An example of changing management to facilitate successful breeding in a group of semi-intensively kept black rhino (*Diceros bicornis*)

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Abstract
The purpose of this study was to examine the lack of breeding in a herd of seven rhino, kept on a game ranch in Zimbabwe. The herd of four females and three males spent the day out on the ranch herded under armed guard and the night penned to protect them from poachers. Despite all females showing behavioural signs of oestrous, at the time of the study (January 1996) only one had produced young. The maintenance activity displayed by the herd was typical of wild rhino. The typical distances of only 5m and 15m between individuals were very different from those displayed by 'solitary' or 'semi-solitary' rhino in the wild, thus proximity relations were compromised. There was some evidence of associations between pairs of rhino - as seen in the wild. All individuals were more socially involved in the pen than out in the day ($p < 0.05$), although the tendency of an individual to be a 'performer' or a 'receiver' remained the same irrespective of location. Penning the rhino at night increased aggressive activity, particularly by the breeding female. It was suggested that the ability of the three 'non breeding' females to reproduce, was being inhibited by both enforced proximity with other individuals (both during the day and at night) and the presence of an aggressive, breeding female. A number of improvements to the management of these rhino were implemented. These included physical modifications to the pen to permit greater individual privacy at night, and allowing individuals to maintain greater distances from each other when herded during in the day. These changes were deemed successful, since by the end of 1998 all of the three 'non breeding' females had bred, and four more calves were born.

Introduction

The black rhinoceros (*Diceros bicornis*) population in Africa has suffered a dramatic decline (first noted by Ritchie, 1963). In 1975 the black rhino was listed in Appendix II of CITES since it was thought that the species could become threatened if their trade was not regulated. By February 1977 it had been moved onto Appendix I as they had become threatened with extinction and subject to international trade. However, despite the trade ban, the African black rhino population continued to decline (Berger, 1993; Thorne & Whalen, 1996). Some 40,000 individuals were killed between 1970 and 1987 to provide over 100 tonnes of rhino horn (Tudge, 1991). The IUCN's African Rhino Specialist Group (AfRSG) reported that in 1980 there were 14,785 individuals, but in 1997 only 2599 black rhino remained (1043 in South Africa, 707 in Namibia, 424 in Kenya and 339 in Zimbabwe).

A number of approaches has been taken in order to secure a sustainable population of African black rhino. The major programmes are protection *in situ*, management to maximize productivity and produce surplus animals, translocation to fenced reserves (intensive protection zones), development of informer networks and specialized investigation outside reserves and ban on the trade of rhino horn. An alternative approach taken in the late 1980s was the dehorning of wild rhino in order to discourage poaching. However, there has been considerable debate regarding the usefulness of this approach (see Leader-Williams, 1989).

Some believe that the survival of rhino can be assured by keeping them in captivity (e.g. Wells, 1997), but captive black rhino tend to be poor breeders. Kock *et al*. (1991) and Miller (1993) both attributed the failure of captive rhinos to breed to an haemolytic syndrome about which very little is known. Although, Miller (1993) did suggest that, in some individuals, the occurrence of haemolytical aenemia may be linked to the spirochete bacterium *Leptospirosis interrogans;* a relative of *Leptospirosis hardjo*, a bacterium known to cause sub-fertility in dairy cattle world wide (Peters & Ball, 1995). Despite this, the basic reproductive biology of the black rhino remains unclear (Blumer, 1996; Mehrdadfar, 1997). To date successful breeding of rhino kept in zoos and wildlife parks is poor (Gould, pers. comm.). Thorne and Whalen, 1996, stated 208 captive born individuals around the world. Whilst this low success may be due to a 'haemolytic syndrome', there may be other causes. One aspect of breeding in captivity which has received very little research attention in black rhino is 'behavioural inhibition of breeding' - where the behaviour of some individuals may inhibit others from reproducing. This phenomenon has been reported in a wider range of other species including dairy cattle (Kiley-Worthington, 1977), mole rats (Bennet *et al*., 1996), alpine marmots (Arnold & Dittami, 1997) and common marmosets (Saltzman *et al.,* 1998).

When keeping wild species in captivity it is important to understand both their social and sexual behaviour in the wild in order to manage them as well as possible in captivity, minimising 'stress' and to encourage breeding (see Mehrdadfar, 1997). In the wild, female black rhino have home ranges (Mukinya, 1973; Estes, 1995). They tend to be solitary (Goddard, 1967), although sometimes associate in pairs (usually a cow and her calf, or a male and a female) or in groups of three (usually a cow and two calves) (Ritchie, 1963). Rhino are both polygynous and polyandrous (Goddard, 1966) and tend to reproduce slowly with an annual birth rate of 6.8-10.9% (Goddard, 1970). Males are fully sexually mature by seven or eight, but can successfully cover females at the age of four. Females reach sexual maturity by four years (Estes, 1995). Oestrous lasts between one and six days. Mating can take place at any time of the year (Ritchie, 1963) and gestation lasts approximately fifteen months (Estes, 1995).

Clearly, since relatively few black rhino remain, the establishment of small breeding herds, kept in appropriately managed systems (Blumer, 1996) in which they can be guarded against poachers, yet still breed successfully, is essential for their preservation. One of these herds was established at Imire Game Ranch in Zimbabwe in 1987. However, by January 1996, only one of the four females had reproduced. Her first calf died within three months of birth and her second was born shortly after this study had ended. The purpose of this study therefore, was to examine the lack of breeding in this herd, using a detailed assessment of the behaviour exhibited by the seven individuals to provide a basis for improving their management. Since evidence of the influence of the behaviour associated with social relationships on breeding success exists for other mammalian species, a detailed assessment of the relations between individuals within the herd was also conducted. This assessment was not limited to the use of 'dominance hierarchies', since these have give an inadequate, oversimplified description of the social relations between individuals within a group (see Syme, 1974; Kiley-Worthington, 1977; Syme & Syme, 1979; Giacoma & Messeri, 1992). Individual attributes have been demonstrated to be important determinants of social relations (Kiley- Worthington, 1977), two of which, 'Total social involvement' (Kiley-Worthington, 1978; Bradshaw, 1992; Arnold & Grassia, 1983) and the tendency to be either a 'performer' or a 'receiver' (Kiley-Worthington, 1978; Berk, 1989; Freeman *et al.,* 1992) are used in this study. Two possible causes of inhibition of breeding (by whatever mechanism) were identified prior to the study: first, enforced proximity and second, the nature of the social relations between individuals in the herd.

Method

Animals and study site

Seven black rhino belonging to the Zimbabwe Department of National Parks and Wildlife Management were involved in this study: four females (Cuckoo, D.J., Mvu and Amber) and three

males (Sprinter, Noddy and Fumbi). At the time of the study all individuals were nine years old. All were born in the wild between April 1987 and June 1987 and had been separated from their dams shortly after birth as their dams were poached and/or died. They were brought to Imire Game Ranch between two and six months of age, and thereafter lived as a single herd. Imire Game Ranch is a 1500ha park in Zimbabwe (30^{o} latitude, 20^{o} longitude) with *Brachystegia* woodland and *Eucalyptus* coppice, and some *Themeda* dominated grassland. Imire supports populations of various antelope, elephants and buffalo, but there are no large predators. The game ranch is run in conjunction with a commercial farm producing cattle, tobacco and maize.

Rhino husbandry

The rhino were kept as a single herd all of the time for security reasons. They spent the night in the 'rhino boma' (pen), surrounded by sand bags within an electrified compound. The males and females were separated on entry to their boma. The females occupied a total area of 15m x 25m (with 3 smaller sub pens each measuring 5m x 4m which they could go into if they wished). The males occupied a similar sized area (15m x 8m) which was not subdivided into smaller areas. At 08:00 they were let out into the game park under the close surveillance of at least three armed scouts. Wire whips were used to discourage individual rhino from straying from the herd (during this study individuals were never observed to be more than approximately 200m from the remainder of the herd). At 13:30 the rhino were herded to a pre-arranged site and fed a small quantity of cattle cubes (approximately 1.5kg each) to enable visitors to the Ranch partaking in a 'wildlife observation drive' to view the rhino at close range. At this time the rhino typically met up with the group of six elephants who were also herded while browzing and grazing. The rhino spent the remainder of the afternoon browzing before being herded back to the rhino boma between 16:30 and 17:00, where they received *ad libitum* hay, minerals and water. At 17:30 they each suckled 5l of a milky solution from a teated container given to them from outside their pens. This was done daily in order to facilitate the administration of medication at any time.

Pregnancy testing was carried out by testing faecal hormone levels. At the outset of the study it was suggested that one female, D.J., was unlikely to breed as she had a prolapsed uterus as a result of a vaginal injury (caused by horning by a male).

Observations

The head rhino scout had notes on the 'sexual activity' of the rhino since January 1995, which included the dates and behavioural indicators of oestrous (frequency of chasing, mounting without copulation and mounting with copulation for each individual. The rhino were observed from 7th - 31st January 1996 (inclusive), between 08.00 and 16.30 when out in the game park and a further hour immediately after penning between 17:30 and 18:30.

The rhino were observed for 407 rhino hours during the day and 119 rhino hours in the pen, i.e. 524 rhino hours in all.

Maintenance activity

The maintenance activities of all of the rhino were recorded onto a check sheet every 15 minutes using scan sampling (Altmann, 1974). Maintenance activity was divided into browsing, walking, standing, drinking, lying resting, engaging in social activity or eliminating (urinating and defecating).

Proximity relations

Proximity relations were also recorded every 15 minutes using scan sampling. The identity of each rhino's nearest neighbour, and the distance to the nearest neighbour was noted onto a check sheet. Distances were coded as follows: 1 = touching; 2 = up to 5m; 3 = 5-15m; 4 = 15-30m; 5 = 30-50m;

6 = 50-100m and 7 = over 100m (adapted from similar work by Kiley-Worthington & de la Plain, 1983; Randle, 1994).

Social interactions
Social interactions between the rhino were observed using 'all-occurrences' sampling (Martin & Bateson, 1986), as and when they occurred (Altmann, 1974). The identities of the 'performer' and the 'receiver', and the behaviours in which they were engaged were either recorded using a programme (Social) written by Lea and Randle (1991) for a Psion 3a organiser (first author), or a dictaphone (second author, two trained scouts).

For the purposes of this study social activity was divided into four broad categories: aggression, withdrawing, affiliation and 'other'. The 'other' category contained behaviors for which the meaning was not clear from the 'receivers' response (Kiley-Worthington & Randle, in prep.).

During the hour directly after penning, the social interactions occurring within the male group were observed by one author, while the social interactions occurring within the female group were observed by the other author, both using 'all-occurrences' sampling. The two authors alternated between the male and female groups on a daily basis.

Data analysis
All of the data were transcribed into the Minitab statistical package. The P/R (performing to receiving) measure was derived from the number of interactions performed divided by the number of interactions received. A ratio of >1 indicates that an individual is a 'performer', while a ratio of <1 indicates that an individual is a 'receiver'. The TSI (total social involvement) measure was calculated from the total number of interactions an individual was involved in (irrespective of whether as a performer or a receiver.) Data analysis was largely qualitative, and where quantitative, mainly nonparametric due to the small sample size.

Results
Behaviour associated with breeding
Only one female (Cuckoo) had calved at the game park (in 1993, then again on 23rd January 1996). At the time of the study none of the other three females were pregnant, however, all had exhibited 'behavioural signs' of oestrous between 1st January 1995 and 1st January 1996: D.J. was observed being chased by a male 14 times, mounted without copulation 10 times and with copulation six times. Mvu was chased by a male 43 times, mounted without copulation eight times and with copulation 11 times. Amber was chased by a male 12 times, mounted without copulation twice and with copulation once.

Maintenance activity
The black rhino spent the majority of their time browsing and grazing (51.4%), walking (19.3%) and standing (16.6%). The remainder of the time was spent resting (7.8%), engaging in social interaction (4.1%), drinking (0.7%) and eliminating (0.1%).

Proximity relations
All three of the males, the breeding female and one of the non breeding females were typically 5-15m from their nearest neighbour. The remaining two non breeding females (DJ and Mvu) were typically 0-5m from their nearest neighbour.

Table 1 summarises the proximal relations between the seven individual rhino, based on 1752 observations, 251 per rhino, over the three week period. Each figure is the total number of times an individual was the nearest neighbour of another individual. An index of 'popularity' (based on

		Nearest Neighbour						
Focal Individual		Males			Females			
		SPR	NOD	FUM	CUC	DJ	MVU	AMB
Males	SPR	---	33	39	31	50	43	22
	NOD	35	---	33	18	81[1]	33	14
	FUM	41	47	---	22	43	31	32
Females	CUC	19	25	22	---	30	30	89[2]
	DJ	33	57[1]	37	32	---	31	24
	MVU	32	36	39	37	41	---	31
	AMB	27	19	24	90[2]	18	37	---
Total times a nearest neighbour		187	217	194	230	263	205	212
Rank popularity'		7	5	6	2	1	4	3

Table 1. Summary of the proximity relations between the seven individual black rhino. [1, 2] indicate alliances based on analysis of standardised residuals subsequent to a significant Chi-squared test. Obvious alliances are evident between [1] a male and a female (DJ and Noddy) and [2] two females (Cuckoo and Amber). [3] The 'popularity' of each individual is derived from the number of times that he/she is the nearest neighbour of other individuals. DJ is the most popular and Sprinter is the least popular.

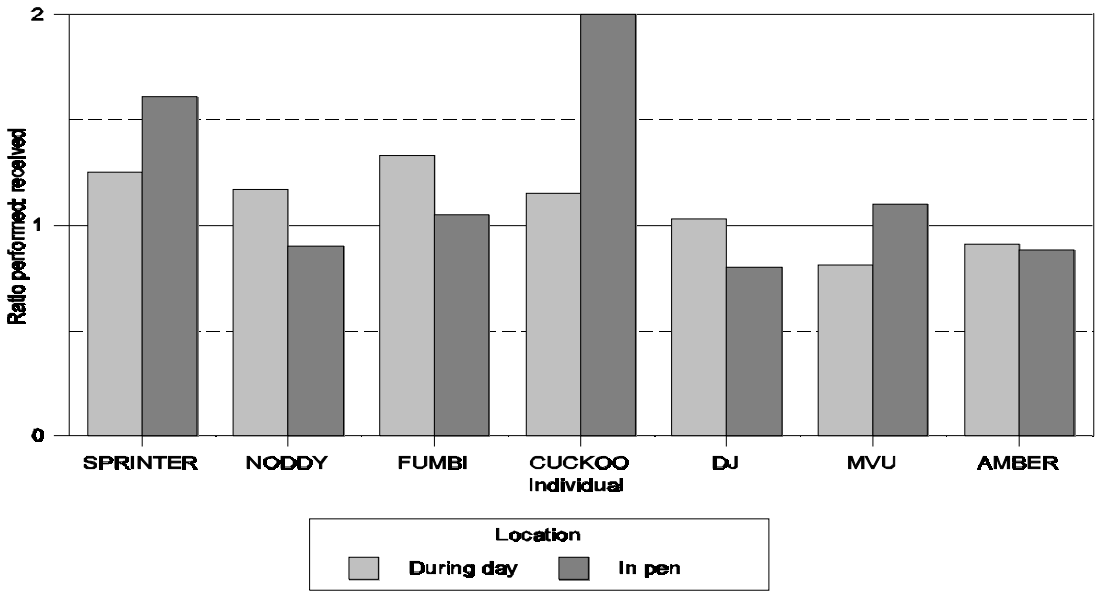
ranks of the number of times an individual is the nearest neighbour of any other rhino) is also shown on the last row of the table.

Both males and females preferred females as their nearest neighbours (χ^2 [with Yate's correction] = 5.84, *d.f.* = 1, $p < 0.05$). There were two obvious alliances, one between two of the females (Cuckoo and Amber), and a slightly weaker one between a female (D.J.) and a male (Noddy).

Social interaction

1778 interactions were observed over 405 rhino hours during the day. 46% of these were of an affiliative nature, 7% aggressive and 5% withdrawing. The remaining 46% were classified as 'other' since their nature was unclear. Analysis of the 867 interactions observed over 119 rhino hours during the first hour of penning for the single sex groups indicated that the types of interactions occurring were similar. Most of the interaction was affiliative (males 18.3%, females 22.5%), with more aggression (males 14.6%, females 16.1%) but less withdrawing (males 1.2%, females 2.5%) when in the pen than when out during the day. During penning males and females also exhibited similar amounts of 'other' social interaction (65.9% and 58.9% respectively). Penned females typically exhibited 7.00 interactions/individual/hour, whilst penned males typically exhibited 7.67 interactions/individual/hour.

More detailed analysis of the social activity (during the day and in the boma during the first hour of penning) established whether an individual tended to be a 'performer' (i.e. perform more than he/she received) or a 'receiver' (i.e. receive more than he/she performed) (fig. 1) and how socially involved he/she was overall (fig. 2).



(A value of less than 1 means 'receiver', more than 1 means 'performer'.)

Figure 1. The tendencies of individual rhino to be 'performers' or 'receivers' during the day and the first hour of penning at night.

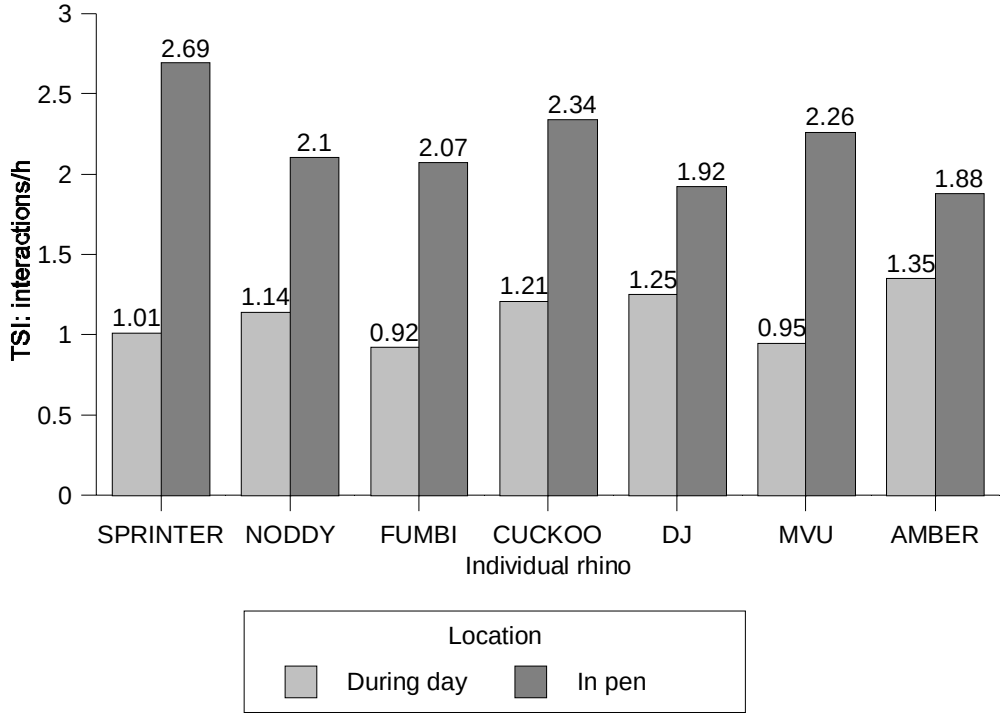


Figure 2. The TSI (total social involvement) occurring per hour during the day and the first hour of penning at night.

Whilst there was no significant difference in the performing/receiving tendency when out in the day and being penned at night (Wilcoxon T = 12; N =7; ns), there was significantly more total social

involvement (TSI) exhibited during the first hour of penning (2.18 interactions/rhino/h ± 0.28) than during the day (1.12 interactions/rhino/h ± 0.17) (Wilcoxon T = 0; N = 7; $p < 0.05$).

The amounts of aggression performed either as an initiator of an interaction ('performer') and as a response to another ('recipient response') by each of the four females and three males within the single sex groups during the first hour of penning at night are shown in Table 2.

Performer	Recipient				
Females	Cuckoo	DJ	Mvu	Amber	**Total**
Cuckoo	---	6	11	15	**32**
DJ	2	---	4	5	**11**
Mvu	0	2	---	6	**8**
Amber	3	7	13	---	**23**
Males	Sprinter	Noddy	Fumbi	**Total**	
Sprinter	---	15	17	**32**	
Noddy	9	---	2	**11**	
Fumbi	6	1	---	**7**	

Data are frequencies and consist of the sum of number of times aggression is performed by the initiator of an interaction (the 'performer') and the number of times that aggression is performed by a recipient as a 'recipient response'.

Table 2. Amount of aggression occurring between individuals within the single sex groups.

Breeding after implementation of suggested changes

A number of changes were suggested regarding both the physical design of the pen and the herding of the rhino during the day. These were implemented in spring 1996 and by the end of 1998 a further four calves had been born. The breeding female (Cuckoo) had her third calf (a female), while the three non breeding females (Amber, Mvu, DJ) each had a male calf. In January 2000 all four females were pregnant again.

Discussion

If, as a result of this study, just one individual of this threatened species (Thorne & Whalen, 1996) breeds successfully, that is an important result of international relevance. Since all of the non-breeding females exhibited behaviour typical of oestrus prior to the study, they should have been breeding, given the multi-male, multi-female structure of the herd. Since, the maintenance activity exhibited was typical of wild individuals (Estes, 1995) there was no evidence of the disrupted time budgeting often seen in individuals kept inappropriately in terms of their physiological requirements (e.g. time spent feeding reduced, leaving more time for 'boredom'). Their environment consisted of mainly low veld with some *Brachystegia* woodland, therefore the ecological carrying capacity would be in the region of one rhino per 1000-1500 ha. Whereas there were actually seven rhinos/1500ha which clearly constitutes a very high stocking density. It could also be argued that a lack of palatable browse could lead to a vitamin and/or mineral deficiency, which may have resulted in the observed extended delay to first calving. While these are both possible contributing factors to the apparent lack of breeding in the females, it must be pointed out that the land the rhino were grazing/browsing was part of a farming system, achieving more growth than that of typical unmanaged low veld. Furthermore, there were no visual signs of poor condition and the rhino were

fed balanced concentrates (cattle cubes) and had access to *ad libitum* hay and mineral supplements when penned in the boma at night.

It was considered more likely that the factors contributing to the lack of successful breeding were behavioural, and more specifically, social. As Ritchie (1963) stated black rhino in the wild tend to be solitary. The rhino in this study were forced to be within 5-15m of their nearest neighbour (by the scouts herding them together in order to protect them from poachers). This enforced proximity must be considered as a possible cause of the lack of breeding. The findings that females were the preferred nearest neighbours of both males and females and there were two clear alliances (one between two females and one between a male and a non breeding female) demonstrate that first, there was opportunity to mate (male-female association) and second, associations typical of truly wild rhino populations occurred (i.e. between two females; see Ritchie, 1963).

It is difficult to determine if the social behavior exhibited by this herd of black rhino was typical of truly wild individuals since very little detailed information has been published to date. All individuals were significantly more socially involved when penned than during the day and, more specifically, there was a substantial increase in aggression on penning (at least doubled), a phenomenon seen in other species such as pigs (Mount & Seabrook, 1993). It is therefore likely that penning the rhino at night was also a major contributing factor to the lack of breeding. Given the size of the females' pen (15 x 25m in total, with three internal pens) it was not possible for each female to maintain a distance of at least 5m from her nearest neighbour. It is therefore likely that the confinement, coupled with the increase in aggressive activity, could exacerbate the tendency of some females to be 'performers' and others to be 'receivers'.

It is suggested that the three non breeding females were being inhibited from breeding by a number of factors; first, enforced close proximity with other individuals when herded during the day and confined with other females in the pen at night and second, increased levels of aggression from the breeding female. Indeed the breeding female was clearly a 'performer' at all times, involved in most of the social interaction occurring in the female pen (particularly aggression), whilst the three non breeding females tended to be 'receivers', especially of aggression (similar tendencies were apparent when out in the herd during the day.) Whilst the amount of aggression occurring was not resulting in obvious physical damage, it might very well have been having a psychological effect on breeding (Skinner, 1972). Obviously the high levels of aggression exhibited by the breeding female may have been due to her imminent calving. However, the reason why is not as important as the fact that she was by nature an aggressive individual and the 'inhibiting' effect she was having on the other three females.

In summary it seems that the lack of breeding in this small group of black rhino was caused (at least partly) by their management. It was acknowledged that the herding by day and penning by night had to continue (in order to protect them from poaching), however, some changes were suggested in attempt to encourage breeding. First, when out in the game park during the day, individual or pairs of rhinos should be allowed to achieve a semi-solitary status, maintaining considerable distances (at least 200m) from the rest of the herd. The guards were instructed to allow the herd to split and to follow different groups of rhino or even a single rhino if necessary. As Kiley-Worthington (1977) pointed out, wild female and male ungulates need to spend a considerable amount of time together in pairs in order to achieve a prolonged courtship, and consequently successful mating. In the reported situation it was likely that the herding was disrupting courtship. Second, measures were also suggested to reduce the aggressive interactions occurring during penning, especially between the females. For the females, this could be achieved in the short term by gating off the existing sub pens in order to separate individuals and allow them privacy. In the long term it was suggested that a larger pen should be constructed where individual

females could withdraw and isolate themselves. A gate between the male and female pen would also be advisable for transfer of individuals for breeding purposes.

It is commonly found that hand rearing individuals and raising white rhino siblings together leads to a failure in breeding in captivity. This could be avoided in this herd of black rhino by allowing voluntary separation of individuals within the herd. There may be more flexibility in such a semi-intensive system as in the game park, however such considerations should be included in the environmental design in urban zoos.

The improvements to the management of this herd of black rhino were implemented in 1996, subsequent to the breeding female having her second offspring in January 1996. To date the breeding female has had another two calves, and all three of the non breeding females have successfully bred on more than one occasion. This successful breeding group has facilitated the reintroduction of black rhino to the wild (under surveillance).

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