This article is dedicated to the 'Great Elephants of Lumumba Hall, Makerere University' whose motto, 'The Struggle continues' has not only inspired me but should be adopted by everybody for the conservation of the African elephant.

Zusammenfassung

Nebennierengewichte von Afrikanischen Elefanten (Loxodonta africana)

In den Jahren 1973 und 1974 wurden von 71 männlichen und 172 weiblichen, in West-Uganda geschossenen Elefanten die Nebennieren gesammelt. Die Tiere wurden bei den Murchison-Falls und im Queen Elizabeth-Nationalpark sowohl zur trockenen als auch zur feuchten Jahreszeit erlegt. Die Analyse des Materials brachte eine Reihe von Ergebnissen. Die rechte Nebenniere ist stets schwerer als die linke. Bei gleichaltrigen Individuen findet man nur geringe Geschlechtsunterschiede im Gewicht der Nebennieren. Bei Jungtieren nimmt das Gewicht der Nebennieren pari passu mit dem Alter zu. Weibliche Elefanten zeigen während der Fortpflanzung Änderungen im Gewicht der Nebennieren, die aber statistisch nicht signifikant sind. Es gibt keinen Hinweis auf saisonale oder geographische Variation im Gewicht der Nebennieren von Elefanten gleichen Alters und/oder gleichen Geschlechts. Die dargelegten Ergebnisse werden diskutiert.

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Author's address: Jonathan Baranga, Zoology Department, Makerere University, Kampala, Uganda

Observations on the ecology and behaviour of the Northern White Rhinoceros *(Ceratotherium simum cottoni)*

By R. van Gyseghem

Uganda Institute of Ecology, Queen Elizabeth National Park, Uganda, and Zoologisches Institut der Universität Kaiserslautern

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Abstract

Studied was a population of the Northern White Rhinoceros, *Ceratotherium simum cottoni*, in the Murchison Falls National Park, Uganda, from September 1977 until July 1978. Population status, social organization, territorial behaviour, habitat utilization, activity patterns and feeding ecology were investigated.

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Introduction

The Northern White Rhinoceros (*Ceratotherium simum cottoni*) has during the recent past suffered a serious decline and is now on the verge of extinction. (Reports on status and distribution: HEPPES 1958; CAVE 1963; SIDNEY 1965; SCHOMBER 1966; CURRY-LINDAHL 1972). In Uganda the species was exterminated by marauding soldiers in the Ugandan – Tanzanian war of 1979 (EDROMA 1982; HILLMAN 1980).

The aim of this study was to provide ecological data which could serve as a basis for the management of the species, and to clarify the subspecies' social organization, range utilisation, activity patterns and feeding ecology which were virtually unknown (BACKHAUS 1964).

The social organization of the southern subspecies *C. s. simum* was from 1966 to 1971 subject of a detailed investigation by OWEN-SMITH (1971, 1972, 1975), but ecological data for this subspecies are scarce too (cf. PLAYER and FEELY 1960; FOSTER 1960; CONDY 1973).

I observed the Murchisons Falls National Park (MFNP) White Rhinos from September 1977 to July 1978.

Population, materials and methods

The MFNP White Rhino originate from 12 individuals who were introduced, in 1961 and 1964, from the Ajais Game Reserve on the West bank of the Nile and released on the Pakuba peninsula (cf. fig. 3). Most if not all the animals took residence near the place of release, emigration being barred by the Nile and rendered difficult by the Tangi River and N-S-extending escarpments in the East.

In November 1977 the population consisted of 20 individuals in the study area. During the next three months this number declined to 15 due to organized poaching. Thanks to intensified antipoaching operations which were stimulated by my studies, the remaining animals survived until July 1978.

All individuals could be identified from close-up photographs (taken with a 600 mm Novoflex lens) (cf. KLINGEL and KLINGEL 1966; GODDARD 1967; KLINGEL 1967, 1972). The animals were mainly distinguished by variations in horn size and shape, differing hair patterns along the edges of the ears and the individually formed tail hair brushes.

The actual study area and an adjacent area in the east were searched for rhinos usually every three days. Position of the animals was determined with the aid of a 1:50 000 topographical map, the odometer of the car and a compass. Travel protocols indicate that bias caused by my own movements in the area can be neglected.

Feeding was observed with binoculars during daytime from 30 to 100 m away, in moonlight nights from 10 to 20 m. Closer approach and, at night, the use of artificial light resulted in disturbance.

The prominent grass species in the grazing grounds were determined using a key of flowering features (HARKER 1960). A key of tufts without blossoms was established with the aid of photographic prints. It was based on the characteristic hair patterns of the leaf, its margin and the sheath as well as on the habitus of the whole plant and its habitats. Quantitative data were collected from 115 m^2 sample plots, arranged 50 m apart each in 8 transects through the grazing areas (Fig. 5).

For assessing the usable primary biomass of typical Rhino grazing grounds, the portion of cover of each grass species was visually estimated through a gratin of 100 dm^2 which was layed on the ground. Primary biomass relevant to Rhinos was measured on each plot by clipping and collecting grasses by species, drying the samples to constant weight and weighing it (EDROMA pers. comm. and 1972; BLACKMANN 1935).

As single grass species were not randomly distributed on a sample line, medians were built from all sample plot values of each sample line. The percentages shown in table 1 are mean values of the eight medians.

From January to July 1978 dung samples from freshly dropped dung piles were collected and stored (50 ml samples in 70 % Ethanol, 500 g portions for drying). A sample was always combined from several dung balls from one defecation.

Dryweight and water content respectively were determined by drying the samples at 60 °C to constant weight ± 1 %).

For the cuticular analysis a reference collection was compiled following the method of STORR (1961). The epidermis fragments in the dung were prepared after STEWART (1970). For practical reasons cuticula fragments were evaluated by planimetry (STORR 1961). In order to avoid the disadvantage of this technique (exceptionally large particles causing high variance, STEWART 1970) the dry sample mixture was screened through meshes of 1.4, 1.0, 0.5, 0.3, 0.125 and 0.063 mm before mazeration. The results of the subsequent analyses of different screening fractions were corrected corresponding to the portions of their fraction in the entire sample.

For the analysis a subsample of each screened fraction was then mazerated, cleared, stained, and well mixed. One drop samples from each fraction where mounted (Storr 1961) and as many mounts analyzed so that 100 identifyable particles were determined from each fraction (the fractions from the 1.4 and 1.0 mm meshes were disregarded because they consisted mainly of fibrous material which was virtually unidentifiable). The percentages given in table 1 are means originating from the portions of cuticula residues of each grass species from the fractions 0.5 — 0.063 mm.

Results

Population composition

The population consisted of one adult bull, age over 20 years, (Fig. 1), 4 adult cows (10 to 20 years), 5 subadult bulls (3 to 10 years), 3 subadult cows (3 to 6 years), 2 calves, male and female (2 years).

Fig. 1. The last and only adult bull of the MFNP-White Rhino population

Associations

Only the adult bull was frequently solitary, whereas the members of the other social classes were usually associated in groups of up to seven individuals (Fig. 2).

Adult cows were in stable association with their last offspring (age 2 years) during the whole period of observation. Two adult females without infants were regularly sighted together for six months. Two subadult males were recorded together for seven months at the beginning of the study. They then separated and it is assumed that this was correlated with their reaching maturity. Their ages were estimated at about 10 years.

Individuals of all classes were observed in medium-term associations, lasting for several days or even up to a month, but subadult bulls were only associated with the adult bull when following a female in heat.

Occasionally different individuals or groups seemed to meet by chance in their grazing grounds or on wandering routes. Sometimes they stayed together for some minutes or even hours, but they then usually continued their ways in different directions.

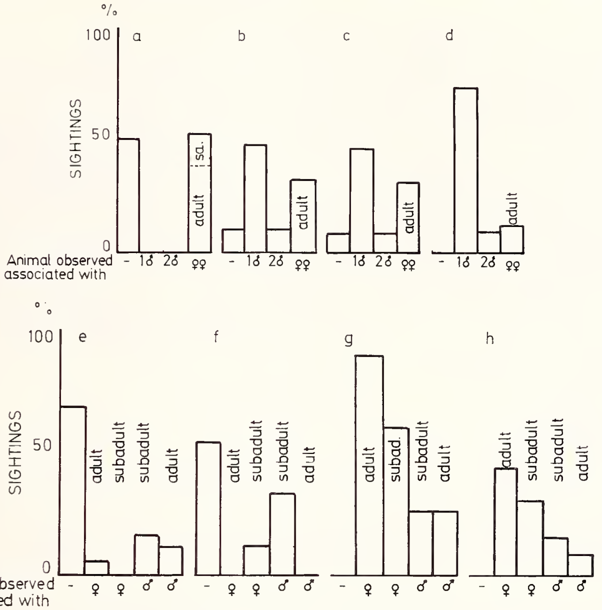

Fig. 2. Relative frequency of associations between animals of different social classes. a = adult bull, n = 25; b = subadult bull near maturity, n = 19; c = subadult bull, n = 26; d = younger subadult bull, n = 26; e = cow and calf, n = 19; f = cow and calf, n = 18; g = adult cow without offspring, n = 29; h = three subadult cows, n = 52

Territoriality

In the adult bull behaviour patterns such as spray-urination with different frequency, alternating kicking movements with the hindlegs when devecating, repeated at the same place, hornbeating on bushes and forcing subadult bulls into submissive behaviour could be observed frequently. These behaviour patterns have been classified by Owen-Smith (1975) as territorial.

Habitat utilization

Between September 1977 and July 1978 the total range of distribution of the population was 130 km^2. The Rhino population occupied a rainy and a dry season range of 66 km^2 and 74 km^2 respectively, with a slight overlap of ca. 10 %. 94 % of the sightings during the rainy season were in the lower, northern part of the Pakuba-peninsula, 95 % of the sightings in the dry season were in the more elevated, central part (Fig. 3).

Home ranges of individuals

It is interesting to note the relative sizes of dry versus rainy season home ranges. The adult bull had a total home range of 30 km^2. During the rainy season he inhabited only 6 km^2, during the dry season 24 km^2, but he was the only individual showing the pattern. In the majority of the animals the dry and rainy season ranges were about the same size, in some individuals the dry season ranges were even smaller.

The two adult females without infant had an identical total home range of 97 km^2, the two with infants stayed in 40 km^2 and 50 km^2 respectively. In subadult males the eldest, reaching maturity, had a home range of 30 km^2, the younger ones both 58 km^2. A subadult female had a home range of 45 km^2 (Fig. 4).

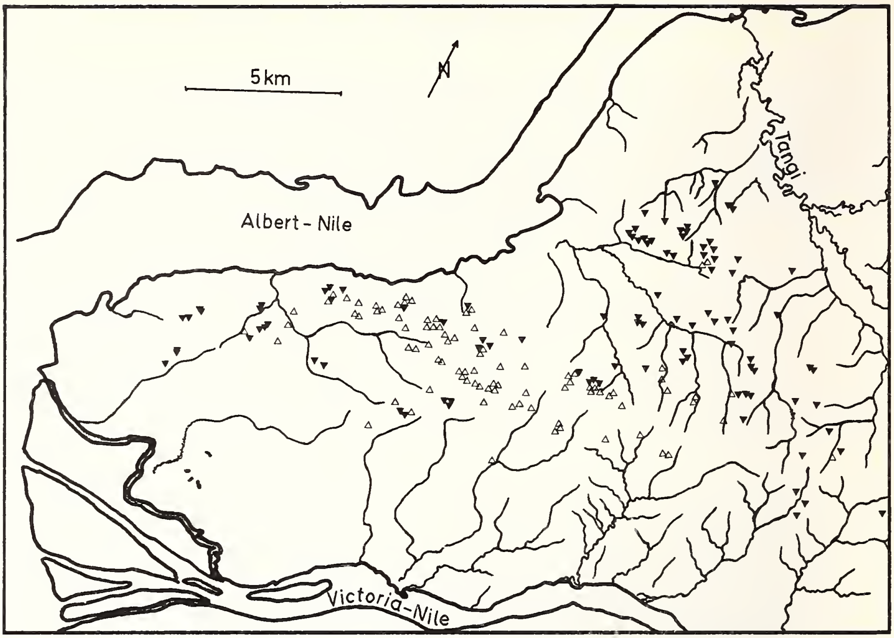

Fig. 3. Pakuba peninsula. Location of all individuals of the population. Up to two points beeing plottet per individual per day. Open symbols: Dry season, grass brown 22. IX. 1977–28. II. 1978; solid symbols: Rainy season, grass green: 1. III.–15. VII. 1978

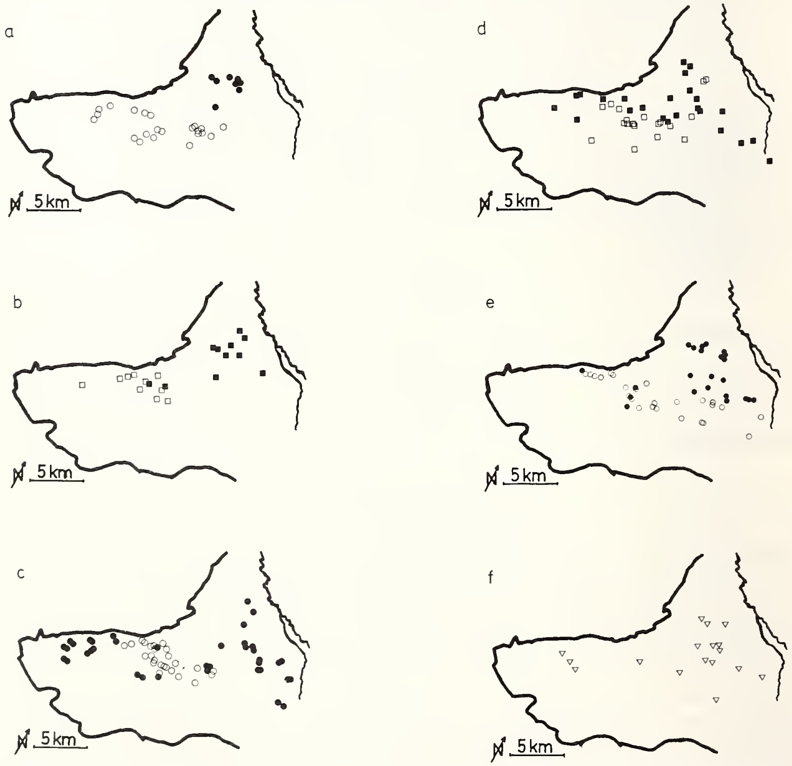

Fig. 4. Points of location of individuals. a = adult bull; b = subadult bull near maturity; c = two subadult bulls; d = cow without offspring; e = two cows with juveniles; f = subadult cow. Open symbols: dry season, solid symbols: rainy season, corresponding with fig. 3

Daily migrations

In six cases individuals could be followed for ten to 12 hours in succession, some even at night. Three covered distances of 4 km, the others 10.5, 13.0 and 15.0 km, respectively, during one day. In two cases the animals were circling and so returned in the evening to their morning departure points.

The speed of their movement varied from 2 to 7 km/h, depending on how intensively they grazed. Generally after a 2 to 3 hour walk the animals lay down in the shade of a tree *(Balanitis aegyptica, Crateva andansonii, Borassus aethiopum, Kigelia aethiopum, Tamarindus indica)* and rested there from 5 min. up to 5 hrs. During these migrations all the rhinos typically displayed the following behaviour patterns: defecating, urinating, grazing, being alert, smelling. Scratching, hornbeating, spray-urinating, kicking and stamping on dung was shown exclusively by the adult bull.

Vegetation analysis

61 % of the grazing area was covered by grasses, 39 % was bare ground between the tussocks of perennial species like e.g. *Hyparrhenia spec.* The bare places were colonized by annual grasses in April after the shading stalks of the perennials had been burnt off and the newly growing plants were not yet fructifying. On slopes the bare places could not be colonized because of soil erosion. For the position of favoured Rhino grazing grounds and sample lines see Fig. 5.

The species listed as (1) to (6) in table 1 were the most common, widely distributed and

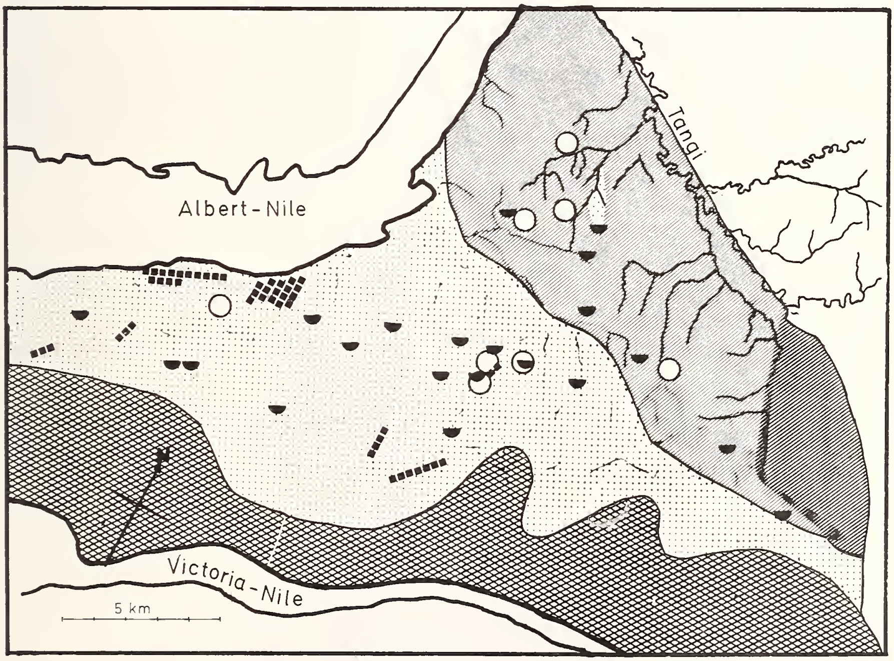

Fig. 5. Vegetation map of the study area (Pakuba peninsula).
○ situation of sample lines (in Rhino grazing areas), ◒ White Rhino wallows, ■■■ eroded areas with *Combretum* societies, favoured White Rhino resting places, ::::::: open grass-(mainly *Hyparrhenia*-) savanna with *Crateva andansonii* thickets spread and *Balanitis aegyptica* stands, ▩ thickets higher than 3 m, ▧ *Borassus aethiopum* thickets in grass-savanna, ▨ densly growing *Borassus aethiopum*

Table 1

The prominent grass species in the study area

1 *Hyparrhenia dissoluta*
(= *Hyperthelia dissoluta*)
2 *Hyparrhenia rufa*
3 *Ctenium concinnum*
4 *Brachiaria bryzantha*
5 *Eragrostis ciliaris*
6 *Sporobolus stapfianus*
7 *Chloris gayana*
8 *Panicum maximum*
9 *Sporobolus pyramidalis*
10 *Eragrostis tremula*
11 *Setaria ciliolata*
12 *Heteropogon contortus*
13 *Perotis patens*
14 *Digitaria longiflora*
15 *Dactyloctenium aegypticum*
16 *Echinochloa colonum*

by far most productive species. The other species were mostly found on insular patches corresponding to their ecological requirements: around termite hills, around trees, around waterholes, around swamps.

Sporobolus pyramidalis was also abundant in moist valleys. *Hyparrhenia dissoluta* is the most frequent and dominating grass species in the grazing area. It is the first growing grass after the grass fires and provides green leaves all the year round, though toward the end of the rainy seasons these are protected between its densely standing stalks. *Ctenium concinnum* is only localy frequent. It first appears in July but then offers strong green tufts of thin, odorous leaves until February. *Brachiaria bryzantha* is a widely spread, small, creeping species (max. hight 15 cm) which though broad-leaved and therfore well covering the ground, is contributing only little to the total production. *Eragrostis ciliaris* with its small tufts (20–25 cm high) was locally dominant in April, but was very susceptible to drought and dried up after a few weeks. Though *Sporobolus stapfianus* produces stalks of up to 50 cm hight, it provides only tiny, slender, week leaves and is mainly growing between the huge *Hyparrhenia* tufts. The composition of the grazing grounds by species is given in table 1.

Feeding behaviour

White Rhinos were mostly found grazing in groups, individuals usually spaced by about one body length.

The grazing periods during daytime are presented in Fig. 6. A maximum of grazing activity was recorded in the afternoon starting at about 16 h and lasting until late in the evening. The animals graze irregularly whilst slowly moving along, only rarely do they

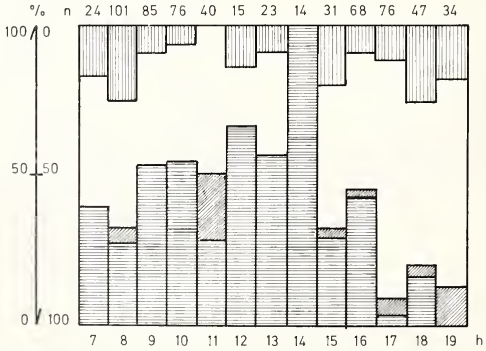

Fig. 6. Portions of 4 different activities of the Kabalega White Rhino population. n = number of observations
▥ wandering, ▭ grazing, ▨ wallowing, ▤ resting

utilize larger, contiguous areas. Usually they step sideways or foreward every 2–3 seconds during intensive grazing, taking the grasses in the perimeter which they can reach by a circular motion of the head at each stop. During the subsequent chewing period when grazing has to be interrupted anyway, they move on a few paces and then stop for the next bites. This kind of "patchwork" grazing could generally be observed in open areas during the rainy seasons.

During the dry seasons Rhinos were observed grazing intensively the circular grass communities (e.g. *Brachiaria bryzantha*) around the trees. They also used to graze for up to 30 minutes in the shade zones of trees before and after resting in the shade. When an association of Rhinos was resting together under a tree younger animals (juveniles) rose about 10 minutes to half an hour earlier than elder ones. As they were waiting for their companions in the vicinity they consequently took in a greater proportion of grasses growing in these special communities. Because of the shyness of the animals and the fact that their grazing traces are similar to those of other grazers, detailed information on the quality (grass species) and the quantity of food ingested could only occasionally be gained by direct observation but this was too sporadic for an evaluation.

Fecal analysis

The availability of different grass species and their cuticula portions in the faeces of MFNP White Rhinos are presented in table 2. The figures are uncorrected and do not necessarily represent the exact ratio of different grass species ingested. It was also not possible to establish correction factors: they would have to consider parameters which can only be worked out in feeding experiments (e.g. different digestibility and/or passing time for different grasses or parts thereof, seasonal variations, effect of growing state: Ivins 1960; Stewart 1967; Owaga 1977). The portions are therfore semi-quantitative being based on the frequency of the different species (cf. Stewart 1967).

Whereas in the vegetation analysis only 1,2 % of the grass samples had to be listed unidentified, a cuticula particle portion of 14 % was not identifiable. All grass species common in the grazing grounds (1–6 in table 2) were present in the Rhino dung.

Table 2

Frequency of the grass species in rhino grazing grounds, and their portions in the dung of *C. s. cottoni*

Grass species	% ground cover n = 115	% biomass 1 m²-fields	% cuticular in dung n = 8 samples from 5 indiv.
Hyparrhenia species	84.0	77.1	52.2
Not recognized species	1.1	–	13.9
Chloris gayana	–	–	10.3
Ctenium concinnum	7.5	18.5	8.5
Sporobolus stapfianus	2.2	–	5.4
Brachiaria species	4.0	2.2	4.7
Eragrostis ciliata	1.0	2.2	3.6
Eragrostis tremula	–	–	0.9

Hyparrhenia dissoluta and *H. rufa* were with 52 % of the total by far the most frequent species, which dominated about five times the 2nd and 3rd frequent species *Chloris gayana* and *Ctenium concinnum*, followed by five species amounting to 5 % and less. Remarcable is the 10 % portion of *Chloris gayana* and a 1 % portion of *Eragrostis tremula*, grasses which were not represented in the open grazing ground samples: *Chloris gayana* occurs under trees and is grazed there, but these patches were for statistical reasons not included in the analysis of the grazing areas as were communities of swampy habitats because of their special composition of *Setaria ciliolata* and *Sporobolus pyramidalis*, species which were completely (*S. pyramidalis*) or largely (*S. ciliolata*) disdained by Rhino (and other herbivores).

Discussion

The White Rhinos of the Murchison Falls National Park population showed social behaviour patterns similar or identical to those observed in *C. s. simum* (Owen-Smith 1971, 1972, 1975; Ripley 1958) and it can be assumed that social organization of the two subspecies has changed little or not at all since they separated in the Pleistocene.

All individuals except the adult bull were usually found associated with conspecifics. Similar associations in populations of the southern subspecies are considered to be the consequence of high population density (5.3/km^2 in Hluhluwe Game Reserve, Owen-Smith 1975). This can no longer be accepted, as in MFNP this behaviour was shown at a population density of only 0.1/km^2. Associations must therefore be interpreted as a behavioural adaptation to life in open plains. In the more bush-dwelling and browsing Black Rhino *Diceros bicornis* subadult groups are rarely found (Klingel and Klingel 1966; Schenkel and Schenkel-Hulliger 1969).

The observed ritualized defecating and urinating behaviour, hornbeating, intimidating subadult bulls, which in *C. s. simum* too was only shown by mature bulls (Owen-Smith 1975) as well as stamping on dung is interpreted as the adult male's demonstration of dominance, displayed even in the absence of a rival. The bull was dominant everywhere within his home range (30 km^2) and displayed sexual activity whenever an estrous cow was present. This indicates that the home range was in fact the mating territory, which was very much larger than in *C. s. simum* bulls (Owen-Smith 1975: 1–7 km^2). The large size of the mating area is considered to be the consequence of the lack of competitors and not a population feature. A similar case has been observed in a low density Roan (*Hippotragus equinus*) population (Joubert 1974), and it is appropriate to speak of an "exploded" territory (Klingel pers. com.). Because of the very small numbers of Nothern White Rhino surviving in the wild this problem can hardly be clarified during the next decades, if ever.

Home ranges of all the individuals of MFNP White Rhinos were found to be 5 to 10 times larger than those found in the southern subspecies in Hluhluwe Game Reserve (Owen-Smith 1975). This can be explained with females tending to move through several male territories, which of course they could not find in MFNP, and consequently juveniles getting accustomed to large home ranges. It can however not be ruled out that large home ranges are the effect of low density or some ecological factor. With the exception of the adult bull MFNP White Rhino did not enlarge their home ranges during the dry season. In fact their ranges were already comparably large during rainy season, and there was no scarcety of waterholes or food.

The White Rhino's square lips function clearly more in a lawn mower fashion rather than being suited for selectively picking out particular food items within a given plant community. This was confirmed through direct observation and fecal analysis.

The rhinos generally cropped green grass from 25–30 cm high to a level of about 5 cm. Whereas Foster (1960) observed White Rhinos feeding on Dicotyledons (*Stapelia* spec. and *Sarcostemma viminale*) during the dry season in Hluhluwe Game Reserve, the MFNP rhinos were strictly grazers. Green grass was never in short supply throughout the year, but during the dry season, when green tillors were only available on the bottom of high stands of dry, brown *Hyparrhenia* stalks, these were occasionally taken as well.

With the exception of *Sporobolus pyramidalis* all grasses in a grazing area were taken corresponding to their frequency in the grazing areas. *S. pyramidalis* seems to be disdained by grazers in general and is considered unpalatable, probably because of its comparatively high silica content.

Foster (1967) found a similar situation in Ajai Game Reserve with respect to *S. festivus* which was disdained whereas *Chloris gayana, Panicum maximum, Heteropogon contortus* and *Brachiaria byzantha* were taken by the Rhinos.

In the grazing areas of the rhinos in MFNP, *Hyparrhenia dissoluta, Ctenium concinnum, Sporobolus stapfianus* and *Brachiaria* spec. were the most abundant grass species, and they were consequently represented in the dung in this order. *Chloris gayana* was only available at the edges of open grazing areas, under trees, around termite hills and wallows, and thus ranked low in the over-all community. However, the Rhinos grazed the *C. gayana* stands whenever they visited these localities, and as this happened several times a day it explains the comparatively high frequency of *C. gayana* in the dung samples (10 %) and is not the result of selectivity as has been suggested by Backhaus (1964).

Whatever the correlation, the feature is of general ecological significance: being a pure grazer, the White Rhino depends on open grassland which is maintained through fire. Being very large, it requires cooling sites such es shade trees and/or wallows. By keeping the grass short in and around their resting places, the White Rhino actively protect seedlings and shade trees from fire. High densities of grazers result in the complete exclusion of fires from the area and consequently bush encroachment and reduction of the grasslands as e.g. in Hluhluwe/Umfolosi Game Reserve and parts of Queen Elizabeth National Park. In very low densities White Rhino will probably not succeed in protecting their shade trees, and this may have consequences for their performance.

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Last not least I remember the courageous Park Rangers, who risked their lives, while protecting the last few Kabalega Rhinos.

Zusammenfassung

Beobachtungen zur Ökologie und zum Verhalten des nördlichen Breitmaulnashorns (Ceratotherium simum cottoni)

Untersucht wurde an der letzten ugandischen Population des Nördlichen Breitmaulnashorns im Kabalega Falls Nationalpark insbesondere das Sozialverhalten, das Raum-Zeitsystem und die Nahrungsökologie. Von den anfänglich 20 Tieren wurden im Laufe der Studie 5 gewildert, Neugeborene kamen nicht hinzu.

Die Beobachtungen deuten darauf hin, daß die nördliche Unterart ähnlich wie die südliche paarungsterritorial ist. Die Aktionsräume der Individuen waren zur Trocken- und Regenzeit verschieden und mit bis zu 97 km^2 um das fünf- bis zehnfache größer als die im Hluhluwe Wildreservat festgestellten Aktionsräume der südlichen Unterart.

Gegrast wurde vor allem während des Wanderns und um Schattenbäume, Suhlen und sandige Liegeplätze herum. Die Tiere zeigten sich als hochspezialisierte Grasfresser, zweikeimblättrige Pflanzen spielen keine Rolle in ihrer Nahrung. Die Nahrungsaufnahme erfolgt nur wenig selektiv. Kurzgras wurde bevorzugt, aber auch trockene, lange Halme wurden verzehrt. Nur stark sklerotisierte Gräser wie *Sporobolus pyramidalis* wurden verschmäht.

Alle übrigen Arten wurden etwa gemäß ihrer Häufigkeit im Weidegebiet aufgenommen. *Chloris*

gayana jedoch, ein Gras welches in den Weideflächen nur punktuell um Bäume und Wasserstellen häufig ist, erscheint in der Kotanalyse als zweithäufigste Nahrungspflanze. Dies kann mit dem häufigen Besuch solcher Plätze durch die Nashörner, primär aus dem jeweiligen Komfortbedürfnis heraus, erklärt werden.

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Author's address: Dipl.-Biol. Roland van Gyseghem, Pfalzmuseum für Naturkunde, Hermann-Schäfer-Str. 17, D-6702 Bad Dürkheim

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