

Breeding the Indian rhinoceros at Dvur Kralove Zoo

Dana Holeckova

Indian rhinoceros

Rhinoceros unicornis
(Linnaeus, 1758)

Taxonomy:

Class:	Mammals (<i>Mammalia</i>)
Order:	Odd-toed ungulates (<i>Perissodactyla</i>)
Family:	Rhinoceroses (<i>Rhinocerotidae</i>)



(dh)

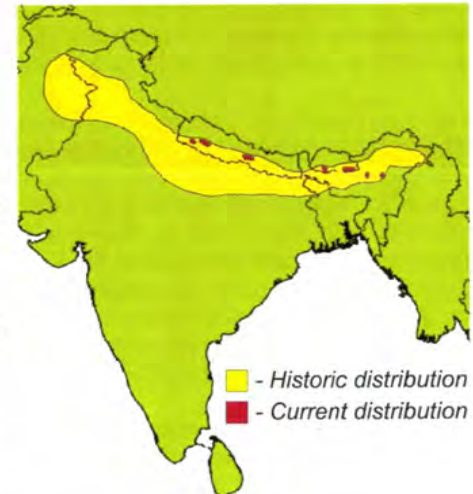
Distribution

Originally, the Indian rhinoceros inhabited northern Pakistan, northern India, southern Nepal, southern Bhutan, northern Bangladesh and western Assam. Today, they range only in India, Nepal and Pakistan.

Biological data

(SCHENKEL and GRZIMEK 1990, PENNY 1988, LAURIE 1982)

Weight:	1,500 (1,700) - 2,500 kg; males are larger and heavier than females; the largest rhino species
Wither height:	159-186 (200) cm - the highest rhino species
Horn length:	A single horn 15-45 cm long, the longest record: 61 cm
Body length incl. head:	2.1-4.2 m
Oestrus cycle:	39-64 days; 45 days on average (SCHWARZENBERGER 1995b)
Gestation period:	462-489 days; 478 days on average
Number of young:	1
Birth weight:	50-81 kg; 65 kg on average (PUSCHMANN 1989, PENNY 1988)
Eyes opening:	At birth
Nursing period:	Up to 18 months
Sexual maturity:	Males 7-9 years, females 3-4 years (PENNY 1988); females in the wild 7.1 years on average (LAURIE 1982)
Reproductive age:	Probably 30-35 years in females, 40 years or less in males
Longevity:	Max. 40-45 years



Geographical distribution of the Indian rhinoceros
(according to www.rhinos-iff.org)

Habitat

Indian rhinos inhabit wet grassy or forest tropical habitats, usually alluvial plains in tropical forest basins, where they occur near waters, in swamps and irrigated valleys (LAURIE 1982).

Diet

Indian rhinos feed mainly on grasses, which forms 70 to 89% of their diet (LAURIE 1982), bamboo, other herbs and plants as well as rhizomes. Occasionally, they eat aquatic plants and fruits and sometimes even graze down rice planted by native people (PENNY 1988, LAURIE 1982).

Ecology

Indian rhinoceroses spend a large part of their day in swamps and water, alternatively resting in the shade of the forest. They go out for grazing usually in the afternoon and early night. They sleep through the night near the place of feeding to resume grazing the early morning. Females with young normally rest in high elephant grass, where the calves are better hidden from tigers. Adult rhinos do not have natural enemies, and therefore are often found in open habitats (PENNY 1988). They protect against insects as well as excessive overheating by wallowing in mud and water. The size of the home range is 2-10 km²; in the Chitwan region, the population density was 4.85 rhinos/km² (LAURIE 1982).

Indian rhinos are solitary animals except for females raising calves. During the time of courtship and mating, the adult male spends a few days in the company of the female. When in oestrus, the female provokes the male by a high-intense whistle. The courtship can be very explosive, with the male rampantly chasing the female. Copulation takes a long time, often over an hour, with 84 minutes being the longest record (PENNY 1988). When fighting, Indian rhinos bite each other by incisor teeth, which may grow up to 20 cm in males (LAURIE 1982).

Breeding males enjoy some type of privileged position within the inhabited area since they range in places that have the largest concentration of adult females and occupy vast areas - up to 6 square km per male. With the exception of mating, the males are solitary and never form groups. They mark the area within their home range by urinating and dragging their rear legs to prevent entry of other breeding males. To facilitate this, they feature scent glands on their feet. Despite the exclusiveness mentioned above, this is not a true territory creating behaviour (LAURIE 1982). Neighbouring breeding males will usually avoid each other rather than perform attacks; however, if a male does enter into the district of another breeding male, it is often attacked and can be killed. Young subadult or subordinate males are tolerated by the breeding male (LAURIE 1982).

Females have their first calf at an average age of 7.1 years and the mean interval between births is 2.8 years (LAURIE 1982). The female is in heat throughout the year, with the cycle length varying between 27 and 42 days. If the calf dies after the birth, its mother enters into oestrus one month after the birth, but if one is bred, the heat does not follow earlier than 10 months, with average of 22 months after the birth (LAURIE 1982). The mother leaves her calf under the age of six months up to 1.5 hours a day to graze at a distance of 800 m. The young begins eat grass from 2 to 3 months of age, and is regularly fed until one year old. Sometimes nursing continues even in the second year, but rarely over the age of 1.5 years (LAURIE 1982). Groups are rarely formed by Indian rhinoceroses; this mostly involves juveniles who never attack the adult males. Infants and juveniles play together. The mother leaves her calf at least one week prior giving birth to the next young; at that time it is becoming more aggressive and separating from other rhinos, when the process of weaning takes place gradually four months or more. At the time of weaning, the calf is usually 2.5 to 3.5 years old. If the mother has lost her last young, sometimes her most recent subadult offspring can turn back (LAURIE 1982).

A natural enemy of the Indian rhino is the tiger, which is able to kill the young. Males can fatally injure each other in duels (LAURIE 1982). The Indian rhinoceros has quite a wide range of audio signals, which may be related to the fact that they live in the habitat providing not very good overview (LAURIE 1982). The largest males become involved in breeding; the length of the horn does not seem to play a role in the process.



Sudan surprising everyone by starting eating the native plants (dh)



Najin in the bigger enclosure the next day after arrival (dh)



Najin and Fatu started grazing within a little while. (dh)



Suni lying in the shade inside the large boma (dh)



The first meeting of the Project Management Committee at Ol Pejeta, December 2009 (dh)



Front, left to right: Rob Brett, Richard Vigne, Dana Holeckova, Martin Mula-ma, Peter Morkel and Ian Craig, back (left to right) Batian Craig, Premysl Rabas, Hamish Currie and Jiri Vahala (jb)



Numa and Nova celebrating their birthday: nineteenth and first, respectively; 13 Sep 1998 (dh)



The Indian rhinoceros features a motile upper lip - the picture shows Numa. (dh)



Indian rhinos spend a large part of their day in water - Numa. (th)



Indian rhino female Numa (th)



Indian rhino female Numa (th)

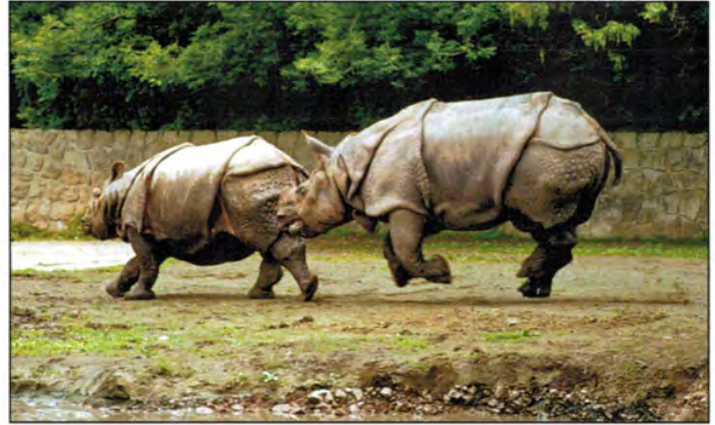


Indian rhinos biting each other (th)



Grazing Indian rhinos - WAP San Diego (dh)

Courtship in the Indian rhino



Courtship is stormy in the Indian rhino, with females whistling and males chasing the females. (th)



A front horn-like protuberance on the head of Indian rhino Ropen (dh)



Numa (dh)

Conservation

Threats that the Indian rhino is facing include, in addition to poaching, the loss of habitat that is cultivated by people for growing rice. Most of the wild population was concentrated in the 1980's into two national parks (Kaziranga and Chitwan) of the total area of 500 km².

Today, rhinos are also threatened by deforestation of the Himalayas and the associated increase in monsoon floods and soil erosion, which continue decreasing the suitable habitat for this species alike the pressure of increasing human populations (LAURIE 1982). In western Bengal and Manas in Assam, the rhinoceros range has been negatively affected by the construction of large dams on the rivers.

The Indian rhinoceros is placed in Annex I (A) of CITES, under which any international trade in both live animals and their derivatives, especially horns and the products thereof, is prohibited. The IUCN Red List 2009 places the species in the vulnerable category (VU - Vulnerable), with the population growing (MILLIKEN *et al.* 2009).

The current poaching situation was reported at the 58th CITES Committee meeting in Geneva on 6-10 July 2009, where it was stated that 48 Indian rhinos were killed from 2007 to 30 June 2009, particularly in the Chitwan National Park (Nepal), where poachers killed 25 individuals. In the Rajiv Gandhi National Park with a total population of 68 rhinos, seven animals were killed in 2008 and additional four hunted in 2009.

Conservation measures

Protection of all three species of Asian rhinos is monitored by the Asian Rhino Specialist Group (ARSG) to the IUCN. Population growth can be attributed not only to successful rhino breeding in Kaziranga, but also to the reduced extent of poaching in the park. In the framework of international cooperation, a conservation project "Indian Rhinoceros - Vision 2020" was developed (BONAL *et al.* 2009), which aims to create a population of 3000 rhinos in Assam across seven protected areas by 2020. In the first stage, 20 rhinos will be moved from Kaziranga and Pobitora Reserve to the nearby Manas National Park (SHARMA 2009). To make sure that everything is successful, training consisting of capture and relocation of the first two rhinos to Manas NP was launched in 2008. Transfer of additional eight rhinos from the Pobitora Reserve and Kaziranga NP was planned for March 2009 (BONAL *et al.* 2009). WWF adopted the Action Strategy for Asian Rhinos and Elephants (AREAS) in 1998, which aims to protect rhinos and increase in wild populations. The activities include creating poaching control patrols, reducing conflicts between villagers and rhinos through moving animals to other sites and creating buffer zones around protected areas (www.wwf.org).



Ropen and Numa in a natural pool (th)

Population status and development

The Indian rhinoceros inhabited the area from the north of Burma as far as northern Pakistan. The species became the first victim of the Asian market with rhino horn, driven to extinction within the most of its original range. The 15th century could still see about half million of animals. In the 20th century, they became critically endangered because in 1960 last 750 individuals were left in the wild (HOLECKOVA and BOBEK 2000). Since then, the wild population has been gradually increasing, counting currently 2,800 individuals according to recent data (MILLIKEN *et al.* 2009). The species has survived in several reserves at the foot of the Himalayas, particularly in the Kaziranga National Park in India containing the majority of the Indian rhino, and in Nepal's Chitwan National Park (www.wwf.org).

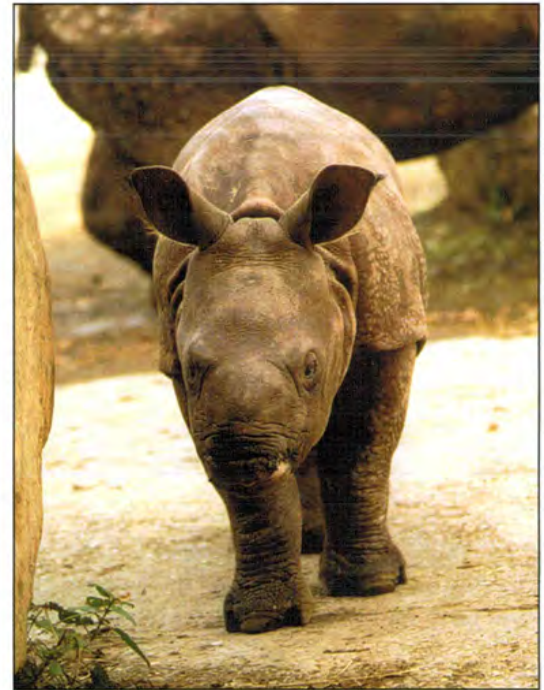
In 1993, there were 2,000 Indian rhinos in eight main locations (India - Kaziranga, Manas, Orang, Pobitora, Jaldapara, Dudhwa; Nepal - Chitwan, Bardia), of which the most stable and growing population existed in the Kaziranga National Park. In Manas, poaching was still on increase; however, in Nepal it was most intense (FOOSE 1993). In 2006, 1,855 and 68 rhinos lived in the national parks Kaziranga and Orang, respectively, and the Pobitora Reserve contained additional 81 animals (BONAL *et al.* 2009).

Currently (2009), four populations in the area of Assam, India, form 92.4% of the global wild population, the largest being Kaziranga NP with 2,048 rhinos and an average annual increase of 3.4% over the last 3 years (Milliken 2009). The population of Indian rhinos in the Kaziranga National Park in India increased from 1,885 in 2006 to 2,048 individuals in April 2009 due to effective protection implemented by the Indian government (SHARMA 2009).

Between 2005 and 2008, the abundance in western Bengal increased by 2.8% per year to 139 individuals. The small population on the border with Nepal (Uttar Pradesh) grew by 6.7% annually since 2004. In Nepal, there has been an increase in poaching as a result of socio-political unrest, when the worst situation exists in Bardia NP, where there were more than 80 rhinos in 2000, with 22 remaining today. The total population in Nepal in 2000 was 612 rhinos in three populations; by 2009, their numbers fell to 435 animals. Yet the largest population in Nepal's Chitwan NP became larger and better secured, since it increased by 3.1% annually from 372 animals in 2005 to 408 in 2008 (Milliken 2009). Data on the development of wild populations are summarised in the following table and chart.

Range sites of Indian rhinos in the wild (PENNY 1982)

Country	Locality	1985 numbers (Penny 1988)	2009 numbers (2008) (MILLIKEN <i>et al.</i> 2009)
India	Kaziranga	1,195	2,048
	Manas	75	
	Pobitora	67	
	Orang	60	
	Laokhowa	40	
	Jaldapara	20	
	Other	30	
	Total India	1,487	2,364
Nepal	Chitwan	400	408
	Bardia	4	22
	Uttar Pradesh		5
	Total Nepal	404	435
Pakistan	Lal Suhanra	2	2 ?
Total	1,893	2,800	

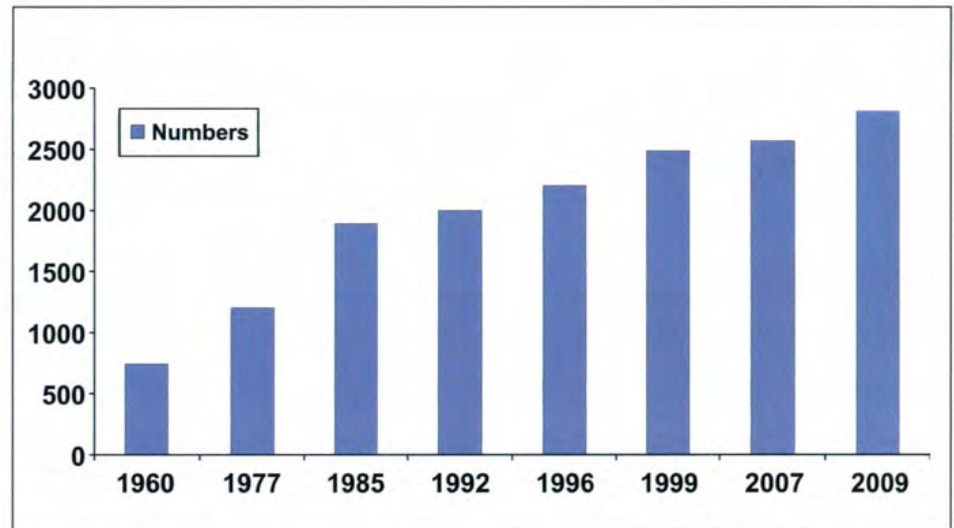


Nim DK 2 (pch)



Nova DK 3 and her fifth birthday (th)

Development of Indian rhino numbers since 1960



Development of Indian rhino numbers since 1600

(FOOSE 1993, HOLECKOVA and BOBEK 2000, EMSLIE *et al.* 2007, MILLIKEN *et al.* 2009)

Year	15 th century	1960	1977	1985	1993	1996	1999	2007	2009
Numbers	500 thousands	750	1,200	1,893	2,000	2,200	2,482	2,565	2,800

Numbers of Indian rhinos as per range country

(PENNY 1988, FOOSE 1993, FOOSE 1999, EMSLIE *et al.* 2007, MILLIKEN *et al.* 2009)

Locality/Year	1985	1999	2007	2009
India	1,487	1,868	2,150	2,364
Nepal	404	612	413	435
Pakistan	2	2	2	2 ?
Total	1,893	2,482	2,565	2,800

CAPTIVE BREEDING

The first zoo-kept specimen: 1513 Lisbon, Portugal (NEUMANN 1925)

First birth and rearing: 1956 Basel, Switzerland (PENNY 1988)

The first rhinoceros in Europe was an Indian rhinoceros, which was according to Plinius imported to Rome for games by Pompeius in 61 BC (NEUMANN 1925). Another Indian rhinoceros got to captivity - to Lisbon - only on 20 May 1513; it was a present of Sultan Muzaffar II dedicated to Alfonso de Albuquerque, governor of Portuguese India, and subsequently Manuel I of Portuguese (Weinberger 2007 NEUMANN 1925). The rhino became a sensation and its illustration was created according to a description by Albrecht Durer in Nuremberg, whose engraving became one of the most famous representations of the species (VERHEIJ 1992).

According to International Studbook (WIRZ-HLAVACEK and STUDER 1998), the oldest registered animal is male Pete, who was introduced to Philadelphia Zoo, the USA, from India as early as 3 March 1875. The male died here 25 years later in 1901.

The first zoological park where an Indian rhinoceros was born became the Swiss Basel Zoo (Penny 1988), where their first calf - male - was born on 14 September 1956 (Rudra Basel 1) according to the data from the International Studbook. Only a year later (29 October 1957), the first calf - female Mohinjia Whip 1 - was born in England's Whipsnade Zoo (according to WIRZ-HLAVACEK and STUDER 1998).

Captive population

The global studbook is managed by Basel Zoo, Switzerland. The first comprehensive data include that of 1972, when the global captive population consisted of 55 (31.24) Indian rhinoceroses. By 1994, the population increased to 134 (75.58.1) individuals, when in the meantime 102 young were born (62.39.1), while 50 (26.24) animals imported from the wild and 73 (44.29) died. As per 31 December 1997 (WIRZ-HLAVACEK and STUDER 1998), the International Studbook included 249 Indian rhinoceroses, while living population was composed of 129 (68.61) animals in 50 collections.

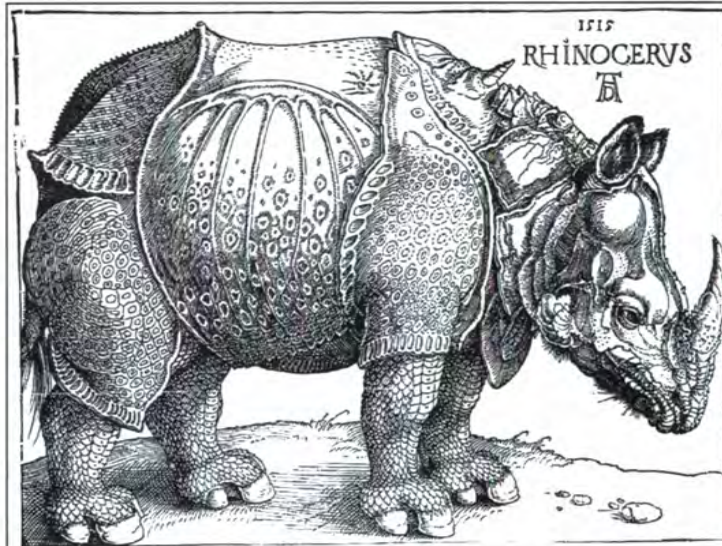
By 2008, this rhinoceros numbers in captivity increased to 171 (85.86) individuals held in 64 collections (STECK pers. comm.). Compared with the year 1972, the captive population more than tripled, with an annual average increase of 5.9% over the period of 36 years. More information on the development of the population in captivity is summarised in the following table.

Indian rhinos are held in three regions - Europe, the USA and Asia, with the European and American collections much more successful in terms of breeding. The least number of offspring can be assigned to Asian holders, where there is the largest proportion of animals imported from the wild, which however often do not breed. The European collection was started in particular by Swiss Basel Zoo and Whipsnade Zoo, England. Most of the holders have no more than five animals, only WAP San Diego and Gauhati Zoo, India, hold more than 10 animals (HOLECKOVA 1996). Both in Europe and the USA, Indian rhinoceroses breed in captive generation 5 and higher; however, with frequent inbreeding due to the small number of founders involved in reproduction, especially in the past (HOLECKOVA 1996).

The major breeders who have been successfully engaged in the Indian rhino include WAP San Diego (the USA), Gauhati (India), Bronx New York (the USA), Los Angeles (the USA), Nagoya (Japan), Basel (Switzerland), Tierpark Berlin (Germany), Planckendael (Belgium) and Whipsnade (England). The largest breeder of the Indian rhinoceros for many years has been the Wild Animal Park (WAP) San Diego, the U.S., where a number of 10 or even more of the rhinos inhabit an enclosure of many hectares in the company of other Asian ungulates and birds.

Development of the global population of Indian rhinos in captivity
[By Tobler (1995) and the International Studbook]

Year	Total
1972	55 (31.24)
1975	61 (34.27)
1980	78 (40.38)
1985	87 (51.36)
1990	116 (67.49)
1994	134 (75.58.1) in 52 coll.
1997	129 (68.61) in 50 coll.
2008	171 (85.86) in 64 coll.



The famous Indian rhino picture engraved by Albrecht Durer, 1515 (VERHEIJ 1992)



An Indian rhino at Nagoya Zoo, Japan (dh)



Indian rhinos at Copenhagen Zoo, Denmark (dh)

Indian rhino holders around the world



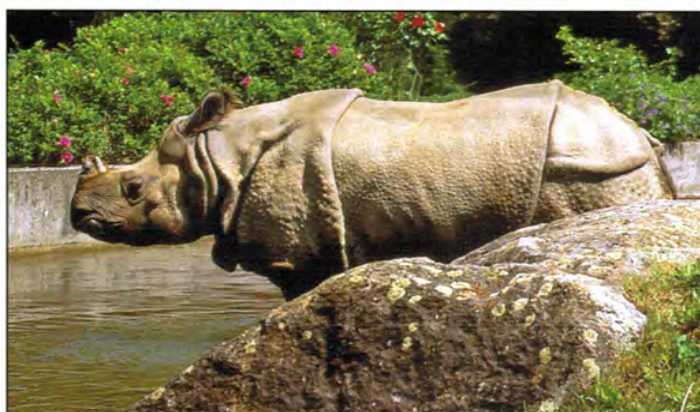
Whipsnade Animal Park (dh)



Indian rhinos at WAP San Diego (dh)



Basel Zoo, 13 June 1992 (lh)



Munich Zoo, 11 May 2007 (lh)



Nuremberg Zoo, 24 April 2001 (lh)



Nuremberg Zoo, 24 April 2001 (lh)



Rotterdam Zoo, 18 June 1994 (lh)



Tierpark Berlin, September 1981 (lh)



Rhino exhibit at Vienna Zoo, 2006 (dh)



Rhino exhibit at Vienna Zoo, 2006 (dh)



Warsaw Zoo - the Indian rhino enclosure, 2007 (dh)



Warsaw Zoo - the Indian rhino house, 2007 (dh)



Singapore Zoo and their Night Safari Park with an Indian rhinoceros, 2008 (dh)



Sosto Zoo, Hungary - 2007 (dh)



Indian rhino enclosure, Lisbon Zoo - 2007 (dh)



Indian rhino enclosure, Lisbon Zoo - 2007 (dh)



Berlin Zoo, 2004 (dh)



San Diego WAP (az)

EEP

The Indian rhino European endangered species breeding programme was established in 1990 and is coordinated by Dr Olivier Pagan from Basel Zoo in Switzerland; Dr Gabriele Hlavacek from the same zoo works as an EEP studbook keeper (STECK 2006). In 1995, the European endangered species breeding programme (EEP) involved 13 parks with 31 (12.19) individuals, when in 1995 only 2 (0.2) calves were born and 2 males died (STUDER 1996). At the same time, STUDER summarised all the data on the animals within the 1934-1995 period, which implies that 19 (8.11) individuals were imported to and 24 (16.8) animals exported out of the EEP population. In 1955-1995, 61 (34.27) births took place, when in 1995 there were 2 births per 10 females able to breed, which is a good ratio, because breeding females should give birth every 3 years. The births occurred throughout the year with peaks in January, August and October, where the highest number of births was in August. In 1960-1995, 26 (15.11) individuals died. Inbreeding coefficient ranged from 0.00 to 0.375. The entire EEP population included in 1995 only 17 unrelated animals, four of which were born in the wild. A total of 15 founders lived within the EEP, one of which (Stdbk #18) was represented until 1995 in over 30.5% of the population.

About 10 years later, in 2005, the EEP collection comprised 46 Indian rhinoceroses, with two (0.2) calves born and two males lost (STECK 2006). As per 31 December 2006 (PAGAN 2008), the EEP stock consisted of 49 (21.28) individuals in 19 zoos; in 2006, 3 (1.2) calves were born and two males died. In 2008, the EEP population increased to 53 (24.29) animals in 20 collections, when four (2.2) young were born and one female died.

Out of the global captive population numbering 171 (85.86) Indian rhinos, 31%, i.e. 53 (24.29) animals are involved in the EEP. Information on the population and holders within the EEP is given in the following tables.

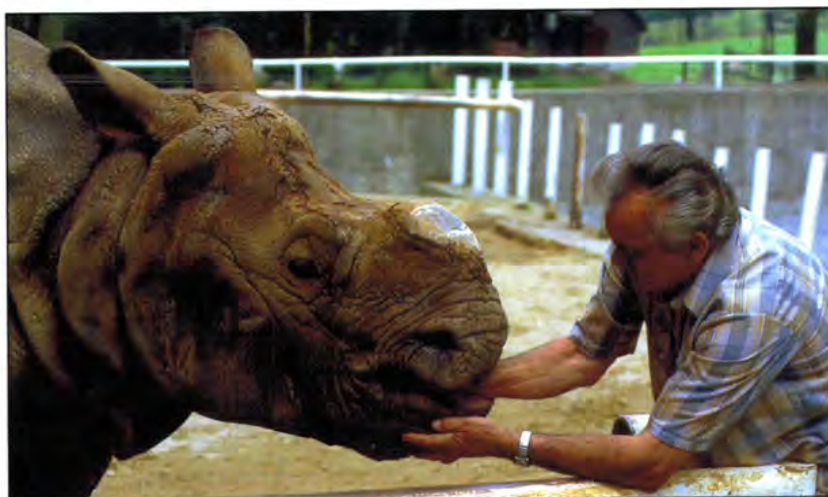
Development of captive Indian rhino population

(HOLECKOVA 1995, FOOSE 1993, STUDER 1996, FOOSE 1999, EMSLIE *et al.* 2007, MILLIKEN *et al.* 2009)

	1994	1999	2008
Total captive population	134 (75.58.1)	139	171 (85.86) in 64 coll.
From which in Europe	31 (12.19) in 13 coll.	35 (15.20) in 12 coll.	53 (24.29) in 20 coll.
EEP percentage	23.9%	25.2%	31%

Development of Indian rhino EEP population in 1995-2008 (STECK 2009)

Year	Number of zoos	Number of animals
1995	13	31 (12.19)
1998	12	34 (14.20)
2004	14	37 (15.22)
2008	20	53 (24.29)



Indian rhino Nim DK 2 at Liberec Zoo (lh)

Indian rhino holders within EEP (according to EAZA Yearbook)

Zoo/Animal number	31 Dec 1995	31 Dec 2005	31 Dec 2006
Amersfoort	-	2 (1.1)	2 (1.1)
Basel, Switzerland	3 (0.3)	4 (1.3)	3 (0.3)
Benidorm, the Netherlands	-	2 (0.2)	2 (0.2)
Berlin Tierpark, Germany	4 (1.3)	6 (3.3)	5 (2.3)
Berlin Zoo, Germany	2 (1.1)	2 (1.1)	2 (1.1)
Chester, England	1 (1.0)	3 (1.2)	2 (0.2)
Dvur Kralove, CR	2 (1.1)	3 (1.2)	2 (0.2)
Edinburgh, Scotland	-	-	2 (2.0)
Cologne, Germany	2 (1.1)	-	-
Liberec, CR	1 (1.0)	-	-
Lisbon, Portugal	-	2 (1.1)	2 (1.1)
Lisieux, France	-	2 (1.1)	2 (1.1)
Madrid, Spain	-	1 (1.0)	2 (2.0)
Munich, Germany	3 (1.2)	4 (2.2)	3 (1.2)
Nuremberg, Germany	2 (1.1)	3 (2.1)	2 (1.1)
Nyiregyhaza, Hungary	-	-	2 (2.0)
Planckendael, Belgium	5 (1.4)	4 (2.2)	3 (1.2)
Rotterdam, the Netherlands	2 (1.1)	3 (1.2)	3 (1.2)
Stuttgart, Germany	2 (1.1)	3 (2.1)	3 (1.2)
Warsaw, Poland	-	1 (1.0)	2 (2.0)
Whipsnade, England	2 (1.1)	4 (1.3)	5 (1.4)
Vienna, Austria	-	-	2 (1.1)
TOTAL	31 (12.19)	46 (21.25)	51 (21.30)

Breeding in Czech and Slovak zoological parks

Breeding of Indian rhinos in the former Czechoslovakia has always been bound to Dvur Kralove Zoo, because the only zoological park of then Czechoslovakia that ever held the species outside Dvur Kralove was Liberec Zoo; this involved the first Indian rhino bred in the CR - male Nim DK 2 from Dvur Kralove.

Indian rhinoceroses held in Czech and Slovak zoological parks prior to 31 December 2009

Zoo	Held in	Import	First birth	Last birth	Total born	Total reared	Status 31 Dec 2009
Dvur Kralove	1980-2009	3 (2.1)	1986	1997	3 (2.1)	2 (1.1)	0
Liberec	1989-2001	1 (1.0)	-	-	0	-	0
TOTAL	1980-2009	3 (2.1)	1986	1997	3 (2.1)	2 (1.1)	0

BREEDING HISTORY AT DVUR KRALOVE ZOO

Indian rhino imports and founders

Dvur Kralove acquired the species by buying a pair of Indian rhinos from German Stuttgart Zoo. In 1980, male Dvityia was introduced, followed by female Numa a year later. They were siblings, with the male two years older than the female. Efforts to obtain an unrelated male led to the importation of Ropen from Whipsnade in 1990 (HOLECKOVA *et al.* 1994). All individuals imported were a generation 3 (F3) born in captivity (according to the International Studbook - WIRZ-HLAVACEK and STUDER 1998). Details are included in the lineages of all three Dvur Kralove rhinoceroses. As is apparent from the genealogy of Dvityia and Numa, which is the same for both rhinos, they are descendants of only two founders originating from Kaziranga Region, India - male Gadadhar Kaz 4 (Stdbk #5, born 1948) and female Joymothi Kaz 5 (Stdbk #7, born 1947). Ropen is a descendant of four founders from Kaziranga NP; they include male Gadadhar as well and female Joymothi, plus male Mehan Kaz 9 (Stdbk #33, born around 1961) and female Renga Kaz 10 (Stdbk #43, born approximately in 1965).

In total, Dvur Kralove Zoo imported a triplet of (2.1) Indian rhinoceroses from European collections; more details are summarised in the following table.

Imports of Indian rhinos to Dvur Kralove Zoo prior to 31 December 2009

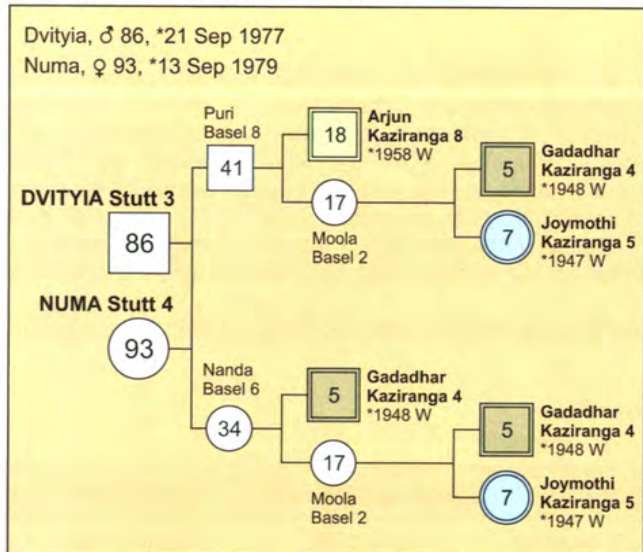
(Stdbk # - Animal number within the International Studbook; M - male, F - female)

No	Sex	Name	Stdbk #	Arrival	Birth	Departure / + Death	Comments
1	M	Dvityia Stutt 3	86	13 Aug 1980 Stuttgart, Germany	21 Sep 1977, Stuttgart, Germany	11 June 1992 Singapore	Breeding male + Singapore
2	F	Numa Stutt 4	93	13 Sep 1978 Stuttgart, Germany	22 Jul 1981, Stuttgart, Germany	13 Mar 2009, Lisbon, Portugal	Breeding female Alive
3	M	Ropen Whip 6	145	17 Jan 1990 Whipsnade, England	8 May 1988 Whipsnade, England	28 Nov 2006 Nuremberg, Germany	Breeding male Alive
Total imported: 3 (2.1)							

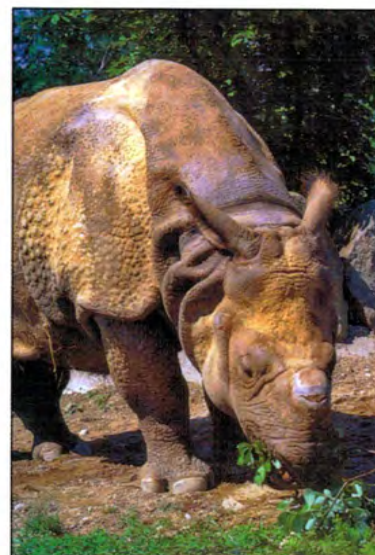


Male Dvityia (right) with female Numa (left) in the enclosure by the elephant house (lh/az)

The lineage of Dvityia and Numa



Numa (dh)

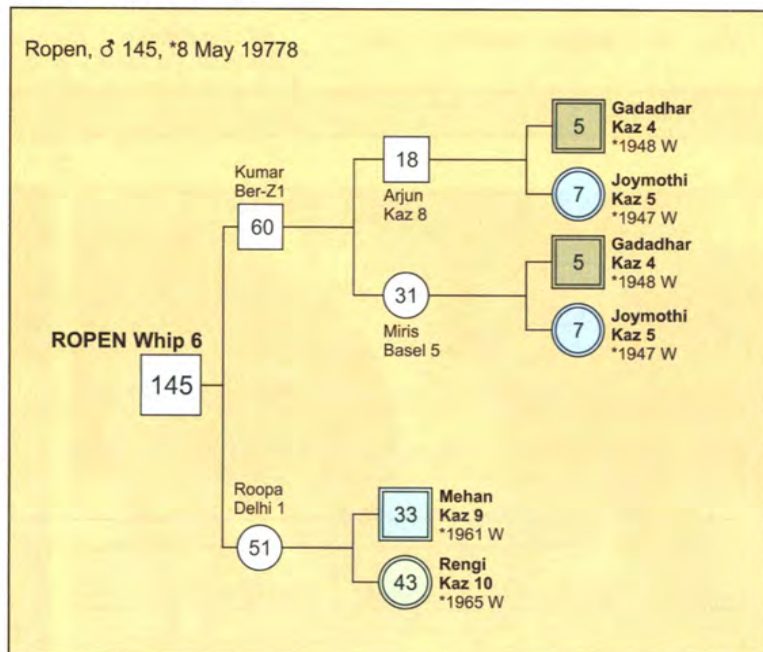


Dvityia (zc)



Ropen – 2005 (dh)

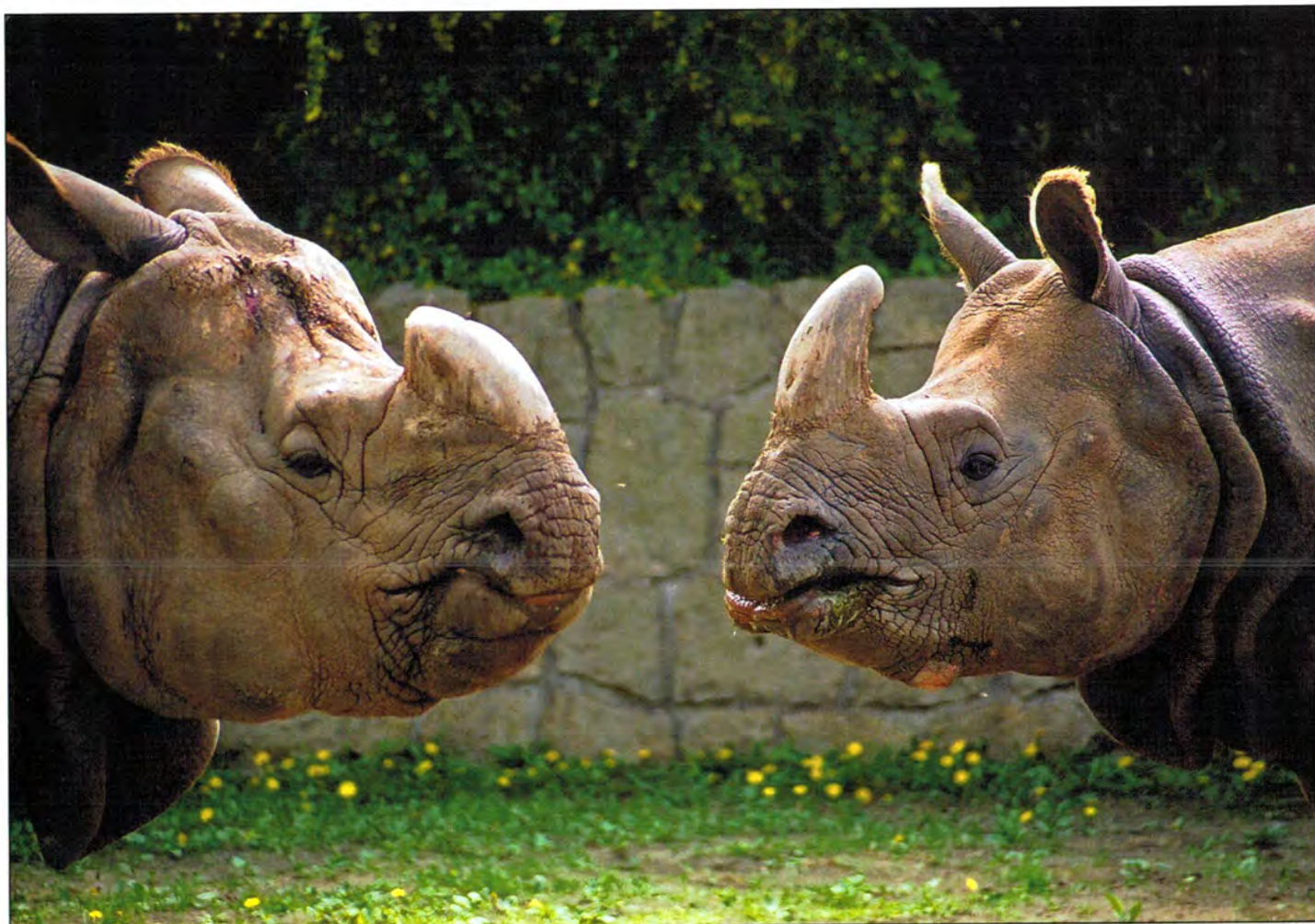
The lineage of Ropen



Breeding history and facilities

Indian rhinos were placed in an extension of the elephant house, where they had available two indoor boxes with a total area of 65 m² and a large grassy outdoor enclosure 740m² large with a pool and full-grown vegetation (HOLECKOVA 1995a). Since the surface of the enclosure was soon completely destroyed, it was replaced with a sand cover in 1986 and, unfortunately, the pool was removed. The first pair (Dvityia and Numa) produced two young. The first female Nelly DK 1 (born 1986) was unable to find the mother's nipples, thus was hand-reared; sadly, she died of infection when 44 days old, although kept gaining weight constantly by then. The second calf - male Nim DK 2 (born 1987) - was reared quite easily; this animal left to Liberec Zoo when 2 years and 3 months old.

In 1990, male Ropen, then 2.5 years old and rather unrelated to Numa, was imported from Whipsnade Zoo, England. This animal was placed, as the very first rhino, in the new rhino house (No 3) that was completed at that time - see page 59. Subsequently, Numa was moved into the house as well. Male Dvityia left in 1992 to Singapore Zoo. The Indian rhinos had available in the new

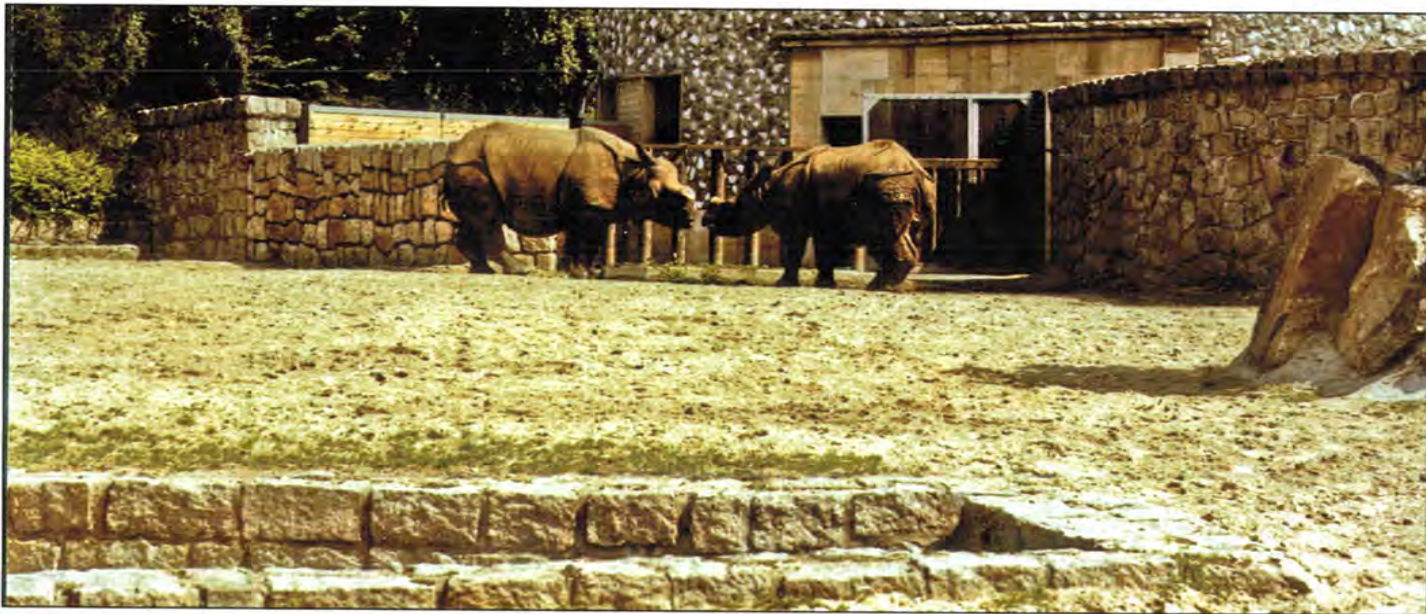


Ropen and Numa (th)

house heated in winter to 18° - 20°C (HOLECKOVA and DOUSEK 2000d) their own part with three indoor boxes and an enclosure. Initially, the enclosure contained only a seasonal mud bath (HOLECKOVA a VONDRA 1994a, HOLECKOVA, VONDRA a ZDAREK 1995b, HOLECKOVA 1996), but since 1996 there was a natural pool with area of 75 m² excavated in the enclosure and containing mud brought from spa, in which all animals spent a lot of time. Later on, following the birth of Nova DK 3, Indian rhinos also used other premises of the house as well as the second enclosure. They were also weighed using the scale located in the outside corridor (see the plan on page 61 for more details), most frequently from all the rhinos held.

Male Ropen reached its adulthood quite late, although gradually beginning showing interest in the oestrous Numa since 1994. Although attracted by Numa showing signs of oestrus, Ropen would lay down his head on the female, but did not mate her. To encourage cycle and male interest, the pair was given TPGS (vitamin E) in October 1994 and in March 1996 Ropen was separated from Numa to the other part of the house for about a month. The female went into oestrus on 6 April, so Ropen was associated with her in the enclosure, but mating did not occurred. It took place only in the subsequent heat on 14 May 1996, when Numa conceived. Ropen was 8 years, while Numa 17 years old. The third baby in the row - female Nova DK 3 - was born on the day of 18th birthday of her mother, 13 September 1997, i.e. after a ten-year break; unfortunately, the situation was the same as with the first birth. Although Nova DK 3 was a vibrant and viable calf alike Nelly DK 1, this young was unable to suckle properly. Therefore, she began to be fed by hand, but permanently stayed with her mother, who was regularly milked by the keepers. As of the day 10, Nova started to suckle milk by herself from her mother, whose lactation was maintained by intentional milking; therefore, the female reared her young by herself from that moment on (HOLECKOVA 1998, HOLECKOVA 2008a). Still before her last pregnancy, Numa started to suffer discharge and inflammation of uterus, which escalated to chronical uteritis. Therefore, even though the female cycled regularly and was mated, she unfortunately did not get pregnant anymore. Because the inflammation of the uterus in Numa began to emerge before the birth of Nova, it may be assumed that it was associated with a too long pause between the births.

Ropen was brought to Nuremberg Zoo in 2006, replacing their breeding male who had died. Because the EEP failed to find an unrelated male to Nova over a period of about five years, both females, Numa and Nova, were loaned to Lisbon Zoo to their adult breeding male (Gangtok, Stdbk #188, born 22 December 1991, WAP San Diego) in March 2009, as getting pregnant timely is very important for a female rhino, otherwise there is a risk of pathogenic changes in the reproductive organs that prevent reproduction. Until their departure, the Indian rhinos lived in the new house.



Indian rhinos in the elephant exhibit with a pool in front of the house (dh)

Indian rhinos in the indoor and outdoor elephant enclosures (1981-1990)



Nine-year old Dvityia in the elephant house (mh)



Ropen in the enclosure by the elephant house (dh)



Dvityia (lh)



Dvityia (lh)



Dvityia (lh)



Dvityia and Numa (lh)

Indian rhinos at the new rhino house (1990-2009)



Numa and Ropen in the natural pool (dh)



There is a U-shaped dry moat separating the enclosures; a black rhino standing to the left, Ropen to the right (dh)



Nova DK 3 playing with a tree branch (dh)



Enclosure #4 by the new house (dh)



Ropen in the enclosure #4 (dh)



Enclosure #3 with Numa and Nova DK 3 (dh)



Indian rhinos in the enclosure #4 by the new house; see the plan on page 61 (dh)

BREEDING ANIMALS

All adult animals held became involved in the reproduction, with the exception of Nova, who was never associated with a male, because efforts to get a suitable partner for her failed. It was a total of three (2.1) animals; more details are summarised in the following tables.

Offspring of individual Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

F/M	Dvityia	Ropen
Numa	Nelly DK 1 Nim DK 2	Nova DK 3

Overview of breeding Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

No	Stdbk #	Sex	Name	Number of young born	Number of young reared
1	86	M	Dvityia	2 (1.1)	1 (1.0)
2	145	M	Ropen	1 (0.1)	1 (0.1)
3	93	F	Numa	3 (1.2)	2 (1.1)

Dvityia - born 21 September 1977, Stuttgart, Germany - Stdbk #86 († 14 Jun 1992, Singapore)

Dvityia became the father of two calves - female Nelly DK 1 and male Nim DK 2. Brother of the breeding female Nova, he was replaced by another male (HOLECKOVA and VONDRA 1994a, HOLECKOVA, VONDRA and ZDAREK 1995b, HOLECKOVA 1996). Dvityia left in 1992 to Singapore Zoo, where he died soon unfortunately.

Ropen - born 8 May 1988, Whipsnade, the United Kingdom - Stdbk #145

Ropen replaced male Dvityia in 1990 but was young and it took 8 years before he began to mate. He became father to Nova DK 3 and even he repeatedly mated Numa after the weaning of Nova, Numa never got pregnant. Therefore, the male left in 2006 to Nuremberg Zoo, Germany (HOLECKOVA 2008a).



Dvityia in the enclosure by the elephant house, 1983 (lh)



Numa in the enclosure by the elephant house, 1993 (lh)

Numa - born 13 September 1979, Stuttgart, Germany - Stdbk #93

No	Sex	Name	Stdbk #	Dam	Sire	Conceived	Birth	Gestation period	House & comments
1	F	Nelly DK 1	167	Numa	Dvityia	?	14 Jan 1986	?	Elephant house
2	M	Nim DK 2	141	Numa	Dvityia	16 Jul 1986	4 Nov 1987	466 days	Elephant house
3	F	Nova DK 3	245	Numa	Ropen	14 May 1996	13 Sep 1997	487 days	New (#3) house

Numa got first time pregnant in 1994, when she was kept with her older brother Dvityia. She failed to rear her first calf, because Nelly DK 1 was not able to find a nipple and suckle naturally. Despite the good hand-rearing progress, Nelly eventually died of infection at 44 days. Another young - male Nim DK 2 - was reared by Numa without any problems (HOLECKOVA and VONDRA 1994a, HOLECKOVA, VONDRA and ZDAREK 1995b, HOLECKOVA 1996). Since 1992, after the males have been exchanged, Numa was associated with male Ropen; however, the male only reached his sexual maturity when eight years old, mating the female in 1996 for the first time. Numa gave birth to her third young - female Nova DK 3 - on the day of her 18th birthday (HOLECKOVA 1998). Sadly, this was followed by inflammation of the uterus of the female, which caused failure to get pregnant any later in this female. All of her three calves were generation 4 born in captivity (F4). In March 2009, Numa left with her daughter Nova DK 3 to Lisbon Zoo to join their unrelated breeding male.



Nelly on day 18, 1 February 1986 (lh)

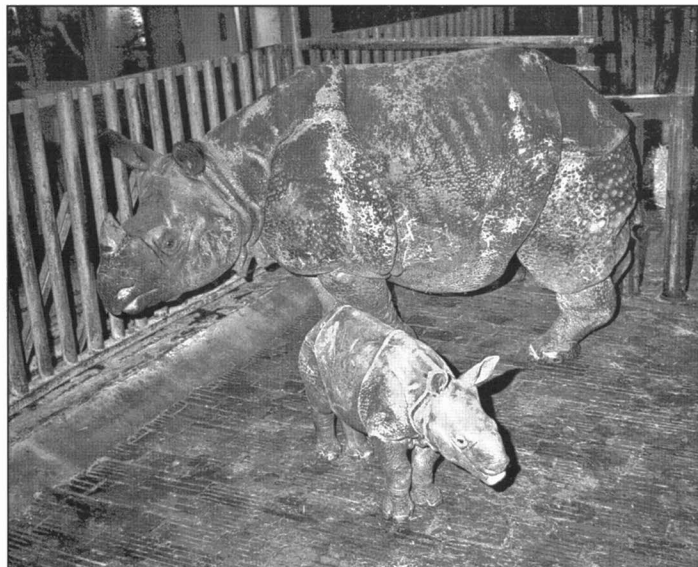


Numa and Nova DK 3 - celebrating the first birthday (dh)



Nim DK 2 after the birth (pch)

Mother-reared Nim DK 2, 1987-1988



Numa and Nim DK 2 at the elephant house, 18 December 1987 (lh)



Numa and Nim DK 2, 14 May 1988 (lh)



Ropen mating Numa on 14 May 1996 and in 2000 (dh)

Rearing Nova DK 3, 1997-1998



Nova DK 3 at the day of her birth (dh)



Numa nursing Nova (dh)



Nova DK 3 being fed while kept with the mother (th)



Nova DK 3 being fed (th)



Nova DK 3 with her mother Numa in the enclosure when several weeks old (dh)



Nova DK 3 with her mother Numa in the enclosure (dh)

BIOLOGICAL DATA

Gestation and cycle length in females

In the Indian rhinoceros, mating is preceded by a wild chase, with the male chasing the female. First Numa conceiving escaped the attention of the keepers. The second was already observed, when mating happened for the first time less than 5 months after Numa gave her first birth. Following repeated mating attempts, Numa got pregnant in July, with the cycle 41 days long. Numa conceived for the third time after many months of offering herself to the young male Ropen, who eventually mated the female only once, on 14 May 1996; lasting 50 minutes, the copulation comprised about 31 ejaculations. Numa got immediately pregnant and bore on her 18th birthday. Pregnancy lasted 487 days, i.e. more than 16 months. The cycle could be found out by mating in 1986, where it was recorded once and lasted 41 days, and later by oestrus, which is a very marked one in the Indian rhino, with intense whistling by the female. It follows from the table on page 308 that the heat usually lasted 2 days and the cycle was initially irregular in 1994-1996; in addition, Numa also had an occasional discharge from the vagina. At that time, Numa's cycle lasted from 37 to 39 days, although by December 1995 it varied between 34 and 80 days, which could be due to some problems of the female (vaginal discharge), as well as stimulation of the female by the male, who was attracted by the female, but did not mate her. HERMES *et al.* (2007) report that in the Indian rhino, the cycle takes 43-48 days; SCHWARZENBERGER (1995) provides the cycle length variation from 39 to 64 days with an average of 45 days, and the gestation period of 459 and 476 days, which is however almost a month less than the length of pregnancy our established and proven in Dvur Kralove. PENNY (1988) indicates the length of the cycle from 5 to 8 weeks and the duration of oestrus period of 24 hours, which corresponds with our findings. Furthermore, this author provides the duration of mating about an hour, with a record length of 83 minutes, which was registered at Swiss Basel Zoo. He also reports that the Basel Zoo recorded a pregnancy period of 462 to 489 days, when this was a summary of 12 pregnancies. Tierpark Berlin recorded the length of gestation of 478, 489 and 494 days (BLASZKIEWITZ 2008). LAURIE (1982) gives the cycle length of 27 to 42 days, while the female is in heat throughout the year. The same author also mentions the length of mating period even over 60 minutes, when the male ejaculates at intervals of between 45 and 170 seconds.



Ropen mating Numa, 14 May 1996 (dh)

Mating, length of cycle and gestation period in Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

No	Pair	Mating date / time	Birth	Name	Gestation period
1	Numa x Dvityia	??	14 Jan 1986	Nelly DK 1	??
2	Numa x Dvityia	5 Jun (46 min), 16 Jul 1986 (45 min)	4 Nov 1987	Nim DK 2	466 days
3	Numa x Ropen	14 May 1996 (50 min)	13 Sep 1997	Nova DK 3	487 days

Cycles in Numa at Dvur Kralove Zoo

No	Date/time of oestrus	Cycle length
1	4 Jun 1986	—
3	16 Jul 1986	41 days
4	4 Aug 1994	
5	11 Oct 1994	68 days
6	14 Nov 1994	34 days
7	27-28 Dec 1994	43 days
8	13-14 Feb 1995	48 days
9	20-21 Mar 1995	35 days
10	1 May / 6 May / 9-10 May 1995	42/47/50 days
11	28-29 Jul 1995	80 days
12	18 Sep 1995	52 days
13	24 Oct 1995	36 days
14	15-16 Dec 1995	52 days
15	21-22 Jan 1996	37 days
16	26-27 Feb 1996	37 days
17	6-7 Apr 1996	39 days
18	13-14 May 1996 - 14 May Mated and conceived	37 days
	13 Sep 1997 gave birth to Nova DK 3	
19	2 Nov 1997 (Day 50 after the birth)	—
20	15 Dec 1997	43 days
	Cycle length	37-39 days



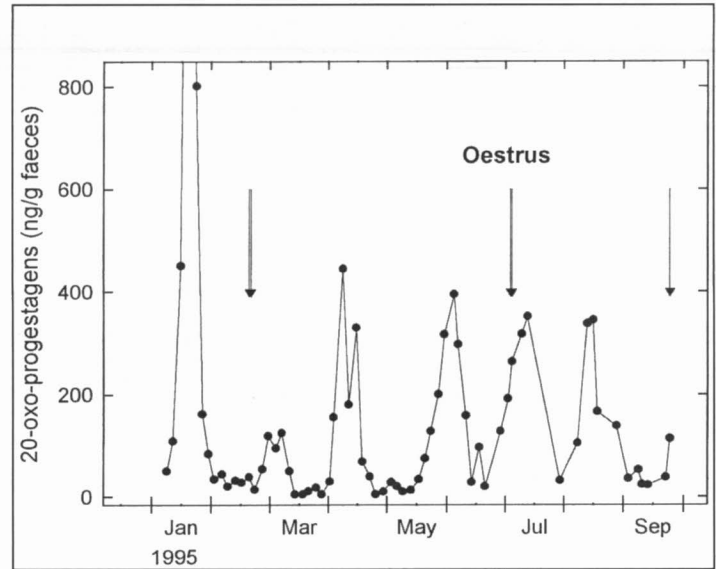
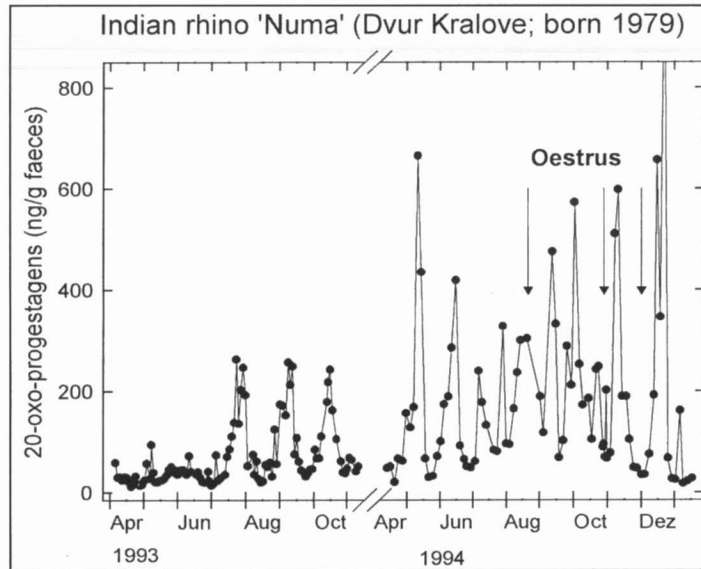
Numa, a profile picture (dh)



Ropen mating Numa, 9 May 2001 (dh)

In cooperation with the Veterinary University of Vienna, we monitored the female's cycle and pregnancy by testing faeces. Dr Franz Schwarzenberger developed a methodology by which pregnancy can be diagnosed based on placental progesterone metabolites (SCHWARZENBERGER 1995a), which we used in all types of rhinoceros. The results of female Numa tests are shown in the following charts.

Breeding activities of Numa (SCHWARZENBERGER)



Sex ratio

Of the three calves born in Dvur Kralove, there was 1 male and 2 females; the ratio of males to females was 1:2 in favour of females, which however has no predicative value given the number of births. According to the International Studbook (TOBLER 1995) summarising births in captivity from 1972 to 1994, there were 102 births with a sex ratio 62 males and only 39 or 40 females; thus, the male to female ratio was 1.5:1.

Birth distribution over the year

Births were recorded in January, September and November, which was influenced by males reaching sexual maturity, as well as breeding following the death of the first calf.

Birth periods and reproductive age

As is apparent from the following table, Numa first conceived in her year 4 and the last time when less than 17 years old. Although mated later, this female did not get pregnant due to prolonged inflammation of the uterus. Males became breeders and mated for the first time when 6 years and 10 months old (Dvityia) and 8 years (Ropen). The time between the first and second birth was 2 years and 8 months, while between the second and third birth almost 10 years elapsed, which was due to the immature male. In each of the males, the fruitful mating last occurred at the age of over 8 years, owing to the separation from a female (Dvityia), or female's infertility (Ropen).

PENNY (1988) indicates that females become fertile once they reach 3 years of age, while in males this occurs between the year 7 and 9. Conceiving in females around year 3 is provided to by BLASZKIEWITZ 1995. Detailed information is summarised in the following table.

BLASZKIEWITZ (2008) gives the interval between births in female Betty whose calf (Patna) born on 21 July 2004 had to be hand-reared to be 16 months, when Betty went into heat and was mated 35 days after the preceding birth (25 August 2004).

LAURIE (1982) indicates that females in the wild have their first calf at the age of 7.1 years and the interval between births is on average 2.8 years, when the female can go into oestrus as early as one month after the birth, if the previous young had died. In females rearing a calf, oestrus was first recorded 10 months after the birth or later, with an average of 22 months.

Age at giving birth and intervals between births in the Indian rhino female at Dvur Kralove Zoo prior to 31 December 2007

Female * Born	Birth series No	Birth date	Female's age at birth	Female's age at mating(Ap- prox. 16 months prior birth)	Interval between births	Reared
Numa, Stdbk #93 * 13 Sep 1979 Stuttgart	1	14 Jan 1986	5 years and 4 months	4 years	—	No
	2	4 Nov 1987	8 years and 2 months	6 years and 10 months	2 years and 8 months	Yes
	3	13 Sep 1997	18 years	16 years and 8 months	9 years and 10 months	Yes

Early sexual maturity in Indian rhino females (according to BLASZKIEWITZ 1995)

Female	Zoo	Born	Date of 1st birth	Age when gave birth	Age when conceived
Jhansi	Tierpark Berlin	20 Jul 1990	21 Jan 1995	4 years and 6 months	3 years and 2 months
Moola	Basel	17 Aug 1958	9 Mar 1963	4 years and 7 months	3 years and 3 months
Tanaya	Basel	24 Aug 1971	26 Mar 1976	4 years and 7 months	3 years and 3 months
WAP San Diego	Goalpara	26 May 1987	22 Dec 1991	4 years and 7 months	3 years and 3 months
WAP San Diego	Ganida	19 Mar 1978	25 Jul 1982	4 years and 4 months	3 years

Age at the time of fruitful mating in Indian rhino males at Dvur Kralove Zoo prior to 31 December 2009

Male * Born	No	Mating	Male's age at mating (Approx. 16 months prior birth)
Dvityia, Stdbk #86 * 21 Sep 1977, Stuttgart	1	July 1984	6 years and 10 months
	2	16 Jul 1986	8 years and 9 months
Ropen, Stdbk #145 * 8 May 1988, Whipsnade	1	14 May 1996	8 years and 6 days

Weight of Indian rhinoceroses

Over the years, a number of weight data were obtained, which initially was at random, usually in connection with the transport of the animal, while after 1986 this involved intentional actions which in particular related to artificial rearing, i.e. Nelly DK 1 and Nova DK 3, inspecting calves after the birth, and installation of a scale in the new rhino house in 1993, which allowed for weighing of adult animals (HOLECKOVA 1995). Due to their quiet nature, Indian rhinos would pass to the scale located in the outside corridor with no problems. A total of 96 weight data was obtained, including 18 of males and 78 of females.

Adult animals were also measured and it was found that the 2,385 kg heavy Ropen stood at the withers 182 cm in 1995, and 186 cm in 2000, and the same parameter in Numa with her weight of 2,130 kg was 170 cm in 1995 and 174 cm in 2000.

LAURIE (1982) gives the weight below 2,100 kg and wither height to 186 cm in Indian rhino males, and weight around 1,600 kg and wither height of 160 cm in females.



Male Indian rhino Ropen standing on the scale in the corridor by the new house (dh)



Male Ropen in flehming position - 2 September 2001 (th)

Weight of adult animals

In total, 69 weight data were obtained in adults (2 males and 2 females) implicating that the weight of adult males varied from 2,230 to 2,464 kg, and the mean individual weight ranged from 2,357 to 2,390 kilograms. Similarly, the weight of adult females varied from 1,690 to 2,364 kg, while the mean weight of individual animals ranged from 2,022 to 2,064 kg. Further details are summed up in the following tables, showing the average weight of about 2,373 kg in males and 2,043 kg in females. The collected data can be compared with that from Bronx Zoo, New York, the USA (CLAUSS *et al.* 2005, Arks 2009), which together with our data are shown in the following tables. These figures are slightly lower than the data obtained in Dvur Kralove, since the average weight was 1,814 kg in one Bronx Zoo's male and 1,895 kg in their three females. The fact that the captive-bred Indian rhinos are significantly larger and heavier than those in the wild can be evidenced based on a comparison with the data of BONAL *et al.* (2009) who report on two wild males about 7 and 10 years old, weighing 1,540 and 1,570 kg, respectively.

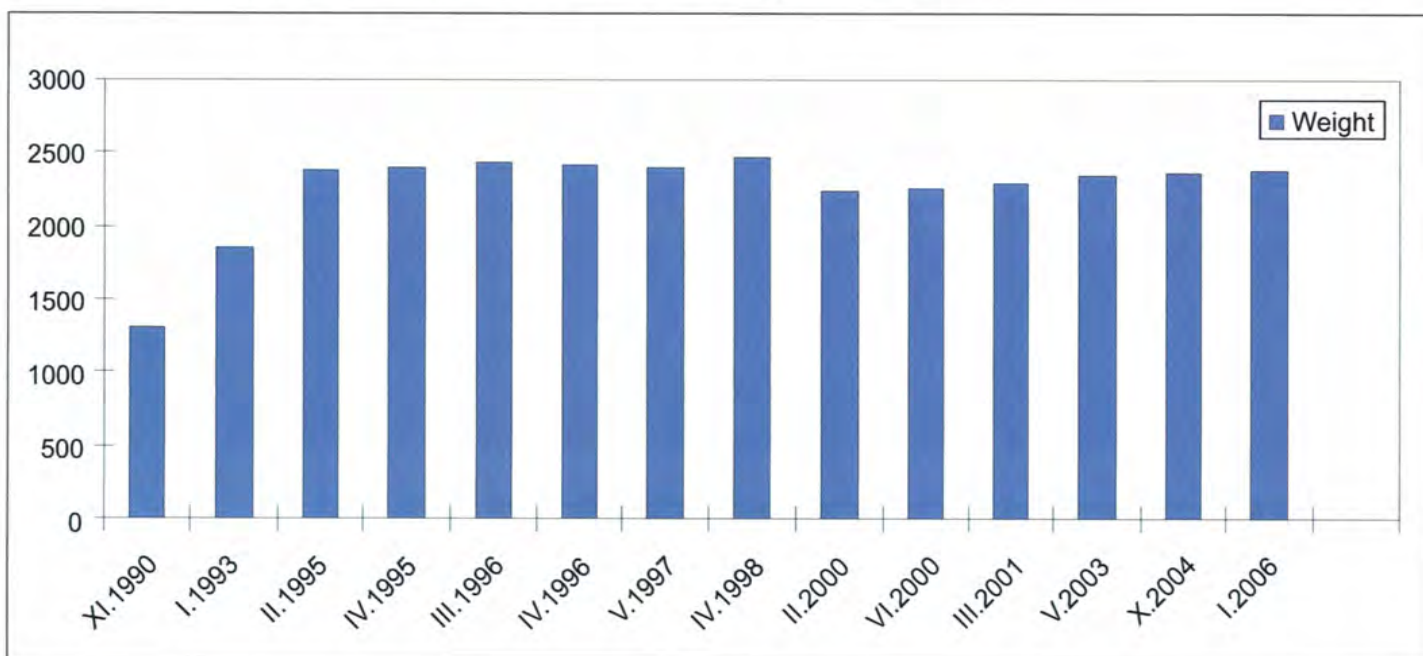
Weight of adult male Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

Male	Stdbk #	Weight (kg; min - max)	Average (kg)	Number	Comments
Dvityia	86	2,390	2,390	1	Age 22 years
Ropen	145	2,230-2,464	2,357	14	Age 7-18
Total	2 animals	2,230-2,464	2,373.5	15	
Vinu	53	1,707-1,899	1,814	22	ARKS - Bronx NY Age 21-38 years

Weight of adult female Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

Female	Stdbk #	Weight (kg; min - max)	Average (kg)	Number	Comments
Numa	93	1,690-2,364	2,022	35	Age 10-28 years
Nova DK 3	245	1,896-2,174	2,065	19	Age 6-10 years
Total	2 animals	1,690-2,364	2,043.5	54	
Pinky	66	1,684-1,943	1,835	16	ARKS - Bronx NY, wb - India, age 20-30 years
Kali	139	1,770-2,218	2,006	18	ARKS - Bronx NY, wb - Nepal 13-23 years old
Penny	223	1,816-2,279	2,017	14	ARKS - Bronx NY, 7-14 years old
Total ARKS	3 animals	1,684-2,279	1,895.3	48	

Growth and variation of adult weight in male Indian rhino Ropen in Dvur Kralove



Birth weight

Birth weight was obtained from both females born, as they were hand-reared. While Nelly DK 1 weighed 59 kg on day 4 (HOLECKOVA, 1998), Nova 3 DK weighed 58 kg the third day after the birth. These data correspond with the reference data, as Penny (1998) gives the birth weight of 65 kg and Puschmann (1989) indicates normal weight 60 to 65 kg with limits 40 to 81 kg. BLASZKIEWITZ (2008) reports on the birth weight of 57 kg in the hand-reared male Patna born 21 July 2004 in Tierpark Berlin.

Growth of calves

From the weight data obtained, weight gain during the growth period can be monitored and is shown in the following tables. Growth of Indian rhinos in Dvur Kralove can also be demonstrated through the following charts.

The growth-illustrating table include 96 weight data, of which 56 were found during weighing of two adult females (Numa, Nova DK 3) and 15 during weighing of two adult males (Dvityia and Ropen). The birth weight determined is based on two figures from the offspring - females aged 3 to 4 days (Nelly DK 1, DK Nova 3), where in both cases, this involved artificial rearing.

These figures implicate the average birth weight of 58.5 kilograms. The female growth figures are based on the data obtained from Nelly DK 1 (up to the age of 1.5 month) and Nova DK 3.



Nova DK 3 when one day old (dh)



Nova DK 3 when two months old (dh)



Nova DK 3 and Numa celebrating their birthday: first and nineteenth, 13 Sep 1998 (dh)



Nova DK 3 with her mother when two years old (dh)



Nova, three years old, 13 September 2000 (th)



Nova DK 3 celebrating her fourth birthday, 15 Sep 2001 (dh)

Growth of female Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

Age	Weight span	Mean	Comments
Day 1 to 4	58-59 kg	58.5 kg	n = 2, Nelly DK 1 + Nova DK 3
Day 15	68 kg	68 kg	
Month 1	82.5 kg	82.5 kg	
Month 1.5 (day 44)	93 kg	93 kg	
7 months	440 kg	440 kg	
7.5 months	458 kg	458 kg	
10 months	590 kg	590 kg	
1 year and 6 months	1,014 kg	535 kg	
1 year and 8 months	1,065 kg	728 kg	
1 year and 9 months	1,082 kg	732.5 kg	
2 years	1,108 kg	785.5 kg	
2 years and 6 months	1,352 kg	720 kg	
2 years and 8 months	1,392 kg	784 kg	
3 years	1,400 kg	993 kg	
3 years and 5 months	1,540 kg	800 kg	
4 years	1,586 kg	909 kg	
4 years and 9 months	1,690 kg	1,146 kg	
5 years	1,700 kg	1,155 kg	
5 years and 8 months	1,832 kg	927 kg	
5 years and 9 months	1,860 kg	965 kg	
6 years	1,936 kg	973 kg	
6 years and 8 months	2,020 kg	972 kg	
Adult	1,896-2,174 kg	2,065 kg	N = 19

Growth of female Indian rhinos at Dvur Kralove Zoo prior to 31 December 2009

Age	Weight span	Mean	Comments
Birth weight	60 kg (estimated)	-	60 kg used in the chart
1 year and 11 months	700 kg	700 kg	
2 years and 6 months	1,300 kg	1,300 kg	
4 years and 7 months	1,860 kg	1,860 kg	N = 2
6 years and 9.5 months	2,385 kg	2,385 kg	
Adult	2,230-2,464 kg	2,357 kg	1 male - Ropen, N=14

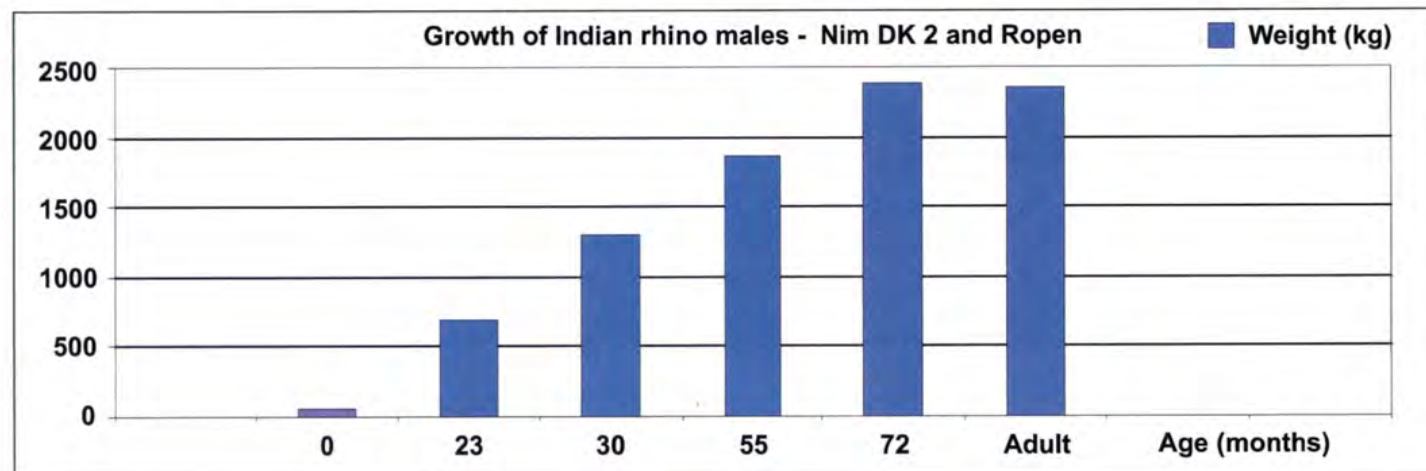
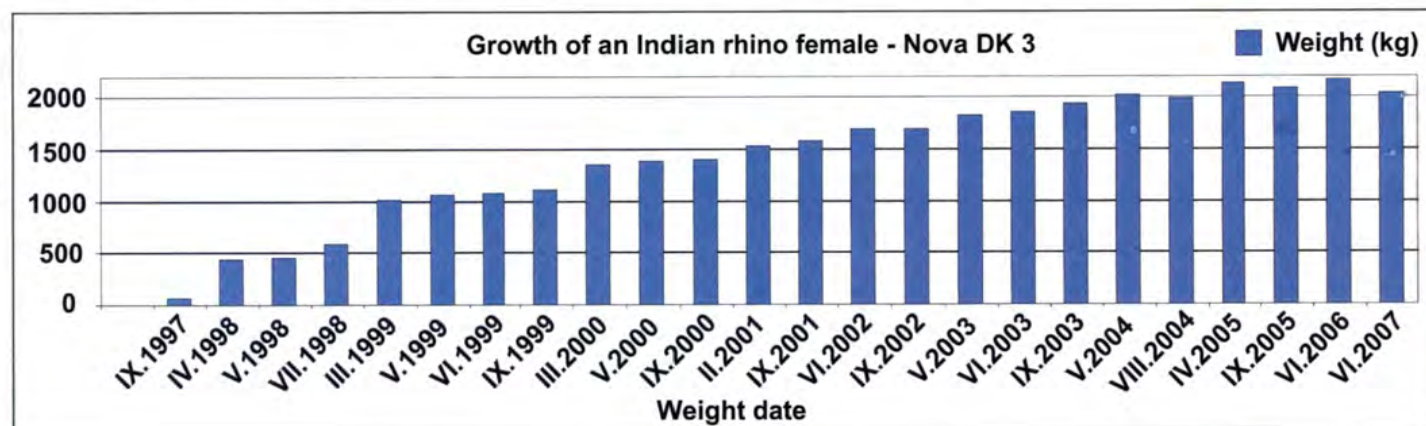
Weight gain

Weighing of young rhino produced data on weight increments during the growth period, as shown in the following tables, which implicate that the daily gains were exceeding 0.8 kg/day during the first month of life, and approximately 1.7 kg/day on average up to 1.5 years of age. For Ropen, the average daily gain was 1.34 kg up to 2.5 years of age. Then it gradually declined and became stable, with about 0.7 kg maintained between the year 2.5 and 7.

The weight gain in Nova DK 3 during the female's first seven months of age averaged 1.76 kg/day, followed by 1.7 kilograms per day up to 1.5 years of age. Subsequently, the weight gain declined. The reasons for the variation might include certain fluctuations in weight (even during the day), the time of the year and the energy loss in the animals. The average increase was 0.77 kg/day between the year 2 and 3, 0.53 kg/day between the year 3 and 4, 0.30 kg/day between the year 3 and 4 and 0.59 kg/day between the year 3 and 4. In her sixth year, Nova DK 3 reached the adult weight.

PENNY (1988) states that the mother can daily produce 20 to 25 litres of milk, making the calf achieve the weight gain 2-3 kg per day. Furthermore, this work indicates that Basel Zoo recorded first eating of solid food in a calf only two months old, but that this animal nipped branches already at the age of 2 weeks.

BLASZKIEWITZ (2008) reports on the weight of artificially reared male Patna (Tierpark Berlin), which increased by 6 kg for the first 8 days, i.e. the increase was 0.75 kg/day.



Weight gain in growing males at Dvur Kralove Zoo prior to 31 December 2009

Date	Age	Weight	Weight gain	Daily weight gain
Nim DK 2 - M *4 Nov 1987 Dvur Kralove				
Birth weight	Estimation	60 kg		
9 Oct 1989	1 year and 11 month	700 kg	+ 640 kg in 735 days	+ 0.87 kg/day
Ropen - M *8 May 1988, Whipsnade				
Birth weight	Estimation	60 kg		
17 Nov 1990	2 years and 6 months	1,300 kg	+ 1,240 kg in 925 days	1.34 kg/day
18 Jan 1993	4 years and 7 months	1,860 kg	+ 560 kg in 792 days	0.71 kg/day
23 Feb 1995	6 years and 9.5 months	2,385 kg	+ 525 kg in 766 days	0.69 kg/day
Nelly DK 1 - F *14 Jan 1986 Dvur Kralove				
18 Jan 1986	4 days	59 kg		
29 Jan 1986	15 days	68 kg	+ 9 kg in 11 days	0.82 kg/day
16 Feb 1986	29 days (1 month)	82.5 kg	+ 14.5 kg in 18 days	0.81 kg/day
27 Feb 1986	44 days	93 kg	+ 10.5 kg in 15 days	0.70 kg/day
Nova DK 3 - F *13 Sep 1997 Dvur Kralove				
16 Sep 1997	3 days	58 kg		
21 Apr 1998	7 months	440 kg	+ 382 kg in 217 days	1.76 kg/day
20 Jul 1998	10 months	590 kg	+ 150 kg in 90 days	1.67 kg/day
25 Mar 1999	1 year and 6 months	1,014 kg	+ 424 kg in 248 days	1.71 kg/day
3 Sep 1999	2 years	1,108 kg	+ 94 kg in 162 days	0.58 kg/day
23 Mar 2000	2 years and 6 months	1,352 kg	+ 244 kg in 201 days	1.21 kg/day
15 Sep 2000	3 years	1,400 kg	+ 48 kg in 176 days	0.27 kg/day
15 Feb 2001	3 years and 5 months	1,540 kg	+ 140 kg in 153 days	0.92 kg/day
1 Sep 2001	4 years	1,586 kg	+ 46 kg in 199 days	0.23 kg/day
10 Sep 2002	5 years	1,700 kg	+ 114 kg in 374 days	0.30 kg/day
9 Sep 2003	6 years	1,916 kg	+ 216 kg in 364 days	0.59 kg/day
6 May 2004	6 years and 8 months	2,020 kg	+ 104 kg in 239 days	0.44 kg/day

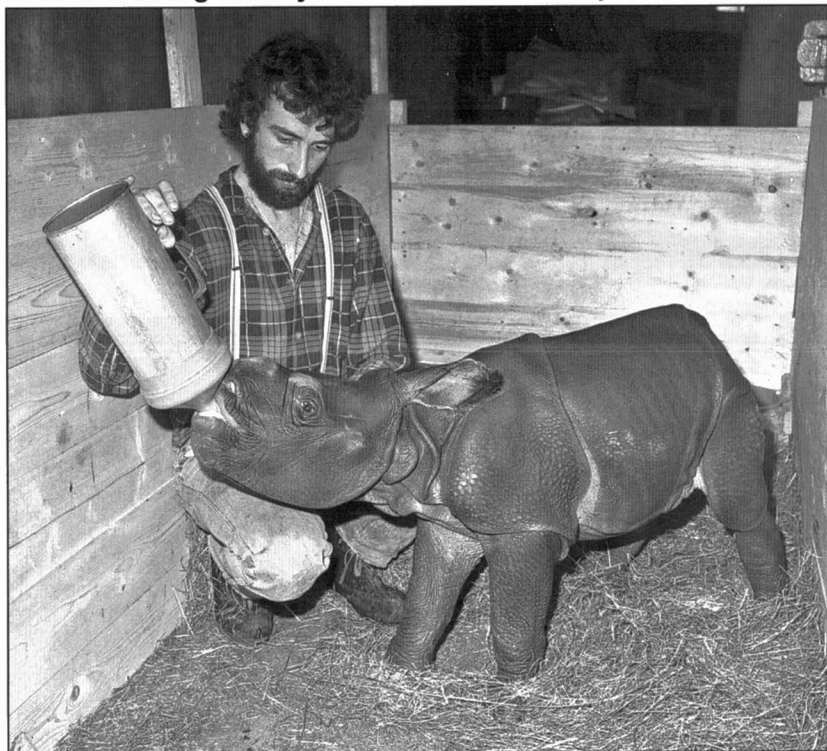
Hand rearing

The first female Nelly DK 1 (born 1986) was unable to find her mother's nipples and was bred by hand. First, this animal was fed by the milk obtained by milking its mother, and later on by milk prepared by hand from cow milk powder (Sunar brand). The calf prospered very well and kept gaining weight. During the hand-rearing period, the female was separated from her mother and lived within the same house placed in the keeper room, where a spacious wooden box was set up for her. She died suddenly in 44 days of being infected probably because of the lack of antibodies that would normally be obtained in sufficient quantities from her mother's colostrum.

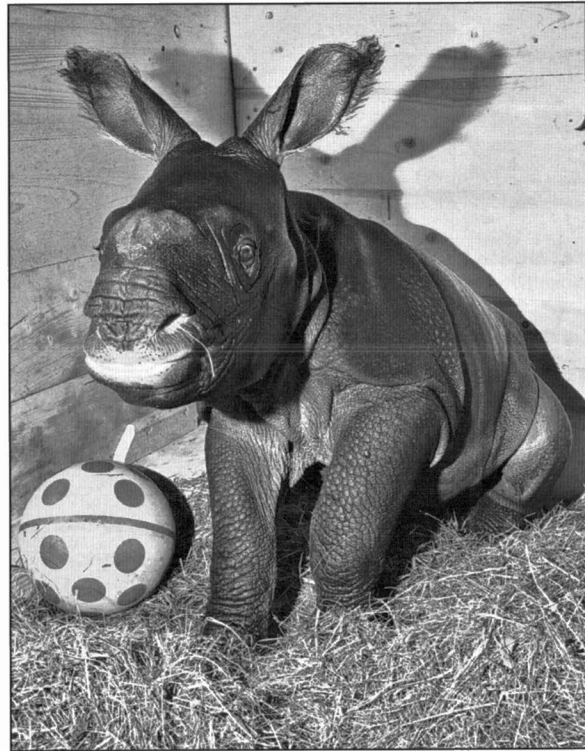
The second time attempt at hand rearing was carried out in the case of Nova DK 3, which, alike Nelly DK 1, was vibrant and viable when born, but unable to suckle properly. Thus, the animal began to be fed by hand. The first days it was given breast milk obtained from both her mother Numa and Sali DK 2, a female black rhinoceros, which at that time had a calf about 3 weeks old. As consumption of milk was high and milking possibilities limited, a part of the milk was supplemented with dried cow milk (Sunar brand). Nova was bottle-fed every 2 to 3 hours, with a total daily ration of 12 litres (HOLECKOVA 1998). Unlike the first artificial rearing, Nova was left with her mother Numa with the exception of feeding. Therefore, this rearing operation can be considered semi-artificial because mother's care and presence was available as well. From the day 10, Nova started suckling by herself, fed by her mother's breast milk, with Numa's lactation maintained by the intentional milking carried out by the keepers, so since then the calf could be reared by its mother (HOLECKOVA 1998, HOLECKOVA 2008a). Milk composition as well as feeding method and frequency was the same as for the rearing of the black rhinoceros Jaga DK 14 (see page 132 for more details).

Artificial rearing of an Indian rhino was successfully performed in Tierpark Berlin (BLASZKIEWITZ 2008), which involved male Patna (born 2004), who was fed with milk from the Salvana company, but lived separately from his mother.

Artificial rearing of Nelly DK 1 in 1986 at the elephant house



Nelly being bottle-fed (day 18) - with her keeper J Kabat at the elephant house - 1 February 1986 (lh)



Nelly on day 18, 1 February 1986 (lh)

Semi-artificial rearing of Nova DK 3, new rhino house, 1997-1998



Nova 3 DK being fed by Martin Vyhledal, 19 September 1997 (lh)



Nova DK 3 was bottle-fed 10 days - pictured with Oldrich Vyhledal (left), Vaclav Hak (middle) and the mother (right) (dh)



Half-year-old Nova drinking from her mother in the enclosure (dh)



Celebrating the second birthday of Nova DK 3 and 20th birthday of Numa (dh)

Maximum longevity

All adult animals left to other collections, with the still living female Numa being the oldest of them; on 31 December 2009, this animal reached the age of 30 years and 3 months. According to the EEP (STECK 2006), the oldest EEP female was 34 years old in 2005. ARKS data show the highest age of the Indian rhinoceros around 40 years.

Nutrition and feeding

Feeding Indian rhino is not problematic, although it appears that this species, unlike the black rhinoceros, can sometimes suffer from obesity and overfeeding (CLAUSS *et al.* 2005).

Throughout the stock history in Dvur Kralove Zoo, the rations underwent several changes that are presented in the table.

Comparison of feeding rations for Indian rhinos at Dvur Kralove Zoo

1990-1996 diet	1997-2000 diet	Diet since 2001
Hay - ad libitum Summers: grass and added hay	Hay - ad libitum Summers: grass and added hay	Hay - ad libitum Summers: grass and added hay
ZOO C pellets - 3.5 kg	ZOO C pellets - 3.5 kg	ZOO C pellets - 3.5 kg
Carrots - in winter	Carrots - 2 kg in winter	Carrots - 2 kg in winter
Roboran H - 3 tablespoons	Fruits and vegetables - 4 kg	Fruits and vegetables - 4 kg
Farmaferr - 1 tablespoon	Farmaferr - 15 g	Bread - 1 kg 1 bread roll
Limestone flour - 1 tablespoon	Limestone flour - 15 g	Sprouted oats - 1 kg
Magnesium salt lick - 1 tablespoon	Mineral salt lick - 30 g	Mineral salt lick (Aminovitan) - 1 tablespoon
Browse (summers)	Browse - particularly in summer	Vitamix standard + H - 2 + 2 tablespoons
	Bread - 0.2 kg	Feed grade limestone - 1 tablespoon
	Roboran H - 45 g	Combisol 4 – 1(4) ml/day Combisol A - 1 ml/month

The basis of the diet is high-quality grass hay supplemented with straw and in summer with meadow grass. This bulk feed as well as water is available to the animals *ad libitum*. In winter, carrots replace the green fodder and from spring to autumn, browse is available from goat willows, fruit trees, etc. In nursing females and growing calves, limestone and skimmed milk powder is added to the diet (PTACKOVA 2009). The current basic diet is shown in the following table.

Basic feeding ration of the Indian rhinoceros at Dvur Kralove Zoo in 2009 (PTACKOVA 2009)

Hay Grass	Pellets ZOO C	Apples	Vegetables	Carrots - only winters	Bread	Aminovitan (Mineral salt lick)	NutriHorse Standard + H	NutriHorse Chondro
Ad libitum	3.5 kg	1.5 kg	5 kg	3 kg	1 kg	0.04 kg	0.08 + 0.02 kg	0.07 kg

The diet includes the following supplements: C - Compositum 50 g/ animal / 3x per week; vitamins A, B and E once per month.

ZOO C pellets (manufacturer De Heus, Bucovice, CR) are produced according to the recipe developed directly in Dvur Kralove (SPALA 1986), with the nutritional composition as given in the following table.

Nutritional values of pellet feeds for Indian rhinos at Dvur Kralove Zoo (PTACKOVA 2009)

Pellets/contents	ZOO C
Nitrogen substances (N)	115.84 g/kg
Fat	29.49 g/kg
Fibre	111.71 g/kg
Vitamin A	40,849 IU/kg
Vitamin E	117.30 IU/kg
Calcium (Ca)	16.39 g/kg
Sodium (Na)	2.70 g/kg
Phosphorus (P)	12.07 g/kg



Two-month-old Nova 3 DK tries eating bread, 15 November 1997 (th)



Vegetable 'birthday cakes' were served only on birthday celebrations (dh)



Health issues

Rhinos never had problems with internal as well as external parasites over the years. The most common health problem involved skin disease (acute or even chronic dermatitis). Despite successful treatment by medicinal spraying, skin cracks with the emergence of purulent fissures would occur on previously affected skin sections, and especially at skin folds when exposed to the sun and dry conditions (VAHALA pers. comm.). Skin problems improved when a mud bath was available to the animals. Coating skin by the healing mud brought from Velichovsky Spa Resort worked well. In connection with the hard surfaces of the enclosure and floor inside the house and a large weight of the animal, excessive hoof abrasion occurred in the male in some fingers, with the consequent emergence of dens, hyper granulation of foot surface with cracking, decay and significant pain (VAHALA pers. comm.). Despite therapeutic interventions including surgery and efforts to soften the surface, the problem which the most of captive adult Indian rhinos suffer (CLAUSS *et al.* 2005a) could not be removed. Ropen, as the heaviest and far more active animal, as with any other male, suffered this the most of all rhinos. To a lesser extent, Numa encountered these problems at an older age as well. Prob-

ably because Ropen still could not reach his maturity and Numa was unable to conceive for several years, the female began to suffer from inflammation of the uterus, which eventually led to the fact that she never got pregnant following the year 1997. This situation could not be changed despite repeated treatment.

Over the years, only one death was recorded - this concerned Nelly DK 1, who died of general infection due to lack of immunity resulting from the artificial rearing.

Causes of deaths in the Indian rhinoceros at Dvur Kralove Zoo prior to 31 December 2009

No	Name	Sex	Died	Age	Cause of death
3/0/DK/1	Nelly DK 1	F	27 Feb 1986	44 days	Bacterial infection - in handrearing

Exports of Indian rhinoceroses

Throughout the holding period, all individuals kept - 5 (3.2) animals - were exported from Dvur Kralove Zoo, except Nelly DK 1, who died at the age of 44 days. All the males went to other collections; unfortunately, Dvityia died shortly after his arrival in Singapore Zoo. Male Nim DK 2 lived until 2001 at the zoo in Liberec, Czech Republic, which then supplied this animal to Chinese Beijing Zoo. Male Ropen left to German Nuremberg in 2006, replacing their previous breeding male. The breeding in Dvur Kralove was temporarily interrupted in 2009 by loaning the two remaining females (Numa and Nova DK 3) to Lisbon Zoo, Portugal, to which they left to join an unrelated breeding male, when one had not been obtained for the Dvur Kralove stock. Further details are summarised in the following table.

Overview of Indian rhino exports from Dvur Kralove Zoo prior to 31 December 2009 (M - male, F - female)

No	Sex	Name	Stdbk #	Departure	Born	Arrival	Comments
1	M	Dvityia	86	11 Jun 1992 Singapore Zoo	21 Sep 1977 Stuttgart, Germany	13 Aug 1980 Stuttgart, Germany	Died in Singapore, 1992
2	M	Nim DK 2	141	24 Jan 1990 Liberec, CR	4 Nov 1987 Dvur Kralove	Reared	Supplied to China in 2001
3	M	Ropen	145	28 Nov 2006 Nuremberg, Germany	8 May 1988 Whipsnade, UK	17 Jan 1990 Whipsnade, UK	Left for breeding purposes
4	F	Numa	93	13 Mar 2009 Lisbon, Portugal	13 Sep 1979 Stuttgart, Germany	22 Jul 1981 Stuttgart, Germany	Breeding loan
5	F	Nova DK 3	245	13 Mar 2009 Lisbon, Portugal	13 Sep 1997 Dvur Kralove	Reared	Breeding loan
Total exported: 5 (3.2) animals.							

Summary

Indian rhinos were held at Dvur Kralove Zoo from 1980 to 2009. The entire breeding period was affected by the fact that it was not easy to obtain breeding and unrelated individuals. Therefore, a pair of siblings was initially held, and it took several years for both animals to reach maturity. Two calves were born consequently. In 1990, an unrelated male called Ropen was obtained, who was however still young and it took him more than 5 years to reach adulthood. Despite initial problems with inflammation of the uterus, Numa conceived and bore female Nova DK 3. Subsequently, she never got pregnant. Because the efforts to get an appropriate male for the subadult female Nova DK 3 failed and the female needed to be involved in the reproduction for medical reasons as quickly as possible, both females were sent to Lisbon Zoo in March 2009 to join a male suitable in terms of both genetics and age, based on the recommendation of the EEP Coordinator. In Dvur Kralove, 3 (2.1) calves were born, of which 2 (1.1) were successfully reared. The first of them died during the artificial rearing and was the only Indian rhinoceros that died at Dvur Kralove Zoo. Summary and more details are provided in the tables on page 322 and 324.

Numbers of Indian rhinos at Dvur Kralove Zoo in the years 1980-2008 (1.0 - male, 0.1 - female)

YEAR	Status as per 1 Jan	Arrival	Departure	Born	Died	Status as per 31 Dec
1980	0	1.0	-	-	-	1 (1.0)
1981	1 (1.0)	0.1	-	-	-	2 (1.1)
1982	2 (1.1)	-	-	-	-	2 (1.1)
1983	2 (1.1)	-	-	-	-	2 (1.1)
1984	2 (1.1)	-	-	-	-	2 (1.1)
1985	2 (1.1)	-	-	-	-	2 (1.1)
1986	2 (1.1)	-	-	0.1	0.1	2 (1.1)
1987	2 (1.1)	-	-	1.0	-	3 (2.1)
1988	3 (2.1)	-	-	-	-	3 (2.1)
1989	3 (2.1)	-	1.0	-	-	2 (1.1)
1990	2 (1.1)	1.0	-	-	-	3 (2.1)
1991	3 (2.1)	-	-	-	-	3 (2.1)
1992	3 (2.1)	-	1.0	-	-	2 (1.1)
1993	2 (1.1)	-	-	-	-	2 (1.1)
1994	2 (1.1)	-	-	-	-	2 (1.1)
1995	2 (1.1)	-	-	-	-	2 (1.1)
1996	2 (1.1)	-	-	-	-	2 (1.1)
1997	2 (1.1)	-	-	0.1	-	3 (1.2)
1998	3 (1.2)	-	-	-	-	3 (1.2)
1999	3 (1.2)	-	-	-	-	3 (1.2)
2000	3 (1.2)	-	-	-	-	3 (1.2)
2001	3 (1.2)	-	-	-	-	3 (1.2)
2002	3 (1.2)	-	-	-	-	3 (1.2)
2003	3 (1.2)	-	-	-	-	3 (1.2)
2004	3 (1.2)	-	-	-	-	3 (1.2)
2005	3 (1.2)	-	-	-	-	3 (1.2)
2006	3 (1.2)	-	1.0	-	-	2 (0.2)
2007	2 (0.2)	-	-	-	-	2 (0.2)
2008	2 (0.2)	-	-	-	-	2 (0.2)
2009	2 (0.2)	-	2 (0.2)	-	-	0
Total	-	22 (14.8)	5 (3.2)	3 (1.2)	1 (0.1)	-

BASIC GUIDELINES FOR REARING THE INDIAN RHINOCEROS

On the basis of almost 30 years of experience, principles of breeding and management in Dvur Kralove creating optimal conditions for natural reproduction of Indian rhinos can be summarised as follows:

1. **Nutrition is not very complicated**, with diet consisting of high-quality hay, grass, fruits, vegetables and pellets. Due to the problem of overweight and excessive abrasion of hooves with resulting leg foot disease, it is desirable that animals are **not overfed and weight is measured regularly**.
2. **Putting the couple together needs to have enough space**. Except calf rearing periods, the male and the female can go into the enclosure together; they are generally very tolerant. When in heat, the female is chased by the male and is therefore appropriate that the enclosure is equipped with vegetation and items to allow for run-arounds and making circles. If animals are tolerant to each other, holding them together in the enclosure may extend the length of staying outdoors, which is desirable in climate-friendly periods of the year.
3. **Monitoring the female's cycle and pregnancy using faeces is very important**, as it will allow for early separation of male and female, leaving the females at rest when pregnant.
4. **When the female is about to give birth, timely isolation into a separate box is necessary**, where a temporary barrier between the fence openings above the ground is required to prevent the calf to escape from the box. **Monitoring the process of birth and the behaviour of the female after the birth using CCTV with a recording feature is preferable**; this will allow evaluating the behaviour of mother and calf, as well as monitor nursing. For a better stability of the calf when trying to stand up after the birth, sprinkling little sand around the box is advisable, depending on the slipperiness of the wet floor.
5. **In hand rearing, the young should be left with the mother and separated only for feeding**. Feeding calves by a horse colostrum after the birth and then by maternal horse and rhino milks during the first weeks has worked well. In the case of hand rearing, making a stock of frozen horse and rhino milk is useful. Leaving the calf grow in the company of the mother even if hand-reared may restore lactation and subsequent nursing.
6. **Health problems include skin lesions, especially in summer**, associated with inadequate protection of skin from the sun. Providing the possibility of staying in the pool and mud bath or coating the back and other body areas by mud, preferably healing mud, is vital.
7. **The surface of both the rhino enclosure and indoor boxes should be soft, ideally with a swimming pool both outdoors and indoors, to avoid excessive abrasion of hooves and foot disease**. Rhinos should walk into their outdoor enclosure daily. In summer, going there at night and during the day is ideal, while in winter a short stay is recommended, even at frost, which typically ranges from -5° to -8° C. Rhinos like wallowing in the snow, but staying outdoors should not be too long.
8. **Having good keepers at hand is essential**.

(dh)



Following overview contains basic historical information about the individual Indian rhinos that were in possession of Dvur Kralove Zoo.

History of Indian rhino keeping at Dvur Kralove Zoo prior to 31 December 2009 (M - male, F - female)

No Name	Sex	ISB/ESB # ARKS #	Born	Arrival in DK Parents	Departure from DK	Died	Comments
1/1/DK/0 Dvityia Stutt 3	M	86 057001	21 Sep 1977, Stuttgart, Ger.	13 Aug 1980, Stuttgart, DE	11 Jun 1992 Singapore	8 Jul 1992 Singapore	1st breeding male
2/2/DK/0 Numa Stutt 4	F	93 057002	13 Sep 1979, Stuttgart, Ger.	22 Jul 1981 Stuttgart, DE	13 Mar 2009 Lisbon, Portugal	-	1st breeding female
3/0/DK/1 Nelly DK 1	F	167 057003	14 Jan 1986, Dvur Kralove	Reared Nova / Dvityia	-	27 Feb 1986, Dvur Kralove	Hand-reared, died of infection
4/0/DK/2 Nim DK 2	M	141 057004	4 Nov 1987 Dvur Kralove	Reared Nova / Dvityia	24 Jan 1990 Liberec	-	Left on 18 Dec 2001 to Beijing Zoo, China
5/3/DK/0 Ropen Whip 6	M	145 057005	8 May 1988, Whipsnade, UK	17 Jan 1990, Whipsnade, UK	28 Nov 2006 Nuremberg, Ger.	-	2nd breeding male
6/0/DK/3 Nova DK 3	M	245 057006	13 Sep 1997, Dvur Kralove	Reared Nova / Ropen	13 Mar 2009 Lisbon, Portugal	-	Hand-reared first 10 days

Explanation for figures: 6/0/DK/3: 6 - Historical (time) serial number of individual at Dvur Kralove Zoo

0 - Historical serial number of import to Dvur Kralove Zoo

DK - Dvur Kralove Zoo abbreviation

3 - Historical serial number of birth at Dvur Kralove Zoo



Indian rhinos (th)



Nova DK 3 (th)



Male Ropen in its enclosure in winter (dh)



Naming party - Numa and Nova DK, 1997 (dh)



Fifth birthday of Nova DK 3 (dh)



Young Nova DK 3 in the natural pool (dh)



Ropen marking the enclosure; note the visible forefront horn-like protuberance (dh)

BIBLIOGRAPHY:

- ALLEN, S., 1995: Tusk Talk. Spring 1995. TUSK Goes Mkomazi. Register Built Machines Ltd. London.
- ANDĚRA, M., 1999: České názvy živočichů II. Savci (Mammalia). Národní muzeum Praha.
- ANONYMUS, 2006a: Critically endangered rhino dies at San Diego Zoo's Wild Animal Park, Press release May 30. WAP San Diego.
- ANONYMUS, 2006b: White Rhino Introduced onto the Ol Pejeta Conservancy. Enewsflash - 26th November (www.olpejetaconservancy.org).
- ANONYMUS, 2006c: Black Rhinoceros. Animal Info - Endangered Animals (www.animalinfo.org).
- ANONYMUS, 2008a: Wildlife Numbers Continue to Increase on the Ol Pejeta Conservancy. Enewsflash - 2nd May (www.olpejetaconservancy.org).
- ANONYMUS, 2008b: In Morani's Footsteps: Blind Black Rhino, Baraka takes on an Important New Role. Enewsflash - 19th December (www.olpejetaconservancy.org).
- ANONYMUS, 2008c: RhiNEWS July 2008 E-zine. Save the Rhino International (www.savetherhino.org).
- ANONYMUS, 2009a: Black Rhinos on the Ol Pejeta Conservancy (www.olpejetaconservancy.org).
- ANONYMUS, 2009b: Two Black Rhino Calves Born on the Ol Pejeta Conservancy! Enewsflash - 6 February (www.olpejetaconservancy.org).
- ANONYMUS, 2009c: News Releases 1. The IUCN Red List of Threatened Species (www.iucnredlist.org/news).
- ANONYMUS, 2009d: RhiNEWS May 2009 E-zine. Save the Rhino International (www.savetherhino.org).
- ANONYMUS, 2009e: Crisis Zimbabwe. Poaching Threatens Rhinos' Survival. Save the Rhino International (www.savetherhino.org).
- ANONYMUS, 2009f: Poaching in practice. Save the Rhino International (www.savetherhino.org).
- ASSENBERG, V., HOUTEN, T., 2008: Concept husbandry guidelines for the black rhino (*Diceros bicornis*). Van Hall Larenstein.
- BACKHAUS, D., 1964: Zum Verhalten des nördlichen Breitmaulnashornes (*Diceros simum cottoni*, Lydekker 1908). Ergebnisse einer Studienreise in den Garamba-Nationalpark (Republik Kongo) 4. Mitteilung. D. Zool. Garten (N.F.) 29/3: 93-107.
- BALL, R. L., 2005: Comparison of anti-phospholipid antibodies between wild and captive Black rhinoceros (*Diceros bicornis*): implications for health and repatriation. Wildlife Disease Association International Conference. CAIRNS.
- BÖER, M., BRAIN, C., CANTZLER, T., HAMZA, H., VENZKE, K., 1997: Reintroduction of a captive born white rhinoceros (*Ceratotherium simum simum*) to the Etosha National Park. Part I: Selection, transfer and adaption. Zool. Garten N.F. 67, 3: 99-107.
- BÖER, M., BRAIN, C., CANTZLER, T., HAMZA, H., VENZKE, K., 1999: Reintroduction of a captive born white rhinoceros (*Ceratotherium simum simum*) to the Etosha National Park. Part II: Behaviour in the boma, procedures before and locomotion during the first ten weeks after release and observations from June until November 1997. Zool. Garten N.F. 69, 2: 73-81.
- BONAL, B. S., TALUKDAR, B. K., SHARMA, A., 2009: Indian Rhino Vision (IRV) 2020 - training cum Translocation of Rhinos within Assam, the first Phase. The Translocation Operation.
- BERTRAM, B., 1983: Spitzmaulnashörner in Menschenobhut. International Studbook for the African Rhinoceroses 2: 30-37.
- BLASZKIEWITZ, B., 1991: Anmerkungen zum Lebensalter und Reproduktionsrate Berliner Nashörner. International Studbook for African Rhinoceroses, 4: 37-41.
- BLASZKIEWITZ, B., 1995: Frühe Geschlechtsreife bei einem Panzernashornweibchen (*Rhinoceros unicornis*). Kleine Mitteilungen. Zool. Garten N.F. 65: 267.
- BLASZKIEWITZ, B., 2008a: Haltung und Zucht des Spitzmaulnashorns (*Diceros bicornis*) im Zoologischen Garten Berlin. Zool. Garten N.F. 77: 207-218.
- BLASZKIEWITZ, B., 2008b: Panzernashorn (*Rhinoceros unicornis*) und Breitmaulnashorn (*Ceratotherium simum simum*) - Bilder aus dem Tierpark Berlin - 3. Nachtrag. Milu, Berlin 12: 236-241.
- BROOKS, M., 2009: Survival strategy for Northern white rhino: AfRSG's updated recommendations.
- CLAUS, M., JESSUP, D. A., NORKUS, E. B., CHEN, T. C., HOLICK, M. F., STREICH, W. J., DIERENFELD, E. S., 2002: Fat soluble vitamins in blood and tissues of free-ranging and captive rhinoceros. Journal of Wildlife Diseases, 38/2: 402-413.

- CLAUS, M., POLSTER, C., KIENZLE, E., WIESNER, H., BAUMGARTNER, K., von HOUWALD, F., STREICH, W. J., DIERENFELD, E., 2005a: Energy and Mineral Nutrition and Water Intake in the Captive Indian Rhinoceros (*Rhinoceros unicornis*). *Zoo Biology* 24: 1-14.
- CLAUS, M., POLSTER, C., KIENZLE, E., WIESNER, H., BAUMGARTNER, K., von HOUWALD, F., ORTMANN, S., STREICH, W. J., DIERENFELD, E., 2005b: Studies on digestive physiology and feed digestibilities in captive Indian rhinoceros (*Rhinoceros unicornis*). *Journal of Animal Physiology and Animal Nutrition* 89: 229-237.
- CLAUS, M., HATT, J.-M., 2006: The feeding of rhinoceros in captivity. *Int. ZOO Yb.* 40: 197-209.
- CLAUS, M., CASTELL, J. C., KIENZLE, E., DIERENFELD, E. S., FLACH, E. J., BEHLERT, O., ORTMANN, S., STREICH, W. J., HUMMEL, J., HATT, L.-M., 2006: Digestion coefficients achieved by the black rhinoceros (*Diceros bicornis*), a large browsing hindgut fermenter. *Journal of Animal Physiology and Animal Nutrition* 90: 325-334.
- CLAUS, M., CASTELL, J. C., KIENZLE, E., DIERENFELD, E. S., FLACH, E. J., BEHLERT, O., ORTMANN, S., STREICH, W. J., HUMMEL, J., HATT, L.-M., 2007a: The influence of dietary tannin supplementation on digestive performance in captive black rhinoceros (*Diceros bicornis*). *Journal of Animal Physiology and Animal Nutrition* 91: 449-458.
- CLAUS, M., CASTELL, J. C., KIENZLE, E., SCHRAMMEL, P., E., DIERENFELD, E. S., FLACH, E. J., BEHLERT, O., STREICH, W. J., HUMMEL, J., HATT, L.-M., 2007b: Mineral absorption in the black rhinoceros (*Diceros bicornis*) as compared with the domestic horse. *Journal of Animal Physiology and Animal Nutrition* 91: 193-204.
- COE, M. J., McWILLIAM, Mc N. C., STONE, G. N., PACKER, M. J. (eds.), 1999: Mkomazi: the Ecology, Biodiversity and Conservation of a Tanzanian Savanna. Royal Geographical Society (with The Institute of British Geographers). London
- COLLET M., 2008: Garamba National Park. African Parks Foundation Annual report 2007. African Parks Network: 10-12.
- DOLLINGER, P., GESER, S., 2008a: Black Rhinoceros (*Diceros bicornis*). WAZA - World Association of Zoos and Aquariums (www.waza.org).
- DOLLINGER, P., 2008b: Operation Black Rhino, Tanzania. WAZA - World Association of Zoos and Aquariums (www.waza.org).
- DOLLINGER, P., 2008c: Critically endangered in the wild - healthy insurance population in zoos (*Diceros bicornis michaeli*). WAZA - World Association of Zoos and Aquariums (www.waza.org).
- DURRANT, B. S., 1995: Northern white rhinoceros reproductive studies. San Diego Wild Animal Park.
- EDWARDS, J., 1996: London Zoo from old photographs 1852-1914. John Edwards, London: 123.
- EMSLIE, R., BROOKS, M., 1999: African Rhino. Status Survey and Conservation Action Plan. IUCN/SSC African Rhino Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK: 92s.
- EMSLIE, R., 2000: African rhinos numbering 13,000 for first time since the mid-1980s. *Pachyderm* 29: 53-56.
- EMSLIE, R., 2002: African rhino numbers continue to increase. *Pachyderm* 33: 103-107.
- EMSLIE, R., 2004: Rhino population sizes and trends. *Pachyderm* 37: 107-110.
- EMSLIE, R., 2005: The African Rhino Specialist Group (AfRSG) - current rhino numbers and trends, recommended conservation strategies and the EAZA Rhino Campaign. Plenary presentation. EAZA Conference. Bristol.
- EMSLIE, R., 2006: Rhino population sizes and trends. *Pachyderm* 41: 100-105.
- EMSLIE, R., 2007a: Rhino issues at CITES CoP14. *Pachyderm* 42: 116-119.
- EMSLIE, R., MILLEDGE, S., BROOKS, M., STRIEN, N. J. van, DUBLIN, H., 2007b: African and Asian Rhinoceroses - Status, Conservation and Trade. A report from the IUCN Species Survival Commission (SSC) African and Asian Rhino Specialist Groups and TRAFFIC to the CITES Secretariat.
- EMSLIE, R., MILLEDGE, S., BROOKS, M., STRIEN, N. J. van, DUBLIN, H., 2007c: African and Asian Rhinoceroses - Status, Conservation and Trade. A report from the IUCN Species Survival Commission (SSC) African and Asian Rhino Specialist Groups and TRAFFIC to the CITES Secretariat.
- EMSLIE, R., 2008a: Brief report on current status and trends in numbers of northern white rhino in the wild. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- EMSLIE, R., 2008b: Rhino population sizes and trends including and populations and by management model. AfRSG Report.

- EMSLIE, R., AMIN, R., KOCK, R., 2009: Guidelines for the *in situ* Re-introduction and Translocation of African and Asian Rhinoceros. Occasional Paper of the IUCN Species Survival Commission No. 39. IUCN, Gland, Switzerland.
- ESTES, R. D., 1991: The Behavior Guide to African Mammals. The University of California Press. Berkeley, Los Angeles, Oxford: 228-234.
- EUSTAGE, M., 2009: Hunting for other ways to protect rhinos. Business Day. 30. 11. 2009 - www.businessday.co.za
- FISKEN, F. A., 2008: International Zoo Yearbook, 42. Zoological Society London: 449.
- FITZJOHN, T., 1993: The Mkomazi Project the Friends of Mkomazi Visit. The George Adamson Wildlife Preservation Trust.
- FITZJOHN, T., 2009: Mkomazi Rhino Sanctuary Development, Mkomazi Game Reserve, Tanzania. Application by the George Adamson Wildlife Preservation Trust.
- FOOSE, T. J., 1983: AAZPA Überlebensplan für Nashörner. International Studbook for the African Rhinoceroses 2: 113-134.
- FOOSE, T. J., 1993: Rhino Global Captive Action Plan (GCAP), Global Animal Survival Plan (GASP). General Guide. Antwerp.
- FRÄDRICH, H., FRESE, R., 1993: International Studbook of African Rhinoceroses 5, Zoologischer Garten Berlin.
- FRÄDRICH, H., OCHS, A., 2001: International Studbook for African Black Rhinoceros 9, Zoologischer Garten Berlin.
- FRANCKE, R., SCHWARZENBERGER, F., 1991: Trächtigkeitadiagnose durch Steroidhormonanalyse aus Kotproben bei einem Spitzmaulnashorn (*Diceros bicornis*) im Zoologischen Garten Berlin. In: KLÖS, H. G., FRESE, R., 1991: International Studbook for the African Rhinoceroses 4: 44-48.
- FRESE, R., 1983: Protokoll einer Spitzmaulnashorngeburt. International Studbook for the African Rhinoceroses 2, Zoologischer Garten Berlin.: 38 - 40.
- FRESE, R., 1993: In gratitude of Prof. Dr. H. c. Heinz-Georg Klös. International Studbook of African Rhinoceroses 5, Zoologischer Garten Berlin: 7.
- FRESE, R., 2009: International Studbook for the White Rhinoceros 11. Zoologischer Garten Berlin AG.
- GODDARD, J., 1967: Home range, behaviour, and recruitment rates of two black rhinoceros populations. East African Wildlife Journal, Vol. 5: 133-150.
- GÖLTENBOTH, R., 1993: Black rhinoceros (*Diceros bicornis*) EEP Annual Report 1993. Zoologischer Garten Berlin.
- GÖLTENBOTH, R., 1994: Black rhinoceros (*Diceros bicornis*) EEP Annual Report 1993. Zoologischer Garten Berlin.
- GÖLTENBOTH, R., GANSLOSSER, U., TOMÁŠOVÁ, K., 1995a: Husbandry guidelines for rhinoceroses. International Studbook for African Rhinoceroses 6, Zoologischer Garten Berlin: 1-17.
- GÖLTENBOTH, R., OCHS, A., 1995b: International Studbook for African Rhinoceroses (*Diceros bicornis/Ceratotherium simum*) 6, Zoologischer Garten Berlin.
- GÖLTENBOTH, R., 1996: Black rhinoceros (*Diceros bicornis*) EEP Annual Report 1995. Zoologischer Garten Berlin.: 255-257.
- GÖLTENBOTH, R., 1997: Black rhinoceros (*Diceros bicornis*) EEP Annual Report 1997. Zoologischer Garten Berlin.
- GÖLTENBOTH, R., OCHS, A., 1997: International Studbook for African Rhinoceroses 7, Zoologischer Garten Berlin.
- GÖLTENBOTH, R., OCHS, A., 1999: International Studbook for African Rhinoceroses 8, Zoologischer Garten Berlin.
- GRZIMEK B. a A., 1966: Ráj divokých zvířat. Orbis Praha.
- HALL-MARTIN, A., 1983: Ökologie und Management des Spitzmaulnashorns in Südafrika. International Studbook for the African Rhinoceroses 2: 17-29.
- HARRIS L. D., 1972: An Ecological Description of a Semi-arid East African Ecosystem. Colorado State University.
- HARTLEY, W., 2009: SA becomes supplier of illegal rhino horn. Business Day. 12. 3. 2009 - www.businessday.co.za
- HELLER, E., 1913: The White Rhinoceros. Smithsonian Miscellaneous Collections, 61/1. Smithsonian Institution Washington.
- HERMES, R., HILDEBRANDT, T. B., WALZER, CH., GÖRITZ, F. a SCHWARZENBERGER, F., 2001: Reproductive assessment in the captive White rhinoceros - current standing. Int. Stb. for African White Rhinoceros, Berlin: 9.
- HERMES, R., HILDEBRANDT, T. B., GÖRITZ, F., 2004: Reproductive problems directly attributable to long-term captivity-asymmetric reproductive aging. Animal Reproduction Science 82-83: 49-60.

- HERMES, R., HILDEBRANDT, T. B., BLOTTNER, S., WALZER, CH., SILINSKI, S., PATTON, M. L., WIBBELT, G., SCHWARZENBERGER, F., GÖRITZ, F., 2005: Reproductive soundness of captive southern and northern rhinoceroses (*Ceratotherium simum simum*, *C. s. cottoni*): evaluation of male genital tract morphology and semen quality before and after cryopreservation. *Theriogenology* 63: 219-238.
- HERMES, R., HILDEBRANDT, T. B., WALZER, CH., GÖRITZ, F., PATTON, M. L., SILINSKI, S., ANDERSON, M. J., REID, C. E., WIBBELT, G., TOMASOVA, K., SCHWARZENBERGER, F., 2006: The effect of long non-reproductive periods on the genital health in captive female white rhinoceroses (*Ceratotherium simum simum*, *C. s. cottoni*). *Theriogenology* 65: 1492-1515.
- HERMES, R., GÖRITZ, F., STREICH, W. J., HILDEBRANDT, T. B., 2007: Assisted Reproduction in Female Rhinoceros and Elephants - Current Status and Future Perspective. *Reprod. Dom. Anim.* 42 (Suppl. 2): 33-44.
- HERMES, R., 2008: Current reproductive status of the captive northern white rhino population and the consequences for future captive breeding management. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- HIERONYMUS, T. L., WITMER, L. M., RIDGELY, R. C., 2006: Structure of White Rhinoceros (*Ceratotherium simum*) Horn Investigated by X-ray Computed Tomography and Histology With Implications for Growth and External Form. *Journal of Morphology* 267: 1172-1176.
- HILDEBRANDT, T. B., HERMES, R., WALZER, CH., SÓS, E., MOLNAR, V., MEZÖSI, L., SCHNORRENBURG, A., SILINSKI, S., STREICH, J., SCHWARZENBERGER, F., GÖRITZ, F., 2007: Artificial insemination in the anoestrous and the postpartum white rhinoceros using GnRH analogue to induce ovulation. *Theriogenology* 67: 1473-1484.
- HILDEBRANDT, T. B., 2008a: Assisted Reproduction Technologies in Rhinoceros. Leibniz Institute for Zoo and Wildlife Research Berlin. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- HILDEBRANDT, T. B., 2008b: Recent results on artificial insemination, oocyte collection and in-vitro fertilisation in rhinoceroses and the future input in conservation projects. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- HILSBURG, S., 2003: Conservation Medicine in Action: Ongoing investigations into a severe disease outbreak in the Ngorongoro Crater, Tanzania during 2000/2001. Wildlife Disease Association Conference.
- HOLEČKOVÁ, D., VONDRA, Z., 1994a: Nosorožci a jejich chov ve Východočeské zoo. QITec. Nové Město nad Metují: 8-9.
- HOLEČKOVÁ, D., VONDRA, Z., ŽDÁREK, J., 1994b: Historie chovu nosorožců ve Východočeské zoologické zahradě Dvůr Králové n. L. Výroční zpráva 1993. Východočeská zoologická zahrada - safari Dvůr Králové n. L.: 29-40.
- HOLEČKOVÁ, D., 1995a: Kolik váží nosorožec? Výroční zpráva 1994. Východočeská zoo - safari Dvůr Králové n. L.: 57-64.
- HOLEČKOVÁ, D., 1995b: Narodí se v naší zoologické zahradě slon? Výroční zpráva 1994. Východočeská zoologická zahrada - safari Dvůr Králové n. L.: 39-43.
- HOLEČKOVÁ, D., 1996: Čtvrtstoletí chovu nosorožců v Zoologické zahradě Dvůr Králové. Výroční zpráva 1995. Východočeská zoologická zahrada - safari Dvůr Králové nad Labem: 57-64.
- HOLEČKOVÁ, D., 1998: Ve znamení nosorožce. Výroční zpráva 1997. Zoologická zahrada Dvůr Králové nad Labem: 51-55.
- HOLEČKOVÁ, D., 2000a: Mládě milénia - odchov severní formy nosorožce tuponosého v zajetí. *Živa* 5: 230-232.
- HOLEČKOVÁ, D., BOBEK, M., 2000b: Mládě milénia. Ohrožený svět nosorožců. Český rozhlas a ESCAD Trade, Praha.
- HOLEČKOVÁ, D., BOBEK, M., 2000c: Baby of Millennium. The Endangered World of Rhinos. ZOO Dvůr Králové nad Labem, Český rozhlas, IRF, Praha.
- HOLEČKOVÁ, D., DOUSEK, J., 2000d: Podmínky chovu savců volně žijících druhů v zajetí. Doporučení Ústřední komise pro ochranu zvířat. Ministerstvo zemědělství ČR.
- HOLEČKOVÁ, D., TOMÁŠOVÁ, K., 2000e: Narodí se ve Dvoře Králové nejvzácnější mládě roku 2000? Výroční zpráva 1999. Zoo Dvůr Králové n. L.
- HOLEČKOVÁ, D., 2001: Mládě milénia. Výroční zpráva 2000. Zoologická zahrada Dvůr Králové: 152-159.
- HOLEČKOVÁ, D., 2002: Procházka po ZOO. Velký obrazový průvodce. ZOO Dvůr Králové.
- HOLEČKOVÁ, D., 2008a: Breeding of Rhinoceroses in ZOO Dvůr Králové. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.

- HOLEČKOVÁ, D., SMRČEK, M., 2008b: Akční plán na záchranu severního bílého nosorožce. ZOO Dvůr Králové.
- HOLEČKOVÁ, D., 2008c: Musí severní bílý nosorožec vyhynout? Severní bílý - poslední šance. ZOO Dvůr Králové.
- HOLEČKOVÁ, D., 2008d: Nevšední zážitky ze Svazijska. Výroční zpráva 2007. ZOO Dvůr Králové: 209-215.
- HOLEČKOVÁ, D., 2009a: První reintrodukce nosorožců dvourohých z České republiky do Afriky. Živa 6, Academia Praha: 275-279.
- HOLEČKOVÁ, D., 2009b: ZOO Dvůr Králové navrácí nosorožce do Tanzanie. Ochrana přírody 4: 35-36.
- CHAUSI, E. B., 1998: The Ngorongoro Rhino Programme. Kakakuona Tanzania Wildlife 8.
- IRF, 2008: 2007 Annual Report. White Oak Road Yulee. The International Rhino Foundation: <http://www.rhinos-irf.org/>
- IRF, 2009a: Africa Programs. International Rhino Foundation Programs in Africa - Intl Rhino Foundation (www.rhinos-irf.org).
- IRF, 2009b: Spotlight on: Black Rhinos. International Rhino Foundation (www.rhinos-irf.org).
- IRF, 2009c: White Rhino (*Ceratotherium simum*). Intl Rhino Foundation (www.rhinos-irf.org).
- IRF, 2009d: Tanzania. Intl Rhino Foundation, Conservation, Africa (www.rhinos-irf.org).
- ISIS Specimen Reference, 2000: Mammalia, 31.3.2000, Minnesota.
- IUCN, 2007: 207 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 28 June 2008
- IUCN, 2008: Rhinos on the rise in Africa but Northern white rhino nears extinction. IUCN News Release. June 17.
- IUCN SSC African Rhino Specialist Group, 2009a: Black Rhino Distribution Table by Country. Intl Rhino Foundation (www.rhinos-irf.org).
- IUCN SSC African Rhino Specialist Group, 2009b: White Rhino Distribution Table by Country. Intl Rhino Foundation (www.rhinos-irf.org).
- IUCN - www.iucn.org
- JAROFKE, D., KULOW, W., 1991: Die Wichtigsten Krankheiten der Nashörner mit Hinweis auf umfassende Bibliographien sowie einer Nashorn-Zuchtbuchauswertung. International Studbook for African Rhinoceroses 4: 49-51.
- JONES, D. M., 1983: Klinik und Pathologie des Nashörner. International Studbook for the African Rhinoceroses 2: 94-112.
- JONES, D. M., 1991: Black Rhinos in Britain - November 1989. International Studbook for the African Rhinoceros 4: 52-53.
- JONES, M. L., 1993: Longevity of ungulates in captivity. Int. Zoo Yb. 32: 159-169.
- KAMPAMBA, G., 2003: Black rhinos reintroduced to North Luangwa National Park, Zambia. Pachyderm 34.
- KEMEI, K., MNYAMWEZI, R., 2009: Poachers now target endangered black rhino. The Standard, Online Edition (www.eastandard.net).
- KING, J., 2009: NRT Research & Monitoring Programme. Annual Report 2008 (www.nrt-kenya.org).
- KLÖS, H. G., FRESE, R., 1981: International Studbook of the Square-lipped Rhinoceros 1, Zoologischer Garten Berlin.
- KLÖS, H. G., FRESE, R., 1983: International Studbook for the African Rhinoceroses 2, Zoologischer Garten Berlin.
- KLÖS, H. G., FRESE, R., 1987: International Studbook of the African Rhinoceroses 3, Zoologischer Garten Berlin.
- KLÖS, H. G., FRESE, R., 1991a: Introduction to the 4th revised edition of the International Studbook of African Rhinoceroses. International Studbook for the African Rhinoceroses 4, Zoologischer Garten Berlin.: 22-36.
- KLÖS, H. G., FRESE, R., 1991b: International Studbook for the African Rhinoceroses 4, Zoologischer Garten Berlin.
- KLÖS, H. G., FRESE, R., 1993: International Studbook for the African Rhinoceroses 5, Zoologischer Garten Berlin.
- KOCK, R. A., 1995: Rhino Situation in East Africa and Zimbabwe. International Studbook for African Rhinoceroses 6: 18-19.
- KNAPP, S. E., KRECEK, R. C., HORAK, I. G., PENZHORN, B. L., 1997: Journal of Wildlife Diseases, 33(3): 492-502.
- KURNIT, J., MYERS, P., 2009: „Dicerus bicornis“ (On-line), Animal Diversity Web. Accessed July 28, 2009 at <http://animaldiversity.ummz.umich.edu>.
- LACY, B., EMSLIE, R., 2008: Key findings to emerge from northern white rhino population viability modelling. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- LANG, H., 1920: The white rhinoceros of the Belgian Congo. Zoological Society Bulletin. New York Zoological Society, New York.
- LANGE, J., OCHS, A., 2005a: International Studbook for African White Rhinoceros 10. Zoologischer Garten Berlin.
- LANGE, J., OCHS, A., 2005b: International Studbook for African Black Rhinoceros 10. Zoologischer Garten Berlin.
- Laurie, A., 1982: Behavioural ecology of the Greater one-horned rhinoceros (*Rhinoceros unicornis*). J. Zool., Lond. 196: 307-341.

- LINDEMANN, H., 1983: Afrikanische Nashörner in Menschenobhut. International Studbook for the African Rhinoceroses 2: 68-74.
- LINDSAY, N., 2006: EAZA Rhinoceros TAG Annual Report 2005. EAZA Yearbook 2005. Amsterdam: 534-535.
- LINDSAY, N., 2007: EAZA Rhinoceros TAG Annual Report 2006. EAZA Yearbook 2006. Amsterdam: 636-637.
- MARUSKA, E. J., DRESSER, B. L., 1991: Black Rhino Species Survival Plan (SSP) Report. International Studbook for African Rhinoceroses 4: 54-57.
- MASONDO, S., 2009: Rhino horn and ivory grabbed in Addo heist. Weekend Post (www.weekendpost.co.za).
- MILLEDGE, S., 2007: Rhino-related Crimes in Africa: an Overview of Poaching, Seizure and Stockpile Data for the Period 2000-2005. Traffic, CITES CoP14 Inf. 41: 1-18.
- MILLER, R. E., 1987: Haemolytic anemia in the black rhinoceros. Pachyderm 9: 26-28.
- MILLIKEN, T., EMSLIE, R. H., TALUKDAR, B., 2009: African and Asian Rhinoceros - Status, Conservation and Trade. Report IUCN. CoP15 Doc. 45.1 Annex: 1-18.
- MILLS, G., HES, L., 1997: The Complete Book of Southern African Mammals. Struik Publishers. Cape Town: 235-237.
- MILLS, A., MORKEL, P., RUNYORO, V., AMIYO, A., MURUTHI, P., BINAMUNGU, T., BORNER, M., THIRGOOD, S., 2003: Management of Black Rhino in the Ngorongoro Crater. A report on the workshop held at Serena Lodge, Ngorongoro, 3-4 September 2003.
- MORKEL, P., 2004: Post mortem report - rhino Badger. Unpubl.
- NEUMANN, K. W., 1925: Brehmův ilustrovaný život zvířat. Díl I. SFINX, Praha: 283-306.
- NEUSCHULZ, N., MEISTER, J., 1998: Nashörner auf der Spur. Verein der Zooparkfreunde in Erfurt e.V.
- NIJHOF, A.M., PENZHORN, B. L., LYNEN, G., MOLLEL, J. O., MORKEL, P., BEKKER, C. P. J., JONGEJAN, F., 2003: Babesia bicornis sp. nov. and Theileria bicornis sp.: Tick-Borne Parasites Associated with Mortality in the Black Rhinoceros (*Diceros bicornis*). Journal of Clinical Microbiology, 41 (5): 2249-2254.
- OCHS, A., 2001: International Studbook for the African White Rhinoceros 9. Zoologischer Garten Berlin.
- OKITA-OUA, B., AMIN, R., KOCK, R., 2007: Conservation and Management Strategy for the Black Rhino (*Diceros bicornis michaeli*) and Management Guidelines for the White Rhino (*Ceratotherium simum simum*) in Kenya (2007-2011). KWS Species Conservation and Management Department - Rhino Section. Nairobi, Kenya.
- OWEN-SMITH, R. N., 1975a: The Social Ethology of the White Rhinoceros *Ceratotherium simum* (Burchell 1817). Z. Tierpsychol. 38: 337-384.
- OWEN-SMITH, N., 1975b: Reproductive behavior of white rhinoceros in the wild in Umfolozi Game Reserve, South Africa. Centre of African Ecology: 28-35.
- PAGAN, O., 2006: Indian rhinoceros EEP Annual Report 2005. EAZA Yearbook 2005. Amsterdam: 538-539.
- PAGAN, O., 2008: Indian rhinoceros EEP Annual Report 2006. EAZA Yearbook 2006. Amsterdam: 645-647.
- PAGLIA, D. E., MILLER, R. E., 1993: Erythrocytes of the Black rhinoceros *Diceros bicornis*: susceptibility to oxidant-induced haemolysis. Int. Zoo Yb. 32: 20-27.
- PAGLIA, D. E., 2001: Role of excessive maternal iron in the pathogenesis of congenital leucoencephalomalacia in captive black rhinoceros (*Diceros bicornis*). American Journal of Veterinary Research, 62/3: 343-349.
- PENNY, M., 1988: Rhinos Endangered Species. Facts On File Publications. New York.
- PENZHORN, B. L., KRECEK, R. C., HORAK, I. G., VERSTER, A. J. M., WALKER, J. B., 1994: Parasites of African rhinos: a documentation. Proceedings of a Symposium on „Rhinos as Game Ranch Animals“, Onderstepoort, 9 & 10 September.
- PENZHORN, B. L., OOSTHUIZEN, M. C., BOSMAN, A.-M., KILIAN, J. W., HORAK, I. G., 2008: Black Rhinoceros (*Diceros bicornis*) Populations in Northwestern Namibia Are Apparently Not Infected with Piroplasms. Journal of Wildlife Diseases, 44(4): 1032-1035.
- PILGRIM, M., 2007: European regional Black Rhinoceros Studbook *Diceros bicornis*. Chester Zoo.
- PILGRIM, M., 2008: Black rhinoceros EEP Annual Report 2006. EAZA Yearbook 2006. Amsterdam: 642-644.
- POLICHT, R., TOMÁŠOVÁ, K., HOLEČKOVÁ, D., FRYNTA, D., 2008: The vocal repertoire in Northern white rhinoceros *Ceratotherium simum cottoni* as recorded in the last surviving herd. Int. J. Anim. Sound and Recording, 18: 69-96.
- PTÁČKOVÁ, M., 2009: Krmné dávky nosorožců. Vnitropodnikový dokument. ZOO Dvůr Králové.

- PUSCHMANN, W., 1989: Zootierhaltung. Säugetiere. Band 2. VEB Berlin: 356-263.
- REID, C. E., HERMES, R., BLOTTNER, S., HILDEBRANDT, T. B., GÖRITZ, F., WIBBELT, G., WALZER, CH., BRYANT, B. R., PORTAS, T. J., STREICH, J., 2008: Split-sample comparison of directional and liquid nitrogen vapour freezing method on post-thaw semen quality in white rhinoceroses (*Ceratotherium simum simum* and *Ceratotherium simum. cottoni*). *Theriogenology*.
- PÜTTGER-CONRADT, A., 2008: Prokletí rohu. Severní bílý - poslední šance. ZOO Dvůr Králové. II. část: 67-188.
- ROBINSON, P. a J., 2000: History of the *D. b. michaeli*. National Parks Official Site Serengeti.
- ROBINSON, T. J., TRIFONOV, V., ESPIE, I., HARLEY, E. H., 2005: Interspecific hybridization in rhinoceros: Confirmation of a black X white rhinoceros hybrid by karyotype, fluorescence *in situ* hybridization (FISH) and microsatellite analysis. *Conservation Genetics*, 6: 141-145.
- ROOKMAAKER, L. C., 1983: Die Unterarten des Spitzmaulnashorns (*Diceros bicornis*) und ihre Zucht in Menschenobhut. *International Studbook for the African Rhinoceroses* 2: 41-45.
- RRC, 2009a: Black Rhino - *Diceros bicornis*. The Rhino Resource Center (www.rhinosourcecenter.com).
- RRC, 2009b: White Rhino - *Ceratotherium simum*. The Rhino Resource Center (www.rhinosourcecenter.com).
- RRC, 2009c: Indian Rhino - *Rhinoceros unicornis*. The Rhino Resource Center (www.rhinosourcecenter.com).
- RRC, 2009d: Rhino Species - *Rhinocerotidae*. The Rhino Resource Center (www.rhinosourcecenter.com).
- SHARMA, D. C., 2009: Assam rhino population on the rise. The Ecological Society of America (www.frontiersinecology.org).
- SCHENKEL, R., GRZIMEK, B., 1990: Rhinoceroses. *Grzimek's Encyclopedia of Mammals*. Vol. 4. McGraw-Hill Publishing Company: 610-642.
- SCHWARZENBERGER, F., WALZER, C., TOMASOVA, K., VAHALA, J., MEISTER, J., SMITH, R. L., READ, B., 1992: Management Parameters Affecting the Reproductive Potential of Captive, Female Black Rhinoceros, *Diceros bicornis*. *Zoo Biology* 11: 375-383.
- SCHWARZENBERGER, F., FRANCKE, R., GÖLTENBOTH, R., 1993a: Concentrations of faecal immunoreactive progesterone metabolites during the oestrous cycle and pregnancy in the black rhinoceros (*Diceros bicornis michaeli*). *Journal of Reproduction and Fertility* 98: 285-291.
- SCHWARZENBERGER, F., TOMÁŠOVÁ, K., HOLEČKOVÁ, D., OCHS, A., MATERN, B., MÖSTL, E., 1993b: Improved non-invasive monitoring of reproductive steroids in faeces of the black rhinoceros (*Diceros bicornis*) application of specific enzyme-immunoassays for 5 α - and 5 β - reduced 20-oxo-progesteragens. *J. Reprod Fert.* 98: 285-291.
- SCHWARZENBERGER, F. 1995a: Reproductive physiology of black, white and Indian rhinoceroses. Manuscript submitted to EAZA Conf. „Research and Captive Propagation, Ústí n. Labem, Czechia.
- SCHWARZENBERGER, F., TOMÁŠOVÁ, K., HOLEČKOVÁ, D., MATERN, B., MÖSTL, E., 1995b: Measurement of Faecal Steroids in the Black Rhinoceros (*Diceros bicornis*) using Group-Specific Enzyme Immunoassays for 5-reduced 20-oxo-pregestagens. *J. Reprod Fert.*
- SCHWARZENBERGER, F., TOMÁŠOVÁ, K., HOLEČKOVÁ, D., MATERN, B., MÖSTL, E., 1996: Measurement of Faecal Steroids in the Black Rhinoceros (*Diceros bicornis*) Using Group-Specific Enzyme Immunoassays for 20-Oxo-Pregnanens. *Zoo Biol.* 15: 159-171.
- SCHWARZENBERGER, F., WALZER, C., TOMASOVA, K., VAHALA, J., MEISTER, J., GOODROWE, K. L., ZIMA, J., STRAUSS, G., LYNCH, M., 1998: Faecal progesterone metabolite analysis for non-invasive monitoring of reproductive function in the white rhinoceros (*Ceratotherium simum*). *Animal Reproduction Science* 53: 173-190.
- SCHWARZENBERGER, F., 2008: Data of hormone monitoring of the Northern White Rhinos in Zoo Dvur Kralove. Presented at the Creation of the Action Plan for Saving Northern White workshop, Dvur Kralove Zoo, 3 September 2008.
- SILINSKI, S., 2003. Pharmacologically enhanced manual semen collection and computer assisted sperm head morphometry in the white rhinoceros (*Ceratotherium simum*). Dissertation. Salzburg.

- SILBERMAN, M. S., FULTON, R. B., 1979: Medical problems of captive and wild rhinoceros - a review of the literature and personal experiences. *J. Zoo. Med.* 10: 6-16. SMITH, R. L., READ, B., 1992: Management Parameters Affecting the Reproductive Potential of Captive, Female Black Rhinoceros, *Diceros bicornis*. *Zoo Biology* 11: 375-383.
- SMITH, K., SMITH, F., DUBLIN, H., FOOSE, T., 1995a: Options document to guide strategy development for the Northern white rhinoceros (*Ceratotherium simum cottoni*). IUCN/SSC African Rhino Specialist Group.
- SMITH, K., SMITH, F., DUBLIN, H., FOOSE, T., 1995b: Companion reference document to options document to guide strategy development for the Northern white rhinoceros (*Ceratotherium simum cottoni*). IUCN/SSC African Rhino Specialist Group.
- SMRČEK, M., HOLEČKOVÁ, D., DOLLINGER, P., 2008a: *Ex situ* and *in situ* efforts to save African Rhinos. WAZA projects 08013 and 08017. *WAZA News* 4:11.
- SMRČEK, M., HOLEČKOVÁ, D., 2008b: Bude východní Afrika bez nosorožců? Výroční zpráva 2007. *Zoo Dvůr Králové*: 216-230.
- STECK B., 2006: Indian rhinoceros EEP Annual Report 2005. *EAZA Yearbook* 2005: 538-539.
- STEHLÍK, M., 1979: Nosorožci. Studijní informace ÚDVVL, Referáty a semináře o zoologických zahradách 2.
- STUDER, P.: 1996a: Indian rhinoceros (*Rhinoceros unicornis*) EEP Annual Report 1995: 258-259. *EAZA Yearbook* 1995. Amsterdam.
- STUDER, P.: 1996b: Analysis of the 1995 EEP population of the Greater one-horned rhinoceros (*Rhinoceros unicornis*).
- ŠPÁLA, P., 1986: Krmné dávky nosorožců. Vnitropodniková směrnice. Východočeská zoologická zahrada Dvůr Králové nad Labem.
- ŠPINAR, Z. V., BURIAN, Z., 1984: Paleontologie obratlovců. Academia Praha.
- TENYWA, G., 2009: First rhino born in Uganda after 20 years. *The New Vision Online* (www.newvision.co.ug)
- TOBLER, K., 1995: International Studbook for the Great Indian Rhinoceros *Rhinoceros unicornis* (Linné 1758). Zoological Garden Basel.
- TOIT, R., du, EMSLIE, R., BROOKS, M., DACONTO, G., MUNGWASHU, L., 2006: Guidelines for implementing SADC rhino conservation strategies. WWF - Southern African Regional Programme Office (www.rhino-sadc.org).
- TOIT, R., du, BROOKS, M., EMSLIE, R.: Strategic Planning for Rhino Conservation. WWF - Southern African Regional Programme Office (www.rhino-sadc.org).
- TOMÁŠOVÁ, K., 1996: White rhinoceros (*Ceratotherium simum*) EEP Annual Report 1995. *EAZA Yearbook* 1995. Amsterdam: 252-254.
- TOMÁŠOVÁ, K., 2004: Program zlepšení welfare nosorožců dvourohých. Výroční zpráva 2003. Zoologická zahrada Dvůr Králové: 207-215.
- TOMÁŠOVÁ, K., 2005: Deborah. Výroční zpráva 2004. Zoologická zahrada Dvůr Králové: 297-302.
- TOMÁŠOVÁ, K., 2006: White rhinoceros EEP Annual Report 2005. *EAZA Yearbook* 2005. Amsterdam: 536- 537.
- TRENSE, W., 1989: *The Big Game of the World*. Verlag Paul Parey. Hamburg, Berlin: 181-183.
- TSHIKAYA, P., SMITH, F., HILLMAN SMITH, K., MBOMA, G., AMUBE NDEY, A., LIGILIMA, C.: 2004: Sudanese now using donkey trains to transport ivory and rhino horn from Garamba national park. Parc National de la Garamba.
- UTLEY, L., 1990: The Mkomazi Project. Global Communications for Conservation.
- VÁGNER, J. A., 1978: Facilities for Keeping and Breeding of Hoofed Animals at the Zoo Garden Dvůr Králové n. L. (Czechoslovakia). *Zool. Garten N.F.*, Jena 48, 1: 41-48.
- VÁHALA, J., 1993a: Nosorožci a jejich chov ve východočeské zoo. *Živa* 3. Academia Praha: 138-139.
- VÁHALA, J., ŠPÁLA, P., SVITALSKÝ, M., 1993b: Maintaining and breeding the Northern white rhinoceros *Ceratotherium simum cottoni* at Dvur Kralove Zoo. *Int. Zoo Yb.* 32: 16-19.
- VÁHALA, J., VONDRA, Z., KOBER, M., PETRŽÍLEK, P., 1995: Hand-feeding a Black rhinoceros *Diceros bicornis* calf at Dvur Kralove Zoo. *Int. Zoo Yb.* 34: 211-217.
- VÁHALA, J., 2008: Problémy rozmnožování severního nosorožce tuonosého v ZOO Dvůr Králové. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- VÁHALA, J., 2009: Pitevní protokoly ZOO Dvůr Králové z let 1979-2009. Interní materiály ZOO Dvůr Králové.
- VERHEIJ, I. C. J., 1992: *Op reis met Clara, de geschiedenis van een bezienswaardige neushoorn*. Natuurmuseum Rotterdam.
- VERSTEEGE, L., 2008a: White rhinoceros EEP Annual Report 2006. *EAZA Yearbook* 2006. Amsterdam: 638-641.

- VERSTEEGE, L., 2008b: The present state of White Rhino in EEP. A paper presented at the workshop at Dvur Kralove Zoo on 3 September 2008.
- VERSTEEGE, L., 2008c: personal communication - EEP White Rhino EAZA Annual Conference Antwerpen.
- VÍŠEK, J., 1987: Srovnání výrazových prostředků u druhů *Diceros bicornis* (Linnaeus, 1758), *Ceratotherium simum* (Burchell, 1817) a *Rhinoceros unicornis* (Linnaeus, 1758). Diploma thesis. Pedagogická fakulta v Hradci Králové.
- VOELKER, W., 1986: The Natural History of Living Mammals. Plexus Publishing. Medford: 260-263.
- VONDRA, Z., ŽDÁREK, J., KOBER, M., PETRŽÍLEK, P., HÁK, V., 1994: Umělý odchov nosorožce dvourohého (*Diceros bicornis michaeli*). Výroční zpráva 1993. Východočeská zoologická zahrada - safari Dvůr Králové n. L.: 41-49.
- WALKER, E. P., WARNICK, F., HAMLET, S. E., LANGE, K. I., DAVIS, M. A., UIBLE, H. E., WRIGHT, P. F., PARADISO, J. L., 1968: Mammals of the World, second edition, Volume II, Johns Hopkins Press Baltimore, 1968: 1349-1353.
- WANDONGO J., LEUSCHNER, K., 1994: Mkomazi Game Reserve Tanzania. Brochure 1.
- Wildlife Extra, 2008: Africa Rhinos numbers up but Northern white rhino may be extinct (www.wildlifeextra.com).
- WIRZ-HLAVACEK, G., STUDER, P., 1998: International Studbook for the Greater One-horned Rhinoceros (Linné 1758) 1997. Basel Zoo.
- WOODS, R. et al., 2008: Fungal pneumonia in a captive black rhinoceros. Australian Veterinary Journal, 77/11: 717-719.
- WWF, 2006a: Species fact sheet: Asian Rhinoceros. WWF (www.panda.org/species).
- WWF, 2006b: Species fact sheet: African Rhinos. WWF (www.panda.org/species).
- WWF, 2007a: African Rhinoceroses - A Continental Overview. Information Kit: African Rhino Programme 1997-2007. WWF (www.assets.panda.org).
- WWF, 2007b: Success in African Rhino Conservation. WWF International (www.panda.org).
- WWF, 2009a: Black Rhinoceros. WWF International (www.panda.org).
- WWF, 2009b: Rhinoceros Threats. WWF International (www.panda.org).

www.african-parks.org

www.arkive.org

www.cms.iucn.org

www.en.wikipedia.org

www.northernwhiterhinolastchance.com

www.rhino-irf.org/afmsg

www.rhinos-irf.org/technicalprograms/afmsg/index.htm

www.rhinocerosescenter.com

www.rhinokeepersassociation.org

www.savetherhino.org

www.waza.org