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Causes and prevention of foot problems in Greater one-horned rhinoceros *Rhinoceros unicornis* in zoological institutions

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Greater one-horned rhinoceros *Rhinoceros unicornis* have been successfully maintained by and bred at zoological gardens in the past half century. Despite this success, decades ago it was recognized that this species frequently develops foot lesions. Such damage can impair the health and well-being of an individual, and contribute to a reduction of its lifespan. The death of a breeding bull or cow will have an effect upon the success of the breeding programme. Various studies have been carried out to determine the types and causes of foot problems in Greater one-horned rhinoceros with the aim of identifying long-term solutions to this health concern. The most effective method for preventing lesions and improving the health of the feet in rhinoceros is to utilize an appropriate substrate (e.g. 50 cm-deep untreated wood chips) in both outdoor enclosures and indoor stables.

Key-words: causes; foot problems; greater one-horned rhinoceros; husbandry; prevention; zoological institutions.

INTRODUCTION

Greater one-horned or Indian rhinoceros *Rhinoceros unicornis* have been kept at zoological gardens for many centuries (Reynolds, 1960). In 1824, the first recorded birth of a Greater one-horned rhinoceros at a zoological institution took place in Kathmandu, Nepal, followed by a calf that did not survive at Calcutta Zoo, India, in 1925 (Rookmaaker, 1973). In 1956, a calf was born and reared successfully at Zoo Basel, Switzerland (Lang, 1956). This breakthrough in breeding *R. unicornis* led to an increase of their numbers in zoos, and more institutions started to maintain and bred this rare species. At the end of 1975, the international studbook reported 61 [33.28 (♂.♀)] Greater one-horned rhinoceros at 32 institutions worldwide (Lang, 1975, 1977a; Lang *et al.*, 1977). In 1976, the number of *R. unicornis* in the wild was estimated to be only 450 individuals (Lang, 1977b). Nearly 40 years later, at the end of 2014, the global population of *R. unicornis* in zoos was 207 (105.100.2) living individuals at 73 institutions, and the population in the wild at the end of 2013 was recorded as 3339 animals (von Houwald, 2014, 2015).

Although breeding *R. unicornis* is challenging because of the aggressive mating behaviour observed in the species, international studbook data indicate that, on average, eight to 12 calves have been born each year in zoos. Despite this breeding success, a study carried out in 1997 revealed that over 28% of all Greater one-horned rhinoceros in zoos had foot problems (von Houwald, 1997). Besides other health issues seen in rhinoceros, the occurrence of foot problems had been described by various veterinarians in the past. Strauss & Seidel (1982) described an unsuccessful treatment of lesions of purulent pododermatitis in a Greater one-horned rhinoceros at Berlin Tierpark, Germany; Rüedi (1984) wrote about calluses on the soles of the feet of a ♂ *R. unicornis* at Zoo Basel; Mayer & Saksefski (1987) described the occurrence, treatment and final decision to euthanize a bull with foot lesions in all four feet at Milwaukee Zoo, WI, USA; and Miller & Foose (1996) mentioned the occurrence of foot problems in Greater

one-horned rhinoceros in North American zoos. Animal records at Zoo Basel showed that the first foot problems observed in the species occurred as early as 1970.

The causes associated with the occurrence of foot lesions and long-term solutions achieved through the improvement of husbandry for Greater one-horned rhinoceros at Zoo Basel, Switzerland, will be presented in this article.

FOOT ANATOMY

The following definitions are used to describe the anatomical structures of the foot. A digit is defined as 'a structure equivalent to a finger or thumb at the end of the limbs of many higher vertebrates' (http://www.oxforddictionaries.com). The limbs of horses end in a single digit (digit III) that terminates in a hoof. The limbs of rhinoceros end in three digits (i.e. II – inner digit; III – middle digit; IV – outer digit), each of which terminates in a hoof.

According to the *Baillière's Comprehensive Veterinary Dictionary*, a hoof is defined as the horny covering of the digit of ungulates (Blood & Studdert, 1988). The hoof consists of a wall, a sole and, in horses, reflections of the wall that enclose a triangular frog (an elastic horny pad in the sole of the hoof that absorbs shock). In this report, the author will use the term hoof when discussing foot problems in Greater one-horned rhinoceros as the pathological findings are all associated with the horn structures encapsulating the digit or the horn of the pad.

As the life of Greater one-horned rhinoceros is strongly adapted to riverine habitats (Laurie, 1978), the hooves and pads on the feet have developed distinctive structures. The three hooves of a foot of the Greater one-horned rhinoceros surround a big, soft pad (Fig. 1). Each single hoof has a dark weight-bearing rim consisting of very hard horn cells. This rim surrounds the hoof entirely and encloses the horn of the sole of the hoof. In contrast, the horn of the sole is white, brittle and easily worn away. The weight-bearing rim visibly protrudes the horn of the sole and surrounds it almost completely (exceptions are seen in the side hooves, where the rim is less high at the back part of the hoof). The weight of the rhinoceros is primarily carried on the dark weight-bearing rim of all three hooves. The brittle white horn of the sole is not designed to carry the weight of the animal.

The pad of each foot is made up of small, flexible horn-cell structures. Histological examinations revealed that the horn of the anterior part of the pad is not strong enough to withstand physical force and will easily break when pressure is applied (von Houwald, 2001). While walking, the pad spreads the load of the weight of the animal, but it is not made for supporting it alone.

Feet of free-living rhinoceros

In the wild, Greater one-horned rhinoceros have elongated hooves with an elevated rim (up to 3 cm high) between the caudal (posterior) part of the central hoof and the adjacent pad. The soles of the hooves are concave and the cranial (anterior) part of each hoof curves slightly backwards, resembling a claw (Plate 1). The pad consists of firm horn layers that have the appearance of scales. The hooves are positioned in a semi-circle around the pad and carry the animal's weight (Plate 1; Fig. 1), making them appear to walk on their tiptoes. The pad supports the gait as the rhinoceros moves around.

The natural habitats of Greater one-horned rhinoceros are riverine floodplains and tall swampy grassland (Laurie, 1978), both often wet and soft, and the hooves of this species are adapted to such a habitat. The hooves protrude from the pad and the anterior hoof walls are slightly curved, to allow the rhinoceros to walk on slippery surfaces (Laurie, 1978; M. Atkinson, pers. comm.). In the wild, Greater one-horned rhinoceros are primarily 'hoof-walkers'.

Feet of rhinoceros in zoos

In 1997, a study was carried out to investigate the occurrence of foot problems in the

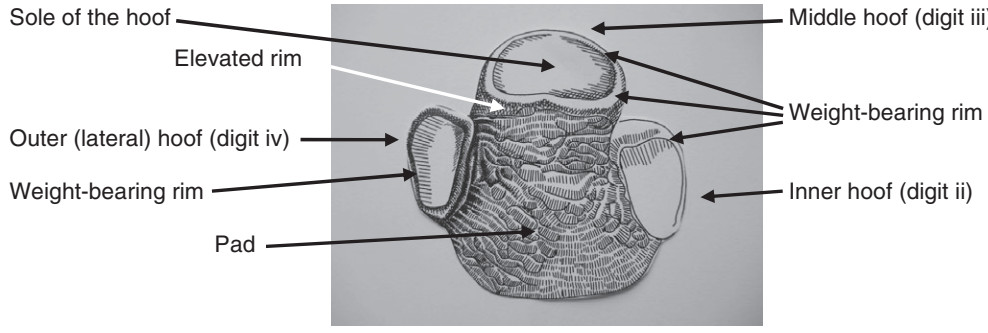

Fig. 1. Graphic description of the distinctive hoof and pad structures of a foot of a Greater one-horned rhinoceros *Rhinoceros unicornis***.**

Plate 1. The front feet of a Greater one-horned rhinoceros *Rhinoceros unicornis* **from the Chitwan National Park, Nepal: the pad has hard horn layers, the hooves all show an elongated rim and the cranial part of the hooves is slightly curved.** *M. Atkinson, The Wilds (private collection).*

Greater one-horned rhinoceros population in zoos. The results revealed that foot problems were common in this population (von Houwald & Flach, 1998). A further study was carried out in 2001 to determine the causes of these foot problems in rhinoceros in European zoos (von Houwald, 2001).

In zoos, Greater one-horned rhinoceros were and, to some degree, still are kept in enclosures with hard, abrasive substrates, and these animals are often overweight and do not move around as much as they would in nature. These factors all contribute to the health issues that have been observed.

The most important findings revealed that the feet of Greater one-horned rhinoceros in zoos look very different to those of their counterparts in the wild (von Houwald, 2001; Atkinson, 2002). The feet have often been remodelled, because the elongated hoof walls and elevated rims are worn down in both front and hind feet (Plate 2). This thinning of the weight-bearing rim causes the remaining horn structures to become fragile and the tissue is prone to traumatic impacts. As a result, cracks develop in the pad. Furthermore, the change in hoof anatomy leads to a shift in weight onto the soft and brittle horn of the pad, an area that is not designed to bear a lot of pressure (Pfistermüller *et al.*, 2011). These changes in the physical composition of the hooves result in the Greater one-horned rhinoceros in zoos becoming 'pad-walkers'.

CLINICAL SIGNS OF FOOT PROBLEMS

There have been many ideas about what might cause the wide array of foot problems apparent in rhinoceros in zoos. Lack of hygiene, excessive hoof wear, bacterial or

Plate 2. The hind left foot of a Greater one-horned rhinoceros *Rhinoceros unicornis* **in a zoological institution: the middle hoof is elongated, abrasion can be seen on the side hoof, and a crack is apparent between the middle hoof and the pad.** *Friederike von Houwald.*

fungal infection, even virus infections have all been regarded as possible causes over the past few decades (Strauss & Seidel, 1982; Mayer & Saksefski, 1987; Göltenboth, 1995; von Houwald, 2001). Feeding regimes as well as the heavier body mass observed in animals in zoos when compared with rhinoceros in the wild have also been discussed as potential causes (Atkinson *et al.*, 2002). A study carried out in 2001 clearly demonstrates a significant difference in the appearance of the feet of free-living Greater one-horned rhinoceros versus those in zoos; in particular, the histological structures of the feet show different horn qualities for the pad and the hoof, with each having different structures and characteristics (von Houwald, 2001). Basically, it was established that the horn on the pads of the feet of this species is not strong enough to withstand much pressure.

Chronic foot disease

Walking on hard and abrasive substrates will wear all horn structures on a foot. As a result of abrasions, a shift in weight will take place from the hooves to the anterior area of the central pad (Pfistermüller *et al.*, 2011), which is a soft and brittle area of minor resistance (von Houwald, 2001). As a result of the additional weight being moved onto this delicate section as well as the tensile forces applied when the animals turn on their hind feet, the horn cells lose their interconnectivity and will break apart. With time, more cells will be damaged and initially result in small cracks, which can go undetected. These will then develop into larger cracks that can only be seen when the animal lies down and has clean feet. Therefore, most cracks will usually only be noticed when the feet are already at an advanced stage of the disease.

Abrasions on lateral walls of hooves

Abrasions of the lateral walls of the hooves occur when the animals lie down or stand up. Observing the way in which a rhinoceros lies down, for some seconds the outer (lateral) hoof of the hind leg moves under the belly and the rhinoceros will slowly go down on this foot (and hoof) before they sit on their bottom and go down with the front feet. Similarly, there is a range of reverse manoeuvres when the animal stands up. Depending on the substrate, temporarily a lot of weight is shifted onto the outer lateral wall of the hoof. It is during this time that abrasions to the horn occur and lateral hoof-horn abrasions are mainly seen on the hind feet (Plate 2). Any abrasions that occur on the front feet are normally the result of the animal moving the lateral hooves over hard ground while lying on their side.

Cracks in the hoof wall

In horses, cracks within the walls of the hooves are a common sight, and they can be superficial or deep (full thickness, bleeding visibly). Various causes are associated with these cracks, including environmental factors, genetics, nutrition, the use of inadequate horseshoes, trauma, management and inadequate training (Booth & White, 2007). Although it is not easy to evaluate the exact cause in each case, it has been established that an improper hoof balance is likely to impair the horn structures of the hooves, leading to cracks (Booth & White, 2007).

In rhinoceros, abrasions also lead to a shift in weight and balance (Pfistermüller *et al.*, 2011). It is therefore not surprising that the weakened horn structures react to trauma and increased pressure (caused by the shift in weight to the pad) by developing cracks.

Haematoma in the pad

Haematomas, seen in the pads as dark spots, are a common finding in the feet of rhinoceros. As a result of walking on abrasive material, the horn layer of the pad is thinner than naturally seen in animals in the wild and is lacking its protective scaly layer (cf. Plates 1 and 2). Walking on stones will cause trauma to the underlying tissue and result in subcutaneous bleeding, which shows as dark spots within the horn layer. The front foot of a deceased Greater one-horned rhinoceros was cut in half, revealing that the horn of the pad measured < 4 mm in thickness (Plate 3) (von Houwald, 2001).

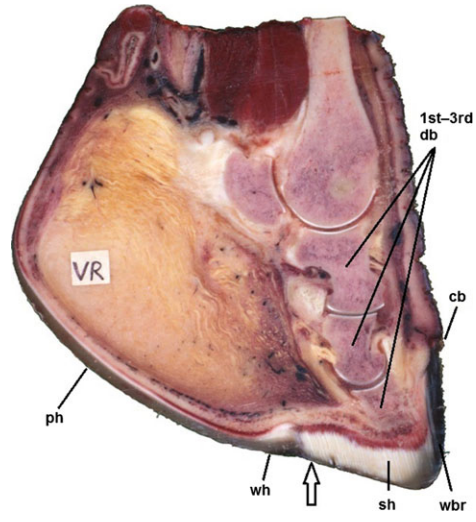

Plate 3. The front foot of a Greater one-horned rhinoceros *Rhinoceros unicornis*, cut in half post mortem. The thin horn layer of the pad is clearly visible: cb. coronary band; db. digital bone (phalanx); ph. pad horn; sh. sole horn; wbr. weight-bearing rim (dark horn = hoof wall), here completely worn and not touching the ground; wh. area of weak horn and origin of cracks between sole and pad. Upward arrow indicates the section of the foot where the elevated rim would be visible in Greater one-horned rhinoceros in the wild; however, in this image from a zoo-based rhinoceros, this area is flat and level with the adjacent pad. *Friederike von Houwald.*

PATHOLOGY

The following pathological findings are associated with the term 'foot problem'.

Chronic foot disease

The most frequently observed problem is the development of cracks between the pad and the central hoof. These cracks vary in size and degree, and small cracks can often go undetected. As the cracks occur between the cranial (anterior) part of the pad and the adjacent central hoof, granulation tissue starts to grow. With time, this granulation tissue increases in mass and poor-quality horn will develop (von Houwald, 2001); sometimes resembling the canker observed in horses (Mayer & Saksefski, 1987). The mass will push the central hoof forward, resulting in an unnatural angle of growth as the hoof wall starts to grow upwards, which leads to an elongated hoof (Plate 2). While walking or standing, the elongated central hoof will touch the ground but the anterior part of the horn (i.e. the weight-bearing rim/hoof wall) will not. Therefore, the weight of the animal will no longer be supported by the hoof wall and the strong weight-bearing rim, but by the pad and the area where there are cracks. With time, more and more granulation tissue will grow between the pad and the hoof, and poor-quality horn develops in response to the increase in weight load. The central hoof will also continue to grow at an unnatural angle. The longer the central hoof grows, the greater the impact while walking. Each time the animal pushes the anterior part of the elongated central hoof off the ground, tensile forces will be applied to the cracks between the pad and the sole, and any regenerative tissue that has formed will be torn apart.

Depending on the onset of this issue, the deformation of the central hoof can be

severe. Animals with chronic foot disease show clear signs of discomfort.

Abraded lateral hoof wall

Other common findings are abrasions along the lateral hoof wall, mainly in the hind feet. A healthy/intact horn wall is dark in colour. The inner layer of the horn wall consists of white horn structures. Abraded horn walls are white in colour because the outer (dark) protective layer of the horn wall is gone. Lesions along the coronary band are commonly seen in association with abraded lateral hoof walls. Healthy lateral and medial (inner) hooves have an oval shape; abrasion alongside the lateral hoof changes the form to a more rectangular shape.

Cracks in the hoof wall

Cracks within the horn wall of all hooves can run horizontally or vertically and can protrude to the deeper inner horn layer. These cracks can start at any location.

Haematomas in the pad

The pads of Greater one-horned rhinoceros appear soft, white in colour and smooth. The horn is very thin (sometimes < 4 mm). As a result, the foot is sensitive to trauma. Haematomas, visible as red dots of various sizes, are frequently seen in this thin layer of whitish–yellowish horn.

TREATMENT

Foot problems in Greater one-horned rhinoceros are common, and there have been many ideas about how to treat them. These ranged from custom-made leather shoes (Mayer & Saksefski, 1987; J. Hess, 'Im Zolli: Ein Schuh für den Nashornbullen Chitwan', *Basler Zeitung,* 1 February 1989), to shortening the elongated central hoof (Göltenboth, 1995; W. Rietschel, pers. comm.), trimming the feet and soles (Atkinson *et al.*, 2002), or using wooden blocks to heighten the hooves artificially (K. Baumgartner, pers. comm.). However, nothing has resulted in a complete long-term improvement or healing of the lesions. Not every rhinoceros is well trained enough to allow keepers to check and treat its feet without sedation; therefore, anaesthesia is often the only way to administer veterinary care for a foot problem in this species.

All the treatments described will treat the symptoms but will not cure the causes of the foot problems or heal the feet of rhinoceros. Various techniques can be used to facilitate the care of rhinoceros feet.

Operant conditioning

Operant conditioning has been used in all three rhinoceros species with great success and can be effective for making the animals comfortable in order to administer foot care when needed, which is especially valuable to prevent any problems from worsening (Holden *et al.*, 2006). An animal has reportedly died following repetitive sedations to administer treatment (E. Flach, pers. comm.), while other animals needed to be euthanized, either because of the severity of the lesions or they died ultimately because they were unable to rise onto their feet and succumbed to heart failure (Mayer & Saksefski, 1987; Wyss *et al.*, 2012). Operant conditioning that allows keepers to administer foot care in the early stages of identified problems has been used to improve the health of the feet of rhinoceros in zoos (Holden *et al.*, 2006).

Foot trimming

The veterinarian may have to cut the length of the central hoof to alleviate the pressure around the area of the crack. When looking at a hoof that has been cut, it is apparent that the hoof wall, made up of dark-horn wall (i.e. the weight-bearing rim), has been pushed upwards and is no longer touching ground and supporting the weight of the animal. The only part of the foot that touches the ground is the soft white horn of the sole of the middle hoof, which is prone to abrasion. Because the supporting-rim wall is not touching ground,

the whole mechanism of the hoof changes. When the granulation tissue (canker) is cut or removed, it will bleed extensively. This can result in momentarily relief, but the granulation tissue will regrow as long as the cause (incorrect foot mechanism as a result of abraded hoof walls) remains.

Hoof elevation using blocks

A potential treatment would be to elevate the hooves to provide a natural look to the feet and protection for the softer exposed white horn and pads, a process that has been attempted by various veterinarians (F. von Houwald, unpubl. data; K. Baumgartner, pers. comm.). However, the downside of this treatment is its practicability. The horn of the hoof will grow at *c.* 1 cm per 6–8 weeks. If the intention is to restore the natural appearance of the hoof (i.e. an elongated supporting rim around the hoof), each hoof on every foot needs to have an artificial elevation of some type in place for at least 4–6 months in order to regain the natural conformation. Trials at Zoo Basel, involving the application of wooden blocks to the hooves showed that it is difficult to fix these in place, and some only last for a day, while others fall off after a week and some last for several weeks. In order to maintain the correct balance of the feet and to prevent further abrasions, every hoof continuously needs to be fitted with these wooden blocks. Even if an animal will lie down voluntarily and allow the fitting of the blocks without sedation, it is almost impossible (and highly dangerous) to lift the leg that the rhinoceros is lying on to apply a wooden block to its inner and outer hooves. Because a satisfactory treatment that works consistently has not been formulated, the best course of action has to be to prevent the foot problems from occurring.

PREVENTION OF FOOT PROBLEMS

To the knowledge of the author, there is no single treatment that will work effectively unless changes are made to the husbandry protocols. The most constructive modification appears to be the use of a softer substrate in both indoor and outdoor areas.

Hard substrate only

Zoo Basel started to maintain Greater one-horned rhinoceros in 1951. At that time, the stables had a hard substrate and the outdoor enclosure was marl. Hygiene, with emphasis on parasitic control seemed highly important, and these surfaces could be easily cleaned during the daily husbandry routine. The animal records from Zoo Basel showed that foot issues started as early as 1970. Although not on a regular basis, ♂♂ appeared to be much more impaired than ♀♀. As a result, the stables were given a straw substrate (on top of the hard surface) and wood chips were spread around the outdoor enclosure. The rhinoceros appeared to have a preference for walking and lying on the softer substrates but these materials never lasted for long, and soon, the animals were walking on the hard substrate again and the foot problems started to get worse.

Wood-chip substrate indoors and outdoors

In 2004, a complete renovation of the rhinoceros enclosure started at Zoo Basel. At that time, all the adults had cracks in their hind feet, showed abrasions on the outer hind hoof walls and had very thin pads that had visible bruises on them.

In 2007, the new indoor stables and outdoor enclosures were finished, and the substrate used for both inside and outside consists of a 50 cm-deep untreated wood-chip layer (von Houwald, 2016). This material is bouncy, easily replaced and can also be eaten or played with.

Over the next 8 years, all adults and their offspring (6 calves) were closely monitored, and their feet inspected regularly. All animals, with the exception of the hind foot of a single rhinoceros, now have hooves with elevated rims, intact outer horn walls, feet with thick pads, no cracks and no abrasions

along the coronary band. The oldest ♀ has had deep cracks in her hind left foot for a long time. Although three of her feet improved with the new substrate, the crack in her left hind foot has not closed up. In earlier years, the Zoo veterinarian was able to cut around the cracks to alleviate the pressure in this area without sedation; however, once the horn wall of the hooves started to regrow, this supportive treatment became unnecessary.

Hygiene

Over 8 years of use, the substrate has only been completely replaced once. Hygiene protocols involved removing faeces daily, removing the wood-chip substrate from those areas where the rhinoceros frequently urinated and dampening the wood chips weekly to keep the dust levels down. The wood chips were topped up as required in specific places (e.g. the urination area). Apart from one year when a fungus growth was identified, the result of too much water being used to dampen the substrate in the stables over a long period (i.e. 6 months), no side effects or improper hygiene issues have been detected over the 8 years.

Mixed substrates

In 2014, Zoo Basel send out a questionnaire to all holders of Greater one-horned rhinoceros (n = 24) in Europe, asking for information about their holding facilities and requesting photographs of the feet of their animals. Replies were received from 33% (8 out of 24) of the institutions. It is interesting to note that those that changed their husbandry practices (by providing softer substrates) according to the recommendation of the European Association of Zoos and Aquaria Indian Rhino European Endangered Species Programme had fewer problems with the occurrence of foot problems than those that still keep the rhinoceros on hard ground. Furthermore, keeping Greater one-horned rhinoceros on soft ground outside but with a rubber floor inside did not result in healthy feet. Rubber flooring had been used at Zoo Basel, prior to the renovations, but the results were disappointing. Pour-on soft rubber (Horsefloor) was used in the stables at various thicknesses (2–4 cm). At Zoo Basel, the signs of abrasions on the feet remained clearly visible, especially on the side hooves and coronary bands, the pads remained thin, the supporting weight-bearing rim regrowth did not occur to the extent required and cracks remained. Rubber flooring intensifies the friction between substrate and hooves when a rhinoceros turns, which increases the tensile forces in the area of the most minor resistance. Therefore, in the refurbished enclosures rubber was not used in places where the animals walk around or spend a lot of time.

CONCLUSION

Keeping Greater one-horned rhinoceros in zoos is more important than ever. At the time of writing, poaching has reached frightening dimensions. In 2014 alone, the South African Department of Environmental Affairs reported the loss of 1215 rhinoceros (Department of Environmental Affairs, 2015). The Asian rhinoceros are less numerous in the wild than the African species. Apart from poaching they also face threats from habitat loss and new infrastructure projects (e.g. road building, railway building) that fragment their current habitat (Talukdar, 2014). Therefore, breeding rhinoceros in zoos is highly important. Not only can the individuals be ambassadors for their species, to educate and sensitize millions of visitors about the conservation needs for rhinoceros, but also by maintaining comprehensive studbooks the population can be kept genetic viable, which one day may allow for reintroductions to the wild. In order to manage this, zoos must ensure the well-being of the animals in their care.

In 2002, the *Husbandry Manual for Greater One-Horned or Indian Rhinoceros* was published (Guldenschuh & von Hou-

wald, 2002). Clear recommendations are given on how to keep *R. unicornis* based on the findings from a detailed study (von Houwald, 2001). At that time, it was assumed that altering the husbandry and management for Greater one-horned rhinoceros would lead to an improvement in the health of their feet, but evidence to support this theory was lacking. In 2004, the enclosure for *R. unicornis* at Zoo Basel was completely rebuilt to meet the new standards and in 2007 the animals were moved onto the new area. After 8 years, almost all the feet of the individuals at the Zoo have improved significantly.

A questionnaire sent out to all institutions in Europe keeping Greater one-horned rhinoceros revealed that many *R. unicornis* still suffer from foot problems, mainly because the husbandry recommendations have not been put into effect. Institutions that only improved the outdoor areas, while keeping the hard, easy-to-clean surfaces in stables, still report foot problems. Most zoos that only started to keep Greater one-horned rhinoceros in the past 8 years planned new enclosures taking the recommendations into account and their animals have healthy feet. Although not all the animals show chronic foot disease there are clear signs of abrasions (soft pads, abrasions along the side hooves, loss of the dark weight-bearing rim protruding from the hooves), rendering the feet vulnerable to traumatic impacts. The Association of Zoos and Aquariums recently published the *AZA Rhino Husbandry Manual* recommending a brushed or broom-finished concrete floor that is well drained and provides adequate footing in the indoor stables as the main substrate (Metrione & Eyres, 2014). As the study reported here demonstrates, this is unlikely to be adequate to maintain good foot health. Rubber flooring still leads to abrasions. Stables with abrasive and hard floors will cause the thinning of the horn layers and render the feet vulnerable to trauma. Using natural flooring inside the stables for Greater one-horned rhinoceros at Zoo Basel over the past 8 years has provided a lot of detail about what substrate is best to use and how to manage it. So far the thick layer (50 cm deep) of wood-chip litter has worked both for keepers in their everyday work and, most importantly, for the health of the animals. In many zoos it is still common that keepers, curators and veterinarians think that the feet of their rhinoceros look healthy; however, very often this is not the case. The first signs, such as abrasions along the lateral hoof, the coronary band, the pad and the soles of each hoof, render the feet susceptible to trauma but they are often not identified. Every Greater one-horned rhinoceros showing these signs is a potential candidate for the development of further problems, unless a change in husbandry practices allows the supporting horn structures on the feet to regrow.

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PRODUCT MENTIONED IN THE TEXT

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

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