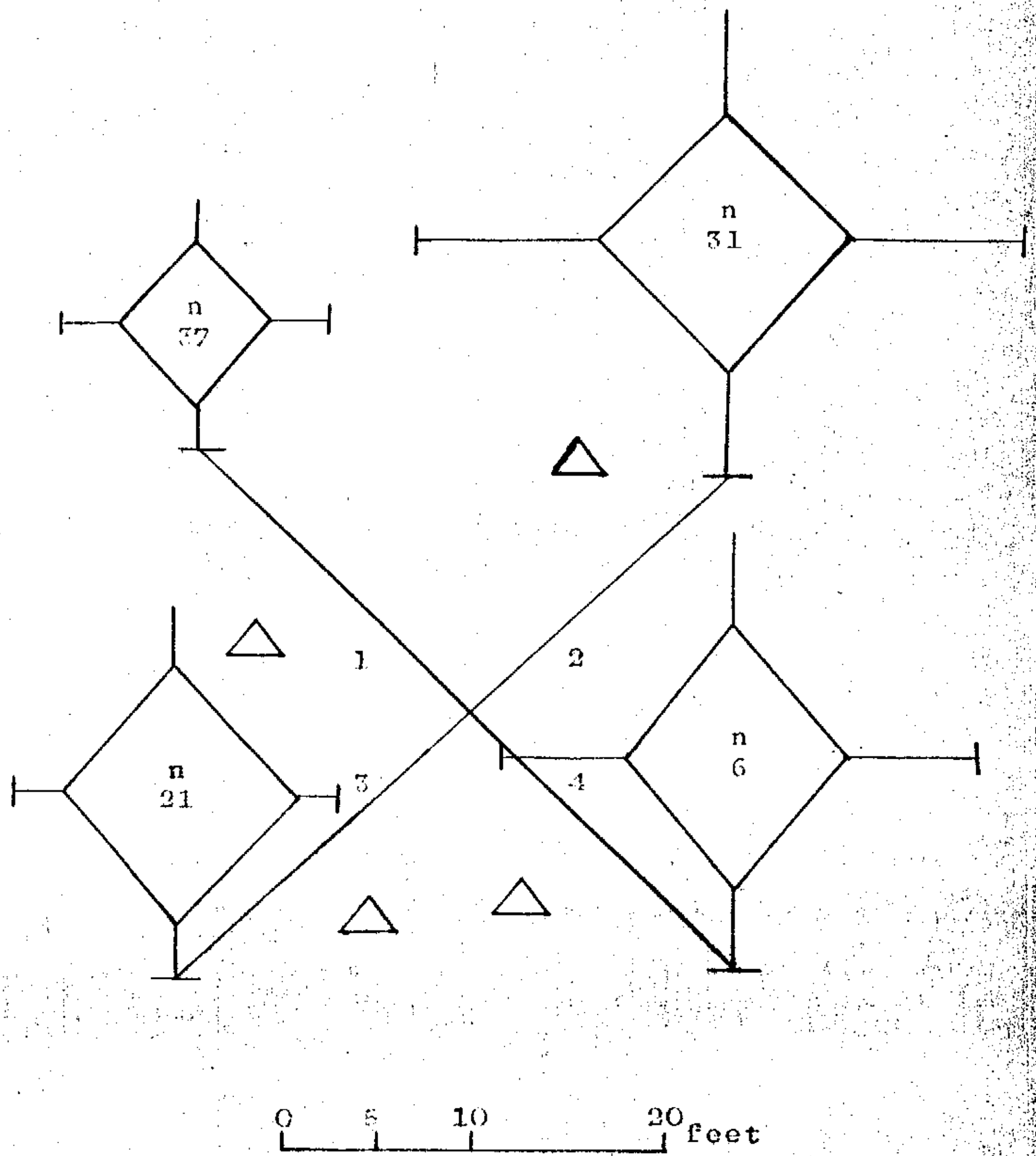
TABLE : 12.

THE SPECIES COMPOSITION OF THE MORE COMMON SHRUBS IN THE *COLOPHOSPERMUM MOPANE*, *TERMINALIA PRUNIOIDES* AND *COMBRETUM APICULATUM* ASSOCIATION.

Species.	Average distance from point (feet).	No. of points of occurrance.	No. of plants.	Relative frequence %.	Relative density %.
Combretum apiculatum	12.1	19	33	26.7	33
Colophospermum mopane	15.5	9	14	12.6	14
Commiphora pyracanthoides	12.4	11	13	15.4	13
Catophractes alexandri	9.8	8	9	11.2	9
Terminalia prunioides	9.8	6	9	8.4	9
Grewia species	18.1	7	9	9.8	9
Montinia caryophyllacea	12.1	6	7	8.4	7
Monechma genistifolium	17.0	2	2	2.8	2
Mundulea sericea	16.0	1	2	1.4	2
Acacia senegal	3.0	1	1	1.4	1
Croton species.	4.0	1	1	1.4	1

FIGURE : 11

MEAN AND MAXIMUM HEIGHT AND WIDTH OF CROWN AND MEAN DISTANCE FROM THE POINT FOR THE FOUR DOMINANT TREE SPECIES IN THE <u>COLOPHOSPERMUM MOPANE</u>, <u>TERMINALIA PRUNIOIDES</u>, <u>COMBRETUM APICULATUM</u> ASSOCIATION.



Tree species.	Shrub species.
Combretum apiculatum.	Combretum apiculatum.
Terminalia prunioides.	Colophospermum mopane.
Colophospermum mopane	Commiphora pyracanthoides.
Sesamothamnus guerichii	Catophractes alexandri

The vegetation consists of scattered mopane trees, fifteen to twenty-five feet high. These trees are seldom single boled, the usual number of trunks being two or three. Some of the trees show browsing damage by elephant. Boscia albitrunca occur thinly scattered throughout the area, forming trees up to twenty-five feet in height. Terminalia prunioides and Combretum imberbe mostly occur in the ecotones.

A dense growth of Combretum apiculatum forms a substorey six to fifteen feet high. C. apiculatum usually occurs in coppice-like stands with an average height of eight to nine feet. These stands are up to nine feet in diameter. Occasionally they will form a tree-like growth up to fifteen feet high. C. apiculatum is one of the first plants to defoliate with the onset of winter. Also in this layer, one finds shrub mopane, Catophractes alexandri in isolated patches but more abundant towards the ecotone, and Montinia caryophyllacea, being quite numerous in certain localities. Rhigozum brevispinosum is also found in small numbers.

Certain shrubs occur in the grass layer; of these Commiphora pyracanthoides is one of the most prominent. This plant is excessively excavated by elephant who eat the roots. Petalidium engleranum and Monechma genistifolium also have a wide distribution throughout this plant association.

Grewia bicolor G. tenax
Grewia flavescens Leucosphaera bainesii
occur in the ecotones.

Some herbs which occur are :

Harpagothytum procumbens Celosia linearis
Heliotropium giessii Nelsia quadrangula

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TABLE . 15.

THE SPECIES COMPOSITION AND DIFFERENTIATION OF THE TREE LAYER IN THE COMBRETUM APICULATUM COLOPHOSPERMUM MOPANE ASSOCIATION.

Species.	Average distance from point (feet).	Average height of trees (feet).	Average diameter of crown (feet).	Average circumference of trunks (inches).
Combretum apiculatum	22.1	8.2	7.5	15.8
Colophospermum mopane	29.2	13.0	10.7	24.6
Boscia albitrunca	25.6	17.0	11.8	27.8
Terminalia prunioides	39.0	15.0	15.0	24.0
Combretum imberbe	21.0	18.0	12.0	32.0

TABLE : 13 continued.

Species.	No. of points of occurrance.	No. of trees.	Total basal area (square inches).	Relative frequency (F) %	Relative density (D) %	Relative dominance (Do) %	Importance value (F+D+O).
Combretum apiculatum	25	68	1882.73	51.1	68.0	48.2	167.3
Colophospermum mopane	17	25	1544.66	34.7	25.0	39.3	99.0
Boscia albitrunca	55	5	348.31	10.2	5.0	8.9	24.1
Terminalia prunioides	1	1	45.84	2.0	1.0	1.2	4.2
Combretum imberbe	1	1	81.49	2.0	1.0	2.1	5.1
Total	99	100	3909.03	99.0	100.0	99.7	299.7

Average distance : 27.3 feet
Trees per acre : 58.44
Average basal area per tree : 39.03 square inches.
Basal area per acre : 9750 square inches.

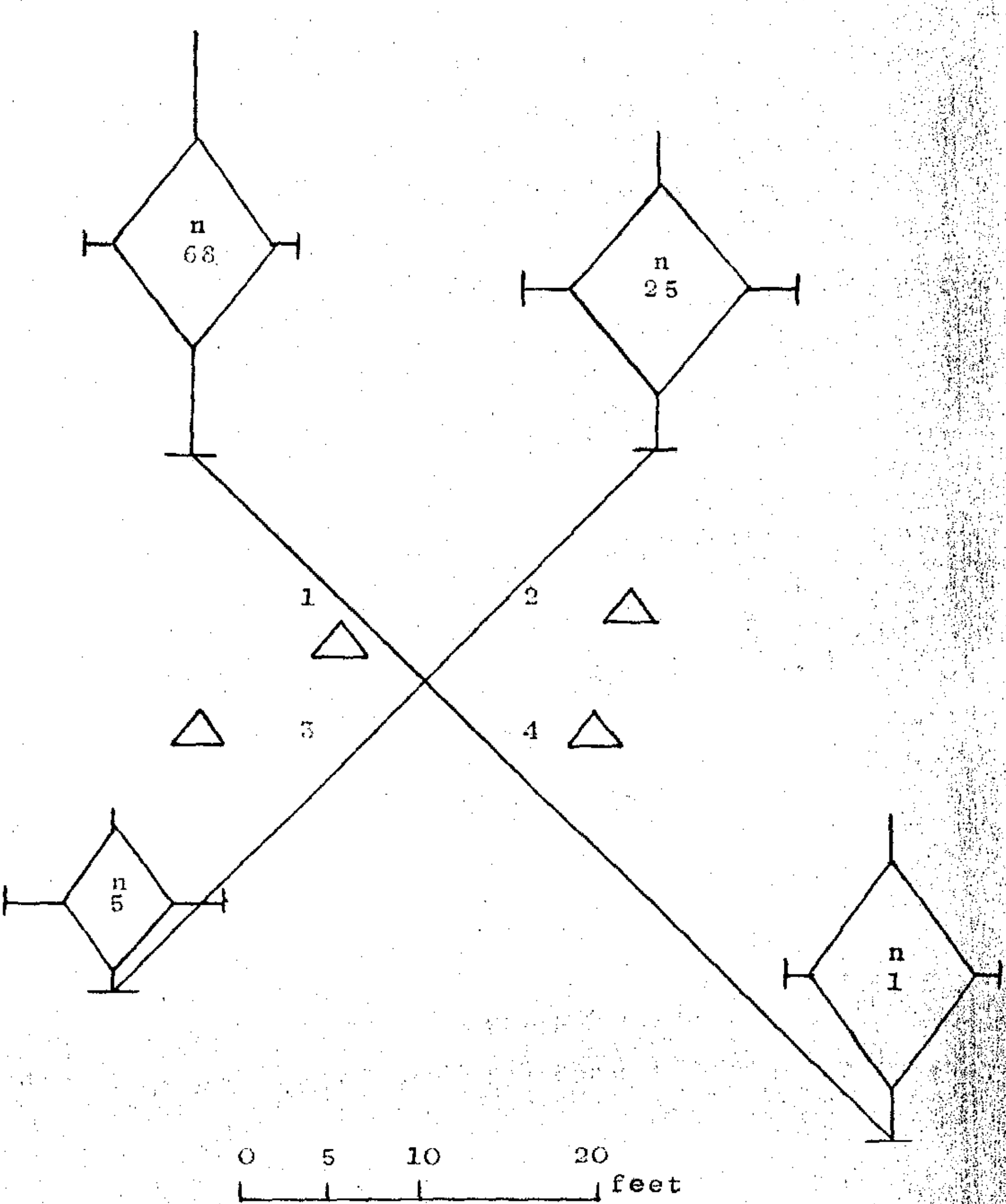
TABLE : 14

SPECIES COMPOSITION OF THE MORE COMMON SHRUBS IN THE *COMBRETUM APICULATUM, COLOPHOSPERMUM MOPANE,* ASSOCIATION.

	Average distance from point (feet)	No. of points of occurrance.	No. of plants.	Relative frequence %.	Relative density %.
Combretum apiculatum	11.6	15	29	23.1	29
Colophospermum mopane	8.0	17	26	26.1	26
Commiphora pyracanthoides	7.8	10	16	15.3	16
Monechma genistifolium	9.0	7	9	10.7	9
Petalidium engleranum	10.6	6	8	9.2	8
Catophractes alexandri	10.0	4	6	6.1	6
Montinia caryophyllacea	4.7	4	4	6.1	4
Grewia species	15.0	1	1	1.5	1
Leucosphaera bainesii	2.0	1	1	1.5	1

FIGURE : 12

MEAN AND MAXIMUM HEIGHT AND WIDTH OF CROWN AND MEAN DISTANCE FROM THE POINT FOR THE FOUR DOMINANT TREE SPECIES IN THE COMBRETUM APICULATUM, COLOPHOSPERMUM MOPANE ASSOCIATION.



Tree species.

Combretum apiculatum.
Colophospermum mopane.
Boscia albitrunca.
Terminalia prunioides.

Shrub species.

Combretum apiculatum.
Colophospermum mopane.
Commiphora pyracanthoides.
Monechma genistifolium.

5.4.3 Shrub savanna on calcrete rubble and alkaline soils.

5.4.3.1 Colophospermum mopane - Catophractes alexandri shrub savanna.

This vegetation type occurs mainly on the red kalahari-like sand which covers a large portion of the plateau in the study area. It occurs from the hills in the east to the Colophospermum mopane - Terminalia prunioides - Combretum apiculatum association in the west frequently along the omurambas. Tall trees form a very insignificant portion of this vegetation type. These trees are :

Colophospermum mopane
Boscia albitrunca
Terminalia prunioides
Combretum imberbe
Lonchocarpus nelsii

The shrub layer is formed mainly by shrub mopane and Catophractes alexandri. The shrub mopane occur in coppice stands up to nine feet in diameter and three to four feet high. This growth form is usually fire and/or frost induced. In localities where these shrubs find protection against fire viz. termite mounds, they grow into large trees. Other shrubs that occur are :

Commiphora pyracanthoides
Leucosphaera bainesii
Grewia villosa
Mundulea sericea
Lycium trothae
Elephanthiorrhiza suffruticosa
Gossypium triphyllum
Grewia tenax
Grewia bicolor
Monechma divaricata
Ptoptera burchellii

The most conspicious and dominant cover of this association, however, is formed by perennial grasses. They forms tufts, sometimes widely separated with a well defined erosion pavement. The most common perennial grass is *Anthephora pubescens*. Some other grasses are :

Eragrostis denudata	*Aristida effusa*
Schmidtia kalahariensis	*Stipagrostis uniplumis*
Heteropogon contortus	*Bothriochloa radicans*
Panicum coloratum	*Stipagrostis hochstettarana*
Enneapogon cenchriodes var. *secalina*	
Enneapogon brachystachys	*Eragrostis porosa*
Urochloa brachyura	*Eragrostis superba*
Tragus racemosus	*Rhyncolytrum villosum*

Pogonarthria fleckii and *Eragrostis annulata* form the main annual grass cover. Underneath the tall trees pure stands of *Cenchrus ciliaris* sometimes occur. *Triraphus fleckii* occur in dense stands in isolated localities.

Herbs do occur in a very large variety. The most common are :

Helichrysum tomentoculum	*Plectranthus hereroensis*
Hibiscus caesius	*Hibiscus calyphyllus*
Senecio marlothianus	*Abutilon franticosum*
Geigeria ornativa	*Geigeria acaulis*
Harpagophytum procumbens	*Solanum rautanenii*
Petalidium variable	

Climbers occur in relatively large numbers especially during the rainy season. They are :

Gloriosa superba	*Dolichos chrysanthes*
Neorautanenii amboensis	Rhynchosia ssp.

Mainly due to the rank grasses this association is poorly utilized by game.

5.4.3.2 *Catophractes alexandri* - *Acacia nebrownii* association.

On the plateau long ridges are formed by surface

TABLE 15

SPECIES COMPOSITION AND BASAL COVER OF THE GROUND LAYER IN THE *COLOPHOSPERMUM MOPANE*, *CATOPHRACTES ALEXANDRI* SHRUB SAVANNA.

Grasses.	Basal Strikes	% Rel. Frequency	% Cover.
Anthophora pubescens	109	22.0	5.4
Pogonarthria fleckii	52	12.5	2.6
Eragrostis annulata	49	9.9	2.4
Eragrostis denudata	33	6.7	1.6
Aristida effusa	32	6.5	1.6
Schmidtia kalahariensis	30	6.1	1.5
Stipagrostis uniplumis	23	4.6	1.15
Cenchrus ciliaris	23	4.6	1.15
Heteropogon contortis	17	3.4	.9
Stipagrostis hochstettiarana var. secalina	16	3.2	.8
Bothriochloa radicans	14	2.8	.7
Panicum coloratum	11	2.3	.6
Enneapogon cenchroides	7	1.4	.4
Enneapogon brachystachys	7	1.4	.4
Eragrostis porosa	6	1.2	.3
Urochloa brachyura	5	1.0	.25
Eragrostis superba	5	1.0	.25
Tragus racemosus	5	1.0	.25
Rhyncolytrum villosum	4	.8	.2
Tragus berteronianus	3	.6	.15
Setaria verticilliata	2	.4	.1
Aristida meridionalis	2	.4	.1
Eragrostis pallide-fuscia	1	.2	.05
Stipagrostis hirtigluma var. patwea	1	.2	.05
Sub Total	457	94.2	22.90

Basal strikes recorded 457
% grass cover 22.9%

TABLE : 15 continued.

Shrubs and Herbs	Basal Strikes	% Rel. Frequency	% Cover.
+Colophospermum mopane	35	7.1	1.8
+Catophractes alexandri	22	4.4	1.1
Leucosphaera bainesii	7	1.4	.4
Gossypium triphyllum	5	1.0	.25
Geigeria acaulis	5	1.0	.25
Mundulea sericea	4	.8	.2
Commiphora pyracanthoides	3	.6	.15
Grewia tenax	2	.4	.1
Grewia bicolor	2	.4	.1
Geigeria africana	2	.4	.1
Cyperus fulgens	2	.4	.1
Unidentified	2	.4	.1
Monechma genistifolium	1	.2	.05
Grewia villosa	1	.2	.05
Celosia linearis	1	.2	.05
Hirpicium gorterioides	1	.2	.05
Cleome diandra	1	.2	.05

basal strikes recorded	96	
++% basal cover	4.1%	1.00%
++Total basal strikes recorded	496	
++Total % basal cover	24.9	

+A strike were recorded every time the selected spoke touched the ground within a shrub mopane or Catophractes stand.

++C. mopane shrub and C. alexandri community excluded sheet and rubble calcrete. The vegetation on these ridges are usually short and early successional mainly due to poor humus and lime-rich soils. The dominant vegetation is formed by *Catophractes alexandri* and two-to three-stemmed *Acacia nebrownii* with a height of about 3 feet. The ground layer is formed by karroid shrub :

Monechma genistifolium	*Petalidium engleriamrum*
Leucosphaera bainesii	*Leucas pechuellii*

The grasses are short, mainly annual, *Anthophora schinzii* being the most common. These ridges with the short vegetative cover are sometimes utilized by springbok.

5.4.3.3 *Sesamothamnus guerichii* association.

This association occur in the northern section of the study area. It is not clearly definable as most of the members of the other associations occur here in an extremely mosaic pattern. The soil is very alkaline with calcrete rubble on the surface, in some areas hampering movement.

Sesamothamnus guerichii is not only the dominant element but also have a uniform distribution throughout the association. In some areas however, as around Otjikowares east of the Chopoho road, they occur in dense stands.

Mainly due to the shallow soil the tree growth in this area is usually stunted as shown in table 16. Large trees however also occur in certain areas, and especially along the fringes of the pans they are usually taller. Trees that occur are :

Terminalia prunioides	*Combretum apiculatum*
Colophospermum mopane	*Ziziphus mucronata*

Boscia foetida

Acacia nebrownii

The shrub layer is formed mainly by *Catophractes alexandri* and *Rhigozum brevispinosum*, which form pure stands in some localities, and also shrub mopane,

Grewia bicolor
Montinia caryophyllacea
Petalidium engleranum
Monechma genistifolium
Mundulea sericea
Maerua parvifolia

Herbs are well represented by :

Blepharis obmitrata
Hiernia angolensis
Helichrysum tomentosulum
Euphorbia glanduligera
Plinthus fructicosa
Melsia quadrangularis
Pseudogaltonia pechuelii
Melhania ssp.
Dichoma tomentosa
Lantana angolensis
Tribulus zeyheri

A creeper sometimes found in the shrub mopane and *Catophractes alexandri* is *Dolichos chrysanthes*.

Grasses are represented by :

Anthophora pubescens
Schmidtia kalahariensee
Urochloa brachyura
Stipagrostis hirtigluma
Pogonarthria fleckii
Stipagrostis uniplumis
Bothriochloa radicans

5.4.4 Valley community on alluvial soils.

The vegetation in this community shows the best growth, the trees usually being taller and the grass cover denser and higher than anywhere else in the study area.

The distribution of some trees are confined to this area. They are :

TABLE : 16.

THE SPECIES COMPOSITION AND DIFFERENTIATION OF THE TREE LAYER IN THE SESAMOTHAMNUS GUERICHII ASSOCIATION.

Species.	Average distance from point (feet).	Average height of trees (feet).	Average diameter of crown (feet).	Average circumference of trunks (inches).
Sesamothamnus guerichii	18.1	11.7	8.8	82.3
Terminalia prunioides	18.2	12.2	10.2	32.3
Combretum apiculatum	14.2	8.2	5.5	13.1
Colophospermum mopane	37.7	12.5	8.8	29.5
Boscia foetida	19.5	7.0	3.5	13.0
Acacia nebrownii	21.0	12.5	8.0	30.0

TABLE : 16 continued.

Species.	No. of points of occurrance.	No. of trees.	Total basal area.	Relative frequency (F) %	Relative density (D) %.	Relative dominance (Do) %.	Importance value (F+D+O).
Sesamothamnus guerichii	20	37	19598.14	29.3	37	73.98	140.28
Terminalia prunioides	16	23	2140.82	23.5	23	8.08	54.58
Combretum apiculatum	14	17	3220.80	20.6	17	12.16	49.76
Colophospermum mopane	12	15	1118.02	17.6	15	4.22	36.82
Boscia foetida	4	4	108.92	5.8	4	0.41	10.21
Acacia nebrownii	2	4	297.94	2.9	4	1.12	8.02
Total	68	100	26484.64	99.7	100	99.87	299.67

Average distance : 21.4 feet
Trees per acre : 95.1
Average basal area per tree : 264.84 square inches.
Basal area per acre : 66200 square inches.

TABLE : 17.

SPECIES COMPOSITION OF THE MORE COMMON SHRUBS IN THE SESAMOTHAMNUS GUERICHII ASSOCIATION.

Species.	Average distance from point (feet).	No. of points of occurance.	No. of plants.	Relative frequency %.	Relative density %.
Catophractes alexandri	5.0	22	35	26.8	35
Colophospermum mopane	12.0	14	15	17.1	15
Combretum apiculatum	13.2	8	9	9.7	9
Rhigozum brevispinosum	11.0	6	7	7.3	7
Monechma genistifolium	6.0	6	6	7.3	6
Grewia bicolor	6.3	6	6	7.3	6
Gossypium triphyllum	6.5	5	6	6.1	6
Petalidium engleranum	5.0	3	4	3.6	4
Boscia foetida	16.0	4	4	4.8	4
Mundulea sericea	5.0	2	2	2.4	2
Commiphora pyracanthoides	7.0	2	2	2.4	2
Sesamothamnus guerichii	18.0	2	2	2.4	2
Montinia caryophyllacea	13.0	2	2	2.4	2

Acacia tortilis ssp. *heteracantha* *A. giraffae*
Acacia hebeclada ssp. *hebeclada*

Other trees contributing to this canopy are :

Acacia senegal var. *rostrata* *A. erubescens*
A. Mellifera ssp. *detinens* *Albizzia anthelmintica*
Lonchocarpus nelsii *Boscia albitrunca*

Colophospermum mopane also occur and along the stream edges they grow to 45 feet tall. Other elements also found in the ecotones are *Sesamothamnus guerichii* and *Catophractes alexandri* are common in some localities with scattered *Acacia nebrownii*. Other shrubs are :

Gossypium triphyllum *Mundulea sericea*
Grewia bicolor *Lycium boscifolium*
Grewia villosa *Grewia tenax*
Montinia caryophyllacea *Adenium boehmianum*

Herbs are also very common, the foll wing occurring :

Nerine duparquetiana *Ammocharis coranica*
Cyperus fulgens *Cleome diandra*
Cleome elegantissima *Petalidium coccineum*
Cassia italica var. *micrantha*, Raphionacme ssp.

This community is very popular and is frequented by a large number of zebra, gemsbok and springbok. In areas where overgrazing occurs

Pechuel-Loeschea reubnitziae *Bidens biternata*
Indigofera pechuellii *Leuchas pechuellii*

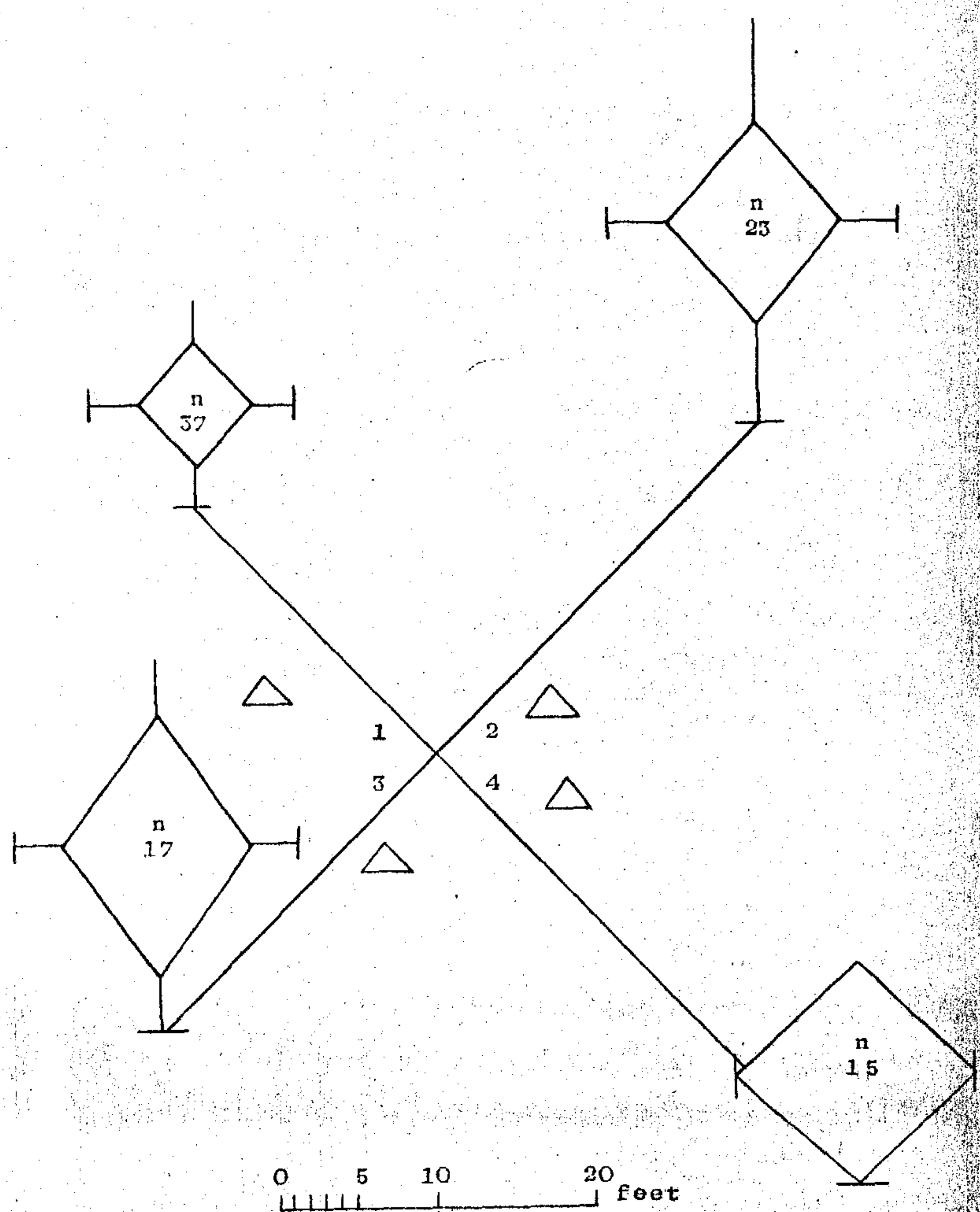
Tribulus terrestris are found. The latter is very conspicuous in the early rainy season. *Crotalaria podocarpa* sometimes forms pure stand during good rainfall years. Other legumes occurring are :

Indigofora rautanenii *Cylitra biflora*

99/...

FIGURE : 13

MEAN AND MAXIMUM HEIGHT AND WIDTH OF CROWN AND MEAN DISTANCE FROM THE POINT FOR THE FOUR DOMINANT TREE SPECIES IN THE SESAMOTHAMNUS GUERICHII ASSOCIATION.



Tree species.

Sesamothamnus guerichii
Terminalia prunioides
Combretum apiculatum
Colophospermum mopane

Shrub species.

Catophractes alexandri
Colophospermum mopane
Combretum apiculatum
Rhigozum brevispinosum

Lessertia benguellensis

Seeds formed by all the latter species support a large number of guinea fowl in this area.

A creeper sometimes encountered is Cyphostemma ssp.

A great variety of grasses also occur in this community. The dominant grass cover is formed by :

Anthophora schinzii	Eragrostis porosa
Schmidtia kalahariensis	Aristida effusa
Monelytrum luderitzianum	Stipagrostis uniplumis
Eragrostis plachnifusca	Eragrostis rotifer
Enneapogon brachystachyus	Eragrostis superba
Cenchrus ciliaris	Heteropogon contortus
Rhyncolytrum villosum	Bothriochloa radicans
Panicum coloratum	Tragus racemosus

Where streams debouch onto these valleys, stands of Sorghum verticilliflorum sometimes occur.

5.4.5 Commiphora - Sterculia association on rocky outcrops

This association only occur in rocky outcrops on the dolomite ridges in the study area. These rocky outcrops are strikingly covered by several Commiphora species viz. :

C. multijuga	C. mollis
C. glaucescens	C. crenato-serrata and

also by Sterculia zastrowiana and S. africana. Other trees that occur are Vangueria infausta, Phyllogeiton

discolor	Acacia senegal var.
Acacia nilctica	rostrata
Ficus soldanella.	Combretum apiculatum

TABLE : 13

SPECIES COMPOSITION AND BASAL COVER OF THE GROUND LAYER IN THE VALLEY COMMUNITY.

Grasses.	Basal Strikes	% Rel. Frequency	% Cover.
Anthephora schinzii	95	21.4	4.8
Eragrostis porosa	85	19.2	4.3
Schmidtia kalahariensis	82	18.5	4.1
Aristida effusa	37	8.4	1.9
Monelytrum luderitzianum	27	6.1	1.4
Stipagrostis uniplumis	15	3.4	.8
Eragrostis plachnifusca	14	3.2	.7
Eragrostis rotifer	12	2.7	.6
Enneapogon brachystachyus	9	2.0	.5
Eragrostis superba	5	1.1	.3
Cenchrus ciliaris	4	.9	.2
Heteropogon contortus	4	.9	.2
Rhyncolytrum villosum	4	.9	.2
Setaria verticillata	3	.7	.15
Bothriochloa radicans	2	.5	.1
Panicum coloratum	2	.5	.1
Tragus racemosus	2	.5	.1
Stipagrostis hirtigluma	2	.5	.1
Aristida rhinochloa	1	.2	.05
Urochloa brachyura	1	.2	.05
Sub Total	406	91.3	20.65
Herbs.			
Tribilus terrestis	16	3.6	.8
Gossypium triphyllum	8	1.8	.4
Cyperus fulgens	5	1.1	.3
Unidentified herbs	4	.9	.2
Cassia italica ssp miarantha	3	.7	.15
Cleome diandra	1	.2	.05
Sub Total	37	8.3	1.90
TOTAL	443	99.6	22.55

Total basal strikes recorded : 443
Total % grass cover : 20.65%
Total % basal cover : 22.55%

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sometimes occurs in a large tree growth form. Due to the large number of fruitbearing trees this community harbours a great variety of fructivorous and insectivorous birds during the spring and summer months. This tree layer is fully deciduous.

A few shrubs occur viz.

Euclea divinorum
Barleria senensis
Manuleopsis dinteri
Acacia ataxacantha
Hiernia angolensis

and also stunted growth of Terminalia prunioides.

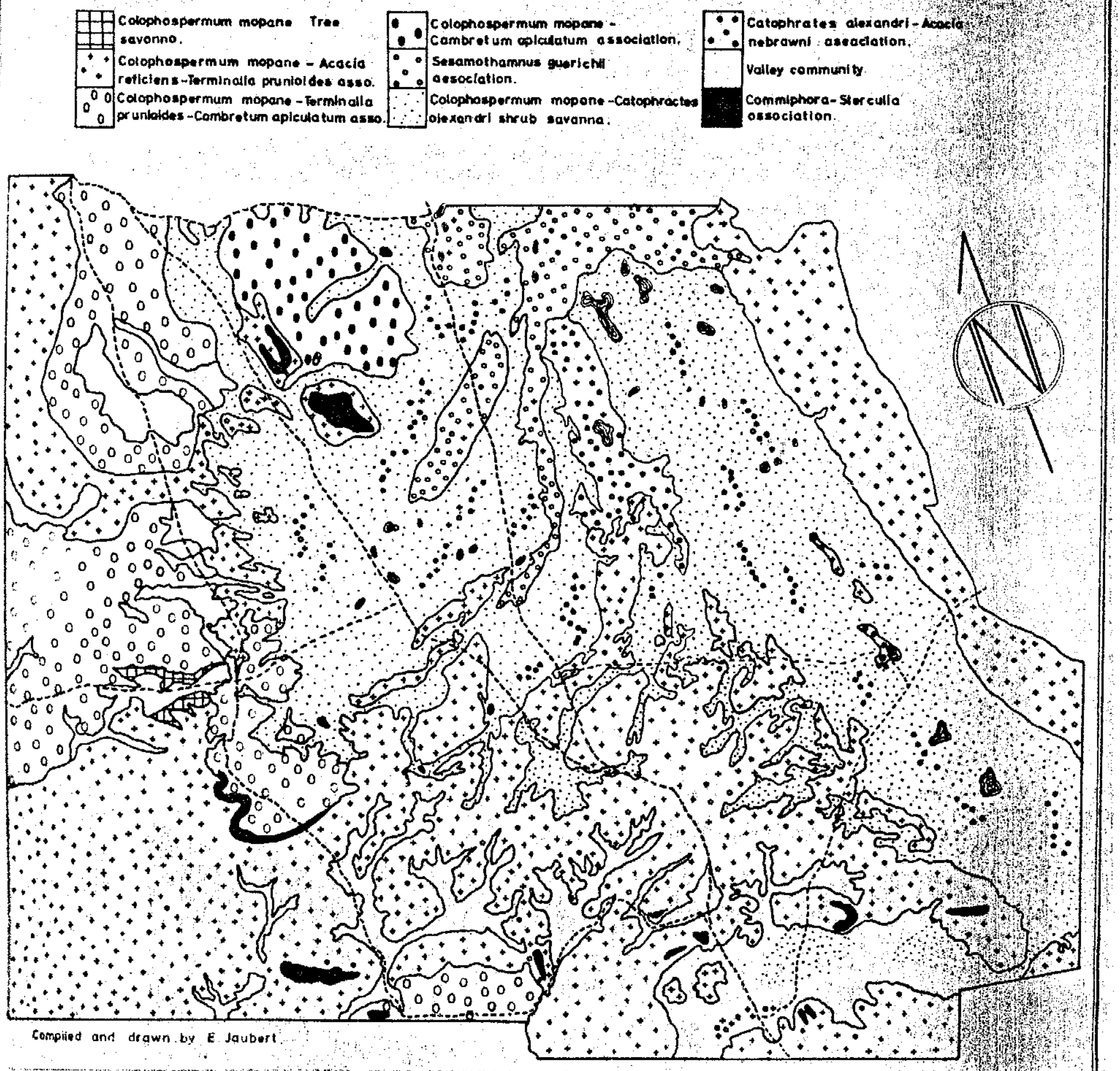
Herbs occurring are :

Aptosimum leucorrhizium
Sesamum schinzianum
Bonamia schinzantha
Rogeria adenophylla
Blepharis obmitratra
Aptosimum ssp.
Plectranthus hereroensis

Grasses that occur are mainly :

Stipagrostis uniplumis
Triraphis ramosissima
Danthoniopsis dinteri

VEGETATION MAP OF THE STUDY AREA AT OTJOVASANDU SOUTH WEST AFRICA



CHAPTER : VI

HABITAT CHARACTERISTICS AND PREFERENCES.

One finds many descriptions in literature of typical rhino habitats, viz. Sclater (1900), Roosevelt and Heller (1915), Fitzsimons (1920), Haagner (1920), Neumann (1926), Lydekker (1926), Percival (1927), Harper (1945), Roberts (1951), Lamprey (1963), Ritchie (1963), Steward (1963), Smithers (1966), Guggisberg (1966). According to these authors rhino are found in a wide variety of habitats, from sea level to about 12,000 feet (Steward), from plain and desert to high rain forests and cloud-soaked moorlands of the great mountain ranges (Ritchie).

In South West Africa the black rhinoceros distribution may also appear, at a first glance, to include a great variety of habitats : from locations near the coast in the Namib desert (viz. Koichab, Unjab and Munutum rivers) through the mountainous transition belt of the escarpment to the featureless plains on the plateau. A careful study of the distribution shows, however, that 91% of the present black rhino population occurs in the mountainous transition belt. Those individuals sometimes observed in the Namib desert, only visit these localities moving down river courses during the rainy/post-rainy season when conditions are favourable. Their habitats are in the mountainous areas to the east. Some of the rhino also wander during the rainy/post-rainy season on to the plateau immediately to the east of the escarpment zone; they are never resident in these areas.

It may be argued that the present distribution of rhino is limited to those areas because of human settlement elsewhere. To a limited extent this is true, especially in areas to the north and south of the Etosha National Park boundaries.

The Etosha National Park stretches from the Atlantic coast (Approx. 12° 40' East) to east of Namutoni (Approx. 17° 10' East), a distance of 290 miles. This area includes the Namib desert, the mountainous transition belt of the escarpment and the plains of the plateau with grass and shrub mopane, karroid-like vegetation around Okaukuejo to the true sandveld vegetation types around Namutoni. In this whole area only 8 rhino (9%) do not occur in the mountainous areas. They occur at Grünewald (three - P. Starke, pers. com.) and at Gobaub (minimum of three - P. Starke, about five, P. van der Westhuizen, pers. com.).

The fact that the black rhinoceros has chosen the mountainous areas around and to the west of Otjovasandu for its biggest concentration in the Game Reserve is a clear indication of habitat preference.

This preference coincides with the previous distribution pattern as mentioned under the heading : Distribution and Status, Distribution before 1900. This preference was also noted by Steinhardt, 1922, "The Kaokoveld rhinos prefer mountainous or rocky localities over which they climb with astonishing facility", with which Shortridge (1934), agrees : "They are partial to bush-covered hill country, with plenty of outcrop over which their tracks wind along the levels and up the slopes."

The reasons why black rhino show a preference

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for this mountainous transition belt are vague. The following factors may all contribute to a varying extent to this preference :

1. Water : It is a geological phenomenon that this area is rich in natural, permanent waterholes. No doubt this is the most important single factor which influences rhino distribution.

2. Vegetation : Suitable vegetation is also an important factor. The water-suitable vegetation combination determines to a large extent the ultimate rhino distribution. The mountainous transition belt is covered mostly by an Acacia-Combretum - Mopane vegetation type which is also rich in herbs and shrubs. This vegetation type may thus include (as previously mentioned) most of the qualifying aspects preferred by rhinos viz.

    cover and
    preferred food plants.

3. Protection : This broken terrain offers a certain amount of protection against man. This may be true in the Kaokoveld, but in the Etosha National Park where they are protected they still show this marked preference for the escarpment zone. The mountainous transition belt may also offer a limited amount of protection against weather extremes. (See Influence of Weather). The cold Benguella current along the coast tends to cause severe fluctuations in temperature.

In the study area, which also has the largest concentration of black rhinoceros in South West Africa, basically two types of habitats occur viz. :

A shrub savanna - open plain with scattered trees and a

Tree and shrub (thorn scrub) savanna, which has a denser vegetation.

In all the instances the black rhino home ranges were situated in plant communities within the latter, type of habitat although individuals sometimes wandered into the shrub savanna.

The plant communities preferred by black rhino are discussed under Vegetation.

The method suggested by Wight (1938), (see Procedure and methods) was used to determine horizontal density (Obstruction to vision). He also suggested that a vegetation type with a per cent horizontal density of lower than 16 should be classified as open, with a per cent horizontal density of between 33 to 66 as medium and with a per cent horizontal density of over 66 as dense. The results obtained give some indication of the cover density preferred by black rhinos. As can be seen from table 15 the typical rhino habitat in the study area, according to the suggested classification, (Wildlife Investigational Techniques) falls within the limits classified as medium. The average horizontal density during the dry season was 41.74 per cent and during the wet season 53.39 per cent. This represents a difference in the horizontal cover density of only 11.65 per cent. Although the horizontal density of the typical rhino habitat is classified as 'medium' by the abovementioned method, it is almost the densest vegetation found in the study area. It is doubtful whether a vegetation type in the arid savanna zone will reach horizontal densities of over 66 per cent.

TABLE : 19.

AVERAGE HORIZONTAL DENSITY OF THE COVER IN TYPICAL BLACK RHINOCEROS HABITAT IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

October 1966 (Dry Season).			April 1967 (Wet Season).		
Transect.	Total.	%	Transect.	Total.	%
A	256	48.76	A	279	53.14
B	238	45.33	B	309	58.85
C	136	25.90	C	236	44.95
D	253	48.19	D	290	55.23
E	199	37.90	E	260	49.52
F	233	44.38	F	308	58.66
Total	1315	250.46	Total	1682	320.35
Average		41.74	Average		53.39

Horizontal density per cent.	Classification.
16	Open
33 to 66	Medium
66 and over	Dense

CHAPTER : VII

FOOD AND DRINKING HABITS

7.1 Food species and preferences.

Although the black rhinoceros in South West Africa, feeds on a wide spectrum of plant species (see table 20), it shows a tendency to concentrate on a few preferred species which form the bulk of its food throughout the year.

A survey was carried out in four rhino home ranges to determine the preferences and utilization of food plants by the black rhinoceros. (See Procedure and methods). When more than five twigs were removed from a plant it was considered to be heavily browsed, if less than five twigs were removed it was considered to be moderately browsed upon.

The results are shown in table 21. The bulk of their diet consists primarily of *Acacia* species, which are usuallly heavily browsed. The most preferred species are *A. reficiens*, *A. mellifera* var. *detinens* and *A. senegalensis*. Of the *Combretum* species, *Terminalia prunicides* is also a very much preferred food plant. The more important smaller shrubs which also contribute to a significant extent to the rhino diet are *Grewia bicolor*, *G. tenax*, *G. villosa*, *Catophractes alexandri* and to a lesser extent *Combretum apiculatum*.

Some of these preferred food plants were analysed by C.I.S.R. to determine their nutritional value. Samples were taken at the height of the growing season (March) during the winter (July) and during the spring flush (September). The results can be seen in table 22.

TABLE : 20.

Plante gevreet deur swartrenosters in Namibia

PLANTS EATEN BY BLACK RHINOCEROS IN
SOUTH WEST AFRICA.

Stipagrostis uniplumis	Gramineae
Phragmites communis	"
Scirpus littoralis	Cyperaceae
+Asparagus denudatus	Liliaceae
Ximenia americana	Olacaceae
+Acacia reficiens	Mimosaceae
+Acacia mellifera var. detinens	"
+Acacia senegal	"
Acacia ataxacantha	"
Acacia fleckii	"
Acacia erubescens	"
Acacia hebeclada	"
Acacia tortilis	"
Acacia nilotica	"
Albizia anthelmintica	"
+Dichrostachys cinerea	"
Colophospermum mopane	Caesalpinieae
Parkinsonia africana	"
Zygophyllum stapffii	Zygophyllaceae
Commiphora glaucescens	Burseraceae
Commiphora saxicola	"
+Euphorbia guerichiana	Euphorbiaceae
+Euphorbia phylloclada	"
Rhusmarlothii	Anacardiaceae
+Grewia bicolor	Tiliaceae
+Grewia tenax	"
+Grewia villosa	"
Grewia flavescens	"
Helinus integrifolius	Rhamnaceae
+Gossypium triphyllum	Malvaceae
Hibiscus palmatus	"
Hibiscus ceasius	"
Hermannia amabilis	Sterculiaceae
Combretum imberbe	Combretaceae
+Combretum apiculatum	"
+Combretum prunioides	"
Merremia guerichii	Convolvulaceae
Merremia multisecta	"
Ipomoea arachnosperma	"
Bonamia schizantha	"
+Lycium trothae	Solanaceae
Manuleopsis dinteri	Scrophulariaceae

TABLE 20 continuod.

Hierna angolensis	Scrophulariaceae
Aptosimum angustifolium	"
+Catophractes alexandri	Bignoniaceae
Monechma arenicola	Acanthaceae
Monechma salsola	"
Ruellia diversifolia	"
+Barleria senensis	"
Justicia odora	"
+Justicia platysepala	"
+Blepharis obmitratra	"
Blepharis gigantea	"
Petalidium coccineum	"
Dactylandra welwitschii	Cucurbitaceae
Citrullus ecirrhorus	"
+Cordia gharaf	Heliotropiaceae
Curronia decidua	Periplocaceae
Sarcocaulon mossamedense	Geraniaceae
Calicorema capitata	Amaranthaceae
Otoptera burchellii	Fabaceae
+Rhynchosia spp.	"
Dolichos chrysanthus	"
Neorautenia amboensis	"
Tamarix usneoides	Tamaricaceae
Welwitschia mirabilis	Welwitschiaceae
Lycium boscifolium	Capparaceae
Montinia caryophyllacea	Montinaceae
Bidens biternata	Asteraceae
Osteospermum nervosum	"

+Preferred food plants.

TABLE : 21.

Die belangrikste voedsel plante benut en voorkeur getoon

THE BULK FOOD PLANT UTILIZATION AND PREFERENCE SHOWN BY DICEROS BICORNIS IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

deur swartrenosters in Namibia

Species.	Browsing category. (Vreetkategorie)			utilized (Benut)	preference. (Voorkeur)
	Heavy (Swaar)	Moderate (Matig)	Not browsed (Nie benut)		%
Acacia reficiens	48	39	13	87	36.6
Acacia mellifera var. detinens.	28	41	31	69	21.4
Acacia senegalensis	22	47	31	69	16.8
Terminalia prunioides	18	38	44	56	13.8
Grewia species	12	37	51	49	9.2
Catophractes alexandri	3	41	56	44	2.2
Combretum apiculatum	0	40	60	40	–
Colophospermum mopane	0	11	89	11	–

Although no positive conclusions can be based on these figures some interesting trends may be observed.

The protein percentage value shows a tendency to decline from March to September, the exception being the two Acacia species. A. reficiens reaches its highest protein value in September, while A. mellifera var. detinens reaches its highest protein value in June. The September protein value for A. mellifera var. detinens is still high, however, compared with the other food plants. This high protein value is probably due the fact that the Acacias are generally in flower during September.

The percentage value of ash also shows a tendency to decline from March to September, but with A. reficiens again being one of the exceptions. The percentage ash shows an increase for A. reficiens during September. Terminalia prunioides, the other exception, reaches its highest percentage ash value during June.

As can be expected the percentage crude fibre shows a tendency to increase from March to September. A. reficiens however, has a lower percentage crude fibre value during September than during June.

The percentage value of fat shows no clear pattern in most species. The percentage value of fat for A. reficiens shows an increase from June to September.

The percentage calcium, however, shows a clear tendency to reach its highest values during June.

The percentage phosphate on the other hand shows a marked decrease in June followed by an

TABLE : 22.

Die voedsaamheidswaarde van sommige plante deur swartrenoster benut in Namibia

THE NUTRITIOUS VALUE OF SOME PREFERRED FOOD PLANTS OF *DICEROS BICORNIS* IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

Species.	Protein Nx6.25 %			~~Ash~~ As %			Crude Fibre. (Ruvesel) %		
	M	J	S	M	J	S	M	J	S
Acacia reficiens	8.2	6.5	10.7	3.99	2.13	3.90	44.4	45.8	39.0
Acacia mellifera var. detinens	7.9	9.6	9.2	3.45	2.86	1.81	44.2	42.6	48.3
Terminalia prunioides	5.7	4.7	4.6	3.45	6.60	2.44	41.6	43.6	57.6
Grewia species	4.6	4.6	3.8	4.98	2.70	1.95	42.7	47.6	49.5
Catophractes alexandri	5.3	4.2	5.3	2.70	1.55	1.31	43.9	42.6	44.0
Combretum apiculatum	7.5	4.8	4.1	5.50	3.01	2.04	33.7	41.4	49.2
Blepharis obmitratra	6.9	5.8	5.7	6.80	5.35	4.6	38.7	35.2	37.3

TABLE : 22. continued.

Species.	Fat %			Ca %			P %		
	M	J	S	M	J	S	M	J	S
Acacia reficiens	1.6	1.2	1.5	1.2	1.7	1.3	0.08	0.04	0.17
Acacia mellifera var. detinens.	1.8	1.9	1.4	1.4	1.4	1.4	0.18	0.07	0.15
Terminalia prunioides	0.7	0.7	0.7	1.6	3.2	1.6	0.09	0.04	0.07
Grewia species	1.1	1.0	1.0	1.6	1.9	1.9	0.14	0.06	0.07
Catophractes alexandri	1.4	0.9	1.0	0.7	0.7	1.0	0.09	0.05	0.08
Combretum apiculatum	1.3	2.5	1.0	2.5	1.8	1.5	0.07	0.07	0.06
Blepharis obmitratra	0.8	0.8	0.9	2.1	1.6	1.1	0.07	0.06	0.08

increase during September.

Although the black rhinoceros is in most cases a browser, an individual was once observed grazing grass. The animal was feeding on Stipagrostis uniplumis, cutting the stems about an inch or more above the ground and letting the plumes fall from the other side of his mouth. (See photo 17). Only the fibrous parts of the plants were thus being utilized. The first rhino to be kept in a new boma and exercise camp constructed near Okaukuejo grazed all the grass within the exercise camp. This, however, was under abnormal conditions and it was later found that the daily supply of natural food was too little to satisfy the animal's needs.

In the study area the greater part of the vegetation consists of a thorn scrub savanna. It was therefore difficult to distinguish trees on height alone. For the study of food utilization and preferences, only plants, one or multiple stemmed, with no side branches lower than six feet, were classified as trees. Plants falling in this category were therefore usually out of reach for rhino feeding. The plants classified as trees fell mostly into the following species : Colophospermum mopane, Commiphora pyracanthoides, Boscia albitrunca, Lonchocarpus nelsii and Combretum imberbe. Plants from the other species viz. Terminalia prunioides and the Acacia species, usually had branches lower than six feet. Of the former mentioned only mopane is a food plant, but was still abundantly represented by shrub mopane.

Lamprey (1963) found that he could group rhino food plants into the following categories viz. trees, shrubs, herbs, sedges and grasses. The rhino in the Tarangire Game Reserve, Tanzania, showed the following selection of food plants :

Shrubs	:	41.33%
Grasses	:	36.00%
Trees	:	11.33%
Herbs	:	9.33%
Sedges	:	2.00%

In the study area it was found that the bulk food plants remain the same throughout the various season of the year. A slight shift in the percentage composition of the total food plants was notable with the change of seasons.

Rainy/Post-rainy season.
(Jan. to June/July).

Trees	:	0%
Shrubs	:	87%
Herbs	:	13%
Grasses	:	0% +

Dry season.
(Sept./Oct. to Nov.).

Trees	:	0%
Shrubs	:	95%
Herbs	:	5%
Grasses	:	0%

(+One casual observation).

During the rainy season the rhino feed on the greatest variety of food plants. The annual herbs contribute to a greater extent to the total diet, viz.

Blepharis obmitratra   *Osteospermum nervosum*
Dactylandra welwitschii   *Ipomoea arachnosperma*
Dolichos chrysanthes   *Melinus integrifolius*
Neorautenia amoensis   *Aptosimum angustifolium*
Bidens biternata   *Hibiscus caesius*.

Colophospermum mopane is now also utilized in a li limited way. Those rhino that move down into the Namib feed to a large extent on succulents and other plant species available in these regions.

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Bonamia schizantha — *Euphorbia guerichiana*
Merremia guerichii — *Ruellia diversifolia*
Hermannia amabilis — *Sarcocaulon mossamedense*
Merrenmia nuttisecta — *Calicorema capitata*
Monechma salsola receiving most of the attention. Records were also obtained of *Welwitschia mirabilis* being utilized by rhino.

After the first killing frost of the year rhino show a marked preference for the smaller shrubs and herbs shorter than the height of the surrounding grass. These plants are protected to some extent by the grass cover and show little or no frost damage. Also parts of the taller shrubs which were not burned by frost were preferred to sides which did have frost damage. During this time of the year seedling *Acacia* and *Combretum* species are also excessively browsed upon.

7.2 Feeding behaviour.

Rhino show a regular feeding rhythm through a twenty-four hour cycle. This rhythm is closely correlated with the activity of the rhino as most of the activity is directed at feeding. The two main feeding peaks fall within the dawn activity period and the crepescular activity period. (See Daily activity cycle, fig. 13). A third and less important feeding peak takes place at about midday between the two abovementioned activity periods. A fourth feeding activity may exist around 2400 hours to 0100 hours, but no positive proof could be obtained.

It was found that rhino have a browse line approximately five feet high. The optimum browsing height however, is between twenty-four to forty-eight inches.

Rhino usually stand next to the shrub it is feeding on. Sometimes, however, it pushes its head right in among the branches, obscuring what the animal is feeding on. A rhino was once kept under observation standing with its head amongst the branches of a shrub mopane. It showed similar behaviour at a number of these shrub mopanes. It was later found to have been feeding on a climber plant (*Dactylandra welwitschii*) within the shrub.

Rhino have various ways of making food available. The commonest is when the horns are brought into play to snap off branches. The rhino in captivity was also observed to hook the pile of branches , thrown into the boma as food, and shake the pile apart. Apparently this was done to make other or more branches available for feeding. In the study area it sometimes happens that they walk over the stems of *A. reficiens* and *A. mellifera* var. *detinens* so that more of the plant becomes available (See photo 25).

When actually browsing the prehensile upper lip is used to a considerable extent. It is used to pull a twig into the mouth; the twig is then cut off with the molars at the proximal end; a second and more twigs are dealt with in the same way. Tho rhino then starts chewing with the distal ends of the twigs slowly disappearing into the rhino's mouth. All this is accompanied by loud crunching noises, no doubt the origin of Alexander's 'horn clacking' noises (see Taxonomy; History). The twigs are cut into pieces one cm. long on the average. During digestion the bark is removed and the woody parts as well as the thorns are found in the dung. Although these woody parts were still abundant during the rainy season, a certain percentage seems to be replaced by residual leaf nervature (See photos 20 and 21).

On several occasions rhino have been observed defoliating Grewia bicolor by running their lips over the twigs (See photo 16).

No record was ever obtained in South West Africa of rhino digging for roots.

7.3 Effects on range vegetation.

Browsing rhino sometimes do serious damage to vegetation but never to the extent found with elephant. Frazer Darling (1960) considers the rhino as a key species in management of African vegetation. It utilizes coarse vegetation which is not usually utilized by other game.

Rhino browse twigs up to the thickness of one centimeter (Photo 17) giving the plant a pruned look. While excessive browsing is damaging to the plant, browsing may also lead to the formation of new shoots. This was found to be the case with especially A. reficiens (Photo 23 and 24) and Terminalia prunioides. Many other species showed the same tendency.

Elephant usually have a twisting action to break off branches. A tree at which an elephant has fed usually has strips of bark hanging down from the broken-off ends of the branches causing an untidy appearance. Rhino on the other hand cut off twigs with a surgical neatness and a 'pruning shears'-like action (See photo 23, 28 and 29).

When rhino bite off twigs they sometimes move their heads sideways, thus causing the twigs to tear slightly apart at the first fork. These twigs then

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usually die off. During the survey to determine food preference, record was also kept of the number of trees on which branches died after rhino cut off the distal end and/or tore it off at the first fork.

The results are shown in table 23.

A. reficiens which is most heavily utilized showed the highest number of plants with dead branches. 38% of the A. reficiens plants utilized had dead branches. It is interesting to note that the plants with pliable branches and little or no forks, viz. the grewia species and C. alexandri had no dead branches resulting from rhino browsing.

No record was kept of the number of branches dead per plant, but it was found that the plants on most of the occasions had more than one dead branch. Those plants which were heavily browsed showed the most damage.

A considerable amount of damage is also done to range vegetation by plants dying off after rhino have trampled the stems to make more of the plant available for browsing (Photo 25).

From the abovementioned it may therefore be deduced that rhino do play a role in the management of vegetation as suggested by Frazer Darling.

7.4 Competition with other species.

As a result of its solitary living habits, the black rhino is a species which tends to under-utilize its home range and intra-specific competition for living space is non-existent in South West Africa.

The only other resident browsers in the study area are giraffe, kudu, black-faced impala, and dik-dik.

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TABLE : 23.

THE NUMBER OF FOOD PLANTS IN WHICH BRANCHES DIED OFF AFTER THE DISTAL ENDS HAD BEEN REMOVED AND/OR THE FIRST FORK TORN BY BROWSING RHINO IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

Species.	Food plants with dead branches.		Total food plants utilized.		% F.P.U.[+] with dead branches.
	Grazing Category.				
	Heavy	Moderate	Heavy	Moderate	
Acacia reficiens	23	5	48	39	32.2
Acacia mellifera var. detinens.	9	4	28	41	18.8
Terminalia prunioides	4	1	18	38	8.8
Grewia species	0	0	12	37	0
Catophractes alexandri	0	0	3	41	0

[+]F.P.U. = Food plants utilized.

Giraffe and rhino feed at different levels and could therefore utilize the same plants without any competition. This is also true to some extent for the kudu. The latter three ungulate browsers viz., kudu, black-faced impala and dik-dik do not feed on the main food plants of the rhino. If they did it would only be the leaves and extreme tips of the branches. The tendency of woody plants to form new shoots after being 'pruned' by black rhino would thus increase their food supply. By trampling down grass and feeding on smaller shrub rhino would also actually be improving the dik-dik habitat.

Mitchell (1966) found that in two habitats, viz. plateau and valley the rhino was able to hold its own amongst heavy ungulate concentration. He also states that this is due mainly to the fact that elephant and the other large mammals do not utilize rhino food plants to any great extent.

In the Tsavo National Park, however, Glover and Sheldrick (1963) found that an over-population of elephant resulted in widespread destruction of rhino habitat. This could have led to the elimination of rhino in this area.

There are no resident elephant in the study area. During the rainy season large number of elephant pass through this region. They leave in their wake a path of destruction, usually of acacia and mopane trees (See photo 29). Although there is no serious threat to the rhino habitat at present, it may well be the case when the Etosha National Park's boundaries are fenced off, causing the present migratory elephant to stay for longer periods in this rhino habitat

7.6 Drinking Habits.

The drinking habits of rhino vary from locality and from season to season.

In South West Africa they usually drink from sunset or just after sunset till about 2200 hours. This preference for drinking at night is also found in the semi-arid Northern Frontier province of Kenya (Guggisberg, 1966). Although not strictly applicable to the study area, the following factors may have had on influence on this behaviour pattern in South West Africa.

1. In the Kaokoveld the waterholes are usually utilized by livestock during daytime, giving rhino and other game a chance to visit them only at night.

2. In the semi-arid region, especially in areas closer to the Namib desert, the rhino have large home ranges. The animals may be as far as twenty or more miles from the water causing them to reach the waterhole after sunset.

3. With the livestock utilizing the pastures in the immediate vicinity of the water the rhino have to move further away with the same results as in 2 above.

It was found that rhino tend to attach themselves to a waterhole. During the rainy season they drink at available rainwater pans throughout their home ranges. As these dry up, however, they return to the same permanent waterhole. During the time of study not one of the rhino in the study area drank at any one of the other permanent waterholes that did not lie in their home ranges. In areas where they utilize extensive home ranges, and two or more permanent or semi-permanent waterholes fall within these home ranges, they visit all these waterholes.

To illustrate their attachment to a certain waterhole the following can be related. The animals in home range F_1 (See Home range, map 5) utilized the waterhole at Otjovasandu. A windmill was then erected at Renostervlei. Although they passed frequently within a few yards from the water at Renostervlei, they kept on coming to the waterhole at Otjovasandu, nearly five miles away, for another couple of months before starting to drink at Renostervlei.

In the study area some of the rhino had such distinct characteristics, viz. shape of the horns, and/or family groups, viz. female and calf of a certain size, that they could be identified at night. Watch was kept at the waterholes in the study area to determine the frequency with which rhino visit waterholes. The following results were obtained.

Observations carried out during :

June - July 1966.	end October 1966.
12 nights at 3 different waterholes.	4 nights at one waterhole.
Drank every other night.	Drank nightly

By the June-July and October period in 1966, all the rainwater pans in the study area were dried up. During this time they drank every other night. In October they drank every night. Although this gives some indication of their drinking habits variations may occur. Rhino may be able to go without water for longer periods, especially where they feed on succulents.

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Many of the waterholes in South West Africa are situated in river-beds where the water is forced to the surface by transverse rock barriers, etc. (See Study area, Topography). During the rainy season the water may flow along the surface of the river-bed for distances of up to one mile, but only one or two small permanent puddles will remain during the dry season. It was found that even in the rainy season the rhino will move past all the other stretches of open water along the river-bed and drink at the permanent puddle.

At Omborongbonga, a natural waterhole in the study area, the water flows for a distance of about twenty yards from a pool before disappearing beneath the sand during the dry seasons. One individual excavated a 'gorra' with his front feet every time he came down to water, next to the little 'stream' of water. Sometimes he would just open up the old 'gorra'. He would then stand around until this is filled with water and then noisilly drink his fill. (Photo 30)

The time spent at the actual water's edge may vary, but it was found that on the average rhino spent about 30 to 40 minutes here. Most of this time is taken up actually for drinking water. Whether this indicated that they drank large quantities of water, or whether they were very slow drinkers could not be ascertained.

7.6 Mineral Needs.

Little work has been done on the mineral requirements of rhino. During this study this aspect also received little attention owing to lack of facilities.

Most of the water in South West Africa is brackish-alkaline (See table 24). This water may satisfy their needs to a certain extent, or it may aggravate the need. At some of the waterholes it was found that a whitish crust, with a salty taste, formed at the water's edge, Several records were obtained of rhino eating this 'crust'.

TABLE : 24.

CHEMICAL ANALYSIS OF WATER SAMPLES
(parts per million).

	Otjovasandu	Renoster-fontein.	Kowares	Renoster-vlei.
Cu	.0009	.00013	.0020	.0013
Zn	.062	.041	trace	.032
Fe	-	.0009	-	-
pH	8.4	8.08	8.26	8.35
*T.D.S.	848	652	695	443
Na^+	180	93	131	50
K^+	122	15	13	8
$SO_4^=$	74	57	45	43
F^-	2.1	1.5	1.7	1.3
Cl^-	153	98	109	56
**Tot. cal.	515	380	434	239

*T.D.S. Total dissolved solids.
**Tot.cal. total calcium content.

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CHAPTER: VIII

BEHAVIOUR AND LIVING HABITS.

8.1 Territorialism.

Territorialism was first defined for birds. It consists of a limited area in which an individual, a pair or a group shows antagonism or defends this area against other individuals of the same species. Manufestations of presence are important in the maintenance of a territory.

Amongst the large mammals territorial behaviour has been recorded for an increasing number of animals. In most of the cases territorial behaviour seems to be associated with the mating season. Darling (1937), found that during the rutting season the Scottish red deer stag defends his group of hinds. The stag does not seem to defend a certain area but rather his group of females against encroachment by other males. With the Uganda Kob the situation changes. Here the males each defend a small area while waiting for females to come along (Buechner 1961). Estes (1968), found the same with wildebeest. Buechner and Estes came to the same conclusion viz. that the males compete for territories and never for females.

The Indian rhinoceros (Rhinoceros unicornis) shows territorial behaviour (Ripley 1952, Ripley and Hutchinson 1964). The individual animals of either sex live solitary on definite territories during the greater part of the year. Ripley (1952) states that adult animals are never seen together except when mating or during a fight. Although it is not clearly stated as such, it can be deduced that the territories are defended.

As the black rhinos are known to be solitary and often sedentary in their habits they were often considered to be territorial. Their excretory habits were used as proof to confirm this belief. Hutchinson and Ripley (1954) states that in Natal the black rhinoceros is strongly territorial.

During the last few years detailed study in various localities have shown that this is not the case (Spinage 1962, Guggisberg 1966, Klingel and Klingel 1966). Von Schenkel (1966), have done work in the Amboseli - Reserve and also in the Tsavo National Park. He came to the conclusion that there was no territoriality in black rhinoceros and that intra-specific aggression is of minor importance. He states that conflicts between bulls, more rarely between bull and cow, occur, but severe fighting is rare. Hence the well defined marking patterns of the species (with faeces and urine) have no relationship to territoriality.

Goddard (1967) observed in the Ngorongoro crater that rhino inhabiting the same community are not aggressive to one another, but aggressive behaviour are shown to 'strange' rhino that might enter the caldera.

In the study area and in the Kaokoveld no indication of territorial behaviour fitting the given definition, were observed in the black rhinoceros. This might be due to the low numbers in the various distribution areas. The long distances between these areas also limits the chances of a 'strange' rhino appearing there.

8.2 <u>Home range</u>.

According to Dice (1952), the area over which an individual animal habitually travels while engaged in his usual daily activities may be called his home range. This area includes all the animal's feeding sites and also the resting and breeding sites.

The sedentary habits of rhino have long been known and most workers remarked on this. Shortridge (1934), noted that they often attach themselves to a particular area about ten miles in diameter. Steinhardt (1924), mentioned that they seem to have "established headquarters". In describing the daily activity of rhinoceros, Ritchie (1963), states that on returning from water no serious feeding takes place until the rhinoceros "gets to his 'home' ground". Guggisberg (1966), also notes that under suitable conditions black rhino are very sedentary. Available literature thus indicates that these animals live within home ranges.

To determine whether the rhinos in the study area showed home range behaviour and to determine the extent of these home ranges the following method was used. A map of the study area was compiled with the aid of aerial photographs. The locality of every encounter with every rhinoceros was plotted and marked on the map. Whenever possible the daily movement of the animal was also plotted.

After some time it became quite clear that the black rhinos in the study area do have home ranges. Although no clear bounderies could be ascertained it was quite possible to link the various individuals with certain areas. It was also noted that the different sexes of rhino showed a tendency to frequent the same home range. In three instances males only frequented home ranges, but in all the instances females shared their home range with a male.

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The only other indication that could be found in literature of different sexes of black rhino frequenting the same home range was in Von Schenckel's (1966), publication. In his paper on the territorial behaviour of black rhinos van Schenckel states that he was able to distinguish four home ranges in his study area at the Amboseli Game Reserve. The following individuals frequented these home ranges :

Home range	I	: Solitary bull.
Home range	II	: One dominant bull. One old cow. Two smaller cows. One young bull.
Home range	III	: One solitary bull.
Home range	IV	: Two cows and one sub-adult calf.

No information on how the boundaries were determined is given, and one wonders whether he came to the correct conclusions regarding the boundaries of the home ranges in the study area.

Klingel and Klingel (1965), states that especially the bulls establish well defined home range in the Ngorongoro crater. Much movement by rhino in and out of the crater, as well as from one area to another in the crater exists. Goddard (1967), found in the Ngorongoro crater that home ranges can overlap to a considerable extent. Guggisberg (1966), also points out that in areas with a dense rhino population the feeding ground of the various animals overlap.

In none of the study areas elsewhere in Africa were the numbers of black rhino as low as in the study area in South West Africa. No apparent reason for this behaviour (both sexes sharing one home range) thus exists in the study area. This tendency for both sexes to occupy the same home range in areas with a low population density may be an evolutionary one to ensure the survival of the species.

By comparing the home ranges in the study area with the vegetation and topography maps one finds similar features in the various home ranges. All are more or less situated within the Colophospermum mopane - Acacia reficiens- Terminalia prunioides association. Home range F_2 falls partly within the Colophospermum mopane - Combretum apiculatum association.

This association however, shows great similarity with the former, and differs only in the plants which form the dominant cover. The home ranges all lie within the broken or hilly parts of the study area. As previously mentioned this is probably due to the food available in these areas and to a lesser extent the protection offered within these hills against

Man
Weather extremes.

Apart from the tentative size mentioned by Shortridge only Goddard (1967), gives any indication of home range sizes. Goddard found that the mean home ranges varied in size in various habitats viz.

Location	Mean home range.
Lerai Forest (Green food abundant)	1.0 sq. miles.
Central Ngorongoro (Open grassland)	6.0 sq. miles.
Olduwai (Dry Acacia - Commiphora bush).	11.7 sq. miles.

Goddard also mentions a size variation in home range during different seasons of the year. The present author holds the viewpoint that a rhino's home range consists of all the localities visited by the animal during the different seasons of the year.

The other factorsgoverning home range size according to Goddard is sex and age class. Goddard states that immature animals have larger home ranges than adult animals. That they move over larger areas than adults is certainly true. As will be seen under Social structure and behaviour (8.3), sub-adult male (MMB_1) left his mother shortly before the new calf was due to be born. For the next nine months, till he joined her again for short periods from January 1968, he wandered extensively over certain parts of home ranges B_1, B_2 and P_1. The present author does not think however, that this area can be considered as his true home range. The association between the immature individual and the adult animal should first be finally broken and, as stated in Dice's definition, the animal should have started with its own breeding activities before one can concider determining his home range.

It was found in South West Africa, that the size of the home ranges varies from locality to locality. Home range size is dependent on :

(a) Available food and cover.
(b) Population pressure.
(c) "Lebensraum".

(a) <u>Available food and cover.</u>

It was found that the home ranges in the study area with its abundant food supply varied between 12 to 16 square miles. The further west one goes the lower the car-

carying capicity becomes with resulting larger home ranges. In the Kaokoveld it was found that the home ranges were usually some distance be- tween 5 to 15 miles) from the waterholes. This is due to concentration of livestock and man in the immediate vicinity of the waterholes. On the Namib edge (sub-desert) the home ranges cover areas between 50 and 60 square miles. In this region the home ranges are usually in the form of an umbrella, the handle pointing towards the west down a dry river course. Apart from the fact that the topography in this area is mostly flat the home range always in- cludes a range of hills and/or part of the mountainous escarpment area.

The influence of rainfall and the resulting food supply on home range utilization is clear- ly illustrated by the rhino concentration aro around Orupembe. During the 1966/1967 rainy season the northern part of the Kaokoveld received abundant rain. Rhino from Orupembe (one family group - see 8.3 Social structure), moved down the Munutum River to localities twenty five miles deeper into the desert. Here they fed mainly on succulents. During the 1967/1968 rainy season this region had very little rain. Although a permanent supply of water was available at Orupembe, the vegetation in the usual rhino haunts was completely dried out. The rhino that frequented this area moved sixteen miles to the east, deeper into the mountains around Sanitatas where there was still ample food.

(b) Population pressure.

Population pressure from within are non-existent in the rhinos occurring in South West Africa. Its influence on the size of home ranges is therefore limited.

(c) 'Lebensraum'.

This concept might be shortly defined as the vital living space required by an organism to survive. The need for lebensraum is of more importance in species with solitary tendencies than in social species. In an animal with solitary habits such as the black rhinoceros this concept no doubt plays an important role. This aspect should be kept in mind when determining the carrying capacity for rhino in a certain area. Because of the lack of numbers this aspect was neglected during the study.

Normally the resting place, within the home range, that a rhino will visit during a certain day is quite unpredictable. It was found however that with the change of seasons certain areas within the home range were visited more frequently then other areas. Although it is impossible to lay down hard and fast rules, it seems that during the warmer part of the year they tend to visit the hilly parts of the home range more often. During the rainy season they stay on the plateau. This might be due to a greater variety of food plants, especially herbs, during this season. Another aspect may be the availability of water in rainwater pans in the depressions.

Early in the study it was thought that during the rainy season the rhino wandered over a larger area.

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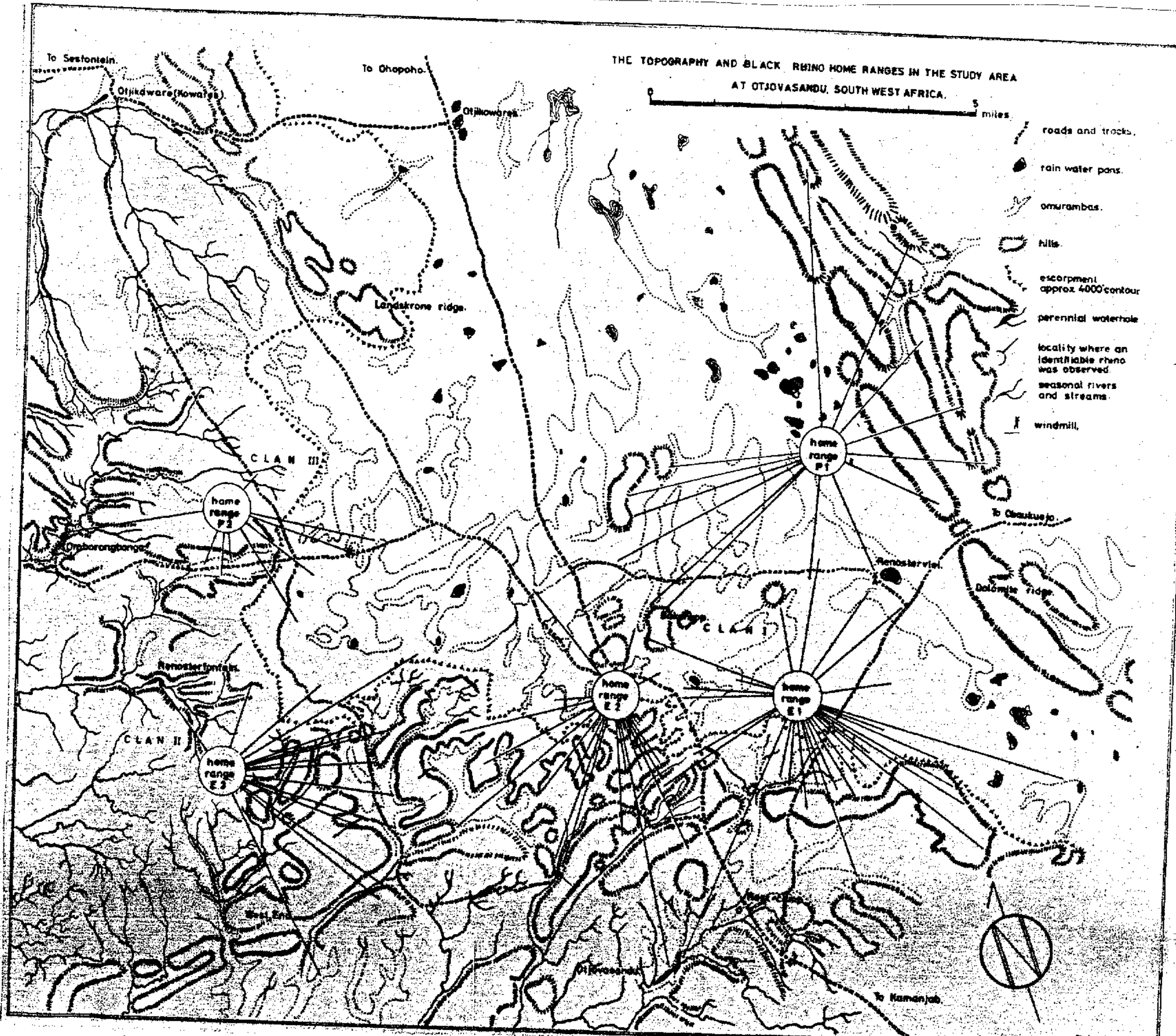
THE TOPOGRAPHY AND BLACK RHINO HOME RANGES IN THE STUDY AREA
AT OTJOVASANDU, SOUTH WEST AFRICA.
0
5
miles.
roads and tracks.
rain water pans.
omurambas.
hills.
escarpment
approx 4000' contour
perennial waterhole
locality where an
identifiable rhino
was observed.
seasonal rivers
and streams.
windmill.
To Sesfontein.
Otjikdware(Kowares)
To Ohopoho.
Otjikowares
Landskrone ridge.
CLAN III
home range P2
Otjoborongbonga
home range P1
To Okaukuejo.
Renostervlei.
Dolomite ridge.
CLAN I
home range E2
home range E1
Renosterfontein.
CLAN II
home range E3
Otjovasandu
To Kamanjab.

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Although this might be true of certain individuals, the majority of rhinos in the study area, however, showed no indication of range expansion. Some of them tend to stop visiting the usual waterholes but this is only because of the availability of rainwater in the home ranges. Some of the rhino in the sub-desert region wander down the water courses during the rainy season. All these movements however, are annual and it can be considered that these areas still fall within their normal home ranges, but are only visited when conditions are favourable and that accordingly it is not range expansion in the true sense of the word.

8.3 Social structure and behaviour.

For the convenience of the study it was found necessary to classify the rhino in three age groups; namely calves, immature animals and adults. Calves consist of animals still dependent on their mothers; immature animals are those no more dependent on their mothers, but not yet fully grown. These individuals may still be in their mothers company; adult animals are those attached to a specific home range.

As previously mentioned, both sexes of rhino frequented the same home range. The females were usually accompanied by a calf. The rhino frequenting one home range thus forms a family group. The three natural water-holes in the study area each had its group of rhinos that patronized it. Each natural waterhole's rhino were regarded as a clan, with family groups within the clan. (See table 25). Although the home ranges of some of the individuals within the clan may overlap, no over-lapping of home ranges between different clans existed in the study area.

Clan I is formed by the animals from home ranges F_1, E_1 and E_2. These animals mainly drink at the Otjovasandu waterhole. The animals from P_1 utilized the Otjovasandu waterhole until the windmill was erected at Renostervlei. The individuals from E_1 were also seen on occasion to drink water at Renostervlei.

It was found that a male, female, calf association frequented home ranges E_1, E_2 and P_1 respectively. The fourth male in clan I (see table 24) frequented a home range to the south of Otjovasandu. (This home range is not shown on map 7). It is on record that during 1965 a cow and calf was shot by poachers in this area and during the study no females were observed in this particular home range. The immature animal in this clan is the son of FE_1. This young male now seems to inhabit the area roughly between home ranges E_1, E_2 and P_1 though he was still frequently seen in home range E_1. It would be interesting to see whether a new home range will be established by this individual. It might well be that individuals such as this young immature male indulge in the wanderings that are sometimes recorded (see 8.9 Movement).

Clan II is formed by the animals in home range E_3 (See table 25). It is very probable that the two females in this clan forms a mother - daughter association. The areas covered by the two females in this clan overlap to such an extent that they were regarded as one home range. These two females, with their calves, were never seen together. All these animals use the waterhole at Renosterfontein.

Clan III consists of the animals drinking at Omborongbonga (See table 25). Two females share home range F_2 with one male, while the two other males had solitary home ranges outside the study area (Not shown in map 7).

In home range I_2 the female FF_2 was accompanied by her immature daughter and calf from the time the study commenced in June 1966. Due to the difficult terrain this group was infrequently seen. On 31st August 1967 the young female (FFI_2) with a very young calf was seen in this home range. In this case a mother - daughter association is thus confirmed.

Although the male and female traversed the same home range they were only seen in 15.4% of the observations to browse or lie down together. This solitary behaviour by the black rhinoceros is clearly illustrated in table 25. The female/immature groups were seen much more frequently than the solitary males. The reason might be that these groups were more conspicuous than solitary animals.

On occasions the two sexes were separated by a short distance (a few hundred yards) but showed no indication of being aware of each other's presence. During the 27th and 28th August 1967, the male and female of home range E_1 were seen together for two days. The cow (FE_1) was accompanied by her 18 week old calf. On the morning of the 29th August the cow and calf were seen about two miles east of the abovementioned locality slowly moving towards the area where she was first observed with her new-born calf on the 24th April 1967. Although they were kept under constant observation first from a hill and later followed on foot, no sign could be detected of their companion of the previous days. On another occasion (11th January 1967) the male and female of home range E_2 were seen together. The behaviour of the female, viz. frequently urinating and keeping her

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TABLE : 25.

SOCIAL GROUPS STRUCTURE OF THE BLACK RHINO POPULATION IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

Clan.		Male.	Female.+	Total.
I	Adult.	4	3	7
	Immature.	1	0	1
II	Adult	1	2	3
	Immature.	-	1	1
III	Adult	3	2	5
	Immature.	-	-	0
	Total	9	8	17

+All females accompanied by calves.

TABLE : 26.

SOCIAL RELATIONS OF THE BLACK RHINOCEROS IN THE STUDY AREA AT OTJOVASANDU, SOUTH WEST AFRICA.

	No. of Observations.+	No. of individuals.	Single %	With Male. %	With Female++ %
Male	26	8	73.6	-	26.4
++Female	44	9	73.6	26.4	-
immature male	5	1	66.6	-	33.4
immature female	3	2	33.4	-	66.6

+Night observations at waterholes were ignored.
++Females were always acccompanied by a small calf.

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tail in the air for prolonged periods, suggested that she was in oestrus. Being solitary animals one may presume that the two sexes are mostly seen together only when the females are sexually receptive.

Regarding the female - calf assocation the following observations were made :

In 73.6 per cent of the observations females were accompanied by only a small calf, in 33.4 per cent of the observations with a immature male and in 66.4 per cent of observations with a immature female. On a few occasions a male, female, calf and sub-adult group were also seen (See table 26).

The female (FB_3) in home range B_3 was still accompanied by her sub-adult daughter although she (FB_3) was very heavy in calf at the beginning of December 1967. On the 28th December 1967 FB_3 was seen with her new-born calf in home range B_3. There was no sign of the sub-adult daughter. A few days later, 4th January 1968, FB_3 and her young calf were again seen without the previous calf.

The sub-adult male calf (MFB_1) of FB_1 were last seen together on the afternoon of the 8th February 1967. That was approximately two months before FB_1's younger calf were born. On the 1st January 1968 the sub-adult male (MFB_1) was seen for the first time again in company with FB_1 and her new calf. This association between FB_1 and the sub-adult male (MFB_1) was very loose from this stage onwards. MFB_1 was mostly single. As previously mentioned FP_2's sub-adult daughter FFP_2 accompanied FP_2 and her younger calf until a few months before FFP_2 had her own calf during the first half of August 1967.

From the above it seems as though the immature calves leave their mothers shortly before a new calf is due to be born and may join them again after some time. Goddard (1967), found that the immature animals try to join adult animals. Guggisberg (1966), points out that in the Amboseli Reserve, calves remained with their mother for periods varying between two and three-quarter years to over five years. The present author thinks the association between mother-daughter is usually broken when the daughter has her own offspring as is suggested by the observations already mentioned in home range P_2, and the mother - son bond usually with the next calf.

There can be no doubt of the importance of the waterhole, and to a lesser extent the rhino footpaths leading there, to the rhino population. Most of the social contact is centered around these waterholes. One may also presume that in the majority of cases the initial contact between a cow in heat and a bull takes place here. The biggest concentrations of rhino in the study area were observed around waterholes. During June, July and again in October 1966 twenty-four hour observations were carried out at the various waterholes in the study area. Because of the flatness of terrain and the small pool most of the observations were done at Renostervlei. On various occasons two family groups were seen at the waterhole at the same time. Although they showed no marked reaction towards one another the fact remains that they made contact. Although no such behaviour was observed in the study area various workers have remarked on the playfull behaviour of black rhino at the waterhole. Percival (1928), records "they gambol in sheer lightness of heart, romping like a lot of overgrown pigs." Ritchie (1963), also claims that they are in playfull mood while at the water.

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8.4 Parental care.

It has been reported that females are more antagonistic during the period that their calves are still young. This is most probably due to the maternal instinct of these animals. In the study area the author was charged three times by cows with calves. On the 31st May 1966, the author did his first reconnaissance of the study area. In home range E_3, the author saw fresh tracks crossing the road. He stopped and after a snort a rhino charged the vehicle. She hit the right hand mudguard with her shoulder and her horn made a dent on the door. As she made off, the author noticed the very small calf.

While watching the male and female with her calf in home range E_2 on the 27th August 1967 an observation was made that suggests protective behaviour by the male towards the female and calf. They were kept under observation all day. At about 17.30 hours they started browsing, moving slowly in the author's direction. As the author was sitting on a rocky outcrop on the hill on which the rhino were browsing he had a clear view of all three individuals. Shortly afterwards the author sent his bantu assistant to fetch a roll of film from the vehicle . The bantu left the outcrop and cautiously made his way down the hill. He had to pass about 70 yards from the rhino group - still unaware of the author's presence. The bantu then dislodged a stone which rolled down the hill with a clatter. All three rhino immediatly stopped browsing. The cow turned to face the direction from which the noise came. The calf, who was about 15 yards from her, moved closer and stood next to the cow in line with her hind quarters. The bull charged about 20 yards past them. While facing in the direction from which the disturbance came, he snorted twice. After about 10 minutes he relaxed and resumed his browsing.

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The cow was still apprehensive after 25 minutes.

Guggisberg (1966), mentions that all the cows he watched suckling their young did so while standing. Percival records one lying down like a pig to let her offspring suckle. The author had the opportunity of observing both FB_1's previous and the new calf suckling. Also the small calf of FFP_2 at Omborongbonga (P_2). On all these occasions the female did so standing. Condensed from field notes are two examples of female-calf activity during the periods of observation :

1. Female FE_2 with previous calf : 13th October 1966.

Temp.: Max. 33°C Min. 13°C Cloudcover : 2/10;0/10;0/10
Wind : West 4 (Noon).

Hours.	
0742	First observed. Both are browsing.
0957	Both lie down.
1201	Cow gets up.
1207	Moves closer to the *Terminalia prunioides* tree and lies down.
1440	Calf stands up.
1445	After being nudged by the calf the cow also stands up. The calf kneels down next to the cow, throwing his head far back while suckling. The calf's horn was quite long at this time and it appeared that the above action was either to prevent his horn from irritating FE_2 or so that the horn would not prevent him from reaching the udder.
1456	Stop suckling. Calf remains lying on the ground.
1500	Cow also lies down.
1506	A kudu passes close to them. Both jump up.
1510	Calf lie down.

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1547 Cow lies down.

1600 Cow stands up.

1630 Calf stands up.

1638 Calf lies down.

1640 Cow moves over to another shrub and stands in the shade with head hanging.

1652 Calf stands up. Moves over to cow.

1710 Both start browsing.

1915 Both still browsing.

2. Female FE_2 with new calf : 24th April 1967.

Temp.: Max. :30°C Min.:17°C Cloudcover: 3/10;1/10;4/10
Wind : East 5 (Noon).

Hours.

0715 Cow observed. Browsing with front part of body obscured by the shrub she is feeding on.

0723 Slowly moves towards another shrub. Notice the very small calf for first time.

0930 After moving about 200 yards from the place of first observation she lies down. Calf slowly moves about cow, smelling at various objects - cow included.

1000 Calf lies down next to cow.

1400 Cow and calf get up. Calf suckles.

1405 Stops suckling. Did not suckle continuously for the whole period. They both lie down.

1500 Cow stands up. Rubs both sides of the head slowly. Against <u>Terminalia prunicides</u> twig. (Bull-dozer working in distance can be heard).

1520 Moves to other tree, rubs rest of body. Starts browsing. Still in this area when we leave at 1800 hours.

As can be seen from the above, the calves suckle

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at about midday. Although no observations could be made in the study area it is quite certain that the calf, especially when young, must also suckle during early morning and/or during the evening when the cow is not actively feeding.

Aschaffenburg, R., et al (1961), reported the following on black rhino milk that was analysed in Britain. The cow from which the milk sample was taken is at the Chester Zoo. The milk was analysed for fat, solids-not-fat, lactose, protein, casein, soluble proteins, non-protein nitrogen, ash, calcium, phosphorus, sodium, potassium chloride and iron. The milk contained only a trace of fat and less protein and calcium than cow's milk but more lactose. Paper electrophoresis resolved the soluble protein fraction into at least five components. The total ascorbic acid, calcium pantothenate and vit. B_{12} contents were similar to those in cow's milk, whereas values for nicotinic acid, biotin, riboflavin and vit. B_6 were lower and values for thiamine higher.

It has been noted by observers that while the calf usually precedes the cow in the white rhino, the calf of the black rhino usually follows behind. The author had numerous opportunities to observe this behaviour in the black rhino in the study area. Observations suggest that while the calf is still very young it usually follows the mother. As the calf grows older this behaviour is less marked - especially when the calf also starts browsing. The cow and calf usually browse in lines more or less parallel. The author once observed a cow and calf coming down to the water. The cow was leading the way - about 30 yards from the water's edge she stopped, listening and smelling the air. The calf only paused a moment, then walked past the cow to the water and started drinking. When alarmed and running

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away the calf always follows the cow. This behaviour seems quite natural to the author, considering the habitat black rhino usually frequent. The vegetation is usually dense and with the mother leading the way she opens a path for the calf.

During the week of the 24th April 1967 an interesting observation was made. The previous week work started on the construction of a new road to Okaukuejo through home range E_1. Vegetation was cleared in a strip about 30 yards wide. After the preliminary work, this road was left lying like this for about six weeks. In this very loose soil - graded into a smooth surface - animal tracks crossing the road could be very clearly seen. Although rhino tracks were seen crossing this road on several days during this week it was only on Thursday morning (27th April) that I noted the small rhino tracks accompaning those of the female across. This suggests that the calf, which was born on the 23rd April, was hidden by the female for about three nights. Nothing could be found in the available literature of similar observations made elsewhere.

No observations were ever made in the study area resembling grooming behaviour by the female towards the calf.

8.5 <u>Interactions with other animals.</u>

Other animals usually share the same waterhole, and area around it, with rhinos. On the whole there seems to be no relationship between rhino and the other animals. Ritchie (1963) reports that he only knew of one instance where there was a seemingly permanent association with other animals. This was between two rhinos and a herd of buffalo. In the study area, or the

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Kaokoveld, nothing similar was ever observed.

Guggisberg (1966) records that he once saw a small group of zebra approaching a rhino at a gallop and swarming around it. The rhino got annoyed and charged through them and then trotted away. Something more or less similar was witnessed in the study area. On the 18th August 1966 the author was watching MB_1 from a hill in the study area. A small herd of zebra (Equus burchelli) was grazing in a parallel line with the direction the rhino was taking. Due to the dense vegetation it could not clearly be seen what was happening but suddenly the zebra scattered away with the rhino following them at for short distance. The zebra all came trotting back sniffing and snorting at the rhino. He then charged once more at them and, slowing down, proceeded in the same direction as before this little by-play. The reason for this behaviour is not understood. Other instances where rhino scattered buffalo, waterbuck and giant forest hogs are also recorded (Stott, 1950 and Guggisberg 1966).

While doing the survey of rhinos on the farms between the Ugab - and Hoanib Rivers the author came to a farm called Renosterwraak 386, near Welwitchia. The author was told that when the farms were first occupied by white settlers, about nineteen years ago, a rhino once charged through a flock of sheep and scattered them. The farms were not fenced in at the time, and the farmer lost quite a number of animals.

Ritchie (1963) and Guggisberg (1966) both mention the existence of antagonism between elephant and rhinos. According to Guggisberg rhino even act nervously when suddenly affronted by elephant. Both Ritchie and Guggisberg record cases where black rhino were killed by elephant. The author came across one record of an elephant-rhino fight in the Kaokoveld. This occurred at a waterhole near Otjitjekua about five years ago and was told by an Herero man and was later confirmed by the Native Commissioner at Ohopoho. According to the story they came across the carcass of a rhino bull near the water with signs of fighting in the immediate vicinity. According to the signs, the fight must have lasted a considerable time. They later found an elephant carcass (a cow) about three miles from the waterhole, and from the tracks and the marks on her body it was deducted that she was the other participant of the fight.

During the 8th September 1967 the male ME_3 was kept under observation. A herd of six elephants crossed the area under observation but the rhino appeared to be unaware of their presence. About a hour after the elephants passed, ME_3 crossed their tracks. He immediately sniffed at the elephant tracks and backing up against a shrub, urinated. It seemed to the observer as though the fresh elephant odour triggered this behaviour.

Ritchie and Guggisberg both agree that rhino sometimes contest the issue of right of way at waterholes with elephant - and sometimes succeed. During observations at waterholes in the study area several opportunities arose to watch this rhino - elephant behaviour. In all the cases the elephants were in the majority and did not even spare the rhino a second glance. The rhino waited at a distance for the elephant to finish their activities at the waterhole. At the Renostervlei windmill the previous drinking trough's capacity was only about two hundred gallons of water. Once a herd of about twenty-five elephant visited this watering place and stayed there for about two hours. During all this time a rhino stood waiting at a distance for the elephant to move away. Later during this same observation period a rhino was drinking at the waterhole when a herd of elephant appeared. The rhino immediatly left the water and only returned after the elephant had left, about an hour and half later. This behaviour might be different when the rhino is affronted with only one or a small herd of elephants. In Simon's book, "Between the sunlight and the thunder" a photograph appears of three rhinos drinking at "gorras" dug by elephant, while elephant and buffalo stand around.

While browsing, or during the midday rest, rhino show little interest in the activities of other mammals in the vicinity. Once while following a rhino, a herd of zebra (Equus Zebra hartmannae) noticed the author and made off with the usual noises and snorting. The rhino stopped browsing, seemed to satisfy himself that it indeed was zebra and then continued feeding. It did not, as most other animals would have done follow the stampede, or try to locate the origin of the disturbance or become more alert.

The very popular alliance between rhino and oxpeckers (family Buphagidae) seen elsewhere on the African continent is entirely absent in the Kaokoveld and Etosha National Park. This is most probably due to the fact that these areas fall outside the oxpecker's distribution limits.

A group of drongo's (Dicrurus adsimilis adsimilis) were once observed to swoop down and catch insects as they flew up in front of a rhino. The birds perched on surrounding shrubs while waiting for the insects to fly up. The birds left after a while apparently the rhino, who was busy feeding, moved forward to slowly to satisfy their dietary needs.

8.6 Daily activity cycle.

(a) Activity peaks.

By watching black rhino in the study area it was at first thought that their twenty-four hour day could be divided into two periods.

(i) active late afternoon, night and early morning period and

(ii) non-active greater part of the day period.

Very little information, apart from the time when the animals came down to the water, could be gathered about activity during the nights. In home ranges B_1, B_2 and P_1 the animals were frequently found quite close to the waterholes. (from three-quarters to one and a half miles). This leads to the question, where and how do they spend their time during the night, as they drink between approximately 1900 and 2200 hours. Following the tracks (this was extremely difficult and not possible on most of the occasions) it was found that at one or more places one would nearly always find a trampled area and sometimes fresh dung. This indicated that they spent considerable time there during the night. From this point onwards to the place where they took their midday rest, the vegetation showed signs of browsing.

The present author found it difficult to believe that the rhino would be active from about five o'clock in the afternoon till about eleven o'clock the following morning - an activity period of about seventeen hours out of twenty-four. The trampled areas observed, however suggest an inactive period some time during the later night.

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During May 1967, a black rhinoceros bull was immobilized near Wêreldsend and transported to the rhino boma and exercise camp at Ombika, near Okaukuejo. After the animal had spent fourteen days in the camp it was considered to have accepted its new environment. The animal was kept under constant observation for a period of 207 hours. Careful notes were kept on all its activities twenty-four hours a day. The daylight activities of the captured rhino corresponded with the daytime activities of the rhino in the study area. It was presumed therefore that the activities of the animal during the nights would be more or less comparable to its normal activities in nature. Table 26 shows the typical nightly activity behaviour of the captive animal during the observations. The observations were carried out from the 25th May, 1967 to the 2nd June 1967.

The observations support the speculation of a rest period during the night. The average length of this period for the captive rhino was 9.17 hours. There are indications that in nature an activity period of six to seven hours exist.
An inactive period of this length will allow for a visit to the water, substantial browsing, participation in social activities and/or movement back to the home range. In captivity no time is wasted in moving around looking for food and the animal have more time to rest. It was found in cattle (Worden 1950), that they spent seven to eight hours per day grazing. Of this time only about five hours could be counted as actually employed in gathering herbage, the remainder was spent in walking short distances. On the average, 60% of the grazing was preformed during the day, and 40% during the night.

Apart from the other periods of activity, the captive animal showed a rather marked rhythm of activity between 0145 to 0240 hours. This activity was usually limited and consisted of the animal rising, trampling around, nibbling and on four occasions defecating. Most of the activities might be attributed to the abnormal conditions in the boma. It is normal for an animal after lying down for a certain period to get up to exercise its muscles. Table 28 shows an activity rhythm during 1200 to 1400 hours which corresponds with the activity rhythm showed by the captive animal during the inactive period between 0145 to 0240 hours as shown in table 27. The reasons for the activity rhythm in table 28 is probably the same as for the activity rhythm in table 27 viz. exercisings its muscles. Another reason might be however, that the sun has moved so far that the animal has to move to follow the shade.

The observations on the captive animal indicates two activity peaks during a twenty-four hour period :

(i) Early morning peak and a
(ii) Late afternoon-early evening peak.

The author suggest calling the peaks :

(i) The dawn activity period and
(ii) The crepescular activity period.

Studying table 28 it seems as though the dawn activity period is the more important of the two activity peaks. It is felt however that the table does not reflect the crepescular activity period accurately, mainly because so few observations could be made after sunset. The rhinos are active for at least another three hours after sunset.

During the study several behavioural activities of the black rhinoceros during the crepescular activity

24 HOUR ACTIVITY CYCLE FOR BLACK RHINO IN SOUTH WEST AFRICA.

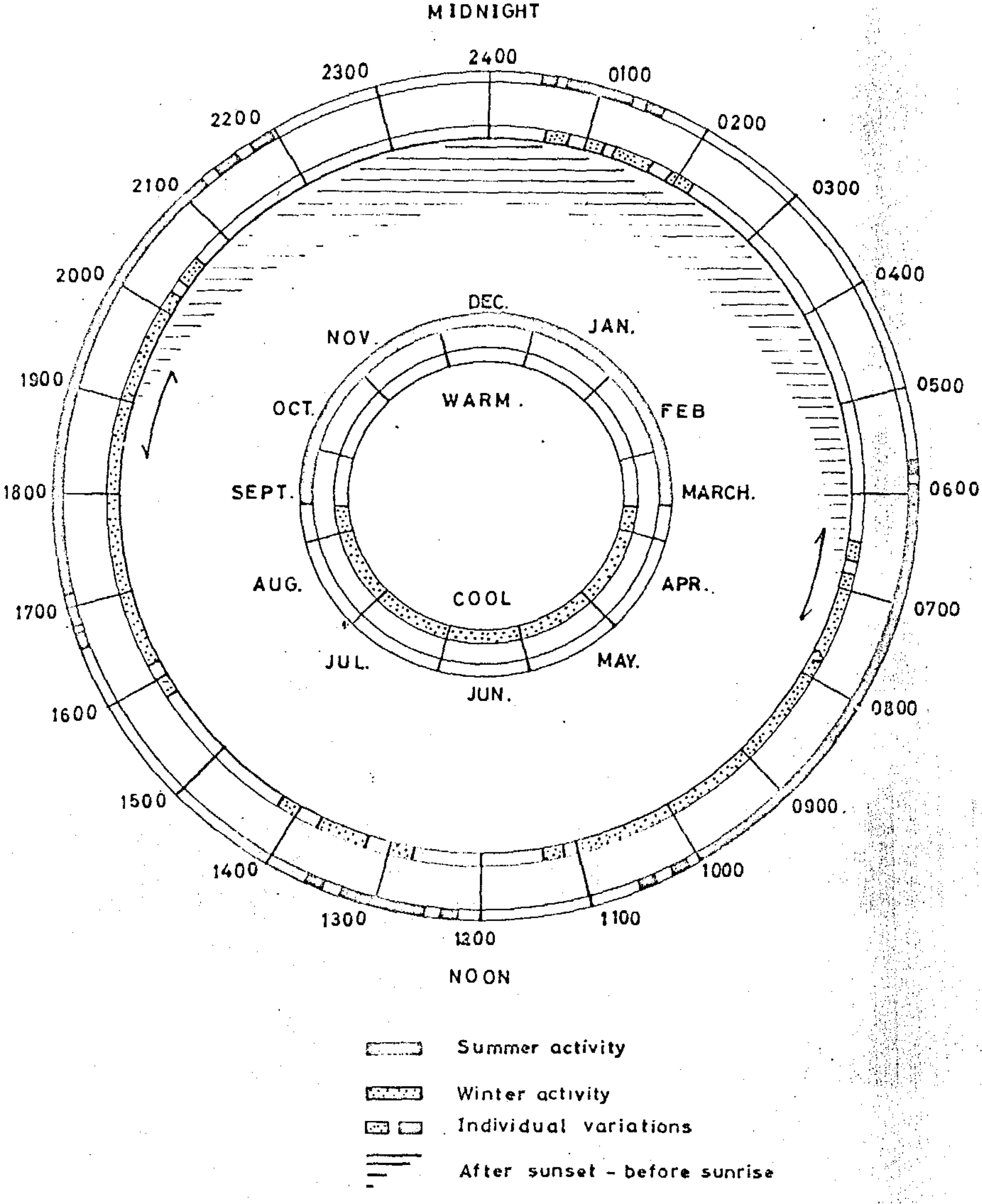

TABLE : 27.

NOCTURNAL ACTIVITY PATTERN OF A CAPTIVE BLACK RHINOCEROS IN SOUTH WEST AFRICA.

25/26 May, 1967.

Time.	Action.	Period. Active	Not active
2045	Lies down		1.25
2210	Up-Move about	0.10	
2220	Lies down		3.30
0150	Up-Move, defecates	0.05	
0155	Lies down		3.10
0505	Up move	0.10	
0515	Lies down		0.57
0612	Up-feed		

Total time active : 0.25 min.
Total time not active : 9.07

26/27 May, 1967.

Time.	Active.	Period. Active	Not active
2015	Down		0.55
2110	Up Move-Nibble	0.30	
2140	Down		5.00
0240	Up	0.15	
0255	Down		3.20
0615	Up feed defecate		

Total time active : 0.45
Total time not active : 9.15

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TABLE : 27 continued.

27/28 May, 1967.

Time.	Active.	Period. Active	Not active
			1.07
2038	Down		
2145	Up-Move-Nibble	0.41	
			3.49
2226	Down		
0215	Up-defecate	0.25	
			4.00
0400	Down		
0640	Up-feed		

Total time active : 1.06
Total time not active : 8.56

28/29 May, 1967.

Time.	Active.	Period. Active	Not active
			1.30
2030	Down		
2200	Up-Nibble	0.20	
			1.50
2220	Down		
0010	Up-Move-about	0.15	
			1.20
0025	Down		
0145	Up-defecate	0.11	
			4.24
0156	Down		
0620	Up feed		

Total time active : 0.46
Total time not active: 9.50

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TABLE : 27. continued.

29/30 May, 1967.

Time	Active.	Period. Active	Not active
2045	Down		1.15
2200	Up-feed	0.52	
2252	Down		1.28
0020	Up-Move-about	0.15	
0035	Down		1.15
0150	Up-Restless	0.09	
0159	Down		3.11
0510	Up-Move-about	0.17	
0527	Down		1.03
0630	Up Feed		

Total time active : 1.32
Total time not active : 8.12

30/31 May, 1967.

Time.	Active.	Period. Active	Not active
2019	Lies down		2.16
2235	Up-Nibble	0.17	
2252	Down		3.38
0230	Up-Move-about	0.07	
0237	Down		5.53
0730	Up		
0733	Start feeding		

Total time active : 0.24
Total time not active : 9.47

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TABLE : 27 continued.

31 May / 1 June, 1967.

Time.	Active.	Period. Active	Not active
1920	Down		1.30
2050	Up-Move-about	0.17	
2107	Down		2.23
2330	Up-Move	0.22	
2352	Down		2.15
0207	Up-Move-about defecate	0.08	
0215	Down		3.04
0519	Up-Move	0.08	
0527	Down		1.23
0710	Feed		

Total time active : 0.55
Total time not active : 10.35

(The observation is made from the time the animal lies down for the first time in the evening - till the time of the first feeding the following morning).

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TABLE : 28

TWENTY-FOUR HOUR ACTIVITY PATTERN OF BLACK RHINOCEROS IN SOUTH WEST AFRICA.+

Time interval	Total Observations.	Standing. %	Lying down. %	Browsing. %	Walking. %
2400 - 0100	7	43	43	14	-
0100 - 0200	6	17	83	-	-
0200 - 0300	7	29	57	14	-
0300 - 0400	4	25	75	-	-
0400 - 0500	4	-	100	-	-
0500 - 0600	8	25	38	37	-
0600 - 0700	8	25	12	50	13
0700 - 0800	14	7	7	50	36
0800 - 0900	22	5	-	54	41
0900 - 1000	26	15	27	31	27
1000 - 1100	28	14	39	18	29
1100 - 1200	28	32	50	7	11
1200 - 1300	25	20	44	16	20
1300 - 1400	26	19	46	19	16
1400 - 1500	24	33	46	8	13
1500 - 1600	21	38	38	10	14
1600 - 1700	25	20	32	24	24
1700 - 1800	19	26	-	48	26
1800 - 1900	13	23	8	46	23
1900 - 2000	10	20	10	50	20
2000 - 2100	8	12	63	25	-
2100 - 2200	9	22	67	11	-
2200 - 2300	15	20	34	33	13
2300 - 2400	5	20	80	-	-

+Observations on captive animal incorporated.

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periods were observed which suggests that this activity period is the more important one in nature. The activities are briefly listed below but are discussed elsewhere.

(i) Their habit of drinking water in the late afternoon (7.6 Drinking habits).

(ii) The fact that they usually cover longer distances during this period (8.9 Movement).

(iii) The tendency to scatter their dung with greater regularity during this period (8.8 Sanitary behaviour).

An aspect which might have an influence on the crepescular activity period of the rhino is the moon. During the study no opportunity arose to do any observations. Mr. F. Gaerdes (<u>pers. com.</u> 1967) observed that the full moon had a marked influence on the activity of kudu, gemsbok and the smaller antelope. During the periods of new moon the animals are much less active.

8.7 <u>Wallowing, dust bathing and rubbing.</u>

Rhino in certain parts of East Africa seem to indulge more frequently in the wallowing habit than those in South West Africa. Both Ritchie (1963) and Guggisberg (1966) state that rhino frequently wallow after they have quenched their thirst. Most of the permanent waterholes in South West Africa are situated in rocky localities unsuitable for wallowing. In the Kaokoveld and western Etosha National Park there are only a few places suitable for wallowing throughout the year. During this study the present author never once had the opportunity of observing rhino wallowing at regular waterholes although considerable time was spent near them.

In the study area most of the wallowing activities observed took place during the rainy season in rain water pans. These pans are regularly visited when they contain water and some of them seem more popular than others.

Several reasons are offered to explain the wallowing behaviour of rhino. One of the most common is that the rhino rolls in the mud and after this has baked dry, the mud falls off or is rubbed off together with the ticks. Ticks observed on rhino in South West Africa were found to occur under the tail around the anus, while the concentrated rubbing effort by rhino after a wallow is directed to the sides of the body.

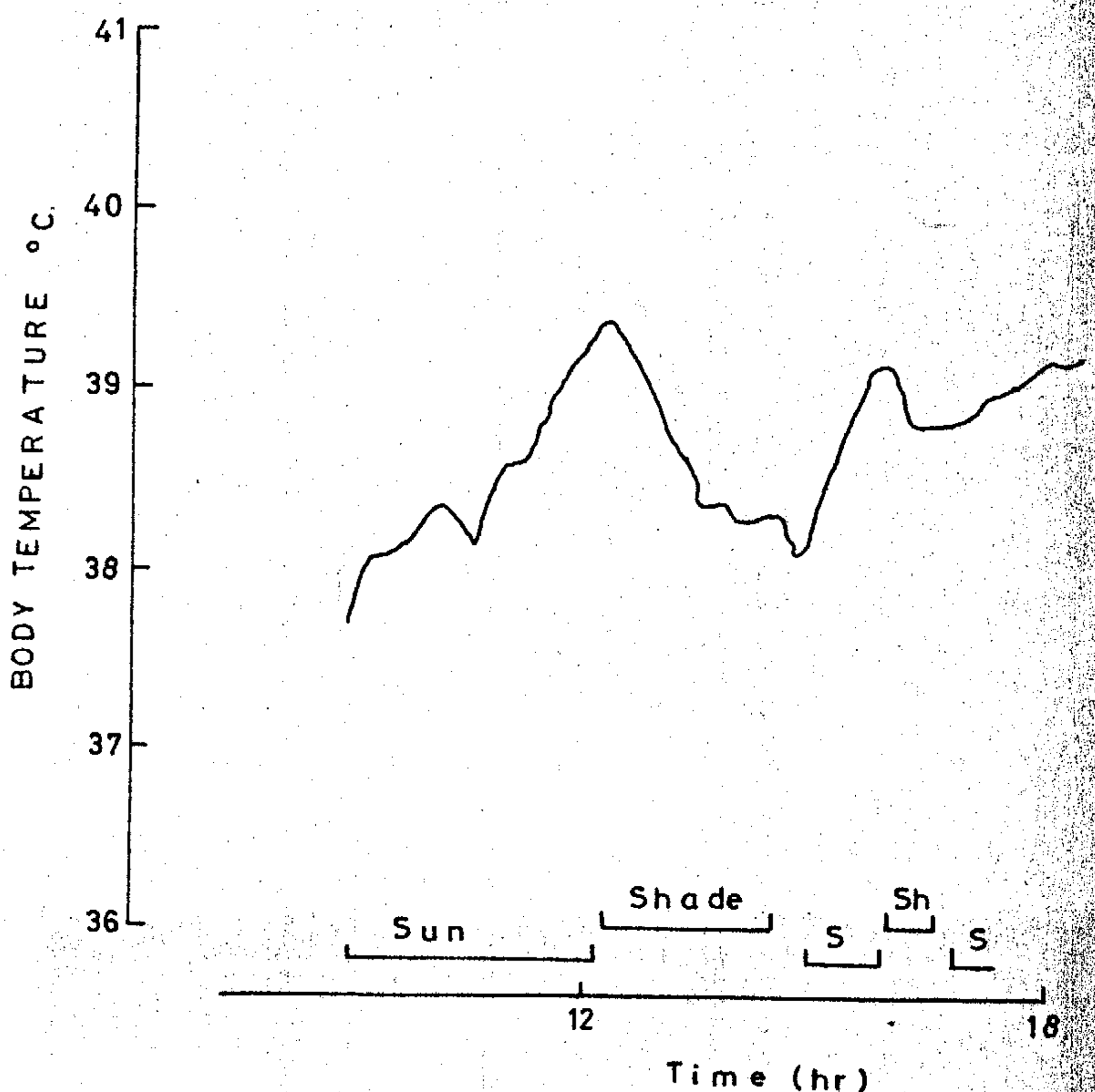
According to Guggisberg (1966) wallowing is "the most important and most efficient way of cooling down, and when rhinos come to drink they almost always take the opportunity of rolling in the mud for a while" Goddard (1967), states that this is undoubtedly a method of cooling, and disposes of excess heat accumulated in the body during the day. While this could be true there are several other factors that must be borne in mind :

(a) Goddard states that more than ninety persent of the observations of rhino wallowing were noted between 1600 hours and 1800 hours. Guggisberg implies that rhino usually drink and wallow at sunset or later. As the maximum daily temperature is usually reached at midday the environmental temperature is well on its way down by sunset, when wallowing takes places.

(b) Harthoorn (1965) has shown with the aid of telemetry how a black rhino's deep body temperature drops when the animal is inactive in the shade (See figure 14). Resting, during the midday heat, is the

FIG.14. THE DEEP BODY TEMPERATURE OF A 2-YEAR-OLD BLACK RHINOCEROS.

(AFTER BLIGH AND HARTHOORN, 1965)



normal occupation of the animal; accordingly very little heat is accumulated in the animal's body.

(c) Although Guggisberg states that rhino do not perspire it was found that they do in South West Africa. This was recorded during the immobilization and translocation of rhinos. It might be argued that these animals were under stress; perspiration, however, was also noticed in animals lying up during the midday rest (10.4 Relative humidity). Perspiration could thus also contribute in lowering the body temperature.

(d) That the greater number of rhino in South West Africa do not wallow during the warm, dry season of the year because of the lack of suitable places. Obviously these animals have to rely on some other mechanism for lowering body temperature.

During the dry season the rhinos usually take dustbaths. Guggisberg (1966), states that they usually take a sandbath as well, after having first wallowed. In South West Africa it was found that the preferred spots are depressions worn out by zebra rolling, filled with a powdery dust. At Renostervlei there is such a depression about a hundred yards from the water, next to the rhino footpath. On the 6th October 1966, in home range P_2, MP_3 was observed taking a dustbath on the hardpacked surface of the red soil in this area.

Rubbing activities can be divided into two distinctly different categories. The first usually takes place after the animal has taken a wallow. The boles of trees surrounding the rainwater pans are often covered by mud. At one of these pans a rock about eighteen inches high was preferred, probably because of the sharp edges. On the farm Landeck 77, in the Welwitchia district, tree stumps that were cut off about thirty inches above the ground were also used as rubbing posts (See photos 35 and 36). Rubbing of the first category is usually a vigorous movement against a tree or any sturdy object. The shoulders, the sides and the hind quarters of the body receive most of the attention. This rubbing may however also take place without being preceeded by a wallow. ME_2 was observed one morning after he had finished browsing, to rub himself against a termite mound. After rubbing both sides of the body, he rubbed his horn, occasionally trying to push it into the mound.

The second rubbing activity takes place throughout the year and more often after the early morning browse and during the midday rest. This rubbing is a more delicate process than the previous activity described. They rub, or scratch, the one side of their head and neck and then the other side against a twig not thicker than a man's thumb. Apparently this is also an enjoyable pastime. During this rubbing process the neck and sides of the head receive most of the attention. The captive rhino as well as others in the study area, were observed to indulge in this activity.

8.8 Sanitary behaviour.

No other single aspect of the black rhinoceros activity has caused so much controversy as the activity during which the dung is scattered. Numerous possible causes for this behaviour have been put forward. According to Ritchie (1963), the native explanation (East Africa) of this habit is that the rhino was ordered

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by the elephant to scatter their dung because it looked so much the same as the elephant's and they (the elephants) disliked the idea. The Zulus believe that the rhino is looking for a mythological needle which the first rhino put in his mouth for safe keeping after all the animals had sewed themselves up. The rhino then swallowed the needle by accident and all the rhinos have been looking for this needle ever since. Another popular reason given is that the rhino is subjected to constipation, due to its diet, and after having finished defecating, kicks the dung apart in blind fury. The habit of rhino to deposit dung in certain limited localities was also used at one stage to confirm their supposed territorial behaviour.

Detailed study during the last few years brought other probable explanations to light. Work by Guggisberg (1966), and von Schenkel (1965), indicates that the scraping and urinating activities of the male rhino at times become part of the sexual behaviour. Scraping by females are more or less intended to be examples for their young calves. Experiments by Goddard (1967) in the Ngorongoro crater prove that rhino are able to follow faecal scent trails. The scraping movements of the hindlegs smear the hind feet, which leaves a scent trail. Goddard suggests that those scent trails enable the animal to orientate itself within its home range. The terrain within the study area unfortunatly did not allow for any experimental work of this kind to be carried out.

Von Schenkel (1965) is most probably right when he assumes that the scraping of dung and spraying of urine in rhino are a form of marking. Marking he defines as "when a mark is set which persists and can be perceived by other members of the species and therefore make possible an indirect contact between them".

He came to the conclusion that the single behaviour patterns belonging to marking can be observed as signs of excitation when two animals meet, but also when rhinos meet indirectly by means of marks. Occasionaly an aggressive component in the excitation is undeniable, especially in males - in other cases marking rather expresses an atmosphere of familiarity or solidarity. According to von Schenkel marking has important fuctions for the population :

(i) the indirect contact amongst individuals of a population and

(ii) the modelling of the environment as home range which is adjusted to the life of the population.

In the study area and with the captive animal at Ombika the following observations were made. The act of defecating usually follows the same pattern. When reaching the dung heap the animal usually walks slowly across it without any perceptible indication of smelling at it. At the far end of the heap it stops and does a few preliminary scraping movements with each leg. While keeping the front legs stiff it slowly shuffles the hindlegs forward until the hindquarters project at an angle backwards. The tail is curled tight over the small of back. The animal then proceeds to defecate. Having finished, the animal scrapes both hindlegs in three or four vigorous movements through the dung - sometimes slowly moving forward while doing so. The animal then walks off, usually without any backward glance. Goddard (1967), found that the rhino in the Ngorongoro crater sniffed at the dung pile extensively before defecation. This behaviour might be due to the high rhino population in the crater and the extensive overlapping of home ranges.

The animals there might be constantly on the alert for strange individuals. In the study area it was found that the maximum number of individuals that might pass a certain dung pile, favourably situated 'en route' to water, would be three during twenty-four hours. During the time of study no strange individuals were noticed in the home ranges. This would suggest that because of familiarity with other members of the group and/or the clan the rhino in the study area is less inclined to smell at the dung except possibly on perceiving a strange smell or when sexually stimulated.

It was also observed that the length and depth of furrows, caused by scraping, differed in the same type of soil. This suggests that the intensities of these movements also differ. On only one occasion a rhino (ME_2) was observed slashing at a mopane bush with its horn after defecation (Photo 27). The present author never observed or saw any indication of rhino scattering dung with their horns as is sometimes stated.

During observations in the study area it was noticed that rhino tend to scatter their dung more often during the crepescular activity period. Most of this scraping activity takes place along footpaths leading to the waterhole. During the dawn activity period the animal is usually within his home range where defecating is frequently not accompanied by scraping. The rhino in captivity at Ombika scraped nearly every time he defecated.

In the study area dung was deposited at the following localities :

(i) Along the footpaths leading to the water-holes - the distances between the deposits becoming shorter the nearer one gets to the water. The deposits along these footpaths

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were invariably scattered. No dung was ever noticed in the waterholes, or near the edge. A pile of dung is usually made about 10 to 15 yards from the water's edge, the best examples being at Springbokwasser and Ombarundu. Elephant seem to defecate and urinate with concentrated effort at waterholes, sometimes befouling the water to such an extent that it is hardly utilized by other game.

(ii) The rhino footpaths leading to waterholes in the study area had to pass in most cases over ridges and hills. In all the instances large deposits can be found just where these footpaths pass over the hill top. At some of these localities the dung is about twelve inches deep and spread along the footpath for five to ten yards. No other deposits of this size, were found anywhere else in the study area.

(iii) At irregular intervals on the tops of the ridges and hills that are frequented during the summer months in the study area. Defecation is frequently not accompanied with scattering behaviour. Defecation might occur on old dung.

(iv) At random localities throughout the plateau area of the home ranges. Defecation seldom occurs on old localities - the possibilities of the rhino coming across old dung are less due to the extensive area. Scattering of dung is usually limited to sites along the roads crossing this area.

The rhino in captivity defecated four to five times every twenty-four hours at irregular intervals. The rhinos in the study area were also observed to defecate more than twice during a twenty-four hour period. The most constant defecating time, in the captive animal, during the period of observation, was every morning between 0603 hours to 0645 hours. This early morning defecating habit was also noticed in the study area. During this defecating activity more dung was dropped by the captive animal (3-4 balls) than any other time during the twenty-four hour period. In the study area this also seemed to be the case. It was observed that the rhino in captivity, when passing his dung pile usually stopped and defecated, sometimes depositing only one ball after standing for four to five minutes. The same behaviour was observed in the study area. During the 20th April 1967 the male ME_2 was kept under observation. During the dawn activity period he crossed his own dung deposited only a few days previously, (which he scraped at the time) and, without sniffing at it, paused a moment, deposited one ball and moved off without scraping. This would suggest that rhino are stimulated to defecate through both physiological and psychological impluses. Physiological when the need should arise and psychological whenever passing a dung pile. They do not, however, defecate at every dung pile they pass.

In the captive animal, urinating sometimes preceeded or followed defecation by only a few minutes. But neither the captive animal nor any rhino in the study area ever defecated and urinated at the same time. According to Ritchie (1963), elephant frequently do so. In the males the urine is sprayed backwards through the hindlegs (photo 39) - usually against a shrub. On top of one of the hills the footpath to water passes close to a mopane tree which grows within a dung pile. The bole of this tree is covered by a white coat of urine. In contrast with the males the females usually did not urinate against shrubs.

8.9 Movement.

Movement is one of the chief means by which the higher animals maintain themselves within the fairly wide limits of ecological normality (Darling 1936). It was found that, with the black rhinoceros, movement is primarily induced by body requirements, i.e. the need to feed and/or to quench a thirst. The physiological process of reproduction and the influences of climatic factors also contribute to the movement of black rhinoceros over the home range. The influence of the latter two on movement is, however, much more variable. Movement in the black rhinoceros may be divided into three categories viz. :

8.9.1 Daily movement

8.9.2 Seasonal movement and

8.9.3 Wandering.

8.9.1 Daily movement.

No definite information on the range of daily movement has been published. Guggisberg (1966), reports that along the Uaso Nyiro, rhino are said to travel eight to ten miles to water and back into the thornbush. Ritchie (1963) states that the feeding area is usually situated 5 to 15 miles from water. In desert country rhino are sometimes found 30 miles from water. G Guggisberg reports that in well-watered places, like Amboseli and Mara Reserves, many of the rhino hardly move more than two to three miles in twenty four hours.

He states that one individual does not move more than a few hundred yards from his bed in twenty-four hours. It was found in the study area that apart from the regular visits to the waterholes the movement of rhino were for the greater part very irregular. Movement within the home range is highly unpredictable. The average daily distance covered by rhino in their home ranges also shows a great variation.

In the study area the distance covered by one individual during the course of twenty-four hours may vary from one to eight miles. Because of individual variations it is impossible to give definite figures.

As one moves west, the differences between the minimum and maximum distances covered during twenty-four hours become greater - mainly due to the resulting larger home ranges. During May 1966 a series of observations were carried out on three successive days on the same family group in the sub-desert region, at Springbokwasser. The first day they rested three miles from the waterhole, on the second day they rested within two hundred yards from the waterhole and on the third day sixteen miles away. During the 1966/1967 rainy - post-rainy season a family group of rhino utilized a range of hills twenty-five miles west of Orupembe. The nearest water is the seasonal waterhole Ombarundu, which lies approximately 16 miles to the north west of the abovementioned hills. During this period the animals covered the total distance of 32 miles every second night.

Although individual variation does exist there seems to be an inclination by the rhino to move over greater distances during the crepuscular activity periods than during the dawn activity periods. The animals usually visit the waterholes during this crepescular activity period. As has been stated previously, the animals whose home ranges are some distance from the waterhole first cover this distance after drinking water before they start active browsing. This distance to and from the water has to be added to the total distance covered during the crepescular activity period. Movement during the dawn activity period usually only consists of the distance covered during the early morning browse to the midday resting place.

9.2 Seasonal movement.

As already mentioned, the black rhinoceros shows an inclination for seasonal movement within the home range. In the study area it consists of a vague preference for the hilly parts during the non-rainy season and a preference for the plateau during the rainy season. In the desert region with larger home ranges, and subsequently longer distances to cover, this seasonal movement is much more marked. The movement in the sub-desert region is usually along the dry river courses. These movements have been recorded along the Springbok-, Unjab-, Munutum-, and to a lesser extent the Hoanib and Hoarusib Rivers.

The movement along these rivers usually coincides with the rainy season. Although no or little rain falls in the desert the run-off from rains in the escarpment area feeding these rivers is considerable. The movement along these rivers is usually inverse to the drop in the average temperature from about May (See 10.2 Temperature).

At Orupembe, situated in the sub-desert about fifty miles from the coast, on the lower edge of the escarpment, the author was able to make some observations on this behaviour. About halfway down to the coast the Munutum River cuts through a range of hills. The hills on the northern side are formed by a blackish shale and mica formation. The drainage system of these hills consists of deeply eroded gullies and lie at right angles to the prevailing south-west winds. Different species of Euphorbias, aloes, certain dwarf commiphora and other succulents abount in these hills. Nothing similar has been observed elsewhere in the Namib north of the Unjab River.

The individuals of one family group with their home range to the north west of Orupembe move down the Munutum River every year. They visit the abovementioned hills regularly between January till about July. The gullies offer protection against the cold winds and also provide a variety of food plants. During these cold periods the midday rest is spent basking in the sun at the bottom of one of these gullies.

8.9.3. Wandering.

Apart from the regular daily and seasonal movement, black rhinoceros reveal another type of movement which can be called wandering. This occurs when an individual or individuals leave their home range and wander to regions beyond normal boundaries of activity. This tendency may occur more frequently in areas with high population densities.

The opportunity did not arise during this study to make any personal observations. A few records of this behaviour are available however. A game ranger reported that while patrolling the southern border of Etosha National Park, during 1965 he noticed the spoor of an individual, which he followed for fifty miles along the fence. During 1967, tourists reported that they saw two rhinos, later confirmed to be a cow and her calf, at Wolfnes. These two rhinos immediately left the area again. No rhino has ever been known in this area. The nearest resident rhino population to Wolfnes is at Grünewald, about thirty miles away. Presumably the cow and calf were from Grünewald.

No reference could be found in literature indicating similar behaviour in black rhino elsewhere. Ripley (1952) however found something similar in the Indian rhinoceros. He reports that one rhinoceros crossed the Brahmaputra River and arrived at the Orang Sanctuary. He does not mentions the distance covered by the individual. Both males and females show this behaviour and he attributes it to the physiological impulses of reproduction, as this movement usually takes place during the breeding cycle.

From the few available records pertaining to the Kaokoveld, it seems that there is a tendency for this wandering to occur during the rainy season, and also that males are more apt to show this behaviour. It is difficult to explain this behaviour but the movement might be influenced by any one or more of the following :

(i) a natural urge to expand their distribution.

(ii) inquisitiveness.

(iii) unfavourable conditions in their previous home range.

(iv) sexual motivations.

No information could be found on the eventual destiny of these animals. Much more information is needed before the questions raised by this particular behaviour can be answered.

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CHAPTER : IX

REPRODUCTION.

Owing to the difficult terrain of the study area and the small number of black rhinos it was extremely difficult to obtain information on reproduction and mating behaviour through observation only. Most of the data have been obtained from published results of work done elsewhere, mainly in zoological gardens.

9.1 Gestation period.

A great many different periods of time are given in literature for the gestation period of black rhinoceros. According to the undermentioned authors it varies from :

330 - 390 days (Astley Maberley 1959).
360 - 390 days (Bere, 1962).
446 - 478 days (Goddard, 1967).
450 - 480 days (Ulmer 1958, Crandall 1964).
480 - 540 days (Shortridge 1934, Roberts 1951, Smithers, 1966).
540 - days (Ritchie 1963, Carter 1965).
more than 540 days (Klingel and Klingel 1966).

Records available from zoological gardens are on the whole more accurate because of the closer watch that can be kept on the animals and one should let this guide one to the most probable length of time for the gestation period. Black rhinos have been bred in captivity since 1956, when the first calf was born at the Rio de Janeiro Zoo, Brazil. Since then rhinos have been bred all over the world viz. U.S.A., Europe, Britain, Australia and Japan. From table 29 it would then appear as though the

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TABLE : 29

DATA ON THE BREEDING BIOLOGY OF THE BLACK RHINOCEROS.
(FROM INTER ZOO YEARBOOK 1967).

Name of Zoo.	Age of 1st successful mating	Oestrous cycle length	Duration of oestrous.	Gestation period.
Bristol	6 years	21-45 days	1-2 days	438 days
	ca 6 "	17-60 "		419 "
		21 "		438 "
Hanover	ca 7 "	28 "	3-4 "	469 "
	ca 9 "			
Kobe		28-30 "	5-6 "	ca 465 "
				ca 462 "
Mysore	ca 17 "	30-35 "	1-2 "	458 "
Pittsburgh	ca 7 "			463 "
				454 "
				457 "
Sydney		18 "	2-3 "	ca 476 "

gestation period of black rhinoceros is between 438 to 476 days. This compares favourably with the two records obtained by Goddard (1967), at the Ngorongora viz. : 446 to 478 days.

9.2 Breeding Cycles.

It is a well-known fact that wild animals usually calve at certain times of the year. This takes place during the period of the year that assures optimum conditions for the suvival and growth of the young.

With the black rhinoceros, however, this does not seem to be the case. Asdell (1946), Ripley (1958), Ansell (1960), Burton (1962), Ritchie (1963), Smithers (1966), take the view that the mating and calving of this particular animal takes place throughout the year. Guggisberg (1966), comments that the available evidence goes a long way to prove this. Ripley (1958), states that Ward reports that calves appear approximately twice a year - eg. winter calves and summer calves. Lydekker (1926), states that calving takes place at the end of the rainy season. Wilhelm (1933), notes that in the Caprivi calving takes place during the rainy season. Klingel and Klingel (1966), mention that during two years eight calves were born in Ngorongoro crater, all during the rainy season (December to May). During the same observation period as that of Klingel and Klingel and also in the Ngorongora crater, Goddard (1967) records the birth of calves from August to September. Accepting the fact that black rhinos do calves throughout the year it is logical that a certain percentage would be born during the rainy season. The majority of workers accept that mating and calving takes place throughout the year.

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TABLE : 30.

BREEDING DATES OF *DICEROS BICORNIS* IN SOUTH WEST AFRICA.

28th December 1967	:	Otjovasandu (P_2).
January 1967	:	Springbokwasser.
March 1966	:	Versteende Woud (Farm 485).
March 1966	:	Noupoort (Farm 511).
March 1967	:	Kaross.
March 1968	:	Orupembe.
April 1967	:	Otjovasandu (E_1).
May 1966	:	Otjovasandu (E_3).
May 1967	:	Usakos.
June 1967	:	Kaross.
Beginning of August 1967	:	Otjovasandu (E_3).

Most of the abovementioned information was obtained by workers on the eastern side of the African continent. Although evidence at present is still only tentative, it seems that the black rhinos in the Kaokoveld tend to drop their calves during the rainy season and post-rainy season (See table 30). In this way the cow has the drain of lactation during the vegetative growing season. This latter is very short as the Kaokoveld is extremely arid. On the eastern part of the rim of the escarpment the average rainfall is 12 inches, with an evaporation rate (from a free water surface) of 120 inches a year. The rainfall decreases sharply towards the west; in the relatively short distance of eighty miles it may decrease to 4 inches or less a year.

Accepting the possibility that the calving season in the Kaokoveld is adapted to the rainy season, the mating must take place from about August to December. To be able to do this the animal must possess an internal physiological mechanism and/or it may also be influenced by physical factors. There are the following possibilities :

9.2 Infertility during certain seasons of the year.

9.2.2 The influence of day length.

9.2.3. The physiological influence of nutrition.

9.2.1 Infertility during certain seasons of the year.

According to Yeates and Parer (1962) high environmental temperature predisposes to a lowering of fertility in males. Thus rams, bulls and boars sometimes display lowered fertility in hot weather and this has been referred to as "summer sterility" in the case of rams. Gunn, et al, (1942) states that high air temperatures leading to increased body temperatures and subsequently increased scrotal temperatures are associated with poor semen quality in rams and bulls. Heat stress of the female is known to result in lowered reproductive efficiency in some species of farm animals. (Yeates and Parer 1962).

No work of this kind has been done on the black rhinoceros. The present author does not think, however, that this factor plays an important role in the reproductive physiology of this animal. During the part of the day when the temperature is at its highest and the heat radiation from the calcium and metaquartzite pebbles, which cover large areas in the Kaokoveld, must also be high, the animal rests in shade. In this way his body is not exposed to these possibly harmful effects from temperature. Harthoorn (Ecological Symposium, Pretoria 1967) showed that the body temperature of animals (rhino included) drops considerable when inactive in shade (See 8.7 Wallowing).

If temperature did have an influence on the fertility of black rhinoceros it follows that they must be infertile from about September - October to the end of March, the hottest months of the year. This does not fit in with the breeding pattern showed by rhinoceros in the Kaokoveld.

9.2.2. The influence of day length.

Rowan published his paper on the inlfuence of light in 1925. Since then a large amount of work has been done in this particular field. Bullough in his Vertebrate Sexual Cycles (1951) briefly discusses some of the more important works.

Day length is an environmental variant which is always constant in a particular latitude for a given day. The light reacts on the retina of the eyes and the impulse is relayed from here to the hypothalamus via the optic nerves. The hypothalamus then releases a substance into the blood stream that stimulates the release of gonadotropins by the pituitary gland. (Lasley 1962).

From 21st June, the day length increases daily with resulting shortening nights. It could be that by

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about September the day length has increased sufficiently to trigger the abovementioned mechanism in the black rhinoceros. Another Perissondactyl - namely the horse, shows that sexual activity in both sexes is influenced by the season of the year and is probably related to day length. Activity is usually greatest during the spring and summer when the days are long (Fig. 15).

Considering the abovementioned, day length might well be the cause of the breeding cycle in the Kaokoveld black rhinoceros. However, the fact that the black rhinoceros on the eastern side of the continent does not show breeding cycles eliminates day length as a possible factor in determing the onset of the mating behaviour by black rhinoceros. This leaves the third possibility.

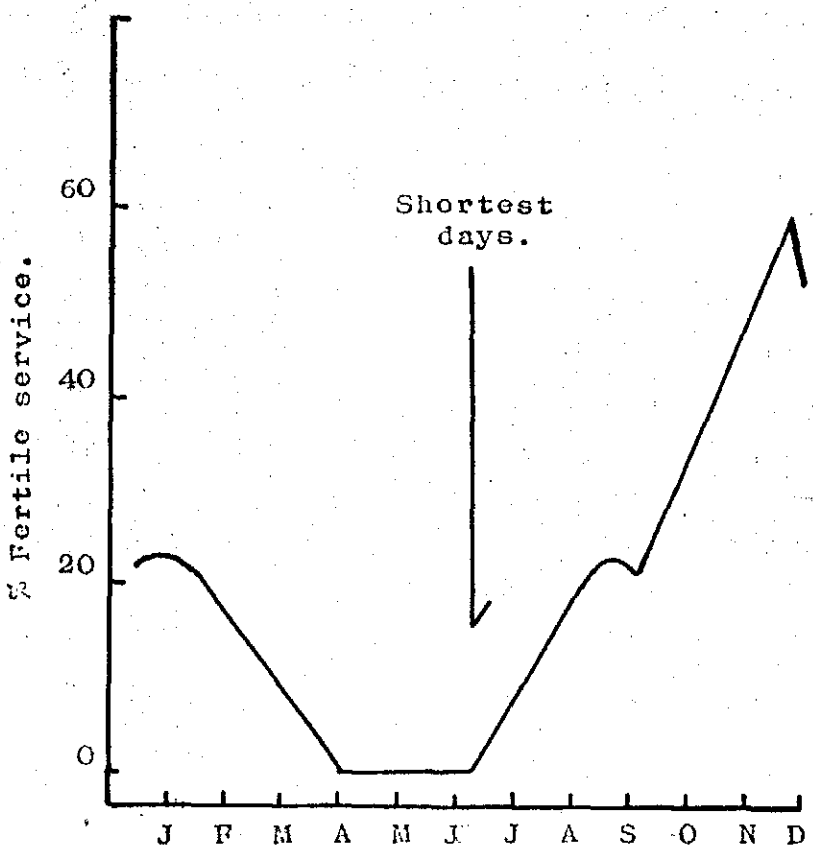
9.2.3 <u>The physiological influence of nutrition.</u>

Rams and bears have been noted to suffer seminal degeneration some months after being on a low plane of nutrition. Protein deficiency can affect fertility and sexual expression and in bulls the density and viability of sperm have been shown to be in direct proportion to the amount of protein in the ration. Males may be more susceptible to vitamin A deficiency than females. In vitamin A deficient rams, seminal degeneration is present whether the animals have lost body weight or not (Yeates and Parer 1962).

Other workers have also shown the importance of the abovementioned facts (Cheatum and Severinghaus, 1950, Hart and Guilbert 1933, Allen and Lamming 1961, Mann and Rowson 1951). It can thus be accepted that protein and vitamin A play an important part in the succesful calving and mating of most animals.

FIGURE : 15

BREEDING SEASON OF MARES AT ONDERSTEPOORT, PRETORIA.



(From : The reproduction of horses, by Nishikawa and Hafez who adopted the graph from Quinlan, <u>et al</u>., 1950. Onderstepoort J. Vet. Res. 25.105).

In nature the natural source of protein and vitamin A is green vegetation. This again is closely correlated with rainfall. Observations on some of the wild ungulates in Africa have shown that there appears to be some relationship between the rutting and breeding activities and the rain. Talbot and Talbot (1963) found that through the effect of rainfall on vegetation, rainfall does exert a significant effect on the timing and success of calving. It was found in the Etosha National Park that springbok, wildebeest and burchells zebra also tend to calf/foal during the rainy season.

With black rhinoceros, being a browser, the situation slightly changes. During September to October some trees (especially the acacia species) and shrubs show flushing independent of rainfall. Flushing is caused by increased day length and temperature and causes a greater flow of sap. During this period the protein (See Food preferences) and vitamin A content of the plants are higher than in the preceding months. It is also known that some of the plant hormones present in the plant during the growing season closely resemble certain sexual hormones in mammals. No physiological work has been done but the author thinks that this factor (flushing of trees and shrubs) may prove an important factor in the stimulation of mating activity in the South West African black rhinoceros.

9.3 Mating habits.

Goddard (1967) states that rhino are polyandrous and polygamous. Although the females tend to share a home range with one male in the study area no proof could be found that these animals are not polyandrous and polygamous. The chances are good for a 'bachelor' male to meet a female in oestrous at the regular waterhole.

9.4 Sex ratios, breeding rate and survival rate.

In the study area the ratio of male : females was 1:0.87. All the females (apart from the immature ones) were accompanied by calves, giving a cow; calf ratio of 1:1. This is the absolute maximum and indicate that the study area at present allows an optimum population increase. Elsewhere in the Kaokoveld the male: female ratio is very much higher in favour of the males, the most obvious reason being that the females are antagonistic while they have young calves, with the result that they are wiped out more frequently than males, which are less antagonistic, by the local inhabitants.

No records are available from the study area on breeding rates but Goddard (1967) found that available evidence elsewhere suggests that a healthy female could be expected to produce a calf approximately every 27 months. As all the females during the two year study period, were always accompanied by calves one may deduce that the survival rate of the calves is also quite high in the study area.

CHAPTER : X

INFLUENCE OF WEATHER.

10.1 General.

Complex elements of nature constitute the climate of a given area. These elements are interrelated, and their influences on biota are exerted in various ways. Although the influence of the microclimate is infinitely more important to plants and the smaller mammals, one cannot under-estimate its importance on black rhinoceros behaviour. They use the microclimate to reduce the severity of macroclimatic factors. Only instruments to record macroclimatic factors were available, but certain activities were thought to be related to some microclimatic influence. During this study the macroclimate received more attention than the microclimate.

Although the fluctuations of the physical factors in the study area, or the Kaokoveld for that matter, are severe, it recurs in a regular rhythm. Accordingly, it was extremely difficult to assess the influence of climatic factors on the behaviour pattern of the black rhinoceros. With the present meagre information and the lack of controls, it was usually impossible to ascertain in more than a general way how the innumerable possible combinations of these physical factors may affect the behaviour pattern.

Changes in the habitat brought about by changing physical factors, affect every community directly or indirectly. One cannot overemphasise the importance of physical factors on the normal life, both biological and physiological. In this regard temperature and rainfall are the two more important physical factors in the ecology of the black rhinoceros.

10.8 Temperature.

Table 30 shows the fluctuations in temperature recorded in the study area during the time the study was carried out. The range between the mean maximum and mean minimum monthly temperatures varied between 13°C in February to 24°C in August. From April till September the nights were extremely cold whilst the days were moderately hot. The absolute maximum and minimum temperature recorded for September was 37.7°C and 1.1°C. This represents a variation of 36.6°C. It is interesting to note that the lowest recorded maximum temperature (31.1°C) and the lowest minimum temperature (1.1°C) were not recorded during the same month. The daily temperature is usually reached at about two o'clock in the afternoon. South West Africa and the Republic use the 30th longitude to calculate their time. Due to this the local "sun time" is approximately one hour behind the calculated time.

That the rainfall and cloud cover have a marked influence on temperature is clearly shown by the moderate temperature range recorded during February when 19 days were recorded to have a 5/10 or more cloud cover.

The influence of temperature on black rhinoceros behaviour is both physiological and biological and shows marked rhythms, both daily and seasonally. Temperature has

(a) a direct bearing on food intake as it has a marked influence on the total time spent during the day on browsing, and

(b) an indirect influence on the nutritious value of the vegetation through the occurrence of frost.

TABLE : 31.

MONTHLY TEMPERATURE (°C) AT OTJOVASANDU,
SOUTH WEST AFRICA, 1966/1967.

	MAXIMUM.				MINIMUM.				
	Mean	Range	Highest max.	Lowest max.	Mean	Range	Highest min.	Lowest min.	Range max.-min. means.
January	35.0	10.6	40.0	29.4	15.3	10.0	20.0	10.0	19.7
February	32.4	9.5	37.2	27.7	19.4	7.8	22.2	14.4	13.0
March	33.0	11.1	37.7	26.6	16.6	8.9	20.0	11.1	16.4
April	30.1	7.8	34.4	26.6	12.1	20.0	20.0	0.0	18.0
May	28.0	5.6	32.2	26.6	10.1	13.3	18.8	5.5	17.9
June	27.8	6.6	31.1	24.4	10.5	16.6	17.7	1.1	17.3
July	27.3	4.5	31.1	26.6	7.6	11.1	16.4	3.3	20.2
August	29.4	13.3	33.3	20.0	5.4	18.8	17.7	1.1	24.0
September	33.6	12.2	37.7	25.5	12.2	16.6	17.7	1.1	21.4
October	35.1	8.8	38.8	30.0	17.1	10.0	21.1	11.1	18.0
November	37.7	14.5	42.2	27.7	16.0	11.1	22.2	11.1	21.7
December	34.7	13.4	40.0	26.6	15.9	8.9	21.1	12.2	19.0

The biological influences comprise largely the factor of disturbance by insects. The insects mainly responsible for this are mopane bees (Genus Trigona) and stinging flies. These insects are generally more numerous during the warmer part of the year and also more active during the heat of the day.

While sleeping, during their midday rest, the rhino keept their ears and tails in constant motion. The ears sometimes stop this rhythm and cock - apparently to listen - then resume the motion, starting with a quick twitch. Mopane bees can nearly always be seen flying around the ears, nose and eyes of the rhino. The following observation was made in the study area of a rhino calf that was most obviously being agitated by mopane bees.

11th August 1967 : Home range E_3 ; Female FE_3 and calf.

Temp.Max. 24°C : Min. 9°C : Cloud cover 0/10 : Wind East 3 (Noon).

The animals left their resting place at 1307 hours. This was in a dense clump of vegetation and their forms were only vaguely visible. No reason can be given for this sudden change. At the new resting place they lied down underneath a mopane tree at 1400 hours. At 1420 hours the calf started showing signs of being uncomfortable. She fanned her ears vigorously, occasionaly tossing her head. At 1437 hours she got up and shook her head a few times and finally with a snort pushed it into a dense stand of mopane bush. Use of binoculars showed insects, which resembled mopane bees, flying around her head. At about 1445 hours the calf walked around and lay down on the other side of the cow. During this episode FE_3 lied undisturbed fanning her ears without even opening her eyes.

10.2.1 Daily rhythm.

There is a definite relation between the temperature and the length of browsing during the day. The higher the temperature, the shorter the daylight time spent on browsing. The opposite is also true to a certain extent. How sensitive to temperature these animals are can clearly be shown by the following example. A rhino in captivity was watched continuously for 207 hours. During the first few days of observation, a 24 hour activity cycle for the rhinoceros was established (See full details under : Daily activity cycle). During the last few days an exceptionally cold spell of weather occurred and it had a marked influence on the daily activity of the rhinoceros. The condensed data from field notes show the daylight activity of the rhino during this period.

29th May 1967 : Temp.: Max. 26.8°C Min.: 9.2°C.

0620	Rhino up feeds.
0720	Urinates, continue feeding.
0928	Defecates.
0935	Stops feeding. Stands with head hanging low. Typical posture when at rest while standing.
0958	Moves over and lies down in shade of mopane tree.
1140	Gets up - Moves around - nibbles a few minutes.
1205	Lies down in shade.
1320	Defecates.
1325	Drinks water - moves to shade.
1400	Walks to place where he usually defecates -

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urinates.

1428 Lies down. Up till now he has stood with head hanging down.

1715 Gets up - starts feeding.

2045 Lies down.

30th May 1967 : Temp.: Max.: 26.6°C Min.: 13.3°C

0630 Up feeds.

0653 Urinates.

0705 Defecates.

0943 Stops feeding, stands with head hanging low in shade.

1104 Drinks water.

1121 Defecates.

1125 Returns to shade - lies down.

1520 Gets up, moves around. Moves around. On passing dung pile stops, drops one ball after standing some time. Lies down after a while.

1625 Gets up. Moves around in exercise camp. Stops to nibble a few times.

1653 Starts feeding in earnest.

2019 Down.

31th May 1967 : Temp.: Max.: 26.5°C Min.: 5.8°C.
Note the drop in min. temperature.

0733 Starts feeding now.

0754 Urinates.

0840 Defecates.
The rhino feeds with vigour.

1012 Stops feeding. Rubs horn and body.

1025 Starts feeding again.

1034 Stops feeding.

1045 Defecates.

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1048	Lies down next to dung heap in the sun (see photo 32).
1204	Gets up. Drinks water.
1208	Lies down again.
1406	Gets up, when crossing dung heap - stops, defecates. One ball.
1420	Lies down.
1549	Starts feeding.
1920	Down.

As can be seen from the above the animal started feeding about one hour later in the morning than during the previous days. It also started feeding more than an hour earlier in the afternoon than during the previous days. It fed for about the average length of time and this had a influence on the day time spent resting. That night it also lied down an hour earlier than usual. On that day (31st May), the rhino chose the sunny part of the exercise camp to lie down instead of the usual shady place of the previous days.

During the colder months of the year the influence of maximum temperature on daily activity is minimal. The low temperatures at night exerts a greater influence and limits the activities at night, causing a need for longer daylight browsing. They only lie down after they are satiated. During the summer mornings they start feeding earlier and is usually satiated before the temperature reaches approximately 26°C. The temperature may however, have a continuous influence on the time the afternoon browsing starts. The temperature usually rises very quickly (fig. 20) during the first two hours in the morning. It then rises more slowly till it levels off. The air keeps its temperature for a long while during the evening as it is warmed by radiation from the ground.

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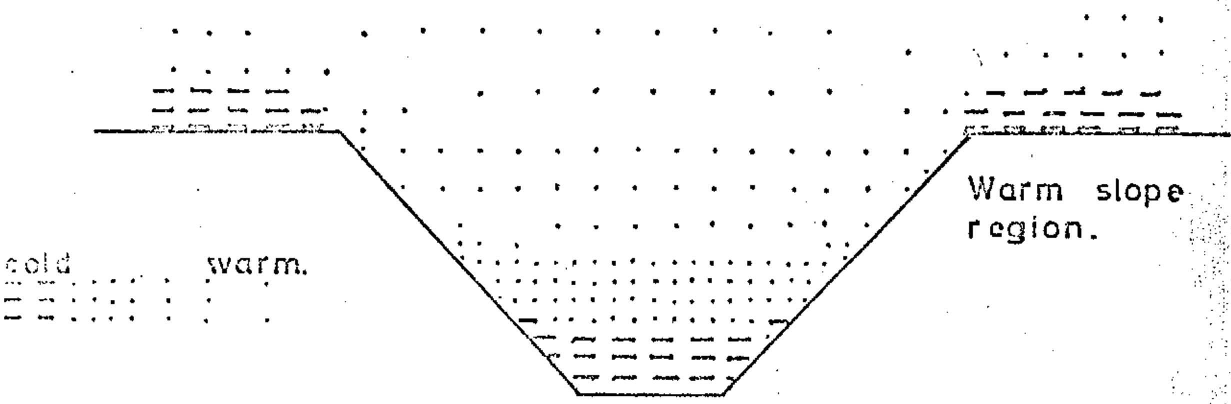
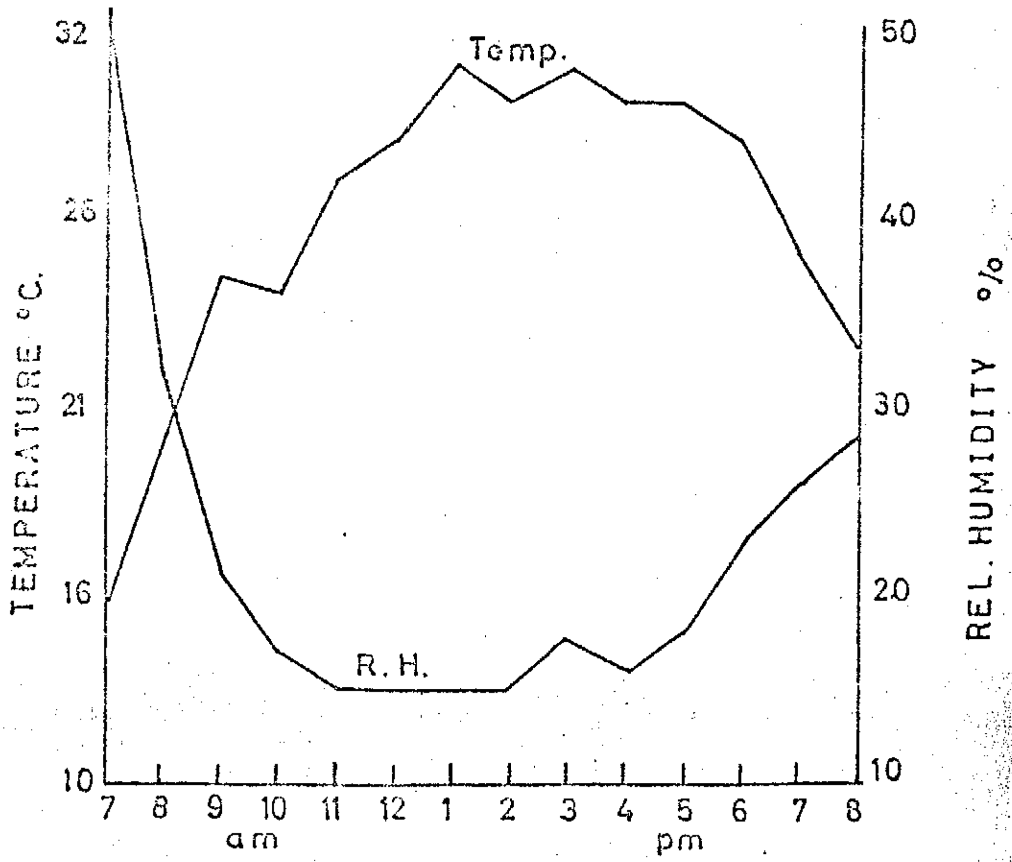
FIG. 16. NOCTURNAL TEMPERATURE IN VALLEYS.



(After Geiger, 1959.)

FIG.20.



AN AVERAGE DAY TO SHOW TEMP/REL. HUMIDITY RATIO OTJOVASANDU. (SEPT., 1967)

During the colder months of the year it was noticed that rhino tend to spend the night hours, especially the hours before dawn, on the slopes of the valleys and hills. The food available here may play an important role, but it may also be because of microclimatical influences. It was shown by detailed study (Geiger 1959) that because of a series of small air circulations on the slopes, the cold air on the slopes is mixed with neighbouring warm air, of which there is a great reservior between the valley walls (see fig. 16). The valley floor and plateau is very cold, while the higher parts of the slopes are warm. This effect can sometimes be observed in the Kaokoveld after an occurrence of frost. The frost-sensitive Colophospermum mopane illustrates this point. Another factor which may also have an influence is the sunnyness of the different slopes.

The influence of plant cover on temperature extremes and the resulting influence on rhinoceros behaviour is another aspect which must receive attention. The habit of rhino of lying down in the shade of a thicket or tree to rest during the warmer part of the day is well known. This leads to an aspect generally not considered, viz. the marked difference of air temperature in dense vegetation and over bare ground on warm days and cold nights.

10.2.3 Seasonal rhythm.

Temperature also effects the seasonal rhythm of the behaviour pattern of the black rhinoceros, particularly on the frequency with which waterholes are visited. It is also bound to have a marked influence on the amount of water they drink. During the colder months of the year the black rhinoceros in the Kaokoveld only drink every second night. During the warmer months of the year they drink every night. (See 7.5 Drinking habits).

As already mentioned the daily temperature has an influence on daily feeding. It is impossible to give an exact routine of daily feeding because a set of physical factors changes daily. Each individual rhinoceros may also behave in a different way to each set of physical factors. It can be said however that during the summer months they lie down earlier in the mornings, and start browsing later in the afternoons than is the case during the winter months (See 8.6 Daily activity cycle).

Another seasonal movement, which is influenced by temperature, is that to be found on the western edge of the escarpment and the Namib flats. When the nights become markedly colder one finds a general movement of rhino into the higher country to the east. This area is more mountainous and is covered by a denser vegetation. These movements are usually centered around a permanent waterhole.

10.3 Rainfall.

The rainfall is usually of the thunderstorm type. The isohyets are more or less parallel to the coastline and mean annual rainfall increases towards the east. The yearly rainfall pattern is extremely irregular and being dispersed patchily some localities experience long droughts. Distribution of rain showers and amount of precipitation are the two main factors which cause the tremendous annual variations in vegetation cover.

According to fig.18 it is apparent that the main rainy season is from January to March while some rain also fall during the early months of September to December. Rain during January to March tend to be more widespread, whilst those during September to December are usually scattered.

10.3.1 Influence on reproduction.

The main influence of rain on the black rhinoceros is physiological, primarily on reproduction. This influence takes place indirectly through the vegetation. Green forage is the only natural source of Vitamin A, which plays an important part in the physiological process of reproduction. (Hart and Guilbert (1933) and others). This has been discussed under reproduction.

10.3.2. Movement.

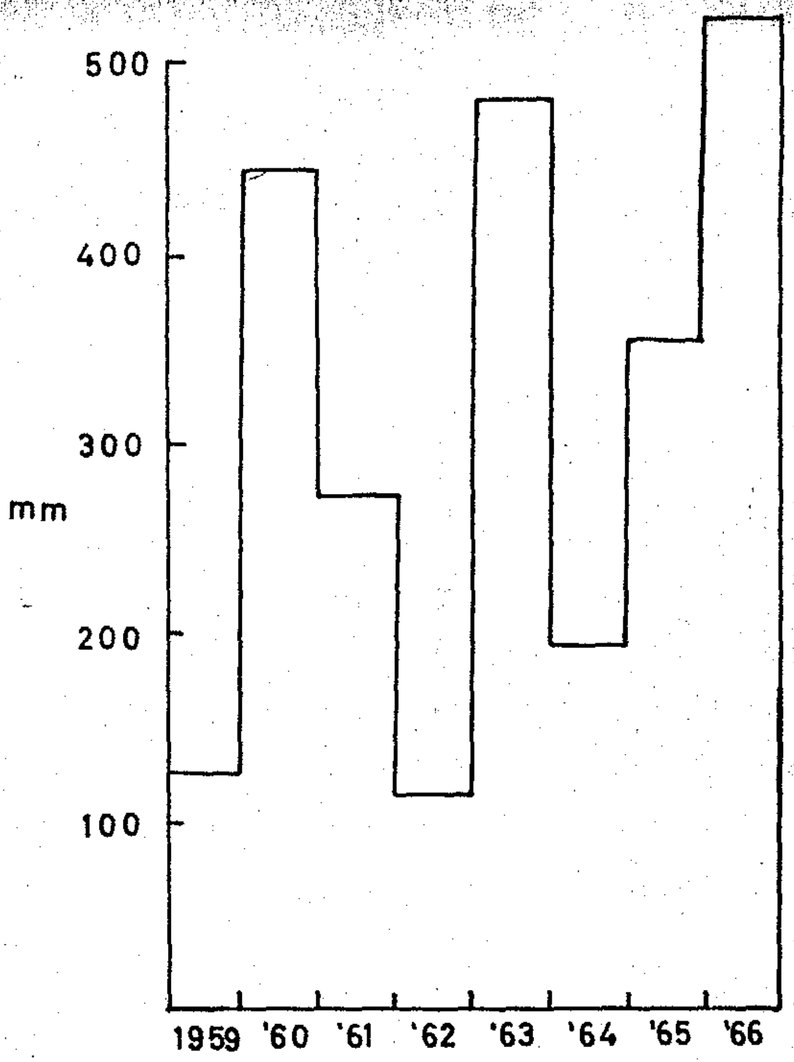
Movement of black rhinoceros within their home ranges are also influenced by rainfall. During the rainy season, when they are not bound to the permanent water-holes which they use during the rest of the year, they move over a larger area within the home range. The rainwater pans contain water from January to May. The rainfall before January and after March are usually insufficient to fill them.

During the rainy season some individuals show a tendency to wander away from their normal home range. (See 8.9 Movement).

10.3.3. Influence on feeding habits.

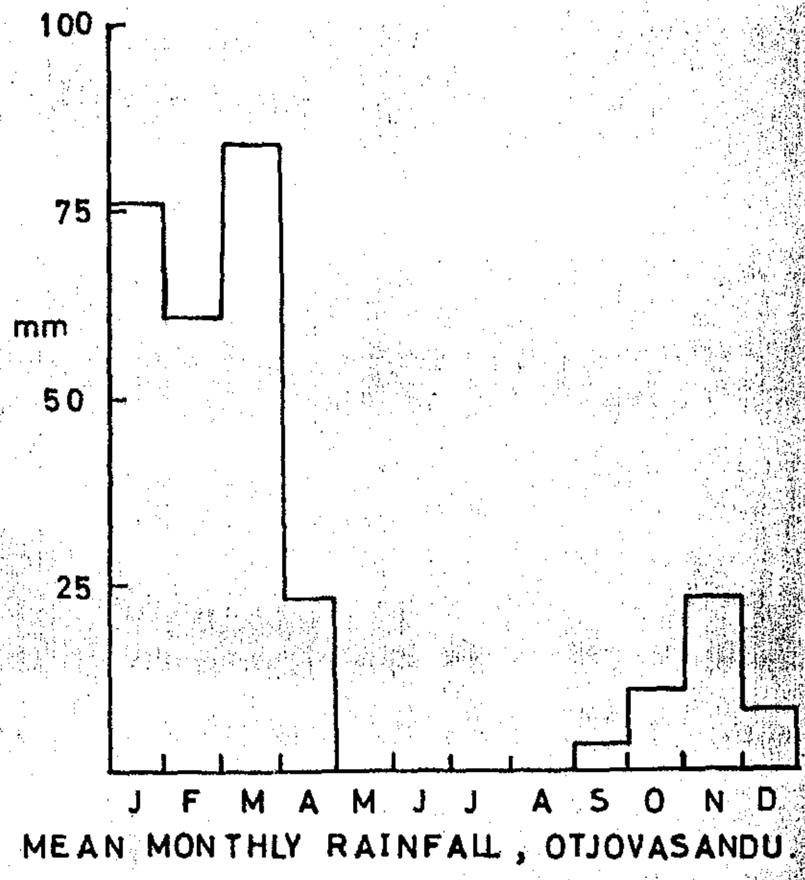
Although no real evidence exists, it seems as if the amount of forage they eat during this time of the year, might be less than during the dry season.

FIG. 17.



YEARLY RAINFALL, OTJOVASANDU.

FIG. 18.



MEAN MONTHLY RAINFALL, OTJOVASANDU.

They also feed on a larger variety of food plants (See 7.1 Food species and preferences).

10.3.4 Wallowing.

During the rainy season the black rhinoceros also wallows to a very large extent, and trees, surrounding rainwater pans, are used to rub themselves and trunks acquire a "mudpack" appearance (See 8.7 Wallowing).

10.4 Relative humidity.

Relative humidity is the perçentage of moisture saturation of the air at a given temperature. The higher the temperature of the air, the more moisture it can absorb.

The Kaokoveld has an extremely low atmospheric relative humidity. This important factor effects both plants and animals. The daily range of relative humidity is greater than the annual range. This variation is caused by intense heat, excessive and prolonged radiation, quick evaporation, wind, scarcity of rain and distance from water masses. The problem of atmospheric humidity is aggravated when the combined effects of high air temperature and low relative humidity excercise additional strain on the water balance of plants and animals (Kirmitz 1962). It was observed during the study that the rhinos perspire during the midday rest. The animals probably perspire during the rest of the day too, but it is most noticable while they are lying down. The perspiration is usually limited to certain areas on the body viz. the folds on the neck, the ventral side of the body, the folds behind the shoulder and in front of the flanks. No doubt this perspiration is higher during hot weather with a low relative humidity and this serves to

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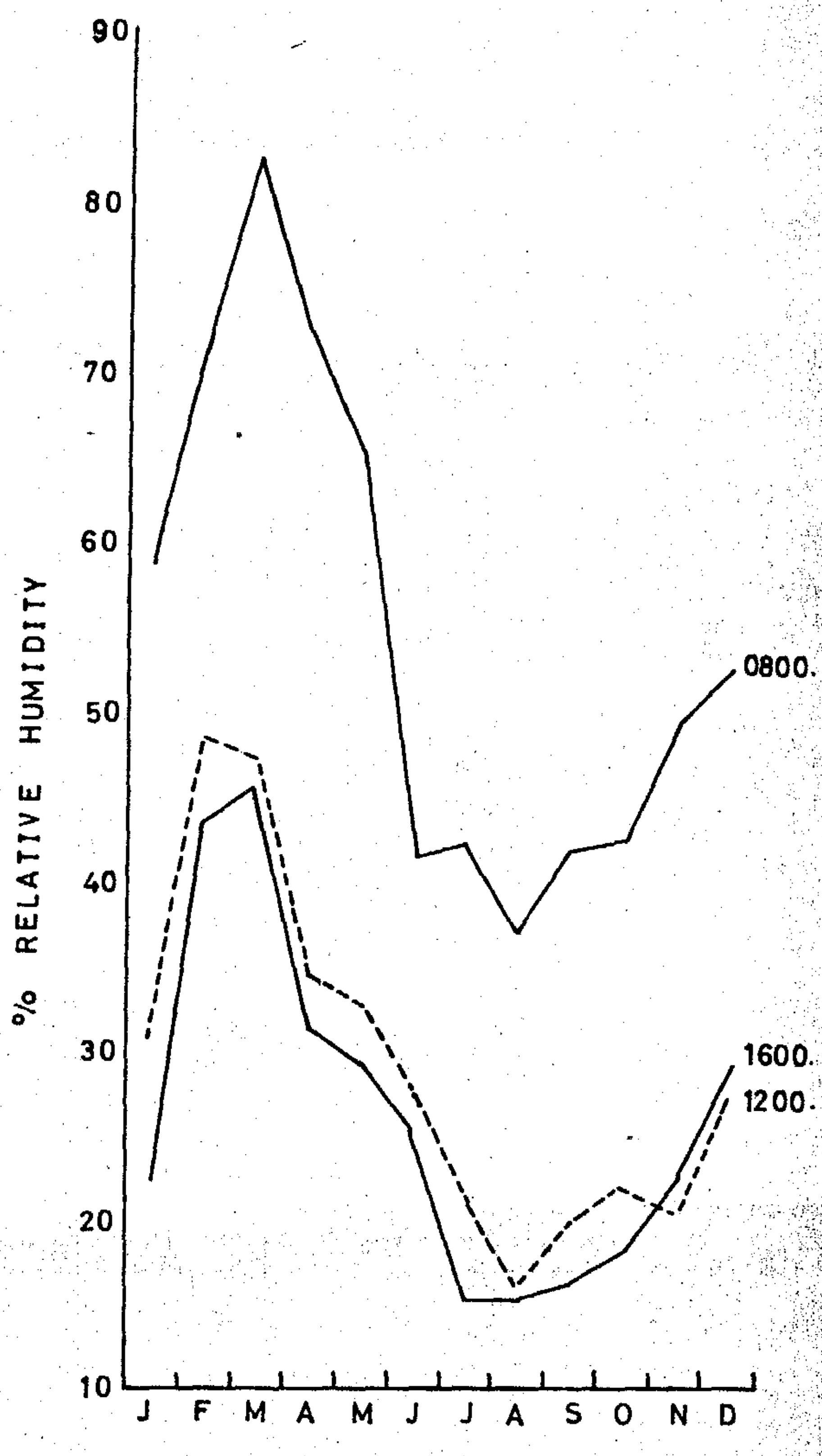
FIG. 19.



AVERAGE RELATIVE HUMIDITY AT OTJOVASANDU.

cool the animal.

10.5 Wind movement.

The estimated average wind velocities are between 10-15 miles per hour, but frequently values of 20 miles per hour have been recorded.

In the study area the two main wind movements are from the west during the summer months and from the north to north east during the winter months. These movements and direction changes are determined by the pattern of barometric pressure changes during the season. From about November to January an area of low barometric pressure (1000.8 mb.) is situated over the inland plateau south of the Caprivi strip. During the winter months the isobars change and form a high pressure area over the inland plateau creating a prevalent eastern air movement (Philips Atlas for Southern Africa).

Apart from the relation between wind movement and rate of evaporation that has already been mentioned, the rate of wind movement has important indirect effects upon certain physical factors of the rhinoceros habitat. A wind blowing from the west lowers the temperature, while the eastern winds are usually hot and during the rainy season moist.

When browsing they show very little regard to which way the wind is blowing. They may move across wind and have even been noticed to browse down wind (See figure 22). When moving from one area to another however, they tend to move against wind, probably to attain higher efficiency with their smelling ability.

During the summer season they tend to lie down on the summits of the low hills in the study area. It

FIG. 21.

ACTUAL NUMBER OF DAYS WITH EASTERN TO NORTH EASTERN AND OR WESTERN TO SOUTH WESTERN WIND MOVEMENT. OTJOVASANDU, 1966/67.

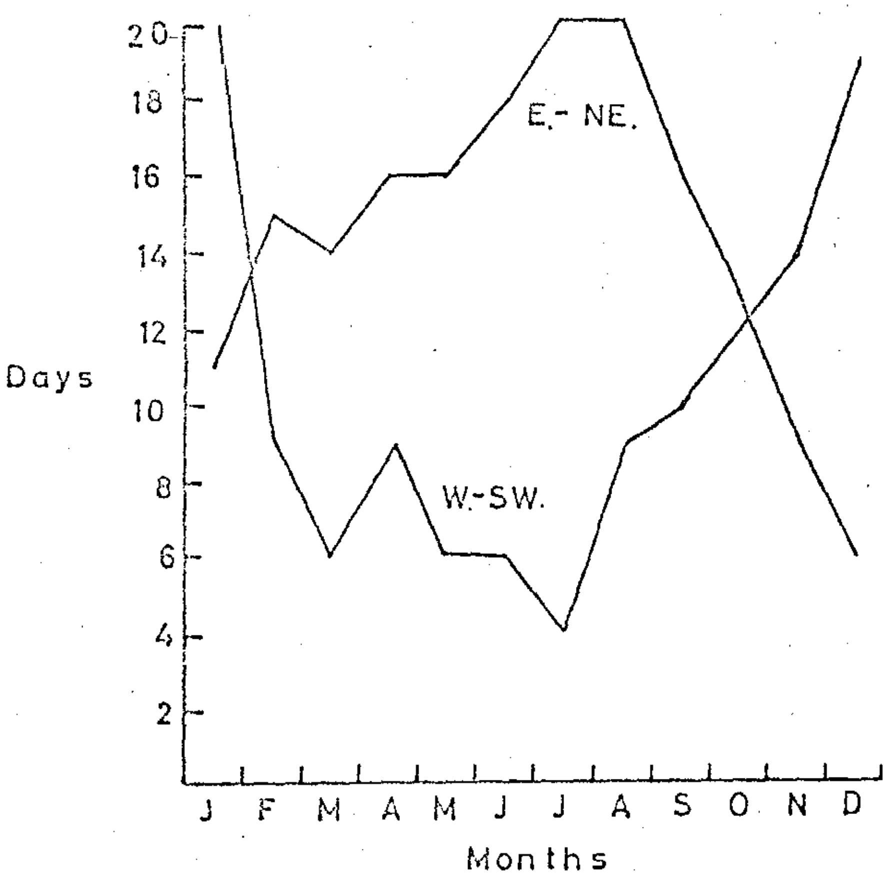
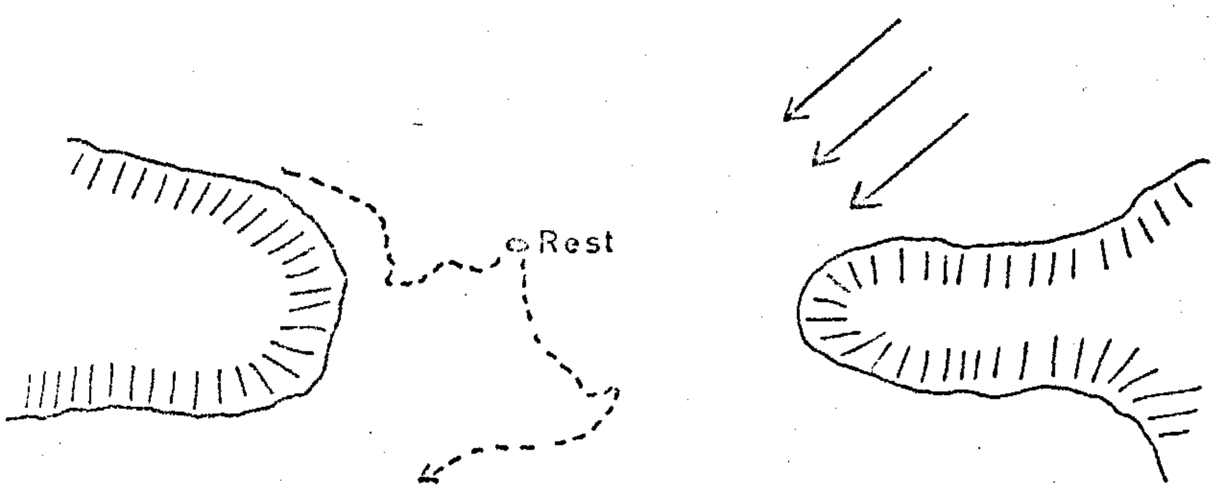
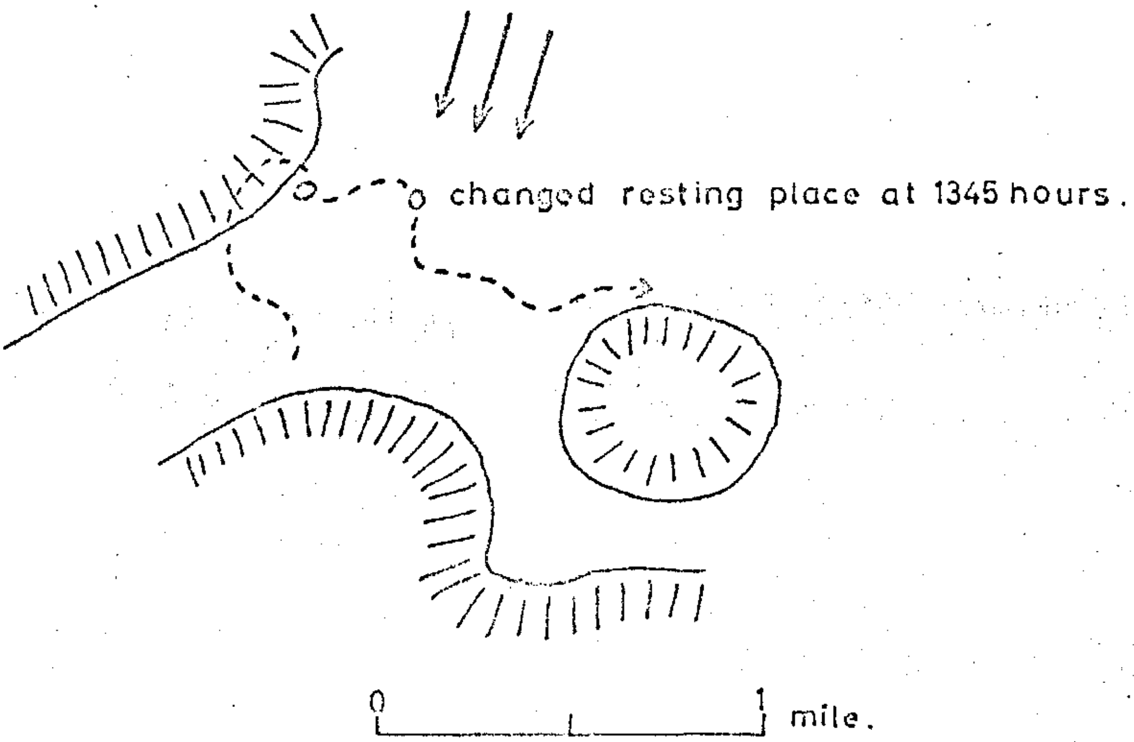


FIG.22. THE INFLUENCE OF WIND ON RHINO FEEDING BEHAVIOUR.

Date 24 APR. 1967. Temp. 30°C. Wind. E 5.



Date 15 OCT. 1966. Temp. 36°C. Wind. NE. 5.



might be to make full use of the cooling effect that the breezes have as a result of the evaporation of their perspiration. During July and August, when the prevalent wind movement averages about 15 miles per hour, the wind did not change the normal activities of the black rhinoceros in the study area in a marked way. During this period they no longer tend to lie down on the hill summits but move down to the sheltered slopes or into the dense shrublands of the plateau. This was especially noticeable with the cows that had small calves. During June and July when the prevailing wind blows from the east and north-east, they also usually lay facing west of south-west (down-wind). The west and south-west winds apparently never reach velocities high enough to induce this behaviour.

One did not get the impression however that wind was hampering their normal daily activities in any marked way.

10.6 Frost.

In the Kaokoveld frost occurs only a few nights per year in spite of the low night temperatures recorded. During the study period frost occurred during May and August only. This might be due to the cold air drainage and eddy effect down the valleys of the escarpment. The first killing frost of autumn is nevertheless a most significant annual event. Many of the annual plants are killed by the first frost, and if the frost is severe the above-ground vegetation is also damaged, inducing an early loss of leaves.

The dominant plant cover over large areas in the study area and the Kaokoveld is mopane tree and shrub savanna. This plant maintains it's leaves for the greater part of the year, and in large areas it occurs in a shrub form. It is frost-sensitive and was used extensively as indicator plant to study the effects and distribution occurrence of frost. The valley floors and depressions on the plateau showed the heaviest effect by frost. This confirmed the observations made by Geiger (1959), namely that the cold air settles in the depressions. Shrub mopane also showed that frost and/or low temperature damage usually only occurs in the first few feet above ground level. Sometimes only the one side of the plant was damaged depending on air movement and direction.

Shrub mopane thickets also showed that although burning by frost on the outside was severe the shrubs in the centre of the thicket showed no damage. This illustrates another microclimatical factor that might be used by black rhinoceros and other animals. They could lie up in the thicket to escape the low temperature and/or they might only feed on the centre part of the thicket.

The important effect of frost however is indirect on the nutrition of the rhinos. In certain areas, especially where the grass cover was good, the shrub mopane showed damage by frost. Herbs and the smaller shrubs, below the height of the surrounding grass, showed little or no damage. No doubt the grass cover served to ameliorate temperature extremes and protected this vegetation stratum. This factor influences the browsing behaviour of the black rhinoceros (See 7.1 Food species and preferences).

CHAPTER: XI

LIMITING FACTORS.

During the study several limiting factors were observed. Although most of them were discussed elsewhere they are listed again.

11.1 Predation.

Cattle ranching makes an important contribution to the economy of South West Africa with the result that the larger carnivores have been strictly controlled and are nearly extinct in many areas. Even in the Kaokoveld and Etosha National Park their numbers are relatively low. Consequently they have very little, if any, effect on the present day rhino population.

This seems to be the case elsewhere in Africa too. Although it seldom occurs, various references can be found in literature of rhino being attacked, and sometimes killed, by lion (Ritchie 1963 and Guggisberg 1966). Only one record could be found of rhino being killed by lion during the last decade in South West Africa. This happened near Orupembe late in 1968 when a rhino calf was killed by lion.

The most important predator is man. In East Africa rhino are primarily killed by poachers for their horns. According to Huxley (1961), the poachers receive from 7 shillings to 10 shillings per pound (and for ivory 2 shillings to 3 shillings per pound). The legal auction price in Mombasa during the first ten months of 1960 was between 90 shillings and 94 shillings per pound for rhino horn (and between 9 shillings and 23 shillings per pound for ivory). The annual total of rhino legally and illegally killed in Kenya is estimated at 670 to 960.

In South West Africa no market exist and the rhino horn prices in Angola are relatively low. According to a Portugose farmer, just north of the Kunene River, the price varies between 50 cent to 75 cents per pound. One must also remember that rhino horns in South West Africa are usually small, making the small profit not worth the trouble.

It was found that in South West Africa rhino were, and still are, primarily killed because of their nuisance value (see 3.3.1 Past status and 4.2.2 Effects of man). This led to the present situation in the Kaokoveld and on private farms, where the male ; female ratio is completely unbalanced in favour of males. This alone creates serious problems for the survival of the species in these areas.

11.2 Vegetation and water.

In South West Africa with its periodical droughts and rising stock numbers, competition with livestock for food and water is an actual problem. It is only in the Etosha National Park where this problem does not exist.

11.3 Diseases, parasites and associated flies.

Very little is known of diseases that may affect black rhinos. Brocklesby and Fidler (1965) have recorded certain Protozoa in rhino bloodsmears. They were represented by *Trypanosoma* and *Theileria* species. A *Babesia* species was also recorded by Brocklesby and Fidler.

In East Africa and Natal most of the black rhinos have open sores on the sides of their bodies.

This condition has commonly been thought to be glandular in origin, connected in some way with the reproductive cycle of the animals. Microscopic examination, however, showed that the parasite <u>Stephanofilaria dinniki</u> was present and probably the cause of these sores (Schultz and Kluge 1960, Tremlett 1964 and Round 1964).

Not one of the black rhino observed in South West Africa (5 immoblized individuals included) showed any sign of skin lesions on their bodies. According to Dr. Brand (<u>pers. com.</u> 1967), a young black rhino from South West Africa was taken to the National Zoological Gardens in Pretoria. This individual had no skin lesions but these eventually developed. This rhino was sharing a rubbing post with other black rhino (from Natal) which did have skin lesions.

In only one of three individuals on which post-mortems were carried out in South West Africa were internal parasites found. These Nematodes viz. <u>Kiluluma magna</u> <u>K. stylosa</u> and <u>K. goodeyi</u> were also reported from rhinos in Natal. (Zumpt 1964). Zumpt also recorded the following nematodes from African rhinoceroses. (Zumpt did not always distinguish between black and white rhino).

<u>Kikukuma africana</u>, <u>K. brevicauda</u>, <u>K. brevivaginata</u>, <u>K. cylindrica</u>, <u>K. Longispiculata</u>, <u>K. macdonaldi</u>, <u>K. pachyderma</u>, <u>K. rhinocerotis</u>, <u>K. solitaria</u>, <u>Quilonia africana</u>, <u>Q. parva</u>, <u>Q. rhinocerotis</u>, <u>Paraquilonia brumpti</u>, <u>Murshidia bozasi</u>, <u>M. didieri</u>, <u>M. omoensis</u>, <u>M. raillieti</u>, <u>Buissonia africana</u>, <u>B. longibursa</u>, <u>B. rhinocerotis</u>, <u>Khalilia buta</u>, <u>K. rhinocerotis</u>, <u>K. sameera</u>, <u>Grammocephalus intermedius</u>, <u>Oxyuris karamoja</u>, <u>Habornema kjalili</u>, <u>Parabronema rhinocerotis</u>.

Only one Termatode, <u>Brumptia bicaudata</u> and one Cestode, Anoplocephala vulgaris has been recorded in rhinos (Zumpt 1964).

In South West Africa ticks were only found around the anus where the skin is relatively thin. On three of the immobilized animals Hyalomma species were collected. Zumpt (1964) and Guggisberg (1966) reported the following ticks from African rhinoceroses :

Amblyomma gemma, A. hebraeum, A. lepidum, A. personatum, A. rhinocerotis, A. sparsum, A. tholloni, A. variegatum, Haemaphysalis leachi, Hyalomma impeltatum, Dermacentor rhinocerinus, Hyalomma albiparmatum, H. rufipes, H. truncatum, Rhipicephalus appendiculatua, R. capensis, R. compositus, R. humeralis, R. hurbi, R. jeanneli, R. maculatus, R. muhlensi, R. neavi, R. pulchellus, R. sanguineus, R. senegalensis, R. simus, R. supertritus, R. ziemanni.

Several flies associated with black rhino were collected in South West Africa. Unfortunately the specimens were lost before they could be identified. In Kenya and Natal several flies associated with rhino have been collected and identified. (Parsons and Sheldrick 1964, Zumpt 1964). Some of these flies are blood suckers in the adult stage. To finish their life cycle they have to pass through the digestive system of the rhino, where they feed on blood and tissue exudate.

The flies associated with rhino are the following :

Glossina pallidipes, Gyrostigma conjugens, G. pavesii, Haematopota sp., Lyperosia thirouxi, Morellia paradoza, Musca conducens, M. lusoria, M. xanthomelas, Pangonia aethiopica, P. brunnipennis, P. pallidipennis, Rhinomusca dutoiti, Tabanus africanus, T. biguttalus, T. maculatissimus, T. taeniola.

CHAPTER XII

CONCLUSIONS.

12.1 The South West African black rhinoceros population was found to have larger skulls than the Natal population. This tendency to increase in size is shown by the 75 per cent parameter to be still below the conventional percentage joint nonoverlap of subspecific difference. The black rhinoceros population in South West Africa and that occurring in Natal are therefore below the level of subspecific distinctness. The two populations are consequently taxonomically synonymous.

12.2 In the era before 1900, the black rhinoceros was distributed from the Kunene River in the north, down to the Orange River in the south and extended westwards to the eastern boundary of the Namib desert. During the rainy season it penetrated the Namib along river courses. Towards the east its distribution ranged past the present day Gobabis. In the sandveld areas to the north and south of Gobabis and adjoining Botswana and Caprivi its distribution was hampered by the lack of surface water and suitable vegetation.

12.3 The black rhinoceros at present has a limited distribution. It occurs only in the most inaccessible, mountainous areas of the escarpment zone north of the 22th latitude in the northwestern corner of South West Africa.

12.4 It is doubtful whether the black rhinoceros population ever reached very high numbers in

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South West Africa. During the 1966 census it was found that only 90 animals were left in the Territory. These animals were distributed as follows :

72 per cent .... In Bantu areas or proposed Bantu areas.
11 per cent .... on privately owned farms.
17 per cent .... within the proposed new boundaries of the Etosha National Park.

Immediate action should be taken to ensure their survival in South West Africa.

12.5 Man has an adverse effect on wildlife in the Kaokoveld. Wildlife is influenced by man in the following ways :-

(a) competition with livestock for water at waterholes during the dry season.

(b) competition with livestock for available food.

(c) competition with livestock and man for "lebensraum".

(d) Hunting pressure.

The survival of rhino in this region is in question.

12.6 The study area falls within the arid savanna. Plant surveys carried out on the incidence and distribution of plants indicate that nine plant associations exist in the study area. The Colophospermum mopane - Acacia reficiens - Terminalia prunioides association forms the major vegetative cover type found in the Kaokoveld between the 100 mm and 300 mm isohyets. This plant association also carries the richest mammal and bird life of the region.

12.7 The black rhinoceros in South West Africa shows a marked preference (91 per cent) for the broken mountainous terrain of the escarpment zone. Its home ranges usually lie within the tree and shrub (thorn shrub) savanna. This preference coincides with its earlier distribution pattern in the rest of South West Africa, and should be taken into consideration when individuals are translocated to new areas.

12.8 Although the black rhinoceros in South West Africa feeds on a wide spectrum of plant species it shows a tendency to concentrate on a few preferred species, some of which form the bulk of its food throughout the year. Acacia reficiens, the most important single plant on the list, is also heavily utilized (and destroyed) by elephant. When the western sector of the Etosha National Park is fenced off special attention should therefore be paid to any deterioration in the rhino habitat in this area.

12.9 Owing to its solitary habits the rhino tends to under-utilize its home range. Considering the availability of food plants the number of rhino and the extent of the home ranges the rhino habitat at Otjovasandu with the highest black rhinoceros concentration in South West Africa, is at present still very much under-populated.

12.10 The black rhinoceros exhibits two activity peaks every twenty-four hours- a dawn activity period and a crepuscular activity period. Behavioural activities viz. its habit of drinking water in the late afternoon, the longer distances covered and the tendency to scatter dung with greater regularity during the crepuscular activity period indicate this activity peak to be the more important one.

12.11 Wallowing is more an enjoyable pastime and not solely a factor controlling body temperature.

12.12 The scattering of dung expresses an atmosphere of familiarity or solidarity with the home range and sometimes forms part of the sexual behaviour. It is in no way connected with any territorial behaviour.

12.13 With the black rhinoceros any movement is primarily induced by bodily requirements. The physiological process of reproduction and the influence of climatic factors also contribute to movements over a home range.

12.14 In South West Africa calving shows a tendency to adapt itself to the rainy/post-rainy season. Spring flush during September induces a greater flow of sap in the food plants of black rhinoceros and this may trigger off the mating activities during the second half of the year through the physiological influence of nutrition. The gestation period of the black rhinoceros is between 438 and 476 days.

12.15 Temperature and rainfall are the two more important physical factors in the ecology of the black rhinoceros. The influence of temperature is both physiological and biological and shows marked rhythms, both daily and seasonal. Rainfall has an influence on

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reproduction, movement, feeding habits and wallowing. The influence of wind on rhino behaviour is limited. Frost influences the feeding habits of rhinoceroses indirectly.

12.16 Limiting factors are the following : predation - mainly by man; competition with livestock for food, water and "lebensraum", and possibly diseases.

CHAPTER XIII

SUMMARY.

A research project was launched during 1966 to obtain information regarding status, distribution, requirements of life and limiting factors and to advise on a future conservation policy to ensure the survival of the black rhinoceros in South West Africa.

During the study statistical analyses of skull measurements showed that a tendency exist in the South West African black rhinoceros to differ from the Natal population.

Available information indicates that the black rhinoceros was formerly distributed from the Kunene River south to the Orange River, along the escarpment and eastwards past Gobabis. At present its distribution is limited to the northwestern corner of South West Africa. During 1966 there were only 90 animals left in the territory.

The study area around Otjovasandu consists of three physiographic features viz. escarpment, plateau and eastern dolomite ridges. The soil in the area is discussed under six headings. The soils tend to be shallow, alkaline, high in water soluble salts, poor in phosphates and nitrogen content.

The study area falls within the arid savanna. The vegetation was sub-divided into nine smaller associations. To characterise each plant association quarter method surveys and wheelpoint surveys were carried out.

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The black rhinoceros population shows a preference for the escarpment zone. Factors contributing to this preference may be availability of water, suitable vegetation and protection against man and weather extremes. In all instances black rhinoceros home ranges were situated in plant communities within the tree and shrub savanna.

A few preferred plant species form the bulk of the black rhinoceros's food throughout the year. Some of these food plants were analysed to determine their nutritional value. During the rainy season annual herbs contribute to a greater extent to the total diet. The rhinoceros shows a regular feeding rhythm through a twenty-four hour cycle. Browsing rhinoceroses sometimes do serious damage to vegetation but never to the extent found with elephant.

No indication of territorial behaviour was observed in South West Africa. They do have home ranges and in the study area all the females shared a home range with a male. The size of the home range is dependent on available food, cover, population pressure and "lebensraum". The home range sizes varied from 12 to 16 square miles in the study area; to 50 to 60 square miles on the Namib edge.

The rhinoceroses frequenting one home range form a family group. Rhinoceroses using the same natural waterhole were regarded as a clan. Males and females were only seen in 15.4 per cent of the observations to browse or lie down together.

There is no social relationship between rhinoceroses and other animals. The alliance between rhinoceros and oxpecker found in Natal and East Africa is entirely absent in the territory.

Observations indicate two activity peaks within twenty-four hours viz. the dawn activity period. There are indications that a six to seven hour period of inactivity exists during the night hours. Behaviour activities show the crepuscular activity period to be more important.

Wallowing is mainly limited to the rain-water pans. Although wallowing may contribute to the lowering of body temperature its influence is not considered to be important. Rubbing and dust bathing activities also take place.

The scattering of dung expresses an a atmosphere of familiarity or solidarity. Dung is scattered with greater regularity during the crepuscular period. Rhino are stimmulated to defecate through both physiological and psychological impulses.

With rhinoceroses, movement is primarily induced by body requirements. Movement is divided into three categories viz. daily movement, seasonal movement and wandering. The distances covered increase towards the west and reach their maximum in the sub-desert.

Calving in South West Africa shows a tendency to adapt itself to rainy/post-rainy seasons. In the study area the male : female ratio is 1:0.87 and the adult cows were normally seen with calves.

Temperature and rainfall are the two more important physical factors in the ecology of the black

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rhinoceros.

Limiting factors are predation, competition with livestock and possibly diseases.

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SAMEVATTING

Gedurende 1966 is begin met 'n navorsingsprogram om inligting in te samel oor die status, verspreiding, lewensbehoeftes en beperkende faktore van swartrenosters in Suidwes-Afrika. Hierdie inligting sal gebruik word om 'n beleid op te stel om die voortbestaan van die swart renoster in Suidwes-Afrika te probeer verseker.

Analiese van skedelmates toon 'n geringe verskil tussen die Suidwes-Afrika populasie en die populasie van Natal.

Alhoewel swart renosters vroeër relatief wyd versprei was, is hulle nou beperk tot die noordwestelike hoek van Suidwes-Afrika. Daar is nog selgs 90 individue oor in die gebied.

Grondontledings en 'n plantkundige opname is in die studie area by Otjovasandu gedoen. Die renosters vertoon 'n voorkeur vir die eskarpementgebied in die boom- en struiksavanna.

'n Paar voorkeur voedselplante vorm die hoofbron van voedsel deur die jaar. Gedurende die reënseisoen word kruie ook benut. Renosters rig soms skade aan, aan die plantegroei maar nooit tot dieselfde mate as olifante nie.

Die renosters openbaar geen territoriale gedrag nie, maar het wel loopgebied wat gedeel word tussen bul en koei. Die grootte van die loopgebied hang saam met beskikbare voedsel, beskutting, populasiedruk en „lebensraum". Die groottes van die loopgebied het gewissel tussen 12 tot 16 vierkante myl in die studie area, en 50 tot 60 vk. myl langs die Namib.

2/........

Die renosters wat dieselfde loopgebied gebruik, is beskou as 'n familiegroep, terwyl renosters wat dieselfde watergat gebruik, beskou is as 'n „clan". In slegs 15.4 persent van die waarnemings het bulle en koeie saam verkeer.

Daar bestaan geen sosiale verhouding tussen renosters en ander diere nie. Die simbiose tussen renoster en renostervoëls wat in Natal en Oos-Afrika bestaan, is afwesig in die gebied.

Twee hoogtepunte van aktiwiteit kom voor gedurende 24 uur. Die hoogtepunt van aktiwiteit gedurende die laatmiddag-vroegaand is die belangrikste. 'n Rusperiode van tussen ses tot sewe uur kom voor gedurende die nag.

Rondrol in modder is hoofsaaklik beperk tot die reënseisoen. Droeë rolplekke en skuuraktiwiteite kom dwars deur die jaar voor.

Die deurmekaarkrap van mis beeld 'n gevoel van familiariteit en solidariteit uit. Mis word met groter reëlmatigheid gedurende die agtermiddag aktiwiteitsperiode deurmekaar gekrap. Beide sielkundige en fisiologiese impulse stimmuleer renosters om te mis.

Liggaamsbehoeftes is verantwoordelik vir die meeste bewegingsaktiwiteite. Beweging kan verdeel word in daaglikse beweging, seisoenale beweging en rondswerf. Die daaglikse afstand afgelê word groter na die westelike kant van die gebied. Die verhouding tussen die twee geslagte in die studie area is 1 : 0.87 (bul : koei).

3/.........

Temperatuur en reën is die twee belangrikste fisiese faktore in die Ekologie van die renoster.

Beperkende faktore is roofdiere (mens ingesluit), kompetisie met vee en moontlike siektes.

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CIMBEBASIA No. 13-1965.

APPENDIX : 1.

DICEROS BICORNIS SKULL MEASUREMENTS FROM A SOUTH WEST AFRICAN SAMPLE.

Skull.	a/a	b/b	c/c	d/d	e/e
1	-	57.5	22.9	-	-
2	-	-	22.3	-	18.2
3	55.7	50.2	21.6	-	-
4	63.0	56.1	21.6	-	-
5	56.5	46.7	20.8	18.5	15.9
6	63.3	57.8	21.8	20.9	16.3
7	59.4	54.2	24.2	-	-
8	57.0	52.8	22.3	18.6	17.2
9	56.5	51.2	19.9	17.9	14.3
10	59.0	53.7	23.1	-	-
11	58.4	54.8	21.9	18.7	16.3
12	58.2	53.3	19.3	19.5	17.7
13	61.2	57.3	21.8	-	-
14	59.8	51.5	20.0	19.8	16.4
15	60.5	51.0	22.5	-	-
16	55.2	46.8	20.3	18.2	16.5
17	59.8	53.8	23.3	-	-
18	55.5	53.1	20.7	18.3	

a/a : Greatest length Condylo-Nasal length.
b/b : Greatest length Occipito-Nasal.
c/c : Anterior orbital.
d/d : Nasal length.
e/e : Nasal width.

APPENDIX : 1 continued.

Skull	f/f	g/g	h/h	i/i	j/j
1	27.3	34.2	12.2	20.7	-
2	28.3	33.7	12.0	19.3	29.5
3	25.7	32.6	10.8	19.6	26.8
4	27.1	34.1	11.4	21.2	31.9
5	23.9	31.1	11.9	18.8	30.3
6	27.9	34.8	12.1	20.3	31.8
7	27.4	35.4	12.1	19.8	29.1
8	27.5	33.5	10.8	19.6	26.8
9	26.4	30.4	10.3	18.6	27.9
10	26.5	33.3	11.7	22.2	30.8
11	26.3	32.9	12.0	18.6	29.6
12	27.6	33.1	12.0	17.7	29.9
13	27.1	32.7	11.6	19.9	30.9
14	27.6	31.0	10.8	19.4	30.2
15	-	35.4	11.9	-	28.9
16	26.7	32.4	11.8	-	29.1
17	28.3	33.6	11.5	20.1	30.5
18	-	-	10.7	-	-

f/f : Length upper tooth row.
g/g : Zygomatic.
h/h : Post orbital constriction.
i/i : Palatine length.
j/j : Post. edge Palatine - basilar length.

APPENDIX : 1 continued.

		1/1				
Skull	k/k	Post	ant	m/m	n/n	o/o
1	6.2	4.9	2.4	26.9	45.5	23.5
2	7.2	4.1	1.5	27.5	45.3	25.2
3	6.5	3.9	1.4	–	–	–
4	6,3	3.4	1.4	24.8	46.0	24.2
5	–	4.1	1.8	–	–	–
6	6.4	4.7	1.7	–	–	–
7	6.5	4.4	1.6	27.3	47.3	24.6
8	5.8	4.3	1.9	–	–	–
9	6.1	3.5	1.5	–	–	–
10	6.9	4.4	1.6	26.2	44.5	22.6
11	7.8	4.6	1.8	26.7	46.4	24.1
12	7.5	4.6	1.7	26.5	45.8	24.3
13	6.7	4.0	1.8	25.7	45.6	26.5
14	7.6	3.8	1.3	27.8	46.6	25.8
15	–	4.0	1.9	–	–	–
16	–	3.7	1.6	–	–	–
17	7.2	3.8	1.8	–	–	–
18	–	–	1.8	–	–	–

k/k : Interpterygoid width.

1/1 post : Lacrimal length from post edge of foramen.

1/1 ant : Lacrimal length from anterior edge of foramen.

m/m : Length of lower tooth row.

n/n : Greatest length lower jaw.

o/o : Greatest height of lower jaw.

APPENDIX : 2.

DICEROS BICORNIS SKULL MEASUREMENTS FROM A NATAL SAMPLE.

Skull.	a/a	b/b	c/c	d/d	e/e
1	56.9	54.5	21.7	19.2	16.0
2	56.7	53.0	21.5	18.9	16.0
3	59.6	57.2	24.0	16.2	13.9
4	51.7	49.1	21.0	17.3	15.1
5	51.2	47.6	22.3	18.4	15.7
6	52.5	47.5	20.0	17.1	14.7
7	51.2	48.3	21.3	17.7	16.2
8	44.3	41.5	16.8	14.7	12.1
9	52.5	48.8	19.9	16.1	14.6
10	49.4	46.5	19.4	16.1	14.6
11	54.0	50.7	19.1	18.0	11.3
12	48.4	44.9	19.2	16.9	15.0
13	43.9	38.5	18.0	15.5	12.6
14	48.3	44.3	19.1	16.9	15.0
15	50.4	48.9	20.7	18.0	16.1
16	51.7	48.2	18.7	17.2	13.9
17	54.1	47.1	20.0	18.4	16.8
18	52.0	47.7	21.9	18.0	15.6
19	55.2	53.3	22.3	18.5	16.5
20	51.1	48.9	19.5	17.5	15.1

a/a : Greatest length Condylo-Nasal length.
b/b : Greatest length Occipito-Nasal.
c/c : Anterior orbital.
d/d : Nasal length.
e/e : Nasal width.

APPENDIX : [illegible] continued.

Skull.	f/f	g/g	h/h	i/i	j/j
1	26.7	32.3	11.1	20.0	29.5
2	29.1	33.1	11.6	20.5	28.2
3	28.8	34.3	11.9	20.6	28.9
4	24.7	31.1	10.2	18.3	27.5
5	26.9	34.3	10.6	18.7	29.2
6	25.7	30.7	10.3	18.5	27.7
7	24.0	32.1	10.2	16.6	27.1
8	19.4	25.9	9.3	15.6	25.1
9	24.6	31.1	10.9	18.5	27.1
10	25.8	30.0	10.0	17.3	28.5
11	19.5	26.5	9.2	16.0	30.4
12	24.4	29.4	10.2	17.1	27.1
13	19.4	26.7	9.6	14.9	23.8
14	24.6	29.3	10.1	17.1	27.1
15	24.9	30.8	10.1	17.9	26.7
16	25.9	30.4	9.4	13.1	24.3
17	27.6	30.9	10.1	16.3	29.3
18	25.4	30.1	10.4	18.7	26.1
19	27.8	32.5	11.7	19.9	27.3
20	25.1	30.7	10.6	17.9	28.3

f/f : Length upper tooth row.
g/g : Zygomatic.
h/h : Post orbital constriction.
i/i : Palatine length.
j/j : Post. edge Palatine - basilar length.

APPENDIX 2 continued.

Skull.	k/k	1/1 post	1/1 ant	m/m	n/n	o/o
1	7.4	4.3	1.8	24.4	44.0	23.7
2	9.2	4.4	1.8	26.5	43.7	23.4
3	7.8	4.4	2.1	23.1	44.3	22.5
4	6.5	3.8	1.7	26.5	41.1	21.2
5	6.5	4.6	2.1	26.2	43.7	22.2
6	6.9	4.4	2.0	26.2	43.3	23.9
7	6.6	4.1	1.8	25.2	42.4	22.7
8	6.6	3.3	1.5	22.0	37.7	18.9
9	6.9	4.1	2.0	23.6	43.1	23.1
10	7.1	4.1	1.9	28.8	41.6	21.0
11	6.5	5.4	2.9	22.9	41.3	24.1
12	7.3	3.4	1.6	23.6	40.2	21.1
13	7.1	3.3	1.8	20.2	34.7	18.4
14	7.1	3.6	1.5	24.0	39.9	21.1
15	6.1	3.9	1.8	24.4	41.7	21.8
16	6.7	3.6	1.7	27.5	43.8	23.3
17	6.3	4.6	2.3	24.7	44.6	24.3
18	7.3	3.8	1.6	24.8	41.3	21.1
19	8.0	4.8	2.0	26.8	43.5	23.1
20	6.2	3.9	1.5	26.9	43.7	22.3

k/k : Interplerygoid width.

1/1 post : Lacrimal length from post edge of foramen.

1/1 ant : Lacrimal length from anterior edge of foramen.

m/m : Length of lower tooth row.

n/n : Greatest length lower jaw.

o/o : Greatest height of lower jaw.

APPENDIX : 3.

PAIRED MEASUREMENTS OF SAMPLES FROM SOUTH WEST AFRICA AND NATAL FOR GREATEST SKULL LENGTH (x) AND LENGTH OF PALATINA (y).

South West Africa.

X	Y
557	196
630	212
656	188
633	203
594	198
570	196
565	186
590	222
584	186
582	177
612	199
598	194
598	201

Natal.

X X	Y Y
596	200
567	205
595	206
517	183
512	187
525	185
512	166
443	156
525	185
494	173
540	160
484	171
439	149
483	171
504	179
517	181
541	163
520	187
552	199
511	179

APPENDIX : 4.

THE DISCRIPTION OF PROFILE PITS IN VARIOUS SOIL TYPES IN THE STUDY AREA AT OTJOVASANDU.

Profile Pit.	Natural plant cover.	Soil type.	Colour.	Texture.
1	C. mopane - C. alexandri - shrub savanna.	Kalahari-like red sand.	Red	sand
2	C. mopane - C. alexandri - shrub savanna.	Kalahari-like red sand.	Red	loamy sand
3	C. mopane - T. prunioides C. apiculatum asso.	Granitic red sand	Red	sand
4	C. mopane - T. prunioides C. apiculatum asso.	Granitic red	Red	loamy sand
5	S. guerichii asso. and - C. alexandri - A. nebrowni asso.	Surface limestone and calcrete rubble.	Reddish brown	loamy sand.
6	S. guerichii asso. and C. alexandri - A. nebrowni asso.	Surface limestone and calcrete rubble.	Greyish	loamy sand.
7	S. guerichii asso. and C. alexandri - A. nebrowni asso.	Surface limestone and calcrete rubble.	Brown	loamy sand.

APPENDIX : 4 continued.

Profile Pit.	Natural plant cover.	Soil type.	Colour.	Texture
8	Valley community	Alluvial soil	Brown	sandy loam gravel.
9	Valley community	Alluvial soil	Reddish brown	loamy clay.
10	Valley community	Alluvial soil	Reddish brown.	sandy loam.
11	*C. mopane* - *A. reficiens* - *T. prunioides* asso.	Sceletal soil	Greyish	sandy loam
12	Grass on rain water pan surface	Claylike soil	Blackish	sandy clay-like.

APPENDIX : 4. continued.

Profile Pit.	Horizon.	Depth.	Structure.	Stone.	Roots.
1	B_2	0-21"	Sub-angular	A none	Moderate
	B_3	21"-24"	-	stony layer.	none.
Sub-strate :- Sheet Calcrete.					
2	B_2	0-24"	Angular	none	few
	B_3	24"-36"	Sub-angular	calcrete rubble	few
Sub-strate :- Sheet calcrete.					
3	B_2	0-12"	Sub-angular	none	abundant
	B_3	12"-16"	columm	gravel	moderate
Granite - divided in columm blocks by root erosion.					
4	B_2	0-18"	Sub-angular	none	abundant
	B_3	18-24"	Sub-angular	gravel	moderate
Granite covered by sheet calcrete.					
5	B_2	0-12"	Columm	none	few
	B_3	12"-24"	-	small angular	none.
Sub-strate :- Sheet calcrete with layer of rubble.					
6	B_2	0-12"	granular	none	moderate
	B_3	12"-24"	Sub-angular	calcrete rubble	none
Sub-strate :- Sheet calcrete.					
7	B_2	0-12"	angular	moderate	moderate
	B_3	12"-36"	granular	abundant	none
Sub-strate :- Sheet calcrete.					
8	B_2	0-48"	angular	none	abundant
	B_3	48"-54"	Solid	calcrete rubble	none
Sub-strate :- Sheet calcrete.					
9	B_2	0-72"	Prismatic	moderate	abundant
				moderate	few

APPENDIX : 4. continued.

Profile Pit.	Horizon.	Depth	Structure	Stones	Roots.
10	B_2	0-34"	Sub-angular	gravel	abundant
	B_3	34"-50"	Sub-angular	meta-quartzite pebbles.	none
11	B_2	0-19"	Sub-angular	none	few
	B_3	19"-24"	Sub-angular	meta-quartzite	few
	C		Shale		
12	B_2	0-9"	Granular	moderate	abundant
	B_3	9"-13"	Prismatic	none	none
	Sub-strate :- Sheet calcrete.				

APPENDIX : 5.

ANALYSIS OF SOIL SAMPLES TAKEN FROM PROFILE PITS IN STUDY AREA, OTJOVASANDU.

Profile Pit.	pH	Resistance in Ohms.	N.	P_2O_5	K_2O.
1	8.00	1200	0.0350	0.0020	0.0038
	8.19	1400	0.0280	0.0033	0.0026
2	7.02	890	0.0434	0.0024	0.0036
	7.90	410	0.0504	0.0035	0.0017
3	7.98	8000	0.0238	0.0026	0.0046
	5.12	10	0.0196	0.0014	0.0017
4	7.11	2650	0.0322	0.0015	0.0017
	8.16	1900	0.0238	0.0010	0.0018
5	6.38	1280	0.0308	0.0021	0.0017
	7.86	520	0.0535	0.0061	0.0173
6	8.00	760	0.0728	0.0111	0.0139
	8.10	820	0.0504	0.0030	0.0097
7	8.10	155	0.0406	0.0023	0.0096
	8.33	44	0.0196	0.0031	0.0221
8	8.11	900	0.1260	0.0061	0.0034
	8.01	3590	0.0476	0.0027	0.0010
9	8.26	790	0.0378	0.0031	0.0022
	8.06	670	0.0378	0.0042	0.0036
10	7.06	3050	0.0252	0.0108	0.0046
	8.34	1880	0.0182	0.0096	0.0068
11	6.65	460	0.0812	0.0029	0.0072
	6.57	270	0.0798	0.0300	0.0139
	7.09	500	0.0490	0.0014	0.0020
12	6.99	820	0.0700	0.0027	0.0072
	7.38	610	0.0406	0.0019	0.0038