Influence of density on the seasonal utilization of broad grassland types by white rhinoceroses

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We monitored seasonal use of grassland types by white rhinos at two sites within the Hluhluwe-iMfolozi Park (HiP). Thirty-two rhinos were removed from one site to reduce rhino density. Seasonal use of grassland types was similar at both sites, but differed to what a previous study reported. This was likely due to higher food availability during our study, coupled with lower white rhino density. These findings suggest that during high rainfall years, white rhinos at a density of 3/km² will not overutilize food in the park. Dispersal, initiated by declining food resources, is used to manage white rhino population size in HiP. We suggest that during high rainfall years it is unlikely that dispersal rates will increase. The impact that a similar density would have on food availability and dispersal during low rainfall years is uncertain.

Key words: herbivore density, habitat utilization, white rhinoceros.

Large grazers forage in grasslands where food quality and availability vary seasonally (O'Reagain 2001). During the dry season, food availability declines through utilization and senescence reduces quality (Owen-Smith 1982). As favoured food types become scarce, optimal foraging theory predicts that herbivores should widen diet breadths to include previously avoided species (Owen-Smith & Novellie 1982; Stephens & Krebs 1986). Depending on the spatial distribution of food, this may ultimately lead to herbivores shifting between habitat types.

Owen-Smith (1988) recorded that white rhinos (*Ceratotherium simum* Burchell, 1817) utilized four broad grassland types throughout the seasonal cycle in the Hluhluwe-iMfolozi Park (HiP). In the summer rainy season, white rhinos foraged in short grasslands dominated by *Digitaria argyrograpta, Panicum coloratum, Urochloa mosambicensis* and *Sporobolus nitens.* At the start of the dry season, as short grass turned brown, white rhinos fed in woodland grasslands dominated by *Panicum maximum.* Later in the dry season, they used accessible *Themeda* grasslands. By the end of the dry season, when these grasslands were depleted, white rhinos fed in remote *Themeda* grasslands on hillslopes.

The effect of white rhino density on grassland utilization has direct implications for white rhino management. HiP manages white rhinos using the 'Sink management policy' (Maddock 1992). This policy facilitates dispersal, the natural process that regulates white rhino population size (Owen-Smith 1981). This is achieved by removing rhinos to generate low-density areas (termed dispersal sinks) within the park (Maddock 1992). The idea is that once rhinos deplete food outside these sinks, individuals (subadults and a few adult males) will disperse into the sinks in search for food. It is, however, uncertain to what degree food influences white rhino dispersal. Shrader & Owen-Smith (2002) suggested that companionship through the 'buddy system' was the main mechanism behind white rhino dispersal. However, significant declines in food availability will likely lead to increases in dispersal.

White rhinos account for over 50% of the total large herbivore biomass in HiP (Owen-Smith 1988). To understand how food resources and rhino density influence grassland use, we determined the seasonal utilization of grassland communities at two sites differing in white rhino density. We hypothesized that, 1) at both sites white rhinos would utilize broad grassland types in a pattern similar to that described by Owen-Smith (1988), and 2) available resources at the high-density site would decline at a faster rate, thus rhinos would use woodland and *Themeda* grasslands more extensively than at the low-density site.

We conducted the study from July 1995 to August 1996 within the iMfolozi portion of HiP (28°20′S, 31°51′E). Sites were similar in topography and size (56 km² and 52 km²) but differed in white rhino density. The high-density site (*c.* 3 rhinos/km²) was in the southern portion of the park. Thirty-two white rhinos were removed from the

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eastern portion of the park, reducing the white rhino density there to <1 rhino/km^2. Twenty-year mean annual rainfall is 700 mm (Ezemvelo KZN Wildlife).

The use of grassland types by white rhinos was determined by walking eight, 5 km transects at each site. Transects were separated by 1 km and covered the majority of each site. Two transects were walked each day, one during the morning and one in the afternoon when rhinos were most active (Owen-Smith 1988). We collected data over 14 months during seven sampling sessions. All transects were walked four times each session.

Transect width was truncated to 500 m to reduce the chance of double sampling. Maximum observation distances, however, varied in the different grassland types. For each observation, we recorded the number and age (Hillman-Smith *et al.* 1986) of the rhinos and the grassland type in which they fed.

Transects were separated into grassland types based on grass species composition (Downing 1972; Owen-Smith 1988). We extrapolated availability from the total length of transects running through each grassland type. GPS positions were recorded and distances determined using Arcview 3. The overall distance of each grassland type was then divided by the total transect distance to estimate availability.

We sampled species composition of the grassland segments with three 0.5 m^2 quadrats. Within each qudrat, we recorded grass species and grass greenness (very green, mainly green, mainly brown, and very brown). Grass species composition was then determined using the dry-weight-rank method (t'Mannetje & Haydock 1963). We defined grassland types in accordance with Downing (1972). Rainfall was recorded monthly at each site.

Grassland compositions of the two sites were compared using MANOVA. Replicate samples of the sites were generated using the proportions of the grassland types recorded along the transects. Data were Arcsine transformed for normality.

To correlate use with availability, the number of rhinos recorded foraging in each grassland type were analysed using a *G*-test for goodness of fit and Bonferroni confidence intervals (see Byers & Steinhorst 1984). We used the total number of individuals recorded to estimate density, excluding those less than 18 months old from the analysis (n = 89) as they were still suckling (Owen-Smith 1973).

Seasonal samples were defined by grouping data for wet (October 1995 – March 1996) and dry (July–September 1995 and April–August 1996) months. Six grassland types were found at the high-density site (*Themeda,* Short, Woodland, Sandy, *Cynodon* and *Bothriochloa*). We recorded these same grassland types at the low-density site, but combined *Bothriochloa* grasslands with *Trichoneura,* and other less extensive grassland types. White rhinos did not feed in remote *Themeda* grasslands during our study.

Grassland compositions of the two sites did not differ (Wilks' lambda = 0.31, d.f. = 1.14, $P > 0.05$). As expected, the availability of green grass decreased from summer towards winter. The low-density site experienced a significantly greater amount of rainfall (1218 mm) than the high-density site (892 mm; $T = -2.69$, d.f. = 6, $P < 0.05$). Annual rainfall during the study was greater than the 700 mm long-term mean and the annual rainfall recorded during Owen-Smith's (1973) study (657 mm, 545 mm and 712 mm).

We recorded 644 white rhinos at the high-density site and 209 at the low-density site. At both sites, the use of the grassland types differed significantly from availability during the wet (high-density: $G = 108.38$, d.f. = 5, $P < 0.001$; low-density: $G = 52.76$, d.f. = 5, $P < 0.001$) and dry ($G = 84.05$, d.f. = 5, $P < 0.001$, low-density: $G = 16.51$, d.f. = 5, $P < 0.01$) seasons.

At the high-density site, white rhinos favoured Short and *Cynodon* grassland types and neglected *Themeda* and *Bothriochloa* grasslands during the wet season (Fig. 1a). In the dry season, they continued to favour Short grasslands and neglected both the *Themeda* and *Bothriochloa* grassland types.

During the wet season, white rhinos favoured Sandy grasslands and neglected *Themeda* grasslands at the low-density site (Fig. 1b). In the dry season, they neglected *Cynodon* grasslands but utilized all other grassland types in proportion to availability.

In contrast to the pattern described by Owen-Smith (1988), white rhinos consistently used short grasslands throughout the seasonal cycle at both sites. They also did not feed in *Themeda* grasslands on hillslopes. Despite the use of *Themeda* grasslands doubling at both sites during the dry season, use was still below expected levels. These findings suggest that, owing to the above-average rainfall, sufficient food was available throughout the study. The preferred utilization of Sandy grasslands at the low-density site during the wet season is likely due to the presence of the palatable species *Enteropogon monostachyus* and *Digitaria* spp. (van

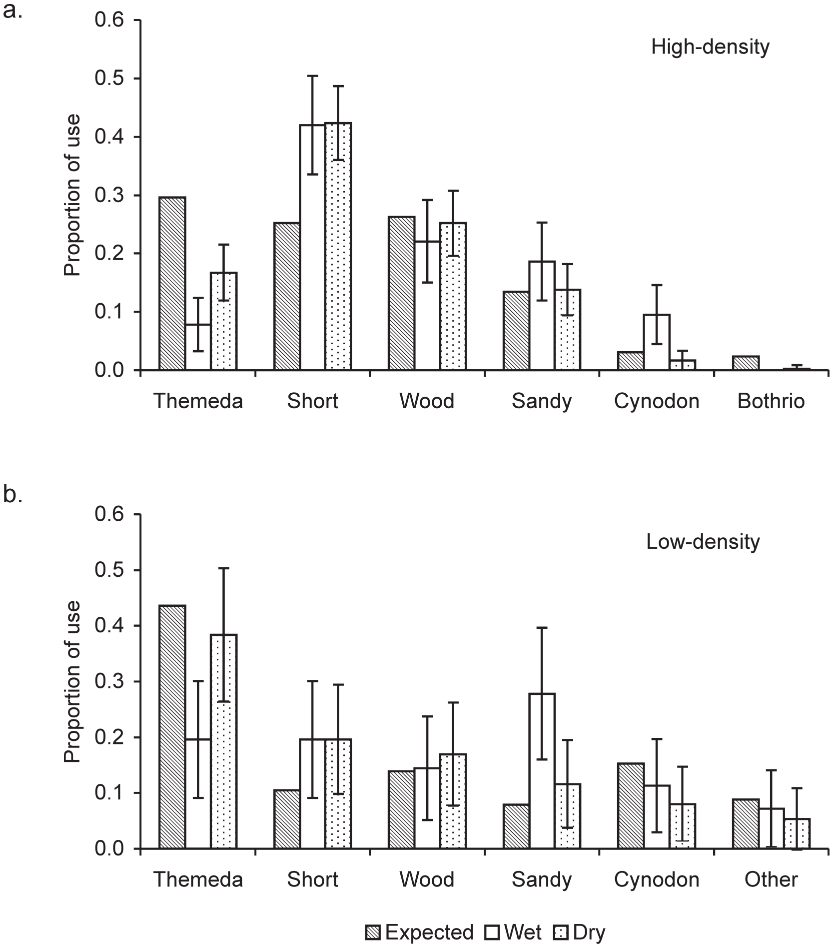

Fig. 1. Seasonal utilization of grassland communities (±Bonferroni CI) by white rhinos at (**a**) high-, and (**b**) low-density sites in relation to expected utilization. Bothrio represents the *Bothriochloa* grassland type. (High-density: wet $n = 231$ rhinos; dry $n = 413$ rhinos; low-density: wet $n = 97$ rhinos; dry $n = 112$ rhinos.)

Oudtshoorn 1999).

The similar utilization patterns of the grassland types at the two sites suggest that white rhino density did not influence utilization. This, however, could be due to both densities being too low to reduce food availability extensively. White rhino density during Owen-Smith's (1988) study was 5.6 rhinos/km^2. Results thus indicate that during high rainfall years a white rhino density of 3/km^2 is not sufficient to greatly reduce food availability. Thus, white rhino dispersal rates are unlikely to increase. However, it is uncertain what impact this density would have on food availability and dispersal rates during low rainfall years when food is scarce.

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