MOVEMENT PATTERNS, HOME RANGES AND MORTALITY FOR REINTRODUCED WHITE RHINOCEROS IN THE MOREMI GAME RESERVE, BOTSWANA.

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Movement patterns, home ranges and mortality of re-introduced White rhinoceros in the Moremi Game Reserve, Botswana

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PREFACE

Rhinoceros are one of the most charismatic mega-herbivores left on the planet and they have become flagship species for international conservation. Botswana used to host a healthy population of white rhinos but it was exterminated by poaching. Re-introduction of rhinos is a viable option for re-establishing the rhinos back into Botswana, and the Department of Wildlife and National Park, where I work, adopted that. Considering the importance and success of the re-introduction programmes, I found it necessary to do research on the movement patterns and home ranges of the white rhinos, which will provide a better understanding and planning for future re-introductions.

I would like to express my gratitude to the Ministry of Environment Wildlife and Tourism for granting me study leave to pursue my studies. I would like to thank Lånekassen for granting scholarship for my studies, and the Department of Ecology and Natural Resource Management for their financial support for my fieldwork. To the Department of Wildlife National Parks (DWNP), thanks for assisting me with transport and personnel during my fieldwork. Hopefully the study will be a benefit to DWNP for future conservation of white rhinos.

I am grateful to my supervisor Dr Stein R. Moe and co-supervisor Dr Ole-Gunner Støen for their guidance and suggestions towards the development of the thesis. Stein, that red pen in my draft thesis inspired me to work harder. Ole-Gunner, I am now an expert on a lot of programmes, hopefully even Microsoft Access because of your patience and assistance.

Lastly I would like to thank my family, mother, sisters, brother and my in-laws for their support and encouragement. To my husband words can't express how thankful I am for keeping the family intact in my absence, taking care of kids is a challenge but you made it. To my kids thanks for being such good receptionist as you always answered the phone whenever I called home. To my friends, Eda Gaobinelwe, Moses Selebatso, Baseki Gaebepe, Mmabontle Malete, Malebogo Sentsho, Elizabeth Mabaila, you have been there for me all the time

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ABSTRACT

Rhinoceros are an important species both as ecosystem landscapers and a source of revenue through eco-tourism. In Botswana white rhinos went extinct because of human poaching. From 2001 to 2003 white rhinos were re-introduced in Moremi Game Reserve. All the rhinos were fitted with transmitters and ear notched, and monitored on a regular basis permitting a study of mortality, movement patterns and home ranges. The rhinos were introduced in four different batches and all batches were released at the same location. Out of the thirty-two released rhinos five died. A comparatively large proportion of the sub-adult males (2 out of 8) and adult males (1 out of 3) died while there was one adult female mortality and only one sub-adult female died, despite that 21 out of the 32 released animals were females. There was a significant difference in distance moved from release site between animals in different batches. Rhinos released in the last batch moved furthest from the release site. Six female rhinos from batch four dispersed out of the park. Home range sizes decreased with years after release and rhinos in batch four had the largest home ranges. Rhinos in batch one, two and three had larger home range overlaps than rhinos in batch four. The number of rhinos present at the time of release influenced the movement pattern and home range sizes of the re-introduced white rhinos. For the success of re-introduction programmes the number of animals previously released should be considered. If larger areas of suitable habitats are available animals should be released at different sites. Based on mortality relatively few sub-adult males should be translocated.

Keywords: Botswana, home ranges, Moremi game Reserve, movement patterns, re-introduction, rhinos

INTRODUCTION

The black (*Diceros bicornis*) and white (*Ceratotherium simum*) rhinoceros, being among the most charismatic terrestrial mammals, have become flagship species for international conservation (Bowen-Jones & Entwistle 2002, Emslie & Brooks 1999). As mega-herbivores, rhinoceroses are important species both ecologically and economically (Sinclair 2003). Rhinos are often an important source of revenue through eco-tourism (Gordon et al. 2004). In many parts of the world, populations of wild large herbivores provide a substantial resource in generating revenue to local and regional communities (Ogutu 2002). Most importantly, large herbivores have ecological value as they have a major impact on the physical structure of habitats, rates of ecosystem processes and the diversity of communities, that is they are ecosystem landscapers (Gordon et al. 2004, Sinclair 2003).

Except for the adult mother with her most recent offspring and associations of sub-adult males, white rhinos are generally solitary (Owen-Smith 1988). The dominant male lives in clearly defined territories that they vigorously defend against other neighboring males (Owen-Smith 1971, Rachlow et al. 1999). Solitary adult males are also present in the population of white rhinos. They lack the characteristic features of territorial behaviour, but each of this non-territorial bulls essentially confines his activities to the territory of another single territorial bull (Owen-Smith 1971). White rhinos cows have home ranges independent of males and with extensive overlap (Adcock et al. 1998, Owen-Smith 1971).

Both the two species of African rhinoceros have been driven to near extinction in several countries, due to high international demand and over-hunting for their valuable horns (Dublin & Wilson 1998, Department of Wildlife and National Parks 2005, Emslie & Brooks 1999). Due to the drastic decline in African rhino numbers, several countries with previous rhino populations have taken steps to re-introduce rhinos to areas where they used to exist (Adcock et al. 1998). The aim has been to build-up rhino numbers, to preserve their long-term genetic diversity and to provide buffers against future potential poaching (Adcock et al. 1998, Brett 1990).

In Botswana, both black and white rhinos went extinct during the 20th century because of human killing due to the high price on rhino horn (Department of Wildlife and National Parks 2005, Emslie & Brooks 1999). In the case of white rhinos, the species was re-introduced in 1967 but almost exterminated by poaching for the second time by the end of the 1980's (Department of Wildlife and National Parks 2005, Tjibae 2002). The few surviving white rhinos were captured and translocated to protected sanctuaries for safety and breeding in order to build viable populations before the animals were returned to protected areas in Botswana (Tjibae 2002).

Similar establishment of rhino sanctuaries has proven successful in the protection and growth of existing rhino populations (Brett 1990). Between 2001 and 2003 thirty-two white rhinos were re-introduced to Mombo area in Moremi Game Reserve.

Although translocations have been a key component of successful rhinoceros conservation in Africa, the management of these new populations posses a challenge to wildlife managers (Brett 1998). The first months after release in a new area is commonly critical for introduced rhinos, and normally mortality is highest in this period (Adcock et al. 1998). A variety of factors play a role in the survival and breeding of the newly translocated animals. Age and sex of translocated animals rhinos has proven to be important factors to consider during translocation programmes (Adcock et al. 1998). A study by Adcock et al. (1998) has shown that young rhino males do not adapt quickly to the new environment and hence are susceptible to high mortality, whereas adult and near adult males and females adapt quicker. Another factor in the success of reintroductions is whether animals remain where they are released (Rogers 1988).

Regardless of the problems encountered in the translocation programmes, achieving maximum productivity in populations of rhinos is crucial for the persistence of the species (Hrabar & du Toit 2005). The establishment and maintenance of appropriate research and monitoring programmes is essential for rhino management and protection. The information gained from surveys and ongoing monitoring programmes provides managers with necessary data to improve understanding of factors affecting population performance, such as breeding rates, mortality, rhino distribution, social behaviour, density, and dispersal patterns (Adcock et al. 1998, Emslie & Brooks 1999, Hrabar & du Toit 2005).

With white rhinos recently re-introduced to Botswana, detailed studies of rhino post-release movement patterns are called for, since continued survival has to be based on rhino security as well as biological management (Walpole et al. 2001). Therefore, I studied the movements of white rhinos after they were reintroduced to Moremi Game Reserve, Botswana. The objectives addressed in this thesis are;

1. To record the mortality and causes of mortality of the released animals.
2. To determine the distance moved in relation to the release point, focusing on differences in age and sex and on how many animals that had previously been released.
3. To study the establishment of home ranges and relate the home range size and overlap to age and sex and whether the home ranges are affected by previously released animals

METHODS

Study area

The study was conducted in the Mombo area, which is an extension of the northwestern end of Chiefs Island within Moremi Game Reserve, Botswana (Fig 1). Moremi Game Reserve (MGR) is a 4871km^2 unfenced protected area and covers the eastern section of the Okavango Delta in the north west of Botswana at 19^o 23' S and 23^o 32' E (Dangerfield & Schuurman 2000, Beehner et al. 2005). Moremi game reserve is surrounded by buffer zones of wildlife management areas and private hunting concessions where animals can move freely. The reserve is flat and comprises mainly of floodplains with a network of waterways, lagoons and pans, islands and reed banks (Beehner et al. 2005). Dense mopane woodlands and riverine forests changes to open grasslands on the floodplains and aquatic vegetation in wetter areas.

The vegetation pattern is influenced by periodic inundation of floodwaters and seasonal rainfall. The northern side of Botswana has a clearly defined summer wet season from November to April, followed by a cool dry winter (May to August) and a hot dry period from September to October. The mean annual rainfall for Moremi Game Reserve is 475mm, but the spatial and temporal distribution is erratic (Dangerfield & Schuurman 2000). In addition to the white and black rhinos Moremi Game Reserve have populations of other African mega herbivores such as elephants (*Loxondonta africana*) and the hippopotamus (*Hippopotamus amphibius*). Predators like lions (*Panthera leo*), cheetahs (*Acinonyx jubatus*), wild dogs (*Lycaon pictus*) and spotted hyenas (*Crocuta crocuta*) are common, while red lechwe (*Kobus leche*) and roan antelope (*Hippotragus equinus*) are rear species found in this area

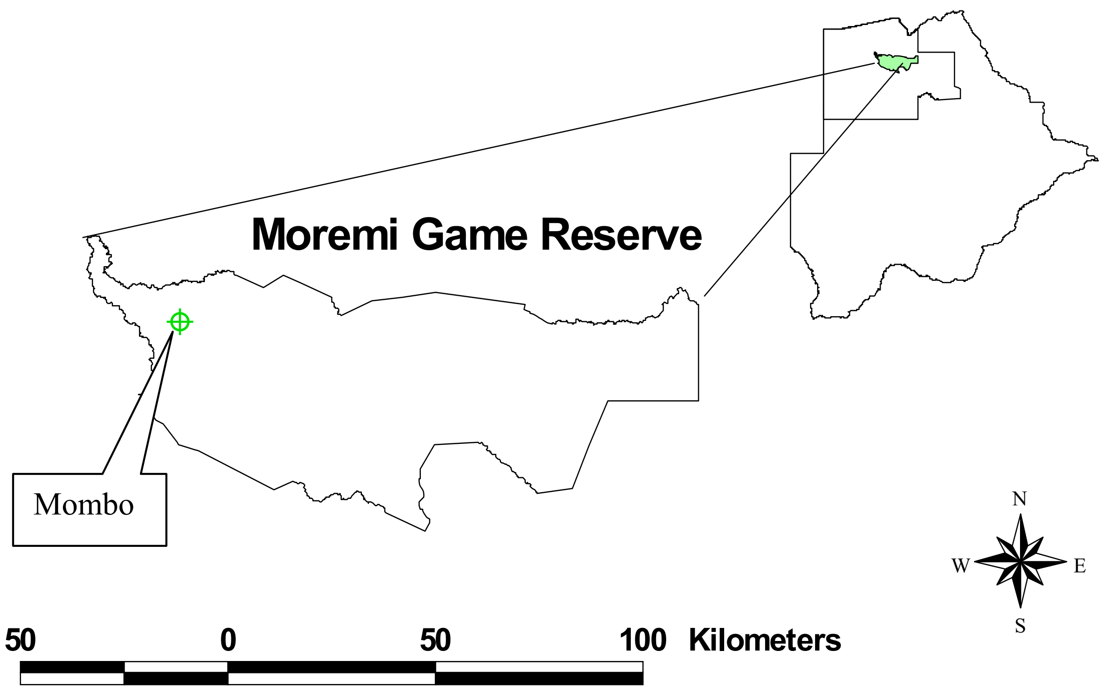

Figure 1: Map of Moremi Game Reserve in the northwestern part of Botswana. Mombo is the area where the rhinos were released.

Data Collection

As part of the joint Department of Wildlife and National Parks (DWNP) and Okavango Wilderness Safaris rhino reintroduction project, 33 white rhinos were translocated to Moremi Game Reserve between 2001 and 2003 (Table 1). Five rhinos died after release and one died before it was released. Track data used in this study are from those 27 animals that survived throughout the study period. On arrival, all the rhinos were fitted with radio-transmitters for monitoring and they were tracked either by a vehicle or an aircraft. Prior to release, each rhino also had a unique pattern of ear notches to facilitate individual identification in the field, in case of transmitter failure. Most animals were tracked on a daily basis during the period immediately after release, but less frequently with time. Once radio transmitters began to fail, rhinos were tracked using spoors and visual identification by their ear notches. Whenever a rhino was located, the precise positions for located rhinos were recorded using a hand held global positioning system (GPS). Age was estimated using information from previous owners, and documented age estimation methods for white rhinos based on Hillman-Smith et al. (1986). Any mortality among the rhinos was also recorded together with the cause of death and the date of death.

Table 1: Sex and age of white rhinos, their release batches and time of release in Moremi Game Reserve, Botswana (one additional animal died prior to release).

Batch	**Time of release**	**Age (at time of release) and Sex**			
		Sub-adult females	**Adult females**	**Sub-adult males**	**Adult males**
1	Nov 2001 & Jan 2002	1	1	-	3
2	Nov 2002	4	1	4	1
3	Jun 2003	2	3	3	-
4	Nov 2003	4	5	-	-

NB: One rhino in the November 2003 batch died before it was released, so it was not included in the table

Data analyses

Distance moved in relation to release point

To map the range and to determine the distance that individual animals moved from the release point. I used ArcView with the Spatial Analyst and Animal Movement extensions (Applegate 1992). Several distances from the release site were calculated, the average distances every three months from the time of release, the maximum distances that the animal had moved during the study period and the distance of the last location of the animals every year were calculated. The animals were grouped according to the time of release, Batch one; animals released in November 2001 and January 2002, Batch two; animals released in November 2002, Batch three; animals released in June 2003 and Batch four; animals released in November 2003.

Home range analysis

RANGES 6 computer package (Kenward et al. 2003) was used to analyse home range data. The minimum outer convex polygon method (95% MCP) was used for annual home range calculations as this is commonly used and thus allow comparison with other previous studies (Harris et al. 1990). The MCP is also unaffected by autocorrelation which can result in an underestimation of home range size (Swihart & Slade 1985). In home range analysis only animals with a minimum of twenty-recorded locations per year were used. For annual home range analysis, batch two and three were combined. This was done because batch two home ranges were calculated from January 2003 and batch three home ranges from June 2003 and accordingly they both had locations in 2003. RANGES 6 computer package (Kenward et al. 2003) was also used for home range overlap calculation expressed as a percentage overlap calculated by the formula: $(O_{ij}/A_i + A_j)) \times 2$, where O_{ij} is the area of overlap between rhino i and rhino j, and A_i and A_j are the areas of the annual home ranges of rhino i and rhino j respectively (Atwood & Weeks 2003).

Statistical analysis

Minitab statistical software (Minitab 14 2003) was used to determine the effects of age, sex and release batches on distance from release site. It was also used to test for significance of age and sex in home range sizes. Statistical analyses used were performed using the General linear Model with Tukey's post hoc test at significance levels of 5%.

RESULTS

Mortality

Out of the thirty-two animals released five rhinos died, and one died before it was released (Table 2). Out of 10 adult and 11 sub-adult females only two died, while two out of eight sub-adult males and one out of three adult males died. Two of the dead animals were poached.

Table 2: Rhino mortality and causes of death

Rhino	Sex and Age	Release date	Date of death	Cause of death
Kgosi	Adult male	Nov 2001	Mar 2003	Territorial fight
Bosweu	Sub-adult male	Jun 2003	Oct 2003	Poaching
Ditsebe	Sub-adult female	Jun 2003	Oct 2003	Poaching
Lonetree	Sub-adult male	Nov 2002	Nov 2003	Bushfire
Makgabisanaga	Adult female	Nov 2002	Nov 2003	Stress during capture
332	Sub-adult female	Not released	Nov 2003	Leg injury during transit

Rate of movement

Distance moved in relation to release site

The average distance moved (calculated every three months) from release site was not dependent on sex (ANOVA; F = 0.49, df = 1, P = 0.4), days after release (ANOVA; F = 1.17, df = 11, P = 0.32) or age (ANOVA; F = 2.58, df = 1, P = 0.12). The distance moved in relation to release site was dependent on batches (ANOVA; F = 19.06, df = 3, P < 0.001). Batch four moved substantially longer distances than all the other batches (Tukey's post hoc test P < 0.05) (Fig 2). There was no significant difference on distance moved by animals in batch one, two and three (Tukey's post hoc test P < 0.05)

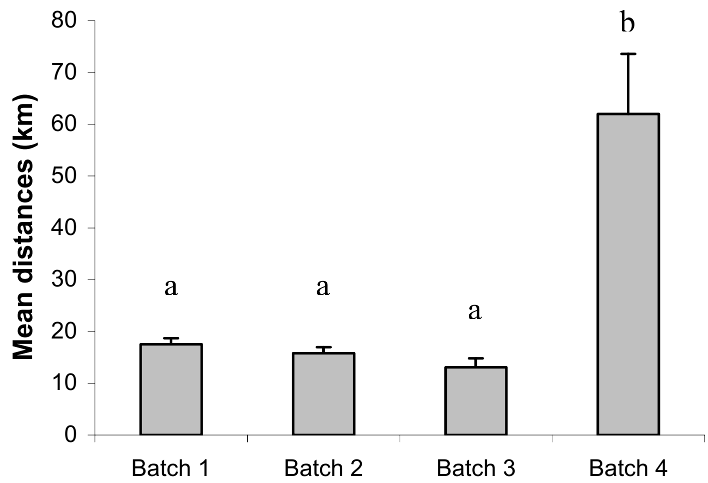

Figure 2: Mean distances (+ SE) moved from the release site by white rhinos The bars represent means of the distances from the release site measured at ninety-day intervals from the time of release. Different letters on top of each bar indicate a significant difference with other batches (Tukey's Post hoc test P < 0.05)

The maximum distance the animals moved from release site throughout the study period differed between batches (ANOVA; F = 5.07, df = 3, P = 0.008). All the batches had a significant different maximum distance from batch four (Tukey's Post hoc test P < 0.05)(Fig 3). Comparing the distance from release site to the last position for each animal within batches, the distance for batch four was different from all other (Tukey's Post hoc test P < 0.05) (Fig 4).

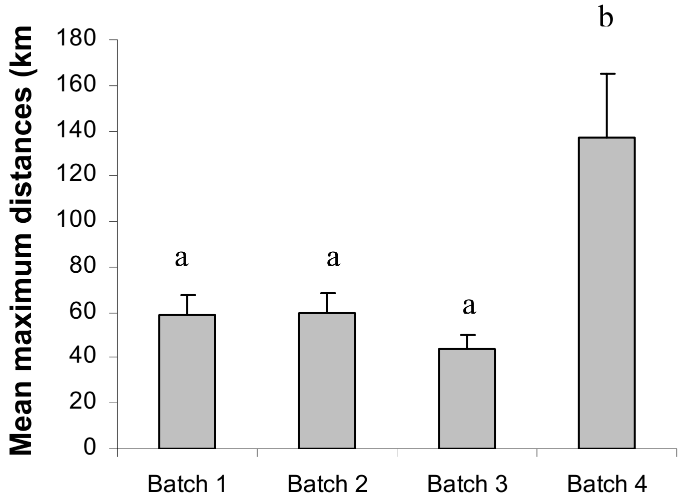

Figure 3: Mean of maximum distances (+SE) that animals moved from the release point in relation to release batches. Different letters on top of each bar indicate a significant difference with other batches (Tukey's Post hoc test $P < 0.05$)

The last position of each animal every year was calculated per batch, and rhinos in batch one stayed within a range of 16-25 km from the release point all the years (Fig 4 a). Animals in batch two also stayed close to the release site with a range of 15-22 km (Fig 4 b). Rhinos in batch three stayed close to the release site the first year of the release and they moved further for the next two years but by year 2006 they were only 16km from the release point (Fig 4 c). Batch four animals had a general consecutive increase in distance from the release point every year, though it was not statistically different (ANOVA; $F = 0.99$, $df = 3$, $P = 0.4$) and by 2006 they were 100 km from the release site (Fig 4 d).

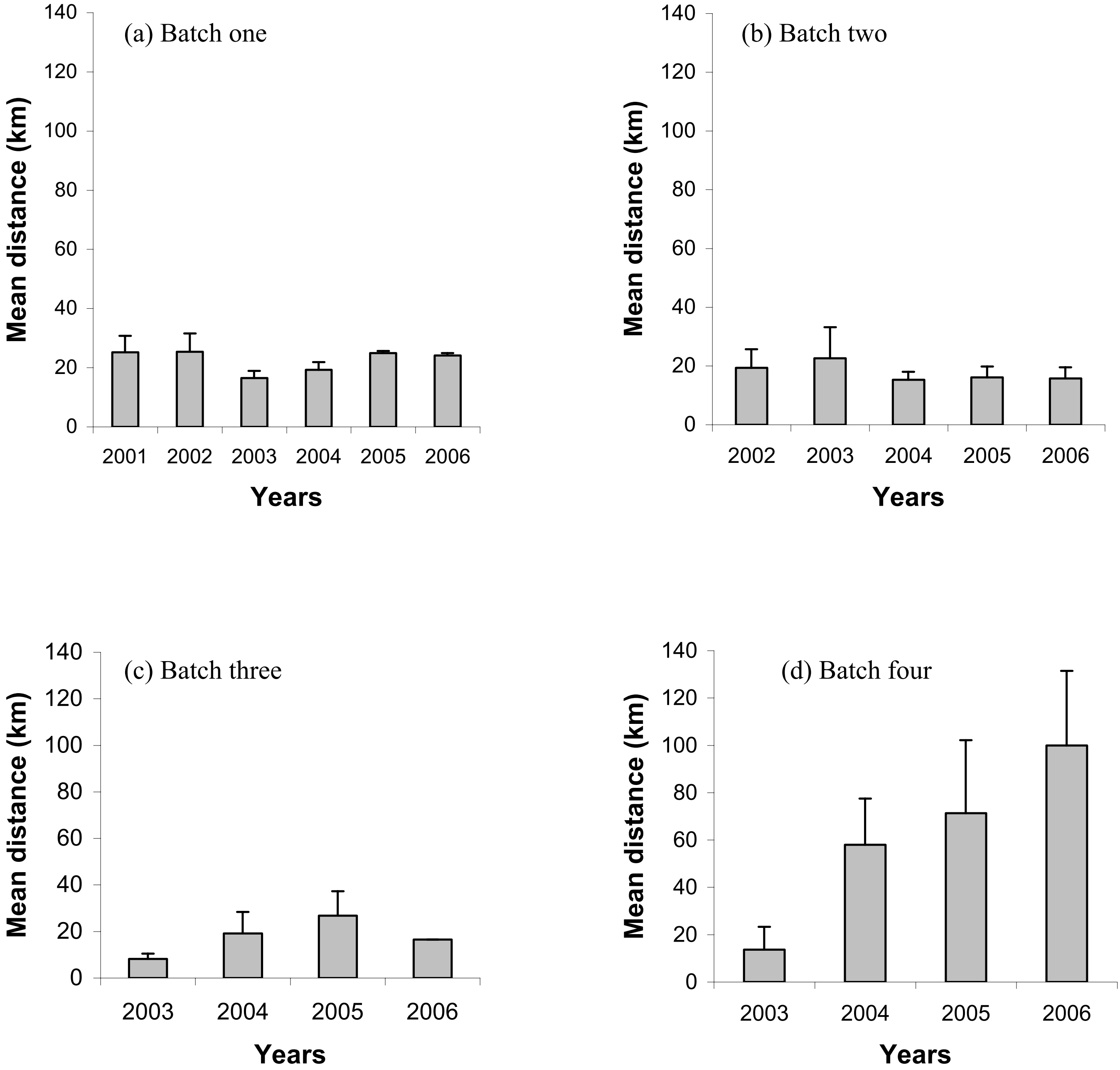

Figure 4: Mean distance (+SE) moved by rhinos in different batches from the release point to the last position they were located each year (Only two animals were located together in batch three in 2006).

Dispersal

Twenty-one rhinos stayed within the game reserve. Only six animals dispersed from the park and these were all females released in the last batch (November 2003). Two of the females, stayed in the park for one year near the release site and then moved out in December 2004 to establish themselves at Makgadikgadi Nxai Pan National Park about 250 km to the south west of Moremi

Game Reserve, where they still resides (Fig 5). The longest distance that they moved from the release site was 257 km. The other four females that dispersed moved out of the park after a month of their release and they seem to be wandering in a big area south west of Moremi Game Reserve approximately 200 km from the release site (Fig 5). In most cases they have been sighted together.

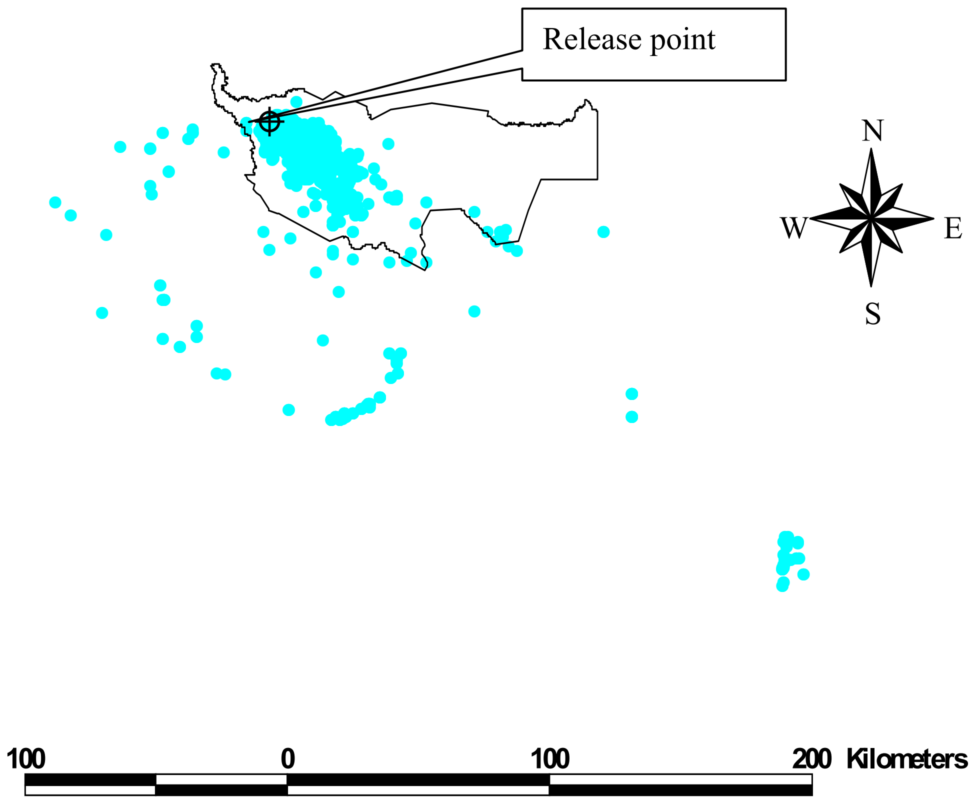

Figure 5: Movement locations of all rhinos, which were released in Moremi Game Reserve. The locations are from 2001 to 2006.

Home ranges

Home range sizes

The home range sizes for the rhinos varied extensively from 17 km^2 to 6706 km^2. Nineteen rhinos had home ranges < 300 km^2 while only two rhinos had home ranges >1000km^2. Core areas calculated at 50% MCP ranged from 5 km^2 to 40 km^2. The two animals that had range sizes >1000 km^2 had core areas of 22 km^2 and 24 km^2, respectively. Home ranges didn't differ significantly with sex (ANOVA; $F = 0.82$, $df = 1$, $P = 0.37$) but were influenced by age (ANOVA; $F = 4.54$, $df = 1$, $P = 0.04$) and release batch (ANOVA; $F = 3.48$, $df = 3$, $P = 0.02$).

Home range sizes for white rhinos released in the last batch were larger than for other release batches (Tukey's Post hoc test $P < 0.05$) (Fig 6). The core areas for all the rhinos in the different batches were not significantly different (ANOVA; $F = 0.45$ $df = 3$, $P = 0.72$)(Fig 7). The mean annual home ranges for batch one and batch two and three (combined) decreased with years after release (Fig 8 a, b)(Fig 9). For batch four rhinos, the mean annual home ranges decreased substantially from 1913 km^2 in 2004 to 30.24 km^2 in 2005 (Fig 8 c)(Fig 9).

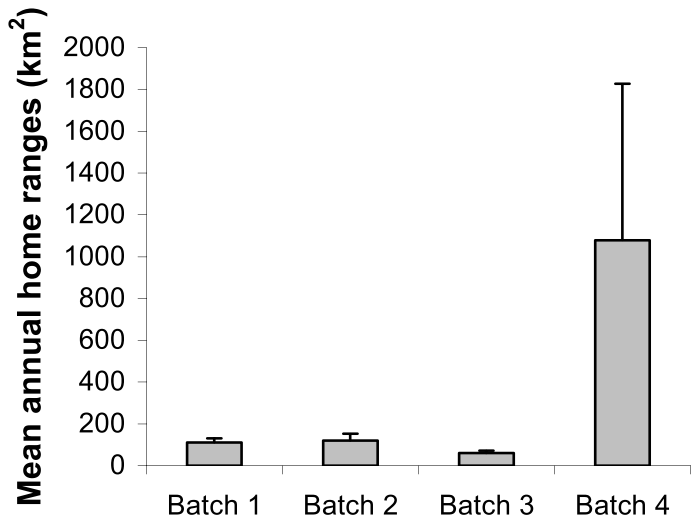

Figure 6: Mean annual home range sizes (+SE) of the rhinos in relation to release batches.

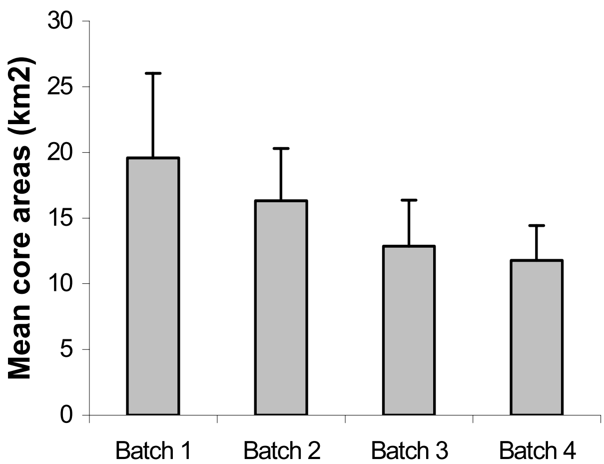

Figure 7: Mean core areas (+SE) of the rhinos in relation to release batches.

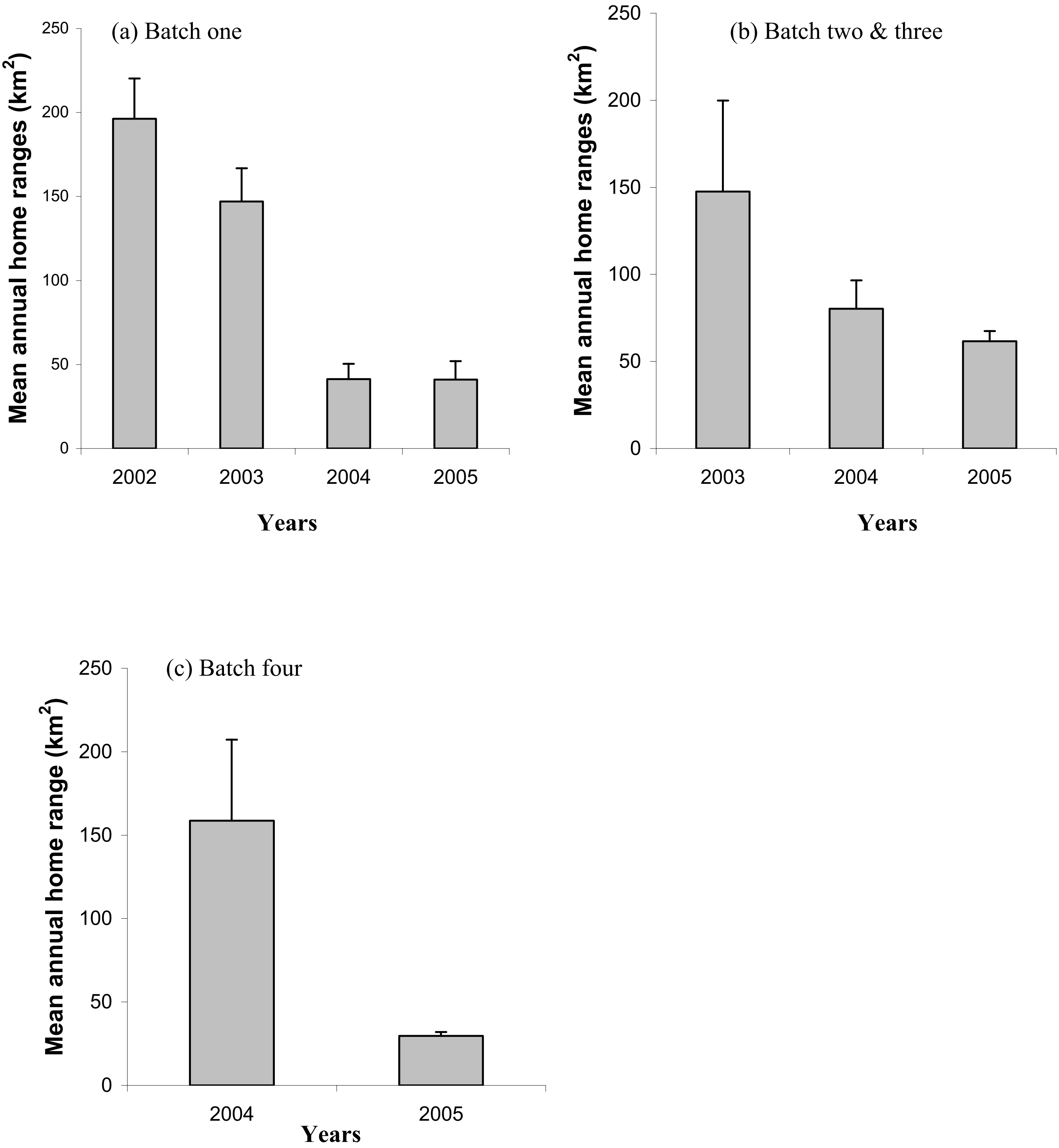

Figure 8: Annual mean home range sizes (+SE) for white rhinos released in the different batches (The two dispersing animals in batch four were not included).

Individual home range overlap between years

Rhinos in batch four had very low overlaps in home ranges between the years and the overlap was different from all the other batches (Tukey post hoc test $P < 0.05$)(Table 3)(Fig 9). Rhinos in batch one had less overlap between years compared with animals in batch three ($T = 6.44$, $df = 5$, $P = 0.001$) (Fig 9). There was an increase in overlap from batch one to batch three (Table 3).

Table 3: White rhino home range overlap expressed as percentage individual home range overlaps of white rhinos between years after release.

Animal	Release batch	% Overlap		
		2002-2003	**2003-2004**	**2004-2005**
Kabelo	1	46	22	43
Mmamatimpane	1	33	-	*22
Sargent	1	31	28	66
Serondela	1	48	26	20
Mombo	2	-	7	69
Maun	2	-	13	29
Moremi	2	-	63	-
Mathathane	2	-	57	2
Mogae	2	-	74	67
Boitumelo	2	-	0	-
Jack	2	-	48	63
Big Joe	2	-	31	47
Mpho	3	-	0	-
Kakana	3	-	70	74
Bogale	3	-	53	76
Tikapoo	3	-	34	-
Amogelang	4	-	-	0
Tebogo	4	-	-	0
Piajo	4	-	-	12

Note * Because of comparison of home range for 2003 and 2005

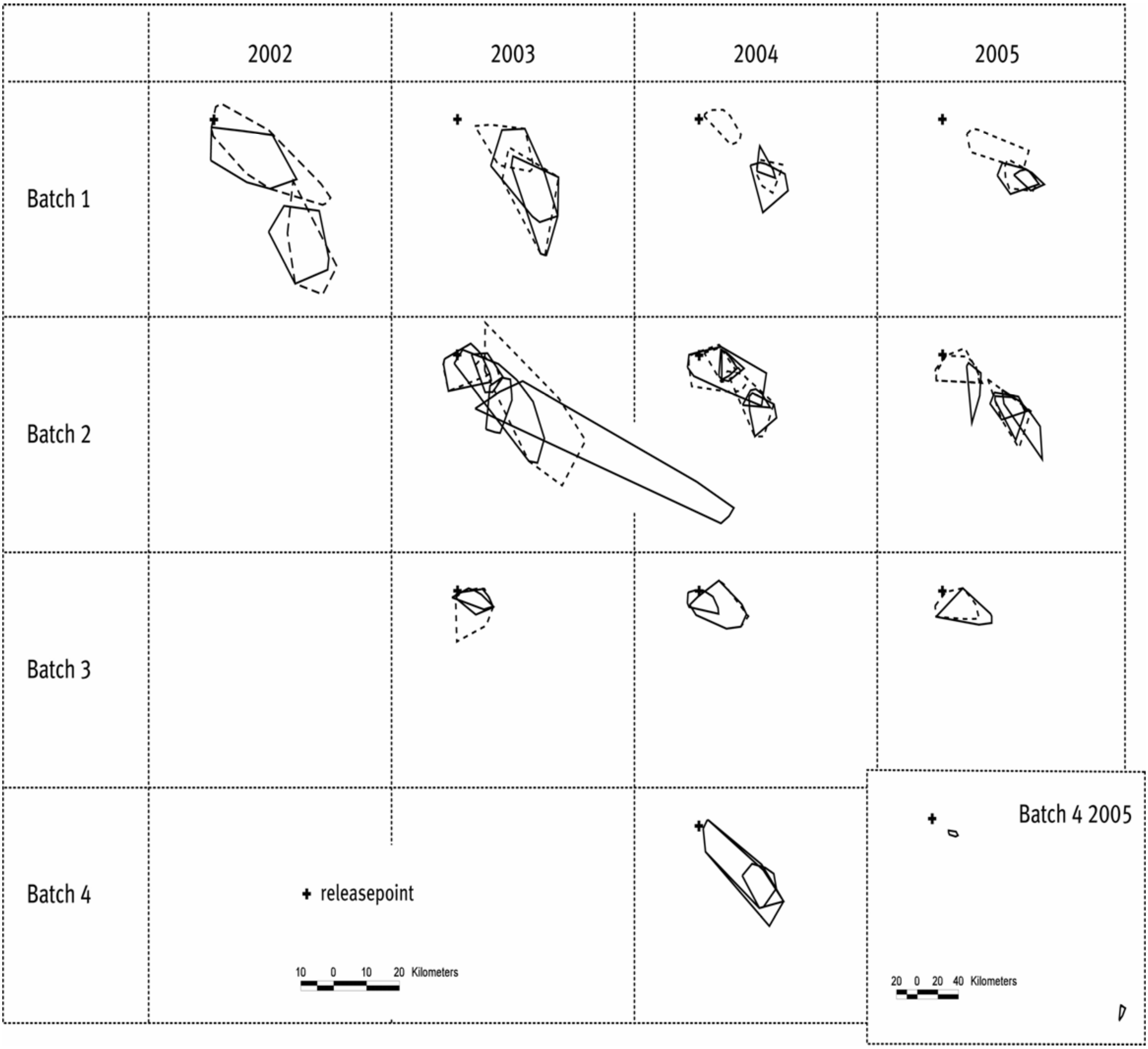

Figure 9: Changes in home range sizes and degree overlap within batches in different years. The scale of all the home ranges is the same except for batch four 2005 because it has a big difference in range sizes.

DISCUSSION

Out of the thirty-two rhinos released five died. A comparatively large proportion of males, three out of eleven died while only two females out of twenty-one females died. Few studies have been done on mortality of translocated white rhinos, but studies done on translocated black rhinos have recorded mortalities from 12.5% to 24% (Adcock et al 1998, Brett 1998). Thus, the 16% (18% including the one that died before it was released) mortality observed in this study is within the mortality ranges recorded for black rhinos. Several factors, such as fighting, capture and translocation stress, and poaching contribute to mortality of translocated rhinos. A study by Brett (1998) showed that territorial fighting was the major cause of mortality, and stress during capture and translocation and poaching were significant. In this study one incidence of mortality by territorial fighting was recorded although only three adult males were released. Two incidences of poaching and one incident of death related to capture and translocation, while one rhino was killed by bushfire.

The group with the highest mortality (40%) was sub-adult males. Adcock et al. (1998) also found that sub-adult males suffered high mortality because they do not adapt quickly to a new environment. One sub-adult died due to natural causes (bushfire), and it was within the reserve. The other sub-adult had dispersed with another sub-adult female and they were both killed. They had moved several kilometers from the reserve to near human settlements where they were poached. Sub-adult males are potentially subjected to territorial aggression from dominant adult males and they also have a tendency to wander during the sub-adult period (Owen-Smith 1988), hence they disperse more than adult rhinos. Though dispersal can be an important aspect of population ecology of large mammals, it is also risky, as dispersing animals are subjected to higher mortality when entering new areas (Shrader & Owen –Smith 2002).

The distance moved by rhinos from the release site varied between batches. Animals from the last batch moved extensively compared to the previously released animals. The last locations for animals in batch one, two and three where within 15-25 km from the release site while batch four animals were 100 km from the release site. Rhinos in batch one, two and three established themselves within the reserve while only six animals in the last batch of released rhinos dispersed out of the reserve. Individual annual home ranges were relatively large just after release compared to the last year of home range calculation. The mean annual home ranges for batch one and batch two and three (combined) decreased with years after release while for batch four rhinos, the mean annual home ranges decreased substantially. The annual home range sizes for the rhinos in this study were large compared to other studies. Pienaar et al (1993) recorded home ranges of 5.5 km^2 – 45.2 km^2 for the reintroduced animals in Kruger National Park and van Gyseghem (1984) recorded home ranges ranging from 6 km^2 to 97 km^2 in Murchison Falls National Park, Uganda. The sizes for the core areas for the rhinos in the different batches were not statistically different. Rhinos in batch four had very large total home ranges, but their core areas were small and not different from the other batches.

Number of previously present rhinos at the time of release seems to be a major factor contributing to the differences in the rate of movement and home range sizes between batches of rhinos. The number of rhinos present in the vicinity of the release site could have an effect on availability of space, availability of suitable habitat and social interactions of the released animals. When the last batch of nine animals was released they faced a situation where eighteen previously established rhinos were found close to the release site. This probably hindered their establishment within the release area and hence they dispersed. Intraspecific competition for resources, most likely food, probably prompted rhinos released later to move further in search of vacant habitat. In increasing densities of most mammals, it has been observed that competition increases the likelihood of dispersal (Matthysen 2005). The same pattern of dispersal was observed in female mountain gazelles (*Gazella gazella*), in central Arabia, released in an area containing conspecifics (Dunham 2000). This resource competition hypothesis is used to explain natal dispersal by many birds and mammals (Greenwood 1980). It was observed that the rhinos that dispersed from the last batch were mostly sub-adults at the time of release and that the adults released the same time stayed within the release site. The resource competition hypothesis proposes that resource scarcity lead to intraspecific competition, so animals with less competitive ability will be forced to disperse (Greenwood 1980). As a general pattern in mammals, dispersing individuals are usually young animals as they are less competitive than adults (Greenwood 1980), which, if true for white rhinos, might explain why young females in batch four moved further than older ones.

In addition to social interactions, the availability of suitable habitat might be another factor that contributed to the long distances traveled and the big home ranges for batch four animals, as it was evident that there was an area in the park that was not occupied. It was observed that the animals concentrated along an island within the reserve as it provides floodplain with nutritious grasses and it has been observed that these areas are preferred by white rhinos (Perrin & Brereton-Stiles 1999, Galpine 2006). The rhinos did not utilise the eastern part of the reserve, and area that has mostly shrubs mixed with mopane (*Colophospermum mopane*) and *Acacia* woodland (Ellery 1993, Ringrose et al. 2002, Department of Environmental Affairs

2005), which is not a suitable habitat for white rhinos. The white rhino's square lips are most suited for mower fashion grazing rather than being suited for selectively picking food items within a given plant community, hence their preferred habitat is mostly savanna grassland (van Gyseghem 1984).

Males seemed less inclined than the females to explore other parts of Moremi in search of home range. They generally settled near the release site, while females found ranges in suitable areas throughout the reserve and even out of the game reserve. In mammals, it has been observed that dispersal is predominantly male biased (Greenwood 1980). Although this might be the case, sex-specific dispersal is dependent on what is being defended, mates or resources and the type of mating system (Wolff 1994). When resource defence systems do occur in mammals, they lead to female biased dispersal and where mate defence system occur they lead to male biased dispersal (Perrin & Mazalov 2000). In this study it is believed that competition for resources, as more animals were released in the same area, influenced the dispersal pattern, hence the dispersal was female-biased. Two of the animals that dispersed moved about 250 km from the release site to another national park where they seem to be establishing. For the other four rhinos that dispersed, only their home ranges for a year after release are available and thus they cannot be compared with the other years, but the rhinos seem to be moving within a relatively large area outside the game reserve. Most of their movements can be related to exploratory movements as these animals displayed signs of not yet being established. The rhinos dispersed in groups of two and four, displaying the behaviour of dispersal of companions observed in white rhinos by Shrader & Owen-Smith (2002).

Rhinos in batch one overlapped less than batch two and three and batch four had very low overlaps compared with the other batches. Most probably this is due to the fact that the first batch included two adult males that have exclusive home ranges. Also with increasing number of rhinos present when batch two and three were released, the overlaps were increasing. However, these two batches only had sub-adult males and females, which are not territorial (Owen-Smith 1988). Batch four had very low overlaps as most of the animals in this batch dispersed from the park to different areas outside the park. The rhinos in batch four were all females and it was expected that they would overlap as several studies have shown that female home ranges do overlap to a considerable extent (van Gyseghem 1984, Owen-smith 1988, Rachlow et al. 1999). The dispersed rhinos in batch four shifted home ranges completely from the first to the second year after release. Such complete change in home ranges may be because new animals have a competitive disadvantage compared to previously established animals.

CONCLUSION

The study dealt with a newly established population of white rhinos and it demonstrated a dynamic situation where occupancy distances from the release site varied between years, especially for animals released in the last batch. Also there was a variation in home range sizes, which decreased from year to year in all the batches. Individual movement data clearly demonstrates that the number of rhinos present at the time of release influenced movement patterns and home range sizes for later re-introduced white rhinos. Other factors like social characteristics of white rhinos and characteristics of the area of release showed that they also had an influence in the establishment of rhinos in the game reserve. It was also evident that with increased number of rhinos in the release site there was more overlap of ranges in the first three batches, except for the two adult bulls in batch one, which had exclusive home ranges. Most of the rhinos in batch four had very low overlaps as they shifted home ranges totally between the first year of release and 2005. Although the sample size is low, mortality seems to be biased towards sub-adult males. Mortality was comparatively low for females, despite that the number of released females were high. Proper monitoring of the released animals is a very important aspect of the re-introduction programmes, so it’s important that the relevant organisations make a commitment to monitoring. Data from monitoring can assist in making better and informed decision on the future translocation programmes, thus achieving the conservation objective of re-establishing rhinos in Botswana.

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