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Habitat use and spatial organisation of relocated black rhinos in Namibia

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Abstract

In this study we systematically examined species-specific exploration behaviour and behavioural acclimatisation of a black rhino *Diceros bicornis* founder group post-translocation. The study was carried out in a fenced region, approximately 350 km^2 in size and directly adjacent to Etosha National Park in Namibia. Rhinos were radio-tracked and movement data were complemented by detailed habitat descriptions at the centres of rhino activity with vegetation plot sampling. Rhinos used both geological formations of the study area: Otavi dolomite and Etosha calcrete substrate. The latter was dominated by *Acacia* spp. due to former land use for livestock farming. The size of total and seasonal home ranges and core areas, as well as home range establishment patterns and habitat use, are highly variable among individual rhinos. Home ranges of most individuals from our study are among the largest recorded for the species. We found age class specific patterns of home range establishment, typical mating and social behaviour, seasonal changes of home range and core area size, and clear shifts in spatial behaviour over time. The results provide our best estimate to date for the natural exploration behaviour and behavioural acclimatisation of black rhinos in a semi-arid savannah ecosystem.

Keywords: behavioural acclimatisation; black rhinoceros; *Diceros bicornis*; Etosha National Park; translocation.

Introduction

Translocation is an invasive procedure that forces animals to quickly adapt to a new environment and to locate resources including water, food and shelter, while simultaneously avoiding predators and interacting with mating competitors. Ideally, translocated animals should quickly establish natural behavioural patterns, related to physiological requirements, social status and reproductive activity. Such adjustments of individuals to the environment are regarded as behavioural acclimatisation (Mazess 1975). Although information on this process is essential for developing translocation procedures, surprisingly behavioural acclimatisation has not been the focus of much attention in the literature, possibly owing to a lack of interaction between animal welfare researchers and conservation biologists (Teixeira et al. 2006).

A good example of the value of translocation in species conservation is the black rhinoceros *Diceros bicornis* Drummond 1826. Owing to systematic poaching, the black rhino population has been dramatically reduced from several 100,000 to 2410 animals remaining in the wild (IUCN 2009). Despite some localised recovery, it remains uncertain if the species can withstand the effects of poaching in the future (Kingdon 2003, Hutchins and Kreger 2006). The major problems associated with black rhino translocations are low reproductive output and high intra-specific fighting mortality of released animals (Brett 1998, du Toit 2002). Thus, a better understanding of the factors that influence the acclimatisation process of black rhinos after translocation is of paramount importance.

Namibia has approximately 1/3 of the entire *in situ* black rhino population. The country includes >95% of the desert-adapted, south-western subspecies *Diceros bicornis bicornis* Linnaeus 1758 with the largest subpopulation in the Etosha National Park (ENP) (Stanley-Price and Dublin 2000). After population decline in the 1970s, Namibia's conservation authorities managed to rapidly breed black rhinos to high densities at state protected areas from 300 individuals in 1980 (Emslie and Brooks 1999) to 1390 individuals in 2007 (IUCN 2009). Owing to sparse human settlement, usable habitat without resident black rhinos remains in Non-Governmental Organization (NGO) areas. In an effort to establish viable subpopulations in these areas, the Rhino Custodianship Scheme has successfully relocated surplus animals from state to private land since 1993 (B. Kötting, Etosha Ecological Institute, personal communication). However, the behaviour of released rhinos has never been intensively monitored for any translocation programme.

In this study, we accompanied and closely monitored a six black rhino founder group after release on a relatively large private conservation area that had been previously used for heavy cattle grazing for more than four decades. The primary goal was to examine the species-specific exploration behaviour and behavioural acclimatisation of reintroduced black rhinos for the first time. We present data on settlement patterns related to the site of release, habitat and conspecifics. The study provides valuable baseline data for future black rhino translocation programmes and is of specific interest for the management of the Etosha subpopulation, a stronghold for the entire *in situ* population of the species.

Material and methods

Study area

The study was carried out in a fenced area of 368 km^2, adjacent to the south-western border of the ENP (between 19°12′ S and 19°21′ S and between 14°54′ E and 15°22′ E; Figure 1). The study area is relatively large compared with the average areas size in the Rhino Custodianship Scheme (150 km^2; B. Kötting, Etosha Ecological Institute, personal communication). Excluding 20.4 km^2 of an inner-fenced section leads to a potentially usable area of 347.6 km^2.

The area is situated in the semi-arid climate zone. Rain falls in the summer months (between October and April), but mainly between January and April. Between 1986 and 2006, average annual rainfall on a neighbouring cattle farm was 281.5 mm. The area covers an altitude range between 1170 and 1350 m. It comprises two broad geological substrates: Otavi dolomite (OD) and Etosha calcrete (EC) (Miller 2008). Vegetation on Otavi dolomite is characterised by tall trees, whereas the calcrete substrate features a mosaic of different habitat types: Etosha mixed low trees, mopane shrubs and Etosha plains (Mendelsohn et al. 2000). The study area is part of the ‘‘Gagarus-block’’, a sector which was cut off from the ENP area in 1947 (Ministry of Environment and Tourism 2007). Since the early 1960s the study area was divided into six private fenced livestock farms (Etosha Heights complex and the farm Moesamoeroep). Between 2001 and 2004 it was converted into a wildlife conservancy by removal of livestock and internal fences and drilling for additional perennial waterholes. During the study period there was a density of 0.07 water sites per km^2. Several large ungulate species have been either introduced or were present in small numbers, including common zebra *Equus quagga* Boddaert 1785, mountain zebra *Equus zebra* Linnaeus 1758, giraffe *Giraffa camelopardalis* Linnaeus 1758, kudu *Tragelaphus strepsiceros* Pallas 1766, eland *Tragelaphus oryx* Pallas 1766, oryx *Oryx gazella* Linnaeus 1758, common wildebeest *Connochaetes taurinus* Burchell 1823 and hartebeest *Alcelaphus buselaphus* Günther 1884. Smaller numbers of large predators, such as lion *Panthera leo* Meyer 1826, leopard *Panthera pardus* Schlegel 1857 and spotted hyena *Crocuta crocuta* Erxleben 1777 were present. During the period of data collection, the average human population density in the study area was 0.14 inhabitants/km^2, the largest human aggregation was a hamlet of approximately 30 people.

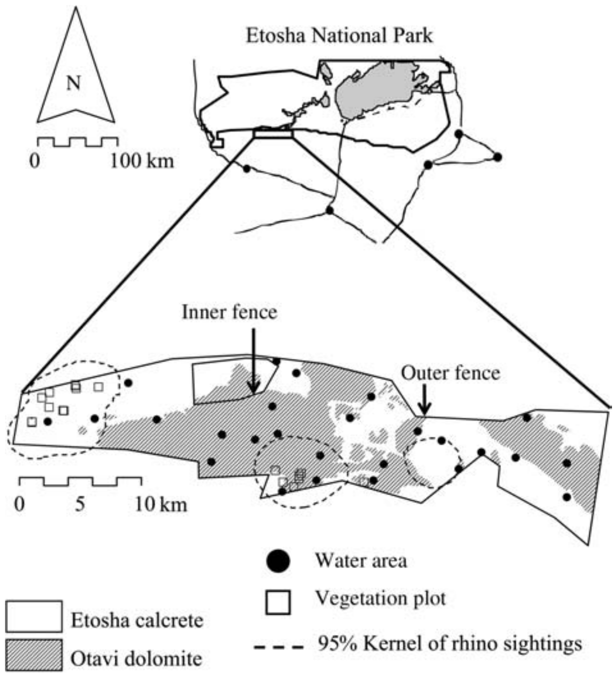

Figure 1 Study area: geographic position, geological formations and distribution of water areas. The 95% Kernel polygon that was calculated from 198 locations, where we observed one or more rhinos, is also given. Rhinos used distinct areas on geological formation. Based on these data, we set up plots on both geological areas for vegetation survey.

Translocation procedures

Hard-release translocation was carried out by different teams within the Rhino Custodianship Scheme. Rhinos were immobilised by helicopter. Age was estimated by tooth wear (Hitchins 1978). Rhinos were ear-marked and diurnal active radio-transmitters were fitted into the front horns. Translocation procedures ranged between 6 and 12 h. Rhinos were then released on their own.

Animals

On November 5 and 6, 2004, two subadult males (age: 2.5 and 5 years) were translocated from a NGO area south of the ENP (linear distance between capture and release site: 231 km). The subadult males were translocated 4 months before data was officially collected and settlement behaviour during that time was not investigated. Introduction of subadult males would have been prior to any olfactory cues that other black rhinos were in the area. Between April 7 and 12, 2005, four additional rhinos were translocated from the ENP (linear distance between capture and release site: 101–144 km). This group consisted of one adult male (age: 11 years), one female adult (age: 12 years) and two subadult females (age: 3 years). Habitats at capture and release sites were similar for all six rhinos.

Data collection

Between March 2005 and February 2007, the animals were located on a regular basis (at least once a week) at irregular intervals between dawn and dusk via VHF radio-telemetry, using a TR-4 receiver (Telonics, Inc., Mesa, AZ, USA). We collected 1329 fixes on six rhinos, with 147–306 fixes/animal. Observation period for individual rhinos varied between 494 and 674 days.

Signals were initially caught from high elevation and then verified by final stalking upwind by foot. On average, 19% (11–26%) of fixes reveal locations where rhinos were directly observed (sightings) and 81% (74–89%) of fixes were triangulation estimates. Therefore, we took bearings from two locations comprising an angle of >60°. The direction was examined by compass to an accuracy of 1°. The intersection of the two lines indicates the probable location of the respective rhino. Positions of sighting and triangulation points were determined by Global Positioning System (GPS). When we observed two or more rhinos in close distance to each other (<50 m), we took only one position.

To interpret rhino habitat use, we analysed the habitat types at the centres of rhino activity. During the dry season in 2006 (September–November), we established 19 vegetation plots of 200 m^2 (10×20 m). Plots were established where rhinos had been observed browsing and vegetation indicated frequent browsing at that time. We established 11 plots on EC and 8 plots on OD (Figure 1). Within each plot, cover (proportion of area covered with the respective vegetation type) of all layers was estimated. Layers include (1) trees (<2.5 m height), (2) shrubs, (3) dwarf shrubs (>0.6 m height) and (4) ground (grass and bare soil). Cover of bare soil and grass was estimated according to the Londo scale (Londo 1976). Cover of remaining layers (trees, shrubs and dwarf shrubs) was calculated from direct measurements. We measured (in the case of trees estimated) minimum and maximum diameter and height of all individual plants within each plot to calculate the size of an ellipsoid from the plant diameter to determine plant cover. Since we calculated cover of the entire vegetation inventory of woody plants per plot, cover can exceed the 100% limit.

Data analysis

We calculated home ranges using two methods: minimum convex polygon (MCP; Mohr 1947, Kenward 1987) and the Kernel method (Worton 1987, 1989). We used the computer programs GPS Track Maker (GPSTM, Freeware, Belo Horizonte, Brazil) and ArcView 3.3 (ESRI, Redlands, CA, USA), and we corrected polygons along study area borders. As most literature references on black rhino home ranges are based on the MCP method, we calculated the 100% MCP of the total home ranges (home range over the study period) for comparison with these references. Accordingly, we estimated total home ranges and seasonal home ranges (dry season: 15 April–14 October, wet season: 15 October–14 April) via the Kernel method with the animal movement extension for ArcView 3.3 (Hooge and Eichenlaub 1997). We estimated Kernel polygons at the 50% and 95% probability levels and used the 50% polygon to visualise black rhino core areas (Lent and Fike 2003). Seasonal home ranges were only calculated when sample size exceeded 40 fixes per individual and season (Lent and Fike 2003). We also measured migratory activity (successive linear distance between fixes). We calculated an index of seasonal home range and core area overlap, using the following formula (Lazo 1994):

$$\text{Home range overlap (V)} = \frac{2P_I}{(P_A + P_B)}$$

where P_I=overlap area of individuals A and B, P_A=area of individual A and P_B=area of individual B. This index can range from 0 (no overlap) to 1 (identical home ranges).

To analyse vegetation data we calculated median and interquartile range (IQR, distance between the 25th and the 75th quartiles) of variables. We carried out a Mann-Whitney U-test to compare samples (plots) from the two main geological formations. We also conducted a detrended correspondence analysis (DCA; Hill and Gauch 1980) to visualise degree of associations among the 19 samples (standard settings, downweighing of rare species and detrending by segments).

Results

Rhino behaviour

The size of total and seasonal home ranges, as well as home range establishment patterns and habitat use, are highly variable among individual rhinos (Table 1). The size of 100% MCP of total home ranges varies from 10.8 km^2 (subadult male 2) to 234.6 km^2 (adult male). The 95% Kernel polygons of total home ranges vary from 7.1 km^2 (subadult male 1) to 220.2 km^2 (adult male).

As expected, the Kernel approach indicated that rhinos were rather concentrated at certain core areas (Figure 2, Table 1). Rhinos established up to four distinct core areas, between which they either regularly switched, or which they established at different times of the survey. The maximum successive distance between fixes ranged from 4.0 km (subadult male 2) to 31.6 km (subadult female 1). We continually observed rhino migrations of approximately 20 km linear distance between core areas during one night.

The size of seasonal home ranges (95% Kernel polygons) varies from 5.7 km^2 (subadult male 1) to 218.6 km^2 (adult male). The size of core areas (50% Kernel polygons) of total home ranges varies from 0.6 km^2 (subadult male 1) to 73.5 km^2 (subadult female 1). Core areas of seasonal home ranges are between 0.6 km^2 (subadult male 1) and 49.2 km^2 (adult male).

Rhinos roamed most of the study area using both geological areas: OD and EC (Table 1, Figures 1 and 2). We found age class specific patterns of home range establishment. All rhinos showed clear seasonal movements or changes in home

Table 1 Home range and core area establishment patterns for total and seasonal home ranges of individual rhinos.

	Subadult ♂1	Subadult ♂2	Adult ♂	Subadult ♀1	Subadult ♀2	Adult ♀
Total home range						
Number of fixes	306	172	298	152	147	254
100% MCP (km^2)	15.0	10.8	234.6	180.4	87.4	152.4
95% Kernel (km^2)	7.1	8.2	220.2	181.3	58.3	64.5
50% Kernel (km^2)	0.6	1.0	26.2	73.5	10.0	8.9
Number of core areas	1	2	1	3	2	1
Core area habitat	OD	OD	EC	EC, OD	EC, OD	EC
Migratory activity[a] (km)	1.1	1.3	4.4	3.5	3.5	3.7
2005 dry season						
Number of fixes	67	57	84	81	82	68
95% Kernel	9.8	9.1	218.6	77.4	61.1	164.6
50% Kernel	1.4	1.6	49.2	16.5	7.3	43.6
Number of core areas	3	3	2	3	1	1
Core area habitat	OD	OD	EC, OD	EC, OD	EC	EC
Migratory activity	1.4	1.5	4.3	2.5	3.4	5.9
2005/2006 wet season						
Number of fixes	96	85	62	47	47	61
95% Kernel	5.7	6.5	60.5	186.2	61.8	55.6
50% Kernel	0.6	0.8	13.3	40.8	12.1	8.7
Number of core areas	1	1	1	1	2	4
Core area habitat	OD	OD	EC	EC	EC, OD	EC
Migratory activity	0.9	1.1	4.0	5.0	3.6	3.9
2006 dry season						
Number of fixes	130	–	112	–	–	95
95% Kernel	7.7	–	112.0	–	–	31.4
50% Kernel	0.8	–	24.4	–	–	2.4
Number of core areas	1	–	2	–	–	1
Core area habitat	OD	–	EC, OD	–	–	EC
Migratory activity	1.1		5.0			2.5
General settlement pattern	Decrease	Decrease	Decrease Increase	Shift	Increase	Decrease

[a] Mean successive linear distance between fixes.

range and core area size. The subadult males established relatively small home ranges in the area of release (OD) and reduced home range and core area size, as well as numbers of core areas, during the wet season. The adults initially dispersed into a westerly direction and had a pronounced exploration phase during the first season after release (2005dry season). During the following wet season, rhino adults significantly reduced home range and core area size and settled into much smaller areas on EC. In contrast, subadult females initially dispersed into an easterly direction and increased exploration activity during a later stage of the study (2005/2006 wet season).

Results on home range and core area overlap reveal seasonal changes of the social structure of the starter group. During the first season after release (2005 dry season), rhinos clearly dispersed forming three dyads: subadult males, subadult females and adults. Each dyad showed a high degree of home range and core area overlap. There was little or no home range and core area overlap between these three dyads. In the 2005/2006 wet season, subadult males retained high levels of home range and core area overlap. Subadult female 1 shifted home range into a new area, forming a social unit with the rhino adults (Table 2).

At 198 locations, we directly sighted one or more rhinos. At most locations rhinos were observed solitary (78.3% of locations) but they occasionally formed groups of two (19.2%), three (2%) and four animals (0.5%). In late October 2006 the female adult was found with a calf.

Description of used habitats

We found 25 woody plant species of which rhinos used 14 species as fodder plants. We found 19 species on OD and 17 species on EC. Cover (%) of woody plants per unit (plot) was high on both geological substrates: OD: 105.6 (IQR: 56.2), EC: 94.6 (IQR: 39.9) ($U=38.0$, $p=0.65$). The species richness (number of species) per plot also did not vary between substrate types: OD: 8.0 (IQR: 0), EC: 6.0 (IQR: 3.5) ($U=30.0$, $p=0.25$). However, there were fewer individual plants on OD: 45.5 (IQR: 14.8) than on EC: 81.0 (IQR: 52) ($U=71.0$, $p=0.03$). Mopane *Colophospermum mopane* was present at most plots, with larger individuals on OD (height in m): 2.08 (IQR: 0.64, $n=8$) and smaller individuals associated with EC: 1.13 (IQR: 0.77, $n=9$) ($U=12.0$, $p=0.02$).

Habitat structure and plant species composition differed markedly between substrates. Most of OD ground layer was

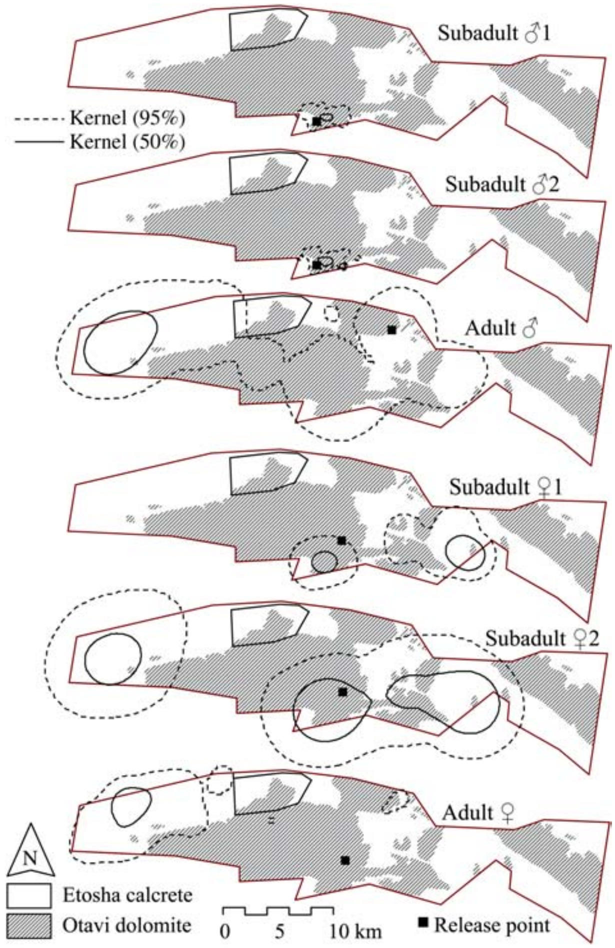

Figure 2 Uncorrected Kernel polygons (95% and 50% probability levels) of total home ranges for each individual.

characterised by grasses (60%), the proportion of trees (52.5%) and shrubs (47.3%) was almost balanced, dwarf shrubs (0.2%) were nearly absent. At EC there was more bare soil (75.5%) than grass cover (24.5%), and shrubs (73.6%) were more important than trees (18.2%). Dwarf shrubs (8.1%) achieved almost half the cover of the tree layer.

OD was dominated by the trees *C. mopane* (34.8% of total cover) and *Terminalia prunioides* (25.4% of total cover). In contrast, the most prominent feature on EC was the dominance of *Acacia* spp., which accounted for 53.4% of the total cover. The most common *Acacia* spp. were *A. reficiens* and *A. luederitzii*, which together accounted for 80% (OD) and 85% (EC) of *Acacia* spp. per area. The shrub *Catophractes alexandri* represented 4.7% (OD) and 15.4% (EC) of vegetation cover. *C. mopane* cover was less than half as high on EC compared with OD. *T. prunioides* composed 25.4% (OD) and 4.5% (EC) of vegetation cover. There was no influence from distribution of water areas on the vegetation.

Data on plant community compositions were summarised in an ordination (Figure 3). The DCA shows that OD samples are distinct from those on EC with only slight overlap. EC vegetation is more widely scattered in the ordination plot indicating larger differences in floristic composition. The greater variation in species composition compared with OD indicates the heterogeneity of the habitat mosaic. The species ordination indicated that *T. prunioides* and bushy three-hook thorn *Acacia senegal* are associated with OD, whereas dwarf shrubs as well as *C. alexandri*, *A. reficiens* and *A. luederitzii* were associated with EC.

Discussion

Behavioural acclimatisation refers to potentially beneficial shifts in sets of behavioural correlates or activity patterns of individual organisms with regard to the environment. To assess these benefits, Mazess (1975) considered different adaptive domains, e.g., reproduction, health, nutrition, physical performance and intellectual ability. In our study, we observed no abnormal behaviour, mortality or signs of diseases.

In October 2006 the adult female was found with a calf. The birth must have taken place between 553 and 558 days after release. Given a gestation period of 438–480 days

Table 2 Sociometric matrix showing the index of overlap (V) of seasonal home ranges and core areas for all possible dyads.

	Subadult ♂1	Subadult ♂2	Adult ♂	Subadult ♀1	Subadult ♀2
2005 dry season					
Subadult ♂2	**0.9/0.9**				
Adult ♂	0.1/0.0	0.1/0.0			
Subadult ♀1	0.2/0.1	0.2/0.2	0.2/0.0		
Subadult ♀2	0.3/0.0	0.3/0.0	0.1/0.0	**0.9/0.5**	
Adult ♀	0.0/0.0	0.0/0.0	**0.9/0.6**	0.0/0.0	0.0/0.0
2005/2006 wet season					
Subadult ♂2	**0.9/0.9**				
Adult ♂	0.0/0.0	0.0/0.0			
Subadult ♀1	0.1/0.0	0.1/0.0	**0.4/0.5**		
Subadult ♀2	0.2/0.1	0.2/0.1	0.0/0.0	0.4/0.0	
Adult ♀	0.0/0.0	0.0/0.0	**0.8/0.5**	**0.4/0.3**	0.0/0.0

Data arrangement: V of 95% Kernel polygons/V of 50% Kernel polygons. For better reading, important dyads are denoted in bold font.

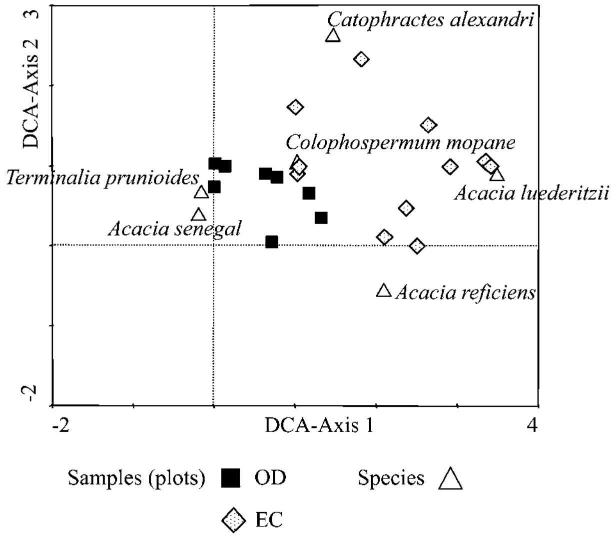

Figure 3 Detrended correspondence analysis (DCA) of species-cover data. From the best fitting 12 species that were most reliable, only dominant species are shown, which have been important black rhino fodder plants (except *C. mopane*) (detrending by segments; no downweighing of rare species; eigenvalue/length of gradient axis 1: 0.71/3.40, axis 2: 0.24/2.33, axis 3: 0.18/1.51).

(Ramsay et al. 1987), successful copulation between adults must have already occurred between 73 and 120 days after their initial translocation. This is also supported by the home range overlap of this dyad during the first season after release (2005 dry season). Because we have not directly witnessed the copulation event, we cannot totally exclude the possibility of delayed gestation of the adult female owing to acclimatisation stress. However, delayed gestation was never reported for black rhinos or for any other perissodactyl ungulate species.

The age of first conception in wild black rhinos ranges from 3.5 years to >9 years (Hillman-Smith and Groves 1994). Hence, the movement of subadult female 1 towards the home range of the adult male during the 2005/2006 wet season could be another indicator for acclimatisation with regard to reproduction.

Our results on home range establishment and habitat use provide information regarding several adaptive domains. Adult rhinos, which should establish the highest social status within the group, had a pronounced exploration period (moving of great distances in search of appropriate habitat) during the first season after release. In contrast, subadult rhinos either showed no distinctly variation in ranging behaviour throughout the study (subadult males) or they increased exploration behaviour at later stages (subadult females). Pronounced exploration was comparable to studies on various mammalian species (Jnawali and Wegge 1993, Miller et al. 1998, Schröpfer 2003).

Black rhinos select for medium to dense cover (Hillman-Smith and Groves 1994). We found rhinos using both geological substrates of the study area, each with a characteristic composition of plant communities. Generally, the utilised habitat types provided a low degree of available plant species (habitat quality) but a high proportion of thicket, which could be important for shelter. The small home range size of the subadult males, which exclusively roamed the OD area, might have been a result of intra-specific competition. However, considering the fact that five out of six rhinos used OD at least for certain periods, relatively small home ranges of subadult males suggest the suitability of this seemingly marginal habitat type. EC substrate features a variety of habitat types, which are also present at large areas of the ENP (Mendelsohn et al. 2002). Rhinos might have been habituated to familiar habitats. However, the dominance of *A. reficiens* and *A. luederitzii* suggests that utilised habitats on EC were markedly influenced by bush encroachment, probably the result of intensive livestock farming. This study demonstrates the ability of black rhinos to rapidly acclimatise and succeed in former intensively grazed farmland. Hence, it should encourage further relocation activities on degraded farmland in this region.

Our results show that home range size and establishment patterns were variable among individuals. Owing to varying habitat quality, the literature reports of black rhino home range size (based on the MCP method) varies considerably: Hluhluwe, KwaZulu-Natal, South Africa: 0.5–0.75 km^2 (Hitchins 1969), Ndumu, South Africa: 4.3–14.3 km^2 (Conway and Goodman 1989), Masai Mara, Kenya: 5.6–22.7 km^2 (Mukinya 1973), Laikipa, Kenya: 2.3–14.4 km^2 (Tatman et al. 2000), Ngorongoro crater, Tanzania: 2.6–58 km^2 (Goddard 1967), Serengeti National Park, Tanzania: 43–133 km^2 (Frame 1980), Damaraland, Namibia: >500 km^2 (Loutit 1984). Lent and Fike (2003) studied ranging behaviour of an expanding black rhino population in Great Fish River Reserve in South Africa. According to our study, these authors found great variances in individual home range size (affected by social factors) and rhinos shifting home ranges over time. The authors report core areas (50% Kernel polygons) between 1.8 km^2 and 9.9 km^2. It has been noted that largest black rhino home ranges are found in Namibia (Loutit 1984, Berger and Cunningham 1995). Accordingly, home ranges of most individuals from our study are among the largest recorded for the species. We observed seasonal effects on home range and core area size or seasonal movements of all rhinos. Several studies have shown seasonal changes of home ranges of reintroduced large herbivores, such as roe deer *Capreolus capreolus* Linnaeus 1758 (Carvalho et al. 2008) and Persian fallow deer *Dama mesopotamica* Brooke 1875 (Perelberg et al. 2003). As acclimatisation includes seasonal and climatic changes (Hart 1957), the seasonal movements observed in our study are further indicators for the acclimatisation of the founder group. Wildlife managers of black rhinos should consider the dimensions of space utilisation and the fact that dramatic shifts in migration activity can occur over time.

Although black rhinos are known to be solitary, temporary associations do occur between individuals (Klingel and Klingel 1966, Goddard 1967, Schenkel and Schenkel-Hulliger 1969). Tatman et al. (2000) used home range overlap to gain insight into black rhino social organisation. The authors found groups of rhinos (one adult male, one or more adult females with their calves and sometimes immature animals) sharing a common home range. Spatial overlap of home ranges from our study suggests similar patterns of social organisation. McLoughlin et al. (2000) developed a model of spatial organisation in vertebrates with regard to habitat quality. The authors modelled large home range size and high home range overlap in areas of low habitat quality, a good fit to the movements of the black rhino study group using relatively low quality habitat.

The main objective of our study was to report species-specific exploration behaviour and behavioural acclimatisation of black rhinos after release into a new environment. The habitat mosaic and large size of the study area, coupled with the study period allowed for detection of behavioural acclimatisation processes, which would not be apparent in smaller areas or over shorter durations. We found age class specific patterns of home range establishment, typical mating and social behaviour, and clear shifts in spatial behaviour, possibly owing to seasonal availability of resources. The results provide our best estimate to date for the natural exploration behaviour and behavioural acclimatisation of black rhinos in a semi-arid savannah ecosystem. The results are valuable for current efforts to establish conservation areas at the borders of the ENP (Göttert and Zeller 2008).

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