

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

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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. $12^{\circ} 40'$, East) to east of Namutoni (approx. $17^{\circ} 10'$, 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 Grünewald (three — P. Starke, *pers. com.*) and at Gobaub (minimum of three — P. Starke, about five, P. van der Westhuizen, *pers. com.*).

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

This preference coincides with 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
Ximenia 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	Ooptera burchellii	Fabaceae
*Lycium trothae	Solanaceae	*Rhynchosia spp	"
*Cordia gharaf	Heliotropiaceae	Dolichos chrysanthus	"
Curronia dedidua	Periplocaceae	Lycium boscüfolium	Capparaceae
Callicorema capitata	Amaranthaceae	Bidens biternata	Asteraceae
Neorautenia amboensis	Fabaceae	Oosteospermum nervosum	Asteraceae
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.

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 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 percen-

tage crude fibre value during September than during June.

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

The percentage calcium, however, shows a clear tendency to reach its highest 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	S	M	J	S	M	J	S	M	J	S	M	J	S	M	J	S
<i>Acacia reficiens</i>	8.2	6.5	10.7	3.99	2.13	3.90	44.4	45.8	39.0	1.6	1.2	1.5	1.2	1.7	1.3	0.08	0.04	0.17
<i>Acacia mellifera</i> var. <i>detinens</i>	7.9	9.6	9.2	3.45	2.86	1.81	44.2	42.6	49.3	1.8	1.9	1.4	1.4	1.4	1.4	0.18	0.07	0.15
<i>Terminalia prunioides</i>	5.7	4.7	4.6	3.45	6.60	2.44	41.6	43.6	57.6	0.7	0.7	0.7	1.6	3.2	1.6	0.09	0.04	0.07
<i>Grewia</i> species	4.6	4.6	3.8	4.98	2.70	1.95	42.7	47.6	49.5	1.1	1.0	1.0	1.6	1.9	1.9	0.14	0.06	0.07
<i>Catophractes alexandri</i>	5.3	4.2	5.3	2.70	1.55	1.31	43.9	42.6	44.0	1.4	0.9	1.0	0.7	0.7	1.0	0.09	0.05	0.08
<i>Combretum apiculatum</i>	7.5	4.8	4.1	5.50	3.01	2.04	33.7	41.4	49.2	1.3	2.5	1.0	2.5	1.8	1.5	0.07	0.07	0.06
<i>Blepharis obmitrata</i>	6.9	5.8	5.7	6.80	5.35	4.6	38.7	35.2	37.3	0.8	0.8	0.9	2.1	1.6	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 pyramidaloides*, *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: 41.350%
Grasses: 36.000%
Trees: 11.350%
Herbs: 9.350%
Sedges: 2.000%

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.

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

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

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

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

(*One casual observation).

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

Blepharis obmitrata
Dactylandra zewelitschii
Dolichos chrysanthos
Neorautalenia amoensis
Bidens biternata
Osteospermum nervosum
Ipomoea arachnosperma
Helinus integrifolius
Aptosium angustifolium
Hibiscus caesiis

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.

Bonania schizantha
Merremia guertchii

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 FE₂ browsing. Notice how difficult it would have been to determine "rhino feeding minutes" per plant species. Photo by E. Joubert

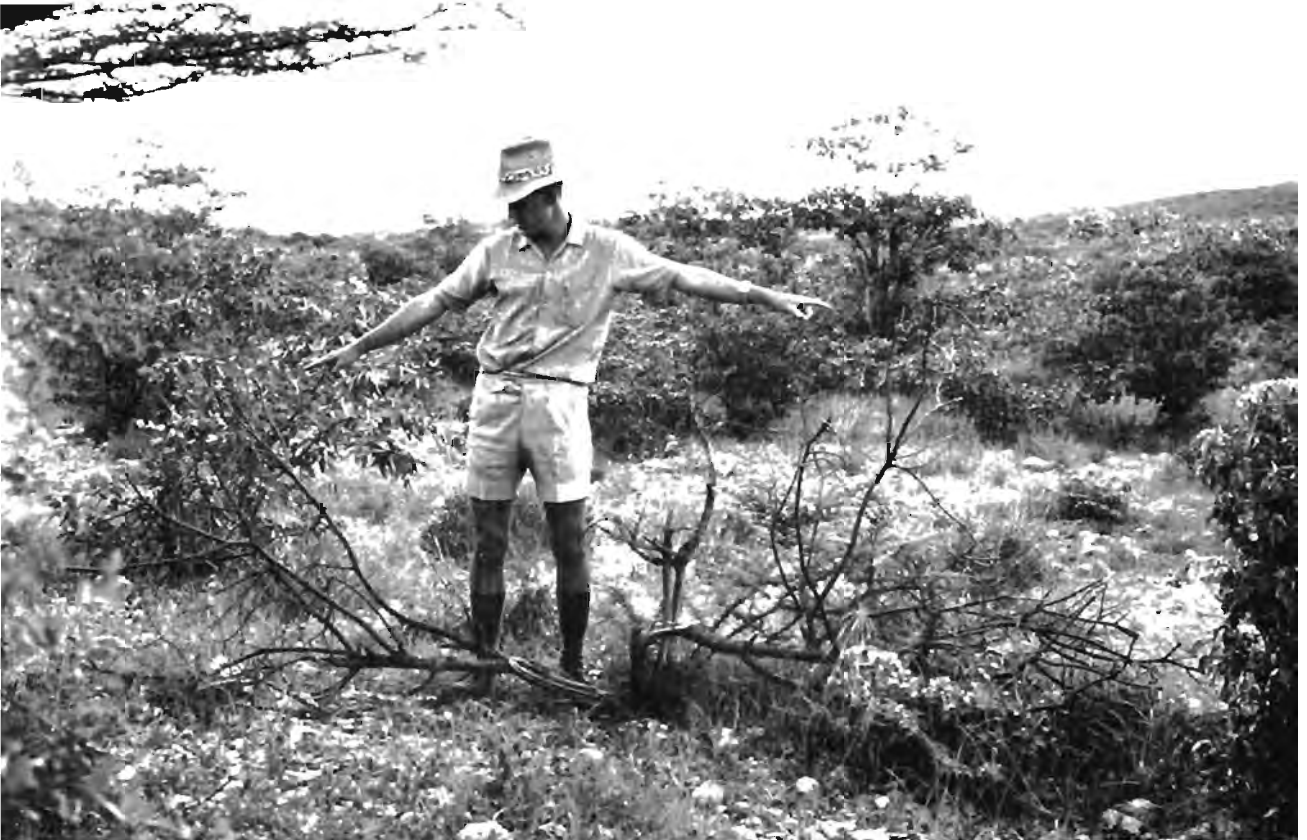


Plate 6 This *Acacia reficiens* shrub died off after being trampled by browsing rhino. Photo by W. P. S. Joubert

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 13. 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

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 P₁. (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.

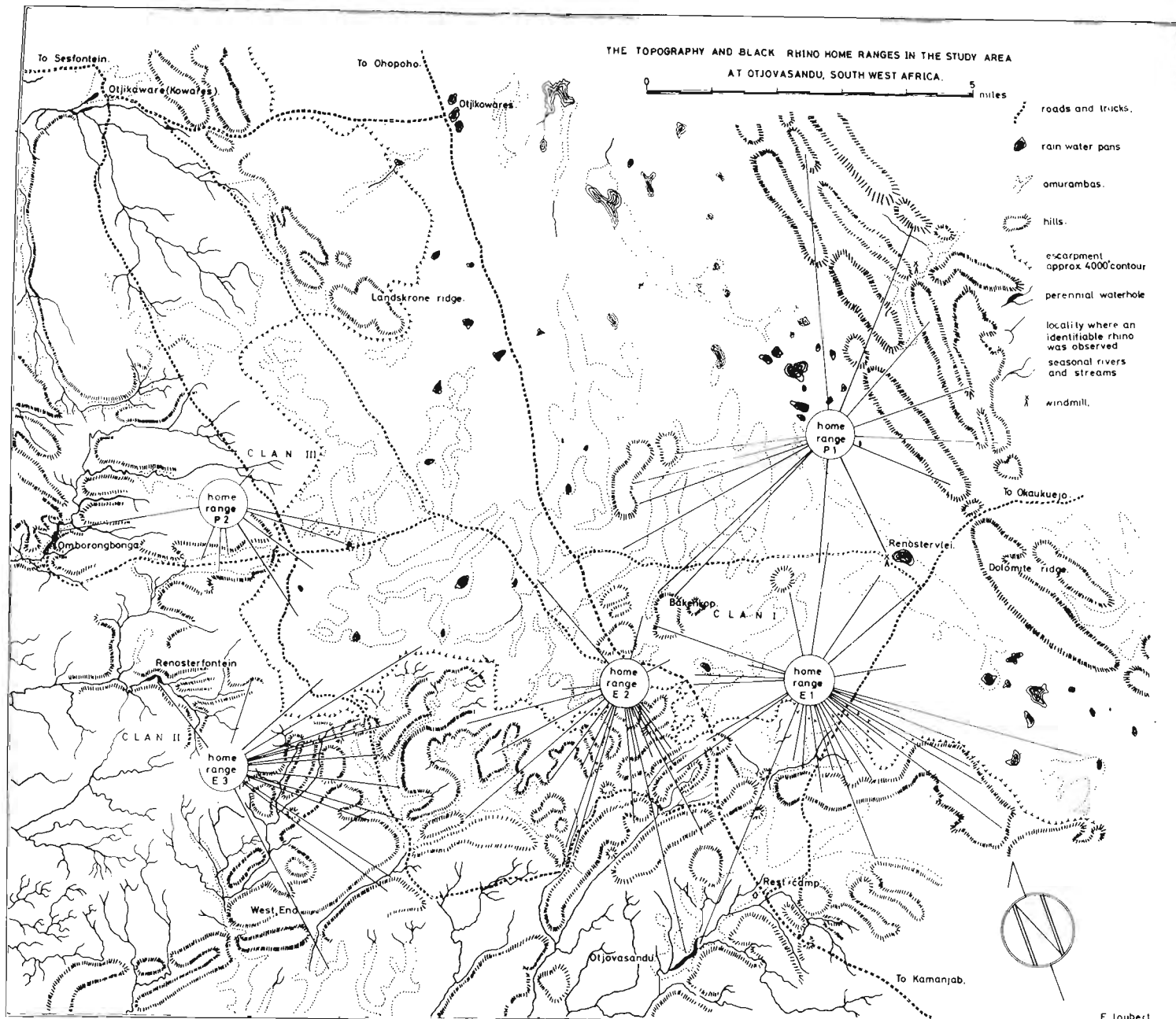
No information on how the boundaries were determined is given.

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



Map 1.

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 grass-land)	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 a greater variety of food plants, especially herbs, during this season. Another aspect may be the availability of water in rainwater pans in the depressions.

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 E₂ (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 Renostervfontein.

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_1 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 P, 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-Feed		

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.

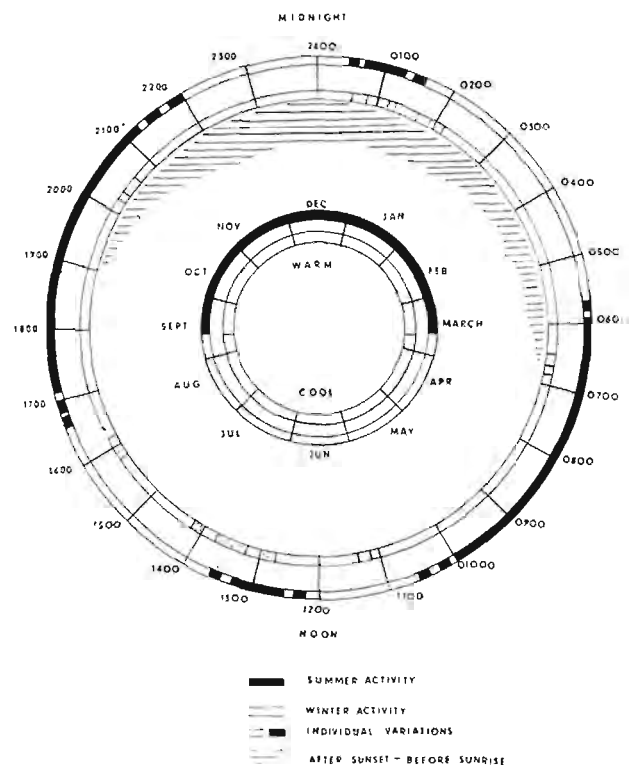


Figure 1. 24 hour activity pattern of black rhinoceros in South West Africa.

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 animals body.
- (iii) Although Guggisberg states that rhino do not perspire it was found that they do in South

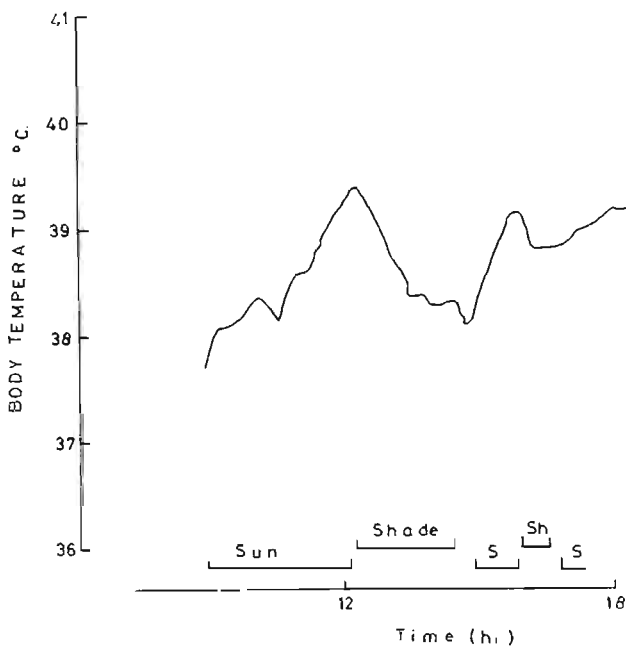


Figure 2. The deep body temperature of a 2-year-old Black Rhinoceros. (After Bligh and Harthoorn, 1965.)

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



Plate 17. A wallow in the study area. Photo by W. P. S. Joubert



Plate 18. A locality used by both rhino and mountain zebra (*Equus zebra hartmannae*) for dust bathing. Photo by W. P. S. 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

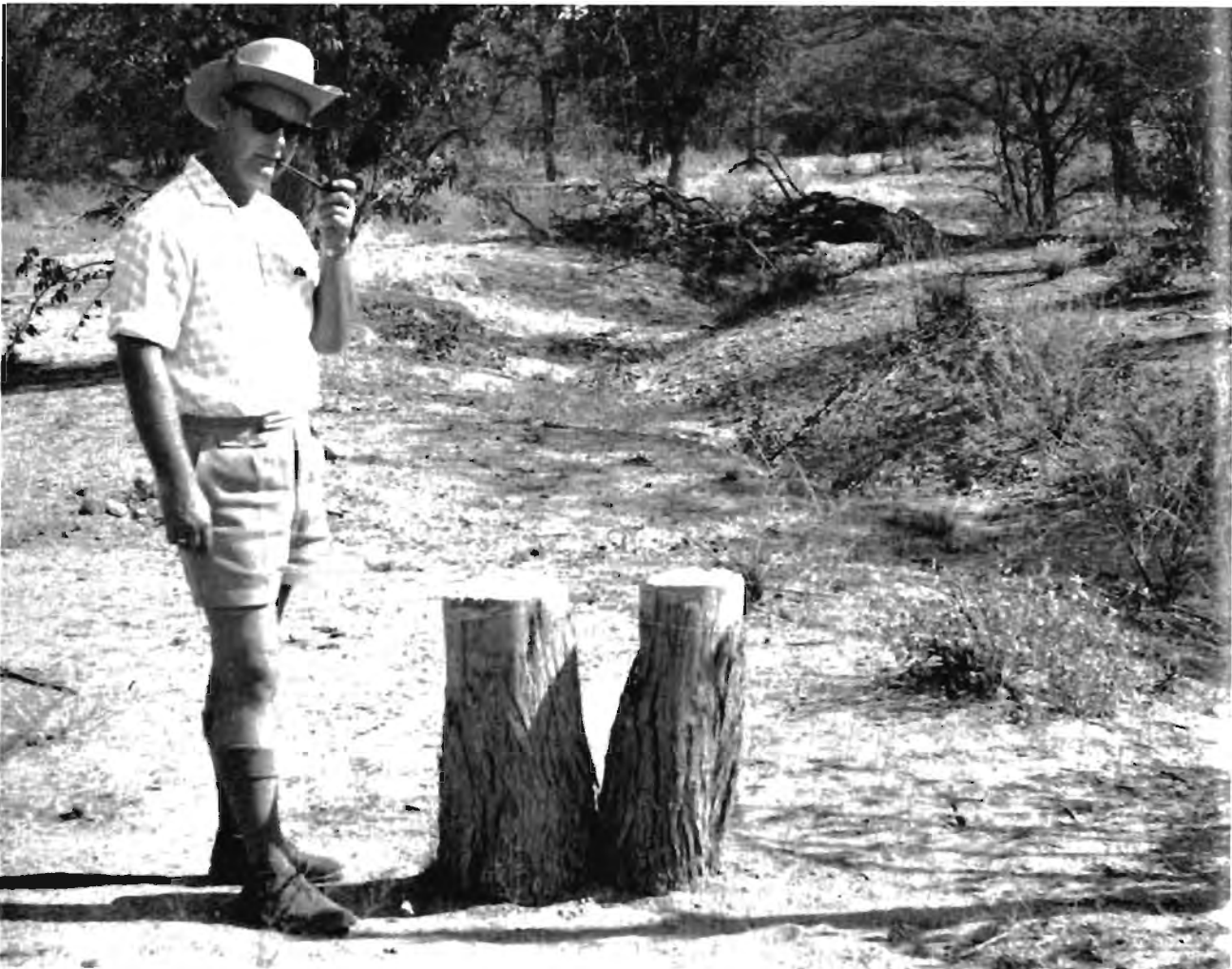


Plate 19. Tree stumps are sometimes preferred by rhino for rubbing. Photo by E. Joubert

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), elephant 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

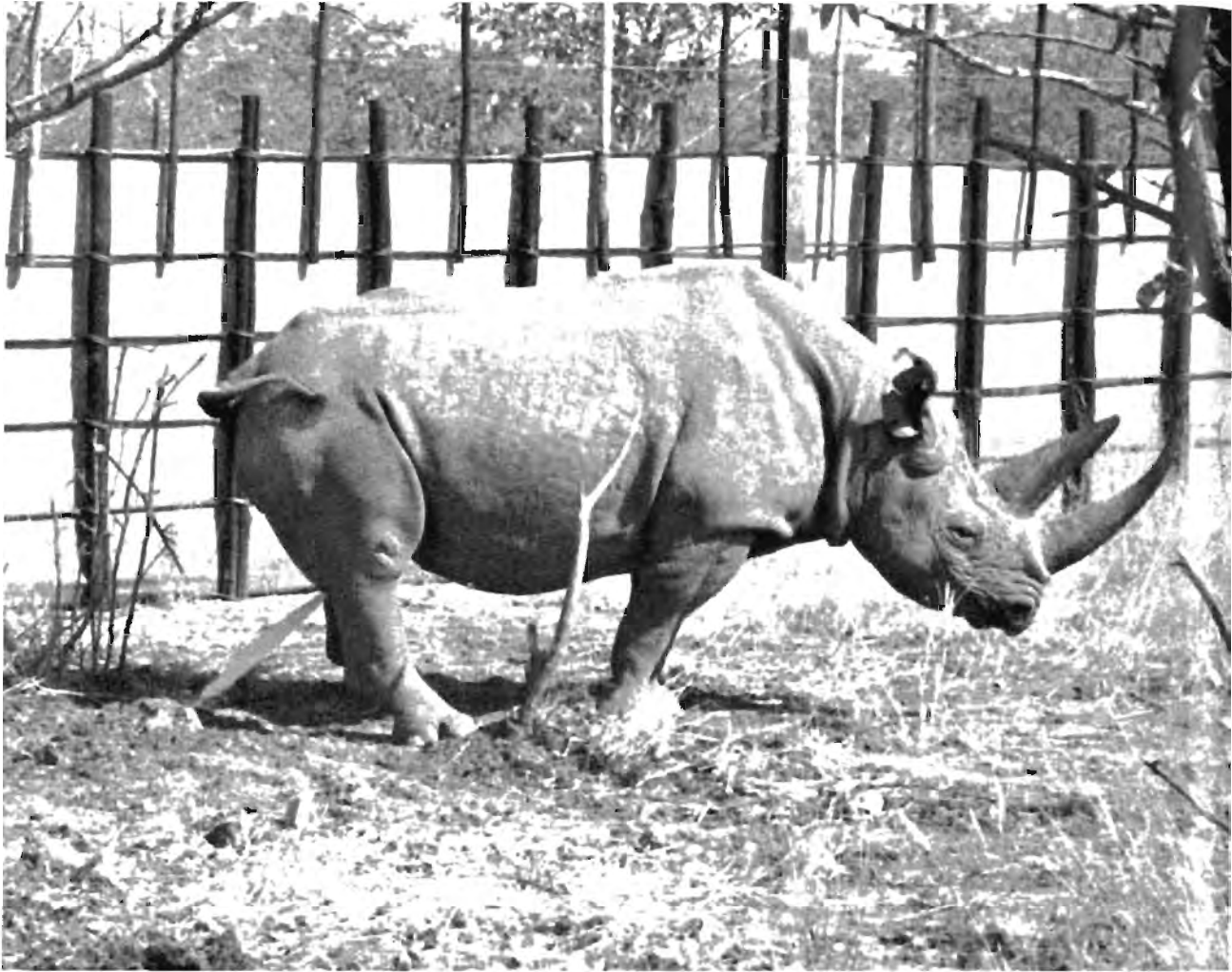


Plate 25. A male rhino urinating. Photo by E. Joubert

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 abound 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 1954, 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
Hanover	ca 7 years	21 days	3–4 days	438 days
	ca 9 years	28 days		469 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 ₁).
May 1967	Usakos.
June 1967	Kaross.
Beginning of	
August 1967	Otjovasandu (E ₁).
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)

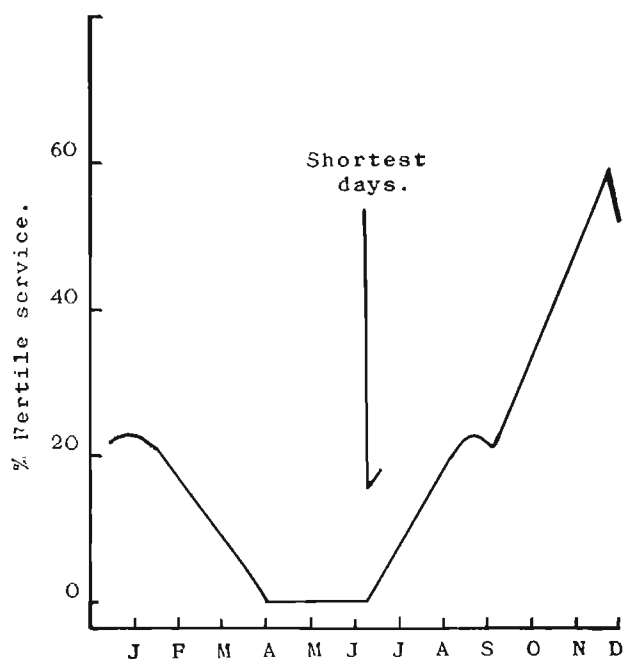


Figure 5. Breeding season of mares at Onderstepoort, Pretoria.

(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 & Lamming 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 FE 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 E.: Female FE_a 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 FE_a 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.: 15.3°C

0630 Up feeds.
0653 Urinates.
0705 Defecates.
0943 Stops feeding, stands with head hanging low in shade.
1104 Drinks water.
1121 Defecates.
1125 Returns to shade — lies down.
1520 Gets up, moves around. 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.

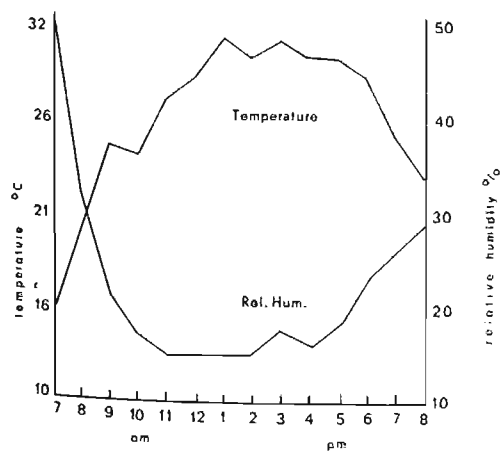


Figure 4. An average day to show temp./rel. humidity ratio Otjovasandu. (Sept., 1967).

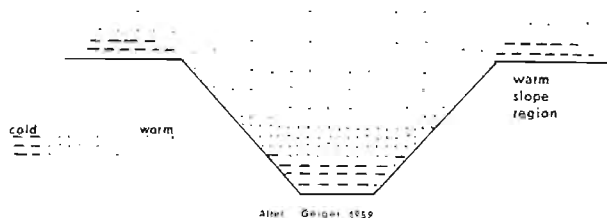


Figure 5. Nocturnal temperature in valleys.

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

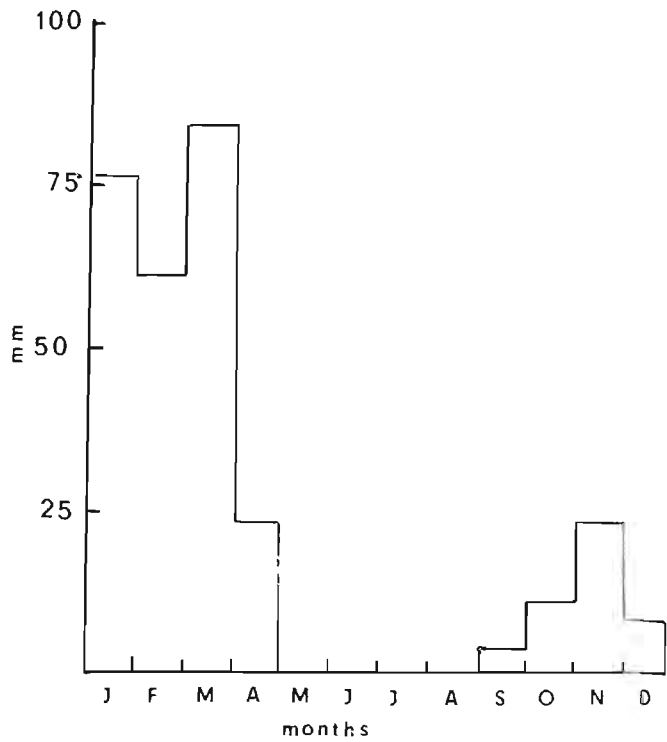


Figure 7. Mean monthly rainfall, Otjovasandu.

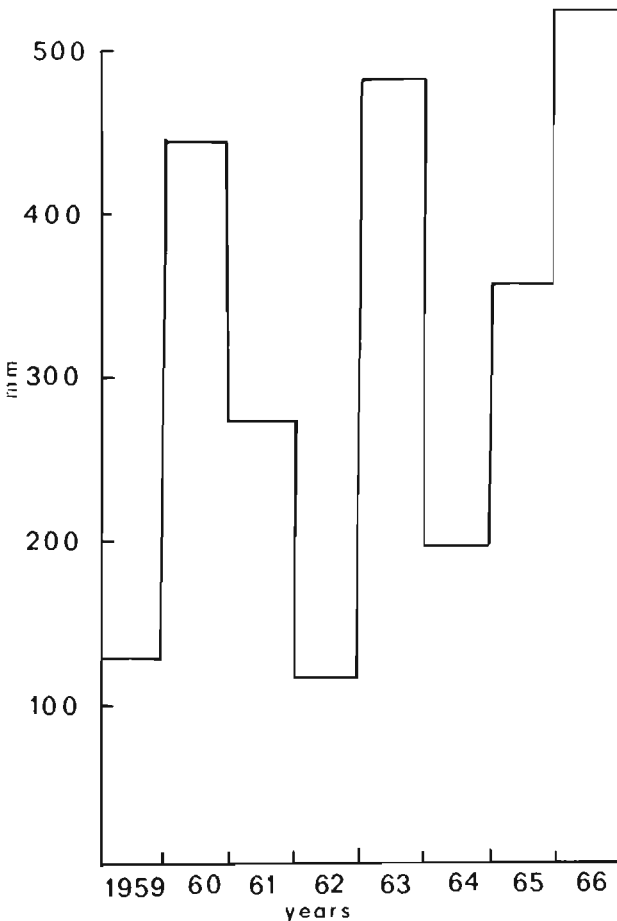


Figure 6. Yearly rainfall, Otjovasandu.

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.

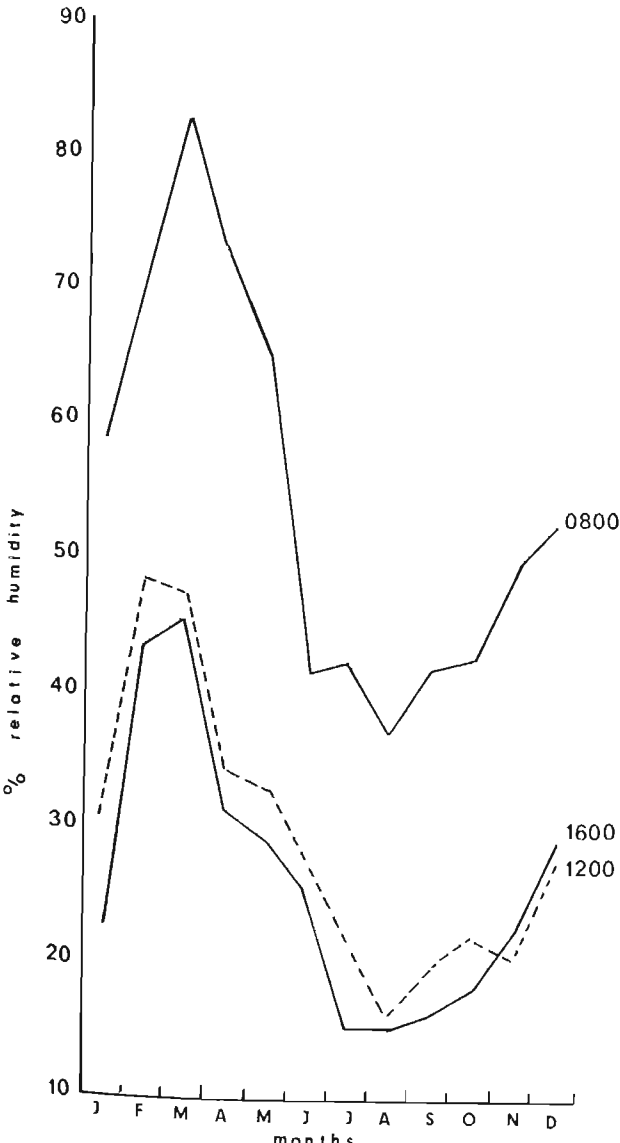


Figure 8. Average relative humidity at Otjovasandu.

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.

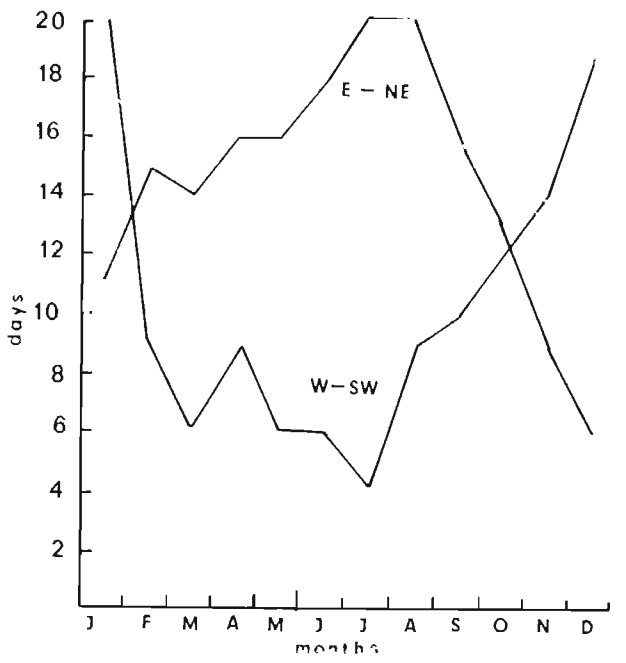


Figure 9. Actual number of days with eastern to north-eastern and or western to south-western wind movement.

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

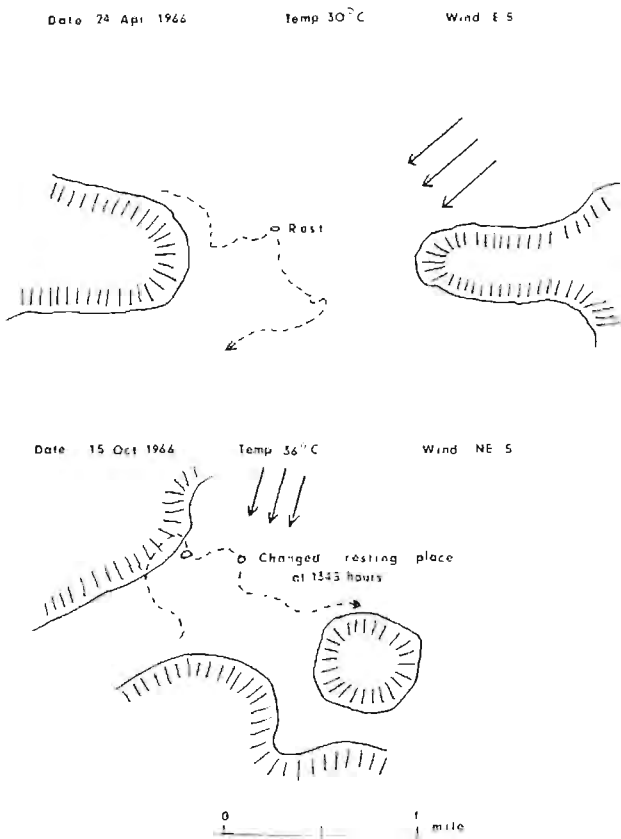


Figure 10. The influence of wind on Rhino feeding behaviour.

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 live-stock 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 *Stenophilaria 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.

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