

Int. Zoo Yb. (2016) **50**: 203–214

DOI:10.1111/izy.12127

Husbandry, management and breeding of the Greater one-horned rhinoceros *Rhinoceros unicornis* at Zoo Basel

F. VON HOUWALD

Zoo Basel, Binningerstrasse 40, CH 4054 Basel, Switzerland

E-mail: friederike.vonhouwald@zoobasel.ch

As poaching incidents of rhinoceros species are continuously increasing in the wild, the need for zoological institutions to breed these charismatic species becomes ever more important. This article summarizes the knowledge gained about keeping, managing and breeding Greater one-horned rhinoceros *Rhinoceros unicornis* at Zoo Basel, Switzerland, over the past 15 years.

Key-words: breeding; enclosures; greater one-horned rhinoceros; husbandry; management; Zoo Basel.

INTRODUCTION

The Greater one-horned or Indian rhinoceros *Rhinoceros unicornis* is listed as Vulnerable by *The IUCN Red List of Threatened Species* (IUCN, 2015). Between 3330 and 3350 wild Greater one-horned rhinoceros remain in their countries of origin (IUCN, 2013). Historically, the species lived along the Indus, Ganges and Brahmaputra River basins, from Pakistan to the Indian–Burmese border, including parts of Nepal, Bangladesh and Bhutan (Foose & van Strien, 1997). At the time of writing, Greater one-horned rhinoceros are only found in National Parks and Wildlife Sanctuaries in India and Nepal (von Houwald, 2014).

As all rhinoceros species face dramatic poaching threats (Emslie & Knight, 2013), it becomes more and more important to manage these species successfully in zoological institutions. Zoo Basel, Switzerland, started to maintain the Greater one-horned rhinoceros over 60 years ago. This report will provide an insight into the husbandry,

management and breeding protocols developed over the past 15 years for the Greater one-horned rhinoceros at Zoo Basel.

HISTORY

The history of keeping Greater one-horned rhinoceros at Zoo Basel started in 1951 with the import of the ♂ ‘Gadadhar’ (international stdbk no. 5) and in 1952 with the import of the ♀ ‘Joymothi’ (international stdbk no. 7) from Kaziranga National Park, India (Lang, 1960). In 1956, the first successful birth and rearing of a calf took place at Zoo Basel (Lang, 1957). Since then, 33 calves [17.16 (♂♂.♀♀)] have been born at this institution. In 1975, a detailed report was published about the enclosure as well as various aspects of the management and breeding of this species at Zoo Basel (Lang, 1975). At that time, the rhinoceros were kept according to a farming system, with each animal having a stall where it could feed and rest. Otherwise the animals were in the indoor pool or outside. The report also noted that zoological institutions that did not provide enough space for the animals to run and chase each other during courtship were not successful in breeding (Lang, 1975). In the following years, more institutions imported Greater one-horned rhinoceros, most of which came from India but a few originated from Nepal.

In 1971, the international studbook for the *R. unicornis* was established by Zoo

Basel. At the end of 1970, there were 44 (24.20) rhinoceros maintained at 25 institutions (Lang, 1975). In 1975, the numbers had risen to 61 (33.28), of which 28 (15.13) were zoo born and reared (Lang *et al.*, 1977). At that time, the wild population was estimated to be *c.* 450 animals in Nepal and India (Lang, 1976). As at 31 December 2014, there were 207 (105.100.2) living Greater one-horned rhinoceros at 73 zoological institutions worldwide (von Houwald, 2015).

BIOLOGY

There have been detailed studies on wild Greater one-horned rhinoceros in Chitwan, Nepal, which have augmented the understanding of the biology of this species (Laurie, 1978; Dinerstein, 2003). In contrast to African rhinoceros species, the Greater one-horned rhinoceros lives next to water all year round. Water not only seems to play an important role in thermoregulation but also provides a food source. Greater one-horned rhinoceros are strong swimmers (Dinerstein, 2003). Wallowing is frequently observed during the monsoon season and less frequently during winter: the animals can spend up to 7 hours wallowing in the morning but tend to avoid lying in the hot sun during the day (Laurie, 1978). By covering their skin in mud, the rhinoceros seem to protect themselves against parasites and hot temperatures, which can range (depending on season) between 0 and 45°C. Greater one-horned rhinoceros consume up to 187 plants species (Laurie, 1978). Depending on the season, grass makes up 70–88% of their diet, browse 8–22% and aquatic plants 5–8%.

Adult breeding ♂♂ have ranges of 4.3 km², whereas ♀♀ utilize less space. During the monsoon, when food is abundant, home ranges are smaller (Dinerstein, 2003), and can be as small as 0.44 km² when habitat diversity is high (Laurie, 1978). Average densities in Kaziranga National Park approached four individuals per km² (Foose & van Strien, 1997). In

Chitwan National Park peak seasonal densities reached 13.3 individuals per km² (Dinerstein, 2003).

There appears to be no detectable seasonality in breeding (Laurie, 1978; Dinerstein, 2003). Mean age at first birth was 7–7.5 years. Females aged 12–20 years had higher birth rates than younger or older adults. In an observed population, interbirth intervals ranged from 34 to 51 months, with a mean of 45.6 months (Dinerstein, 2003). Females are solitary and are accompanied by their offspring until the calves reach 4 years. Females with calves graze near other ♀♀ or share wallows but do not associate in any consistent pattern (Dinerstein, 2003). Loose associations have been observed between subadult ♂♂, subadult ♂♂ and adult ♀♀, as well as a subadult ♀ which joined her mother with a newborn calf (Laurie, 1978). Adult bulls are solitary and defend their territory, which changes according to the availability of food and season (Laurie, 1978). Young bulls will avoid those territorial areas, unless they are preparing to challenge the adult bulls to take over their domain. Serious fights between adult ♂♂ and adult and subadult ♂♂ have been observed, often leading to the death of the younger rhinoceros (Laurie, 1978). This appears to be why bulls aged 15 years are more successful at mating than younger bulls (Laurie, 1997).

Males will fight fiercely for ♀♀ during the oestrous period. The ♂ Greater one-horned rhinoceros uses his lower incisors (they can be up to 8.9 cm in length) instead of his horn for fighting (Dinerstein, 2003). The horn is sharp and pointed but is more often used to dig for roots or minerals. The oestrous period lasts for up to 24 hours, at intervals of 30–48 days. There is no seasonality and mating takes place at any time of the day.

HUSBANDRY

In the past, zoological facilities keeping Greater one-horned rhinoceros were faced with several husbandry and health issues.

Hygiene was highly important as most animals coming from the wild were loaded with endemic worms, leading to severe problems, such as impaction of the gastrointestinal tract, enteritis and lung disorders (Lang, 1966). In order to control the parasitic load, the rhinoceros were kept inside on concrete substrates and easy-to-clean floors were provided outside. Unfortunately, this type of hard substrate led to the occurrence of foot problems (von Houwald & Flach, 1998; von Houwald, 2016). Bulls suffered from severe foot problems and, as a consequence, some of them died at a young age (14–20 years), which led to a loss of breeding bulls in the captive population (von Houwald, 2001). Previously, there were limited biological data available and, therefore, enclosure space was provided in such a way that sometimes more stress was caused to the animals than intended (Lang, 1975). At that time many zoological facilities were not confident (and some still are not) about breeding this rhinoceros species because of the violent behaviour expressed during mating (F. von Houwald, pers. obs).

Zoological institutions now have the task of not only keeping this species under the best possible standards but also raising awareness about the needs of the animals in the wild. Thanks to modern medicine and a better understanding of the biology of the Greater one-horned rhinoceros, enclosures can now be built in a more natural way, leading to an increase in welfare and breeding as well as longevity.

New indoor enclosure at Zoo Basel

In 2006, the indoor and outdoor rhinoceros exhibit at Zoo Basel was rebuilt. Foot problems, seen in all the Greater one-horned rhinoceros at the Zoo, were a major concern as well as the fact that there was only one outdoor enclosure. The outer features of the old building remained but inside the stables and the pool were renovated. Next to the ♀ house, a new house was built for the ♂ and the plant room, which is located

under the ♂'s indoor stable, and accommodates the temperature and ventilation system, as well as the water-cleaning and heating system for the pools (Fig. 1: 'stable 4'). The ♀ house has two stables, each measuring 10 m × 6 m, with one long side open for visitor viewing (Fig. 1: 'stable 1' and 'stable 2'; Plate 1). The upper part of the stable barrier consists of two thick ropes, each *c.* 6 cm in diameter, fixed to the wall at variable heights and two metal poles at the lower level fixed to the side concrete uprights (Plate 1). The upper ropes are flexible; if required another rope can be added to the barrier or, if necessary, ropes can be taken away. A wooden rail with a glass panel keeps visitors at *c.* 1.5 m away from the rope and pole barrier. The stables are separated by a wooden wall, which can be removed if necessary (Plate 1). Wooden panels are fixed to all flat surfaces in the stables to prevent horn damage from rubbing on hard edges. A drinking-water basin with a 150 litre capacity is fixed to the wall next to the keeper corridor, from where it can be drained and refilled. The floor is set concrete, with a 2% slope and drainage at the lowest point. The concrete is topped with a polyester fleece (LoHa 25/30). This is covered with a 50 cm-deep layer of untreated-oak (*Quercus* sp) wood chips.

The feeding station is a concrete trough (6 m × 1 m × 20 cm deep) along the side wall of each stable. Steel poles, covered by wood and spaced *c.* 85 cm apart, are located in front of the trough, keeping the adult animals out but allowing them to put their heads through the poles to access food. When feeding, the rhinoceros put their heads between the poles to reach the food, but they cannot get their shoulders through the gaps. The distance between the side wall and the poles is at least 1.3 m to prevent the rhinoceros from touching the wall with their horns (Plate 1). The trough has a door towards the keeper corridor, allowing keepers to enter the stable safely, in order to administer treatments and carry out training or for observations during births. Fodder is stored in a room located

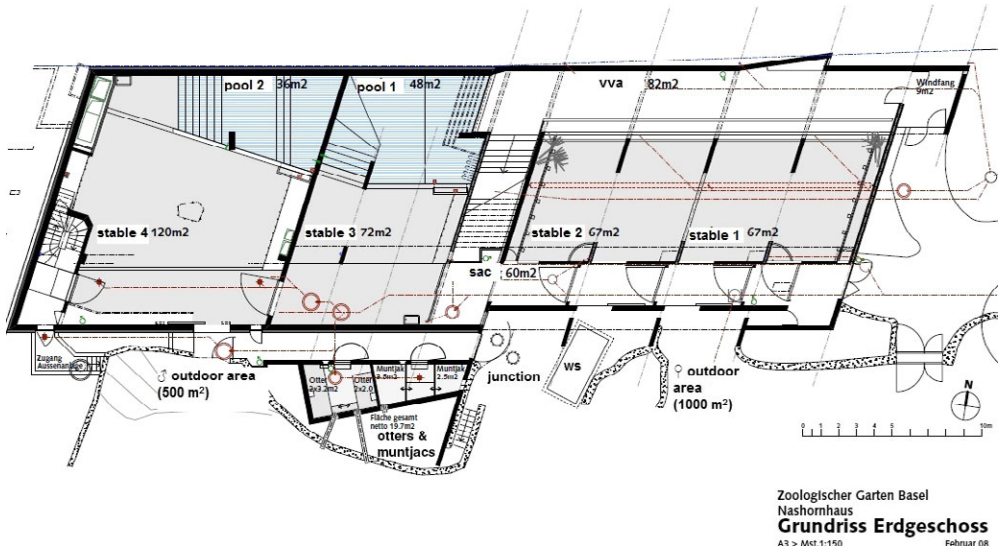


Fig. 1. Plan of the new indoor area for Greater one-horned rhinoceros *Rhinoceros unicornis* at Zoo Basel, Switzerland. Generally, the male uses stable 4, while the females use stables 1 and 2, and have access to the pool in stable 3, although the stables are interlinked: sac, stable-access corridor; vva, indoor visitor-viewing area; ws, weighing scales. The stables for Asian small-clawed otters *Amblonyx cinereus* and Chinese muntjacs *Muntiacus reevesi* are indicated. Zoo Basel.

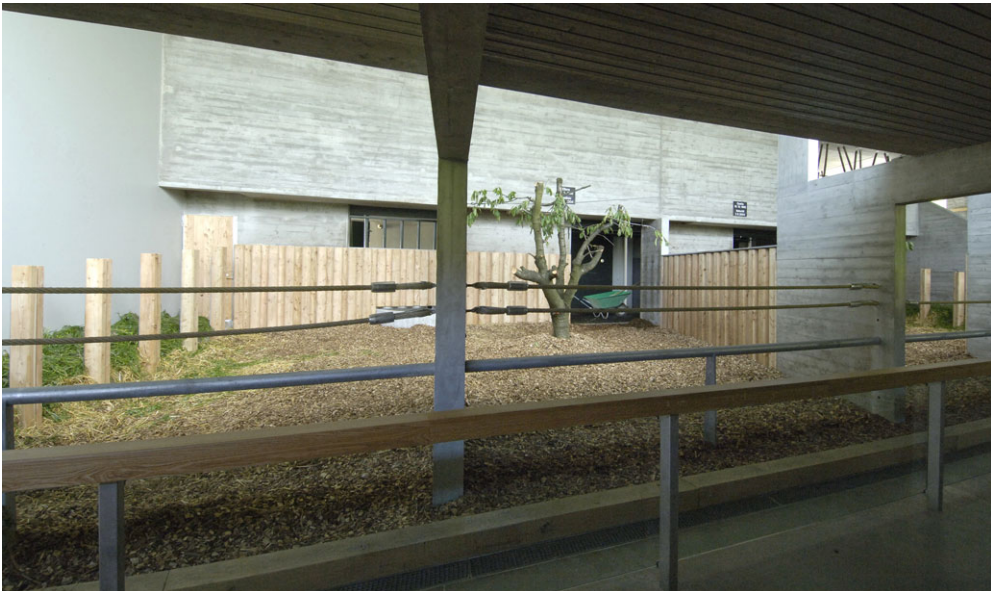


Plate 1. New indoor stables for female Greater one-horned rhinoceros *Rhinoceros unicornis* at Zoo Basel, Switzerland, showing removable wooden wall between the stalls, soft untreated-oak (*Quercus* sp) wood-chip substrate (50 cm deep), the feeding trough to the left (with keeper-access door) and the drinking-water basin straight ahead. Zoo Basel.

above the keeper area and small door in the bottom of the store allows food to fall directly into the trough.

A 2 m-wide manually operated sliding door with vertical bars (28 cm apart) allows the rhinoceros to go via the keeper stable-access corridor (Fig. 1) either directly to the outdoor enclosure or to the indoor pool area. The corridor is 2 m wide so an adult rhinoceros cannot turn around. This allows a keeper to walk behind the animal and guide it gently to another section. One pool of 48 m² is located in a room measuring a total 120 m² (including the pool area) (Fig. 1). The pool is 1.2 m deep, with steps that are up to 80 cm wide and 12 cm high. These dimensions make it possible for a calf to lie down next to the head of its mother

easily without having to enter the deep water, while the mother can lie in the deeper areas of the pool. A closed glass window allows visitors to look into the pool area. The pool bottom is covered with heavy rubber mats (Gummimatten Classic) fixed to the ground; the rest of the pool stable as well as the corridor are covered by rubber (Horsefloor). The first stable leads directly into the larger outdoor enclosure (Figs 1 and 2), while the second stable gives access to the smaller outdoor section that acts as a junction between the two main outdoor enclosures (Figs 1 and 2) and the area with the 48 m² pool connects to the bull's stable through a solid steel door (Fig. 1).

The bull's stable measures a total 156 m², including a 36 m² pool (Fig. 1:



Fig. 2. Site plan of the new Greater one-horned rhinoceros *Rhinoceros unicornis* enclosure at Zoo Basel, Switzerland: si. separating island (80 m²); vp. visitor pathway; vva. indoor visitor-viewing area; ws. weighing scales. Access to the outdoor area from the stable 1 is directly into the 1000 m² outdoor enclosure to the right, while from stable 2 access is via the junction area, past the weighing scales and into the smaller 500 m² outdoor area to the left. The stables for Asian small-clawed otters *Amblonyx cinereus* and Chinese muntjacs *Muntiacus reevesi* are indicated. Zoo Basel.

'stable 4'). The floor is up to 90% covered with 50 cm-deep untreated wood chips. Experience has shown that 50 cm-deep wood-chip substrate is a sufficient depth for a bio-floor system. At this depth, a rhinoceros will not push all the substrate aside and end up touching the ground, even when lying down. The construction and layout is more or less the same as that used in the ♀ stables. A small section in the front of the stable, where the keepers move the wheelbarrow around, is covered with concrete. Along the side as well as in the middle of the bull stable, steel bars (c. 30 cm apart) are installed to provide safety areas for the keepers if needed. The bull is not able to put his head through the bars. The stable of the bull connects directly into the second, smaller outdoor enclosure (Fig. 1).

The inside temperature in winter is c. 18°C. Clear plastic stripes (Leicht PVC Platte) in front of each door leading outside prevent heat loss. Indoor pools are heated to c. 24°C in the winter but they are not heated in summer.

New outdoor enclosure

There are two outdoor enclosures, 1000 m² and 500 m² in size, each containing pools and mud wallows, surrounded by a small river and separated from each other by an island (Fig. 2). The two enclosures can be connected by passing through a junction in a third outdoor area, which is c. 80 m². A scale (DRF/DSF multi-range) is positioned in this area, making it possible to weigh the rhinoceros routinely.

Asian small-clawed otters *Amblonyx cinereus* and Chinese muntjacs *Muntiacus reevesi* share the whole area with the rhinoceros, both indoors and outside, or are able to seek shelter on the islands and in their own stables (Fig. 1). The river is also available for the otters to use. The otters and muntjacs frequently interact with the Greater one-horned rhinoceros, either in the water or at the feeding places, and the rhinoceros are very tolerant towards both species. Young rhinoceros sometimes play

with the otters in the water or chase them on land, if they become too inquisitive. The Chinese muntjac are a non-breeding ♀ group because Asian small-clawed otters will attack and kill newborn muntjac calves.

Each outdoor area has one or more elevated feeding places. Dead trees are fixed in place in each section so the rhinoceros can rub their bodies and horns against them, and enrichment devices can be attached to these structures. The smaller enclosure has a large log positioned in the middle, while the larger enclosure has an island in the middle (Fig. 2). This makes it possible for animals that are being chased to run around solid structures and not to end up trapped in a corner. The island is high enough to avoid visual contact. This is useful during introductions of a ♂ and ♀, or where there are two ♀♀ with calves.

The outdoor substrate has been modified to meet the special requirements for the feet of the Greater one-horned rhinoceros; thus, it is non-abrasive, flexible and comfortable to walk and lie on. The natural-ground substrate is covered by an 8 cm layer of asphalt, topped with a 4 cm-deep drainage panel (ProMa) and a woven polypropylene geotextile (LoHa 25/30), which acts as a filter. The geotextile layer is then covered with a 50 cm-deep layer of untreated-oak wood chips.

The pools are drained and cleaned on a regular basis. In summer, when the pools are frequently used and the weather is warm, the pools are cleaned weekly. During spring and autumn the pools are cleaned once a month. To refill the pools, water is taken from a river that flows through the Zoo. The wood-chip substrate is ploughed preferably once every 2 weeks, to loosen the chips and improve drainage.

MANAGEMENT OF ANIMALS

Group composition

Even though the literature indicates that Greater one-horned rhinoceros are solitary animals (Laurie, 1978; Dinerstein, 2003),

the experiences at Zoo Basel have shown that this species can become social in the environment of a zoological institution. Young animals appear to 'enjoy' the company of other rhinoceros. When very young calves tend to run about and play a lot, and when they become older they learn to play fight.

Young ♀♀ and old ♀♀ get along well, although it is important to allow each animal the freedom to choose a companion or not. This means that an enclosure needs to be built in a way that the rhinoceros can visually 'escape' from each other if required. Offering several feeding places also proves helpful.

A young bull and a young ♀ can also be kept together. Usually this works well until the ♀ reaches sexual maturity. In contrast to wild rhinoceros, ♀♀ in zoological institutions show first signs of oestrus at around 3–4 years (Lang, 1975). However, young bulls will not show serious interest in ♀♀ until they reach 7–8 years. It would also appear that a bull living in close proximity to a ♀ may well regard her as a companion rather than a potential breeding partner. At Zoo Basel, ♂♂ are physically separated from the ♀♀ at the age of *c.* 6 years.

Daily management

As Zoo Basel is a historic city zoo, and therefore space is limited, the emphasis rests on detailed daily management of every species. Keepers of all sections at Zoo Basel interact frequently with the animals in their care. Routinely, and weather permitting, all animals are given the choice to be outside during most of the day. During summer, most animals in Zoo Basel can choose whether they go inside or remain outside. In the past this was not possible with the rhinoceros as it was not safe to leave the whole group together and to give them free access to each section. This has changed and each rhinoceros can go in and out as preferred. In order to prevent heat loss from the indoor stables, plastic stripes

have been installed at each door leading to the outside areas. For routine cleaning of the outdoor enclosures, the rhinoceros are taken into their stables for an hour. The working policy at Zoo Basel is not to enter the enclosure when a rhinoceros is inside (hands-off). However, there are some exceptions to this rule. The rhinoceros are trained to lie down on a vocal command and by being touched on their belly. This training makes it possible to collect blood samples or check the feet. Such processes are carried out in an area that facilitates protected contact (e.g. the pool area in 'stable 3': Fig. 1). As soon as the animal lies down, the keeper and veterinarian will enter the enclosure with the rhinoceros to carry out the procedure(s). While the keeper is stroking the rhinoceros, the veterinarian can check the animal. Food is not given in this situation. Sometimes the rhinoceros falls asleep as they appear to be fond of being stroked.

For further enrichment, the ♂ and ♀♀ regularly utilize all areas of the indoor and outdoor enclosures. Each day, all Greater one-horned rhinoceros are given options to move in and out several times per day to different areas, meaning the animals are active and pay attention to the commands of the keeper. When the ♀♀ are outside, the bull can go into the ♀ indoor pool and stables, or when the ♂ is outside the ♀♀ are able to go into the bull's stable. The keepers often provide the rhinoceros with different options to choose from; for example, the animals can choose to be outside or indoors in all seasons. This free-choice protocol has been interesting to observe, especially in winter. Each rhinoceros appears to prefer to go outside, even when the temperature is below 0°C; however, the animals will come indoors of their own volition when it becomes too cold for them. The new building allows great freedom to permit the animals to go from one area to another, and gives them the option to choose for themselves where to go, at which time and for how long.

BREEDING

Preparation and courtship behaviour

The wild nature of breeding the Greater one-horned rhinoceros can be managed by various means but the most important factor is the enclosure, which needs to be built in a way that it allows animals to run around without being trapped. Round enclosures with no dead ends are favoured. Ditches are not recommended because bulls can push ♀♀ into them. Pools need to have entry and exit points or a very wide entry so the animals can pass each other. Barriers around the enclosure must be at least 1.4 m high; otherwise the rhinoceros may be able to jump or climb over them.

Experience has shown that the bull should not be kept in close proximity to the ♀♀. In the wild, an adult bull is solitary and only seeks out the ♀♀ during oestrus (Laurie, 1978). In zoological institutions, animals get used to each other when contact is permitted routinely and a bull might show either too much aggression or no interest at all in a ♀ in oestrus. About 3–7 days prior to the onset of oestrus, the bull starts to show signs of restlessness and aggressive behaviour. In ♀♀, signs of oestrus include no interest in food, restlessness, frequent urine spraying and whistling sounds. Oestrus lasts *c.* 24 hours.

At Zoo Basel the following protocol is applied, once the ♀ shows signs of oestrus. The ♀ is moved into the bigger enclosure, which has a round shape with no dead ends. Additionally, the middle island is perfectly located to run around. The ♀ in oestrus will be given time to mark the area, while the other ♀ uses the bull's enclosure and he is kept inside. After about an hour, the ♀ in oestrus is taken into her stable and the bull is let into the larger enclosure, where he is also given about an hour to explore the area. Usually, he will show signs of excitement, running around, urine squirting and sniffing the ground. This exchange of ♀ and ♂ in the enclosure is carried out at least another four or five

times. If the second ♀ distracts the ♂, she will be taken into her stable for the duration of the exchanges and possible mating time. Experience has shown that mating usually takes place at the end of the 24 hour oestrous period. In cases where the onset of oestrus is known to the keeper the time available is calculated from this point. When the time of onset of oestrus is not known, the remaining time of oestrus is estimated. The aim is to bring the ♂ and ♀ together near the end of the oestrous period. The bull can become aggressive during courtship and this process of giving him enough time (hours) to search for signs of the ♀, reduces the amount of aggression he directs towards her once he is given full access. Our bull 'Jaffna' showed serious aggression towards one of our ♀♀ ('Quetta'). The first introductions were violent and he bit her severely. Jaffna had never demonstrated such aggressive behaviour with the other ♀. The introduction protocol was changed so the bull was only allowed to come into contact with Quetta near the end of her oestrous period. Instead of chasing, biting and pushing her, Jaffna ran after her for some minutes and mounted her within 30 minutes. This delayed-introduction process was used on three other occasions and each time his behaviour was calm and the ♀ became pregnant. Jaffna appears to prefer the other ♀ ('Ellora') and was never as aggressive with her as he was towards Quetta. This delayed-introduction strategy was also trialled with the older ♀ (Ellora) in order to see how Jaffna reacted. Once again he ran about and mounted the ♀ within the first hour of introduction. In previous years the chasing process took hours, followed by intervals of resting, chasing, fighting, resting and finally mating (Wackernagel, 1962). In the past 10 years, using this delayed-introduction protocol, the breeding behaviour the animals demonstrate is much more focused. Mating often occurs at night and lasts about an hour. The pair is never separated unless clear signs are given; for

example, standing in opposite directions or standing in front of the door. At times, the ♂ appears to lose interest in the ♀, and lies down and is inactive. However, this is normal behaviour. As long as the ♀ shows interest in the ♂ (e.g. going up to him, pushing at his genital region and licking him) it is advisable not to separate the pair. Only if the interest of the ♀ has diminished (e.g. she leaves the ♂ and stands in front of the door to the stables), should the pair be separated. Generally, the bull will get up after his nap and will mount the ♀ shortly after.

When physically introducing the ♂ to the ♀, the ♀ is allowed into the enclosure first, before the ♂ is given access, never the other way around. Males are so eager to meet the ♀ that they might otherwise trap her while she is entering the enclosure.

Separating a pair that is aggressive towards each other is very difficult and needs experienced keepers. Good preparation, such as enclosure design, observation of the onset of oestrus and management of the bull prior to mating, can clearly help to prevent what could become a dangerous situation if the animals are left together unattended.

Birth and management of calves

Much has been written about gestation and births taking place at Zoo Basel in the past (Lang, 1956, 1957, 1967a,b, 1975; Ruedi, 1989, 1991).

At the time of writing, Zoo Basel maintains two breeding ♀♀ and one bull. Normally, both ♀♀ have calves around the same time and they grow up together. A bull calf that grows up without another calf to play with can become a nuisance to the mother and by the age of *c.* 2 years will be sent to another zoo. In cases where there are two calves (bulls) growing up together, they play with each other more than with their mother(s), reducing the stress load on the adult ♀(s); therefore, it is possible to keep these animals at the Zoo for longer. When a ♀ is pregnant again, she can show aggression towards her offspring prior to

the birth, which means the calf has to be separated from its mother. Although the adult ♀ adapts to this separation easily, many calves become nervous and call for their mothers. If there is another ♀ (pregnant or non-pregnant/with or without her own calf) that is familiar with the separated calf, the separation from its mother may be made easier for the calf.

At Zoo Basel, one ♀ is a very experienced breeding cow (Ellora: international stdbk no. 110). In 2013, when she was pregnant with her eighth calf, she was not separated from her 3 year-old calf 'Henna' (international stdbk no. 432). The keepers kept the pair under careful observation in case there was any direct aggression. The aim was to find out more about how to manage rhinoceros during the pre- and post-parturient period. The idea was initiated by observations from Laurie (1978), who described wild ♀ calves being reunited with their mothers after the birth of the next calf. This had never been tried at a European zoo before. To avoid any undue stress for either animal during the birth, Ellora was given the option to use the indoor as well as the outdoor enclosure. This was also a first at a European zoo as previously it seemed important to confine the pregnant ♀ in her stable for giving birth. The birth of Ellora's eighth calf was successful. It took place at *c.* 0130 hours, inside the stable. Soon after the birth Ellora walked outside to eat, followed by the newborn calf and Henna. However, 3 weeks after the birth Henna showed the first signs of oestrus, and this was when Ellora attacked her older calf and chased her away. Prior to this, Ellora had tolerated Henna next to her new calf ('Kiran') (Plate 2), and Ellora and Henna were often seen lying next to each other with Kiran in the middle. Henna never showed any aggression towards her newborn sibling.

Introduction of a female and calf to another female

The company of another calf or adult is the best enrichment for young Greater one-horned rhinoceros. However, the first



Plate 2. Female Greater one-horned rhinoceros *Rhinoceros unicornis* 'Ellora' with her two calves, 'Henna' (3 years) and 'Kiran' (2 days), at Zoo Basel, Switzerland. Zoo Basel.

contact between a ♀ and her calf and another ♀, with or without a calf, is not particularly easy. In our experience, ♀♀ should be left alone with their calves for c. 2–4 months. By this time, depending on the season, bonding between calf and mother is strong. At the point of introduction of a ♀ and her calf to another ♀, all the feeding stations are filled. The feeding stations are located either side of the middle island to prevent the ♀♀ from seeing each other while they are initially feeding. First, the ♀ and youngest calf will be lured to the feeding station behind the island. Then, the second ♀ (with or without a calf) is let into the enclosure and she will often go directly to the most visible feeding station (in front of the island). It usually takes a number of minutes before the ♀♀ recognize the proximity of another rhinoceros. Mothers are highly protective of their calves, and they will stand up and look towards the other ♀. As long as the other animal keeps its distance the situation will remain calm. However, the moment another animal (usually the older calf) approaches the younger calf, the mother will attack (snorting, lowering

her head and running towards the other ♀ and the other calf) in order to ensure that contact with her calf is avoided. Generally the calf will stay with its mother but occasionally it might run towards the other ♀. However, in all the years of breeding this species at Zoo Basel, aggressive behaviour of a ♀ towards another ♀'s calf has never been observed. The better the ♀♀ know each other, the faster the situation will become normalized, although this can take a few days with occasional running, snorting and attacking each other. Eventually the calf is allowed to meet the other ♀ and to play. Since 1967 there have been ten instances when two ♀♀ have had calves at the same time and have been kept together in the enclosure. Apart from the fighting that occurs between cows initially, and these have never been serious or caused injury (apart from some superficial skin wounds), no problems have been encountered during introductions. Furthermore, the best enrichment to provide the Greater one-horned rhinoceros is to allow calves to play with each other and have contact with the other animals in the group.

CONCLUSION

During the past 15 years, the husbandry, management and breeding strategies for the Greater one-horned rhinoceros have changed significantly at Zoo Basel. As a city zoo, the vision of a new house and well-designed outdoor enclosure for the species was developed not only to meet the requirements of good animal husbandry but also to create a multi-disciplinary area that allows keepers to change management strategies frequently providing new methods of enrichment. This new approach to keeping Greater one-horned rhinoceros also improved the health of the animals (no more foot problems) and provided enough space to try new ways of breeding this species. In the past, ♀♀ were locked inside the stable to give birth. However, now the animals are given free-choice. This 'option to choose' a location is also provided during seasonal changes. The rhinoceros are not forced to move to certain areas but are given options, leaving it up to them to decide where to go and when. The behaviour of all five rhinoceros (Ellora, Quetta, Jaffna, 'Jari' and Kiran) at Zoo Basel has changed and many interesting observations have been possible (e.g. giving birth with the older calf present, showing less aggression during mating, more non-food enrichment by providing 'free-choice' to the animals of where and when to go to different areas of their enclosure, better handling in difficult situations, especially the ♂ prior breeding); generally, these animals are gentle and relaxed. Although still at the continuous-learning phase, the success with the Greater one-horned rhinoceros at Zoo Basel has motivated staff to continue watching the animals, and developing new and improved strategies for their management, husbandry and breeding.

ACKNOWLEDGEMENTS

The author would like to thank the Zoo Basel rhinoceros keeper team for their continuous commitment towards the Greater one-horned rhinoceros, as well as Madeleine Leutenegger for her ongoing support.

PRODUCTS MENTIONED IN THE TEXT

DRF/DSF multi-range: heavy-duty scale, manufactured by Mettler Toledo GmbH, Im Langacher 44, 8606 Greifensee, Switzerland.

Gummimatten Classic: solid rubber mats, manufactured by Grüter-Handels AG, Gewerbezone 7, 6018 Buttisholz, Switzerland.

Horsefloor: pour on rubber, manufactured by Dirim AG, Oberdorf 9a, 9213 Hauptwil, Switzerland.

Leicht PVC Platte: clear plastic with metal grid inside, manufactured by Götschi AG, Dornacherstrasse 380, 4053 Basel, Switzerland.

LoHa 25/30: sewed geotextile, manufactured by SFS Unimarket AG, Nefenstrasse 30, 9435 Heerbrugg, Switzerland.

ProMa: drainage rubber mats/panels, manufactured by Werner Abt AG Grenzstrasse 2, 5623 Boswil, Switzerland.

REFERENCES

- DINERSTEIN, E. (2003): *The return of the unicorns. The natural history and conservation of the greater one-horned rhinoceros*. New York, NY: Columbia University Press.
- EMSLIE, R. & KNIGHT, M. (2013): *Update on African rhino status and poaching trends from IUCN SSC African Rhino Specialist Group (AfRSG). Report to CITES Standing Committee 65th meeting*. Geneva, Switzerland: CITES Secretariat.
- FOOSE, T. J. & van STRIEN, N. (1997): *Asian rhinos – status survey and conservation action plan*. Gland, Switzerland, and Cambridge, UK: International Union for Conservation of Nature and Natural Resources.
- VON HOUWALD, F. (2001): *Foot problems in Indian rhinoceroses Rhinoceros unicornis in zoological gardens: macroscopic and microscopic anatomy, pathology and evaluation of the causes*. PhD thesis, University of Zurich, Switzerland.
- VON HOUWALD, F. (2014): *International studbook for the greater one-horned rhinoceros 2013*. Basel, Switzerland: Zoo Basel.
- VON HOUWALD, F. (2015): *International studbook for the greater one-horned rhinoceros 2014*. Basel, Switzerland: Zoo Basel.
- VON HOUWALD, F. (2016): Causes and prevention of foot problems in greater one-horned rhinoceros *Rhinoceros unicornis* in zoological facilities. *International Zoo Yearbook* **50**: 215–224.
- VON HOUWALD, F. & FLACH, E. (1998): Prevalence of chronic foot disease in captive greater one-horned rhinoceros *Rhinoceros unicornis*. *Proceedings of the European Association of Zoo and Wildlife Veterinarians* **2**: 323–327.
- IUCN (2013): *Bandar Lampung Declaration. The first Asian rhino range states meeting, Bandar Lampung, Indonesia, 2–3 October 2013*. Gland, Switzerland: International Union for Conservation of Nature.
- IUCN (2015): *The IUCN Red List of Threatened Species*. Gland, Switzerland, and Cambridge, UK: Interna-

- tional Union for Conservation of Nature. Available at <http://www.iucnredlist.org>
- LANG, E. M. (1956): Geburt eines Panzernashorns. *Jahresbericht Zoologischer Garten Basel* **84**: 31–39.
- LANG, E. M. (1957): Geburt eines Panzernashorns, *Rhinoceros unicornis*, im Zoologischen Garten Basel. *Säugetierkundliche Mitteilungen* **V**(2): 69–70.
- LANG, E. M. (1960): The rhino house at Basle Zoo. *International Zoo Yearbook* **2**: 15–16.
- LANG, E. M. (1966): Krankheit und Tod des Panzernashornbullen Gadadhar. *Proceedings of the International Symposium on Diseases in Zoo Animals* **1966**: 301–307.
- LANG, E. M. (1967a): Safeguarding the Indian rhino. *ZooNooz* **1**: 16–17.
- LANG, E. M. (1967b): Einige biologische Daten vom Panzernashorn *Rhinoceros unicornis*. *Revue suisse de Zoologie* **74**: 603–607.
- LANG, E. M. (1975): The Indian rhino in captivity. In *Breeding endangered species in captivity*: 293–302. Martin, R. D. (Ed.). London: Academic Press.
- LANG, E. M. (1976): The Indian rhino *Rhinoceros unicornis* in captivity. *Journal Bombay Natural History Society* **74**: 160.
- LANG, E. M., LEUTENEGGER, M. & TOBLER, K. (1977): Indian rhinoceros *Rhinoceros unicornis* births in captivity. *International Zoo Yearbook* **17**: 237–238.
- LAURIE, A. (1978): *The ecology and behaviour of the greater one-horned rhinoceros*. PhD thesis, University of Cambridge, UK.
- LAURIE, A. (1997): Das Indische Panzernashorn. In *Die Nashörner Begegnungen mit urzeitlichen Kolossen*: 95–114. Fürth: Filander Verlag.
- RUEDI, D. (1989): Panzernashorn Nr. 21. *Bulletin des Zoologischen Garten Basel* **62**: 7.
- RUEDI, D. (1991): ZOLLI-Panzernashorn Nr. 22 und Nr. 23! *Bulletin des Zoologischen Garten Basel* **66**: 13–14.
- WACKERNAGEL, H. (1962): Von unseren Nashörnern. *Bulletin des Zoologischen Garten Basel* **8**: 5–12.

Manuscript submitted 2 March 2015;
revised 4 March 2016; accepted 16 March
2016