Landscape preference of the white rhinoceros in the southern Kruger National Park

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The long and short-term landscape preference of white rhinoceros in the southern Kruger National Park are investigated. A preference index and a chi-square test are used to ascertain if white rhinoceros prefer or avoid a particular landscape. Landscape 3 (moderately undulating granitoid plains with *Combretum zeyheri* woodland), is the most preferred landscape while landscapes 2 (low granitoid mountains with *Combretum apiculatum* bushveld) and 4 (granitoid lowlands with *Acacia grandicornuta* tree-savanna), are avoided.

Key words: *Ceratotherium simum*, white rhinoceros, landscape preference, preference index, avoidance, preference.

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Introduction

The white rhinoceros *Ceratotherium simum simum* (Burchell) became extinct in the Transvaal in 1896 (Kirby 1896). In 1961 the first white rhinoceroses were re-introduced to the Kruger National Park (Pienaar 1970). Over a 12-year period 345 white rhinoceroses were relocated to the Kruger National Park from the Umfolozi Game Reserve. By 1991 their numbers had increased to 1 565.

Most of the introduced animals were released south of the Sabie River in the southern Kruger National Park. By 1991 there were 1 313 white rhinoceroses in this area. As there are no physical barriers to impede their movements, the white rhinoceroses could move to areas of their choice. This study investigates their distribution in the nine different landscapes (Figure 1) in the southern Kruger National Park.

The boundaries of the southern Kruger National Park are the Sabie River in the north, the Crocodile River in the south, the Phabeni and Nsikasi rivers in the west and the Lebombo Mountain in the east. The study area is fenced in on the south, east and west.

The geomorphology of the western part of this area consists of underlying granite and gneiss that is deeply weathered, resulting in an undulating landscape with distinct uplands and bottom-lands. The eastern part of this area is underlain by basalts and consists of reasonably flat plains with clayey soils. The altitude ranges from 170 m above sea level in the south-east to 800 m in the south-west. Rainfall occurs mainly during the hot summer months (Gertenbach 1980), with a long-term mean of 640 mm per annum.

The landscape white rhinoceroses prefer most in the southern Kruger National Park is that one with which they are associated most frequently. That is, that landscape which had the highest white rhinoceros density and showed the greatest white rhinoceros frequency of occurrence in relation to size.

Preference indices have been used by various authors to study habitat or food utilisation by animals (Ivlev 1961; Jacobs 1974; Pepin 1986; Viljoen 1989).

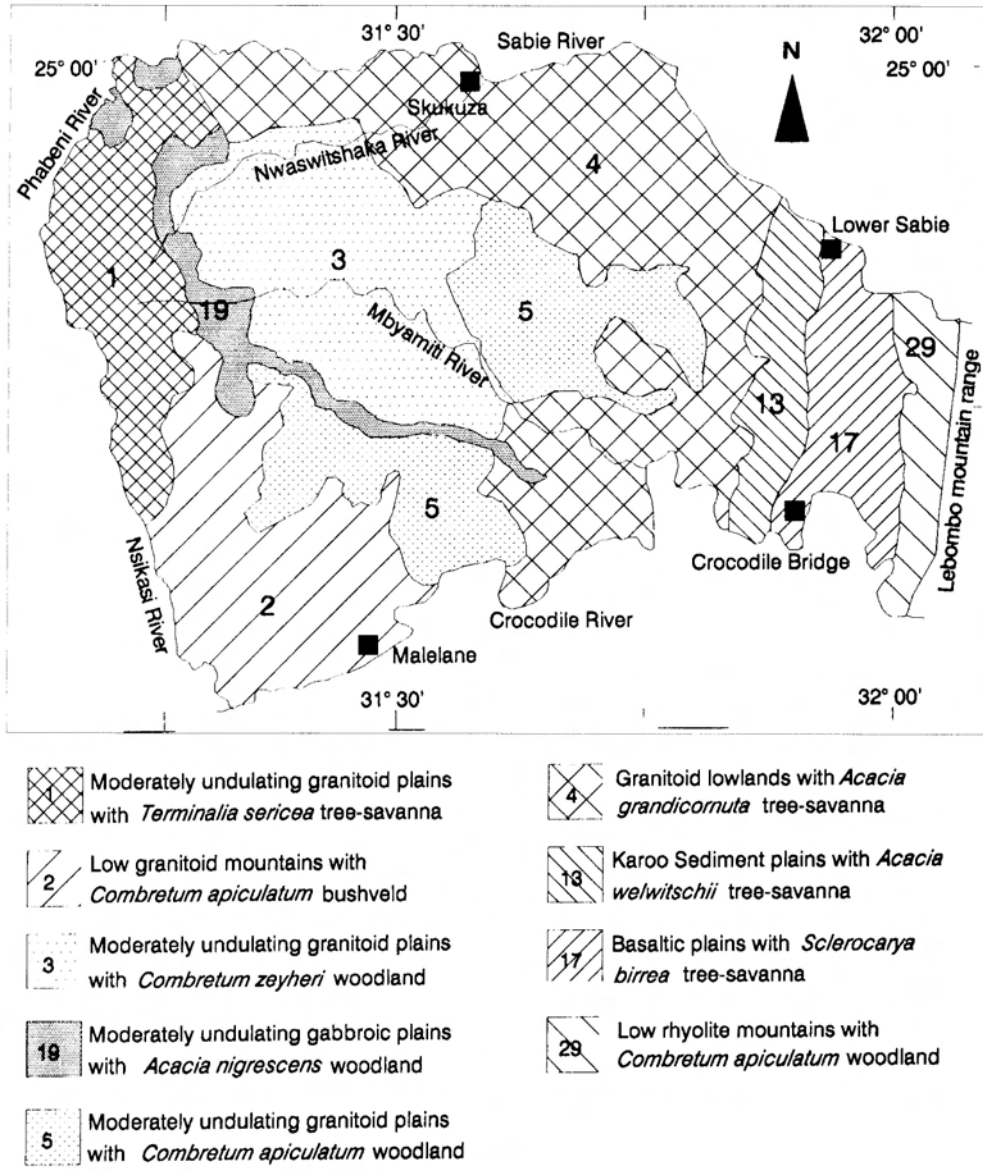

Fig. 1. Landscapes in the southern Kruger National Park as from Gertenbach (1983).

Methods

An annual ecological aerial survey covering the entire Kruger National Park commenced in 1979. The methods are described by Joubert (1983) and Viljoen (1991). The ecological aerial survey is conducted in the dry season and the distribution periods therefore only reflect the dry season habitat utilisation. However, as white rhinoceros in the southern Kruger National Park do not exibit seasonal migrations (Pienaar *et al.* 1992), the distribution data may be considered representative for the whole year. The annual white rhinoceros distribution in the southern Kruger National Park was classified according to the nine landscape type categories (Gertenbach 1983, 1987) (Figure 1; Table 1).

The Kruger National Park is zoned into 35 landscapes. A landscape is an area with a specific geo-

Table 1
Landscapes described by Gertenbach (1983) for the southern Kruger National Park, and their respective sizes (km²)

Landscape number	Landscape name	Size (km²)	Proportion of study area
4	Granitoid lowlands with *Acacia grandicornuta* tree-savanna	1 065	0,292
3	Moderately undulating granitoid plains with *Combretum zeyheri* woodland	570	0,156
2	Low granitoid mountains with *Combretum apiculatum* bushveld	480	0,132
5	Moderately undulating granitoid plains with *Combretum apiculatum* woodland	486	0,133
1	Moderately undulating granitiod plains with *Terminalia sericea* tree-savanna	378	0,104
17	Basaltic plains with *Sclerocarya birrea* tree-savanna	228	0,063
13	Karoo Sediment plains with *Acacia welwitschii* tree-savanna	160	0,044
19	Moderately undulating gabbroic plains with *Acacia nigrescens* woodland	154	0,042
29	Low rhyolite mountains with *Combretum apiculatum* woodland	130	0,036
Total		3 651	1,000

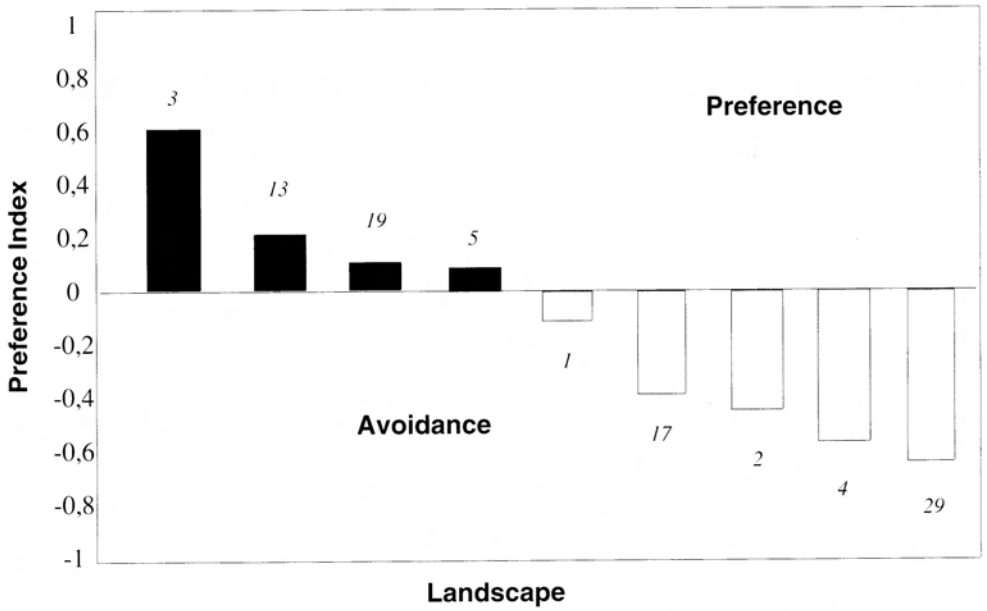

Fig. 2. Preference index for white rhinoceros landscape use in the southern Kruger National Park, for the years 1979-1991.

Table 2

Landscape utilisation data for the white rhinoceros in the southern Kruger National Park, depicting mean density of white rhinoceros per landscape (animals km^{-2}), frequency of white rhinoceros occurrence in each landscape, and preference indices of white rhinoceroses for the nine landscapes for the period 1979 to 1991

Landscape number	Frequency in landscape	Density in landscape	Proportion of count ($\hat{P}_i$)	Preference index
3	3 722	0,5023	0,3623	0,5690
13	597	0,2870	0,0581	0,2459
19	537	0,2682	0,0523	0,1930
5	1 453	0,2300	0,1414	0,0588
1	849	0,1728	0,0826	-0,2017
17	394	0,1329	0,0384	-0,3858
2	824	0,1321	0,0802	-0,3899
4	1 730	0,1250	0,1684	-0,4226
29	167	0,0988	0,0163	-0,5434
Total	10 273	0,2164	1	—

morphology, macroclimate, soil and vegetation pattern and associated fauna Gertenbach (1983, 1987).

To evaluate the white rhinoceros landscape preference in the southern Kruger National Park, aerial survey data from 1979 to 1991 were pooled and the frequency of occurrence of white rhinoceroses in each landscape were calculated. A preference index (P.I.) was calculated for each landscape using an equation adapted by Barrat (*in prep.*) from Ivlev (1961) and Viljoen (1989). A value of zero indicates that a landscape is used in exactly the same ratio as its proportional occurrence. A positive value (maximum +1.0) indicates a landscape use greater than its proportional occurrence while a negative value (minimum -1.0) indicates a landscape use smaller than its proportional occurrence. Four variables were used in the calculations namely:

n_x = the number of white rhinoceros in landscape 'x'.

N_t = the total number of white rhinoceros observed in the southern Kruger National Park.

a_x = the surface area (km^2) of landscape 'x'.

A_t = the total area (km^2) of the southern Kruger National Park.

n_x/N_t = the proportion of white rhinoceros recorded in landscape 'x' relative to the total population in the southern Kruger National Park.

a_x/A_t = the proportion of the southern Kruger National Park covered by landscape 'x'.

If $n_x/N_t \; a_x/A_t$ then $P.I.(x) = \dfrac{-1}{n_x/N_t} \times (a_x/A_t - n_x/N_t)$

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Alldredge & Ratti (1986) consider a preference index to be of limited use because it only provides a ratio of habitat use to habitat availability and does not use a statistical test. Neu *et al.* (1974) and Byers *et al.* (1984) suggests the following approach to overcome this criticism: A chi-square test is performed to test for the goodness-of-fit of utilised habitat to available habitat types. Alldredge & Ratti (1986) define the null hypotheses to be tested by the chi-square test as follows:

H_{01}: Usage occurs in proportion to availability, considering all habitats simultaneously.

H_{02}: Usage occurs in proportion to availability, considering each habitat separately.

When the chi-square test detects a significant difference in usage versus availability, a Bonferroni z-statistic is used to construct confidence intervals based on the proportion of time an animal uses each habitat type, in order to determine which habitat types are used more or less than expected. The following interval is then used:

$$\hat{P}_i - Z_{\alpha/2k} \left[\hat{P}_i (1 - \hat{P}_i)/n \right]^{1/2} \leq p_i \leq \hat{P}_i + Z_{\alpha/2k} \left[\hat{P}_i (1 - \hat{P}_i)/n \right]^{1/2}$$

$\hat{P}_i$ is the proportion of locations in habitat type i, and $Z_{\alpha/2k}$ is the upper standard normal table value corresponding to a probability tail area of $\alpha/2k$; k is the number of habitat types. In this case the confidence

Table 3
White rhinoceros landscape preference or avoidance in the southern Kruger National Park, between 1979 and 1991 (α=0.025 p k=9 $Z_{\alpha 2k}$=2.7725)

Landscape number	x^2 Contribution	Proportion of landscape	Confidence interval	Preference or avoidance
3	2797.424	0.1561	$0.3396 \leq p_3 \leq 0.3835$	Prefer
19	24.809	0.0422	$0.0254 \leq p_{19} \leq 0.0789$	Neutral
5	5.348	0.1331	$0.1158 \leq p_5 \leq 0.1666$	Neutral
13	47.868	0.0438	$0.0314 \leq p_{13} \leq 0.0846$	Neutral
1	43.298	0.1035	$0.0562 \leq p_1 \leq 0.1088$	Neutral
29	108.031	0.0356	$-0.0113 \leq p_{29} \leq 0.0356$	Neutral
17	95.511	0.0625	$0.01136 \leq p_{17} \leq 0.0652$	Neutral
2	205.322	0.1314	$0.0535 \leq p_2 \leq 0.1067$	Avoid
4	535.394	0.2917	$0.1430 \leq p_4 \leq 0.1932$	Avoid

intervals shown in Table 3, are for =0.025 and k equal to nine categories, $Z_{\alpha 2k}$ = 2.7725.

To determine if a habitat is preferred or avoided by white rhinoceros, the confidence interval is checked for overlap with the availability proportion of the corresponding habitat. If the habitat availability proportion falls within the confidence intervals, the null hypothesis cannot be rejected. However, if the lower level of the confidence interval exceeds the availability proportion, a preference is shown for this habitat type.

For this study it was decided to use both the preference index and the chi-square methods to describe the landscape utilisation by white rhinoceros in the southern Kruger National Park. The landscape preference was determined for the summed data from 1979-1991 as well as for each individual year.

Results

The preference index of white rhinoceros landscape use in the southern Kruger National Park indicates landscapes 3, 19, 5 and 13 to be preferred and landscapes 1, 4, 2, 17 and 29 to be avoided (Figure 2). Table 2 shows the frequency, mean density, proportional landscape use and preference index for data summarised for the southern Kruger National Park over the period 1979-1991.

The chi-square test confirmed a significant preference for the overall data set from 1979-1991 (χ^2= 3863.005 $P < 0.0001$ df=8) and the H_{01} is thus rejected.

To determine which landscapes are preferred or avoided confidence intervals were constructed around the proportion of white rhinoceros counted in each landscape from 1979-1991. When the availability proportion of each landscape was checked against the corresponding confidence intervals, the H_{02} was rejected for landscapes 3, 2, and 4 (Table 3). The conclusion is thus that landscape 3 is preferred, landscapes 2 and 4 are avoided, with landscapes 19, 5, 13, 1, 17 and 29 appearing (given the current sample size) to be used roughly in proportion to their occurrence (α=0.025 $P < 0.05$ k=9).

The short term variation in landscape use by white rhinoceros in the southern Kruger National Park was also examined and the results were similar to the above (α= 0.05 $P < 0.1$ k=9).

Discussion

Petrides (1975) defined a "preferred food species" as one which is proportionately more frequent in the diet of an animal than what it is available in the environment. Similarly he

defined "principal foods" as the foods which form the greatest proportion of an animal's diet. The same principals are applied here.

In the present study landscape 3, (moderately undulating granitoid plains with *Combretum zeyheri* woodland), is clearly the most preferred landscape of the white rhinoceros in the southern Kruger National Park on a yearly as well as on a long-term basis. It is also the principal landscape according to white rhinoceros distribution. Landscape 3 has an undulating topography with distinct bottomlands where accumulation of clay and minerals take place. The low shrub stratum is open and the field layer is moderate to dense and usually less than 1 m in height. Field observations have shown that in the mornings white rhinoceros feed by preference on the shade-loving grasses such as *Panicum maximum* that grow on the riverbanks. When it gets warm they utilise the watersheds to rest in the shade. White rhinoceroses are also very partial to wallowing in the mud-holes that form on the clayey soil on the bottom-lands. It seems thus that landscape 3 fulfils most of the white rhinoceros's needs.

Landscapes 2 (low granitoid mountains with *Combretum apiculatum* bushveld) and 4 (granitoid lowlands with *Acacia grandicornuta* tree-savanna), are clearly avoided by the white rhinoceros on the long term.

Although landscape 4 has the second highest frequency of white rhinoceroses in the southern Kruger National Park, the large size of this landscape has the effect that the overall white rhinoceros density is low. Field observations have shown that white rhinoceros are not partial to areas with a dense low shrub stratum such as occurring in landscape 4. In landscape 4 the more open, brackish areas along riverbanks are the only areas used to some extent by white rhinoceroses. Landscape 13 (Karoo Sediment plains with *Acacia welwitschii* tree-savanna), also has a dense woody vegetation but the low shrub stratum is open, and hence white rhinoceros do not avoid this landscape.

White rhinoceros avoided landscape 2 with its shallow leached soils and bush-savanna vegetation. This avoidance could be related to grass quality as well as to the topography as landscape 29 (low rhyolite mountains with *Combretum apiculatum* woodland), which is not so mountainous and where the soil is deeper and better quality grasses are found, is not avoided by white rhinoceros.

Both the methods used to ascertain habitat preference gave similar results. Although the preference index showed landscape 29 to be the least preferred, the habitat availability proportion falls within the confidence intervals and the null hypothesis thus cannot be rejected. Although the preference index does not give a statistical test, it ranks the landscapes according to animal density and provides a direct indication of each landscape's relative importance to white rhinoceros. It is thus an acceptable method to ascertain preference when used in combination with a method that give a statistical test.

Although the landscape preferences of white rhinoceros in the central and northern Kruger National Park will be reported upon in a subsequent publication (*in prep* by Pienaar *et al.*), one would expect the same trends to manifest themselves as was noticed in the southern Kruger National Park. This implies that the white rhinoceros will select for slightly undulating areas with a moderate field layer and that they will avoid areas with a dense low shrub stratum or mountainous areas with poor quality grasses.

Conclusions

White rhinoceros exhibit a definite preference and avoidance for certain landscapes in the southern Kruger National Park. Landscape 3 (moderately undulating granitoid plains with *Combretum zeyheri* woodland), is by far the most preferred landscape while landscapes 2 (low granitoid mountains with *Combretum apiculatum* bushveld) and 4 (granitoid lowlands with *Acacia grandicornuta* tree-savanna), are avoided.

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