

PREVALENCE OF CHRONIC FOOT DISEASE IN CAPTIVE GREATER ONE-HORNED RHINOCEROS (*RHINOCEROS UNICORNIS*)

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Summary

Questionnaires were sent to all collections which kept Greater One-horned rhinos (*Rhinoceros unicornis*) between 1980 and 1996 asking for details about cases of chronic foot disease and, if there had been any, a description of the lesions, the likely cause, treatments used, and their success. The return rate was 53% representing 99 animals over one year old. The 17 year period prevalence of chronic foot disease was 22.2%, with 20.5% of animals still alive having the disease. The incidence rate was 1.83 new cases per 100 animal-years, of which males (2.3/100 animal-years) were almost twice as likely to be affected than females (1.27/100 animal-years).

Zusammenfassung

Fragebögen wurden an alle zoologische Gärten geschickt, die in dem Zeitraum von 1980-1996 Panzernashörner (*Rhinoceros unicornis*) hielten. Detaillierte Fragen wurden über das Vorkommen von chronischen Hufproblemen gestellt und traten diese in den Zoos auf, wurden weitere Fragen über eine genaue Beschreibung der Läsionen, die mögliche(n) Ursache(n), die jeweils angewandte Behandlungsmethode und die Erfolgsrate gestellt. 53% aller zoologischen Gärten schickten die Fragebögen zurück und somit wurden Informationen über 99 Tiere erhalten, die über ein Jahr alt waren. Während dieser 17 jährigen Studienzeit kamen chronische Fußproblem zu 22,2% vor, wobei 20,5% dieser Tiere am Ende der Studienzeit noch lebten. Die Vorkommensrate lag bei 1,83 neuen Tieren pro 100 Tieren-Jahr wobei männliche Tiere (2,3/100 Tiere-Jahr) fast zweimal so häufig betroffen waren wie weibliche Tiere (1,27/100 Tiere-Jahr).

Résumé

Des questionnaires ont été envoyées a toutes les collections ayant élevés des rhinocéros unicorns (*Rhinoceros unicornis*) entre 1980 et 1996, recensant les cas de pododermatite chronique et lorsque qu'il en existait, demandant une description des lésions, l'étiologie la plus probable, les traitements utilisés et leur efficacité. Le taux de réponse fut de 53% ce qui représenté 99 animaux de plus d'un an. Sur une période de 17 ans, la prévalence du pododermatite chronique est de 22,2%, dont 20,5% d'animaux malades toujours en vie. Le taux d'incidence est de 1,83 cas nouveaux pour 100 années-animaux, parmi lesquels les males (2,3/100 années-animaux) sont pratiquement deux fois plus atteints que les femelles (1,27/100 années-animaux).

Key words

Greater one-horned rhinoceros, Indian rhinoceros, *Rhinoceros unicornis*, foot disease, epidemiology, husbandry, captive breeding

Introduction

Greater one-horned (GOH) rhinos (*Rhinoceros unicornis*) are endangered in the wild and only approximately 2000 are thought to remain in India and Nepal. One hundred and twenty-seven animals were in the international captive breeding programme on 1st January 1997 (8), but the rate of reproduction is still insufficient to sustain an independent captive population.

In general, GOH rhinos in captivity are healthy and long-lived (3,4), but Strauss and Seidel (6) described a chronic pododermatitis of the hind feet of a male, for which treatment was difficult and unrewarding. They described overgrowth of the middle toe, separation of the toe from the main weight-bearing pad and papillomatous growths between the toe. Further cases were reported by Göltenboth (1) and Mayer and Saksefski (5).

Two animals at Whipsnade Wild Animal Park, United Kingdom, are currently suffering from chronic foot lesions, and in 1995 a young male died during immobilisation to treat chronic foot disease similar to previous cases. Initial requests for information from other collections revealed that the problem was common and has probably been underestimated in the past. A questionnaire survey was initiated with the aim of quantifying the extent of the problem and investigating possible causes and treatments and we present here the principle findings.

Materials and Methods

At the end of 1996 a five-page questionnaire was drawn up in conjunction with the EEP GOH rhino coordinator, and sent with Studbook questionnaires to all zoological collections which kept GOH rhinos between 1.1.1980 and 30.6.1996. A long study period was chosen because of the chronic nature of the problem. Questionnaires were returned after 31.12.1996, so data for the whole 17 years was available. Page one requested information about all individuals present in the collection at any time during the study period, especially whether or not they had ever suffered from chronic foot disease (CFD). Secondly, each collection was asked for details of enclosures, particularly flooring and substrates. For each animal which had suffered from CFD the other three pages requested detailed information about the lesions, the results of any diagnostic tests, such as microbiology, treatments used and whether or not they were successful, and finally the respondents own views about possible causes of the lesions.

Once the completed questionnaires were received, a second short summary questionnaire was sent to those collections which failed to respond and several more replied. All analyses are thus estimates of the true captive population status based on the data available.

The period prevalence of CFD was estimated as the number of animals which exhibited the disease within the study period, divided by the number of animals present at any time during the period, except the four calves born during 1996, and expressed as a percentage. Rhinos which had moved from non-responder collections to responders were included, but not those which had moved the other way. The point prevalence on 31.12.1996 was calculated as the number of rhinos with CFD on that date, divided by the number of animals alive on the day. The same restrictions were used. The incidence rate was calculated as the number of new cases of CFD in the study period divided by the number of animal-years, and expressed as cases per 100 animal-years. The number of months each individual rhino was alive during the 17 years was summed and the total converted to years. Thus an animal present throughout contributed 17 animal-years whereas individuals which were born, died or moved to a non-responder collection contributed less.

A family tree was established from the GOH rhino studbook 1997 (8) so that the pedigrees of individual animals with foot problems could be found to see whether there was any association with family lines.

Results

Questionnaires were sent to 66 collections which held GOH rhinos during the study period. Twenty-seven (41%) were returned and a further eight collections returned summaries, making an overall response rate of 53%. The response rate was highest from European and North American zoos, therefore the results may be biased towards these and not represent Asian collections accurately. Details of 99 rhinos (≥ 1 year) were received out of a total of 174 recorded in the studbook (57%). The responder collections held more males (53) than females (46), but as a percentage of the total population females were better represented (60%) than males (55%)

Twenty-five animals, 18 males and seven females, were reported to have had foot disease, but three cases (three males) were not chronic. The 17-year period prevalence of CFD was therefore 22.2%, and the prevalence was higher in males (28.3%) than females (15.2%). The point prevalence on 31.12.1996 was slightly lower (20.5%), but again it was higher in males (24.3%) than females (16.7%), although the difference was not as great. The best indicator of a sex-difference is the incidence rate and there were almost twice as many new cases amongst males (13 = 2.3 per 100 animal-years) than females (six = 1.27 per 100 animal-years). Overall the incidence was 1.83 new cases per 100 animal-years.

Of the 22 cases, five (23%) involved just one hindfoot, although one animal also had bleeding from the sole of the opposite hind foot and cracked nails on the fore feet, 11 (50%) involved both hindfeet, one also having cracked nails on the fore feet, and six (27%) involved all four feet. In most of these latter cases the hind feet were affected more severely than the fore feet. Details of lesions were given for 20 rhinos and all of them had separation of the middle toe from the weight-bearing pad. Overgrowth of the middle toe was reported in 14 animals (70%) and papillomatous/hyperplastic growths in 11 (55%). "Classical" CFD, with all three of these lesions, was seen in nine rhinos (eight males and one female), two of the three lesions were present in a further seven (six males and one female) and just one lesion in four (one male and three females). In many instances the animals were not reported to be lame, but the most severe separations of the toe from the pad were usually complicated by necrotic tracks and bled when the animal walked. Lesions were said to have resolved in four animals, two of each sex, but CFD continued in all of the others, although several collections reported that lesions improved seasonally and others that the problem was minimised by regular treatment (see below).

The age at onset of CFD was recorded for 12 rhinos. The two earliest cases started at four years of age. Four cases started when the animals were five to nine years of age, three from ten to 14, one from 15 to 19, one from 20 to 24 and one from 25 to 29. Thus the median age of onset was nine and a half. The four rhinos with the earliest onset all had classical CFD, as did animals which presented at 11 and 17 (median 5.5), the age of onset of those with two lesions were nine, 10, 11 and 20 (median 10.5) and the two animals with just one lesion presented at nine and 26 (median 17.5).

Of the 22 cases of true CFD, five were wild founders and none of their descendants suffered from the disease. Fourteen of the seventeen others were descended from just two captive males, studbook numbers 0005 and especially 0018, although the majority of captive GOH rhinos can be traced back to one or both of these. Seven of these had an inbreeding coefficient greater than or equal to 0.125 and a high mean kinship, which is the average relatedness of an individual to all other individuals in the zoo population.

Bacteriological examinations were performed on four cases, samples being taken from deep tracks in the area of separation of the middle toe from the pad. *Streptococcus* species, *Staphylococcus aureus*, *Corynebacterium* species, *Klebsiella pneumonia*, *Escherichia coli* and *Bacterioides melanogenicus* were isolated on different occasions, usually in mixed culture.

Most collections with rhinos suffering from CFD with middle toe overgrowth trimmed the toes regularly. Many also trimmed excess papillomatous/hyperplastic tissue and cleaned out infected tracks. In addition, topical application of copper sulphate (in a foot bath), copper naphthenate, oxytetracycline and other antibiotics have been used. A lot of work could be done on conscious individuals with occasional immobilization for more radical treatment. Dressings rarely stayed on feet for more than 24 hours, but were thought to be useful for haemostasis following radical trimming. Two zoos reported that long-term supplementation with biotin improved hoof quality. Six collections found that lesions healed better when the animal had constant access to water, one reported that the lesions disappeared after the animal spent five days in a row in the pond.

Regarding the cause of the problem, there were many suggestions including hard surfaces, chronic trauma, lack of moisture/humidity especially in the winter, insufficient access to water, and the animals being over-weight and getting insufficient exercise. Despite the fact that there were often infected tracks in the feet, respondents felt that bacteria were a secondary problem.

Discussion

This study has shown, thanks to a good international response, that chronic foot disease is common in Greater one-horned rhinos and has been underestimated and overlooked in the past. This is a matter of concern not only for the individual animals' wellbeing, but also for captive breeding because the most severe stages of the disease could affect mating. Indeed, foot problems have occurred in a female rhino following mating (2).

Of the cases which were defined as chronic, all involved one or both hindfeet, and in all cases there was separation of the middle toe from the weight-bearing pad. Overgrowth of the middle toe was commonly reported and more than half had papillomatous or hyperplastic growths between toes. Thus all cases could be easily identified with the original description of Strauss and Seidel (1982). Similar separations were seen in the forefeet of almost half of the cases. Cracks in the hoof wall were also reported in the forefeet, but these were seen in animals without other lesions. Other diseases of the foot are seen in GOH rhinos, especially abscesses at the coronary band, but these usually resolve with treatment and can be readily distinguished from classical CFD.

Chronic foot disease was found to be more common in males than females, and affected them more severely and earlier in life. Therefore, whatever the impact substrates and enclosure design have on the disease, the influence of gender is at least as important, if not more so. Possible reasons for males being affected more commonly are: firstly they are heavier. Unfortunately only a handful of zoos had the facilities to weigh their rhinos, but males were heavier than females of the same age. Secondly, they may traumatise their feet, especially the hindfeet, more than females. Males do push/scrape faeces back with their hindfeet into faecal piles and thus could put pressure on the middle toe and introduce faecal contamination to the sole of the foot. Mature males are very restless when females are in oestrus and pace around more than normal. Additionally, during mating, the male puts extra weight on his hindfeet as he mounts the female. However, there were several young males which had CFD before they mated. Thirdly there may be an anatomical difference between the sexes in their hindfeet. This would need to be tested by taking detailed measurements of a large number of males and females. Fourthly, there could be a physiological difference to explain the lesions, for example testosterone concentrations.

The fact that the most severe form of CFD was seen in the youngest animals was of interest, but unfortunately, because the age of onset was only recorded for 12 rhinos this should be treated with caution. Likewise, there may be a genetic predisposition in the rhinos descended from males 0005 and 0018, but because they have been the most prolific founders this survey will need to be extended to include all rhinos to test this hypothesis.

The pathogenesis of the disease can only be guessed at, but the following is a hypothesis based on the results of this survey. Firstly cracks occur at the junction of the middle toe and the pad. These open up due to the shearing forces acting on the area and allow in bacteria. The middle toe is no longer held in a near-vertical position and so overgrows as a result of insufficient wear. The loose edge of pad becomes traumatised and further opens up the area. Granulation tissue at the lateral border of the separation becomes hyperplastic and also contributes to the problem. It is notable that separation was seen in all cases and was the lesion seen in affected forefeet. Also, there is histological evidence that the toe-pad junction is a site of least-resistance (7). Many factors could contribute to the initial cracks, including a) the innate, inherited strength of the area, b) the elasticity of the area which could be affected by moisture, c) trauma acting on the area due to, for instance, rough substrate or scraping with the hindfeet, and made worse if the animal were overweight.

It could be argued that the primary problem is overgrowth of the middle toe causing the shearing forces in the toe-pad junction. However, overgrowth was not reported in all cases. A detailed anatomical investigation of a large number of individuals would allow this alternative hypothesis to be tested. A third primary cause, bacterial invasion of the area, was not considered likely by the respondents, and there was no predominant species cultured from lesions. However, none of the bacteriological

examinations were carried out on early lesions, and it was no surprise to find opportunist and faecal contaminant bacteria. Full bacteriological examinations are recommended in all cases and should always include anaerobic culture because of the importance of *Bacteroides* species as causes of footrot in domestic animals.

One factor which was not included in the questionnaire, but which should have been, was nutrition. The weight of animals has already been mentioned and is affected by both their diet and energy expenditure. Overgrowth of hooves and underlying laminitis are both also associated with diet in domestic animals. Two collections reported improvements in CFD with the addition of biotin to the diet and future investigation should consider this and other nutrients which are known to be important for the skin, such as zinc, fatty acids and vitamin A.

Chronic foot disease is very difficult to treat once established, not only due to the severity of the lesions, but their location and the nature of the rhinos. Routine treatments in the conscious animal are recommended to avoid the risks of immobilization, but for the most severe cases immobilization may be unavoidable. It does allow good visualization of, and access to, the lesions and the possibility of radical surgery. However, prevention is absolutely essential and it is recommended that all collections allow free access to ponds and wallows, provide a variety of substrates (not just concrete), monitor for early signs of foot disease and train their animals to allow inspection and routine foot care on a regular basis.

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