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SELECTED DISEASES OF BLACK RHINOCEROSES IN CAPTIVITY

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Introduction

The growth of the captive black rhinoceros population (*Diceros bicornis*) has been limited by several diseases of an unusual nature and an uncertain etiology. Hemolytic anemia is one example; in one survey of captive black rhinoceroses, it accounted for 40% of all adult deaths (MILLER, 1993; MILLER and BOEVER, 1982). A syndrome of mucocutaneous ulcers has had a similar impact (MUNSON, 1992), and other poorly understood conditions include an apparently increased incidence of fungal pneumonia, hemosiderosis (KOCK et al., 1992), and encephalomalacia (MILLER et al., 1990). Although there are few, if any, reports of these syndromes in the wild, there are reports of similar diseases occurring in black rhinoceroses shortly after capture; and thus, these syndromes may have significance for black rhinoceroses maintained in even semi-captive situations. In contrast to the black rhinoceros, the diseases reported in captive white rhinoceroses (*Ceratotherium simum*) in North America are of lower incidence and a more routine nature.

This paper provides a brief overview of the diseases noted above. References regarding general medicine, (JAROFKE and KLOS, 1979; JONES, 1979; KOCK and GARNIER, 1991; SILBERMAN and FULTON, 1979), capture techniques (KOCK and MORKEL, 1993; ROGERS, 1993), infectious diseases (RAMSAY and ZAINUDDIN, 1993), and reviews of the veterinary literature (MILLER, 1991) are available.

Hemolytic anemia

A fatal case of hemolysis at the St. Louis Zoo led to subsequent surveys that noted 47 episodes of hemolysis in 39 individual black rhinoceroses. Cases can be classified as "primary," i.e., those hemolytic events that occur without other obvious underlying disease, and "secondary," those cases that occur as agonal events in rhinoceroses dying of other causes. Although several familial groupings of affected rhinoceroses exist, no sex, age, or captive-bred vs. wild-caught patterns were evident (MILLER and BOEVER, 1982). Early reports suggested that at least some of the acute cases of hemolysis were associated with leptospirosis (DOUGLASS et al., 1980; MIKULICA, 1986). Indeed, the advent of the fluorescent antibody (FA) test for *Leptospirosis interrogans* confirmed that several cases that had negative titers were positive on the FA test (JESSUP et al.,1992). Currently, biannual vaccination of all black rhinoceros with leptospiral bacterins containing serovars *icterohemorraghiae* and *grippotyphosa* (serovars that have elicited elevated titers in two reports of rhinoceroses surviving hemolysis) is recommended (JESSUP et. al., 1992; MILLER and BOLIN, 1988). It should also be noted that *Leptospirosis interrogans* has been identified in an aborted greater one-horned Asian rhinoceros (*Rhinoceros unicornis*) at the Bronx Zoo.

However, not all of the cases of hemolysis could be accounted for by leptospiral infection, and a series of investigations was initiated to determine if other etiologies or properties inherent in black rhinoceroses increased their susceptibility to hemolysis from a number of causes (drug exposure, bacterial infection, etc.). Various studies indicated that the anemia was unlikely to result from autoimmune disease (CHAPLIN et al., 1986), uncomplicated vitamin E deficiency (DIERENFELD et al., 1988), nor from an unstable hemoglobin (FAIRBANKS and MILLER, 1988). The most significant findings resulted from investigations into the metabolism of the black rhinoceros red blood cell. Initial studies focused on RBC levels of glucose-6-phosphatase dehydrogenase (G-6 PD) and other enzymes commonly recognized to cause hemolysis in man, but those levels were either normal or elevated compared to human values (PAGLIA et al., 1986). However, on a more fundamental level, the black rhinoceros RBCs were noted to be markedly deficient in energy (ATP) when compared to other mammalian species.

The RBCs of white rhinoceroses, a species which has been apparently healthy in captivity, were also low in ATP, but they also had significantly higher levels of the enzyme catalase than black rhinoceroses (PAGLIA and MILLER, 1994). The full significance of this is unknown, but further metabolic studies are underway in Dr. Paglia's laboratory at the University of California-Los Angeles and at that of Dr. Eric Harley at the University of Capetown (South Africa). One hypothesis is that the energy deficiency of the black rhinoceros RBC may be an adaptive characteristic for hemic parasitism in the same manner than G-6-PD deficiency is considered adaptive in man.

At the present time, suggested treatment of acute cases of hemolysis is supportive and includes penicillin and possibly dihydrostreptomycin (in the event that it is leptospiral-induced), parenteral vitamin E (to assist in the maintenance of membrane stability), enteral and/or parenteral phosphorous supplementation (see below - many of the chronically hemolytic individuals have become hypophosphatemic) (GILLESPIE et al., 1990), and possibly blood transfusion. The latter has been attempted in two black rhinoceros as preliminary findings suggest that rhinoceroses do not have inherent antibodies to other blood groups of their species.

Mucocutaneous Ulcerative Syndrome

Oral, nasal and cutaneous ulcers have been frequently reported in black rhinoceros, and in captivity, can lead to debilitation and in some cases, death. Infection with *Stephanofilaria dinniki*, the most common cause of skin ulcers in wild black rhinoceroses, has not been identified in captive animals. At the present time, the ulcerative syndrome has been identified in 47 black rhinoceroses in North America (MUNSON, 1992). A typical case starts with raised plaques that progress to vesicles and subsequent ulcers. Often they start over points of wear (where early lesions are difficult to clinically differentiate from scrapes) and peripheral areas such as ear tips and coronary bands. In severe cases they may progress to cover larger areas (up to 70% of the body surface). Typically, the lesions are bilaterally symmetrical.

Histologically, the initial lesions are characterized as superficial necrolytic dermatitis. When inflammatory changes are present, they are found in association with ulcers. At the present time, the etiology remains unknown. Bacterial isolates from the lesions have been variable and most likely reflect secondary infection. Viral inclusions nor viral particles have not been noted in the cases examined histologically and viral culture has been negative in two additional cases. Additionally, there has been no evidence of autoimmune disease in two cases that were examined using anti-porcine, anti-equine or anti-rhinoceros immunoglobulin. Due to the similarity with superficial necrolytic dermatitis, the possibility of concurrent liver disease, nutritional deficiencies, and/or endocrine abnormalities are being evaluated.

In many of the less extensive cases, the ulcers spontaneously resolve. Others have noted an apparent marked response to corticosteroid therapy (OTT et al, 1982); however, that therapy is associated with an increased incidence of fungal pneumonias (primarily *Aspergillosis* species, see below) and should be used only in cases that are clearly life-threatening.

Fungal Pneumonia

The author knows of at least nine cases of fungal pneumonia in black rhinoceroses - seven due to infection with *Aspergillosis sp.*, three with species of *Phycomyces* (there was one dual infection). Four of the fungal infections occurred after corticosteroid therapy, three were associated with other chronic illnesses (two with end-stage lesions of the mucocutaneous syndrome), and two cases were "spontaneous," i.e., no other illness or immunosuppressive factors were evident. Cases in animals on concurrent corticosteroid therapy occurred after even apparently low dose therapy (e.g., 1 mg/kg for several days) and so extreme caution should be used whenever immunosuppressive drugs are used in this species. Fungal pneumonias are unusual in most mammalian species and when they occur, are most commonly associated with immunosuppression. In the cases that occurred during treatment with corticosteroids, it is not clear if those drugs contributed to pre-existing immunosuppression, or if black rhinoceroses are particularly sensitive to the effects of this class of drugs. Studies to better characterize the immune status of black rhinoceroses are proposed in order to address this issue and to possibly identify a serological test for antemortem diagnosis. Additionally, Dr. Mike Worley of the San Diego Zoo is evaluating the possibility of a black rhinoceros retrovirus.

At the present time, treatment is speculative. Prophylaxis has been attempted with thiabendazole (GILLESPIE et al., 1990) and itraconizole (JANSSEN, 1994). The latter was administered at the rate of 13 mg/kg with no signs of ill effects; however, at this time, the cost of this medication is prohibitive.

Encephalomalacia

Encephalomalacia has been reported in three black rhinoceros calves and one two year old animal. All were female. Clinical signs varied from somnolence and hyperthermia to hyperexcitability (KINNEY, 1993; MILLER et al., 1990). Three died during their episodes and one was euthanized subsequent to becoming a "dummy" calf. Histologically the lesions were notable for massive white matter necrosis (leucoencephalomalacia), with occasional necrosis of adjacent gray matter. Evidence of inflammation was evident only in the older lesions where presumably it was a reaction to necrosis. The variable neurological signs may simply reflect which areas of the brain in each individual were most severely affected.

Histology or specific diagnostic tests were not supportive of vitamin E-induced malacia, polioencephalomalacia, or viral infections (e.g., encephalomyocarditis virus or equine encephalitis). The histologic pattern most closely resembled that of leucoencephalomalacia due to ingestion of food contaminated with the mold *Fusarium moniliforme*, however, feedstuffs ingested prior to the onset of the neurological symptoms were not available for analysis.

The variable clinical presentation of this disease emphasizes the importance of collecting brain and spinal cord tissues from all rhinoceros deaths, particularly those in which a diagnosis is not readily evident. It is possible that this syndrome is under-diagnosed due to the difficulties in removing a rhinoceros brain.

Hemosiderosis

Accumulation of iron has been noted in tissues of captive black rhinoceroses (KOCK et al., 1992; SMITH et al., in press), and has been shown to be positively correlated with length of time in captivity (KOCK et al, 1992). At the present time it is uncertain if this may represent a chronic stage of hemolysis or nutritional deficiencies/excesses in the captive diet.

Other Diseases

Black rhinoceroses are susceptible to tuberculosis. Recommendations for the most effective testing regimens for this disease have been limited by a lack of positive individuals. In the past, two black rhinoceroses infected with *Mycobacteria bovis* and one exposed to those individuals were positive on intradermal testing with MOT (mammalian old tuberculin) and ELISA (MANN et al., 1981). More recently, a black rhinoceros at the Detroit Zoological Park who was culture positive for *Mycobacterium tuberculosis*, was positive when 0.1 ml of USDA bovine tuberculin was administered intradermally in the eyelid, and this animal was also positive on ELISA testing (BARBIERS and AGNEW, 1994). It has been our recommendation that any suspicious or positive tuberculin test be followed by acid-fast culture of gastric lavage or tracheal wash samples.

Several cases have also been reported in black rhinoceroses of a paratuberculosis-like disease suspicious of infection with either *Mycobacterium avium* or *Mycobacterium paratuberculosis*. Specific identification of the organisms is needed in each case and again, the question of immune status arises. In Australia, treatment with pyrazinamide (Zinamide, Merck Pharmaceutical Co., White House Station, New Jersey, USA) has been attempted.

Hypophosphatemia has been reported in several black rhinoceroses undergoing other systemic illnesses (BARRIE, 1994; GILLESPIE et al., 1990). In some cases of mucocutaneous ulcerative disease, sera phosphorous levels have fallen below 1 mg/dl. In cattle, this level of hypophosphatemia can cause hemolysis. At this time it is unclear if these low levels of sera phosphorus are related to diet, but one can speculate that a dietary calcium / phosphorous imbalance may be involved. Treatment of hypophosphatemia has included oral phosphorus supplementation in mild cases, and intravenous supplementation in more severe ones.
Preliminary results from one study indicate that increasing sera phosphorous levels were correlated with increasing levels of intracellular ATP in red blood cells (PAGLIA, 1994).

In maintaining black rhinoceroses in captivity, it is advisable to avoid exposure to creosote and other phenolic compounds. Exposure to these and possibly other chemicals may induce and/or contribute to a syndrome of liver necrosis and failure. Epidemiology suggests that several recent black rhinoceros deaths in North America have been associated with exposure to creosote. Initial clinical signs are related to liver failure, including marked hyperbilirubinemia (both direct and indirect bilirubin are elevated). Terminally, mucocutaneous ulcers and hemolytic anemia may develop (it is unclear if these signs are from the toxic exposure or simply agonal events as has been noted in other black rhinoceroses with chronic diseases). The signs of liver necrosis and skin ulcers are similar to those previously reported in black rhinoceroses exposed to creosote in North America and southern Africa (BASSON and HOFMEYR, 1973; HOFMEYR et al, 1975; KOCK et al., 1994; SCHMIDT et al., 1982).

Integral to many of the projects noted above has been comparative data from white (*Ceratotherium simum*) and greater one-horned Asian (*Rhinoceros unicornis*) rhinoceroses (and in the future, hopefully from the Sumatran (*Didermocerus sumatrensis*) rhinoceros). In addition to their comparative value, these data are useful for establishing individual baseline values for each species. Frozen (-75 °C) sera and tissue banks have aided such comparisons, and allowed retrospective analysis as knowledge and assay availability improve. Presently, over 400 sera and tissue samples from 25 black, white and greater one-horned Asian (*Rhinoceros unicornis*) rhinoceroses are stored at the St. Louis Zoological Park. The establishment of regional sera / tissue banks elsewhere is strongly encouraged.

In summary, although much progress has been made in understanding the diseases of the black rhinoceros, much remains to be learned. In North America, under the auspices of the Rhinoceros Taxon Advisory Group (TAG) and the black rhinoceros Species Survival Plan (SSP), research into the diseases of black rhinoceroses remains an active and ongoing effort. In August 1993, a meeting of a diverse group of specialists interested in the medicine of rhinoceroses was organized by Dr. Evan B l u m e r , Research Coordinator for the Rhinoceros TAG. Priority areas were identified for future research. They included further studies of nutrition, stress, mucocutaneous ulcerative disease, comparative cellular metabolism, and management issues. Additionally, enhancement of intra- and interregional cooperation and sample and data acquisition was strongly endorsed. Presently, these recommendations are being organized, interested researchers and institutions identified (Dr. E. D i e r e n f e l d is organizing nutritional research), and steps taken so that the TAG may seek funding for priority projects. Hopefully, this enhanced effort will result in a better understanding of the medicine and management of this critically endangered species.

Summary

Selected Diseases of Black Rhinoceroses in captivity

This report describes several diseases of unusual nature that affect the captive population of black rhinoceroses. These include hemolytic anemia, mucocutaneous ulcers, fungal pneumonia and encephalomalacia. Tuberculosis, a paratuberculosis-like syndrome, hypophosphatemia and creosote toxicosis are also discussed. Additionally, future plans for black rhinoceros veterinary research are briefly outlined.

Zusammenfassung

Einige Erkrankungen des Spitzmaulnashorns in Gefangenschaft

Die vorliegende Arbeit behandelt verschiedene Erkrankungen mit außergewöhnlichen Verläufen bei Spitzmaulnashörnern in Gefangenschaft, darunter Anämien mit Hämolyse, Schleimhautgeschwüre, pilzbedingte Pneumonien sowie Enzephalomalazien. Außerdem werden Tuberkulose, ein paratuberkuloseartiges Syndrom, Hypophosphatämien und Kreosot-Toxikosen diskutiert. Es folgt eine kurze Darlegung geplanter Forschungsmaßnahmen für künftige veterinär-medizinische Untersuchungen am Spitzmaulnashorn.

Résumé

Maladies particulières du rhinocéros noir gardé par l'homme

L'exposé décrit les diverses affections non habituelles dont sont atteintes des populations de rhinocéros noirs gardés en captivité. En font partie entre autres l'anémie hémolytique, des ulcères muco-cutanés, des pneumonies fongiques et des encéphalomalacies. Il est également question de tuberculose, d'un syndrome

similaire à la paratuberculose, de l'hypophosphatémie et d'une toxicose créosote. En plus de cela, sont brièvement mentionnés des programmes d'avenir pour la recherche médicale sur le rhinocéros noir.

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