

MADOQUA

Vol. 1, No. 1 (1971)

A
D
O
O
Q
U
A



Published by the National Geographic Society, Smithsonian Institution
Journal of Marine Conservation Research, 2101 L Street, N.W.

MADOQUA

Hoof Redakteur / Editor-in-Chief

B. J. G. de la Bat

Nature Conservation and Tourism Branch, South West
Africa Administration, Windhoek (South West Africa)

Hulp-Redakteurs / Associate Editors

C. G. Coetzee

State Museum, Windhoek (South West Africa)

F. C. Eloff

University of Pretoria, Pretoria (Republic of South
Africa)

J. M. de Kock

University of Stellenbosch, Stellenbosch (Republic of
South Africa)

U. de V. Pienaar

National Parks Board, Pretoria (Republic of South
Africa)

H. P. van der Schijff

University of Pretoria, Pretoria (Republic of South
Africa)

P. S. Swart

Nature Conservation and Tourism Branch, South West
Africa Administration, Windhoek
(South West Africa)

Voornemende outeurs word versoek om die instruksies aan
outeurs te verkry van:

Die Redakteur

Natuerbewaring en Toerisme,
Privaatsak 13186,
Windhoek, Suidwes-Afrika.

Manuskripte wat nie in ooreenstemming is met hierdie in-
struksies nie, sal teruggestuur word vir wysigings.

Prospective authors are requested to obtain the instructions
to authors from:

The Editor

Nature Conservation and Tourism,
Private Bag 13186,
Windhoek, South West Africa.

Manuscripts which are not in accordance with these instruc-
tions will be returned for modification.

Gedruk deur John Meinert (Edms) Bpk., Windhoek - 1/94
Printed by John Meinert (Pty) Ltd., Windhoek - 1/94

Prys van No. 3 (a) Binnelands R3.95
(b) Buitelands R4.45
Price of No. 3 (a) Interior R3.95
(b) Exterior R4.45

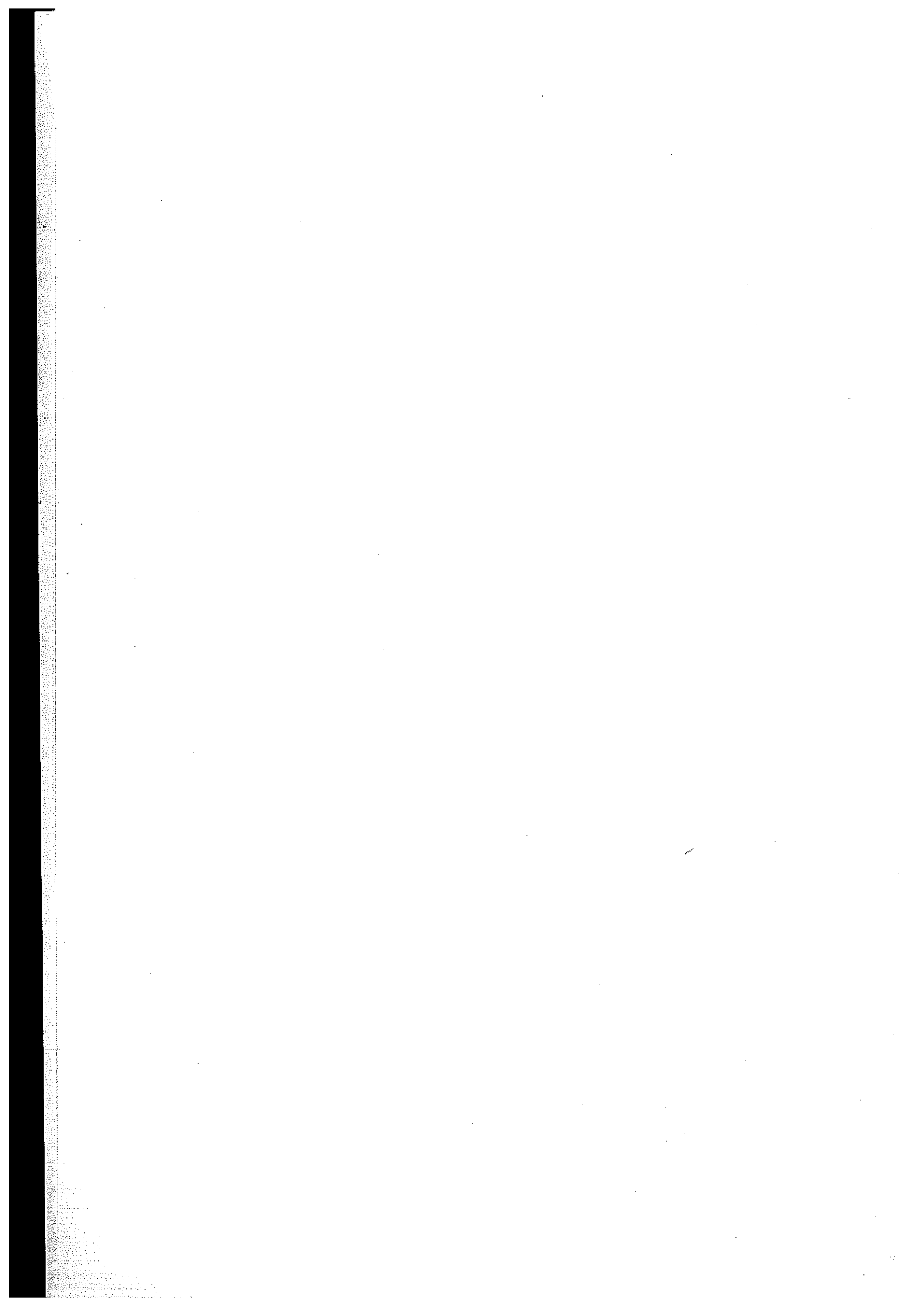
MADOQUA

Ser. I, No. 3, 1971



GEPUBLISEER DEUR AFDELING NATUURBEWARING EN TOERISME
VAN DIE ADMINISTRASIE VAN SUIDWES-AFRIKA.

PUBLISHED BY THE NATURE CONSERVATION AND TOURISM BRANCH
OF THE SOUTH WEST AFRICA ADMINISTRATION.



CONTENTS

Notes on the Ecology and Behaviour of the Black Rhinoceros <i>Diceros bicornis</i> Linn. 1758 in South West Africa. By E. Joubert and F. C. Eloff	5
Observations on the Habitat Preferences and Population Dynamics of the Black-Faced Impala <i>Aepyceros petersi</i> Bocage, 1875, in South West Africa. By E. Joubert	55
The Capture of Plains Zebra <i>Equus burchelli antiquorum</i> , H. Smith 1841, with M-99 (Reckitt) and Tranquillizers in the Etosha National Park. By H. Ebedes	67
<i>Trionyx triunguis</i> (Forskal), a Reptile new to the South West African Fauna. By M. J. Penrith	77

Notes on the Ecology and Behaviour of the Black Rhinoceros *Diceros bicornis* Linn. 1758 in South West Africa

by

E. Joubert

Nature Conservation and Tourism Branch
South West Africa Administration

and

F. C. Eloff

Department of Zoology,
University of Pretoria

CONTENTS

I. Introduction	6	c) (i) Infertility during certain seasons of the year	41
II. Procedure and methods	6	(ii) Influence of day length	41
a) Horizontal density of vegetation	6	(iii) The physiological influence of nutrition	42
b) Food species and preferences	6	d) Mating habits	42
c) Behaviour and living habits	6	e) Sex ratios, breeding rate and survival rate	42
III. Habitat characteristics and preferences	7	VII. The influence of weather on the black rhinoceros	43
IV. Food and drinking habits	11	a) Temperature	43
a) Food species and preferences	11	(i) Daily rhythm	44
b) Feeding behaviour	13	(ii) Seasonal rhythm	45
c) Effects on range vegetation	15	b) Rainfall	45
d) Competition with other species	18	(i) Influence on reproduction	46
e) Drinking habits	20	(ii) Influence on movement	46
f) Mineral needs	20	(iii) Influence on feeding habits	46
V. Behaviour and living habits	20	(iv) Influence on wallowing	46
a) Territorialism	20	c) Relative humidity	46
b) Home range	22	d) Wind movement	47
c) Social structure and behaviour	25	e) Frost	48
d) Parental care	26	VIII. Limiting factors	48
e) Interactions with other animals	28	a) Predation	48
f) Daily activity cycle	28	b) Vegetation and water	49
g) Wallowing, dust bathing and rubbing	31	c) Diseases, parasites and associated flies	49
h) Sanitary behaviour	34	IX. Summary	49
i) Movement	36	X. Acknowledgements	50
Daily movement	37	XI. Bibliography	50
Seasonal movement	38		
Wandering	39		
VI. Reproduction	40		
a) Gestation period	40		
b) Breeding cycles	41		

I. INTRODUCTION

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 animals 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 is made extremely difficult 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 S.W.A. 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. At the same time a research project was launched. The main object 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 Kaokoveld and all other distribution areas could also easily be reached from there.

II. PROCEDURE AND METHODS

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.

a) Horizontal Density of Vegetation

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 cover at a distance of 66 feet (one chain). (See plate 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.

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

c) Behaviour and Living Habits

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



Plate 1. "Density Board" used to measure horizontal density of vegetation. The reading here is $(4 + 5) = 9$.
Photo by W. P. S. Joubert

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 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 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. (See plate 2).

III. 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 (1915), Lamp-

rey (1963), Ritchie (1963), Stewart & Stewart (1963), Smithers (1966), and Guggisberg (1966). According to these authors rhino are found in a wide variety of habitats, from sea level to about 12,000 feet (Stewart and Stewart) from plain and desert to high rain forests and cloud-soaked 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 percent of the present black rhinoceros 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 onto 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 these areas because of human



Plate 2. The male MP., showing „square cut” right ear, an aspect used to identify this animal. Photo by E. Joubert

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 stretched 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 around Otjovasandu. They occur at Grünwald (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 their previous distribution pattern as mentioned elsewhere. (Joubert, in Press). 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 level and up the slopes.”

The reasons why black rhino prefer the mountainous transition belt are not clear. The following factors may all contribute to a varying extent to this preference.

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

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 the following qualifying aspects preferred by rhinos: Cover and preferred food plants.

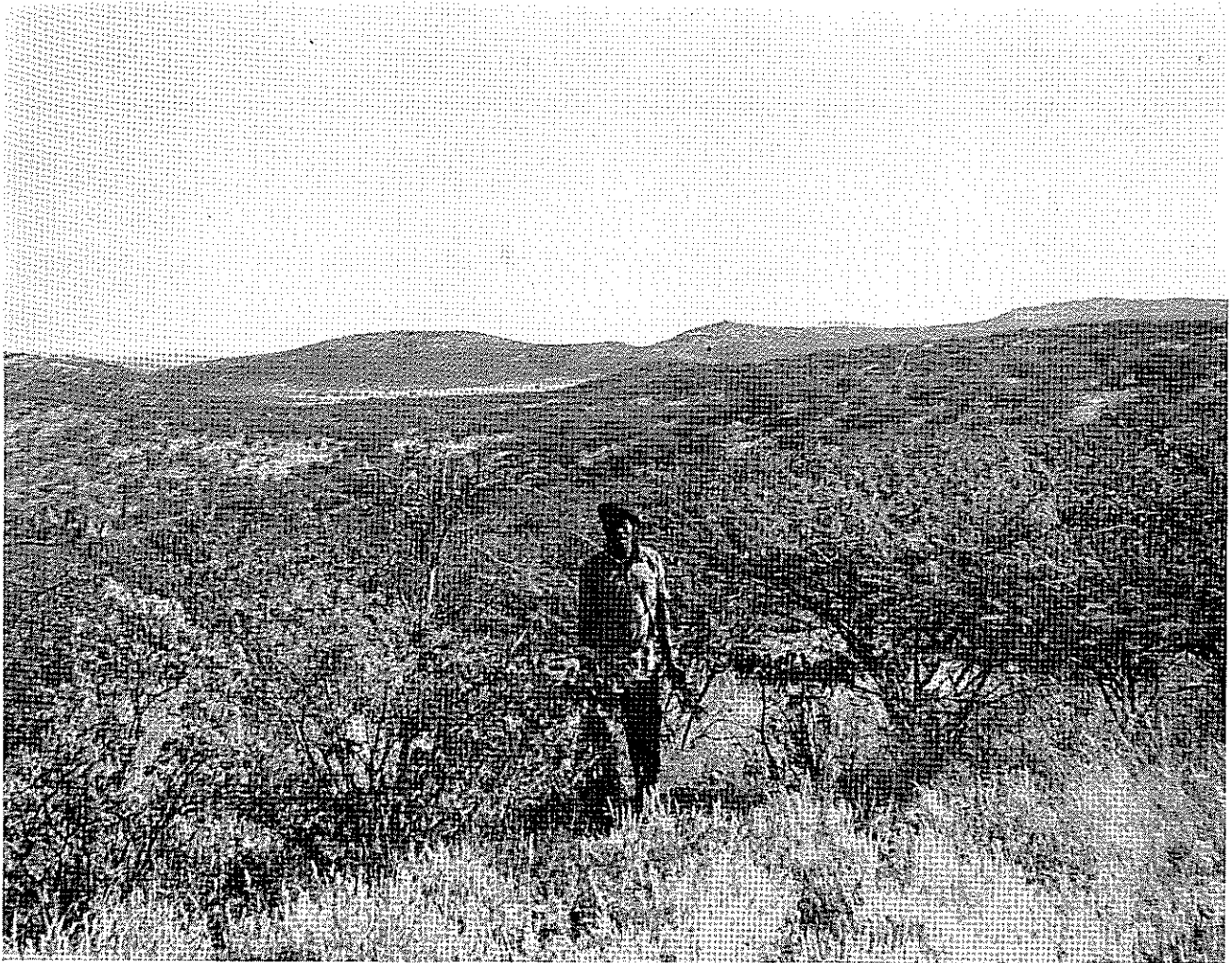


Plate 3. A view of preferred rhino habitat. Home range E., looking west. Photo by E. Joubert

Protection: The 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 trees and shrub (thorn shrub) 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. (See plate 3)

The plant communities preferred by black rhino are discussed elsewhere (Joubert, in Press).

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 I 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 1. 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	1 315	250.46	Total	1 682	320.35
Average		41.74	Average		53.39

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

Table 2. Food plants of the Black Rhinoceros in South West Africa.

Plants eaten throughout the year.		Plants eaten mainly during the rainy/post rainy season.	
Stipagrostis uniplumis	Gramineae	Welwitschia mirabilis	Welwitschiaceae
Phragmites communis	"	Montinia caryophyllacea	Montinaceae
Ximenesia americana	Olacaceae	Acirpus littoralis	Cyperaceae
*Acacia reficiens	Mimosaceae	*Asparagus denudatus	Liliaceae
*Acacia mellifera var. detinens	"	Colophuspermum mopane	Caesalpinaeae
*Acacia senegal	"	Helinus integrifolius	Rhamnaceae
*Acacia ataxacantha	"	Hibiscus palmatus	Malvaceae
Acacia fleckii	"	Hibiscus ceasius	"
Acacia erubescens	"	Hermannia amabilis	Sterculiaceae
Acacia hebeclada	"	Merremia guerichii	Convolvulaceae
Acacia tortilis	"	Merremia multisecta	"
Acacia nilotica	"	Bonamia schizantha	"
Albizia anthelmintica	"	Manuleopsis dinteri	Scrophulariaceae
*Dichrostachys cinerea	"	Hierna angolensis	"
Parkinsonia africana	Caesalpineae	Aptosium angustifolium	"
Zygophyllum stapffii	Zygophyllaceae	*Catophractes alexandri	Bignoniaceae
Commiphora glaucescens	Burseraceae	Monechma arenicola	"
Commiphora saxicola	"	Monechma salsola	"
*Euphorbia guerichiana	Euphorbiaceae	Ruellia diversifolia	"
*Euphorbia phylloclada	"	*Barleria senensis	"
Rhus marlothii	Anacardiaceae	Justicia odora	"
*Grewia bicolor	Tiliaceae	*Justicia platysepala	"
*Grewia tenax	"	*Blepharis obmitrata	"
*Grewia villosa	"	Blepharis gigantea	"
Grewia flavescens	"	Petalidium coccineum	"
*Gossypium triphyllum	Malvaceae	Dactylandra welwitschii	Cucurbitaceae
Combretum imberbe	"	Citrullus ecirrhorus	"
*Combretum apiculatum	"	*Cordia gharaf	Heliotropiaceae
*Terminalia prunioides	"	Sarcocaulon mossamedense	Geraniaceae
Ipomoea arachnosperma	Convolvulaceae	Otoptera burchellii	Fabaceae
*Lycium trothae	Solanaceae	*Rhynchosia spp	"
*Cordia gharaf	Heliotropiaceae	Dolichos chrysanthus	"
Currionia dedidua	Periplocaceae	Lycium boscuifolium	Capparaceae
Calicorema capitata	Amaranthaceae	Bidens biternata	Asteracea
Neorautenia amboensis	Fabaceae	Oosteospermum nervosum	Asteracea
Tamarix usneoides	Tamaricaceae		

* Preferred food plants.

IV. FOOD AND DRINKING HABITS

a) Food species and preferences

Although the black rhinoceros in South West Africa, feeds on a wide spectrum of plant species (see table 2), 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.

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 to 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 per-

Table 3. The bulk food plant utilization and preference shown by *Diceros bicornis* in the study area at Otjovasandu, South West Africa.

Species	Browsing category.			Utilized	Preference %
	Heavy	Moderate	Not Browsed		
<i>Acacia reficiens</i>	48	39	13	87	36.6
<i>Acacia mellifera</i> var. <i>detinens</i>	28	41	31	69	21.4
<i>Acacia senegal</i>	22	47	31	69	16.8
<i>Terminalia prunioides</i>	18	38	44	56	13.8
<i>Grewia</i> species	12	37	51	49	9.2
<i>Catophractes alexandri</i>	3	41	56	44	2.2
<i>Combretum apiculatum</i>	0	40	60	40	—
<i>Colophospermum mopane</i>	0	11	89	11	—

The results are shown in table 3. The bulk of their diet consists primarily of *Acacia* species, which are usually heavily browsed. The most preferred species are *A. reficiens*, *A. mellifera* var. *detinens* and *A. senegalensis*. Of the *Combretum* species, *Terminalia prunioides* 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. villosa*, *Catophractes alexandri* and to a lesser extent *Combretum apiculatum*.

Some of these preferred food plants were analysed by C.S.I.R. to determine their nutritional value. Samples were taken at the height of the growing season (March) during winter (July) and during the spring flush (September). The results can be seen in Table 4.

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 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 value during June. The percentage phosphate on the other hand shows a marked decrease in June followed by an 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 plate 4). 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.

Table 4. The nutritious value of some preferred food plants of *Diceros bicornis* in the study area at Otjovasandu, South West Africa.

Species	Protein Nx 6.25 %		Ash %		Crude Fibre %		Fat %		Ca %		P %				
	M	J	M	J	M	J	M	J	M	J	M	J			
	S	S	S	S	S	S	S	S	S	S	S	S			
<i>Acacia reficiens</i>	8.2	6.5	10.7	3.90	44.4	45.8	39.0	1.6	1.2	1.5	1.5	1.3	0.08	0.04	0.17
<i>Acacia mellifera</i> var. <i>detinens</i>	7.9	9.6	9.2	1.81	44.2	42.6	49.3	1.8	1.4	1.4	1.4	1.4	0.18	0.07	0.15
<i>Terminalia prunioides</i>	5.7	4.7	4.6	2.44	41.6	43.6	57.6	0.7	0.7	0.7	0.7	1.6	0.09	0.04	0.07
<i>Grewia</i> species	4.6	4.6	3.8	1.95	42.7	47.6	49.5	1.1	1.0	1.0	1.0	1.9	0.14	0.06	0.07
<i>Catophractes alexandri</i>	5.3	4.2	5.3	1.51	43.9	42.6	44.0	1.4	0.9	1.0	1.0	0.7	0.09	0.05	0.08
<i>Combretum apiculatum</i>	7.5	4.8	4.1	2.04	33.7	41.4	49.2	1.3	2.5	1.0	1.0	1.5	0.07	0.07	0.06
<i>Blepharis obmitrata</i>	6.9	5.8	5.7	4.6	38.7	35.2	37.3	0.8	0.8	0.9	0.9	1.1	0.07	0.06	0.08

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 in 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.

<i>Rainy/Post-rainy</i> <i>season.</i> <i>(Jan. to June/July).</i>		<i>Dry season</i> <i>(Sept./Oct. to Nov.).</i>	
Trees:	0%	Trees:	0%
Shrubs:	87%	Shrubs:	95%
Herbs:	13%	Herbs:	5%
*Grasses:	0%	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 obmitrata
Dactylandra welwitschii
Dolichos chrysanthes
Neorautenia amoensis
Bidens biternata
Osteosoernum nervosum
Ipomoea arachnosperma
Helinus integrifolius
Aptosium angustifolium
Hibiscus caesius

Colophospermum mopane is now also utilized in a 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.

Bonamia schizantha
Merremia guerichii

Hermannia amabilis
Merrenmia multisecta
Euphorbia guerichiana
Ruellia diversifolia
Sarcocaulon mossamedense
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.

b) Feeding behaviour

Rhino show a regular feeding rhythm through a twenty-four hour cycle. This rhythm is closely cor-

related 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 dusk activity period. (See Daily activity cycle, fig. 1). A third and less important feeding peak takes place at about midday between the two above-mentioned 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 and 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 actually 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.



Plate 4. A tuft of grass cut off by a feeding rhino. Notice the defoliated sometimes cut off branches of *Grewia bicolor*. Photo by E. Joubert

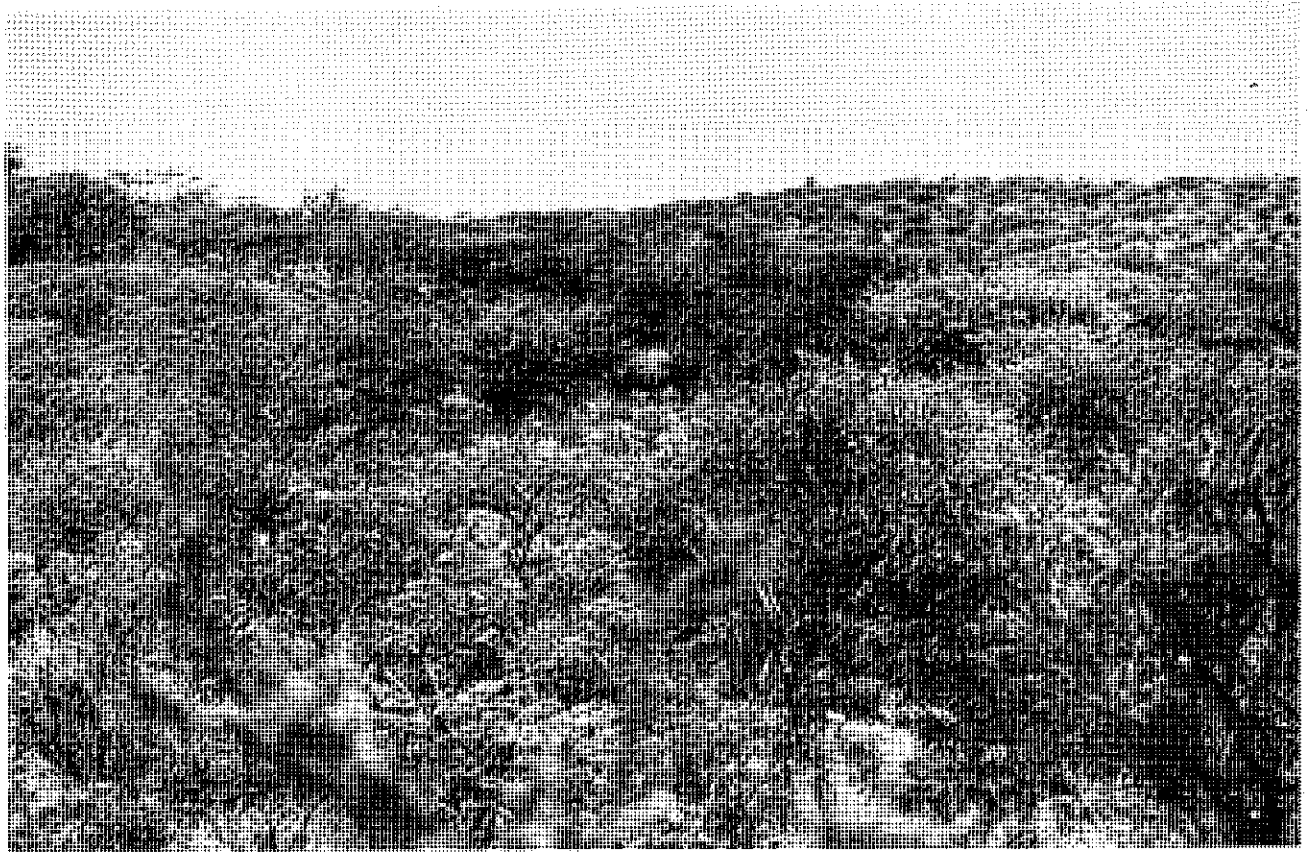


Plate 5. Showing female FE₀ browsing. Notice how difficult it would have been to determine "rhino feeding minutes" per plant species. Photo by E. Joubert

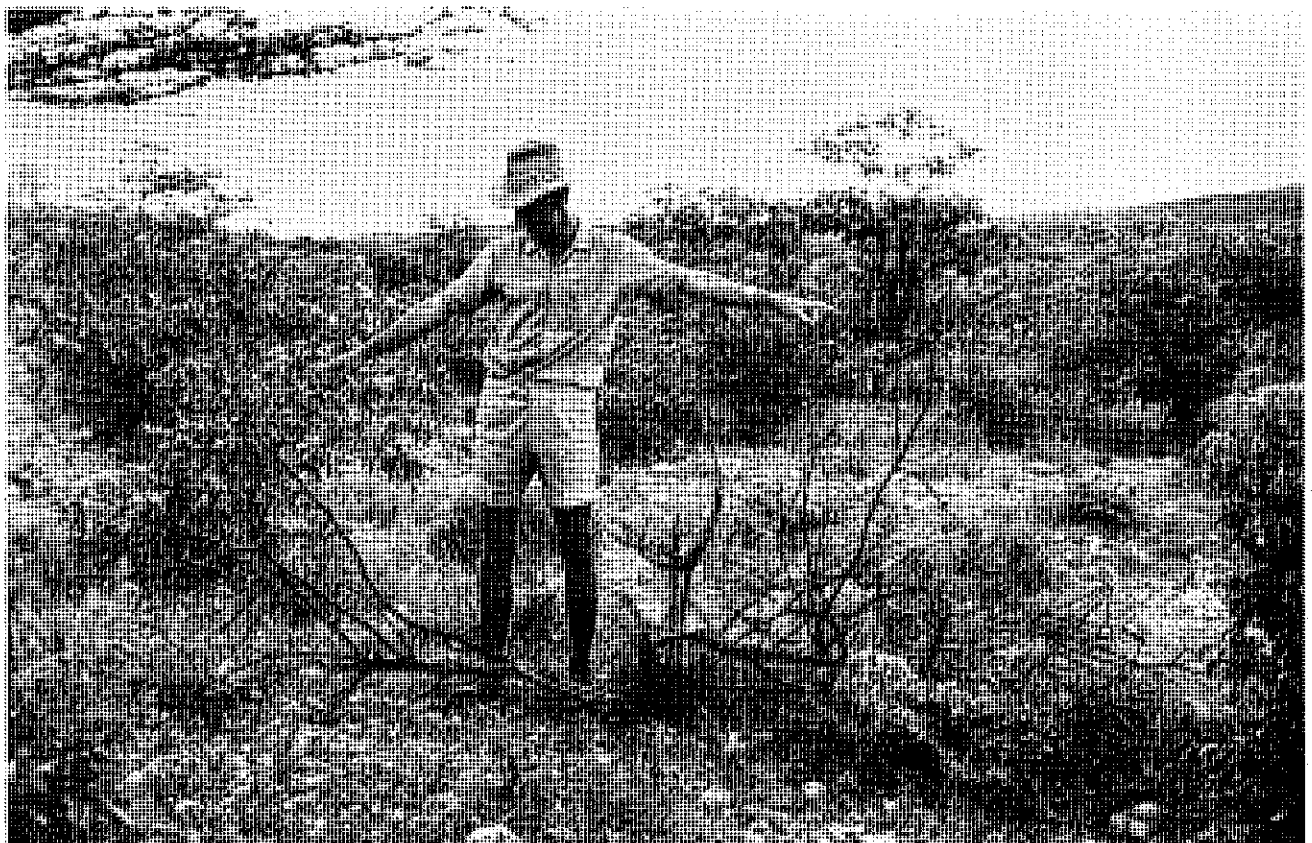


Plate 6. This *Acacia reficiens* shrub died off after being trampled by browsing rhino. Photo by W. P. S. Joubert

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 this study area it sometimes happens that they trample the stems of *A. reficiens* and *A. mellifera* var *detinens* so that more of the plant becomes available. (See plate 5)

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. The 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 (Joubert, 1970). 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 plate 7, 8 and 9)

On several occasions rhino have been observed defoliating *Grewia bicolor* by running their lips over the twigs. (See plate 4).

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

c) 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 (plate 10) 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* (plate 12) 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



Plate 7. A rhino cutting off the proximal ends of twigs while browsing. Photo by E. Joubert



Plate 8. Texture of rhino dung during dry season. Compare with plate 9. Photo by E. Joubert

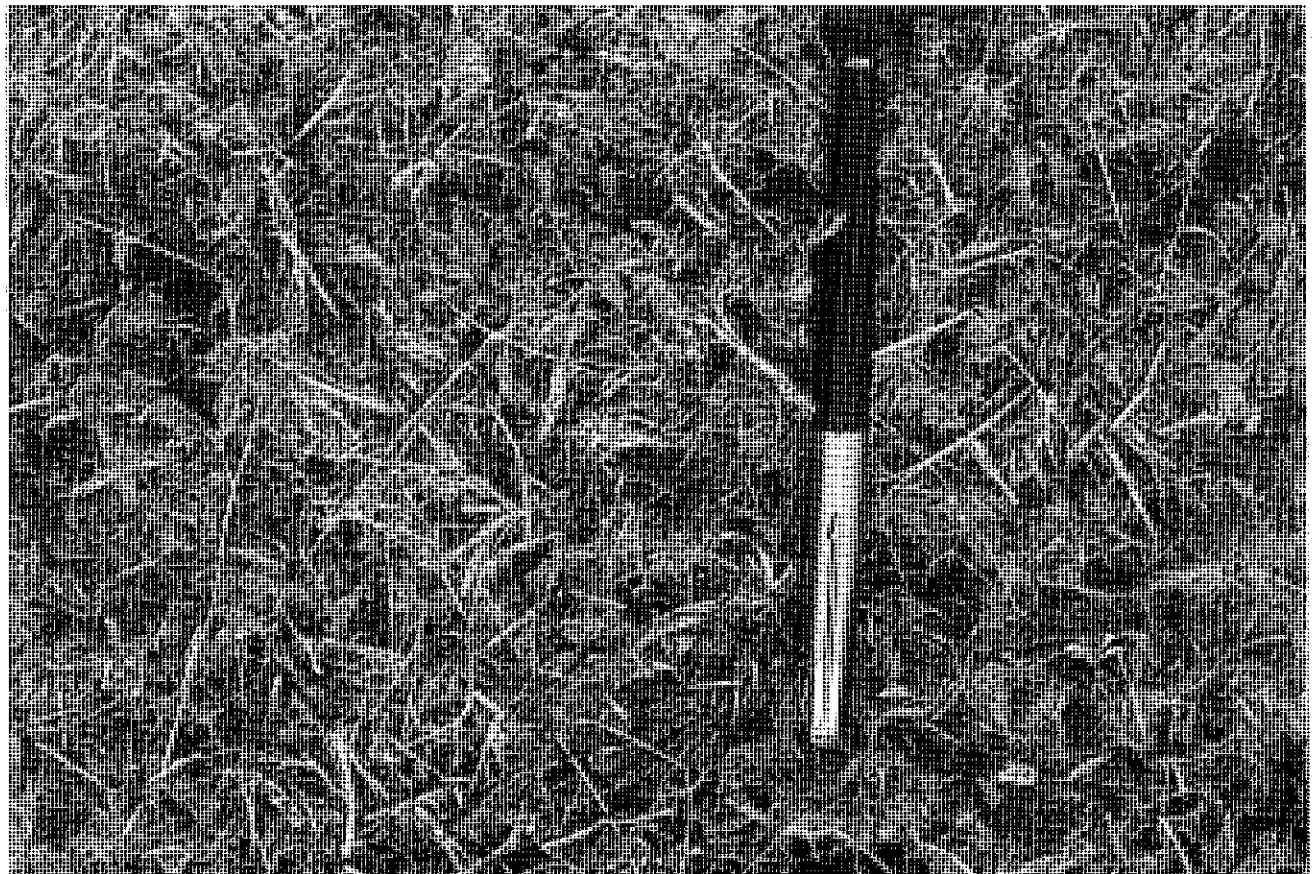


Plate 9. Texture of rhino dung during rainy season. Compare with plate 8. Photo by E. Joubert

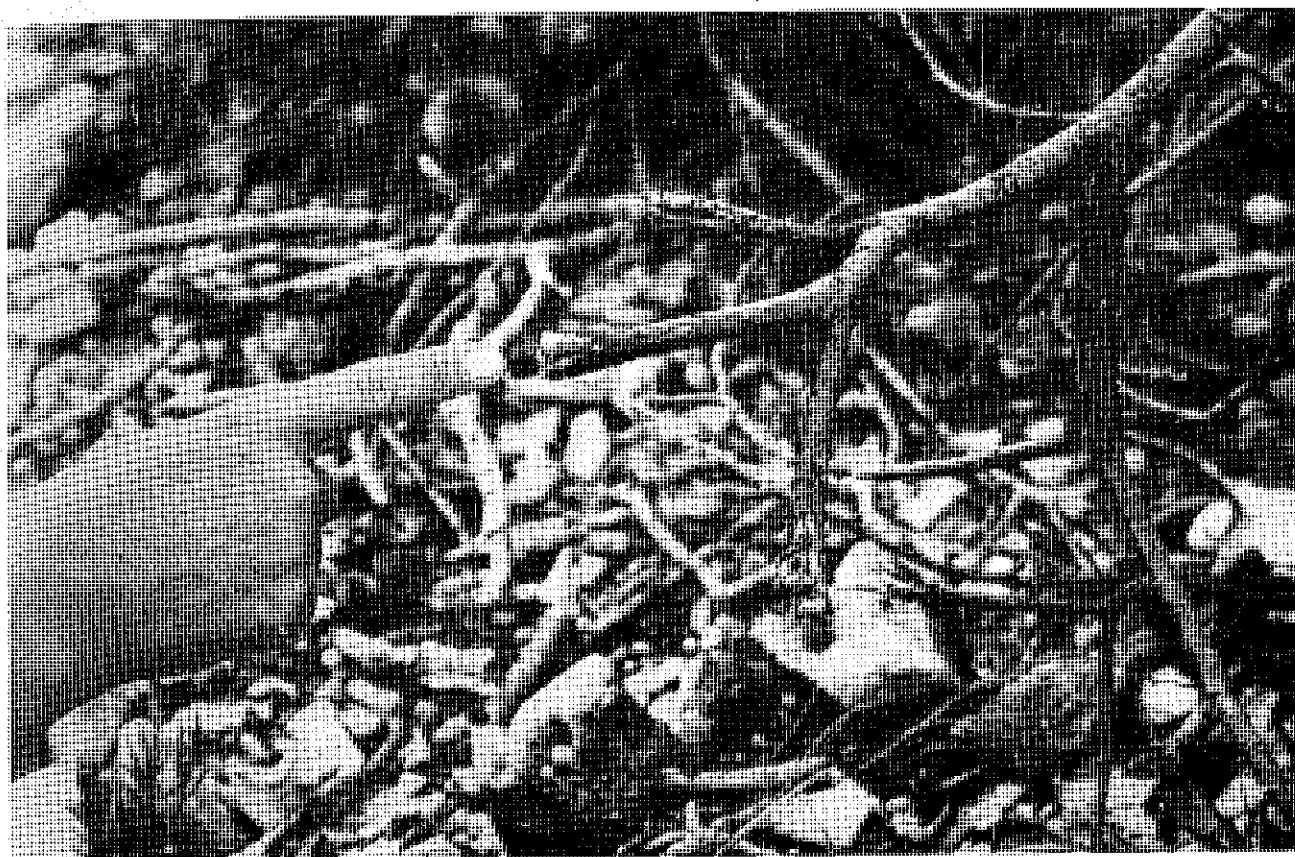


Plate 10: Approximate maximum thickness of twigs cut off by browsing rhino. Photo by W. P. S. Joubert

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 plates 13 and 14). When rhino break off twigs they sometimes move their heads sideways, thus causing the twigs to tear slightly apart at the first fork.

These twigs then 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/ or tore it off at the first fork.

The results are shown in table 5.

A. reficiens which is most heavily utilized showed the highest number of plants with dead branches. 32 per cent 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.

Table 5. 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.
	Browsing Category.				
	Heavy	Moderate	Heavy	Moderate	
<i>Acacia reficiens</i>	34	5	48	39	32.2
<i>Acacia mellifera</i> var. <i>detinens</i> .	9	4	28	41	18.8
<i>Terminalia prunioides</i>	4	1	18	38	8.8
<i>Grewia</i> species	0	0	12	37	0
<i>Catophractes alexandri</i>	0	0	3	41	0

* F.P.U. = Food plants utilized.



Plate 11. Approximate browsing height of black rhino. The person on the right is 6 feet tall. Photo by W. P. S. Joubert

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. (See plate 6).

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

d) 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. 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 shrubs 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 numbers of elephant pass through this region. They leave in their wake a path of destruction, usually of acacia and mopane trees (See plate 14). 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.

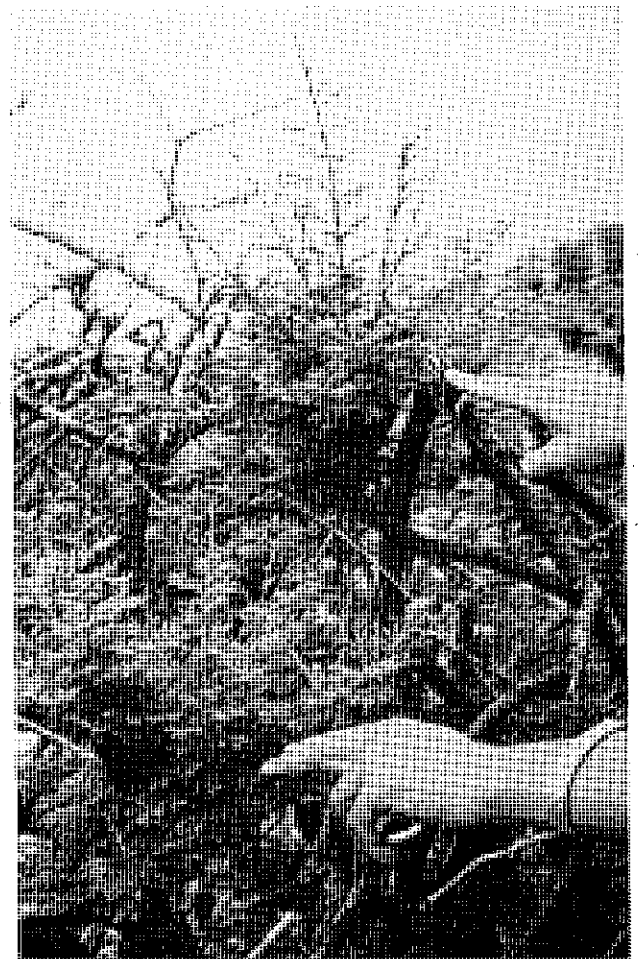


Plate 12. An *Acacia reficiens* shrub sprouting after browsing damage by rhino. Photo by W. P. S. Joubert



Plate 15. The twisted off branch illustrates elephant method of browsing. Photo by E. Joubert



Plate 14. Typical damage to vegetation by elephant browsing. Photo by E. Joubert

thus
grass
also
viz.
d its
e al-
that
tilize

and
n of
hino
n of

area.
hant
wake
pane
rious
well
oun-
atory
hino

rowsing

e) Drinking habits

The drinking habits of rhino vary from locality to 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 an 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 waterholes 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.
4. 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 P. (See Home Range, map 1) utilized the water hole 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.

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. (Joubert, in Press). 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 filled with water and then noisily drink his fill. (Plate 15).

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 drinking water. Whether this indicated that they drank large quantities of water, or whether they were very slow drinkers could not be ascertained.

f) 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 6). 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'.

V. BEHAVIOUR AND LIVING HABITS

a) Territorialism

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 does not seem to defend a certain area but rather his group of females

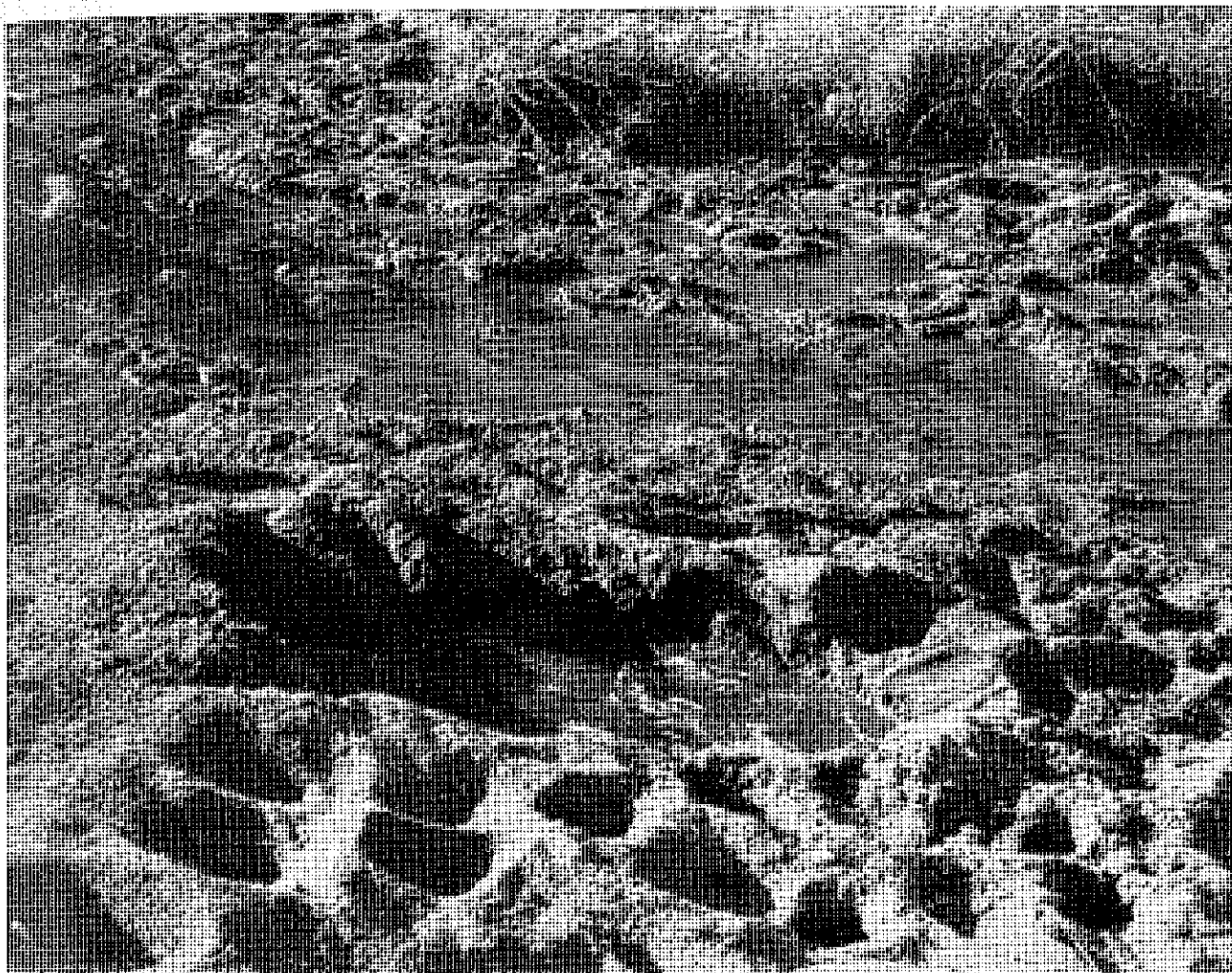


Plate 15. A "Gorra" dug by rhino at Omborongbonga. Photo by E. Joubert

Table 6. Chemical analysis of water samples taken from waterholes in the study area at Otjovasandu, South West Africa (parts per million).

	Otjova- vasandu	Renoster- fontein	Kowares	Renoster- vlei
Cu	0.0009	0.00016	0.0020	0.0013
Zn	0.062	0.041	Trace	0.032
Fe	—	0.0009	—	—
pH	8.4	8.08	8.26	8.35
*T.D.S.	848.0	652.0	695.0	443.0
Na ⁺	180.0	93.0	131.0	50.0
K ⁺	122.0	15.0	13.0	8.0
SO ₄ =	74.0	57.0	45.0	43.0
F ⁻	2.1	1.5	1.7	1.3
Cl ⁻	153.0	98.0	109.0	56.0
**Tot. cal.	515.0	380.0	434.0	

* T.D.S. Total dissolved solids.

**Total cal. Total calcium content.

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 & Hutchinson 1954). 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.

Hutchinson & Ripley (1954) states that in Natal the Black rhinoceros is strongly territorial. 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.

During the last few years detailed study on the black rhinoceros in various localities have shown that this is not the case (Spinage 1962, Guggisberg 1966, Klingel & Klingel 1966).

Von Schenkel (1966), has 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 is shown to 'strange' rhinos 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.

b) Home Range

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. Map 1 shows the area utilized by the rhino of each home range. The circles on the map are used to number the various home ranges and are not necessarily the centre of the individual home ranges. The lines radiating from these circles indicate the various localities where rhino of this specific home range were seen.

The animals utilizing a home range were then numbered. The system used was the following: each individual would get the same number as his/her home range with a prefix M or F to indicate sex. To number the various calves the number of their mother was used with a prefix M or F to indicate sex. For example, MFE1, indicates the male calf of female FE., which frequents home range E1. As shown by map 1 it is quite clear that the black rhinos in the study area do have home ranges. Although no clear boundaries 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. The only other indication that could be found in literature of different sexes of black rhino frequenting the same home range was in Von Schenkel's (1966), publication. In his paper on the territorial behaviour of black rhinos Von Schenkel 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.

Klingel & Klingel (1965), states that especially the bulls establish well defined home ranges 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 grounds 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.

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 P2 falls partly within the *Colophospermum mopane* — *Terminalia prunioides* — *Combretum apiculatum* association. This association however, shows great similarity with the former, and differed 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 and weather extremes.

Apart from the tentative size mentioned by Shortridge (1934) 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 <i>Acacia-Commiphora</i> bush)	11.7 sq. miles

Goddard also mentions a size variation in home range during different seasons of the year. It is felt that the correct viewpoint is that a rhino's home range consists of all the localities visited by the animal during the different seasons of the year. Early in the study it was thought that during the rainy season the rhino wandered over a larger area. 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.

The other factors governing home range size according to Goddard is sex and age class. He states that immature animals have larger areas than adult animals. That they move over larger areas than adults is certainly true. As will be seen under the heading Social structure and behaviour (c), immature male (MFE₁) left his mother shortly before the next calf was due to be born. For the next nine months, till he re-joined her for short periods from January 1968, he wandered extensively over certain parts of home ranges E₁, E₂ and P₁. The authors do 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 consider 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 available food and cover, population pressure and "Lebensraum".

Available food and cover: 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 carrying capacity becomes with resulting larger home ranges. In the Kaokoveld it was found that the home ranges were usually some distance between 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 includes 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 clearly illustrated by the rhino concentration around Orupembe. During the 1966/1967 rainy season the northern part of the Kaokoveld received abundant rain. Rhino from Orupembe (one family group — see (c) Social structure), moved west, 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.

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

"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 than 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 the greater variety of food plants, especially herbs, during this season. Another aspect may be the availability of water in rainwater pans in the depression.

c) 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 dependant 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 waterholes 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 7). Although the home ranges of some of the individuals within the clan may overlap, no overlapping of home ranges between different clans existed in the study area.

Table 7. Social group 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 8. Social relations of the Black Rhinoceros in the study area at Otjovasandu, South West Africa.

	* No. of Observations	No. of Individuals	With		
			Single %	Male %	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 accompanied by a small calf.

Clan I is formed by the animals from home ranges P₁, E₁, and E₂. These animals mainly drank at the Otjovasandu waterhole. The animals from P₁ utilized the Otjovasandu waterhole until the windmill was erected at Renostervlei. The individuals from E₁ were also seen on occasion to drink water at Renostervlei.

It was found that a male, female, calf association frequented home ranges E₁, E₂ and P₁ respectively. The fourth male in clan 1 (see table 7) frequented a home range to the south of Otjovasandu. (This home range is not shown on map 1.) It was recorded 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 FE₁. This young male now seems to inhabit the area roughly between home ranges E₁, E₂ and P₁ though he was still frequently seen in home range E₁. 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 Movement).

Clan II is formed by the animals in home range E₃ (see table 7). 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 Renostervlei.

Clan III consists of the animals drinking at Omborongbonga (see table 7). Two females share home range P₂ with one male, while the other males had solitary home ranges outside the study area (Not shown in map 1).

In home range P₂ the female FP₂ 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 21st August 1967 the young female (FFP₂) 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 per cent of the observations to browse or lie down together. This solitary behaviour by the black rhinoceros is clearly illustrated in table 8. 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 E₁ were seen together for two days. The cow (FE₁) 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 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 association 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 an immature male and in 66.4 per cent of observations with an immature female. On a few occasions a male, female, calf and immature calf association were also seen (See table 8). The female (FE_3) in home range E_3 was still accompanied by her immature daughter although she (FE_3) was very heavy in calf at the beginning of December 1967. On the 28th December 1967 FE_3 was seen with her new-born calf in home range E_3 . There was no sign of the immature daughter. A few days later, 4th January 1968, FE_3 and her young calf were again seen without the previous immature daughter.

The immature male calf (MFE_1) of FE_1 were last seen together on the afternoon of the 8th February 1967. That was approximately two months before FE_1 's younger calf was born. On the 1st January 1968 the immature male (MFE_1) was seen for the first time again in company with FE_1 and her new calf. This association between FE_1 and the immature male (MFE_1) was very loose from this stage onwards. MFE_1 was mostly single. The younger immature male calf of FE_1 was seen trying to join her on the 19th June 1969 soon after her new calf was born. FE_1 would not tolerate his presence however, and kept making short charges at him. 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 and her own calf during the first half of August 1967. From the above it seems as though the immature calves leave or are forced to 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 mothers for periods varying between two and three-quarter years to over five years. The authors think that 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 size of the pool, most of the observations were done at Renostervlei. On various occasions 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 playful behaviour of black rhino at the waterholes. 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 playful mood while at the water.

d) 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 aggressive behaviour by cows with calves was observed thrice. On the 31st May 1966, during the first reconnaissance of the study area, home range E_3 fresh tracks crossing the road were observed. The vehicle was stopped and after a snort a rhino charged. She hit the right hand mudguard with her shoulder and her horn made a dent on the door. As she made off, a very small calf was noticed. 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 observer's direction. As the observer 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 bantu assistant was sent to fetch a roll of film from their 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 observer's presence. The bantu then dislodged a stone which rolled down the hill with a clatter. All three rhino immediately 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. 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 FE_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 FE₂ with previous calf: 13th October 1966.

Temp: Max. 33°C. Cloud cover: 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 FE₂ 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 lies down.
1547 Cow lies down.
1620 Cow stands up.
1630 Calf stands up.
1633 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 FE₂ 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 first observed she lies down. Calf slowly moves about cow, smelling at various objects cow included.
1005 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 *Terminalia prunioides* 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 at about midday. Although no observation 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.

Aschaffenberg, 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. B12 contents were similar to those in cow's milk, whereas values for nicotinic acid, biotin, riboflavin and vit. B6 were lower and values for thiamine higher.

It has been noticed 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. Once a cow and calf coming down to the water was observed. The cow was leading the way — about 200 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 away the calf always follows the cow. This behaviour seems quite natural considering the habit at 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 from Okaukuejo through home range E₁. 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 the small rhino's tracks were noted accompanying 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.

e) Interactions with other animals

Other animals usually share the same waterhole, and area around it, with rhino. 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 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 swarm 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 ME₁ was kept under observation 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 a 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 directions as before this little by-play.

There exists 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 deduced that she was the other participant of the fight.

On the 8th September 1967 the male ME₃ 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 an hour after the elephants passed, ME₃ 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 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 immediately left the water and only returned after the elephant had left, about an hour and a half later. This behaviour might be different when the rhino is confronted with only one or a small herd of elephant. 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 observer 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 oxpeckers 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 too slowly to satisfy their dietary needs.

f) Daily activity cycle

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. This would be an active late afternoon, night and early morning period and a 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 nights. In home ranges E₁, E₂ and P₁ 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.

It was found 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.

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 9 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.

Table 9. 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-Fced		

Total time active: 0.25 Min.
Total time not active: 9.02 Min.

26/27 May, 1967

Time	Action	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 Min.
Total time not active: 9.15 Min.

27/28 May 1967.

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

Total time active: 1.06 Min.
Total time not active: 8.56 Min.

28/29 May, 1967.

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

Total time active: 0.46 Min.
Total time not active: 9.04 Min.

29/30 May, 1967.

Time	Action	Period	
		Active	Not active
2045	Down		1.15
2200	Up-feed	0.52	
2252	Down		1.28
0020	Up-Moves-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: 1.33 Min.
Total time not active: 8.12 Min.

30/31 May, 1967.

Time	Action	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		3.53
0730	Up		
0733	Start feeding		

Total time active: 0.24 Min.
Total time not active: 9.47 Min.

31 May/1 June, 1967.

Time	Action	Period	
		Not active	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 Min.
Total time not active: 10.35 Min.

(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.)

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 animals 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 per cent of the grazing was performed during the day, and 40 per cent 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 10 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 9. The reasons for the activity rhythm in table 10 is probably the same as for the activity rhythm in table 9 viz. exercising its muscles. Another reason might be however, that the sun has moved so far that the animal has to move to follow the shade.

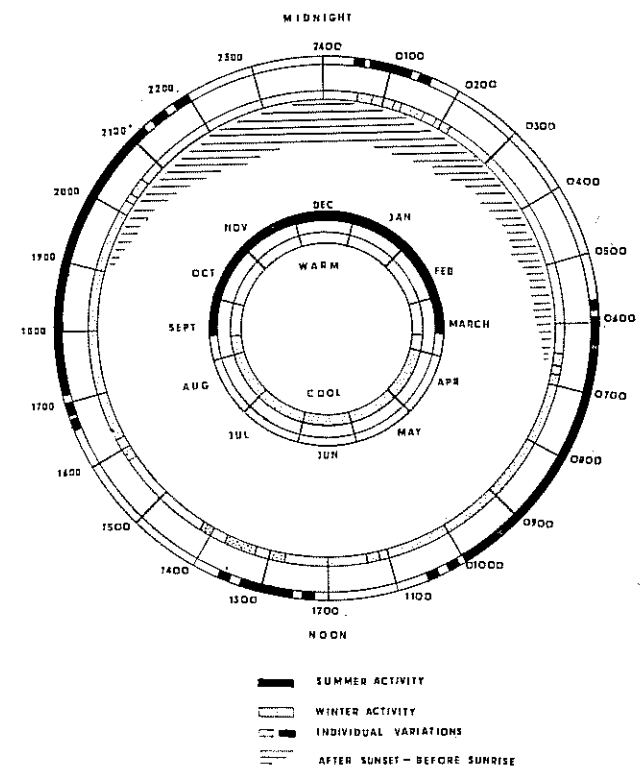


Figure 1. 24 hour activity pattern of black rhinoceros in South West Africa.

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

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

The authors suggest calling the peaks:

- (i) The dawn activity period; and
- (ii) The dusk activity period.

Studying table 10 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 dusk 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.

Table 10. 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	23	75	—	—
0400—0500	4	—	100	—	—
0500—0600	8	25	38	37	13
0600—0700	8	25	12	50	36
0700—0800	14	7	7	50	—
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.

During the study several behavioural activities of the black rhinoceros during the dusk activity 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 (IV, e, Drinking habits).
- (ii) The fact that they usually cover longer distances during this period, (V,i Movement).
- (iii) The tendency to scatter their dung with greater regularity during this period (V,h Sanitary behaviour).

An aspect which might have an influence on the dusk activity period of the rhino is the moon. During the study no opportunity arose to do any observations. Mr. F. Gaerdes (*pers. com.* 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.

g) Wallowing, dust-bathing and rubbing

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 wallowing at waterholes was never once observed, 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 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:

- (i) Goddard (1967), states that more than ninety per cent of the observations of rhino wallowing were noted between 1600 hours and 1800 hours. Guggisberg (1966) 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 place.
- (ii) 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 fig. 2). Resting, during the midday heat, is the normal occupation of the animal, accordingly very little heat is accumulated in the animal's body.
- (iii) Although Guggisberg states that rhino do not perspire it was found that they do in South

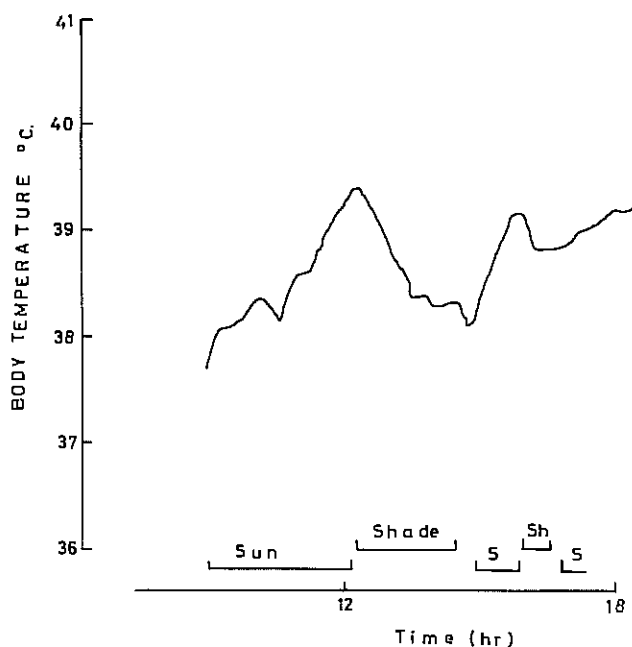


Figure 2. The deep body temperature of a 2-year-old Black Rhinoceros. (After Bligh and Harthoorn, 1965.)

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 mid-day rest (10.4 Relative humidity). Perspiration could thus contribute in lowering the body temperature.

- (iv) 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 dust-baths. Guggisberg (1966), states that sandbathing usually follows wallowing. In South West Africa it was found that the preferred sandbath spots are depressions worn out by zebra rolling and 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 P₂, MP₂ was observed rolling on the hardpacked surface of the red soil in this area.



Plate 16. A rainwater pan in the study area. This is typical of the localities at which wallowing occurs. Photo by W. P. S. Joubert

ring the
rimmed
the were
was also
he mid-
teropira
ring the

a South
as warm
the lack
animals
them for

the dist-
bathing
Africa
pits are
led with
such a
a water,
October
and roll-
will in



Plate 17. A wadi in the study area. Photo by W. P. R. Joubert



Plate 18. A locality used by both river and mountain sheep (*Egona ovina hartmanni*) for dust bathing. Photo by W. P. R. Joubert



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 Welwitschia district, tree stumps were also used as rubbing posts (See plate 19). 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 preceded by a wallow. ME₂ 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.

h) 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 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

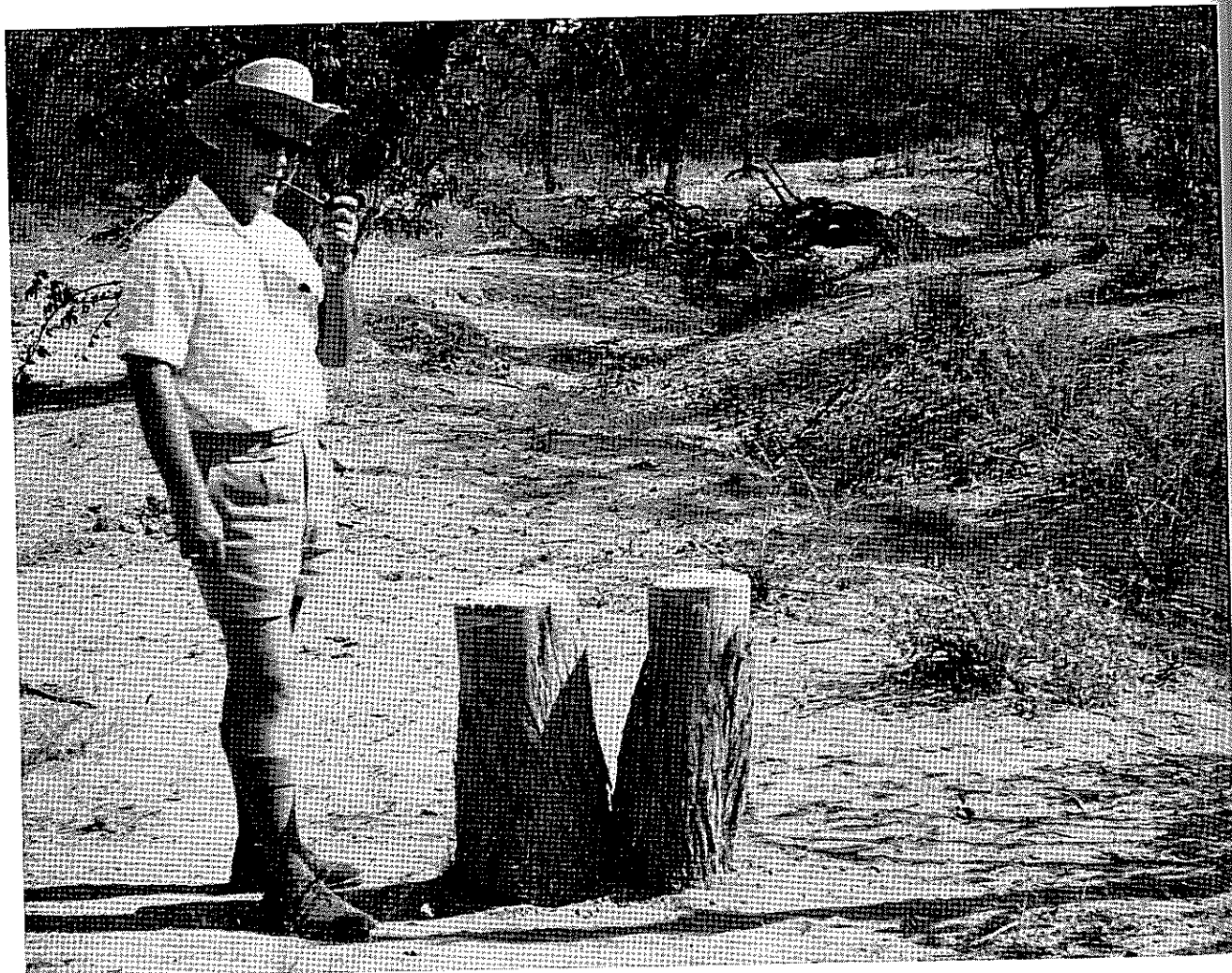


Plate 19. Tree stumps are sometimes preferred by rhino for rubbing. Photo by E. Joubert

n's thumb.
time. Dur-
des of the
he captive
, were ob-

rhinoceros
sy as the
d. Numer-
have been
) , the na-
habit is
phant to
much the
hants) dis-
ie rhino is
the first
g after all
The rhino
nd all the
ever since
e 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 is 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 hind legs smear the hind feet, which leaves a scent trail. Goddard suggests that these scent trails enable the animal to orientate itself within its home range. The terrain within the study area unfortunately did not allow for any experimental work of this kind.

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 makes 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. Occasionally an aggressive component in the excitation is undeniable, especially in male — in other cases marking rather expresses an atmosphere of familiarity or solidarity. According to von Schenkel marking has important functions 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

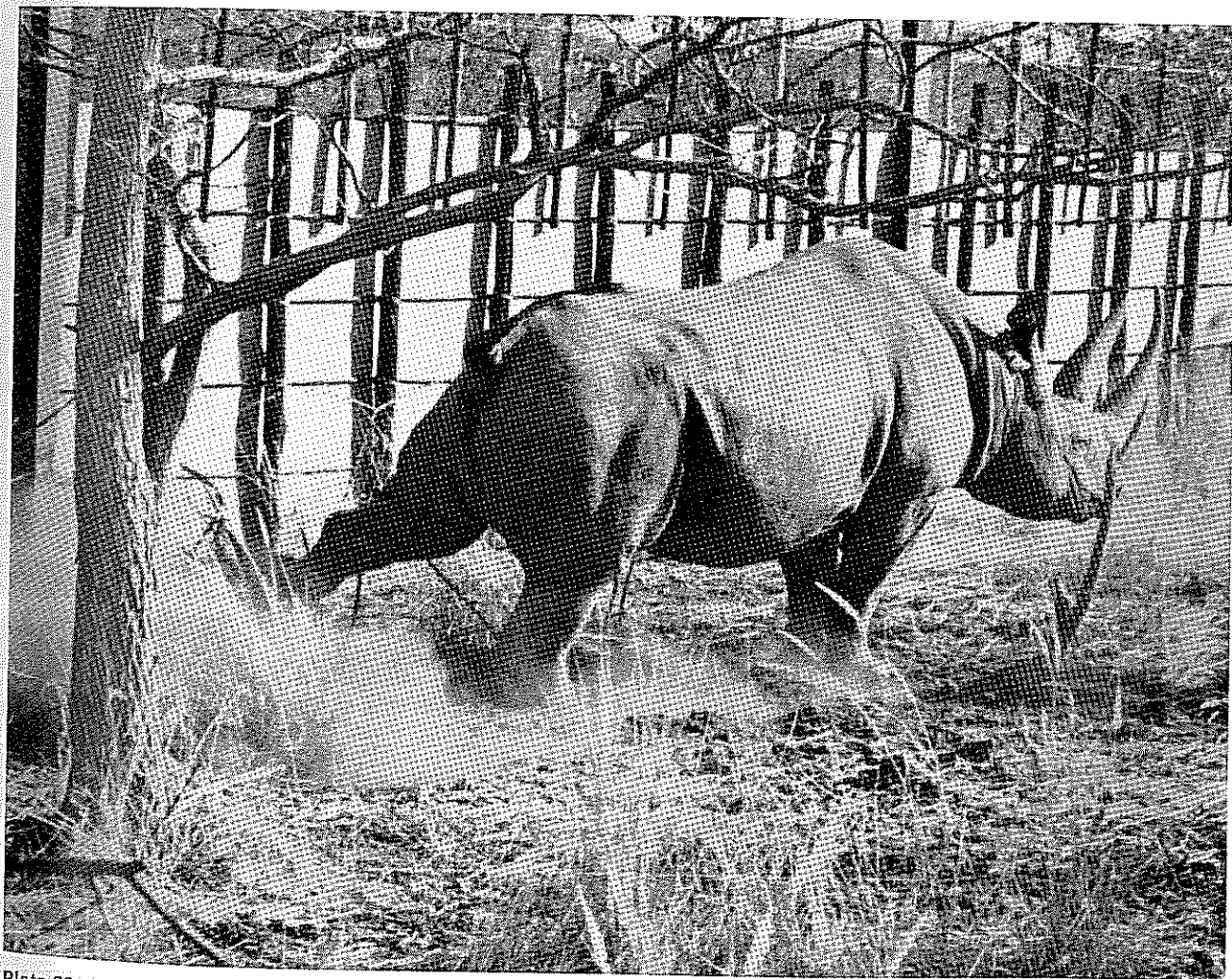


Plate 20. A rhino scattering dung. Photo by W. P. S. Joubert

legs stiff it slowly shuffles the hindlegs forward until the hind-quarters 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 defecating. This behaviour might be due to the high rhino population in the crater and the extensive overlappings 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 a waterhole 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, differ in the same type of soil. This suggests that the intensities of these movements also differ. On only one occasion a rhino (ME₂) was observed slashing at a mopane bush with its horn after defecation (plate 29). It was never observed nor was any indication found 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 dusk activity period. Most of this scraping activity takes place along footpaths leading to the waterholes. 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 waterholes, the distances in between becoming shorter the nearer one gets to the water. The deposits along these footpaths were invariably scattered. No dung was ever noticed in the water's edge, the best examples being at Springbokwasser and Ombarundu. Elephant defecate and urinate 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

- (ii) 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 some 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 rhino 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 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. On 20th April 1967, the male ME₂ 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 impulses. 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 preceded 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), elephants frequently do so. In the males the urine is sprayed backwards through the hindlegs (plate 31) — 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.

i) 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



Plate 21. A mopane bush after a rhino slashed at it with its horn. Photo by E. Joubert

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 in movement is, however, much more variable. Movement in the black rhinoceros may be divided into daily movement; seasonal movement; and wandering.

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. 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 cov-



Plate 22. Damage done to vegetation by rhino scattering dung. Photo by W. P. S. Joubert

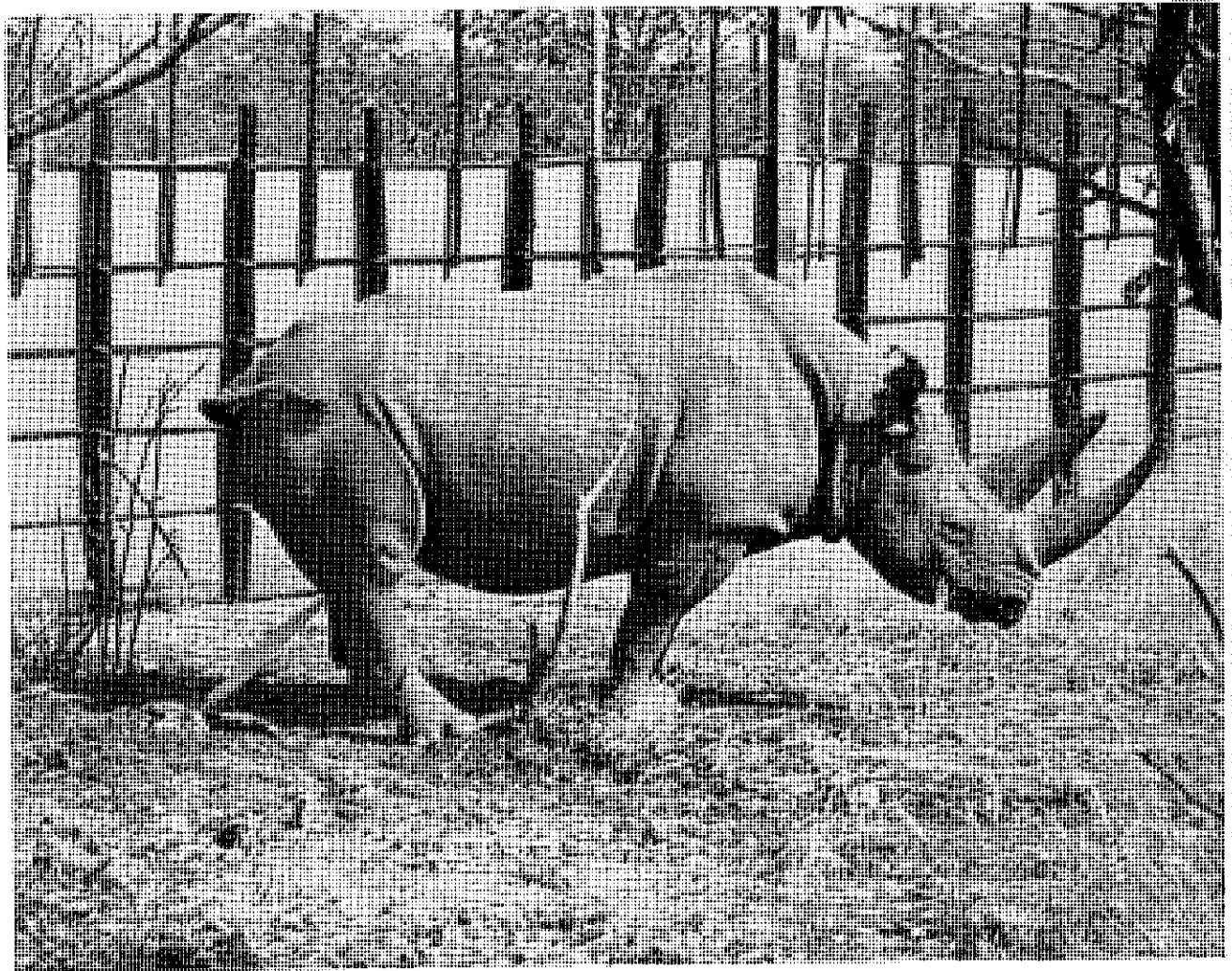


Plate 25. A male rhino urinating. Photo by E. Joubert

ered 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 difference between the minimum and maximum distances covered during twenty-four hours becomes greater — mainly due to the resulting larger home ranges. During May 1966 a series of observations were carried out in 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 a greater distance during the dusk activity periods than during the dawn activity periods. The animals usually visit the waterholes during this dusk 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 dusk 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.

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



Plate 24. A rhino sleeping. Photo by E. Joubert

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 little or no rain falls in the desert the runoff from the 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 VII, a Temperature).

At Orupembe, situated in the sub-desert about fifty miles from the coast, on the lower edge of the escarpment, it was possible 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 about 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 annually down the Munutum River 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.

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 bor-

der 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 other 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 Oran Sanctuary. He does not mention the distance covered by the individual 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; and
- (iii) unfavourable conditions in their previous home range.

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.

VI. REPRODUCTION

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

a) 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:

More than 540 days (Klingel & Klingel 1966).

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).

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 11 it would appear as though the gestation period of black rhinoceros is between 438 to 476 days. This compares favourably with the records obtained by Goddard (1967), at the Ngorongoro viz.: 446 to 478 days.

Table 11. 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 years	17—60 days		419 days
				438 days
Hanover	ca 7 years	21 days	3—4 days	469 days
	ca 9 years	28 days		
Kobe		28—30 days	5—6 days	ca 465 days
				ca 462 days
Mysore	ca 17 years	30—35 days	1—2 days	458 days
Pittsburgh	ca 7 years			463 days
				454 days
				457 days
Sydney		18 days	2—3 days	ca 476 days

b) 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 survival 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 — i.e. 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 & 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 & Klingel and also in the Ngorongoro crater, Goddard (1967), records the birth of calves from August to September. Accepting the fact that black rhino do calve 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.

Table 12. 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. Orupembe.
April 1967	Otjovasandu (E ₁).
May 1966	Otjovasandu (E ₃).
May 1967	Usakos.
June 1967	Kaross.
Beginning of	
August 1967	Otjovasandu (E ₃).
June 1969	Otjovasandu (E ₁).

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 rhino in the Kaokoveld tend to drop their calves during the rainy season and post-rainy season (See table 12). 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:

1. infertility during certain seasons of the year;
2. the influence of day length; and/or
3. the physiological influence of nutrition.

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. It is felt, however, that this factor does not play an important role in the reproductive physiology of the 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 (1967) showed that the body temperature of animals (rhino included) drops considerably when inactive in shade (see V, g, Wallowing page 31).

If temperatures 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.

2. The influence of day length

Rowan published his paper on the influence 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 about September the day length has increased sufficiently to trigger the abovementioned mechanism in the black rhinoceros. Another Perissodactyl — 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. 3)

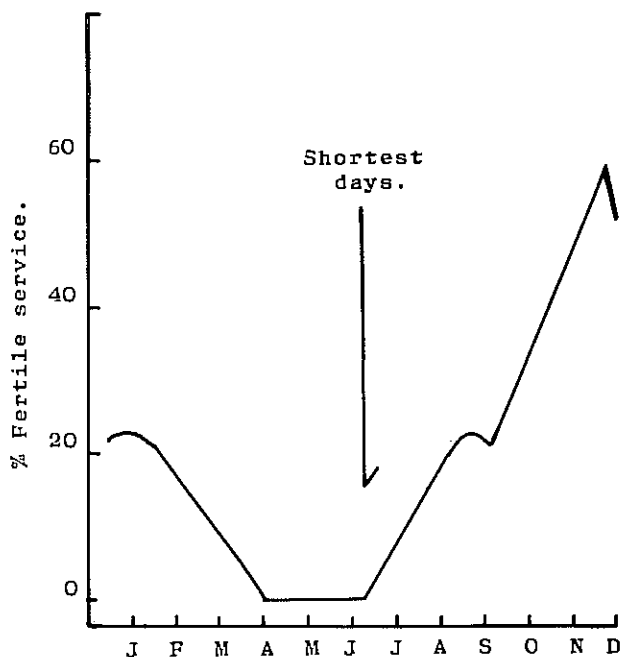


Figure 5. Breeding season of mares at Onderstepoort, Pretoria.

(From: The reproduction of horses, by Nishikawa and Hafez who adopted the graph from Quinlan, *et al.*, 1950. Onderstepoort J. Vet. Res. 25:105).

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 determining the onset of the mating behaviour by black rhinoceros. This leaves the third possibility.

3. The physiological influence of nutrition

Rams and boars 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 & Severinghaus 1950, Hart & Guilbert 1933, Allen & Lammington 1961, Mann & Rowson 1951). It can thus be accepted that protein and Vitamin A play an important part in the successful calving and mating of most animals.

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 & 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 burchell's 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 (specially 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 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.

d) 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.

e) 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.

Goddard (1967) found that available evidence elsewhere suggests that a healthy female could be expected to produce a calf approximately every 27 months. Only one definite record is available from the study area. Female FE₁ calved during April 1967 and then again during June 1969. This gives a figure of approximately 26 months which compares favourably with the figure viz. 27 months, given by Goddard. 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.

VII. INFLUENCE OF WEATHER ON THE BLACK RHINOCEROS

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 effect the behaviour pattern. Changes in the habitat brought about by changing physical factors, affect every community, directly or indirectly. One cannot over emphasize 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.

a) Temperature

Table 13 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 temperature 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 maximum 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. But due to this the local "sun time" is approximately one hour behind the calculated time.

Table 13. Monthly temperature (°C) at Otjovasandu South West Africa, 1966/1967.

	Maximum				Minimum				Range max. min. means
	Mean	Range	Highest max.	Lowest max.	Mean	Range	Highest min.	Lowest min.	
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

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 direct bearing on food intake and it has a marked influence on the total time spent during the day on browsing, and an indirect influence on the nutritious value of the vegetation through the occurrence of frost.

The biological influence 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 keep 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 E₃: Female FE₃ 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 lay down underneath a mopane tree at 1400 hours. At 1420 hours the calf started showing signs of being uncomfortable. She fanned her ears vigorously, occasionally tossing her head. At 1347 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 FE₃ lay undisturbed fanning her ears without even opening her eyes.

i. 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, continues 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 — 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.
- 0945 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. 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.

31st 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.
- 1048 Lies down next to dung heap in the sun.
- 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 on the morning of the 31st 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 an influence on the day time spent resting. That night it also lay 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 day.

During the colder months of the year the influence of maximum temperature on daily activity is minimal. The low temperatures at night exert a greater influence and limit 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 are usually satiated before temperature reached 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. 4) 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.

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 reservoir between the valley walls (see fig. 5) plateaus are 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-covered *Colophospermum mopane* illustrates this point. Another factor which may also have an influence is the sunniness of the different slopes.

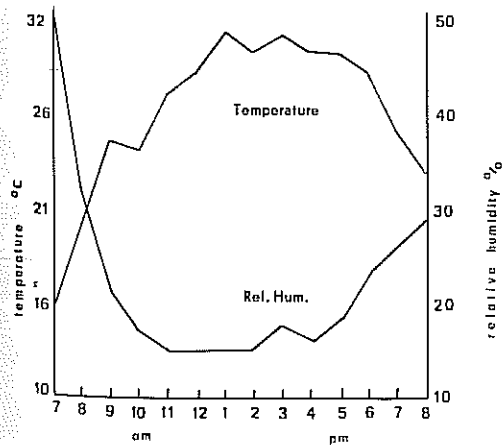


Figure 4. An average day to show temp./rel. humidity ratio Otjovasandu. (Sept., 1967).

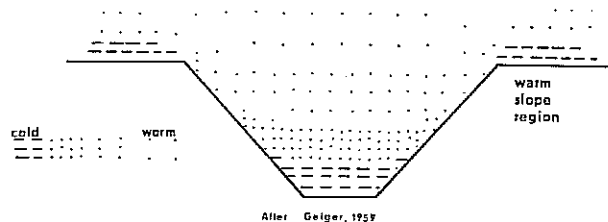


Figure 5. Nocturnal temperature in valleys.

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 during the warmer part of the day is well known. This leads to an aspect generally not considered viz. the marked differences of air temperatures in dense vegetation and over bare ground on warm days and cold nights.

ii. 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 factor 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 winter months (see V,f Daily Activity Cycle).

Another seasonal movement, which is influenced by temperature, is that to be found on the western side 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.

b) 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. 7, it is apparent that the main rainy season is from January to March while some rain also falls during early months of September to December. Rains during January to March tend to be more widespread, whilst those during September to December are usually scattered.

ii. 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 & Guilbert (1933) and others). This has been discussed under reproduction.

ii. Influence on Movement

Movement of the black rhinoceros within their home ranges is also influenced by rainfall. During the rainy season, when they are not bound to the permanent waterholes which they use during the rest of the year, they move over a larger area within the home range. The rainwater pans contain

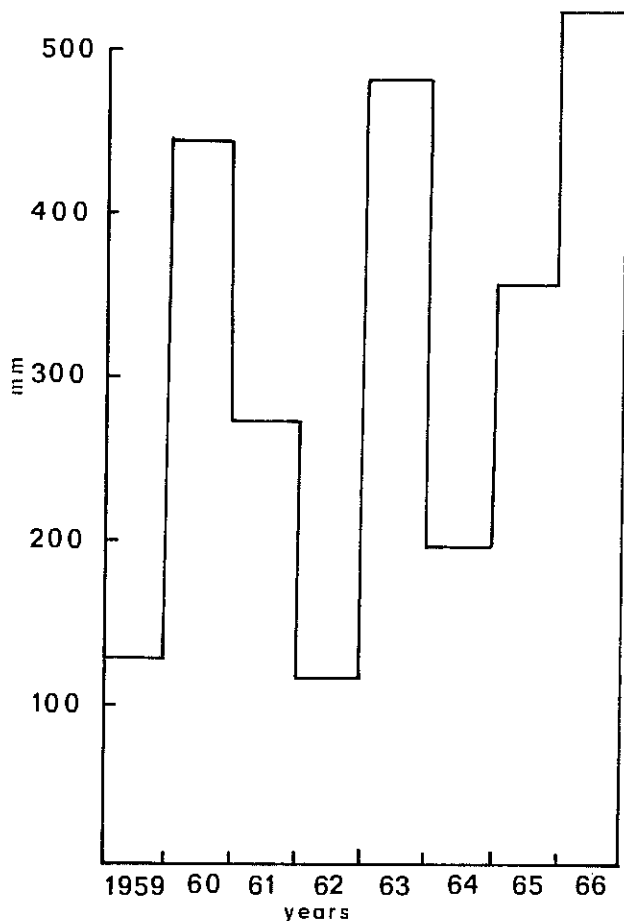


Figure 6. Yearly rainfall, Otjovasandu.

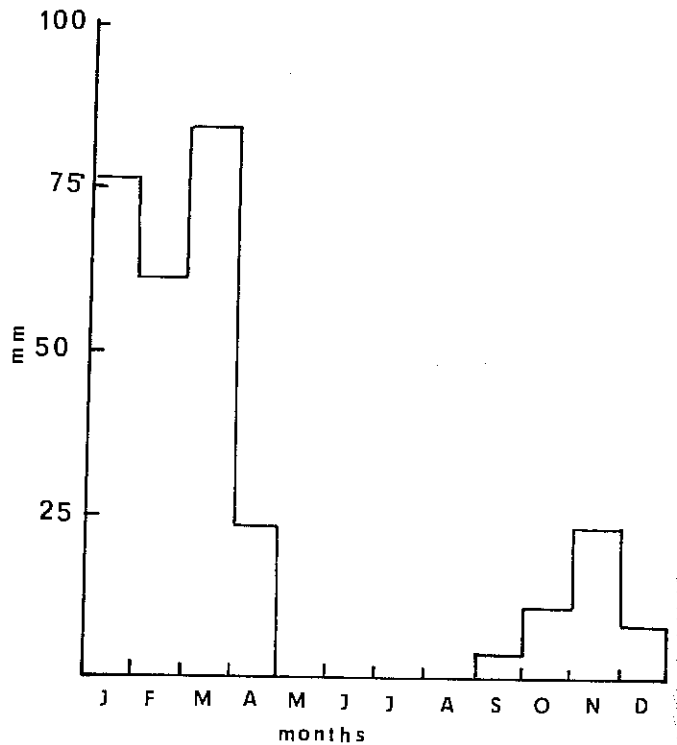


Figure 7. Mean monthly rainfall, Otjovasandu.

water from January to May. The rainfall before January and after March is usually insufficient to fill them.

During the rainy season some individuals show a tendency to wander away from their normal home range. (See V,i Movement).

iii. 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. They also feed on a larger variety of food plants (See IV, a, Food Species and Preferences page 11).

iv. Influence on 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 V, a, Wallowing page 31).

c) Relative Humidity

Relative humidity is the percentage 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 exercises 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 noticeable while they are lying down. The perspiration is usually limited to certain area 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 cool the animal.

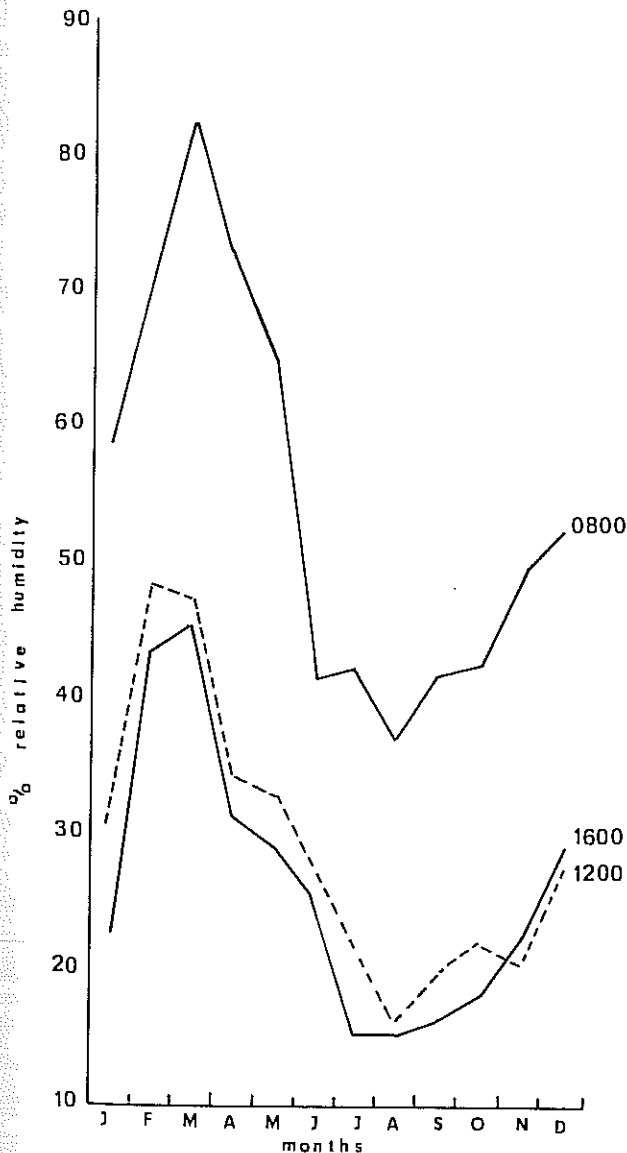


Figure 8. Average relative humidity at Otjovasandu.

d) 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.

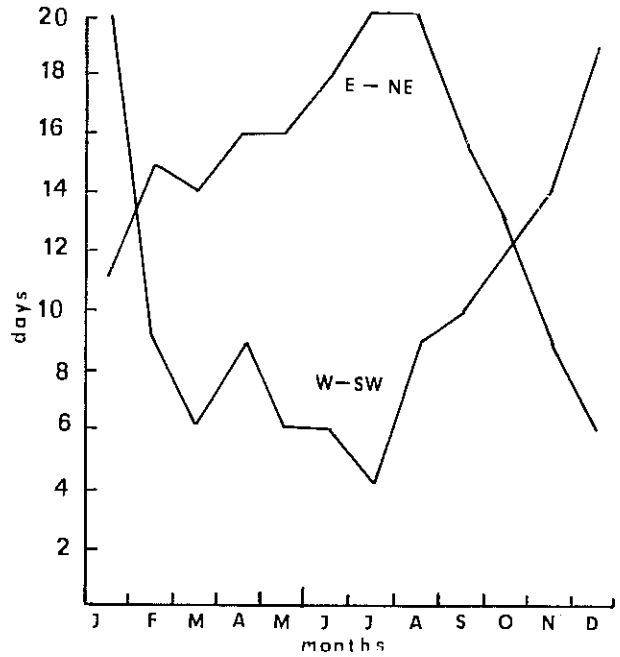


Figure 9. Actual number of days with eastern to north-eastern and or western to south-western wind movement.

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 fig. 10). 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 might be to make full use of the cooling effect

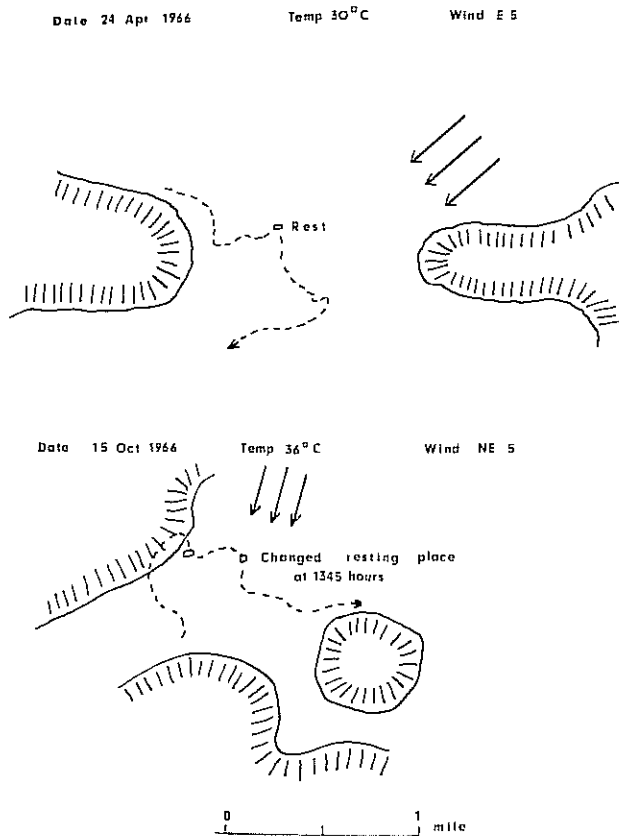


Figure 10. The influence of wind on Rhino feeding behaviour.

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 have small calves. During June and July when the prevailing wind blows from the east and north-east, they also usually lay facing west or south-west (downwind). 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.

e) Frost

In the Kaokoveld frost occurs only a few nights per year in spite of the low night temperature recorded. During the study period frost occurred during May and August only.

This might be due to the cold air drainage and 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 its 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 occur 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 IV, a, Food Species and Preference page 11).

VIII. LIMITING FACTORS

During the study several limiting factors were observed. Although most of them were discussed elsewhere they are listed again.

a) Predation

Cattle ranching makes an important contribution to the economy of South West Africa with the result that the larger carnivora 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 can be found of rhino being killed by lion during the last decade in South West Africa. This happened near Orupembe late in 1963 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 675 to 950.

In South West Africa no market exists and the rhino horn prices in Angola are relatively low. According to a Portuguese 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 (Joubert, in press). 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.

b) Vegetation and Water

In South West Africa with its periodic 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.

c) 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 *Stephanofilaria dinniki* 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 immobilized individuals included) showed any sign of skin lesions on their bodies. According to Dr. Brand (*pers. com.* 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. *Kiluluma magna* K. *stylosa* and *K. goodeyi* were also reported of rhinos in Natal (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.

IX. SUMMARY

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 rhinoceros 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 rhinoceros frequenting one home range form a family group. Rhinoceros 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 and a dusk activity period. There are indications that a six to seven hour period of inactivity exists during the night hours. Behaviour activities show dusk activity period to be more important.

Wallowing is mainly limited to the rainwater 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 atmosphere of familiarity or solidarity. Dung is scattered with greater regularity during the dusk period. Rhino are stimulated to defecate through both physiological and psychological impulses.

With rhinoceros, movement is primarily induced by body temperature. 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 main important physical factors in the ecology of the black rhinoceros.

Limiting factors are predation, competition with livestock and possibly diseases.

X. ACKNOWLEDGEMENTS

We are grateful to Mr. de la Bat, Director of Nature Conservation and Tourism for his advice and criticism, also to Mr. C. G. Coetzee for critical reading through the manuscript.

We wish to extend grateful appreciation to Roy Sterley, Ken Tinley, Mr. and Mrs. Tromp, Mr. P. van der Westhuizen, Mr. Magura, Mr. F. Gaerdes and everybody else mentioned in the text.

We are grateful to Mrs. Joubert who shared constant hardships during the study and who typed the original manuscript.

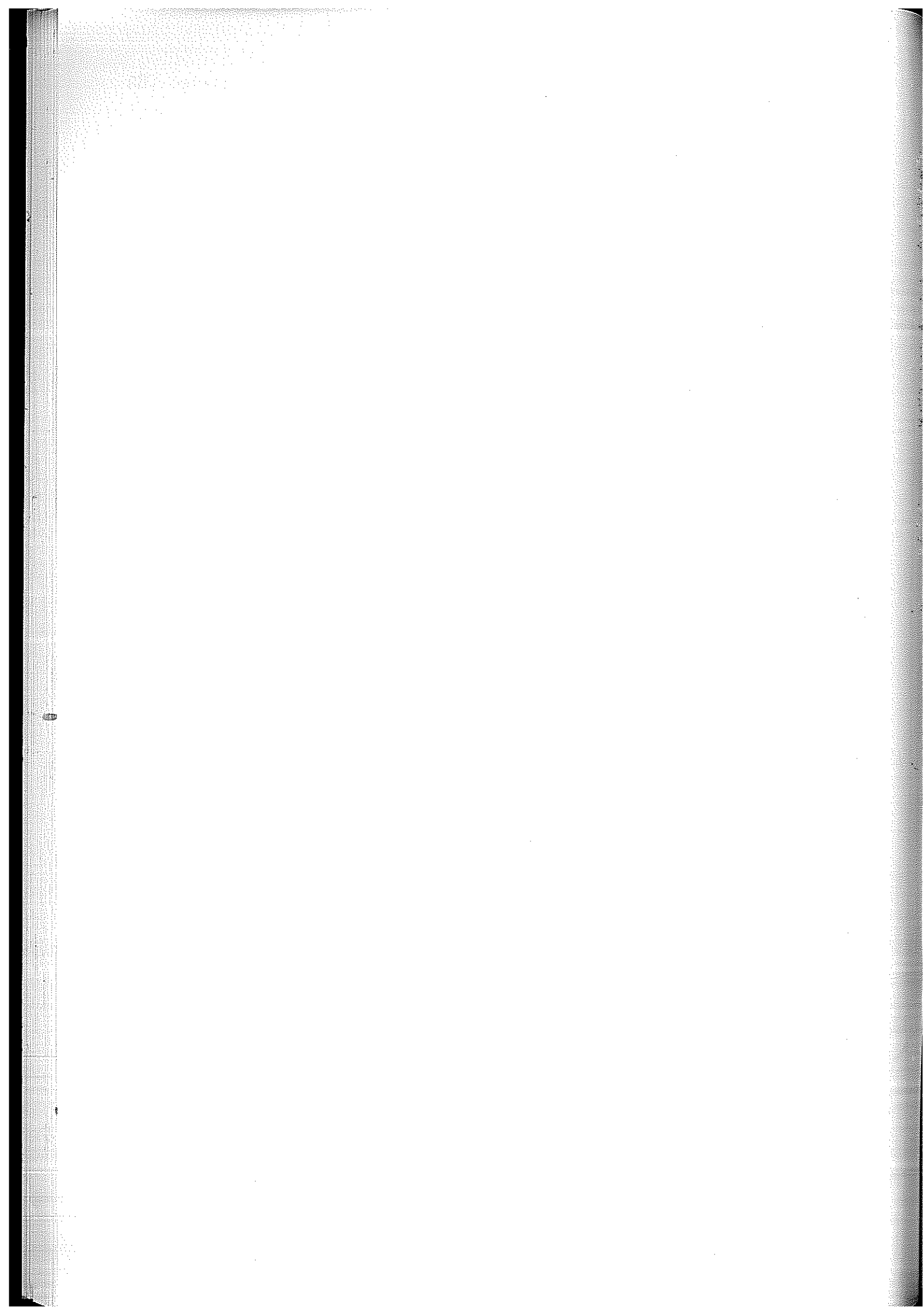
XI. BIBLIOGRAPHY

- ALLEN, G. M.
1939 Checklist of African Mammals. *Bull. Mus. comp. Zool. Harv.* 83; 1-7-63.
- ANSELL, W. F. H.
1952 The status of Northern Rhodesian Game. *Afr. Wild Life* 6(2): 108-16.
- ANSELL, W. F. H.
1960 Breeding of some larger mammals in Northern Rhodesia. *Proc. Zool. Soc. Lond.* 134: 251-274.
- ANSELL, W. F. H.
1967 *Preliminary identification manual for African mammals*. Edited J. Meester, Smithsonian Institution, United States National Museum Washington, D.C.
- ASCHAFFENBURG, R. et al
1961 The composition of the milk of the African black rhinoceros. (*Diceros bicornis*.) *Proc. Zool. Soc. Lond.* 137: 475-479.
- ASDELL, S. A.
1946 *Patterns of Mammalian Reproduction* London. Constable and Company Ltd.
- BLIGH, J. & HARTHOORN, A. M.
1965 Continuous Radiotelemetric Records on the Deep Body Temperature of Some Unrestrained African Mammals under Near-Natural conditions. *J. Physiol.* 176, pp. 145-162.
- BLUMENBACH
1803 "*Rhinoceros africanus* Blumenbach (1803)". *Man. Hist. Nat.* 1: 156.
- BROCKLESBY, D. W. & VIDLER, O.
1965 Some parasites of East African Wild animals. *E. Afr. Wildlife J.* 3: 120-122.
- BUECHNER, H. K.
1961 Territorial behaviour in the Uganda Kob. *Science* 135: 698, 1961.
- CAMPBELL, G.
1957 Rhino on two legs (erect stance in browsing). *Field* 209: 570.
- CARTER, NICK.
1965 S.O.S. *Rhino*. Animal Life 30: 16.
- CARTER, W. H.
1965 *The Arm'd Rhinoceros*. London Andre Deutch.
- CAVE, A. J. E.
1959 The foramen ovale in the Rhinocerotidae. *Proc. int. Congr. Zool.* 15: 419-421.
- CAVE, A. J. E.
1962 Wurchell's original specimens of *Rhinoceros simum*. (Tax. history of recent Rhinocerotidae disc. Original specimens reviewed. Lectotype selected, tax., diagnostic characters disc., compared with *Diceros bicornis*.) *Proc. Zool. Soc. Lond.* 139: 691-700.
- CAVE, A. J. E.
1962 The pedal scent gland in Rhinoceroses. *Proc. Zool. Soc. Lond.* 139: 685-690.
- CAVE, A. J. E.
1964 The processus Glandis in the Rhinocerotidae. *Proc. Zool. Soc. Lond.* 143(4): 569-586.
- CAVE, A. J. E. & AUMONIER, F. J.
1962 Elephant and Rhinoceros lymph-node histology. *J. Roy. Micr. Soc.* (3) 80: 209-214.
- CRITCHLEY, R. A.
1959 Operation Noah. *Oryx* 5(1): 100-107.
- CRANDALL, L. S.
1964 *The Management of Wild Mammals in Captivity*. London. The University of Chicago Press.
- DARLING, F. F.
1960 *A Wild life In An African Territory*. London. Oxford University Press.
- DARLING, F. F.
1960 B. An Ecological Reconnaissance of The Mara Plains in Kenya Colony. *Wildlife Monographs*. 5: 5-41.
- DERANIYAGALA, P. E. P.
1953 The extinct and living subfamilies of African Rhinocerotidae. *Spoilia Zeylan.* 27 L: 13-14.
- DICE, L. R.
1962 *Natural Communities*. The University of Michigan Press.
- DRUMMOND, W. H.
1867 On the African Rhinoceroses. *Proc. Zool. Soc. Lond.* pp. 109-114.
- DRUMMOND, W. H.
1875 *The Large Game and Natural History of South and South East Africa*. Edinburgh. Edmonsten and Douglas.
- ELLERMAN, J. R., MORRISON-SCOTT, T. C. S. & HAYMAN, R. W.
1953 *Southern African Mammals, 1758-1951: A reclassification*. London. Trustees of the British Museum.
- ESTES, R. D.
1968 The territorial behaviour in the Wildebeest. *Ph.D. Thesis* Cornell Univ. Unpub.
- FAUST, R.
1958 Die Geburt eines Spitzmaulnashornes. (*Diceros bicornis* L. in Frankfurt. *Zool. Gart. Lpz.* 22: 208-214.

- FISCHER, A.
1914 "Menschen und Tiere in Deutsch-Südwestafrika". Stuttgart.
- FITZSIMMONS, F. W.
1920 *The Natural History of South Africa*. London Longmans, Green and Co.
- FLOWER, W. H. & LYDEKKER, R.
1891 "An Introduction to the study of Mammals living and extinct!". London, Adam and Charles Black.
- FOSTER, J. B.
1965 Mortality and ageing of black rhinoceros in East Tsavo Park, Kenya *E. Afr. Wild. J.* 3: 116-119.
- GEE, E. P.
1953 The life-history of the great Indian one horned rhinoceros (*R. unicornis* linn.) *J. Bombay Nat. Hist. Soc.* 51: 341-348.
- GEE, E. P.
1950-52 The Great Indian One-Horned Rhinoceros. *Oryx*. 1(5): 224-227.
- GEE, E. P.
1959 The Great Indian Rhinoceros (*R. unicornis*) in Nepal. *J. Bombay nat. Hist. Soc.* 56: 484-510.
- GEIGER, R.
1959 *The Climate Near the Ground*. Harvard University Press. Cambridge, Massachusetts.
- GLOVER, P. E. & SHELDRIK, D.
1964 An urgent research problem on the Elephant and Rhino population on the Tsavo National Park in Kenya. *Bull. ejiz. Dis. Afr.* 12(1): 33-38.
- GODDARD, J.
1966 Mating and Courtship of the Black Rhinoceros (*Diceros Bicornis* L.). *E. Afr. Wildlife J.* 4: 69-75.
- GODDARD, J.
1967 The Validity of censusing black rhinoceros populations from the air. *E. Afr. Wildlife J.* Vol. 5: 153-150.
- GODDARD, J.
1967 Home Range, Behaviour and Recruitment Rates of Two Black Rhinoceros populations. *E. Afr. Wildlife J.* Vol. 5: 18-23.
- GRAY, J. E.
1867 Observation on the Preserved specimens and skeletons of the Rhinocerotidae in the collection of the British Museum and the Royal College of Surgeons, including the description of three new species. *Proc. Zool. Soc. London*. 1003-1032.
- GRAY, J. E.
1875 On the Dentition of Rhinoceroses (Rhinocerates) and on the Characters offered by their skulls. *Ann and Mag. Nat. Hist. London. Ser. 4. Vol. 11(65):* 356-361.
- GREED, R. E.
1960 The composition of the milk of the Black Rhinoceros. *Inter Zoo. Yearbook* 2: 106.
- GRZIMEK, B.
1961 Die Zusammensetzung der Nashornmilch. (Milk Analysis). *Zool. Gart. Leipzig* 25: 202-204.
- GUGGISBERG, C. A. W.
1963 *The Sanctuaries of the South*. *Africana* 5: 8-11.
- GUGGISBERG, C. A. W.
1964 An Appreciation of African Rhinoceroses. *Animal Kingdom* 67(4): 115-121.
- GUGGISBERG, C. A. W.
1966 *S.O.S. Rhino*. London. Andre Deutch Ltd.
- GUNN, R. M. C. SANDERS, R. N. & GRANGER, W.
1942 Studies in fertility in sheep 2 Seminal Changes affecting fertility in rams. *Bull. Coun. Sci. Industr. Res. Aust.* 148.
- HAAGNER, A.
1920 *South African Mammals*. A short manual for the use of Field Naturalists, Sportsmen and Travellers. London. Witherby.
- HAERLEN, E. et al
1959 *Wild und Jagd in S.W.A.* Andalusia, 45.
- HART, G. H. & GUILBERT, H. R.
1933 Vitamin-A deficiency as related to reproduction in range cattle. *Univ. Calif. Agric. Exp. Sta. Bull.* 560 30 pp.
- HARTHOORN, A. L.
1967 Adaption to solar radiation by African large herbivores. *Roneod*.
- HARTHOORN, A. M. & LOCK, J. A.
1960 The rescue of Rhinoceros at Kariba Dam. *Oryx*. Vol. 5: 352.
- HAYMANN, R. W.
1956 The Rhinoceros. *Zoo Life* 11: 2-6.
- HEMINGSON, A. H.
1960 Energy metabolism as related to body size and respiratory surfaces, and its evolution. *Rep. Steno. Mem. Hosp.* 9(11): 1-110.
- HOPKINS, B.
1966 *Forest and Savanna*. London. Heinemann.
- HOWARD, D. A.
1964 The copper content of the liver of some game animals in Kenya. *E. Afr. Wildlife J.* 2: 47-50.
- HUTCHINSON, C. E. & RIPLEY, S. D.
1954 Gene dispersal and the ethology of the Rhinocerotidae. *Evolution* 8: 178-179.
- HUXLEY, J.
1960 *The conservation of wildlife and natural habitats in Central and East Africa*. Unesco.
- IONIDES, C. J. P.
1953 Nature notes (1). *Afr. Wild Life* 7: 127-155.
- JACKSON, F. J.
1894 "The Rhinoceros" in: *Badminton Library of Sports and Pastimes*, Big Game Shooting. London 1894.
- JACOBI, E. F.
1957 Recuperative power of the horn of the black rhinoceros. *Zool. Gärt. Lpz.* 23: 225-227.
- JOUBERT, E.
1970 The taxonomic status of the black rhinoceros in South West Africa. *Madoqua* 2: 1970.
- KING, J. M. & CARTER, B. H.
1965 The use of the oripavine derivative M. 99 for the immobilisation of the Black Rhinoceros. (*Diceros bicornis*), and its antagonism with the related compound M. 285 or Nalorphine. *E. Afr. Wild J.* 3: 19-26.
- KIRBY, F. V.
1896 "In Haunts of Wild Game". London. Rowland Ward. Ltd.
- KIRMIZ, J. P.
1962 *Adaptation to Desert Environment*. Butterworths London.
- KLINGEL H. & KLINGEL, U.
1966 The rhinoceros of Ngorongoro Crater. *Oryx*. 8(5): 302-306.
- KREAG, K. K.
1966 Hand rearing of Black Rhinoceros. *The Inter Zoo Yearbook*. 6: 87-88.
- KRUMBIEGEL, I.
1962 Quellenstudien über Asiatische Nashorne Säugtierk. *Mitt.* 10: 1-2.
- KUIPER, K. & SCHNEIDER, K. M.
1940 Zur Gestalt des Nashorn-Penis. *Zool. Garten Leipzig* 17: 288-291.
- LAMPREY, M. F.
1963 Ecological separation of the large mammal species in the Tarangire Game Reserve, Tanganyika. *E. Afr. Wildlife J.* 1: 63-92.
- LAMPREY, M. F.
1964 Estimation of the large Mammal densities, Biomass and Energy exchange in the Tarangire Game Reserve and the Masai steppe in Tanganyika. *E. Afr. Wildlife J.* 2: 1-46.
- LITHGON, T.
1961 The possible extinction of rhino at the Ngorongoro crater. *Afr. Wildlife* 15: 162-165.
- LYDEKKER, R.
1911 On African Rhinoceros, Klipspringer and Gazelle *Proceeding of the General Meetings for Scientific Business of the Zoological Society of London*. pp. 953-962.
- LYDEKKER, R.
1926 *The Game animals of Africa*. London. Rowland Ward. Ltd.

- MACKENZIE, P. Z.
1950 Black Rhino of the Twij Field, London. 1961 586.
- MEESTER, J. DAVIS, D. H. S. & COETZEE, G. G.
1964 *An interim classification of Southern African Mammals* (Roneod).
- MITCHELL, B. L.
1966 The survival of an archaic vertebrate (*Diceros bicornis*), in central Africa. *The Pulm* 4: 190-192.
- NEITZ, W.O.
1965 A checklist and host-list of the zoonoses occurring in mammals and birds in South and South West Africa. *The Onderstepoort J. Vet. Res.* 32(2): 318.
- NEUMANN, A. A.
"Black Rhinoceros in Kenya" in Lydekker, *The Game animals of Africa*, London, 1926.
- NISHIKAWA, Y. & HAFEZ, E. S. E.
1962 The reproduction of horses. In *Reproduction in farm animals* edited by E. S. E. Hafez, London Bailliere, Tindall and Cox.
- OBOUSSIER
1956 Die Hypophyse des Nashorns. (*R. unicornis* + *Diceros bicornis*). *Zool. Anz.* 157: 1-11.
- OWEN, T. R. H.
1956 *The Black and the White Rhinoceroses. Uganda Wild Life and Sport, Game and Fish Dept.*, Entebbe 1: 27-31.
- PARSONS, B. T. & SHELDRIK, D. L. W.
1964 Some observations on Biting flies (Diptera, Muscidae, Sub-fam Stomoxydinae) associated with the black rhinoceros (*Diceros bicornis*). *E. Afr. Wildlife J.* 2: 78-85.
- PERCIVAL, A. B.
1924 *A Game Ranger's Note Book*. London. Nisbet and Co. Ltd.
- PITMAN, C. R. S.
1950 Annual Report of the Game Department (Uganda) for 1949.
- PITMAN, C. R. S.
1956 Weapons of the two African Rhinoceroses. *Oryx* 3: 195-196.
- POTTER, H. B. & MITCHELL, D. C.
1947 Rhino — Black or White. *Field*, London. 190: 384-385.
- POTTER, H. B.
1949 Rhino as we know them. *Afr. Wild Life*. 3: 128-138.
- RIPLEY, S. D.
1952 Territorial and sexual behaviour in the Great Indian Rhinoceros, a speculation. *Ecology*, N.Y. 33: 570-573.
- RIPLEY, S. D.
1958 Comments on the black and square-lipped rhinoceros spp. in Africa *Ecology*. 37(1): 172-174.
- RITCHIE, A. T. A.
1963 The Black Rhinoceros (*Diceros Bicornis* L). *E. Afr. Wildlife J.* Vol. 1: 54.
- ROBERTS, A.
1951 *The Mammals of South Africa*. Trustees, "The Mammals of S. Afr." Book Fund.
- ROEDEL BERBER, F. A. & GRESCHOFF, V. I.
1964 *African Wildlife*. London. Constable.
- ROOSEVELT, T. & HELLER, E.
1922 *Life histories of African game animals*. London. Juhn Murray.
- ROOSEVELT, T.
1915 *Life Histories of African Game Animals* Vol. 2 London. John Murray.
- ROUND, M. C.
1964 A New Species of Stephanofilaria in skin Lesions from the Black Rhinoceros (*Diceros Bicornis* L), in Kenya *Journ. Helminth* 38: 87-96.
- RUSHBY, G. G. & SWYNNERTON, G. H.
1946 Notes on some game animals of Tanganyika Territory. *Tanganyika Notes + Rec.* 22: 14-26.
- RYDER, M. L.
1962 Structure of rhinoceros horn. *Nature, London* 195: 119-1201.
- SANDEMAN, N.
1959 Kenya control measures. *Wild Life Nairobi* 1(1): 16-17.
- SCHAUTRE, W. T.
1967 Thoughts of Wildlife Preservation. *Zoön*.
- SHENKEL, R.
1966 "Zum Problem der Territorialität und des Markieren bei Säugern am Beispiel des Schwarzen Nashorns und des Löwens". *Zeitschrift für Tierpsychologie* 23(5): 195-626.
- SCHULTZ, K. C. A.
1961 Ulcerating wound behind the shoulder of the Black Rhinoceros (*D. bicornis*) in the Hluhluwe and Mkuzi Game Reserves of Zululand. *Afr. Wild Life* 15(1): 55-59.
- SCHULTZ, K. C. A. & KLUGE, E. E.
1960 Dermatitis in the black rhinoceros (*Diceros bicornis*) due to filariasis. *J. S. Afr. Vet. med. Ass.* 31: 265-269.
- SCHLATER, W. L.
1900 *The Mammals of South Africa*. Vol. 1. pp. 303-308. London. Porter.
- SELOUS, F. C.
1881 "On the South African Rhinoceroses". *Proc. Zool. Soc. London*. p. 725.
- SHEBBEARE, E. O.
1953-1954 The Three Asiatic Rhinoceroses. *Oryx* V. 2: 141-149. Bailliere, Tindall and Cox.
- SHORTRIDGE, G. C.
1934 *The Mammals of South West Africa*. Vol. 1 pp. 412-424. London William Heinemann Ltd.
- SIDNEY, J.
1965 The past and present distribution of some African ungulates. *Trans. Zool. Soc. London* 30: 61-87.
- SIMON, N.
1962 *Between the Sunlight and the Thunder*. London. Collins.
- SMITH, A.
1837 "*Rhinoceros ketloa* A. Smith (1837)". *Cat. S. Afr. Mus.* 7.
- SMITHERS, R. H. N.
1966 *The Mammals of Rhodesia, Zambia and Malawi*. London. Collins.
- SODY, H. V.
1959 Das Javanische Nashorn *Rhinoceros sondaicus*. *Z. Säugetierk.* 24: 109-240.
- SPINAGE, C. A.
1961 Some notes on the rhinoceros. *Afr. Wild Life* 14: 95-100.
- SPINAGE, C. A.
1962 *Animals of East Africa*. London. Collins.
- ST. CROIX, O. H. de
1962 The white rhinos of Hluhluwe. *J. Bombay Nat. Hist. Sci.* 58: 321-335.
- STEINHARDT
1922 *Ehombo*. J. Neumann, Neudamm.
- STEINHARDT
1924 *Vom warhaften Riesen und seinem Reiche*. Alfter-Verlag. Hamburg.
- STEVENSON-HAMILTON, J.
1912 *Animal Life in Africa*. London. William Heinemann.
- STEVENSON-HAMILTON, J.
1917 *Animal Life in Africa*. Part 2. London. William Heinemann.
- STEVENSON-HAMILTON, J.
1947 *Wild Life in South Africa*. London Cassel & Co. Ltd.
- STEWART, D. R. M. & STEWART, J.
1963 The Distribution of Some Large Mammals in Kenya. *J. E. Afr. Nat. Hist. Soc.* 24(5): 8.
- STOCKLEY, C. H.
1950 The Hook-lipped Rhinoceros. *Zoo Life London* 5: 88-91.
- STOTT, K.
1950 Monstep of the Mist Forests. *Nat. Hist. N.Y.* 59: 20-23.

- SUTHERST, R. W.
1964 Now Kenya saves its Rhinos. *Animals* Vol. 4 pp. 215.
- SWYNNETON, G. H.
1959 Threat to Black Rhino in East Africa. *Wild Life*, Nairobi 1(1): 14-16.
- TALBOT, L. M.
1960 A look at threatened species. A report on some animals of the Middle East and Southern Asia which are threatened with extermination. *Oryx* 5: 155-295.
- THENIUS, E.
1955 Zur Kenntnis der unter-pliozänen Dicerdos-Arten. *Ann. naturh. Mus. Wien.* 60: 202-211.
- THENIUS, E.
1955 Die verknöcherung der Nasenscheidewand bei Rhinocerotiden. *Mem. Suisse Paleont.* 71(4): 1-17.
- TINDELL HOPWOOD, A.
1957 "Contributions to the study of some African Mammals. — II. The subspecies of the Black Rhinoceros, *Diceros bicornis* (Linnaeus), defined by the proportions of the skull". *Journ. Linn. Soc. — Zoology*, Vol. XL. pp. 447-457.
- TREMLETT, J. G.
1964 Observations on the pathology of lesions associated with *Stephanafilaria dimmiki* Round, 1964 from the Black Rhinoceros (*Diceros bicornis*). *Journ. Helminth.* 58: 171-174.
- ULMER, F. A.
1941 The living Rhinoceroses. *Fauna* 3(1): 3-10.
- WATSON, J. M.
1949 The wild mammals of Teso and Karamoja — 11. *Uganda J.* London 13(2): 182-201.
- WELLINGTON, J. H.
1955 *Southern Africa: A geographical study.* Vol. 1 Cambridge.
- WELTY, J. C.
1962 *The Life of Birds* W.B. Saunders Co. London.
- WIGHT, H. M.
1958 *Field and laboratory techniques in Wildlife management* Investigational Techniques.
1965 Edited by: Henry A. Mosby. The Wildlife Society, Washington D.C.
- WILSON, V. F. & EDWARDS, P. W.
1965 Data from a female rhinoceros and foetus (*Diceros bicornis* Linn.) from the Fort Jameson District. *The Puku* Vol. 5: 179.
- WOOD, H. E.
1949 Evolutionary rates and trends in Rhinoceros *Genetics, Paleontology and Evolution* Princetown N.J. 1949: 185-189.
- WYNNE-EDWARDS, V. C.
1962 *Animal dispersion in relation to Social behaviour.* London Oliver & Boyd.
- YEATES, N. T. M. & PARER, J. T.
1962 Effects of stress on reproduction. In *Reproduction in farm animals* edited E. S. E. Hafez. London
- YOUNG, E.
1965 b. 'n Verslag oor die versameling van saad 'n Swart renosterbul, *D. bicornis*. *J. S. Afr. vet. med. Ass.* 36(3): 305.
- YOUNG, E.
1965 b. 'n Verslag oor die versameling van saad by 'n Swart renosterbul, *D. bicornis*. *J. S. Afr. vet. med. Ass.* 36(3): 305.
- YOUNG, E.
1966 Treatment of cutaneous granulomata in the Black Rhinoceros *Diceros bicornis*. *Inter Zoo Yearbook* 6: 275.
- ZAPHIRO, D. R. P. & TALBOT, L. M.
1961 The use of light aircraft in East African wildlife research and game management. *Oryx* 6(3): 190-199.
- ZUKOWSKY, L.
1949 Eine neue Nashornrasse aus dem Schari-Tschad Gebiet. *Arche Noah* 1: 16.
- ZUKOWSKY, L.
1924 *Opsiceros occidentalis* Zukowsky. *Archiv. für Naturgeschichte*, 90 A, 1-6: pp. 80-82.
- ZUKOWSKY, L.
1922 Vorläufige Mitteilung über eine neue Art des Spitzschnauz-Nashorns aus Südwest-Afrika *Archiv. für Naturgeschichte*, 88 a, 7-12: 162-165.
- ZUMPT, F.
1964 Parasites of the white and black rhinoceros *The Lammergeyer*, Vol. 5(1): 59.
ment. Univ. of Mich. Press, Ann Arbor.



Observations on the Habitat Preferences and Population Dynamics of the Black-Faced Impala *Aepyceros petersi* Bocage, 1875, in South West Africa

by
Eugene Joubert
Nature Conservation and Tourism Branch
South West Africa Administration

CONTENTS

I. Introduction	55
II. Distribution and present status	55
III. Ecology	57
a) Habitat preference	57
b) Feeding records	58
c) Associated animals	60
d) Predation	60
IV. Population structure	60
V. Social structure	62
VI. Growth rates	62
VII. Reproduction	64
VIII. Endo- and ectoparasites	64
IX. Summary	64
X. Acknowledgements	64
XI. References	65

I. INTRODUCTION

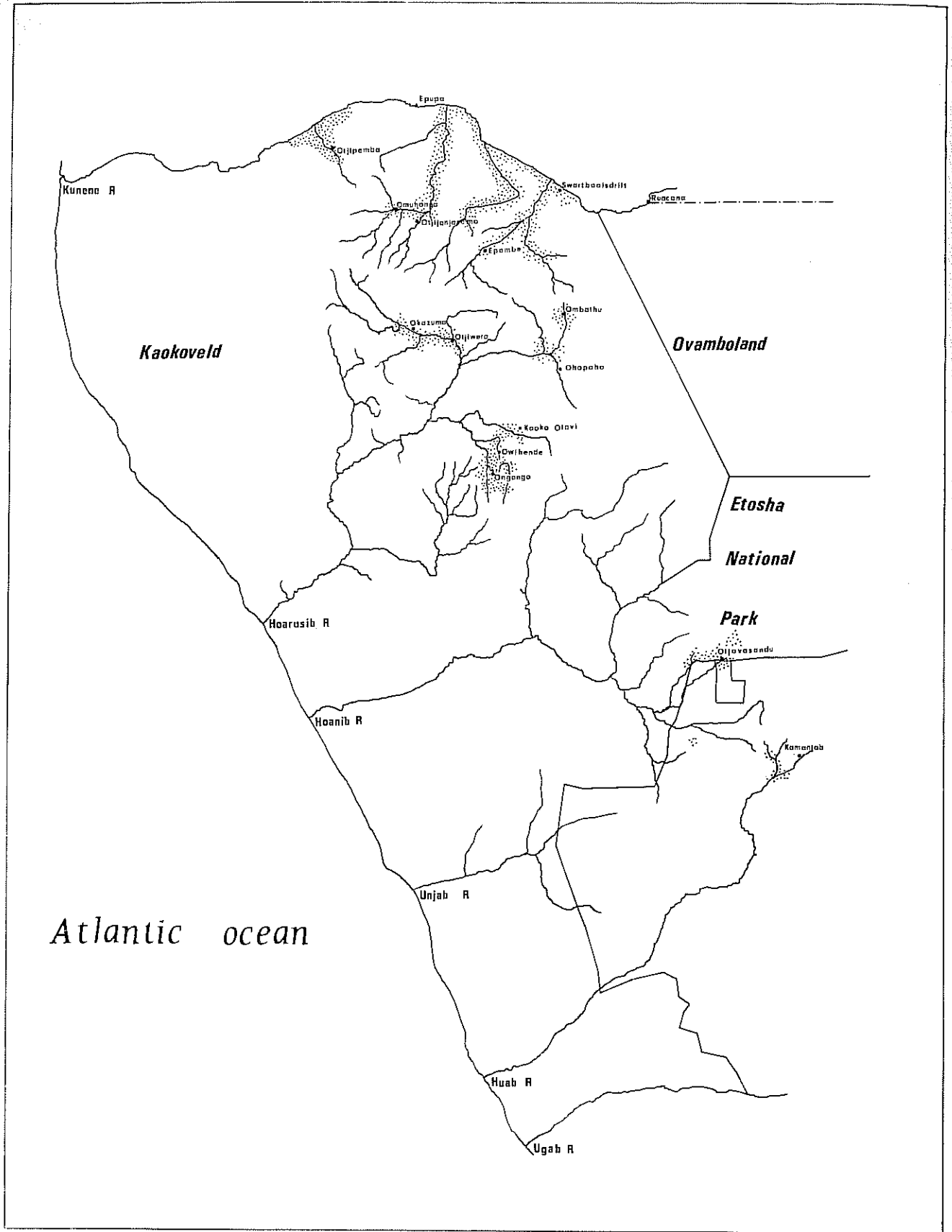
In South West Africa the black-faced impala occurs only in the zoogeographic entity known as the Kaokoveld which is bounded by the Namib desert to the west and by the inland plateau to the east. The southern border of this area is described by Shortridge (1934) as being the Ugab River. The Kaokoveld approximately falls between the latitudes 17°S and 19° 15'S and longitudes 11° 50' E and 14° 13'E.

Apart from a small group of about 60 animals at Otjovasandu in the western Etosha National Park all the black-faced impala occur in the northern Kaokoveld. Here their numbers have dwindled away, mainly owing to continuous drought, hunting pressure and competition from livestock. To ensure the survival of the black-faced impala, the Nature Conservation and Tourism Branch of the SWA Administration in 1968 decided to translocate as many as possible of these animals to Otjovasandu, a portion of the Etosha National Park lying within the zoogeographic borders of the Kaokoveld.

During this operation information was gathered regarding the weights and body sizes of the impala. These results, as well as notes kept by the author wherever he infrequently encountered the black-faced impala during four years spent in the area on another research project are used in this and another paper. The latter will deal mainly with their taxonomy. In this present paper Oboussier (1967) is followed in regarding the black-faced impala as a species distinct from *Aepyceros melampus*.

II. DISTRIBUTION AND PRESENT STATUS

Very little is known about the past distribution of the black-faced impala in South West Africa. It seems possible that they might have occurred in suitable localities throughout the Kaokoveld. Steinhardt (1924) records that a pair moved as far south as Franzfontein where they were shot. Until recently a small number still occurred on the farm Katemba in the upper reaches of the Huab River near Kamanjab. According to the first white inhabitants in this region they came across black-faced impala at Kaross, Otjovasandu and Kowares. According to most recent authors, Steinhardt (1924), Shortridge (1934), Roberts (1952), Gaerdes (1965) and Swart (1967) the black-faced impala never occurred more than a few miles south of the Kunene River. Shortridge gives their range as the Kunene Watershed west of Longitude 13E. Shortridge and Steinhardt names Ombathu as the most southerly permanent habitat of the black-faced impala in the Kaokoveld, although a few individuals have been known to visit the springs at Okorosawe and Onjanjeresse during the rainy period. Gaerdes states that the black-faced impala have completely disappeared from former inland habitats around the permanent waterholes of Ombathu, Korosawe, Kaoko-Otavi and Otjanjeresse.



Map 1. The present distribution of the black-faced Impala in South West Africa.

During the four years the author spent in the Kaokoveld he established their present distribution fairly accurately. They are not restricted to the banks of the Kunene River but also occur in several other localities, some of which are very isolated. They still occur along the Kunene River where they reach their highest concentrations between Swartbooisdrift and Epupa. Between Epembe and Otjanjeresse several small herds have also been noticed. At Otjirekeha a concentration of these animals has been recorded. The biggest concentration in the northern Kaokoveld occurs at Omuhonga. Apparently the floodplain and riverine vegetation in this area suits them or their requirements very well. (See habitat preference). The furthest west that black-faced impala occur along the Kunene River is at Otjiomborongbonga. The small number previously seen at Otjinungua has not been seen for the past five years. Black-faced impala still occur in small numbers at Ombathu, Otjirekeha, a small way north of Ohopoho, Etanga and Otjiwero.

As already mentioned Gaerdes states that the black-faced impala has disappeared from its previous distribution areas at Korosawe and Kaoko-Otavi. At both of these fountains Herero's are practicing limited irrigation and this might have caused the impala to move to Omeamo and Owihende. They also occur at Ongango, a little way to the south. At present their most southern distribution is at Kamanjab. During a census carried out in 1969 at Otjovasandu 57 animals were counted.

It is difficult to estimate the exact population numbers of animals for the various localities at which black-faced impala occur. At Omuhonga they number approximately 500 individuals. Their second biggest concentration is along the Kunene River where there are not more than 150 animals. At Ongango and Otjirekeha an average of 50 individuals were counted during several aerial surveys. At all the other localities mentioned only very small groups of fewer than 25 individuals exist. The total number of black-faced impala for South West Africa is between 750 and 1 000 individuals, with the former probably the more accurate figure.

III. ECOLOGY

a) Habitat preference

Physiographically the Kaokoveld shows the following characteristics. From the western edge of the plateau the country falls away to the west to form an extremely broken landscape. The mountains are composed of the Nosib and Damara sediments which rise above the surrounding granites and gneiss's which have been more severely weathered and eroded. The Kaokoveld is dissected by the tributaries of the Kunene River, the Hoarusib River and the Hoanib River which all form part of a well developed eshorheic drainage system. The only perennial river is the Kunene.

This area lies within the 25—300 mm isohyets. Owing to an extremely patchy rainfall pattern some areas experience long or repeated droughts while other areas may receive a fair rainfall for one or two seasons before they, in their turn experience the drought. This arid climate with its frequent drought carries a typical arid savanna vegetation. Within the Kaokoveld the distribution of the black-faced impala is limited to areas with suitable vegetation, cover and apparently to areas within reach of surface water. It may well be that the vegetation available in these areas is the chief factor determining this distribution pattern. It is noticeable that most of these localities are comprised of zones of dense riverine vegetation bordered by zones of moderate vegetal density. The impala appear to prefer these localities because of the greater variety of food plants available in the ecotone of the two vegetation types and also the protection offered by the denser vegetation.

In the Kaokoveld the impala reach their greatest density in the vicinity of the Omuhonga waterhole. Here the seasonal river winds through a flat valley with rocky hills on either side. The valley floor varies in width from localities where the hills press against the river to open flood plains about one and a half miles wide. The water is contained in the sandy riverbed about 2 feet below the surface and both the pastoralist Ovahimbis and the elephants dig "gorras" in the sand to obtain their water supply.

The valley floor where it is more open, can be said to form a flood plain with a distinct vegetation. The riverine vegetation is dominated by the tall *Acacia albida* trees which may reach heights of 20—23 metres with trunks of up to 10 metres in circumference. These trees are abundant in the valley floor and in the sandy river bed. The spacing varies from dense aggregations to open stands with crowns more than two diameters apart. Also contributing to the tree canopy are — *A. giraffae* and *Combretum imberbe*. Although these trees do not occur in such large numbers as *A. albida* they also form large spectacular trees. The Makalani palm, *Hyphaene ventricosa*, is present but is not as common as it is along the Kunene River. *Ficus petersi* is present in small numbers.

The second storey is formed by a semi-deciduous tree and tall shrub layer which is almost impenetrable and as a result grass cover is absent. This second storey may reach to eight metres in height. The two most dominant plants are *Diospyros lycioides* and *Euclea pseudebenus*. In between, one also finds *Ziziphus mucronata*, *Combretum hereroense*, *Croton subgratissimus*, *Acacia tortilis* on the valley floor and closer to the hills *Colophospermum mopane*. *Lonchocarpus nelsii* also occur but are not very abundant. In certain localities along the river *Tamarix usnoides* and *Salvadora persica* form large communities. *Gardenia spatulifolia* and *Diospyros mespiliformis* are immigrants from the Kunene riverine vegetation. *A. albida* seedlings occur in large numbers.

The third layer consists of shrub such as *Rhigozum brevispinosum*, *Pechuel-Loeschea leubnitziae*, *Mundulea sericea* and *Montinia caryophyllacea*.

Between these thickets of trees and shrubs, large open glades occur which are covered by lawn-like short grasses which are kept short by the multitude of sheep, goats, cattle and to a lesser extent by impala, Damara dik-dik *Madoqua kirki*, Duiker *Sylvicapra grimmia*, and Steenbok *Raphicerus campestris*. The grass cover consist mostly of *Cynodon dactylon* and *Odyssea paucinervis*.

The important herbs which occur are mainly *Geigeria* spp., *Datura* species, *Otoptera burchellii*, *Vernonia cinerrasiens* and *Juncellus laevigatus*.

In this Omuhonga valley the Ovahimbas, a primitive Herero-speaking race, practice a shifting cultivation and open up plots in the riverine vegetation. Their only produce is maize which they cultivate during the rainy season. During the rest of the year these open plots are often used by the impala to lie up at night.

The vegetation on the surrounding hills consists predominantly of a mopane woodland. The trees are often stunted, especially where the soil is shallow. Other trees which occur are *Terminalia prunioides*, and in smaller numbers *Acacia reficiens*, *Maerua schinzii* and *Combretum apiculatum*. *Berchemia discolor* and *Pachypodium lealii* also occur where it is more rocky. Shrubs are represented mainly by *Ximenia americana*, *Croton*, *Euclea* and *Grewia* species. *Stipagrostis uniplumis*, *Aristida rhiniochloa*, *Pogonarthria fleckii*, *Eragrostis denudata*, *Enneapogon brachystachus* and *Eragrostis porosa* are the most common grasses.

Along the Kunene River the riverine vegetation is more or less the same but *Acacia albida* does not occur in such large numbers as along the Omuhonga River and the other tributaries. Along the Kunene the dominant tree growth consists of *Hyphaena ventricosa*, *Acacia sieberiana* var. *vermoeseni*, *Balanites welwitschii*, *Maerua schinzii*, *Colophospermum mopane*, *Combretum imberbe*, *Cordia gharaf* and *Salvadora persica*.

The impala usually keep to the dense riverine vegetation during the day where they tend to lie up in the thickets. From the time that the *A. albida* pods drop in October and November, the animals concentrate on the floodplains to feed on these pods. During the rainy season the Ovahimba cultivate their plots and at this time the impala utilize the ecotone between the riverine vegetation and the mopane woodland.

Further south the Hoanib and Hoarusib Rivers which cut through several mountain ranges have a riverine vegetation, elements of which they carry through the sub-desert and even into the desert itself. Impala, however, do not occur in the lower reaches probably owing to a lack of suitable cover. They usually only occur in the upper reaches of the Hoarusib and Hoanib River drainage systems. Here the eshorheic drainage systems sometimes open up and form wide valleys with ill-defined drainage

lines. Some of the seasonal streams debauching into these valleys have perennial waterholes. Isolated populations of these impala inhabit the various valleys and hills adjoining these waterholes, namely Okauzuma, Otjirekeha, Epembe, Omeamo, Ongango and Otjovasandu.

The vegetation in the hills surrounding these valleys is the same as that described earlier. The vegetation in the valleys is however very typical. Trees occurring are *A. tortilis* ssp. *heteracantha*, *A. giraffae*, *A. hebeclada*, *Albizia anthelmintica*, *Lonchocarpus nelsii*, *Boscia albitrunca* and *Colophospermum mopane*. In the ecotones *Sesamothamnus guerichii* and *Catophractes alexandri* are sometimes common with scattered *Acacia nebrownii* within the community.

These valley plant communities contain a wide variety of shrubs the more common being *Grewia* species, *Mundulea sericea*, *Gossypium triphyllum*, *Lycium oxycarpum*, *Montinia caryophyllacea*, shrub *Colophospermum mopane*, *Rhigozum brevispinosum*, *Pechuel-Loeschea leubnitziae*, *Bidens biterinata* and *Leucas pechuelii*.

Herbs are also common, the following occurring: *Nerine duparquetiana*, *Cyperus fulgens*, *Cleome diandra*, *C. elegantissima*, *Petalidium coccineum*, *Cassia italica*. During the early rainy season *Tribulus terrestris* is conspicuous. Legumes occurring are *Crotalaria podocarpa*, *Indigofera rautanenii*, *Ptychobium biflorum* and *Lessertia benguelensis*. The grass cover is chiefly *Antheophora schinzii*, *Eragrostis porosa*, *E. rotifer*, *Stipagrostis uniplumis*, *Enneapogon brachystachyus*, *Cenchrus ciliaris*, *Panicum coloratum*, *Tragus racemosus* and *Monechlytrum luderitzianum*.

b) Feeding records

Impala are known to be both browsers and grazers (Ansell, 1960), the intensity of either form of feeding is determined by the season of the year. It was observed in the Kaokoveld that during the rainy season they browse and graze with apparently the same intensity. During this period they move away from the flood plains and browse on the young leaves and shoots of shrubs and trees varying their diet by grazing in the ecotones with the open woodland areas.

During the dry season they move into the riverine and floodplain vegetal areas where the emphasis is mainly on browsing. As already mentioned, in these floodplains and wide valleys with their ill-defined drainage lines, *Acacia* species form part of the dominant cover. Here the black-faced impala feed on the dropped pods which have a high protein value. *A. albida* sheds its flowers as well as the pods during this period, and large numbers of impala have been noticed picking up these flowers from the sandy river beds. Certain dominant plants confined to the riverine vegetation are not subjected to heavy browsing such as *Diospyros lycioides* and *Euclea pseudebenus*.



Plate 1. A small group of black-faced impala in the Omuhonga River bed. (Photo D. v. d. Heever).

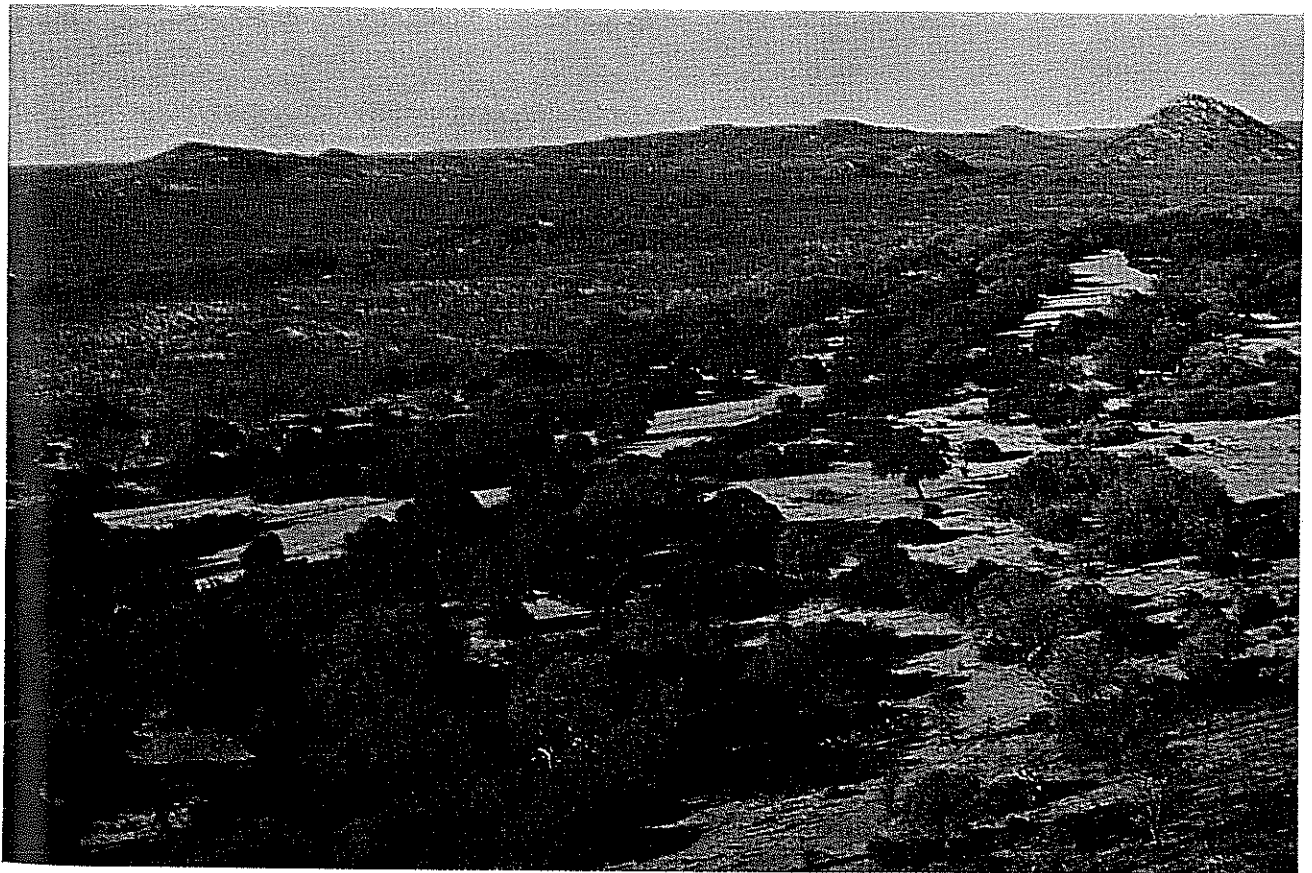


Plate 2. A view of the Omuhonga River. Note the tall *Acacia albida* trees and dense riverine vegetation. (Photo E. Joubert).

The following feeding records have been obtained in South West Africa.

Trees and shrubs

(Mainly leaves and shoots).

Acacia albida
A. tortilis ssp. *heteracantha*
A. hebeclada ssp. *hebeclada*
A. giraffae
A. hebeclada ssp. *tristis*
Asparagus denudatus
A. mellifera var. *detinens*
Croton subgratissimus
Colophospermum mopane
Combretum imberbe
C. hereroense
C. apiculatum
Dichrostachys glomerata
Euclea pseudebenus
Ficus petersi (mainly fruits)
Grewia bicolor
G. flavescens
Mundulea sericea
Terminalia prunioides
Ximenia americana (fruit, bark and leaves)
Ziziphus mucronata

Grasses and other herbs

Aristida effusa
Aristida rhiniochloa
Cassia italica
Cynodon dactylon
Eragrostis nindensis
E. porosa
Ooptera burchellii
Odyssea paucinervis
Vernonia cineracens
Senecio marlothianus
Stipagrostis uniplumis
Panicum coloratum

c) Associated animals

Animals which share the black-faced impala's habitat to some extent are black rhino, kudu, dik-dik and duiker. The inter-relationships between these animals are not known. No direct competition between the species has been noticed. It may be, however, that these animals are complementary to one another viz. the rhino and kudu making more fodder available for impala and dik-dik by breaking branches and also bringing about the growth of new shoots. The black rhino, black-faced impala and kudu maintain a suitable habitat for dik-dik through a trampling effect and feeding on smaller shrubs in open ground storey.

At Ongango and Otjovasandu the spectrum of game species that might intermingle with the black-faced impala is slightly larger. Here one finds that springbok (*Antidorcas marsupialis*) and Burchells zebra (*Equus burchellii antiquorum*) sometimes utilize the open valleys and mopane woodland. Giraffes also

feed in the same areas occasionally. As already mentioned no direct competition was observed, owing to the fact that all these species actually utilize different vegetation communities and where these communities overlap in the ecotones they feed on different levels.

In the northern Kaokoveld, where the bulk of the black-faced impala occur the only serious competition noticed was between them and domestic livestock. Goats especially, are a menace to the existence of the impala. In these regions a marked browse line is noticeable around waterholes and in the riverine vegetation. The domestic livestock, mainly the goats, outnumber the black-faced impala by approximately 100 to 1, resulting in keen competition when the *Acacia* shed their pods.

d) Predation

At Otjovasandu the black-faced impala is confronted with the whole spectrum of natural predators. In the northern Kaokoveld, however, where the inhabitants are mostly pastoralists the larger carnivores have been ruthlessly hunted and are extinct in many places. After man, the leopard is considered to be the most important predator in this area. The inherent astuteness of the leopard is complemented by the extremely broken terrain with the result that it is the most abundant natural predator left in the area.

In the northern Kaokoveld the young Ovahimba pastoralists guard the livestock by day. They all own packs of dogs and during the lambing season it is considered a great sport to scatter the female herds and try and catch the new born lambs. On several occasions the author was presented with young lambs that were offered for sale.

The adult animals, with their natural meekness form an easy target for hunters.

IV. POPULATION STRUCTURE

The numbers of black-faced impala in the Kaokoveld have been steadily declining during the last decade. This can be ascertained by comparing the numbers seen by earlier travellers in this region viz. Shortridge (1934) and Gaerdes (1922 and 1960) with the numbers now to be seen and also by the way their distribution area has shrunk since 1934. This decline in population could be attributed to internal factors in the population eg. inbreeding, parasites or diseases and/or to external factors eg. predation and/or competition with livestock. It was, therefore, decided to combine a population analysis with the capture operations of the team of the Nature Conservation and Tourism Branch who were translocating black-faced impala, to determine the population structure.

The catching operations during November 1968 were carried out on a completely random basis for the first 10 nights. During the following nights only

females were caught. This was the first time ever that spotlights were used at night to catch impala in the Kaokoveld. None of these animals, therefore, had any previous experience of such operations and as the whole population at this time was concentrated along the flood plain at Omuhonga, they all stood an equal chance of being caught. During the catching operation in September 1969 it was decided to concentrate on females and only a few males were caught. The females however were still being caught in a completely random way with no selection as to age.

As the impala are seasonal breeders the young born during a lambing season consist of an easily recognizable group of individuals until their second year. During this time they are distinguishable by their body size and the size of their horns.

During the November 1968 catching operation the population thus consisted of animals approximately 20 months old and animals over two years. The animals caught were grouped into two age classes namely adult and juveniles. The latter consisted of animals nine months old to twenty months old. The females caught during September 1969 were divided into age classes according to weight and thus consisted of animals up to eight months old, 20 months old, 32 months old and fully grown animals.

Only the figures obtained during the first 10 nights in November 1968 were used as basis for working out the population structure. The figures obtained during September 1969 were used as a basis to determine the age structure in the female sex class. According to Table 1 juveniles form 20.4 per cent of the population while the adult females (58.1 per cent) and the adult males (21.5 per cent) form the remaining 79.6 per cent. The male:female ratio for the whole population is 1:2.1, the male:female ratio for adults is 1:2.7, while the male:female ratio for juveniles is 1:0.9. The juvenile:adult ratio is nearly 1:3.9.

Table 1. The black-faced impala population structure, Kaokoveld South West Africa.

	Numbers			Ratio	
	Male	Fe-male	Total	Male	Fe-male
Juveniles	10	9	19	1	0.9
Adults	20	54	74	1	2.7
Total population	30	63	93	1	2.1

The same trend is observable when the figures for the females caught during 1969 are studied. The juvenile females (eight months old) form 24.9 per cent of the total females caught, this is 4.5 per cent higher than the percentage juveniles for the whole population sample caught during November 1969. Stewart and Stewart (1966) did a survey in the Mku-

Table 2. Females caught during September 1969 in age classes according to weight. (Kilograms).

± 8 months	± 20 months	± 32 months	Mature
23.6	40.8	47.2	49.9
27.2	41.7	46.3	49.9
29.0	42.6	45.4	51.7
31.8	40.8	46.3	49.1
26.8	41.7	46.3	49.1
30.8		44.5	51.7
33.1			51.3
			49.9
			50.8
% of total population			
24.9	18.0	21.4	35.7

zi Game Reserve to determine sex and age ratios of impala in Natal. The result is shown in table 3. The figures show striking similarities with the figures obtained in the Kaokoveld. In Mkuzi the juveniles also form the smaller part of the population e.g. 21.2 per cent, while the adult females (55.7 per cent) and adult males (23.1 per cent) form the remaining 78.8 per cent. Even the male:female ratio for the different age groups shows a similarity.

Table 3. The population structure of impala in Mkuzi Game Reserve, Natal. (Numbers after Stewart and Stewart, 1966).

	Numbers			Ratio	
	Male	Fe-male	Total	Male	Fe-male
Juveniles	433	400	833	1.08	1
Adults	904	2184	3088	1	2.4
Total population	1337	2584	3921	1	1.9

If one assumes therefore that the Mkuzi Game Reserve's population structure of impala is normal, it follows that the population structure of the black-faced impala must likewise be normal. With the present recruitment rate they were beginning to have problems of over-population in Mkuzi while with similar recruitment rates the population in the Kaokoveld is declining. If this reduction was due to inherent faulty population dynamics it must have shown in the sex and age ratios, which is not the case. One must come to the conclusion that the present state of affairs in the Kaokoveld is due to external factors, and given the opportunity the population of black-faced impala might well re-establish itself.

There are certain doubts as to the accuracy of the figures obtained in the Kaokoveld, owing mainly to the fact that so few were caught. It is also possible that the females and juveniles are more cautious than the males and that certain age groups

learned faster than others to move away when they saw or heard the capture team. It was felt, however, that until a full research project is initiated on these animals, the information may give some indication on the present state of affairs. Furthermore, they compare favourably with the findings of Stewart and Stewart (1966) in Natal.

V. SOCIAL STRUCTURE

It is well known that impala form female herds and male herds, Shortridge (1934), Ansell (1960) and Schenkel and Schenkel (1966). Normally the female herds also contain the young of the season and/or the previous season. The female herds are usually accompanied by a dominant male.

Observations on herd size were made whenever the opportunity arose. The observations were compiled into figure 1. Normally herds tend to be composed of three to fifteen individuals. However, herds consisting of 21 individuals were seen twice. Unfortunately no accurate figures were obtained of herd sizes during or shortly after the lambing season, but one can expect breeding herds to be slightly larger. These larger herds split up into smaller herds again, soon after all the lambs of the season have been born. This might be ascribed to the disturbance factor caused by the dogs and Ovahimba youngsters and to the topography of their area which discourages large herds. This occurrence of small or splinter herds was also noticed at Omuhonga where the greatest concentration of black-faced impala in the Kaokoveld occurs. At Omuhonga the total population numbers 450 to 500 individuals, but rarely were herds exceeding 15 animals seen.

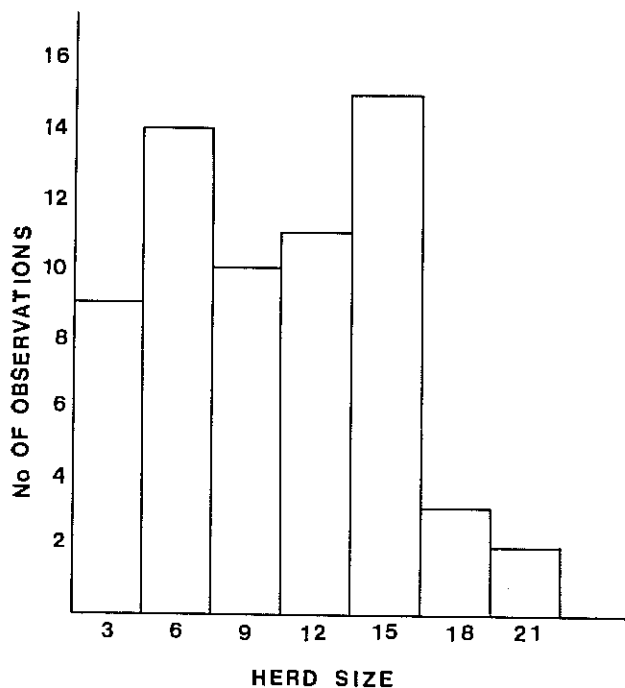


Figure 1. Distribution of herd sizes for the black-faced impala in South West Africa.

Solitary males or just two individuals are often encountered. Although no solitary females were ever observed the author once came across a female with a juvenile of approximately six months old with her and although considerable time was spent in the area no other black-faced impala were observed. On other occasions a pair of females were observed alone.

During the night these herds congregate in open localities to lie up. Disused patches opened up by the shifting cultivation practices of the Ovahimbas along the Omuhonga flood plain are especially favoured. Elsewhere the open glades are used. Between 50 to 150 individuals may lie up in such an open spot. Whether these congregations form a single herd or whether they are separate groups remains a debatable point and more observations are required. The author is under the impression however that this habit must have a survival value in that a more vigilant watch can be kept against predators at night, while during the day the smaller herds are more difficult to track down.

In these clearings, favoured by the black-faced impala, large roughly circular patches of accumulated droppings can be observed. By looking for fresh droppings on these dung heaps one can quickly determine where the different groups of black-faced impala in a certain locality are spending their nights.

It was noticed that the dik-dik, which share this habitat with the black-faced impala also frequently use the same dung piles (Tinley 1969).

VI. GROWTH RATES

Owing to practical considerations not all the animals caught could be weighed and measured. More information was gathered about the females than the males, but it is doubtful as to whether it will have a marked influence on these calculations. Few fully mature males were caught and the highest maximum weight might be slightly higher than the figure given here. This again will only have a limited influence on the calculated average weight for fully matured male animals.

At birth the lambs weigh approximately 5 kilogram. During the first nine months they pick up weight at the rate of approximately 2.69 kg/month for the males and 2.58 kg/month for the females. During the following 12 months the weight gain is approximately 1.34 kg/month for the males and approximately .95 kg/month for the females. The rate at which they gain weight in the following months is less. From their 22nd month they gain weight at about .79 kg/month and .63 kg/month for the males and females respectively. (See Figure 2).

As can be seen in figure 2 the rate of growth during the first 20 to 22 months is very marked. During this period the males increase in height

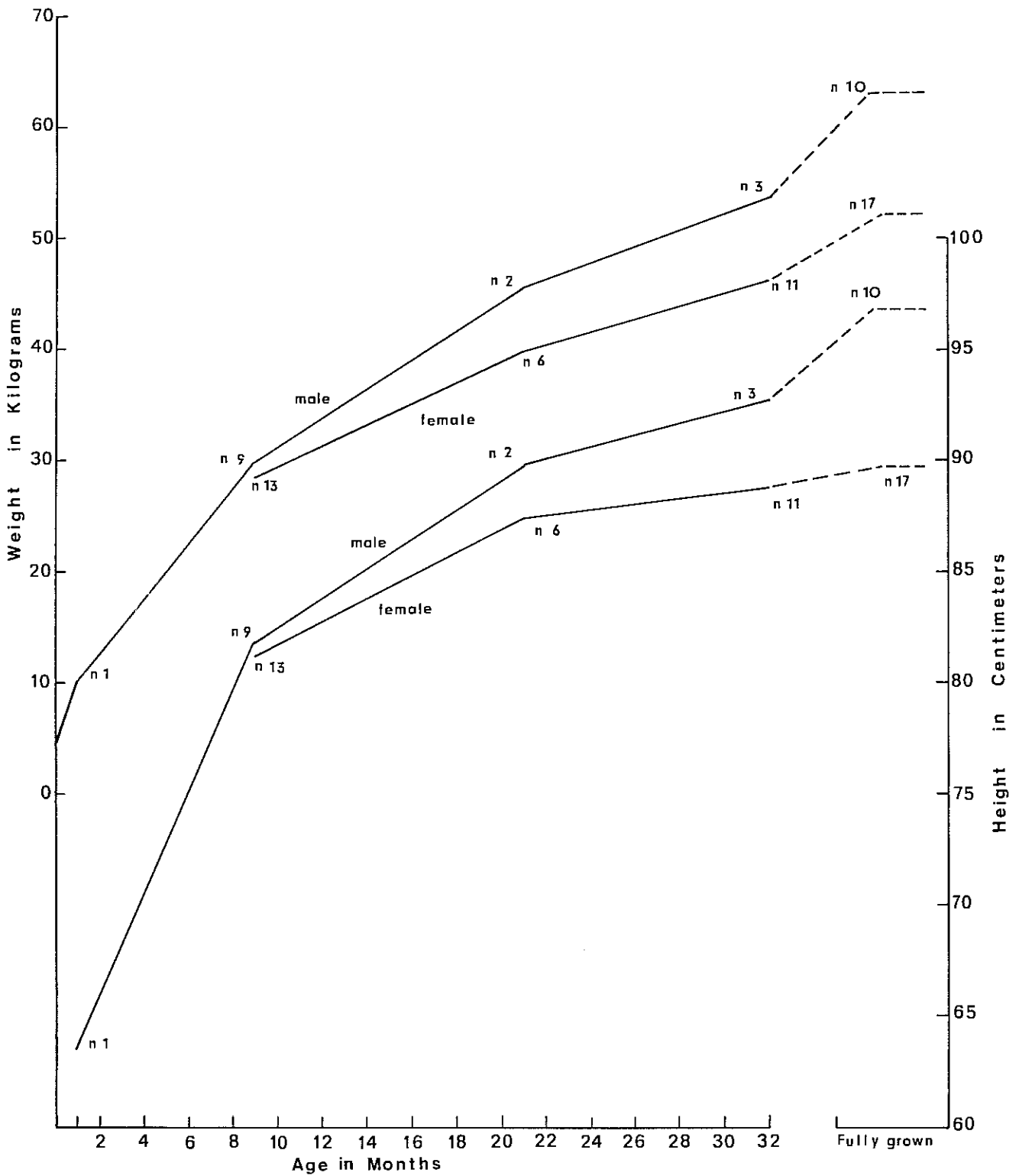


Figure 2. Growth rates — height and weight — for the black-faced impala in South West Africa.

(measured at shoulder) at a rate of .65 cms/month and the females at a rate of .50 cms/month. During the following year the growth rate slows down and the males only gain .26 cms/month and the females .12 cms/month. After the 32nd month the females show a very small height increment. The males however gain an average of 3.9 cms after the 32nd month. Despite this the females gain nearly as much in weight as the males do. The average is 6 kg in the females as against the 9 kg in the males (See figure 2).

VII. REPRODUCTION

In Natal the lambing season of *A. melampus* starts in November and by the end of March all the lambs have been dropped (Stewart and Stewart, 1966). In the Kruger National Park the lambing season is given as "usually in November and December" (Labuschagne and van der Merwe, 1963). In the Kaokoveld the impala appears to have a short and marked lambing season which might be attributed to the equally short rainy season. It was observed that the black-faced impala usually start dropping their lambs at the very end of December with a peak in January. By February new-born lambs were rarely seen. The breeding dates for the females translocated during the past two years were between the 20th December and the 15th January. Of the 28 females translocated to Otjovasandu during November 1969, 10 were under two years of age. All the other females dropped lambs, which indicates a high lambing percentage. At Namutoni one of the translocated black-faced impala females had a pair of twins. One of the lambs was totally ignored despite the fact that it was in excellent health, and it eventually died (R. Biggs, 1970).

VIII. ENDOPARASITES AND ECTOPARASITES

Endo- and ectoparasites were collected only during the dry season. It might well be that the degree of infestation varies during the different seasons of the year. It is known, however, that contamination is usually relatively low in the more arid parts of Southern Africa.

Post mortems were conducted on 9 animals. Only four of these animals had any internal parasites and even so the degree of infestation was very low. In three of the animals hookworm lesions (*Coope-rioides hepatica*) were found. In two of the animals *Haemonchus bedfordi* were found. According to Dr. A. Verster (pers. com. 1969) both of these endoparasites are also found in the Transvaal *Aepyceros melampus*.

Unfortunately no information could be gathered on the actual degree of parasitism in the Transvaal and Natal populations of impala.

Ticks were confined to the scrotal and anal regions and also in external ear canals of the animals. The degree of infestation however was low and only an average of four to ten ticks were found per animal. In the external ear canals however the degree of infestation was markedly higher. The latter infestation were formed mainly by immature stages.

The following ectoparasites were found:

Rhipicephalus duttoni
R. evertsi mimeticus
R. capensis
R. oculatus

IX. SUMMARY

Information on black-faced impala was gathered during the catching operations in 1968, 1969 and also during infrequent encounters over a period of four years. In the Kaokoveld the distribution of the black-faced impala is limited to areas with suitable vegetation, cover and possibly the availability of open water. These localities usually comprise a dense riverine vegetation zone bordering on vegetation zones of moderate density. A detailed description is given in the black-faced impala's distribution areas.

A description is given of the feeding habits as well as a list of food plants. Apart from competition with domestic livestock no direct competition with other animals sharing the black-faced impala's habitat was noticed.

Apart from man, the leopard is the most important single predator of the black-faced impala in the Kaokoveld.

The population dynamics of the black-faced impala in South West Africa show marked similarities with the figures obtained from the Mkuzi Game Reserve's impala population in Natal. Herds seem to be composed of three to fifteen individuals. A description is given of the growth rate of the impala. The most rapid growth occurs during the first 20 to 22 months after which it slows down. The lambing season usually starts towards the end of December with a peak in January.

Infestation by endo- and ectoparasites is relatively low.

X. ACKNOWLEDGEMENTS

I wish to express gratitude to my colleagues for their friendly assistance and co-operation, without which most of this information would have been lost; P. Swart, J. du Preez, J. Dixon, P. Flanagan, D. Fryer, V. du Plessis, H. Conradie, C. van Schalkwyk and D. Coetzee all did more than their share. Mr. Giess from the Herbarium in Windhoek is thanked for identifying the plants and checking the botanical names in the manuscript. Thanks is al-

so due to Mr. C. G. Coetzee, Director of the Museum, Windhoek for his patience and informative discussions. He is also thanked with C. le Roux, Dr. J. Hofmeyer and P. van der Westhuizen for critically reading through the manuscript.

XI. REFERENCES

- ANSELL, W. F. H.
1960 Breeding of some larger mammals in Northern Rhodesia. *Proc. Zool. Soc. Lond.* 134: 251-274.
- BIGGS, R.
1970 Nature conservator, Namutoni: Monthly Report. Dept. Nature Conservation & Tourism, Windhoek.
- GAERDES, J.
1965 The Impala of South West Africa *Afr. Wild Life* Vol. 19 No. 2.
- LABUSCHAGNE, R. J. and VAN DER MERWE, N. J.
1965 *Mammals of the Kruger and other National Parks*. A publication of the National Parks Board of Trustees of the Republic of South Africa.
- OBOUSSIER, H.
1965 Zur Kenntnis der Schatz-Fersenantilope (Impala) *Aepyceros Melampus* unter besonderer Berücksichtigung des Großhirnfurchenbildes und der hypophys. *Z. Morph. Okol. Tiere* 54: 531-550.
- ROBERTS, A.
1951 *The Mammals of South Africa*. Central News Agency, Cape Town.
- SCHENKEL, R.
1966 On sociology and behaviour in Impala (*Aepyceros melampus* Lichtenstein). *East African Wild L.* Vol. IV.
- SHORTTRIDGE, G. C.
1954 *The Mammals of South West Africa*. Vol. 2. William Heinemann, London.
- STEINHARD, R.
1922 *Ehombo*. J. Neumann, Neudamm.
- STEWART, P. G. and STEWART, I. B.
1966 The use of sex and age ratios estimating abundance and productivity of impala. *The Lammergeyer* 6.
- SWART, P. S.
1967 New data on the black-faced Impala (*Aepyceros melampus petersi* Bocage). *Cimbebasia* 20.
- TINLEY, K. L.
1969 Dikdik *Madoqua kirki* in South West Africa: Notes on Distribution, Ecology and behaviour. *Madoqua* 1.

C

The Capture of Plains Zebra *Equus burchelli antiquorum*, H. Smith, 1841, with M-99 (Reckitt) and Tranquillizers in the Etosha National Park.

by

H. Ebedes

Nature Conservation and Tourism Branch
South West Africa Administration.

I. INTRODUCTION

The plains zebra *Equus burchelli antiquorum* H. Smith, 1841 is one of the most numerous ungulate species in the Etosha National Park and its migratory patterns and seasonal movements have never been fully understood. In order to clarify the sometimes confusing migrations a number of zebra were captured with drugs and marked with neckbands so that more definite information could be obtained. At the same time blood samples were collected from the immobilised animals for a study on the blood proteins of equidae by Prof. D. R. Osterhoff of the Faculty of Veterinary Science, Onderstepoort and accurate body measurements of the zebra were taken. The results of the migration study which were made possible by being able to positively identify individually marked animals at various stages of their movements in the Park will be published separately in a later paper.

Before M-99 (Reckitt) became available as an immobilising drug other compounds such as nicotine salicylate, (Grzimek 1961); succinylcholine chloride, (Talbot and Lamprey 1961; van Niekerk 1963; Bigalke 1965); and gallamine triethiodide, (Talbot and Talbot 1962; and Bigalke 1962), were used for capturing free-ranging zebra in East, South and South West Africa. Nicotine alkaloids are highly toxic and dangerous to humans handling the drugs because they can be absorbed directly through the skin. In animals the drug first acts by stimulating the central nervous system often producing convulsions, followed by depression and paralysis. No antidote is available. Using succinylcholine chloride Talbot and Lamprey (loc.cit.) found that although the majority of zebra were excellent subjects for immobilisation, the tolerance of the drug varied among individuals and several deaths were recorded after an apparently safe dose was injected. The zebra were immobilised for periods of 8 to 22 minutes which would have been insufficient time for our requirements. Another serious disadvantage of using succinylcholine chloride is that the potency is affected by heat resulting in deterioration of the drug. In subtropical climates such as that of Etosha National Park (Latitude 19° South) this factor would have been an important practical consideration.

Both Bigalke and the Talbots (loc.cit.) found gallamine triethiodide unsuitable for zebra capture because of the critical tolerances. A dosage-rate of 1.3 mg/lb. was found ineffective and 1.4 mg/lb. produced paralysis of the respiratory muscles and subsequent death.

Graham—Jones (1964) working mainly on captive wild animals commented that zebra were extremely difficult animals to sedate and anaesthetise, and found that paralytic/hypnotic/sedative amnesia combinations were less effective in zebra than in other species.

The promising results, wide safety-margin, good tolerance and low toxicity of M-99 (Reckitt) and the rapid reversal of narcosis by morphine anta-

CONTENTS

I. Introduction	67
II. Drugs	68
III. Antidotes (Morphine antagonists)	68
VI. Methods	69
V. Results	69
VI. Discussion	71
VII. Conclusion	71
VIII. Summary	72
VIX. Acknowledgements	72
X. References	72

gonists reported by Harthoorn (1965(a)), Harthoorn and Bligh (1965), King and Klingel (1965), Pienaar *et al* (1966) and Ebedes (1969) influenced the writer to use this compound for capturing zebra for the marking project. In this paper the results obtained from capturing fifty zebra with M-99 in combination with other drugs such as acepromazine ("Acetylpromazine", Boots), triflupromazine hydrochloride ("Siquil", Squibb Laboratory), phencyclidine hydrochloride ("Sernylan Parenteral" Parke, Davis and Company) and hyoscine hydrobromide (B.P.) are discussed.

II. DRUGS

1. M - 99 (Reckitt)

M-99 (Reckitt) or Etorphine hydrochloride is a powerful synthetic morphine-like narcotic compound with a wide safety-margin and good tolerance. The narcotic effect can rapidly be reversed by the injection of a morphine antagonist. Small quantities of the compound produce anaesthesia and analgesia in ungulate animals.

M-99 (Reckitt) is available in powder-form and solutions containing 20 milligrams and 10 milligrams per ml. were prepared by us. A supply of M-99 (Reckitt) was given to the writer for investigational use by Reckitt and Sons Ltd., Dansom Lane, Hull, England. Reckitt and Colman (Africa) Ltd., P.O. Box 1097, Cape Town, now control all supplies of M-99 for use on wild animals outside the United States of America.

2. Hyoscine Hydrobromide (B.P.) (Burroughs Wellcome & Co.)

Hyoscine hydrobromide or scopolamine has an atropine-like action, depresses the central nervous system, produces general sedation with morphine and morphine analogues and is a powerful mydratic (Krantz and Carr, 1951).

Hyoscine hydrobromide is mainly used in immobilising mixtures because of its potentiating effect on tranquillizers and narcotic drugs (Harthoorn 1965, (a)). It also causes mydriasis which may hasten the capture of the animal because of its inability to see properly.

Hyoscine hydrobromide is obtainable in powder form and multidose solutions of 100 milligrams per ml. were prepared.

3. "Sernylan" (Parke, Davis and Company)

Sernylan or phencyclidine hydrochloride is a neuroleptic drug with anaesthetic properties. Sernylan is rapidly absorbed and potentiates narcotics and anaesthetics, (Harthoorn 1965 (a)). It is a useful drug for immobilising carnivorous mammals (Ebedes, 1968).

Multi-dose solutions of Sernylan 100 milligrams per ml. were obtained from the manufacturers, Parke, Davis and Company, Isando, Transvaal.

4. "Acetylpromazine" (Boots Pure Drug Company)

Acetylpromazine or Acepromazine maleate, a phenothiazine derivative, is a rapidly-absorbed, fast-acting and potent tranquillizer. Its action is potentiated by narcotics (Pienaar, 1966). Multi-dose solutions of 10 milligrams per ml. and 20 milligrams per ml. were purchased from Messrs. A. S. Ruffel and Co., P.O. Box 2905, Windhoek.

5. "Siquil" (Squibb Laboratories)

Siquil or triflupromazine hydrochloride is a potent phenothiazine derivative with 3 to 5 times the activity of chlorpromazine. Siquil prolongs and intensifies the action of many central nervous system depressants including narcotics. Multi-dose solutions of 20 milligram per ml. were obtained from the manufacturers, Squibb Laboratories, Isando, Transvaal.

III. ANTIDOTES (MORPHINE ANTAGONISTS)

One of the main advantages of using M-99 to capture wild ungulates is that the narcotic effect can rapidly be reversed or counteracted by morphine antagonists. The captured narcotised animal can therefore be revived and released immediately after capture. Three morphine antagonists are presently available; one of them Diprenorphine hydrochloride or R & S 5050-M HCl (Reckitt and Sons) has only recently been released for investigational use.

Although the exact mode of action of morphine antagonists is not known it is possible that they compete with morphine and similar drugs for occupation of the receptor sites in the brain. (Bentley, 1964).

1. "Lethidrone" (Nalorphine Hydrobromide) (Burroughs Wellcome and Company).

Lethidrone (B.W. & Co.) is N-allylnormorphine hydrobromide and is a specific morphine antagonist. It is available as a water-soluble powder or in multi-dose solutions of 20 milligrams per ml. from the manufacturers.

2. M - 285 (Reckitt) or Cyprenorphine Hydrochloride (Reckitt).

M-285 (Reckitt) is a specific M-99 (Reckitt) antagonist and produces a rapid and complete reversal of the immobilisation effects produced by M-99. Its potency is up to 35 times greater than

nalorphine hydrobromide. The recommended dosage-ratio of M-285 to M-99 is 2.5:1.

Supplies of M-285 in powder form were made available to the writer for investigational use by Reckitt & Sons, Dansom Lane, Hull, England, but is now available from the South African Company, Reckitt and Colman (Africa) Ltd., P.O. Box 1097, Cape Town.

3. R & S 5050 — M (Reckitt) or Diprenorphine Hydrochloride (Reckitt)

R & S 5050 — M is a new M-99 antagonist developed by Reckitt and Sons. The recommended dosage-ratio of R & S 5050 — M to M-99 is 1:1, however the drug is still in the initial investigational stages and has not been extensively evaluated (J. Visser, 1968, pers. comm.). R & S 550 — M was supplied to the writer for investigational use by Reckitt and Colman (Africa) Ltd., P.O. Box 1097, Cape Town.

IV. METHODS

The apparatus used mainly for darting the zebra was the Palmer Powder Charge Cap-Chur Gun with standard Palmer 1 ml., 2 ml. and 3 ml. volume projectile darts fitted with 1" and 1½" length barbed needles (Palmer Chemical & Equipment Co.). Occasionally the Palmer Short Range Projectile (gas operated) was used when the zebra could be approached from a close range. The darts were sterilised before use and were only used once because the projectory and flight of darts used for more than one darting was found to be erratic and unreliable.

Two methods were used for approaching and darting the zebra:

(i) Darting from a moving Land Rover. On the open shortgrass plains west of the Etosha Salina this was the only practical method of approaching and darting the zebra particularly during the rainy season. The zebra were pursued at speeds of 20 to 35 miles per hour and darted from a distance of 5 to 25 yards.

(ii) Stalking in a Land Rover. On the Andoni Plain north of Namutoni Rest Camp and at waterholes, zebra were stalked in a Land Rover as they approached the water and were darted from a distance which varied from 35 to 60 yards.

All relevant information pertaining to the drugs and dosages used, dart sites, distance, down-times, reaction after immobilisation, rectal temperature, heart-rate, respiration-rate, external temperature and humidity, body-measurements, marking materials and techniques, additional therapy etc., were recorded on standardised departmental immobilisation forms.

(a) Weight.

The weights of all the zebra were based on estimations.

(b) Age.

Ageing was based on Klingel's ageing criteria of zebra (Klingel, 1965). After a visit to the Etosha National Park in 1965, Klingel (pers. comm.) established that there were no significant differences in the dental wear of East African and South West African plains zebra.

(c) Dart site.

Whenever possible it was attempted to dart the animals in a thick muscular area such as the shoulder or hindquarter (hip) so that the drugs could be absorbed rapidly in areas of good vascularity. However, because of the occasional erratic flight of the darts, bumpy conditions when firing from a moving motor-vehicle, the influence of strong winds deflecting the darts and misjudgement of distance, zebra were sometimes darted in the thorax and other areas as noted in the Tables.

(d) Down-time or immobilisation time.

The time-lapse from the moment the dart hit the animal until it became recumbent was determined on a stopwatch. Immobilised zebra usually assumed a position of lateral recumbency.

(e) Recovery Time.

The recovery time is the time recorded from the moment the antagonist was injected until the animal showed signs of recovery and regained its feet. By injecting the antagonist intravenously, reversal of narcosis and recovery was often dramatic and rapid (Plate 1). Because the neckband used for marking the zebra sometimes hindered the injection of the antagonist into the jugular vein, the superficial ear veins were found suitable. In a few cases the injection needle accidentally slipped out of the thin ear vein and a portion of the antagonist was injected subcutaneously resulting in longer recovery times. Intramuscular injection of the antagonist resulted in a less dramatic, smoother and more gradual recovery. No antagonist was injected into zebra N1, TABLE 1, because he was not fully immobilised. The amount of antagonist injected into zebra GW1, TABLE 3 was not recorded on the immobilisation data form.

To counteract possible stress factors and infections which could have resulted from the capture, the zebra were routinely injected with antibiotics, corticosteroid preparations and vitamins, particularly Vitamins A.D. and E and the majority were inoculated against anthrax with 1 ml. Onderstepoort Anthrax Spore Vaccine.

V. RESULTS

The results obtained from immobilising 50 plains zebra in the Etosha National Park are summarised in TABLES 1, 2, 3 and 4.

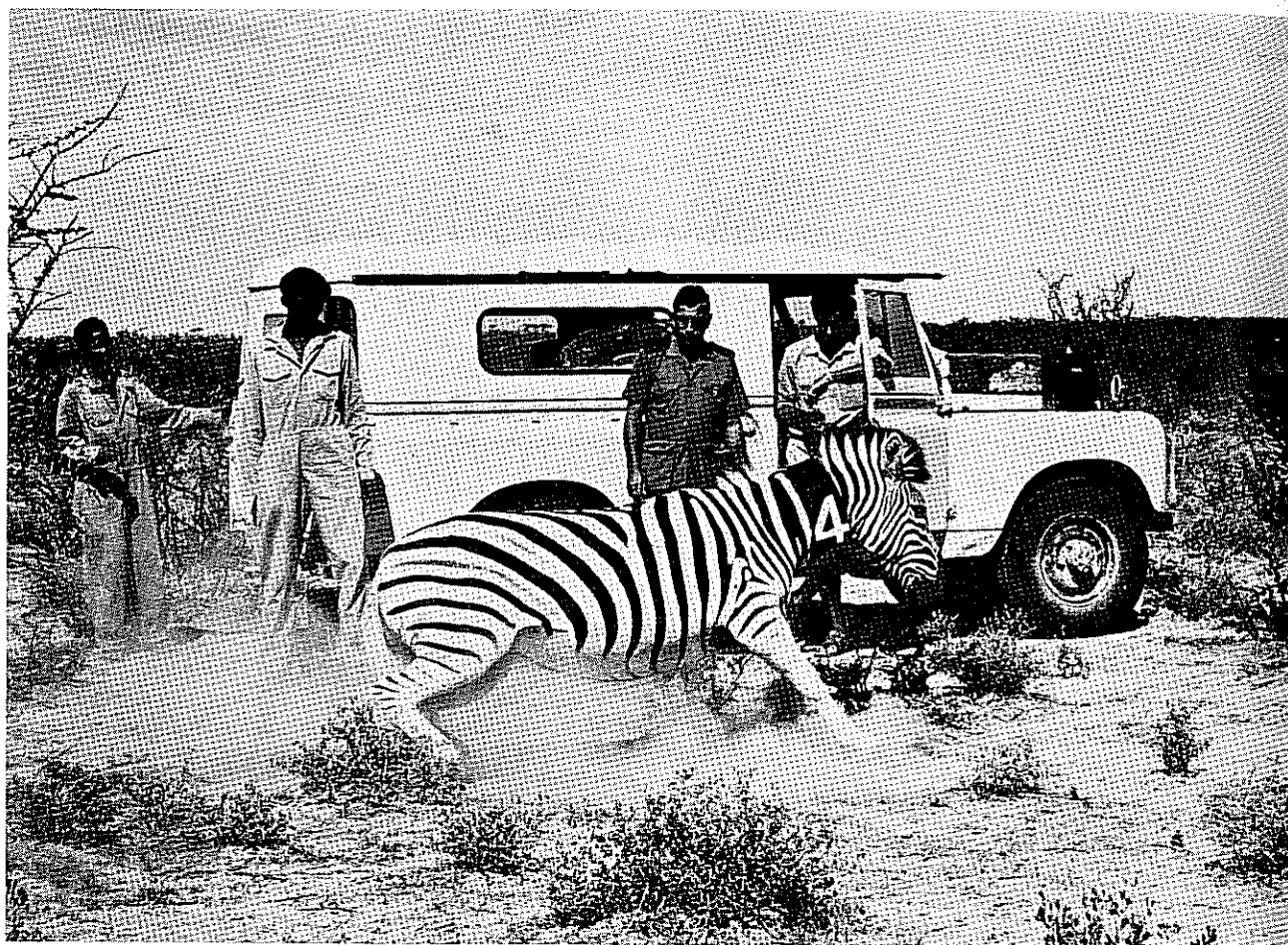


Plate 1. Recovery of marked zebra after injection of antagonist R & S 5050-M (Reckitt). Photo R. Borland.

In TABLE 1 there is a lot of scatter because experience was being gained by the writer in drug-dosages, drug-combinations and darting techniques.

In TABLE 2 the dosage of M-99 and Acetylpromazine was kept constant, hyoscine hydrobromide was excluded from the drug-mixture and zebra of approximately the same weight and age-group were selected for immobilisation.

In TABLE 3 the Acetylpromazine in the drug-mixture was replaced with another tranquillizer — triflupromazine ("Siquil", Squibb Laboratories) at the same dosage rate viz. 20 milligrams per animal.

In TABLE 4 the dosage of M-99 was increased by 0.50 milligram (or 1 microgram per lb. body-weight) and Acetylpromazine and hyoscine hydrobromide were again included in the drug-mixture to determine if the down-time or immobilisation time could be lowered. The new M-99 antagonist R & S 5050 — M was used instead of Lethidrone and M-285 to evaluate its efficacy.

In TABLE 5 the grouped data from TABLES 2, 3 and 4 are summarised.

All the zebra were immobilised satisfactorily and could be marked and measured without additional restraint.

The rectal temperatures of the immobilised zebra were taken shortly after they were recumbent. There was little difference in the average rectal temperatures of the zebra immobilised with combinations of M-99 plus acetylpromazine and M-99 plus triflupromazine. A rise of 1°F was observed in the average temperatures of zebra immobilised with a higher dosage of M-99 plus acetylpromazine and hyoscine hydrobromide. The external environmental temperature and humidity was measured with a whirling hygrometer at each immobilisation. The average external temperature was 84.4°F, lowest temperature 77°F and highest 94°F. High rectal temperatures were usually recorded when the immobilisation time exceeded 10 minutes. The higher rectal temperatures could not be correlated to high external temperatures or to the effects of the tranquillizers, but probably resulted from the increased muscular activity caused by the animal running a longer distance before becoming immobilised.

The normal pulse and respiration-rates of resting zebra are not known to the writer. Average pulse-rates and respiration-rates recorded from 24 zebra shortly after they were recumbent were 82 per minute and 20 per minute respectively. Gibbons, (1966) gives the normal resting pulse-rate for mature horses as 28-40 per minute and the normal resting respiratory-rate for mature horses as 8-16

Table 1. Results of zebra capture with M-99, Hyoscine hydrobromide, Acetylpromazine and Sernylan.

No.	Code No.	Area	Sex	Age years	Est. weight lbs.	Dart site	M-99 mg.	Hyoscine mg.	Acetylpromazine mg.	Sernylan mg.	Down-time	Temp. °F.	Antagonist mg	Recovery time
1	N1	Andoni	M	4	550	Hip	1.5	25	15	—	30 min.	—	—	—
2	N2	Andoni	M	1	320	Hip	1.5	25	15	—	3 min. 30 secs.	—	L 100 I.M.	16 min.
3	N3	Andoni	F	3/4	250	Shoulder	1.5	25	15	—	3 min. 41 secs.	—	L 50 I.V.	3 min.
4	N4	Andoni	F	3	350	Hip	1.5	25	15	—	Approx. 5 min.	—	L 50 I.V.	44 secs.
5	GV1	Grootvlakte	M	10	750	Hip	2.5	25	10	—	33 min. 22 secs.	104	L 60 I.M.	2 min. 30 secs.
6	GV.2	Grootvlakte	F	3	400	Hip	2.5	25	10	—	25 min.	107	L 100 I.M.	6 min. 30 secs.
7	GV.3	Grootvlakte	F	3	375	Hip	2.5	25	10	—	8 min. 33 secs.	103	L 80 I.M.	6 min. 10 secs.
8	GV.4	Grootvlakte	F	?	450	Thorax*	2.5	25	15	—	5 min. 30 secs.	104.2	L 100 I.M.	12 min. 53 secs.
9	GV.5	Grootvlakte	F	4	475	Hip	2.5	25	15	—	20 min.	107	L 70 I.M.	30 secs.
10	A2	Adamax	F	3	400	Flank	2.5	12 1/2	12	—	10 min.	—	L 100 I.M.	6 min.
11	A3	Adamax	M	5	550	Hip	2.5	12 1/2	10	—	12 min.	106	L 100 I.M.	6 min.
12	GV.6	Grootvlakte	F	4	475	Shoulder	2.25	—	5	15	24 min.	—	L 50 I.V.	6 min. 20 secs.
13	L1	Leeubron	F	3	350	Shoulder	2.5	—	5	10	10 1/2 min.	—	L 60 I.V.	15 secs.
14	GV.8	Grootvlakte	F	2	350	Hip	2.5	—	5	10	7 1/2 min.	—	L 80 I.V.	18 secs.
15	GV.9	Grootvlakte	F	5	550	Hip	2.5	—	5	10	10 min.	—	L 60 I.V.	19 secs.
16	L2	Leeubron	F	2	360	Shoulder	2.5	—	5	10	10 1/2 min.	—	M 10 I.V.	1 min. 2 secs.
17	A4	Adamax	M	2	350	Hip	2.25	—	10	—	19 min.	—	M 10 I.V.	5 secs.
18	GV.10	Grootvlakte	M	8	680	Hip	3	—	10	—	7 1/2 min.	—	M 12 I.V.	45 secs.
19	A5	Adamax	M	7	650	Hip	2.25	—	—	—	30 min.	105.4	L 120 I.V.	5 secs.

* Darted twice.

L = "Lethidrone" (B.W. & Co.)

M = M-285 (Reckitts.)

Table 2. Results of zebra capture with M-99 and Acetylpromazine.

No.	Code	Area	Sex	Age years	Est. body weight lbs.	Dart site	M-99 mg	Acetylpromazine mg.	Down-time	Temp. °F.	Pulse per min.	Resp. per min.	M-285 mg.	Recovery time
1	Y1	Andoni	M	6	700	Shoulder	2.5	20	9 min.	101.2	—	—	8 I.V.	5 min. 25 secs.
2	Y2	Andoni	F	5	600	Shoulder	2.5	20	9 min. 30 secs.	103	90	17	5 I.V.	4 min. 30 secs.
3	Y3	Andoni	F	5	630	Shoulder	2.5	20	7 min. 30 secs.	101.5	90	11	5 I.V.	4 min. 30 secs.
4	Y4	Andoni	F	5	630	Shoulder	2.5	20	6 min. 30 secs.	102	—	—	5 I.V.	59 secs.
5	Y5	Andoni	F	5	630	Shoulder	2.5	20	8 min. 23 secs.	103.5	86	14	10 I.V.	1 min. 33 secs.
6	Y6	Andoni	F	5	650	Thorax	2.5	20	27 min.	103	90	24	10 I.V.	32 secs.
7	W1	Andoni	F	5	600	Neck	2.5	20	2 min. 49 secs.	102	70	16	10 I.V.	4 min. 30 secs.
8	W2	Andoni	F	5	600	Thorax	2.5	20	11 min. 25 secs.	105	86	16	10 I.V.	31 secs.
9	W3	Andoni	F	6	650	Jaw	2.5	20	6 min. 43 secs.	101	90	16	10 I.V.	1 min. 25 secs.
10	W5	Springbok-fontein	F	5	650	Sternum	2.5	20	16 min. 15 secs.	103	—	—	10 I.V.	2 min. 54 secs.
11	W6	Springbok-fontein	F	4	550	Cardiac region	2.5	20	2 min. 25 secs.	101.5	—	—	*L 80 I.V.	48 secs.
Average					626			32 microgram per lb.	9 min. 46 secs.	102.4	86	16	13.3 microgram per lb.	2 min. 18 secs.

* = Lethidrone (B.W. & Co.)

Table 3. Results of zebra capture with M-99 and Siquil.

No.	Code No.	Area	Est. weight lbs.	Sex	Age years	Dart site	M-99 mg.	Siquil mg.	Down-time	Temp. °F.	Pulse per min.	Resp. per min.	Antagonist mg.	Recovery time
1	NTV.	Ombika	630	F	6½	Hip	2.5	20	8 min. 25 secs.	100	66	18	7.5 M285 I.V.	1 min. 8 secs.
2	GW. 1	Gobaub	580	M	5	Neck	2.5	20	6 min.	101.8	68	26	*	10 min.
3	GW. 2	Gobaub	560	F	6½	Shoulder	2.5	20	18 min.	103.4	92	22	L 60 I.V.	30 secs.
4	GW. 3	Gobaub	400	F	3½	Shoulder	2.5	20	20 min.	107.2	106	36	L 60 I.V.	2 min. 30 secs.
5	GW. 4	Gobaub	580	F	5	Hip	2.5	20	15 min.	101.4	64	26	L 60 I.V.	35 secs.
6	GW. 5	Gobaub	600	M	6	Hip	2.5	20	6 min.	101.2	42	16	L 60 I.V.	50 secs.
7	OY. 3	Ock/font.	600	F	5	Shoulder	2.5	20	4 min.	—	—	—	L 80 I.M.	3 min. 30 secs.
8	OY. 4	Ock/font.	700	F	7	Shoulder	2.5	20	12 min.	—	—	—	L 80 I.M.	4 min. 20 secs.
9	OY. 5	Ock/font.	450	F	3½	Thorax	2.5	20	11 min.	—	—	—	L 50 I.V.	1 min. 15 secs.
10	OG. 1	Ock/font.	400	F	3½	Shoulder	2.5	20	8 min. 12 secs.	101.4	80	24	L 80 I.V.	36 secs.
Average:			550				4.5 mi-crogr. per lbs.	36 mi-crogr. per lbs.	10 min. 51 secs.	102.3 °F.	74	24	120 microgr./lbs.	1 min. 40 secs.

L = "Lethidrone" (B.W. & Co.)

* Dosage of antagonist not recorded

Table 4. Results of zebra capture with M-99, Acetylpromazine and Hyoscine hydrobromide, and the antagonism of M-99 with R & S 5050-M (Reckitt). Area: Grootvlakte, Etosha National Park.

No.	Est. weight lbs.	Sex	Est. age years	Dart site	M-99 mg.	Hyoscine mg.	Acetylpromazine mg.	Down-time	Temp. °F.	Pulse per min.	Resp. per min.	R & S 5050-M mg. i.v.	Recovery time
R 1	640	F	8	Thorax	3	15	20	12 min. 46 secs.	105	94	16	5	1 min. 18 secs.
R 2	550	F	6	Thorax	3	15	20	13 min. 34 secs.	104	96	14	4	25 secs.
R 3	550	F	5	Shoulder	3	15	20	3 min. 30 secs.	102	84	30	3	1 min. 50 secs.
R 4	580	F	5	Shoulder	3	15	20	8 min. 26 secs.	104.4	80	18	3	1 min. 52 secs.
R 5	580	F	4 1/2	Neck	3	15	20	7 min. 14 secs.	100.6	96	20	6	2 min. 36 secs.
R 6	600	F	7	Shoulder	3	15	20	9 min. 28 secs.	102.6	72	16	6	1 min. 50 secs.
R 7	640	F	10	Neck	3	15	20	3 min. 28 secs.	101.9	84	16	6	1 min. 45 secs.
R 8	720	M	14	Shoulder	3	10	10	16 mins.	104	86	20	6	4 min. 58 secs.
R 9	500	F	4	Shoulder	3	10	10	10 min. 29 secs.	104.6	86	20	4.5	52 secs.
R 10	610	F	7	Shoulder	3	10	10	10 min. 37 secs.	105.8	90	20	6	1 min. 32 secs.
Average:					597	22.5 microgr. per lbs.	28.3 microgr. per lbs.	9 min. 33 secs.	103.5	87	19	8.25 microgr. per lbs.	1 min. 54 secs.

Table 5. Grouped data of Tables 2, 3 and 4.

	Weight	M-99	Hyoscine	Tranquillizer	Down-time	Temp. °F.	Antagonist	Recovery time
Table 2	626 lbs.	4 microgram per lbs.	—	A.C.P. 32 microgram per lbs.	9 min. 46 secs.	102.4	M-285 13.3 microgram per lbs.	2 min. 18 secs.
Table 3	550 lbs.	4.5 microgram per lbs.	—	Siquil 36 microgram per lbs.	10 min. 51 secs.	102.3	Lethidrone 120 microgram per lbs.	1 min. 40 secs.
Table 4	597 lbs.	5 microgram per lbs.	22.5 microgram per lbs.	A.C.P. 28.3 microgram per lbs.	9 min. 33 secs.	103.5	R & S 5050-M 8.25 microgram per lbs.	1 min. 54 secs.

per minute. Harthoorn (1965(b)) suggested that M-99 might have a specific effect on the heart of the donkey because in some instances the pulse-rate doubled and even trebled after M-99 was injected intravenously. Although high pulse-rates were recorded in the zebra, the effect on the heart appears to be transient because the zebra were normal in every respect after recovery from the narcosis.

VI. DISCUSSION

Although there is a lot of scatter in TABLE 1, two-thirds of the zebra were immobilised in less than 15 minutes. These animals are split evenly between those receiving hyoscine and those not receiving the drug. Four of the five animals receiving Sernylan were immobilised in less than 15 minutes. The numbers are too few to draw any firm conclusions, but it was felt that because there is no antagonist for Sernylan and because drug-mixtures should be kept as simple as possible it did not merit inclusion in further drug-combinations. No conclusions can be drawn from the one zebra, A5, that was immobilised with only 2.25 milligram M-99. However the down-time was 30 minutes and it seemed beneficial to include tranquillizers in future drug-mixtures because of the synergism and potentiation of M-99 reported by various workers.

In TABLE 2 the dosage of M-99 and acetylpromazine was kept constant and zebra of approximately the same weight and age group were selected for darting. Hyoscine was excluded from the mixture and results indicate that there is no justification for its use in the immobilisation of zebra on open plains. In thick bush or overgrown environments hyoscine will be beneficial because the mydriatic effect of the drug will result in more rapid capture as a result of the affected animals being impeded by branches and bushes (Pienaar. per. comm.).

When zebra were immobilised with a slightly increased dosage of M-99, and triflupromazine HCl. was used instead of acetylpromazine (TABLE 3), the difference in average down-times was approximately one minute. This is possibly an indication that the two tranquillizers are similar in action at the dosage-rate of 20 milligrams per animal.

In an attempt to immobilise zebra in a shorter time, the M-99 dosage was increased to 3 milligrams per animal (5.0 microgram per lb.), and hyoscine hydrobromide was again included in the mixture (TABLE 4). No significant decrease in immobilisation time was achieved which once again indicated that hyoscine could be left out of future drug-combinations for zebra. Although the writer realises that the rapidity of immobilisation is dependent on the rate of absorption of the drugs and their effect on the central nervous system, he was unable to consistently achieve the rapid immobilisation times of 3 minutes reported by Harthoorn and Bligh (loc. cit). Increased dosage-rates of M-99, from 4 microgram per lb. to 5 microgram per

lb. also did not significantly affect the immobilisation-times. The differences in our findings are most probably due to nutritional, physiological and subspecies differences between East African and South West African zebra. Zebra in Etosha National Park probably have an increased tolerance for M-99.

All the zebra recovered completely after one of the three morphine antagonists were injected. Three parenteral routes were used, viz. intravenous, intramuscular and accidentally the subcutaneous route. It appears from the results that nalorphine hydrobromide, ("Lethidrone" B.W. & Co.) produced the most rapid recoveries, followed by diprenorphine hydrochloride, (R & S 505 0— M (Reckitt). The recovery with R & S 5050 — M was smoother and with less excitement than when either "Lethidrone" or M-285 were used.

No mortality or detrimental side-effects as a result of the drugs were recorded in any of the zebra and the majority of the marked zebra were seen on subsequent occasions. Marked mares rejoined their families shortly after they had recovered from the immobilisation.

VII. CONCLUSION

1. For all practical purposes highly satisfactory results were obtained when 50 plains zebra in the Etosha National Park were immobilised with average doses of 4 to 5 microgram/lb. M-99 in combination with various other drugs such as hyoscine hydrobromide, phencyclidine hydrochloride, acetylpromazine and triflupromazine hydrochloride.
2. Plains zebra in the Etosha National Park have an increased tolerance for M-99 compared with plains zebra in East Africa.
3. Hyoscine hydrobromide does not appear to be necessary in drug-combinations for immobilising zebra on open grass plains, but may be useful in dense and bushy terrain. The inclusion of hyoscine hydrobromide at an average dosage-rate of 22.5 micrograms per lb. did not significantly decrease the immobilisation time.
4. The average rectal temperature of 28 zebra taken shortly after immobilisation was 102.7°F. The rectal temperatures were not influenced by the immobilising drugs. High rectal temperatures were caused by increased muscular activity when immobilisation times exceeded 10 minutes.
5. The two tranquillizers, acetylpromazine and triflupromazine are effective and safe tranquillizers in drug-combination used for capturing zebra.
6. Three morphine and M-99 antagonists "Lethidrone", M-285 and R & S 5050 — M satisfactorily reversed the narcotic effects of M-99 by intravenous, intramuscular or subcutaneous injection routes. A new M-99 antagonist, Diprenorphine hydrochloride (R & S 5050 — M, Reckitt) was found suitable for antagonising M-99 at a ratio of 1:1 and 1:2.

7. No mortality or detrimental side-effects were observed at the various dosage-rates and drug-combinations.

VIII. SUMMARY

A total of 50 plains zebra were successfully captured with M-99 in combination with tranquilizers such as acetylpromazine, triflupromazine hydrochloride, phencyclidine hydrochloride and/or hyoscine hydrobromide, and marked to facilitate the study of zebra migrations in Etosha National Park, South West Africa. The Palmer Powder Charge Cap-Chur Gun and Palmer Short Range Projector were used to fire 1 ml., 2 ml., and 3 ml. projectile darts containing the drug-mixtures.

The details of the results are presented in five Tables. At average dosage-rates of 4 to 5 microgram per lb. M-99, 28 to 32 microgram per lb. acetylpromazine or 36 microgram per lb. triflupromazine hydrochloride and/or 22.5 microgram hyoscine hydrobromide per lb. the zebra were immobilised in average times of 9 to 11 minutes.

The rectal temperature, pulse-rates and respiration-rates of some of the immobilised zebra are recorded.

The benefits of adding hyoscine hydrobromide to drug-combinations for immobilising zebra on open plains is discussed. No significant lowering of immobilisation times was achieved when hyoscine hydrobromide was included in the drug-mixture at average rates of 22.5 microgram per lb. Effective immobilisation was obtained without any additional restraint when M-99 was combined with either acetylpromazine or triflupromazine hydrochloride. Zebra in Etosha appear to have a higher tolerance for M-99 compared with zebra in East Africa.

All the zebra recovered from the immobilisation after parenteral injections of one of three different morphine or M-99 antagonists. None of the animals died or suffered from detrimental side-effects as a result of the capture technique.

A new M-99 antagonist, Diprenorphine hydrochloride (R & S 5050 - M, Reckitt) was used with highly satisfactory results.

IX. ACKNOWLEDGEMENTS

The writer wishes to thank Mr. B. J. G. de la Bat, Director of Nature Conservation and Tourism for permission to immobilise and mark zebra in Etosha National Park, and for his constant encouragement, guidance and assistance.

A special word of thanks to Mr. Ken Tinley for assisting with the initial trials and for his encouragement and comments on this paper and to Dr. Tol Pienaar of Kruger National Park for his constructive criticism of the paper and helpful advice throughout the immobilisation and marking project.

In conclusion the writer is indebted, on behalf of the South West Africa Administration to Messrs. Reckitt and Sons, Hull, England for the generous supplies of M-99 and M-285 and to Reckitt and Colman (Africa) Ltd., for the supply of R & S 5050 - M.

X. REFERENCES

- BENTLEY, K. W.
1964 The relief of pain - the search for the ideal analgesic. *Endeavour* XXIII(89).
- BIGALKE, R. C.
1962 Immobilisation experiments carried out in the Etosha Game Park, S.W. Africa, April 1962. S.W.A. Departmental Report. Unpublished.
- BIGALKE, R. C.
1965 Experiments in immobilising ungulate mammals. *Zoologica Africana* 1(1).
- EBEDES, H.
1969 Notes on the immobilisation of gemsbok *Oryx gazella gazella* in South West Africa using etorphine hydrochloride (M-99). *Madoqua* 1.
- EBEDES, H.
1968 The use of Sernylan as an immobilising agent and anaesthetic for wild carnivorous mammals in South West Africa. In Press. *Madoqua* 2.
- GIBBONS, W. J.
1966 Clinical diagnosis of diseases in large animals. Philadelphia: Lea and Febiger.
- GRAHAM-JONES, O.
1964 Restraint and anaesthesia of some captive wild animals. *Vet. Rec.* 76(44).
- GRZIMEK, M. and B.
1960 A study of the game of The Serengeti Plains. *Zeit. Säugetierk.* 25.
- HARTHOORN, A. M.
1965 (a) Application of pharmacological and physiological principles in restraint of wild animals. *Monographs* No. 14.
1965 (b) The use of a new oripavine derivative for restraint of domestic hoofed animals. *J. S. Afr. vet. med. Ass.* 36(1).
- HARTHOORN, A. M. and BLIGH, J.
1956 The use of a new oripavine derivative with potent morphine-like activity for the restraint of hoofed wild animals. *Res. vet. Sci.* 6(3).
- KING, J. M. and KLINGEL, M.
1965 The use of the oripavine derivative M-99 for the restraint of equines, and its antagonism with the related compound M-285. *E. Afr. Wildl. J.*, 5.
- KLINGEL, H.
1965 Notes on tooth development and ageing criteria in plains zebra. *E. Afr. Wildl. J.*, 5.
- KRANTZ, J. C. and CARR, C. J.
1951 *The pharmacological principles of Medical Practice*. 2nd Edition. The Williams & Wilkins Company, Baltimore.
- PIENAAR, U. de V., VAN NIEKERK, J. W., YOUNG, E., VAN WYK, P. and FAIRALL, N.
1966 Neuroleptic narcosis of large wild herbivores in South African National Parks with the new potent morphine analogues M-99 and M-185. *J. S. Afr. vet. med. Ass.* 37(5).
- TALBOT, L. M. and LAMPREY, M. F.
1961 Immobilisation of free ranging East African ungulates with succinylcholine chloride. *J. Wildlife Mgmt.*, 25(5).
- TALBOT, L. M. and TALBOT MARTHA M.
1962 Flaxedil and other drugs in field immobilisation of large mammals in East Africa. *J. Mammal.*, 45(1).
- VAN NIEKERK, J. W., PIENAAR, U. de V., and FAIRALL, N.
1965 Immobilising drugs used in the capture of wild animals in the Kruger National Park. *J. S. Afr. vet.*

Trionyx triunguis (Forsk.) , a Reptile new to the South West African Fauna

by

M. J. Penrith

State Museum Windhoek

The soft-shelled turtles of the genus *Trionyx* are found in North America, Asia and Africa. In Africa the genus is represented by a single species, *Trionyx triunguis* (Forsk.). This species has a wide range of distribution in tropical and northern Africa. The range is given by Loveridge and Williams (1957) as stretching from Egypt to Kenya on the east coast and from French West Africa to Angola on the west coast. These authors give Benguela as the southern-most record, but Laurent (1964) in revising the reptiles of Angola did not list *T. triunguis*. On two visits to Moçamedes examples of *T. triunguis* were seen in ornamental ponds on the beach front, but their origin could not be ascertained.

During September — October 1969 a joint expedition to southern Angola was undertaken by the State Museum, Windhoek, the South African Museum, Cape Town, and the Instituto de Investigação Científica de Angola, Sá de Bandeira. The main purposes of the expedition were to collect small mammals and to extend an ecological survey of the intertidal fauna of rocky shores of South West Africa, but where possible collections of freshwater fish were made as well. During a camp at Foz do Cunene, approximately 7 km inland from the mouth of the Kunene river, nightlines were set to collect fish. The river at this point is about 20 m wide. Two large *T. triunguis* were hooked on these lines. The smaller of the two was still alive when landed and was cut loose, but the larger, which had drowned, was kept.

This is the first record of the species from a river within the South West African area, and is the most southerly record both for *T. triunguis* and for the genus *Trionyx*.

The Kunene river specimen, now in the collection of the State Museum, Windhoek (catalogue number S.M. 5779) (PLATE 1), has a total carapace length of 492 mm and a width of 358 mm. The hard section of the carapace is 264 mm long and

220 mm wide. The width of the head (PLATE 2) is 54 mm, the interorbital width 13 mm, and the eye diameter 14.4 mm. When freshly collected the proboscis from tip to orbit was clearly longer than the orbit diameter, but this unfortunately was not accurately measured at the time of collecting. It is not possible to give an accurate length as the proboscis was damaged and somewhat dehydrated before the specimen reached Windhoek, since the only way to preserve such a large specimen was to inject it with formalin and store it in a polythene bag in cotton-wool moistened with formalin. The tail is short, not projecting beyond the carapace margin posteriorly. The forefeet have the characteristic three sharp crescentic folds of skin on the anterior surface.

The dorsal colour is olive-grey with pale ocelli, most numerous about the neck and anterior edges of the carapace. The underside of the head and neck is pale with a reticulate pattern of dark lines. Very faint brown marbling is visible on the plastron.

The food of this species appears to have been the source of some confusion. Loveridge and Williams (1957) list several authorities who have claimed a vegetable diet, while others have stated it to be carnivorous. Probably it will take any food matter that it can obtain, animal or plant, living or dead. The Kunene river examples were taken on lines baited with fish fillets, but both were taken in a reedy area between large boulders where the fresh-water prawn *Macrobrachium* was common. Villiers (1958) has suggested that the jaws of *Trionyx triunguis* are modified according to the diet. A diet of fish will result in sharp-edged jaws, while a mollusc diet will cause the edges of the jaws to become abraded and a broad masticating surface to develop. The present specimen appears to have sharp jaws, although it is not possible to open the jaws fully without damaging them.

The records of *Trionyx triunguis* given for Angola by Loveridge and Williams (1957) all appear to be from the lower reaches of the rivers. This appears to be the case in the Kunene river as well, as it is unlikely that the presence of a reptile of the size of *T. triunguis* in the higher, better-known sections of the river could have gone unnoticed. Several authors (Duméril, 1860; Villiers, 1958) have recorded examples of the species taken alive at sea several miles from the land. It is probable that it is in this manner that it has spread at least into the drier extremes of its range. Flower (1933) suggested a similar manner of dispersal for it along the Palestine coasts. Along the Palestine coasts the spread is said to be passive, the turtle being swept along by the inshore currents. The inshore currents along the southern Angolan coasts are northerly, however, which suggests that *T. triunguis* will swim actively along the coast. Even with the ability to move from river to river in this manner, the Kunene river is almost certainly the southernmost possible limit of its range on the west coast of Africa, as the next permanent river, the Orange river, is about 1 400 km south of the Kunene.

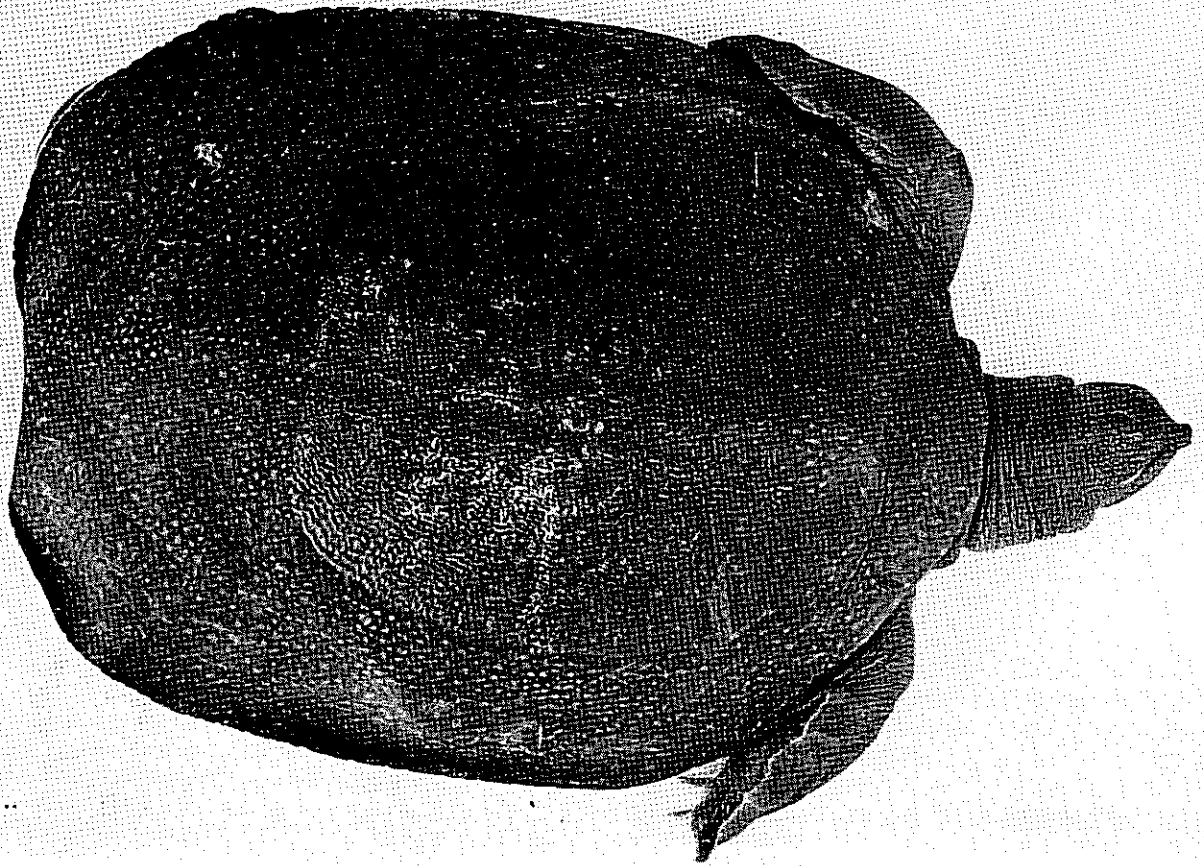


Plate 1. *Trionyx triunguis* (Forsk.) Dorsal view.

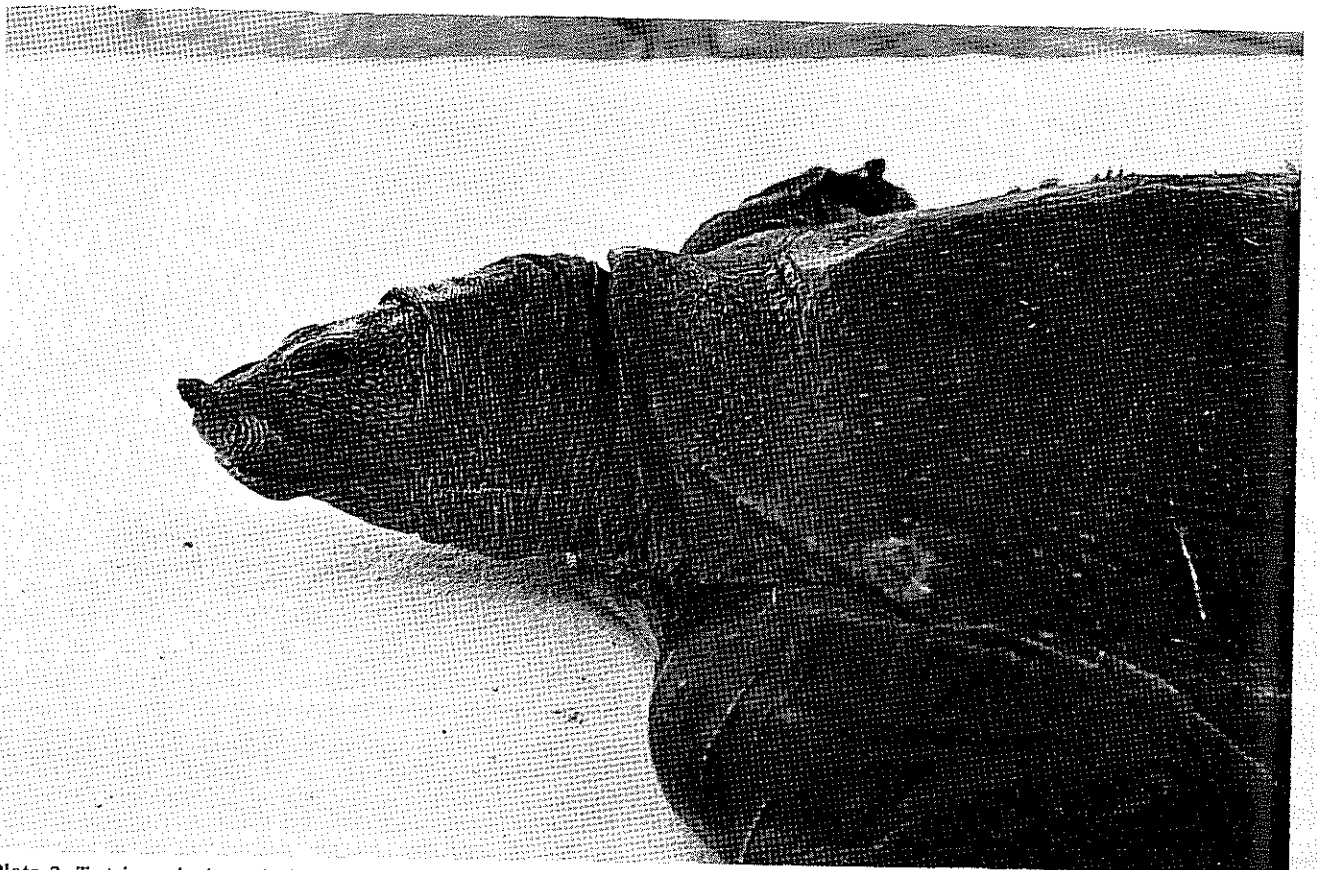


Plate 2. *T. triunguis*, lateral view of head, proboscis damaged.

I am indebted to the Council for Scientific and Industrial Research, by whom I was employed at the time, for permission to accompany the expedition, and to Mr. C. G. Coetzee, Director of the State Museum, Windhoek, for inviting me.

REFERENCES

- DUMÉRIL, A. H. A.
1860 Reptiles et poissons de l'Afrique occidentale. *Archs Mus. nain. Hist. nat., Paris* 10: 137-240.
- FLOWER, S. S.
1933 Notes on the recent reptiles and amphibians of Egypt, with a list of the species recorded from that Kingdom. *Proc. zool. Soc. Lond.* 1933: 735-851.
- LAURENT, R. F.
1964 Reptiles et amphibiens de l'Angola. (Troisième contribution). *Publções cult. Co. Diam. Angola* 67: 1-165.
- LOVERIDGE, A., & E. E. WILLIAMS
1957 Revision of the African tortoises and turtles of the suborder Cryptodira. *Bull. Mus. comp. Zool. Harv.* 115: 163-557.
- VILLIERS, A.
1958 Tortues et crocodiles de l'Afrique noire française. *Init. afr.* 15: 1-354.

Inhoud Contents

- E. Joubert F. C. Eloff** Notes on the Ecology and Behaviour of the Black Rhinoceros *Diceros bicornis* Linn. 1758 in South West Africa. 5
- E. Joubert** Observations on the Habitat Preferences and Population Dynamics of the Black-Faced Impala *Aepyceros petersi* Bocage, 1875, in South West Africa. 55
- H. Ebedes** The Capture of Plains Zebra *Equus burchelli antiquorum*, H. Smith, 1841, with M-19 (Reckitt) and Tranquillizers in the Etosha National Park. 67
- M. J. Penrith** *Trionyx triunguis* (Forsk.) a Reptile new to the South West African Fauna. 77

