



Original Investigation

Social and reproductive behaviour of critically endangered northern white rhinoceros in a zoological garden

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ABSTRACT

Northern and southern white rhinos have poor reproduction in captivity and social interactions between them, especially increased agonistic behaviour, are believed to be one of the possible reasons. Northern white rhino is currently on the brink of extinction with less than ten animals surviving. We studied the social behaviour of northern white rhinos in zoological garden and investigated the effects of separation of the oldest, wild-born female from the herd on the social behaviour of other group members. After the separation, the numbers of agonistic and the play interactions between the animals significantly increased, no change was found in cohesive behaviour. Our results suggest that a composition of white rhino groups has a significant influence on social interactions between the animals and that better knowledge of proper composition of their groups in captivity in terms of age, sex and wild or zoo origin might improve animals' well-being and also increase a chance for reproduction.

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Introduction

The northern and southern white rhinos have very low reproductive rate in captivity (e.g. Patton et al., 1999; Hermes et al., 2005, 2006) and possible reasons for this include factors such as reproductive pathologies (Hermes et al., 2005, 2006), diet composition (Patisaul, 2012) or lack of natural seasonal changes (Kretzschmar et al., 2004). Previous research has shown that social interactions between the animals, especially increased agonistic behaviour might also play a significant role (Meister, 1997; Kuneš and Bičík 2002; Mettrione et al., 2007).

Adult northern and southern white rhino males are territorial while females, subadults and juveniles live in overlapping home ranges in groups consisting most often from 2–3 individuals (Owen-Smith, 1973, 1975; van Gysegem 1984). Companionships between free-ranging white rhinos, mainly those involving subadults, usually last less than a month (Owen-Smith, 1973; Shrader and Owen-Smith, 2002) and home ranges of females can encompass some 6–7 males' territories although they spend most of their time in one or other two adjacent territories (Owen-Smith, 1973). Contrary to this, white rhinos in zoological gardens are often kept in groups of the same composition for many years and although a group could be of optimal size, if its structure and composition are not appropriate, the requirements for the optimal social, reproductive or psychological needs of animals

might not be met (Price and Stoinski, 2007). Appropriate group composition and change of the social structure in white rhino herds could therefore be beneficial for animals' well-being and might also improve a chance for reproduction. However, studies investigating the influence of the changes in group structure on the social behaviour of captive white rhinos are completely lacking.

Recent reassessment of taxonomy of the northern and southern white rhinos, which is currently under discussion (see Knight, 2011), has suggested their recognition as two distinct species: *Ceratotherium cottoni* and *Ceratotherium simum*, respectively (Groves et al., 2010). The only place where wild northern white rhinoceros has occurred since 1980s is Garamba National Park in the Democratic Republic of Congo (Hillman Smith, 2006), but most recent surveys have not found any signs of their continued survival (Brooks, 2009). At present, less than ten captive northern white rhinos survive in Kenya, California and in the Czech Republic.

We investigated possible changes in the behaviour of a group of five northern white rhinos following removal of one female from the herd. We also examined potential social dominance among the rhinos and ascertained if agonistic behaviour between them increased during the feeding.

Material and methods

Animals

We observed a group of six northern white rhinos in zoological garden Dvůr Králové in the Czech Republic from July

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Table 1

List of the rhinos in zoological garden Dvůr Králové.

Rhino	Sex/studbook no.	Age (years)	Born
SUNI	Male/#0630	Adult (25)	1980/Zoo-born (parents NASIMA/SAÚT)
NESÁŘÍ	Female/#0377	Adult (33)	1972/Wild-born (died 2011)
NASI	Female/#0476	Adult (28)	1977/Zoo-born (parents NASIMA/ARTHUR) (died 2007)
NABIRÉ	Female/#0789	Adult (22)	1983/Zoo-born (parents NASIMA/SÚDÁN)
NÁJIN	Female/#0943	Adult (16)	1989/Zoo-born (parents NASIMA/SÚDÁN)
FATU	Female/#1305	Subadult (5)	2000/Zoo-born (parents NÁJIN/SAÚT)

to November 2005 in the outside enclosure (3000 m²). One of them (NASI) was a hybrid between the northern and southern white rhino (Table 1). Clumped grass or hay was available at a feeding place in the enclosure; other food was provided in stables.

Female NESÁŘÍ joined other four females two months prior to the start of this study after four years of separation from them (in the last two years, she had been in group with SUNI) and male SUNI was socialized with them a month later. Before that, the four females were in a group with another male and despite his regular mating with female NÁJIN, no pregnancy was achieved. The management therefore decided to exchange the males. NESÁŘÍ, was separated from the herd seven weeks after the start of this study due to the risk of getting chilled at night, which could have worsened her joint problems (at this time, the other animals were left in the outside enclosure also during the night). The observations were thus divided into two periods: seven weeks before the separation and ten weeks after.

Behavioural observations

The rhinos were observed for 323 h. We registered pre-determined types of the agonistic, cohesive and play behaviour (see Appendix A for ethogram) by focal group sampling. The activity of the rhinos was recorded by scan sampling every 5 min using a timer (Altmann, 1974). The agonistic behaviour was recorded with regards to the fact if it occurred during the feeding (at least one of the participants was feeding) or during other activities. A recipient and/or an actor of agonistic activity “snort” could sometimes not be determined; these situations took place mainly during the feeding, when all rhinos were concentrated at the feeding place. These “snorts” were therefore not registered.

We included into the analysis of social behaviour only data when no female was in oestrus as the behaviour of the whole group was strongly influenced by it. The time of observation was therefore 99 h 50 min for period when NESÁŘÍ had been in the herd and 94 h 10 min after she was separated. A female in oestrus could be recognized well according to the behaviour of the bull. During the courtship, a male approaches a female frequently with distance decreasing vocalization (hic call), places his head on her rump and after that mounts her and mates with her (Owen-Smith, 1973).

To assess possible dominance hierarchy among the animals, we counted a scale score for each animal following Jameson et al. (1999), which depends on the proportion of wins and losses in its encounters with others and also on the scale scores of other animals, which it met in agonistic encounters. Initial scale score: $s(a_t) = [\alpha(2W_t - N_t)/2N_t]$; final scale score: $s(a_t) = [2(W_t - L_t)/N_t] + Q$; where α is a constant = $\sqrt{2\pi} = 2.50663$; W_t is the number of encounters in which animal a_t was observed to have won; N_t is the number of encounters in which a_t was involved; L_t is the number of encounters in which a_t lost; Q_t is the mean initial scale score of those animals that a_t met in agonistic encounters. We

used numbers of agonistic activities directed from or received by a particular animal as numbers of wins and losses.

Statistical analysis

We tested for differences in the social behaviour of rhinos between the periods when NESÁŘÍ had been in the herd and after she was separated by nonparametric Wilcoxon test; social interactions between NESÁŘÍ and other group members were excluded from this analysis. A significance level of 5% (two-tailed tests) was accepted for all statistical tests and we applied a Bonferroni correction for multiple comparisons. Statistical analyses were performed by Statistica 9.0 software (StatSoft Inc, 2009).

Results

Effects of separation of one female on the social behaviour of other group members

Following the removal of one female (NESÁŘÍ) from the herd, the numbers of agonistic (Wilcoxon test: $N = 5$, $Z = 2.02$ and $p = 0.04$) and play (Wilcoxon test: $N = 5$, $Z = 2.02$ and $p = 0.04$) interactions between the remaining rhinos significantly changed, being higher after the removal. No change was found in cohesive behaviour (Wilcoxon test: $N = 5$, $Z = 0.27$ and $p = 0.79$). We registered the differences in agonistic behaviour between the periods with/without NESÁŘÍ mainly in the numbers of “snarl” ($N = 5$, $Z = 2.02$ and $p = 0.04$), “snort” ($N = 5$, $Z = 1.83$ and $p = 0.07$), “clash of horns” ($N = 5$, $Z = 1.21$ and $p = 0.22$) and “grunt” ($N = 5$, $Z = 1.1$ and $p = 0.27$), however, after Bonferroni correction, none of these tests was statistically significant (for $p = 0.0125$) (Fig. 1). We observed the biggest increase of the agonistic behaviour in subadult female FATU, who directed 7.8× more agonistic activities towards bull SUNI after NESÁŘÍ had been separated from the herd.

After NESÁŘÍ had left the herd, dominance hierarchy scale scores increased in initially low-ranked females FATU and NASI and they occupied the second and the third position, respectively, in rank order. Before NESÁŘÍ left the herd, she had occupied the second position. Bull SUNI was the lowest ranked animal in the herd Table 2.

Table 2

Dominance hierarchy scale scores for each animal in periods with/without NESÁŘÍ (following Jameson et al., 1999).

	Final scale score	
	With Nesáří	Without Nesáří
Suni	-1.178	-2.499
Nasi	0.888	1.394
Nabiré	1.134	1.185
Nájin	1.704	1.694
Fatu	0.414	1.475
Nesáří	1.439	-

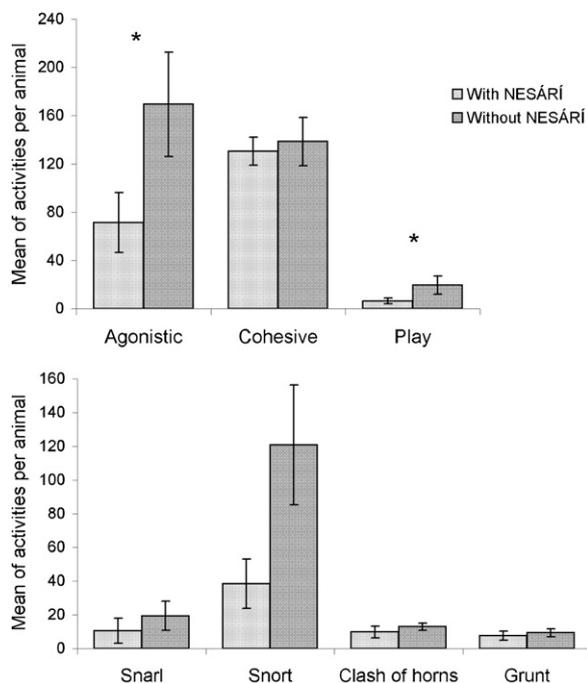


Fig. 1. The comparison of social behaviour categories between two periods (with/without NESÁŘI). The data are mean number of activities observed per animal \pm SEM. Significance of Wilcoxon tests: * $p < 0.05$.

Agonistic behaviour

We recorded 1441 agonistic interactions between the rhinos, which is on average 1.4 activities/animal/h. The most often observed types of agonistic behaviour were “snort” (65.3% of all observed agonistic interactions), “snarl” (11.6%), “clash of horns” (9.1%) and “grunt” (8.7%). Out of all agonistic activities in the herd, 73.4% were directed against the bull. All females directed much more agonistic activities against the bull than vice versa. From all observed agonistic behaviour, 54.3% took place during the feeding. The animals devoted on average 22.0% of their time (range: 20.0–24.2%) to feeding.

Cohesive behaviour

We recorded 1490 cohesive activities between the rhinos, which is on average 1.4 activities/animal/h. The most frequently observed categories of cohesive behaviour were “touch and/or rubbing its horn” (28.8% of all observed cohesive activities), “rubbing its head” (20.3%), “standing side by side” (18.2%), “following” (8.5%), “approaching” (7.1%), “lying side by side” (3.9%) and “walking side by side” (3.5%). Most of cohesive activities occurred between the females in stable bond: NÁJIN–FATU and NABIRÉ–NASI. NESÁŘI did not form a stable bond with any female and therefore she directed only a small number of cohesive activities towards the other animals (Fig. 2).

Play behaviour

We observed a total of 67 “play horn wrestlings”. The bull was involved in 92.5% of wrestling. It was the most frequently recorded between the bull and cows NASI and NABIRÉ.

Reproductive behaviour

We observed a sexual interest of the male 4 \times in female FATU, 1 \times in NÁJIN, 1 \times in NESÁŘI and 1 \times in NASI. Five of these activities

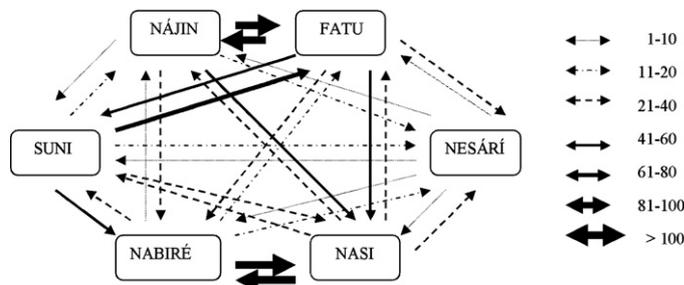


Fig. 2. Sociogram of all cohesive interactions registered between the pairs of animals (lying, standing and walking side by side were considered to be displayed by both animals at the same time so their numbers were counted for both participants).

occurred while NESÁŘI had been in the herd and two after she was separated. However, the activities were only restricted to frequent following the females by the bull with distance decreasing hic call and placing his head on female’s rump. No mating was observed.

Discussion

We investigated the behaviour of newly assembled group of the northern white rhinoceros in zoological garden Dvůr Králové. Bull SUNI and cow NESÁŘI were socialized with a group of other four females in order to change the social relationships in the herd and therefore induce reproduction. Nevertheless, although bull SUNI was sexually interested in females, no mating was observed. Cow NESÁŘI was separated from the herd in the middle of this study which was followed by an increase in agonistic and play behaviour between the remaining animals. Increased agonistic behaviour in southern white rhinos has previously been found to cause an increased secretion of stress hormones (corticosterones: Schmidt and Sachser, 1997 and cortisol metabolites: Meister, 1997) and prolonged or chronic stress may also result in inhibition of reproduction in animals (Dobson and Smith, 2000; Tilbrook et al., 2000). Carlstead and Brown (2005) found that noncycling southern white rhino females have higher corticoid variability compared to the females, which cycle normally. In addition, play behaviour between a bull and cows, which also increased after NESÁŘI’s separation has been recorded in free-ranging rhinos only very rarely or not at all (Owen-Smith, 1973; Cinková et al., 2009).

Female NESÁŘI was the oldest animal in the herd and the only one wild-born. Swaisgood et al. (2006) reported that captive-born females were significantly more likely to reproduce in the presence than in the absence of wild-born females. A presence of older and experienced wild-born female might therefore have a positive influence on reproduction of other females. More studies investigating the influence of the group composition on the social behaviour and reproduction of white rhinos are urgently needed for their better management in captivity.

In free-ranging northern and southern white rhinos, dominance relationships only exist among the bulls; no dominance hierarchy has been observed among the cows (Owen-Smith, 1973, 1975; van Gysegem, 1984). However, a discussion is being held about possible dominance hierarchy among the cows in captive environment, which could cause reproductive suppression in them (Mikulica, 1991; Meister, 1997; Kuneš and Bičík 2002; Swaisgood et al., 2006; Metrione et al., 2007). Most subordinate southern white rhino females in two different groups in zoological gardens were found to exhibit male-like behaviour and they did not reproduce (Metrione et al., 2007). However, development of social dominance might have been caused by higher competition between these rhinos at feeding places as all food was given to them only in the outside enclosures. In the zoo Dvůr Králové, the rhinos were only fed grass

and hay in the outside enclosure; other food including vegetable or feeding mixture was given in the stables, where rhinos were housed separately.

The relationships between the females in our study seemed to correspond to egalitarian relationships, in which the resources are shared and the first individual, who reaches the resource, gets it (Hand, 1986). All females were usually feeding side by side and although we recorded agonistic behaviour between them, no displacement of one female by another from food was registered. After NESÁRÍ was separated, dominance hierarchy scale scores of all females were more even. A presence of old wild-born female in the herd might therefore have had a stabilization influence on agonistic interactions between other group members and her separation then caused an increase in agonistic behaviour between them. Higher aggression of subadult female FATU towards the bull after NESÁRÍ's separation might also be explained by hormonal changes as she probably underwent her first oestrus in time when NESÁRÍ was still in the herd.

Swaigood et al. (2006) suggested that if dominance exists among the captive white rhino females, it is most likely to be between bonded females. However, bonded females show agonistic behaviour towards each other only very rarely (Kuneš and Bičík, 2002; Meister, 1997; Swaigood et al., 2006; Metrione et al., 2007) and we registered some indications of unequal relationships only in the direction of e.g. waiting for each other when leaving a resting or a feeding place (in NABIRÉ–NASI pair) or in “social guarding” (in NÁJIN–FATU pair, NÁJIN protected her daughter FATU when she was followed by the bull during oestrus).

The females displayed during this study the agonistic behaviour against the bull more often than contrariwise, which is in accordance with observations from the wild (Owen-Smith, 1973). However, one of the most frequently used agonistic activities between the rhinos was “clash of horns”, which is only seldom used by free-ranging southern white rhinos (Owen-Smith, 1973; Cinková, 2009). Females also directed play and cohesive behaviour including direct contacts by head and horn towards the bull relatively often contrary to the free-ranging rhinos, in which it has been observed only very rarely or not at all (Owen-Smith, 1973; Cinková et al., 2009). In our study, the use of more extreme agonistic activities and more frequent use of cohesive and play behaviour might be explained as a reaction to limited space, when the animals are in close proximity all the time. In addition, we recorded an increased agonistic behaviour between the rhinos during feeding, which might be managed by dispersing the food at a larger area or by establishing several separate feeding places to avoid frequent agonistic interactions between the animals and thus to decrease their potential stress.

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Appendix A.

See Table A1.

Table A1

The ethogram of white rhino behaviour used in this study (Owen-Smith, 1973; Mikulica, 1991; Meister, 1997; Kuneš and Bičík 2001–2002; Policht et al., 2008).

Category of behaviour
<i>Cohesive behaviour:</i>
Rubbing its head against another rhino
Rubbing its head and neck against the back of lying rhino
Touch and/or rubbing its horn against another animal
Leaning its horn against another lying or standing rhino
Placing its head and neck from the side on the back of partner
Touch and/or moving its lips over a skin of another animal
Pressing its hind part to another animal in T- or L-posture
Placing its head from behind between the hind legs of another standing rhino
Raising the head of another animal with its posterior horn or its forehead
Approaching: the animal then remains in proximity of another rhino. It was recorded only when it was not affected by another stimulation (e.g. feeding or a human factor)
Following another animal
Lying, standing or walking side by side: heads and axis of a trunk in the same line; a distance up to 1 m between rhinos
Rubbing its side against the side of another rhino in passing
<i>Play behaviour:</i>
Play horn wrestling
<i>Agonistic behaviour – defensive:</i>
Snarl: a loud rasping roar with head thrust forwards, ears laid back and mouth opened
Grunt: a low frequency vocalization made with opened mouth and ears laid back
Snort
Protest turning head and/or body towards the disturbing animal
Advancing steps: a few quick steps forward towards the other animal
Threat with moving head: turns its head aside and swings suddenly the head drawing with it a big bow from side to side
Charge: approaches another animal at a rapid trot for a distance at least several metres (x from advancing steps); it is made silently
Clash of horns with another rhino
<i>Agonistic behaviour – subdued aggressive behaviour:</i>
Chase: chases another rhino, which is running away
Attack: several successive horn jabbing movements towards the body of recipient
Pressing against another rhino with its body side or with its neck and head

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