HEALTH

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This section gives a general outline for the diseases of all rhinoceros species but will often discuss at length those of the black rhinoceros (Diceros bicornis). The reason is twofold: 1) the frequent occurrence of disease has been a major limiting factor in the captive black rhino population, and 2) disease problems have been reported with considerably lesser frequency in white (Ceratotherium simum) and greater one-horned (Rhinoceros unicornis) rhinos. Because of the limited number of captive animals, at the present time it is difficult to make general statements regarding disease in Sumatran rhinos (Dicerorhinus sumatrensis).

Throughout this chapter provides only a brief overview, references regarding general medicine (Sullivan & Tait, 1979; Jacobs & Klos, 1979; Jones, 1979; Kock & Garnier, 1991; Miller, 1994), capture techniques (Kock & Morkel, 1993; Rogers, 1993), infectious diseases (Ramsay & Zainuddin, 1993) and a bibliography that reviews the veterinary literature pertaining to rhinos (Miller, 1992) are available.

Physiological Normals

Heart and respiratory rates are variably listed as ranging from 12 to 16 and 64 to 67, respectively (Wallach & Boever, 1983). Electrocardiogram studies have been reported from black rhinos (Jayasinghe & Silva, 1972). Rectal temperature ranges from 37 to 39° C (98.6 to 102.2 F). When dosing rhinos, it is important to know the general size and weight of individuals. When weighed on a truck scale, adult black rhinos at the St. Louis Zoo have ranged in weight from 900 to 1,100 kg (1,984 to 2,426 lb). The white rhinoceros is often considered the second largest land mammal, with adult weight ranging from 1,500 to 2,500 kg (3,308 to 5,512 lb). Others report that greater one horned rhinos range from 1,700 kg (3,748 lb) for females to 2,100 kg (4,630 lb) for males (Wallach & Boever, 1983). The Sumatran rhinoceros is the smallest species of rhinoceros, with large adults weighing approximately 1,000 kg (2,205 lb).

Normal values for blood counts and chemistries are available from captive rhinos in the International Species Information System (1989), in several articles and texts (Hawkey, 1975; Seal et al., 1976; Wallach & Boever, 1983; Pospisil et al., 1986) and from free-ranging black (Kock et al., 1990) and white (Van Heerden et al., 1985) rhinos. Most values do not differ markedly from those of domestic horses.

Hematology

Blood collection from rhinos can take place from several sites. Perhaps most commonly used is the ear vein, which is sufficient for collecting small quantities of blood or for IV injections. A larger medial (radial) vein has been identified in black and several other rhinoceros species and allows collection of larger amounts (1 to 8 liters) of blood (Miller et al., 1989). Whenever rhinos are anesthetized for any reason, blood is requested for a wide variety of research projects, which are outlined in a Rhinoceros Blood and Tissue Collection Protocol.

The ear vein is the most common site for blood collection in rhinos. Larger amounts of blood may be collected from a larger medial (radial) vein. (*Photo: S. Murray, Fort Worth Zoological Park*)

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Due to the predilection to hemolysis of the black rhinoceros, Dr. Donald Paglia of the University of California at Los Angeles has suggested avoiding exposing them to drugs and compounds that are known to induce hemolysis in enzyme-deficient human populations. Included in this list are several classes of pharmaceutical compounds (antimalarials, sulfonimides, sulfones, nitrofurans, acetanilid, chloramphenicol and some vitamin-K analogs), fava beans and a number of chemical compounds (including wood preservatives, rodent-control poisons and other pesticides, and strong cleansers, particularly those containing naphthalene) (Paglia & Miller, 1992). Many other drugs have been associated with hemolysis in these patients but with an uncertain or doubtful role. These drugs include aspirin, phenacetin, aminopyrine, acetaminophen, probenecid, vitamin C, dimercaprol, p-aminosalicylic acid and L-DOPA. Any exposure to creosote should also be avoided. Additionally, in view of the hemolysis induced in horses by the consumption of certain oak and red maple leaves, as well as wild onions and members of the Brassica (kale) family in other domestic species, consumption of these species should be avoided. Until more information is known, it is prudent to implement the above recommendations for all rhino species.

Innoculations

There are numerous reports of leptospirosis in black rhinos (Asakura et al., 1960; Douglass et al., 1980; Mikulica, 1986; Miller & Bolin, 1988; Paras, 1989; Jessup et al., 1992). The only vaccination routinely recommended is the biannual administration of black rhinos with either a 5-way leptospiral bacterin (containing *Leptospirosis interrogans serovar icterohemorrhagiae, grippotyphosa, pomona, canicola, hardjo* - available as Leptoferm-5), or a 6-way bacterin containing serovar *bratislava*, available as Brativac. (Both are manufactured by Norden Laboratories, Lincoln, NE 68521.) However, it should be noted that injection site abscesses are relatively common (5 to 10%) and two cases of apparently marked post-vaccinal reactions have been noted (weakness in both cases, a skin slough in one). Additionally, an abortion of a greater one-horned rhinoceros calf was associated with infection with *Leptospirosis interrogans* (confirmed by fluorescent antibody testing) (Cook, 1994).

Although there are only two reports of clostridial disease (one case of tetanus and one of *Clostridium sordelli*) (Mitra, 1983) and in endemic areas, vaccination for these diseases may be considered. One case of rabies has been reported in a greater one-horned rhinoceros (Mukherjee et al., 1984). During the epidemic of raccoon rabies, zoological institutions on the East Coast of the United States vaccinated for rabies with Imrab (Rhone Merieux, Athens, Georgia).

Neonatal Examinations

Whenever possible, neonatal examinations should be performed. These should include weight, a dipstick blood glucose, total solids, CBC, sera chemistry profile, sera/plasma for vitamin-E levels, and, when possible, stored sera. Examinations may include vitamin supplementation and the placement of an identification transponder.

Parasites

Parasites have been of low frequency and are usually not associated with clinical signs in captive rhinos. In newly captured rhinos, consideration should be given to hemic and skin parasites as well as fecal ones.

A biannual fecal examination for parasites is adequate in rhinos established in captivity. In

newly arrived rhinos, blood examination should be performed for hemic parasites (e.g., *Babesia* sp., trypanosomes, theileriasis and leishmaniasis). Treatment has been described by McCulloch and Achard (1969). Skin lesions in wild-caught black rhinos should be biopsied and examined for the presence of *Stephanofilaria dinniki* (Kock & Kock, 1990).

The most commonly found endoparasites have been tapeworms, which have not been associated with disease in the United States. In rhinos established in captive collections, other endo- and ectoparasites have been unusual. Stomach botfly larvae (*Gyrostigma* sp.) have been noted in recently captured white and black rhinos and usually cause minimal clinical signs.

If fecals are positive, treatment should be based on accepted horse parasiticides that possess a wide safety margin (e.g., bendazole derivatives, pyrantel pamoate). Ivermectin has been used with apparent safety in newly captured black rhinos in Zimbabwe. If hemic parasites are found, treatment should be based on those employed previously (McCulloch & Achard, 1969) and after consultation with those in the field. The presence of ticks (particularly *Amblyomma* sp.) in newly imported black rhinos has caused concern with regulatory authorities. Treatment of ectoparasites in newly arrived rhinos has consisted of the application of coumaphos.

DISEASES

Regarding illness, the behavioral repertoire of rhinos is often quite limited. Depression and inappetence are often the only signs of major disease problems. Following is a discussion of reported rhinoceros diseases and associated symptoms, a summary of which is provided in Table 18.

Tuberculosis

Infection with *Mycobacterium bovis and M. tuberculosis* have been reported in several rhinoceros species, and there is no reason to expect that it could not affect all of them (Griffith, 1928; Hamerton, 1942; Takagi et al., 1964; Mann et al., 1981; Dalvosio et al., 1992). It most often presents as a syndrome of chronic weight loss and wasting. No specific treatment or testing regimens for tuberculosis have been established. One report (Ramsay & Zainuddin, 1993) suggests the concomitant use of MOT, bovine PPD and avian old tuberculin initially in tail folds and collection of sera for ELISA testing. In another case, a black rhinoceros that had a positive tracheal culture for *Mycobacterium bovis* was also positive on intradermal testing using PPD bovis in the eyelid (Barbiers, 1994). If a suspicious reaction occurs, the tests should be repeated 2 weeks later in the neck. In suspicious reactions, additional tests should include biopsy of the reaction site and culture of the respiratory tract or gastric lavage samples.

Skin Conditions

Skin conditions have been noted in all rhino species. Parasitic skin ulcers have been noted in wild black rhinos (Kock & Kock, 1990), and a syndrome of oral and skin ulcers of unknown etiology has been frequently noted in captive black rhinos (Ott et al., 1982; Munson, 1992). Fractured or avulsed horns are a frequent entity (See common injuries below.), and their regrowth has been described (Bigalke, 1946; Jacobi, 1957). Treatment generally consists of topical antibiotics and nontoxic (e.g., pyrethrin) fly repellents, and the hemorrhage generally stops over a period of several hours. Abscesses at the coronary, possibly from plantar sur-

TABLE 18. Rhinoceros diseases and symptoms

Diseases Affecting Rhinos	
Disease	Reported Symptoms
Tuberculosis	Chronic weight loss and wasting
Skin conditions	Skin lesions
Gastrointestinal torsion and impaction	Symptoms similar to those of colic in the horse
Encephalomyocarditis infection	Acute death without clinical signs
Syndromes Apparently Specific to Black Rhinos	
Hemolytic anemia	Depression followed by hemoglobinuria
Oral and skin ulcers	Small, self-limiting lesions over points of wear that may progress to large, bullous lesions encompassing significant areas
Fungal pneumonia	May involve infection with *Aspergillus* sp. (often follows corticosteroid therapy); should be considered when an individual suffers from signs of respiratory illness
Encephalomalacia	Acute and profound stupor or hyperexcitability followed by depression (n=1); occurs in young females
Tissue accumulation of iron	Lesions similar to those of chronic iron exposure
Creosote toxicosis	Hepatic failure, which may include hemolytic anemia and skin ulcers in its terminal stages

face infections (e.g., "gravel" in horses), have been noted and have responded to the application of hot water and topical treatment (Ramsay & Zainuddin, 1993).

Gastrointestinal Torsion and Impaction

Gastrointestinal torsion and impaction have been reported in black, white, greater one-horned and Sumatran rhinos and present with signs similar to those of colic in the horse (Nouvel & Pasquier, 1946; Kloppel, 1956; DeVos, 1975; Haigh, 1975; Simmons & Jenke, 1977; Janssen, 1992; Lewandowski, 1987; Montali, 1992). Rectal prolapse has been described in three black rhino calves (Pearson et al., 1967; Ensley & Bush, 1976; Janssen, 1992). Gastric ulcers are commonly seen in ill rhinos, and the addition of carafate or other protective medications should be considered in any chronically ill individual. Salmonellosis has been seen in a greater one-horned rhinoceros (Windsor & Ashford, 1972; Williamson et al., 1973), and other bacterial enteritides have also been noted (Thomson & Priestly, 1949; Zainal-Zahari et al., 1990).

Encephalomyocarditis Infection

Death following infection with encephalomyocarditis virus has been noted in two black rhinos, and other rhinoceros species may be susceptible as well. Although it was feared that rhinos might be susceptible to Venezuelan equine encephalitis during an equine epidemic in the early 1970s, no cases have been identified. Vaccination for the equine encephalitides is not routinely practiced.

SYNDROMES APPARENTLY SPECIFIC TO BLACK RHINOS

Hemolytic anemia has been the most frequent cause of death in adult captive black rhinos (Miller & Boever, 1982; Miller, 1993). Its initial signs are usually limited to depression followed by hemoglobinuria. The progression of the cases is usually acute, death often occurring within 48 hr of the initial signs. Current research indicates that the red blood cell (RBC) of the black rhinoceros is inherently energy-deficient and thus unstable and susceptible to hemolysis. Apparently a number of oxidant stresses and injuries can "trigger" hemolysis of the black rhinoceros RBC. In approximately 50% of all cases, there has been an association with infection with *Leptospirosis interrogans*. Hypophosphatemia concomitant with hemolysis has been noted in some of the cases (Gillespie et al., 1990; Blumer, 1992). At the present time, recommended treatment includes high-dose penicillin therapy, IV supplementation with phosphorus (available in many "milk fever" preparations) and parenteral supplementation with vitamin E. Transfusion has been attempted in one case, but the results were equivocal.

Oral and Skin Ulcers

Oral and skin ulcers of unknown etiology have been noted in more than 45 captive black rhinos (Ott et al., 1982; Munson, 1992). They may be small, self-limiting lesions that most often start over points of wear or may progress to large, bullous lesions encompassing significant areas and lead to death. Treatments have been subjective (e.g., topical antibiotics, disinfectants, etc). Several cases have apparently responded to corticosteroid therapy, but that therapy should be employed only in extreme cases, as the use of corticosteroids has been

associated with a high incidence of fungal pneumonias. (See below.) The use of corticosteroids in pregnant animals should also be avoided.

Fungal Pneumonia

Fungal pneumonia has been reported in at least nine black rhinos. Nearly all the cases have involved infection with *Aspergillus* sp., and at least five of these have followed corticosteroid therapy, sometimes even relatively low doses administered over short treatment periods. However, at least two of the cases have been "spontaneous" (i.e., no prior history of immunosuppressive therapy). Fungal pneumonia should be considered in all black rhinos with signs of respiratory illness.

Encephalomalacia

Encephalomalacia has occurred in four young (2 months to 2 years of age) female black rhinos (Miller et al., 1990; Kinney, 1993). In three cases, it presented as acute and profound stupor. Two of those calves died within 4 days of onset, but a third lived and became a "dummy" calf that was later euthanized. The fourth rhinoceros, a 2 year old, became hyperexcitable, then depressed. The histological lesions were those of profound leucoencephalomalacia, and the etiology remains unknown. These cases emphasize the importance of collecting brain and central nervous system tissue on all rhinoceros necropsies.

Tissue Accumulation of Iron

Adult black rhinos appear to accumulate iron, particularly in their livers (Kock et al., 1992; Montali, 1992). The lesions are not those of a primary iron-storage disease, but similar to those of chronic iron exposure. Further studies may help determine whether the iron results from chronic subclinical hemolysis or from dietary causes.

Creosote Toxicosis

Several black rhinos that died shortly after importation from Africa have had notable elevations of sera bilirubin (both conjugated and unconjugated forms) and marked biliary stasis at necropsy (Blumer, 1992). The findings in these animals are similar to previous rhinoceros deaths associated with creosote exposure (Basson & Hofmeyr, 1973; Hofmeyr et al., 1975; Kock et al., 1994).

Common Injuries and Treatments

Skin lacerations are relatively common occurrences, and unless deep and/or badly apposed, they normally heal well without significant medical intervention. As noted above, it is difficult to differentiate abrasions over points of wear from early skin ulcers; they should be closely monitored.

Horn avulsions occur with some frequency. (The use of horizontal bars under which rhinos can hook their horns should be avoided.) There may be notable hemorrhage from the base of the horn, but this usually stops with little or no intervention. Treatment is generally limited to the topical application of antibiotics and non-toxic (e.g., pyrethrin) fly repellents.

POST-MORTEM PROTOCOL

Minimally, it is vital that frozen liver, kidney, fat, skeletal muscle, heart and spleen be saved after death. Frozen gut contents should be saved in cases of suspected toxicosis. If a death is anticipated, veterinary coordinators and researchers should be contacted for updated tissue requests. (See inside the back cover for the names and addresses of pathology coordinators.)

RESTRAINT AND ANESTHESIA

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Intensive management of rhinos in captivity necessitates occasional procedures that require restraint of the animal for physical examination, sample collection or medical treatment. The unique anatomy, physiology and temperament of rhinos present many challenges to physical or chemical restraint. However, a number of techniques and facilities have been developed that provide safe options for handling these species. Following is a summary of approaches used by managers both in captivity and in the field. It should be noted that significant variation exists among individual rhinos with respect to the methods outlined below. The following should be used as a guideline only.

PHYSICAL RESTRAINT

A number of approaches to the physical restraint of rhinos have been attempted in recent years.

Box stall/Free stall

A basic box stall is the simplest and often the most effective method for minor restraint of rhinos. Visual inspections and minor physical procedures can be performed with animals in these facilities, and certain individuals can be conditioned to accept more manipulative procedures, such as reproductive examinations and blood sampling. Many institutions have incorporated a box stall within a transfer alley by adding additional gates (at the head and tail) to complete the stall. Several institutions have incorporated a box stall in the corner of a holding pen. The animals are regularly fed inside the stall, and a rear gate can be closed if and when it is considered necessary.

Several principles should be applied in the construction of a box stall. These principles should also be considered when constructing any of the other types of physical restraint devices discussed below.

- The height at the front of the stall should be great enough that the rhinoceros cannot place its chin over the top. If the chin can be placed over the top, the animal may attempt to climb out the front of the stall using its chin for leverage. Additionally, horizontal bars should be avoided in the construction of the front of the stall, as they may provide a step for the animal, which facilitates attempts to climb out the front of the stall and may increase the animal's likelihood of breaking a horn. For these reasons, this author recommends that either smooth surfaces or vertical structures (e.g., steel pipe) be used in the construction of the front portions of a box stall.
- If reproductive examinations and/or rectal palpation procedures will be conducted

A free-stall chute that is incorporated into an enclosure can be particularly effective for relatively non-invasive procedures. Note how the angled entry and safety pipes allow a veterinarian or researcher access to the rear of the animal without the possibility of the animal's backing straight out. (*Photo: Fossil Rim Wildlife Center*)