Diagnosis depends on finding the typical organism in blood smears taken from peripheral blood. The diagnosis may be confirmed by inoculating laboratory rodents.

Postmortem lesions parallel the clinical lesions.

Treatment should include the use of quinapyramine sulfate in the elephant, and in the black rhinceros diminazine aceturate at the rate of 6.0 gm and pyrithidium bromide at the rate of 3.0 gm.[139] There were 40 per cent deaths in treated black rhinoceroses, which were thought to result from heavy loads of alimentary canal nematodes.[139]

Theileriasis (synonym, piroplasmosis) (*Theileria* spp., *Nuttallia loxodontis*) has been reported in the black rhinoceros, white rhinoceros, and the African elephant.[118, 139, 180] Theileriasis is characterized as an acute febrile protozoal infection. The parasite invades the erythrocyte but does not multiply or destroy the cell. Rarely does the infection produce anemia.

Lungworms (synonym, gapeworms) *Mammomonogamus loxodontus*) have been reported in the African elephant,[180] and *Dictyocaulus arnfieldi* have been reported in Hortman's zebra. The *M. loxodontus* occur primarily in the bronchial passages and trachea. Large masses occluding the air passages have been reported.

Diagnosis of lungworms may be made by finding the ova in sputum or feces.

Treatment for lungworms in elephants has not been described; however, levamisole should be useful orally at 10 mg per kg of body weight.

Stomach bots have been reported in the zebra, rhinoceros, and African elephant: *Gasterophilus pecorum* in the zebra; *Gyrostigma pavesii* in the white rhinoceros and the black rhinoceros (Fig. 18–37), *G. conjugens* in the black rhinoceros; and *Platycobboldia loxodontis* and *Pharyngobolus africanus* in the African elephant.[180, 233] The adult flies lay their eggs around the nostrils, the horn base of the rhinoceros, and the trunk sulcus of the elephant. The larvae migrate through the tissues to the stomach.

Clinical signs of stomach bots are usually minimal; however, the eggs may be seen attached to facial hairs; bots or pupae may be found in the feces. Large numbers of *P. loxodontis* and *P. africanus* have been found in the trunk, mouth, and pharynx of the African elephant.

Diagnosis of stomach bots is made by finding the large larvae or pupae in the oral cavity or feces of the host.[180, 233]

At postmortem examination of stomach bot victims large fly larvae are found attached to the epithelial area of the stomach mucosa. Sometimes large concentrations are found at the pyloric outlet. The larvae have strong attachments to the tissue; they feed on the tissue fluids released by the wounds.

Treatment of stomach bots should include the administration of organophosphate vermifuges (Neguvon or Dyrex) at the rate of 30 to 80 mg per kg of body weight.[43, 196]

Figure 18–37 Heavy infestation of stomach bots, *Gyrostigma pavesii*, in a white rhinoceros.

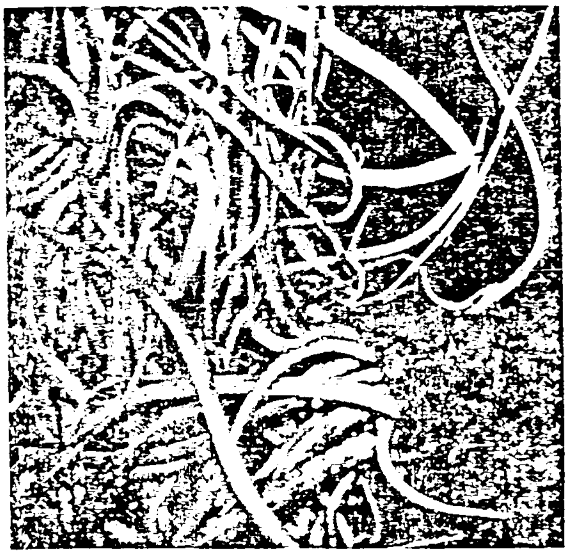

Figure 18–38 Mass of *Parascaris equorum* from the small intestine of a Grant's zebra.

Gastric nematodes (*Pabronema africanum* and *P. rhodesiense* and *Kiluluma* spp.) have been reported in the African elephant. The male nematode is 40 mm in length and the female is 57 mm.[180]

Nematodes of the small intestine have been found in the zebra, black rhinoceros, white rhinoceros, African elephant, and Asian elephant: *Parascaris equorum*, *Oxyuris equi*, and *Strongylus vulgaris* in the zebra (Fig. 18–38); *Strongylus tremletti*, *Kiluluma* spp., *Quilonia africana*, *Q. parva*, *Q. rhinocerotis*, *Paraquilonia brumpti*, *Murshidia* spp., *Buisson* spp., and *Khalilia* spp. in the black and white rhinoceros; and *Murshidia* spp., *Quilonia* spp., and *Amira* spp. in the African and Asian elephant.

Clinical signs of intestinal parasitism include loss of body weight, anemia, gastroenteritis, and colic. Verminous aneurysms occur in the anterior mesenteric artery of zebra that have heavy infestations of *Strongylus vulgaris*.

Diagnosis of intestinal nematode infestation is made by finding ova by the standard flotation techniques.

Treatment of gastrointestinal nematodiasis in the zebra, tapir, rhinoceros, hippopotamus, and elephant should include the use of thiabendazole at the rate of 50 to 60 mg per kg of body weight.[42, 43, 45, 46, 186, 187, 196] Levamisole may be used at 10 mg per kg, and mebendazole may be used at 8 mg per kg of body weight.

Nematodes of the cecum and colon (*Oxyuris karamoja*, *Habronema khalili*, *Parabronema rhinocerotis*) have been reported in the white and black rhinoceros and the elephant.[180, 223] Many of the parasites listed as gastroenteric nematodes of the elephant and rhinoceros are found in the colon. These parasites have not been incrimated in clinical disease.

Treatment of cecal and colon nematodes should include the same anthelmintics as used for gastroenteric nematodes.

Hookworms (*Grammocephalus intermedius*) occur in the large intestine of the white and black rhinoceros and the elephant.[180, 213] *Grammocephalus clathrotus* is found in the bile ducts of both the African rhinoceros and the elephant. In both cases, bile stones have occurred concurrently. Treatment is the same as for the other gastroenteric nematodes.

Tapeworms (*Anoplocephala vulgaris* and *Anoplocephala* spp.) have been reported in the black rhinoceros, white rhinoceros, Asian rhinoceros, and in the zebra and other exotic equids.[72, 180, 233] This tapeworm has a reported length of 12 cm. Larval forms of *Anoplocephala* spp. develop in mites, which are then ingested by the host. Hydatid cysts have been reported in the liver of the Asian elephant, but no reference is available for tapeworms in the African elephant.

Diagnosis of tapeworms in the zebra, tapir, and pachyderms may be made by finding the ova or proglottids in the feces.

Treatment of tapeworms should include the use of Diphenthane-70 (Taniatol) orally at the rate of 40 mg per kg.[186, 187]

Trematodes (*Brumptia bicaudata*, alimentary canal of the African elephant; *Fasciola jacksoni*, bile ducts of the African elephant; *Gigantoatrium gigantoatrium*, *Glyptamphistoma paradoxum*, *Macropharynx sudanensis*, *Nilocotyle pygmaea*, *N. hippopotami*, and *Nilocotyle* spp. in the Nile hippopotamus) are reported frequently; however, little is known about their life cycles and the pathology they produce.[29, 180, 233] *Brumptia gigas* is a large fluke ranging in size from 12 to 15 mm by 7 to 9 mm. It lives in the colon of the African elephant and produces ova that measure 0.112 by 0.076 mm. *Fasciola jacksoni* are found in the biliary system of the African elephant and are often associated with biliary stones. In one case, anemia and hypoproteinemia were attributed to *Fasciola jacksoni*. Treatment with 10 mg per kg of Nithoxynil subcutaneously seemed to help resolve the problem.[18]

External Parasites

A great variety of flies and ticks have been associated with the African ungulate, including the zebra, rhinoceros, and elephant.

Mange (Chorioptes bovis, Sarcoptes scabiei, and *Sarcoptes tapiri)* has been reported in the zebra, elephant, and tapir.[131, 186, 195] *Chorioptes bovis* has a predilection for the hind feet of the host in the area of the pastern. Sarcoptes infections can cover the entire body, with the heaviest infections occurring on the limbs and dorsal midline.

The characteristic clinical signs of sarcoptic mange are increased scruffiness followed by zones of erythema, pruritus, hyperkeratosis, and serum crust formation. The gray to brown crusts may be 2 to 3 cm deep; they dry out and crack, leaving wide bleeding fissures. Severe lesions around the ears, eyes, and mouth result in debilitation, blindness, anorexia, and death. The burrows of the mite are reported to reach depths of 15 mm.

Diagnosis is made by finding the mite on microscopic examination of skin scrapings. Treatment of mange consists of spraying or dipping with commercial dips designed for equines. These may be sprayed with a Gordon sprayer or put in the pool for a dip. Lindane based dips have been used successfully.

Ticks (Amblyomma rhinocerotis, Dermacentor rhinocerimus are typical ticks of the white and black rhinoceros; *Amblyomma tholloni, Dermacentor circumguttatus* are typical ticks of the African elephant) occur commonly on the zebra, tapir, and pachyderms.[180, 233] Several genera of ticks belonging to the family Ixodoidea are involved. Ticks seem to prefer the tail folds, groin areas, and open wounds for attachment (Fig. 18–39). *D. circumguttatus* has been incrimated in the transmission of the eperythrozoan *Nuttalia loxodontis*.

Treatment of tick infestation can vary from removal of the individual parasite to spraying or dipping with acaracides prepared for domestic horses.

Lice (Haematomyzus elephantis) have been reported on Asian and African elephants (Fig. 18–40).[52, 112, 180]

Trichodectes equi occur on exotic equids and zebras.

Clinical signs of louse infestation include pruritus resulting in self-inflicted scratches and bruises. Papules and the highest concentrations of mites and lice occurred behind the ears. The nits are firmly attached to the hair (Fig. 18–41).

Treatment of louse infection in the equines, tapirs, rhinoceroses, elephants,

Figure 18–39 Heavy tick infestation (base of ears) in a black rhinoceros with a severe snare wound.

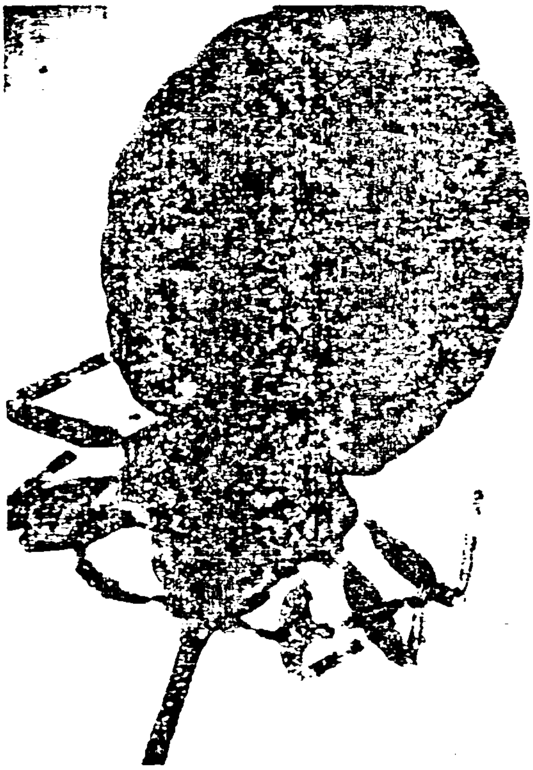

Figure 18–40 Louse *(Haematomyzus elephantis)* from an African elephant. (Courtesy of K. K. Kane, St. Louis Zoological Gardens, St. Louis, Missouri.)

and hippopotamuses may include the use of commercial shampoos or dips approved for horses. These are applied with a sprayer or a fiber bristle scrub brush or a dip in their pool. A thorough rinsing should follow a 15 minute treatment.

Filarioid dermatitis (*Stephanofilaria dinniki*) has been reported in the black rhinoceros of South Africa.[160, 170, 171, 197, 233] The lesion is produced by dermal activities of the adult filaria (3 to 6 mm long) and the microfilaria (50 μ long). The parasite is transmitted by a fly that ingests the microfilaria while feeding on the lesion.

Clinical signs of filarioid dermatitis include a well-demarcated, depigmented lesion 10 to 12 cm in diameter. The lesion is usually fissured and draining serum or blood as a result of self-inflicted trauma during attempts to relieve the pruritus. Hyperkeratosis develops in chronic lesions.

The lesions may be unilateral or bilateral and are invariably located on the midthorax just posterior to the forelimbs (Fig. 18–42).

Treatment of filarioid dermatitis should include the topical applications of insecticides (lindane base) in mineral oil. The topical application of a mixture of 10 per cent iodoform, 10 per cent sulfanilamide, 10 per cent BHC (75 per cent) 20 per cent zinc oxide, and 50 per cent Stockholm tar has been reported to be successful.[229] Spraying with pyrethrin will eliminate the flies that perpetuate this cycle.

Biting flies reproduce in the manure of zebras and pachyderms. The house fly and stable fly have been controlled in the manure of the white rhinoceros by feeding Thompson-Hayward TH 6040 (N-4-chlorophenyl)-N'-(2,6-difluorobenzoyl)urea) at the rate of 0.1 mg to 1.0 mg per kg of feed.[224] The insect growth inhibitor interferes with the formation of the pupal cuticle.

Figure 18–41 Louse nits firmly attached to elephant hair. (×100.) (Courtesy of K. K. Kane, St. Louis Zoological Gardens, St. Louis, Missouri.)

Figure 18–42 Filaroid dermatitis in the foreflank of a black rhinoceros. The well circumscribed crusty lesion is characteristic.

DISORDERS OF THE SKIN

The skin of the zebra is very similar to that of the domestic horse; the skin of the tapir is physically similar to that of the swine; the skin of the rhinoceros, hippopotamus, and elephant is extremely thickened (primarily as a widening of the dermis), leading to the general classification of pachyderm, or thick skin. In the pachyderms, the skin over the feet and ears is the thinnest. Skin thicknesses of 2.5 to 3.5 cm occur on the dorsal and lateral cervical areas of the rhinoceros and at the lateral aspects of the limbs and body of the elephant. The thickest skin occurs in the rhinoceros and occurs in the platelike folds of skin and the callosities in the nuchal hump of the males.

The hippopotamus "sweats" to cool itself and to keep its skin moist. The skin secretions of the large river hippopotamus are oily and reddish brown, giving rise to the myth that the animals "sweat blood." The skin secretions of the pygmy hippopotamus are a foamy white, especially around the ears and tail.

Avulsive wounds may occur as the result of intraspecific trauma caused by bite wounds in the zebra (Fig. 18–43), tapir, and hippopotamus; by entanglement in wire such as snares, fence wire, or cable; or by decubitus ulcerations.

As a result of the great dermal thickening with relatively limited blood supply, healing of lacerations and avulsive wounds is very slow. There is a great tendency for the skin to dry and retract, leaving great gaping wounds that attract flies.

Treatment of avulsive skin wounds requires daily irrigation with antibiotics and healing oils after granulation occurs. When healing begins, it will be by second intention and may be recognized by the appearance of granulation tissue at the edges of the wound.[11] The animal should be given tetanus antitoxin if it has not been previously vaccinated with tetanus toxoid.

A *pox* disease has been reported in the Asian elephant. The syndrome occurs in traveling circus elephants.[63, 130, 138] The lesions are especially severe around the oral cavity, the soles of the feet, and the prepuce.

The horn of the rhinoceros is an accessory skin structure on the dorsum of the nasal and frontal area of the head. There is no bony core or direct attachment. The horn is made up of linear fibers and fibrils of collagenous connective tissue that are cemented together by an amorphous collagen.

The resulting structure is a hard, hooflike material that is easily polished. The base of the horn is slightly concave and is loosely attached to a fibrous subcutaneous layer that is then attached to roughened areas on the skull. The anterior horn is normally many times longer than the posterior horn. Anterior horn measurements of 24

Figure 18–43 Severe bite wounds on rear legs of onager foal produced by jack. (Courtesy of E. Maschgan, Chicago, Illinois.)

Figure 18-44 The use of a chain saw to remove excessive horn growth in a white rhinoceros. (Courtesy of C. Gray, National Zoological Park, Washington, D.C.)

Figure 18-45 White rhinoceros two hours after breaking off anterior horn

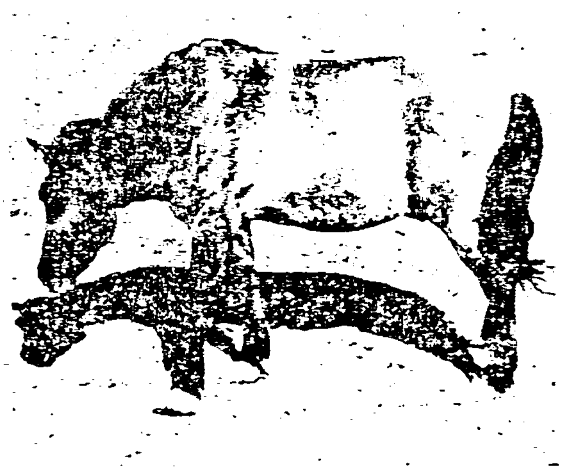

Figure 18–46 Tender front feet and stiff gait produced by laminitis in a tarpan horse.

adult, free-ranging, male white rhinoceroses revealed an average length of 58.4 cm and a basal circumference of 71.75 cm in 16 free-ranging females, the average length of the anterior horn was 60.63 cm and the basal circumference was 60.88 cm.[205] The males possess shorter, bulkier horns than do the females.

Treatment of excessive horn growth requires re-evaluation of the diet to reduce any excess protein and trimming of the horn to the approximate normal shape with a chain saw (Fig. 18–44), rasp, and wood plane.

The *abnormal wearing or grooving* of the horn by rubbing on concrete walls, cables, and floors can be reduced by providing vertical posts or tree trunks for occupa-

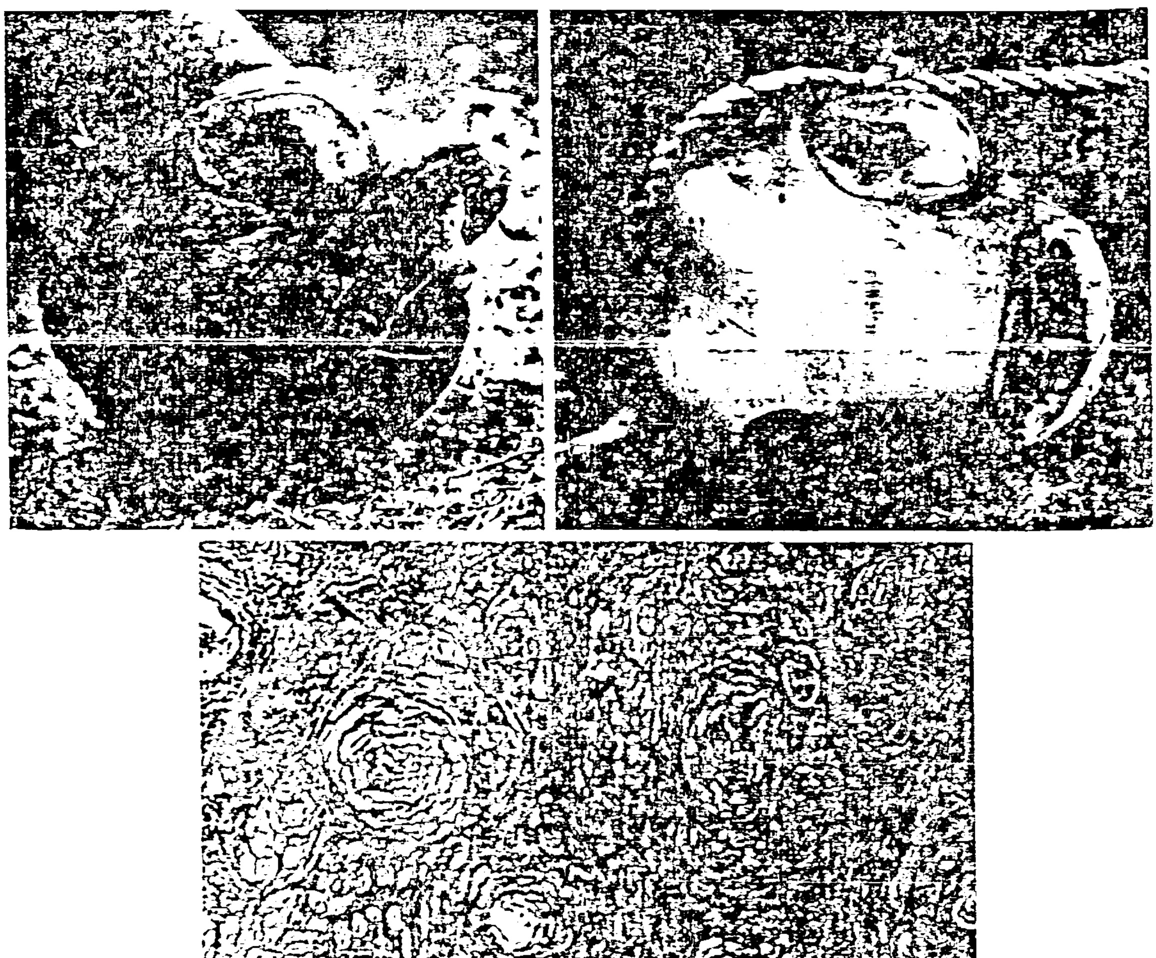

Figure 18–47 *A*, Hornlike papilloma on the foot of a black rhinoceros. *B*, Normal foot of a black rhinoceros. *C*, Photomicrograph of papilloma removed from a black rhinoceros.

tional therapy and coverage of the concrete. Half posts may be bolted to the walls.

The complete loss of the anterior horn usually occurs as the result of trauma, either self- or otherwise inflicted, from a lateral direction. The loss of the horn leaves a raw, bleeding surface 15 to 25 cm in diameter (Fig. 18–45A–C). The horn will regrow to its original length in one to two years.

Treatment of the raw surface left by the horn should include topical application of antibiotic ointment plus pyrethrin spray to keep the flies away. These can be applied with water guns.

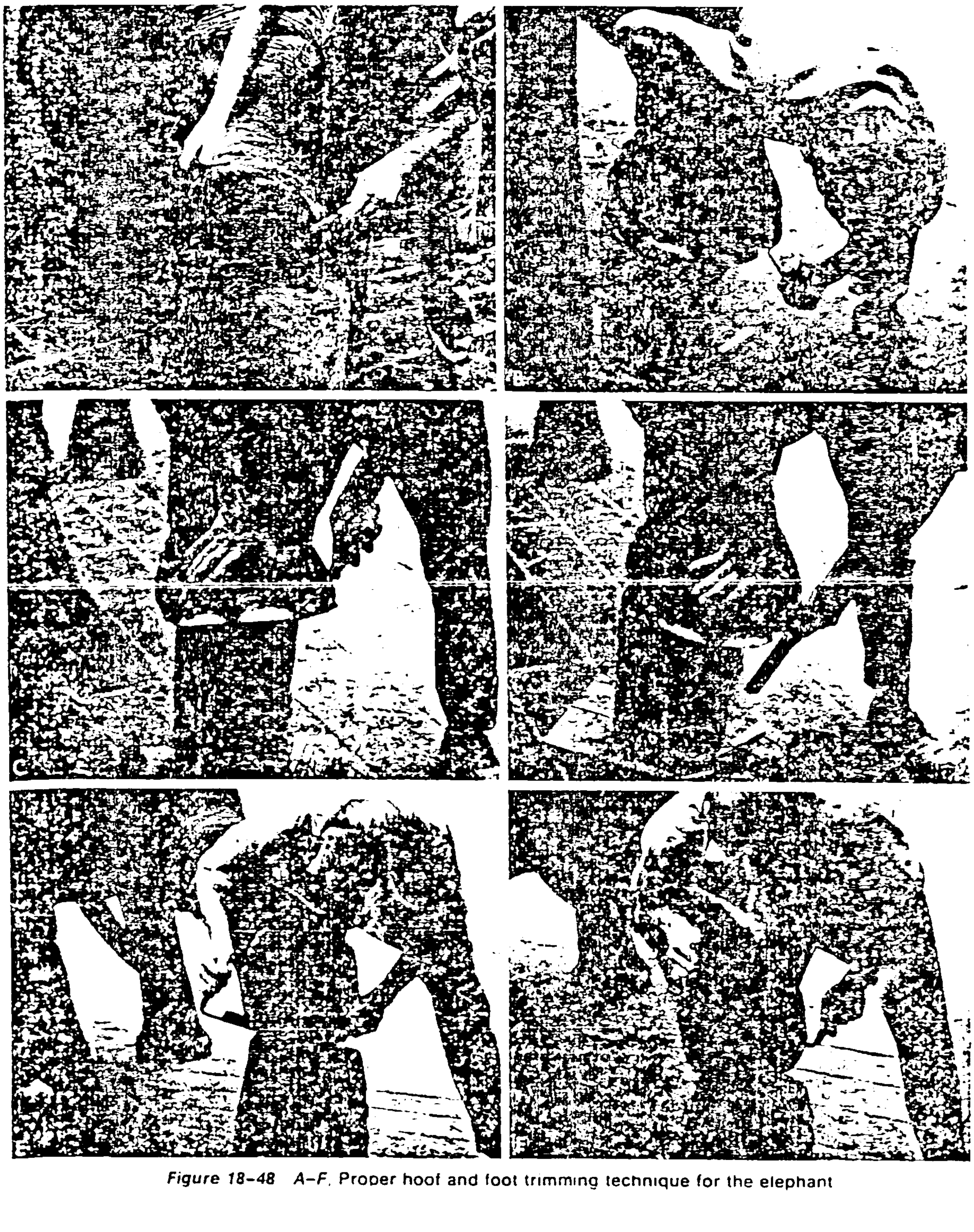

Figure 18–48 A–F. Proper hoof and foot trimming technique for the elephant

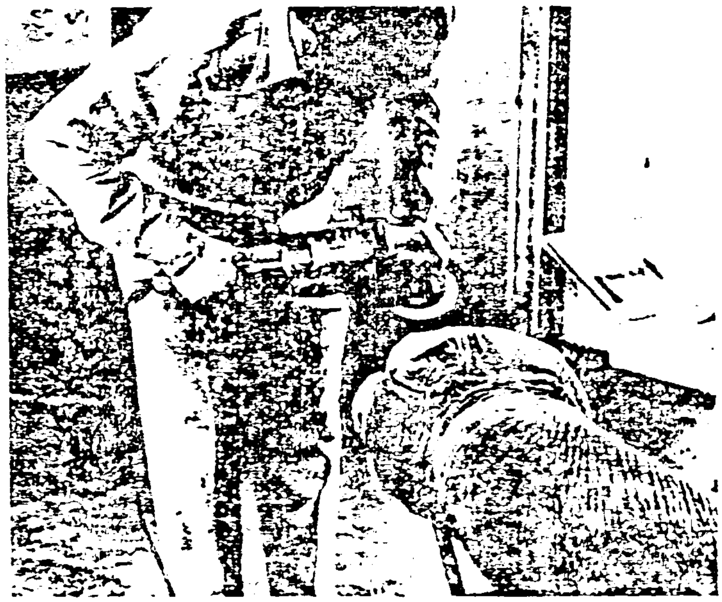

Figure 18–49 Using an electric sander to trim the feet of an immobilized Asiatic elephant.

Foot problems are common in elephants, rhinoceroses, and equids. *Laminitis*, or founder, occurs in the exotic equids (Fig. 18–46). As in the domestic equine, the disease is characterized by an inflammation of the laminae of the hoof. Acute or chronic stages occur, and one or all four feet may be involved.

The etiology of laminitis is thought by some to be related to histamine or histamine-like bacterial toxins that are produced following consumption of large quantities of grain or cold water following exercise.

The clinical signs of laminitis include sudden onset, increased rectal temperatures to 106°F, sweating, and reluctance to move. The pulse of the digital cortex is hard, and the foot is warm to the touch. An edematous fluid collects between the third phalanx and the wall of the hoof that deflects the bony toe downward. The normal pull of the deep flexor tendon aggravates the problem. In chronic cases the dorsal and ventral surfaces of the third phalanx become avascular, producing a long, distorted hoof with a concave anterior wall.

Treatment of laminitis should include local cold packs, corticosteroids, a purgative, and antihistamines. Chronic laminitis may be treated with phenylbutazone.

Sole abscesses may be drained by curetting with a hoof knife. A leather boot should be employed to keep the abscess free of dirt and manure.

Zebras and exotic equids sometimes show *excessive growth of the hooves*. Treatment includes the proper repair and trimming in the same manner as in the domestic horse.

Figure 18–50 Chronic *Candida albicans* infection of toe of Asiatic elephant. (Courtesy of E. Maschgan, Chicago, Illinois.)

Interdigital lesions, such as papillomas, calluses, corns, and cuticle overgrowth occur in the rhinoceros and elephant (Fig. 18–47A–C).[10]

The treatment for interdigital calluses and hoof overgrowth in the rhinoceros and elephant includes proper trimming (Fig. 18–48A–F) and softening with mineral oil. This often requires general immobiliza-

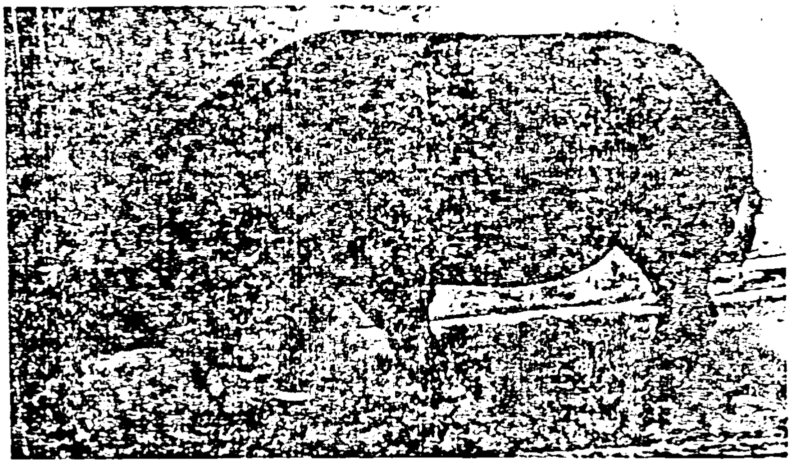

Figure 18–51 Black rhinoceros wearing a foot bandage.

tion to accomplish trimming of the rhinoceros and elephant foot, using a rasp with an interchangeable blade, a draw knife, and an electric sander (Fig. 18–49). Deep crevices need to be opened and trimmed to prevent the buildup of manure in them. Chronic interdigital lesions (Fig. 18–50) or sole disease may be kept clean with bandages (Fig. 18–51) or with boots fashioned of leather or canvas. Cracked toes on elephants are treated with acrylic dental repair material like cracked horse hooves (Fig. 18–52). Routine trimming of the elephant foot is usually accomplished by the trainer or handler under voice commands.

A *fibrosarcoma* has been reported in a four-year-old captive African elephant.[12] The 3 cm tumor occurred on the medial aspect of the carpal area. Local anesthesia was used and the tumor removed. A pendulous *fibropapilloma* was removed from the vulva of an Asian elephant. The tumor took 18 years to develop. It was removed under xylazine tranquilization and local anesthesia.[157]

Segmental gangrene and sloughing of an elephant ear has been reported after the intravenous injection of phenylbutazone.[140] One of the authors has seen this same phenomenon after the administration of glucose through the ear vein (Fig. 18–53).

Freeze branding for identification has been used on the skin of elephants (Fig. 18–54 *A* and *B*).

Cataracts have been observed in elephants and have been surgically removed, using a suction technique to break up and remove the cataract (Fig. 18–55).

DISEASES OF THE CIRCULATORY SYSTEM

The normal circulatory system of the zebra, exotic equine, tapir, or rhinoceros parallels the cardiovascular anatomy and physiology of the domestic horse.[205] The most frequent disease syndrome observed is the *verminous aneurysm* of the anterior *S* mesenteric artery associated with *Strongylus vulgaris* infections.

Figure 18–52 Cracked toe in an Asiatic elephant (Courtesy of Dan Knox, St. Louis Zoological Gardens, St. Louis, Missouri.)

Figure 18–53 Partial ear sloughing in an Asiatic elephant after injection into ear vein.

Figure 18–55 Cataract removal from eye of Asiatic elephant.

The aortic arch in the rhinoceros and elephant is elliptical in shape, has a dorsal wall thickness of 5 to 7 mm and a ventral wall thickness of 2 to 3 mm respectively.[180, 205] The origin of the elephant aorta is 7.5 cm across its widest point; the coronary vessels are 2 cm in diameter at the os.[123]

The anatomy of the elephant heart (Fig. 18–56) is unique in that a double apex occurs as a result of an increased development of the right ventricle, and paired anterior vena cava exist. A good gross description of the elephant arterial system has been made by Sikes.[160]

Blood transfusions and fluid therapy are recommended for treatment of nutritional, hemorrhagic, or parasitic anemia. Transfusions of the exotic equine and the pachyderm should be thought of in terms of gallons rather than pints.[34]

DISEASES OF THE RESPIRATORY SYSTEM

The respiratory system of the zebra, exotic equid, hippopotamus, and rhinoceros is similar in anatomy and physiology to the respiratory system of the domestic horse.[235] The respiratory system of the elephant

Figure 18–54 *A*, Freeze branding for identification of an African elephant immobilized with M99. *B*, Branding iron cooled to −70° C in dry ice and alcohol mixture.

begins with the elongation and joining of the upper lip and nose (trunk). The strong prehensile trunk is innervated by the second branch of the fifth cranial nerve.[180] The trunk of the Asiatic elephant is more flexible and is capable of more extension than that of the African elephant. The anterior nares of the trunk are an average 2.5 cm in diameter.[180] The trunk is also used to suck water up to about one half of its length; the water is then blown out into the oral cavity for swallowing or over the body for cooling. A trunkful of water ranges from 4 to 10 kg in weight.[180] The Asiatic elephant is reported

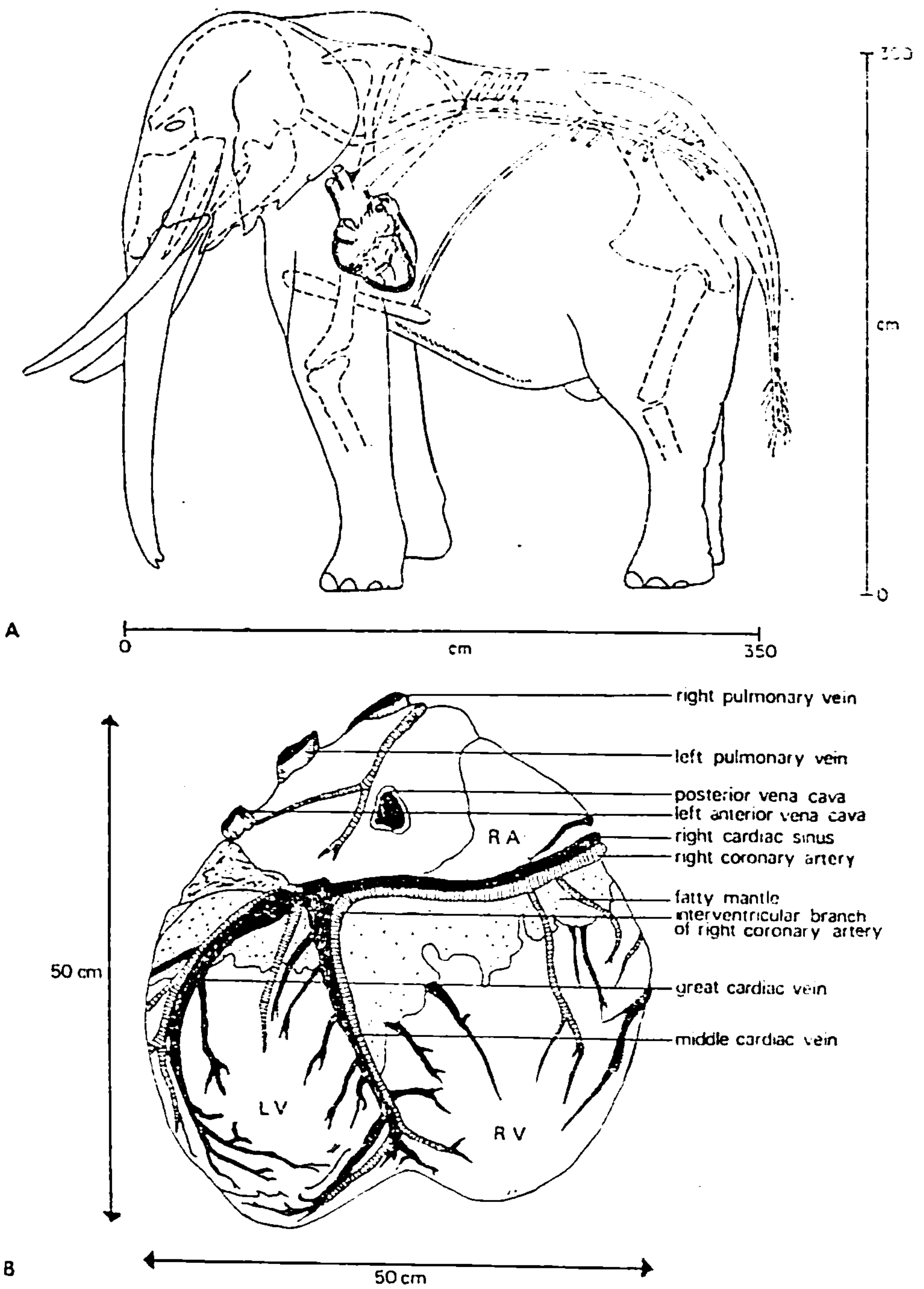

Figure 18–56 *A*, Lateral view of elephant showing the anatomical location and relative size of the heart. *B*, Posterior dorsal view of the elephant heart.

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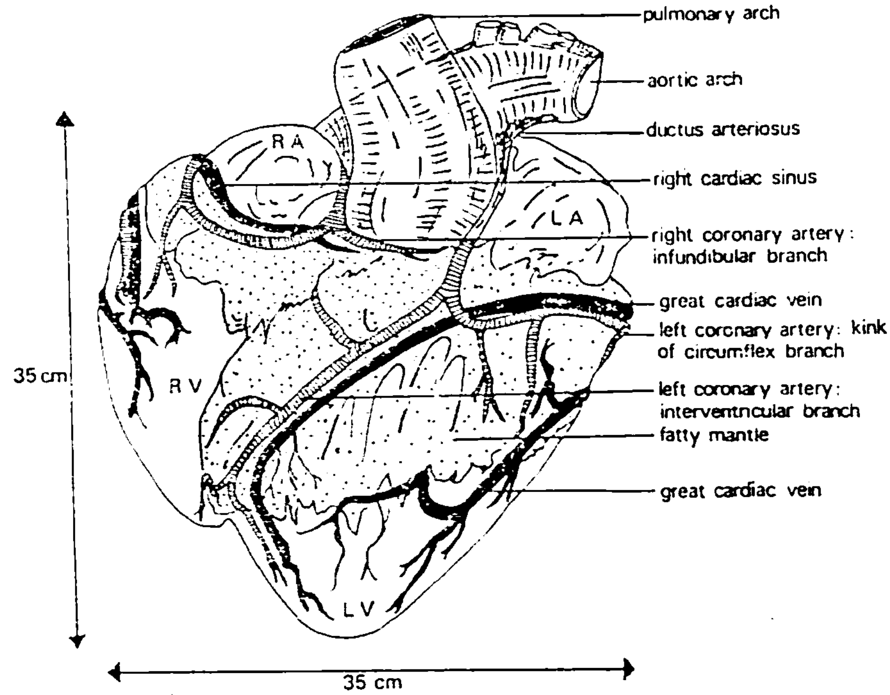

C

Figure 18–56 Continued C. Ventrolateral view of the elephant heart. (From Sikes, S.: The Natural History of the African Elephant. New York, American Elsevier, 1971.)

to have a valvelike foramen connecting the right and left nasal passages approximately 13 cm from the distal end. This structure has not been observed in the African elephant.[150]

The elephant trachea is surprisingly only 5 to 7 cm in diameter and 30 cm in length.[150] The tracheal rings are sturdy but incomplete dorsally. Two short bronchi have only five to six tracheal rings before they enter the lung parenchyma.[150]

The elephant lung fails to collapse, much like that of the domestic horse. The pleural cavity is absent in the elephant. The parietal and visceral pleura are firmly attached at the thoracic wall and diaphragm. Lung expansion and filling is produced entirely by movement of the thoracic musculature. In sternal recumbency elephants show great respiratory distress, including apnea.

Pneumonia and *pulmonary tuberculosis* are common respiratory diseases of the zebra, tapir, rhinoceros, and elephant (see Infectious Diseases). Chronic bronchial pneumonia occurs in all species presented. A thoracic heave line may develop.

The lungs of both the rhinoceros and the elephant show a tendency to have blunt rounded edges and lack a definite gross lobulation. The right lung is larger than the left in both the rhinoceros and the elephant.

Acute post-anesthesia, or neuroleptic, edema has been reported in the zebra and the tarpan horse.[152, 164] Clinical signs include flared nostrils, tachycardia of up to 120 beats per minute, and tachypnea of up to 60 respirations per minute.

Treatment includes passing an endotracheal tube and providing intermittent positive pressure breathing assistance. Thirty-five to 45 cm of H_2O pressure with a fast flow should be used. Four 10- to 12-minute treatments per hour have been used successfully.

Lacerations and *trauma* to the trunk occur.

The trunk of an African elephant was pinched off by the closing of a large iron gate. The stump healed satisfactorily and the elephant learned to pick up food with the side of its trunk.

Lacerations of the trunk often penetrate into the nasal passages. Catgut should be used to close the internal muscle, and stainless steel wire should be used to close the

TABLE 18–9 DENTAL FORMULAE OF ZEBRA, TAPIR, RHINOCEROS, HIPPOPOTAMUS, AND ELEPHANT[3, 109, 180]

	I	C	P/M	M	Total
Zebra	3/3	1/1	3–4/3	3/3	40–42
Tapir	3/3	1/1	4–3/4	3/3	42–44
Rhinoceros	0/0	0/0	4/4	3/3	28
Hippopotamus	2–3/1	1/1	4/4	3/3	38–40
Elephant	1/0	0/0	3/3	3/3	26

skin. The elephant should be watered directly into the mouth by means of a hose until the trunk heals.[194]

DISEASES OF THE DIGESTIVE SYSTEM

With the exception of the oral cavities and dental formulae (Table 18–9), the alimentary canal of the zebra, exotic equine, tapir, rhinoceros, and elephant are almost identical to that of the domestic horse.[180] The teeth of the equine, zebra, exotic equine, rhinoceros, and elephant may be used for age determination (Table 18–10). The mouth of the rhinoceros lacks incisors and canine teeth. A cornified fringe is present at the mucosal-tegmental junction of the lower lip of the white rhinoceros. The fringe runs the breadth of the lower lip, is leathery, and is 1 to 2 cm long and 1 to 2 mm thick.

The esophagus of the equine, tapir, rhinoceros, and elephant has a functional but anatomically collapsed lumen. There are heavy layers of longitudinal and circular musculature. The esophagus enters the cardia of the single stomach at a definite cardial zone that is covered with squamous epithelial tissue. The squamous epithelial area is separated from the glandular area of the stomach by a prominent plica marginale. The anatomy of the small intestine, colon, cecum, and rectum of these species parallels that of the domestic horse (Fig. 18–57). The normal feces of the equine, zebra, tapir, rhinoceros, and elephant is formed into desiccated boluses (Fig. 18–58A and *B*).

The liver of the zebra, exotic equine, rhinoceros, and elephant lacks a gallbladder.

Broken tusks are a common problem in both the elephant and the hippopotamus. If the pulp cavity is not disrupted or entered by the fracture or fault, the raw sharp edge may be "floated" to a smooth safe edge.

In many instances the tip of the tusk is

TABLE 18–10 TOOTH ERUPTION SCHEDULE FOR ZEBRA, RHINOCEROS, AND ELEPHANT[3, 9, 109, 180]

Tooth Eruption	Horse	Grant's Zebra	Grevy's Zebra	Mountain Zebra	Black Rhinoceros	Elephant
Temporary central incisor	1 wk	1 wk	<1 wk	1 wk	–	–
Temporary lateral incisor	4–6 wk	–	1 mo	1–3 mo	–	Birth
Temporary corner incisor	8 mo	6–8 mo	–	6–9 mo	–	–
Permanent central incisor	2½ yr	1–3/4 yr	2½ yr	2½ yr	–	–
Permanent lateral incisor	3½ yr	2½ yr	–	3½ yr	–	1 yr
Permanent corner incisor	4½ yr	3–1/4 yr	–	4 yr	–	–
Canine	4 yr	–	–	3½ yr	–	–
Temporary premolar-4	1 wk	–	–	–	3–5 mo	–
Temporary premolar-3	1 wk	–	–	Birth	2–3–1 mo	–
Temporary premolar-2	1 wk	–	–	Birth	3–1/5 mo	–
Temporary premolar-1	–	–	–	–	1 yr	–
Permanent premolar-4	4 yr	–	–	3½ yr	18 mo	–
Permanent premolar-3	3 yr	–	–	3 yr	2 yr	–
Permanent premolar-2	2½ yr	–	–	3 yr	2 yr	–
Permanent premolar-1	5–6 mo	–	–	–	20 mo	–
Molar-1	9–12 mo	–	–	1 yr	18 mo	–
Molar-2	2 yr	–	–	2 yr	7 yr	–
Molar-3	3½–4½ yr	–	–	3 yr	Mature	–

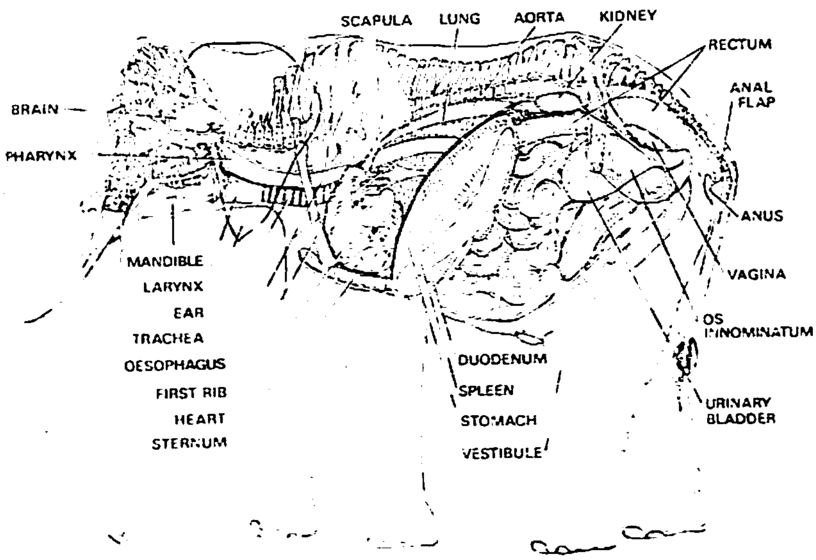

Figure 18–57 Left lateral view of the female African elephant, showing anatomical relationships of the stomach (From Sikes, S. The Natural History of the African Elephant. New York, American Elsevier, 1971.)

broken off, exposing the pulp cavity (Fig. 18–59). If infection can be prevented, dental amalgam or metal caps may be used to plug the cavity. If severe infection occurs, removal of the tusk may be necessary. In one report the tusk was rotated back and forth with a pipe wrench while the root was being loosened with an elevator (long shanked screw driver).[182] The resulting root cavity should be irrigated regularly with antibiotics.

Frequently the tusks of the elephant will grow medially forming a bridge over the dorsal aspect of the trunk. The abnormal position of the tusks will inhibit dorsal extension of the trunk. The tusk may be sawed through at the junction of the middle and distal one third or gradually returned to its normal position by means of an orthodontic device (Fig. 18–60*A* and *B*).

Dental caries has been reported in a river hippopotamus.[184]

Ulcerations of the mouth have been observed in tapirs (Fig. 18–61). Gastric ulcers occur regularly in the newly acquired zebra and rhinoceros. The gastric ulcer syndrome is apparently the result of acute psychological stress (Selye's syndrome) producing *anorexia nervosa*.

Clinical signs of gastric ulceration include anorexia, pale mucous membranes, enteritis, hemorrhagic enteritis, abdominal colic, and anemia.

The characteristic postmortem findings in the gastric ulcer syndrome are a large fresh ulceration through the gastric mucosa,

Figure 18–58 *A*. Normal feces of the elephant. *B*. Normal feces of the rhinoceros. Both the black and white rhinoceros defecate in "dung heaps."

Figure 18–59 Asiatic elephant with a tusk infection

thick gelatinous edema of the stomach wall, and fresh hemorrhage into the gastric lumen.

Treatment of gastric ulcers in the rhinoceros should include mild tranquilization with acepromazine or promazine HCl, oral electrolytes in the drinking water, parenteral vitamin therapy (including A and B-complex), and blood transfusions.

Colitis X occurs in newly acquired zebras, exotic equids, tapirs, rhinoceroses and elephants. The cause is usually a bacte-

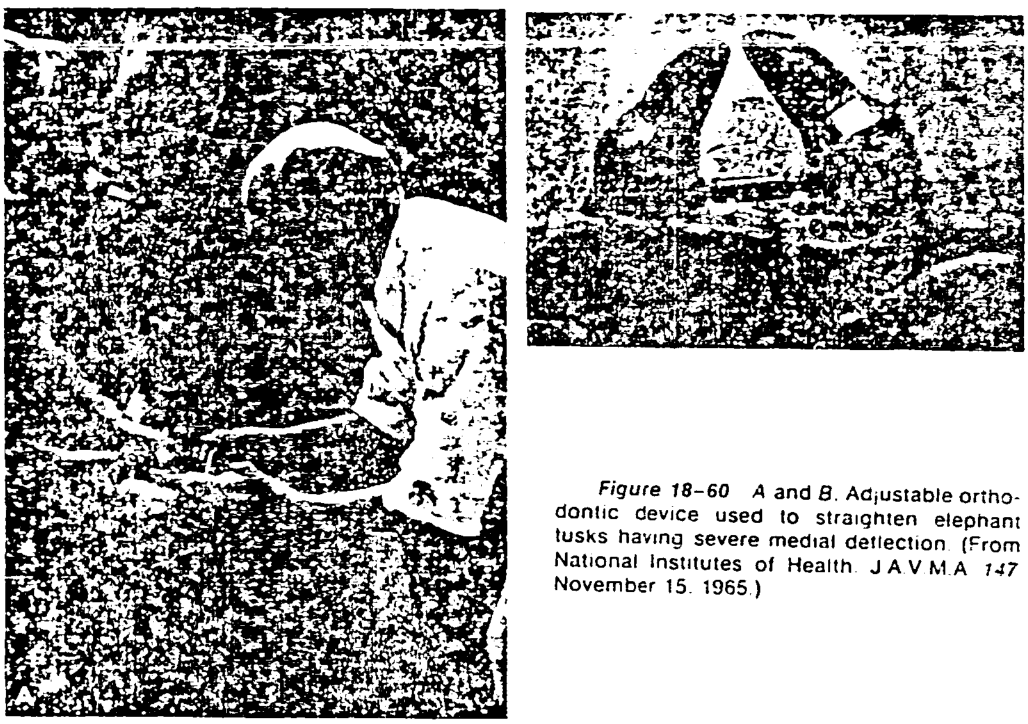

Figure 18–60 *A* and *B*. Adjustable orthodontic device used to straighten elephant tusks having severe medial deflection. (From National Institutes of Health. J.A.V.M.A. *147* November 15, 1965.)

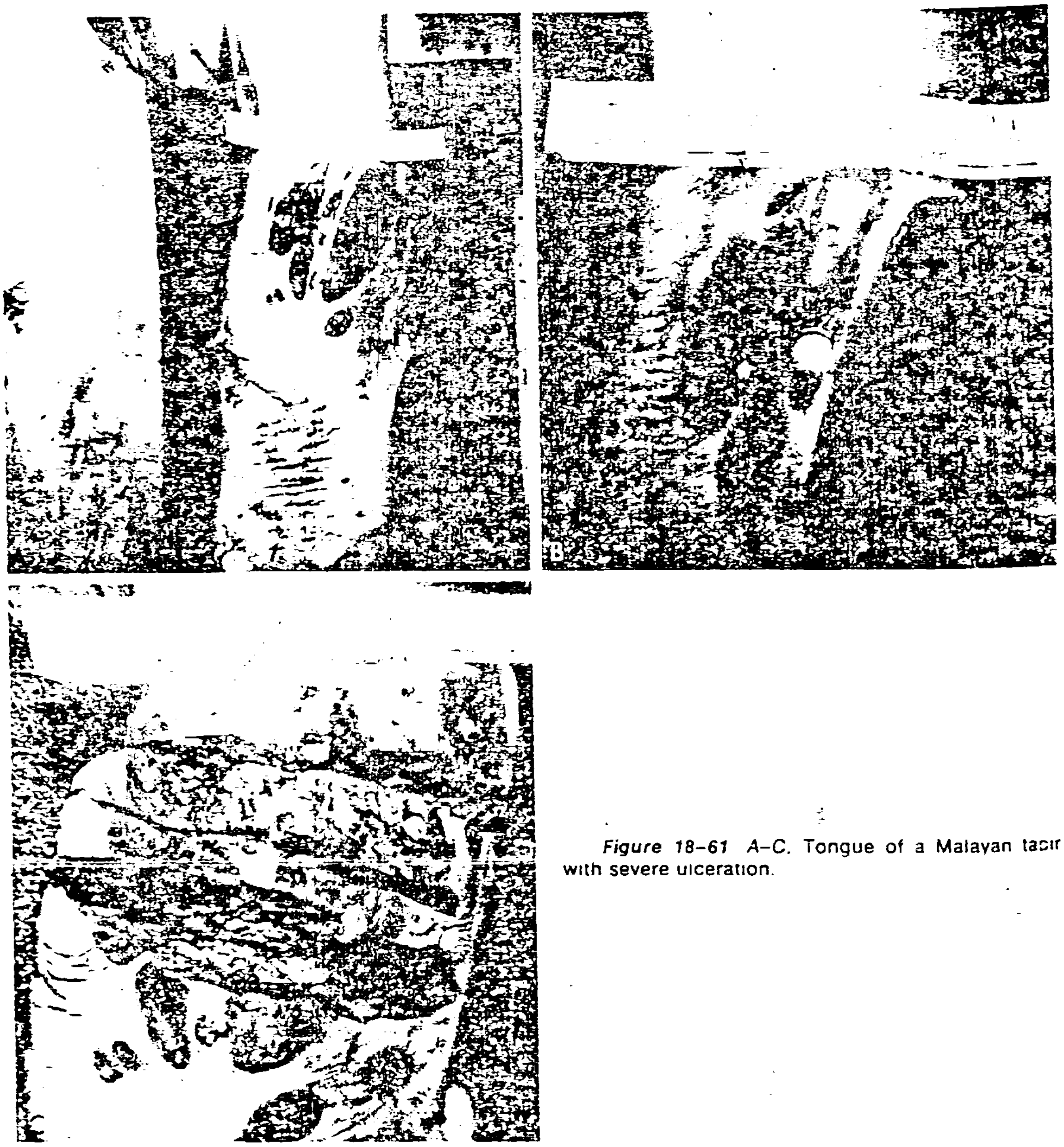

Figure 18–61 *A–C.* Tongue of a Malayan tapir with severe ulceration.

nal bloom associated with a sudden increase in bacterial flora resulting from the sudden introduction of a rich diet or a change in diet and the resulting production of endotoxins and exotoxins.[151]

Clinical signs of colitis X include severe projectile gastroenteritis, dehydration, and depression.[151] Death occurs in chronic untreated cases.

Treatment of colitis X should include electrolyte and fluid replacement therapy. This may be administered in the drinking water.[151] Sulfamethazine to lower the bacterial population of the alimentary canal may also be considered. Parenteral vitamin therapy should be instituted, with special attention to vitamin A and B-complex vitamins.

Rectal prolapse has been reported in the tapir and Indian rhinoceros (Fig. 18–62 *A* and *B*) and has been observed in the zebra by one of the authors.[48] Enemas are given to remove all fecal material, then 5% alum or granulated sugar is massaged into the mucosa to reduce edema. Once the edema is reduced sufficiently, the prolapsed rectal tissue is replaced and held by a purse-string suture threaded through preplaced loops of umbilical tape. Rectal prolapse is common

Figure 18–62 *A*, Prolapsed rectal tissue in an Indian rhinoceros. *B*, Pursestring suture technique used to restrain prolapse. (From Ensley, P. K., and Bush, M., J. Zoo Anim Med. 7:22–25, 1976.)

in the tapir. The use of a watering pool for defecation may help to prevent the prolapse. In one case involving a tapir, the rectal prolapse was corrected by an abdominal surgical approach in which the musculature of the rectum was spot sutured to the right abdominal wall.[163]

Biliary stones and *hepatic cirrhosis* have been reported in the elephant, zebra, and tapir, and have been observed by one of the authors in the black rhinoceros (Fig. 18–63). The biliary stones are usually associated with infestations of bile duct nematodes, *Grammocephalus clathrotus*, flukes, or salmonella infections.[32, 180] The stones observed are soft, amorphous, and waxy, are brown to black in color, and made up of bile salts and cholesterol. Some icterus has been associated with biliary stones in the elephant.

Intestinal blockage has been reported and observed by the authors. One was caused by the scarring of the digestive tract in a Grevy's zebra, with resulting shrinking of the lumen.

Enteroliths have also been reported in the zebra (Fig. 18–64*A* and *B*). Enteroliths usually deposit on a foreign body. The enteroliths are primarily ammonium and magnesium phosphate. The source of ammonium phosphate is commonly thought to be dietary bran consumed in large amounts. Signs of obstruction include anorexia, depression, and signs of colic. Treatment includes oral administration of mineral oil and warm water and mineral oil enemas.

Constipation occurs regularly in wean-

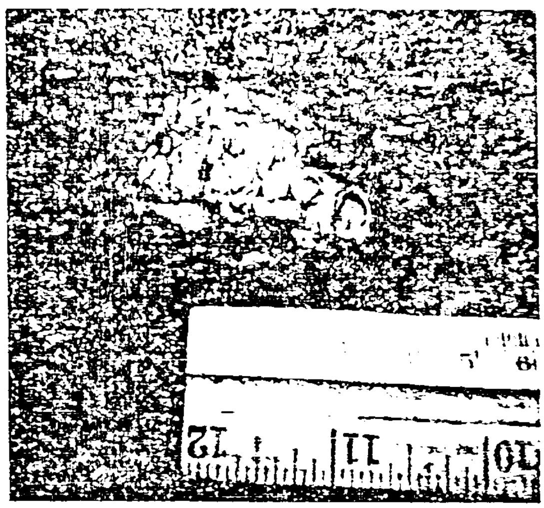

Figure 18–63 Biliary stones in the bile ducts of a 33-year-old black rhinoceros.

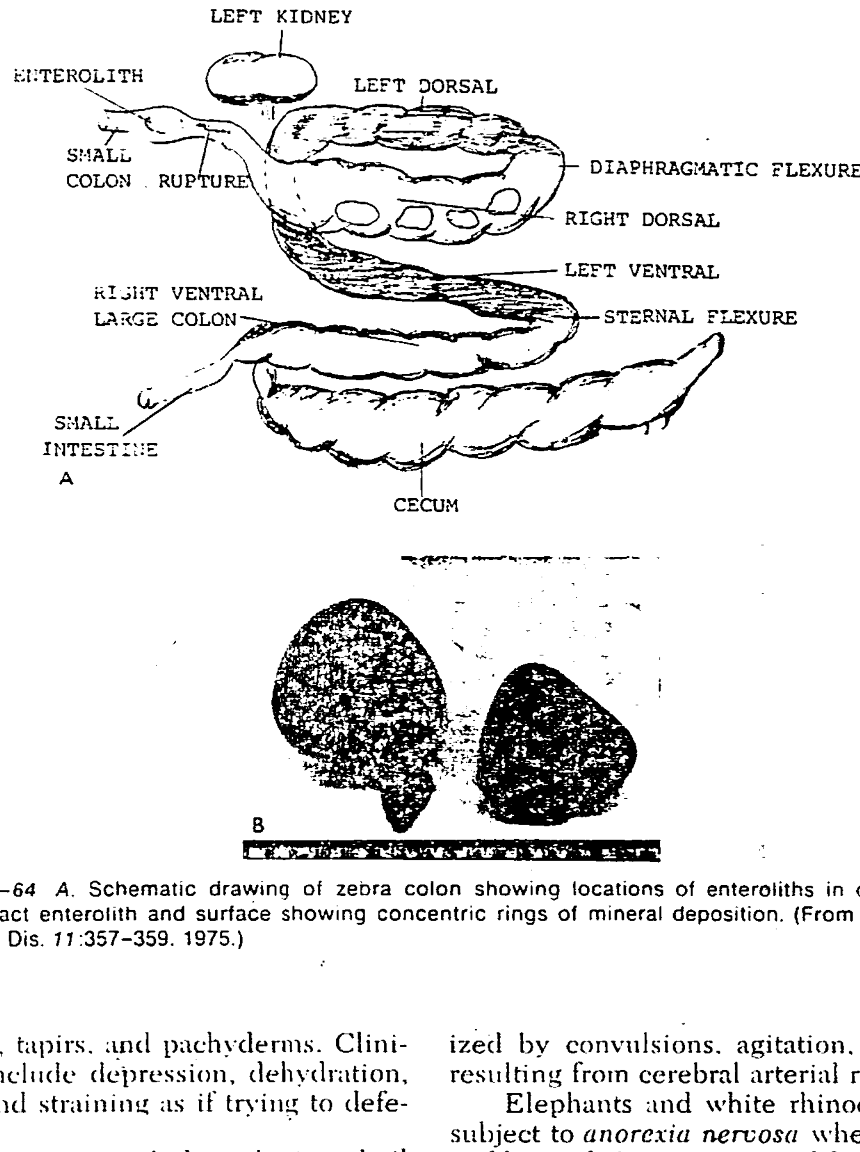

Figure 18–64 A. Schematic drawing of zebra colon showing locations of enteroliths in diaphragmatic flexure B. Intact enterolith and surface showing concentric rings of mineral deposition. (From Decker, R. A., et al., J. Wildl. Dis. *11*:357–359. 1975.)

ling zebras, tapirs, and pachyderms. Clinical signs include depression, dehydration, anorexia, and straining as if trying to defecate.

Treatment may include oral mineral oil or prune juice; manual evacuation or enemas with warm water followed with mineral oil may be necessary to break up impacted feces.

DISEASES OF THE NERVOUS SYSTEM

The brain of the zebra, tapir and smaller pachyderms is anatomically similar in weight and shape to that of the domestic horse. The brain of a 900 kilogram rhinoceros weighs 549 grams, and an adult bull African elephant's brain weighs 4.2 to 5.4 kilograms.[180]

Sunstroke has been reported in the Asiatic elephant. The syndrome was characterized by convulsions, agitation, and death resulting from cerebral arterial rupture.

Elephants and white rhinoceroses are subject to *anorexia nervosa* when captured and housed alone or removed from a captive group and housed alone. Adrenal cortical exhaustion or the Selye syndrome is apparently responsible for the deaths of such animals.

Fibroma of the falx cerebri (Fig. 18–65) and *cholesteatomas* of the choroid plexes in the lateral ventricles were observed as incidental findings by the author during the post mortem of a Grant's zebra that died during transportation.

Injury to the fifth cranial nerve as it leaves the infraorbital foramen can cause *paralysis of the trunk* in the elephant.[180] The elephant should be fed and watered directly into the mouth until it learns to compensate and feed itself by jerking its head up and catching the feed in its mouth. Parenteral administration of cortisone, B-

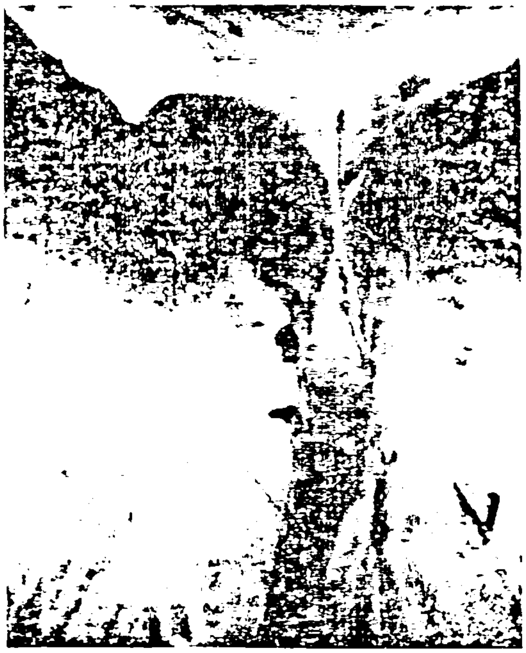

Figure 18–65 Fibroma of the falx cerebri in a Grant's zebra. This lesion was asymptomatic clinically.

complex vitamins, and vitamin E/selenium will hasten recovery.

Radial paralysis has been reported in a black rhinoceros transported in lateral recumbency for several hours.

The author has observed a case of "sweeny" or *suprascapular paralysis* in an Asian elephant. The classical semicircular swinging gait occurred, as well as atrophy of the supraspinatus and infraspinatus muscles.

Encephalomyocarditis has been reported in the African elephant and can be found in the section on infectious diseases.

DISEASES OF THE GENITOURINARY SYSTEM

The genitourinary system of the equine, zebra, tapir, and elephant is similar to that of the domestic horse. The kidneys of the rhinoceros differ from those of the equine by being multilobuled, similar to those of the bovine. The reproductive tract of the elephant differs in that the vagina is long and vertical and the paired mammae are located on the pectoral area between the forelegs (Fig. 18–66).

Male zebras and other exotic equidae have reproductive organs similar to those of the domestic equine stallion. The Grevy's zebra has large seminal vesicles containing from 400 to 1000 ml of fluid. The tapir has relatively small externally placed testes and a rearward deflection of the nonerect penis, as does the hippopotamus and rhinoceros. The erect penis of these animals has a fluted flanged glans penis (Fig. 18–67*A* and *B*). The erect penis of the black rhinoceros has been reported to be 75 cm. in length.

The testes of the rhinoceros are located in the scrotal fold just outside of the inguinal ring. The elephant's testes are located intra-abdominally just posterior and medial to the kidneys. They are suspended from a 6.25 cm stalk and never descend to the inguinal area.

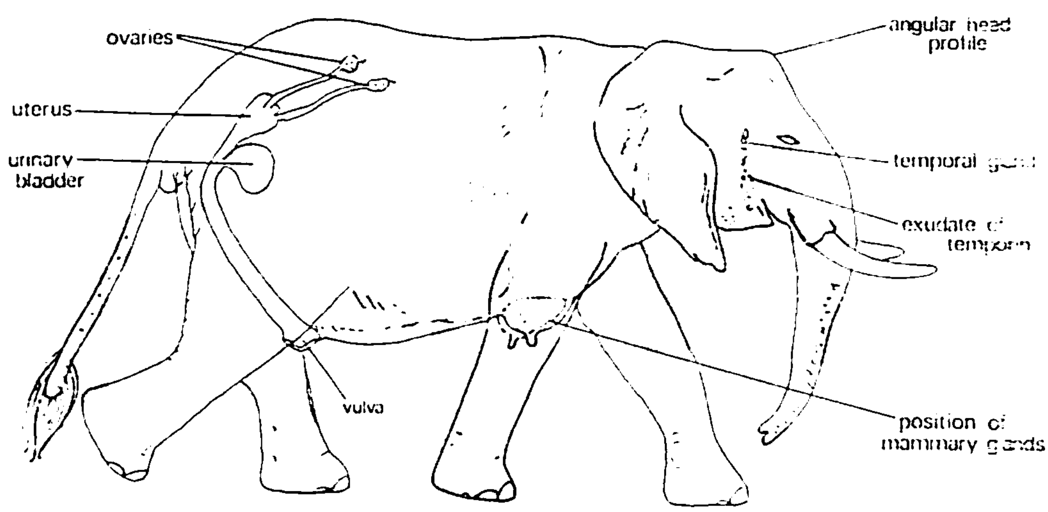

Figure 18–66 Lateral view of the genital organs and mammae of the African elephant cow.

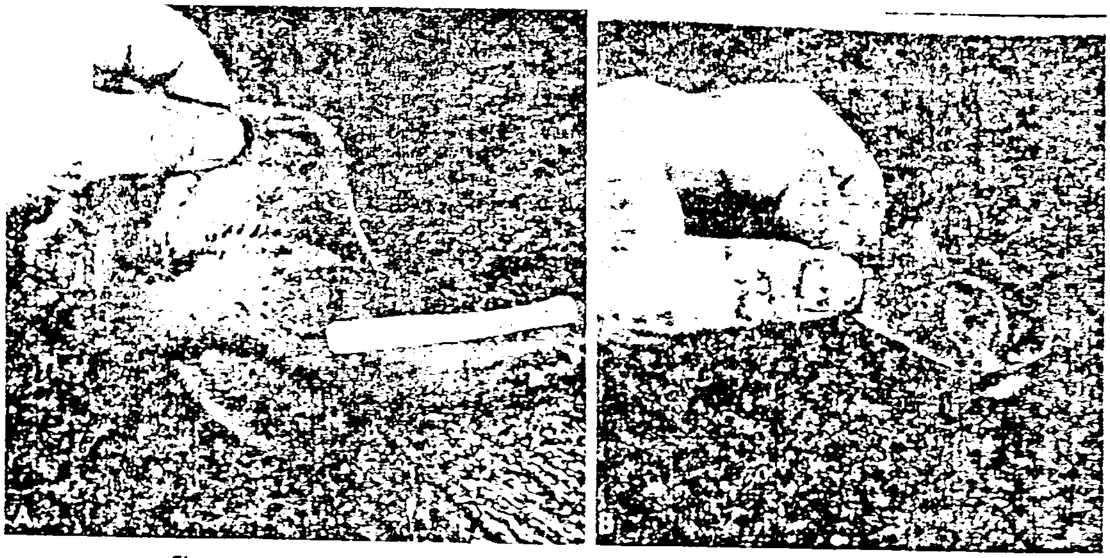

Figure 18–67 A and B. Normal anatomy of the penis of a black rhinoceros.

The clinical problems of the genitourinary tract of the zebras, tapirs, and pachyderms are similar to those of the domestic horse.

Uterine inertia has been reported in an Asiatic elephant. Parenteral administration of oxytocin produced active labor contractions, and the birth proceeded normally.

Uterine prolapse has been reported in the black rhinoceros. A prolapsed uterus in a pygmy hippopotamus has been reported.[m] The hippopotamus was immobilized with phencyclidine and promazine. Twenty units of POP were given IV. The uterus contracted and was replaced and held in place with four vertical mattress sutures of umbilical tape. Recovery was uneventful.

A variety of *genital tumors* have been reported in the elephant: melanoma of the seminal vesicle, fibroma of the uterus, calcified leiomyoma of the uterus.

An adenocarcinoma of the uterus and cervix of a 33-year-old black rhinoceros has been recorded (Fig. 18–68A and *B*). Clinical signs included anorexia, vaginal drainage of a fetid, blood-tinged, purulent exudate.

A B

Figure 18–68 A. Adenocarcinoma of the cervix of a 33-year-old black rhinoceros. B. Metastatic cervical adenocarcinoma in uterus of same animal.

Figure 18–69 Photomicrograph of the kidney of a nephrotic Brazilian tapir with calcified uroliths typical of magnesium deficiency. (H and E; ×460.)

Oral administration of sulfonamides produced an apparent "clinical recovery" for one year prior to death. The rhinoceros had been barren throughout life.

Cystic kidneys have been reported in the elephant. *Microuroliths*, typical of magnesium deficiency, have been observed in microscopic sections of kidney from a tapir fed a high bran diet (Fig. 18–69).

BREEDING AND REPRODUCTION

Reproduction has been reported in captive zebras, tapirs, rhinoceroses, hippopotamuses (Fig. 18–70) and elephants, and the gestations and estrous cycles have been recorded (Table 18–11).

Estrous cycles range from 17 to 31 days, and estrus lasts from two to seven days

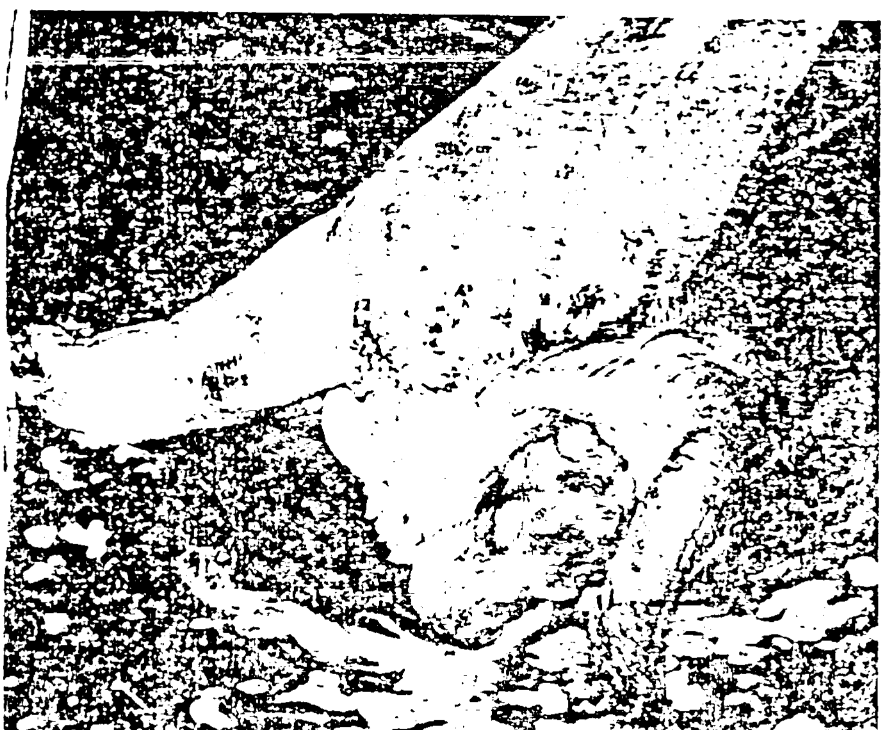

Figure 18–70 Normal presentation of a term hippopotamus calf. (From Jarofke D Zootier Krankheiten. Berlin. Paul Parey, 1976, p. 187.)

TABLE 18–11 REPRODUCTION DATA FOR ZEBRA, TAPIR, RHINOCEROS, HIPPOPOTAMUS AND ELEPHANT

Species	Gestation (Days)	Estrus Cycle (Days)	Estrus (Days)	Avg. Wt. of Newborn (Kg)	Sexual Maturity (Years)	Postpartum Estrus (Days after birth)
Grant's zebra	371	19–33	2–9	30–35	2.5–4 male 1.8 female	
Grevy's zebra	399	19–33	2–9	40	4 male 3–4 female	9–14
Mongolian wild horses	330					
Tapir	390–400		4–5			
White rhinoceros	458–500			35–40		
Black rhinoceros	419–469	26–30	3–4	22–38.5	4.5	20
Indian rhinoceros	474–477			30–35		
Nile hippopotamus	237–245	35		37.4–44	6–7	
Pygmy hippopotamus	200–270			5.0–7.5	2–3	
African elephant	649–661		2–6	115	9–15 male 10–16 female	
Asiatic elephant	650–667	120–130	2–8	50–150	9–15 male 10–16 female	

References: 7, 15, 22, 24, 25, 26, 28, 35, 38, 39, 67, 68, 69, 75, 80, 85, 95, 119, 128, 136, 177, 180, 184, 200, 225.

TABLE 18–12 BIOCHEMISTRY OF ELEPHANT SEMINAL PLASMA[96]

Sodium (mEq/L)	Potassium (mEq/L)	Chloride (mEq/L)	Fructose (mg %)	Total Protein (mg %)	Glutamic Oxalacetic Transaminase (IU/L)	Acid Phos. K-A (μ/100 ml)	Amylase (Somogyl U/100 ml)
64	128	117	67	900	29–47	4/6000	133

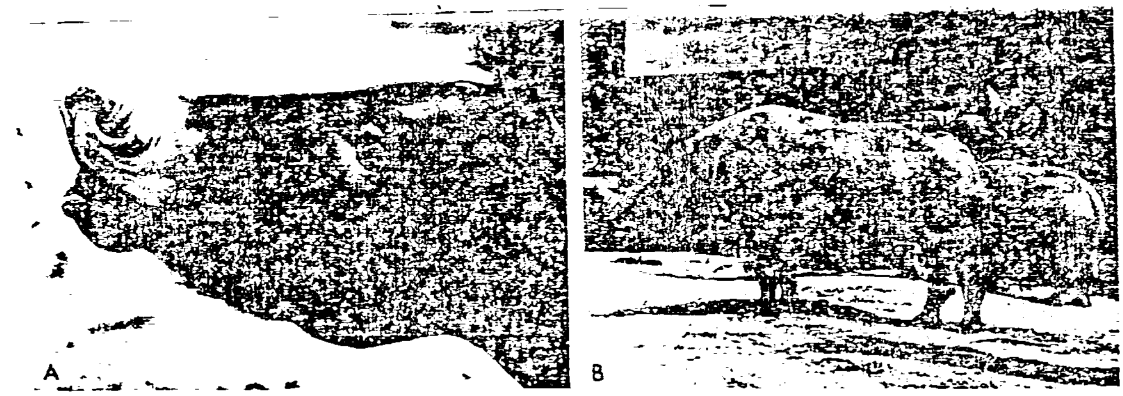

Figure 18–71 *A*, Flemen response in Przewalski stallion after sniffing the estrous mare's urine. (Courtesy of L. LaFrance, Chicago Zoological Society, Brookfield, Illinois.) *B*, Flemen response in black rhinoceros bull after sniffing cow's urine.

(Table 18–11). Estrus in the zebra, tapir, rhinoceros, and hippopotamus is marked by restlessness in the female; she also makes squeaking and squealing sounds and urinates frequently. Estrus in the elephant tends to be a quiet event. Increases in the number of cornified vaginal epithelial cells are reported during "standing" estrus in the elephant. A device has been used to collect cervical mucus for cytological examination to detect estrus. The device is a polyethylene sleeve tube 90 cm long and slightly curved. The sample is collected on a gauze swab at the end of a nylon rod. No sedation is required.[142]

When a male zebra, rhinoceros, tapir, elephant, or hippopotamus is placed with the estrous female, urine tasting takes place and a Flehman response is exhibited (Fig. 18–71*A* and *B*). The rhinoceros mock fights rather roughly for 30 to 60 minutes prior to copulation.

All copulation of the zebra, tapir, rhinoceros, and elephant takes place with the male mounting the female in estrus in the same manner as in domestic livestock (Fig. 18–72*A*–*D*). The hippopotamus employs the male mounting position in the water.

The plasma levels of testosterone of the elephant are of interest in that they show an increase from a normal of 4.3 to 13.7 ng per ml to peak levels of 29.6 to 65.4 ng per ml during *musth* (Table 18–3). Musth in the elephant is thought to be the equivalent of rut in the deer. Musth is characterized by continuous draining of the temporal glands and marked aggressive behavior. Musth per se has been reported only in the Asian elephant.

Semen has been collected from the black rhinoceros by manual manipulation.[228] An erection was produced by manual manipulation of the prepuce by the keeper. A latex funnel and collecting tube were placed over the glans penis. After 15 minutes of massage, 3 to 15 ml of semen are produced. Semen has also been collected by electroejaculation in the rhinoceros and the tapir.

Analysis of the biochemistry of elephant seminal plasma has been reported (Table 18–12).

Pregnancy may be diagnosed by a rectal examination in all the animals presented in this section except the elephant. Electrocardiographic equipment has been used by several clinicians to monitor the fetal heartbeat of the elephant.[137]

To obtain a recording of the fetal heartbeat, two silver plated needle electrodes are used, one placed 4 inches anterior to the vulva on the abdominal midline and the second placed 18 inches anterior to the first electrode. A Birtcher electrocardiographic unit with a hand-held transmitter was used. The fetal heartbeat rate is 120 per minute; when it drops to 90 per minute, delivery is imminent.

Milk appears in the mammae of the elephant one month prior to delivery and in the black rhinoceros 12 to 24 hours prior to delivery.

A large brown mucous plug was passed by an African elephant 24 hours prior to birth. The elephant placenta is passed one to three hours after the calf is born.[132]

Breech births have been reported in the African elephant and Great Indian rhinoceros.[132]

The principles used to relieve obstetri-

Figure 18–72 A. Mating approach in the elephant prior to mounting. B. Partial erection of penis in bull with standing estrous female. C. Chin resting posture during mounting. D. Mounting and copulation. (From Jainudeen, M. R., et al., J. Reprod. Fert. 27 321–328, 1971.)

cal problems in the domestic horse may be used in zebra, tapir, and pachyderm except for the elephant. The anatomy of the elephant vagina makes the vaginal approach to reduction of dystocia impossible.

PEDIATRICS

Baby zebras, tapirs, rhinoceroses, hippopotamuses, and elephants have all been hand reared with success.

The primary requirement for a good successful hand rearing (Table 18–13) is a good formula based on the chemical make-up of natural milk (Table 18–14). Growth of 0.33 to 0.9 kg per day should be expected until weaning, at which time 1.1 kg per day can be expected. Often young equines and pachyderms have been kept with domestic animals rather than raised in solitude (Fig. 18–73A and B).

Diseases of the newborn include hypoglycemia and exhaustion.[19, 204] The baby should be kept warm and given electrolyte and glucose intravenously, orally, or rectally.

Elevation of temperature, anorexia, and constipation or diarrhea regularly accompany tooth eruption.[196, 204]

Constipation is common, especially in the baby hippopotamus, which requires a bath or digital stimulation of the anus to initiate defecation.

TABLE 18–13 FORMULA FOR HAND-REARING ZEBRA, TAPIR, AND PACHYDERMS

Zebra Tapir	1–4 parts homogenized milk to 1 part water or Foal-Lac (Borden)
Rhinoceros	227 gm of skim milk powder 227 gm of calf milk replacer 2 tbsp vitamin enriched skim milk powder 2.25 liters of water
Hippopotamus	Enfamil (Mead-Johnson Laboratories) with iron
Elephant	16 oz evaporated milk 16 oz boiled rice water Skim milk Q.S. 2 quarts 100 mg ascorbic acid or 4 oz tomato juice 2–4 tbsp Tib-Ad-II

TABLE 18–14 COMPOSITION OF ZEBRA, TAPIR, RHINOCEROS AND ELEPHANT MILK[78, 134, 135, 143, 154, 180]

SPECIES	STAGE OF LACTATION	Total Solids (gm %)	Fat (gm %)	Lactose (gm %)	Protein (gm %)	Ash (gm %)	Ca (gm %)	P (gm %)	Mg (gm %)	Na (gm %)	F (gm %)	pH
Grant's zebra	1 month	11.2	4.65	3.8	2.0	0.67	0.099	–	0.01	0.07	0.117	–
Grevy's zebra	3 months	8.2	0.8	5.8	1.1	0.35	0.068	–	0.01	0.035	0.072	–
Brazilian tapir	average	13.57–16.04	3.40–3.77	5.06–5.70	0.87–0.96	–	–	–	–	–	–	–
White rhinoceros	5 months	8.84	0.60	6.50	1.54	0.20	–	–	–	–	–	0
Black rhinoceros	18 months	8.26	trace	6.85	1.18	0.23	–	–	–	–	–	6.4
African elephant	average	18.0	7	6.5	4.0	0.5	–	–	–	–	–	–
Asiatic elephant	5 days	8.27	0.62	4.01	3.0	0.64	–	–	–	–	–	7.8
	2 months	16.4	5.8	5.4	4.45	0.67	0.098–0.178	0.309	–	–	–	Neutral
	4 months	19.15	8.5	5.25	4.65	0.63	0.095	0.245	–	–	–	–
	1 year	21.17	10.0	5.4	4.93	0.66	0.084	0.305	–	–	–	–
	1.5 years	22.34–28.55	19.0	3.6	5.25	0.64	0.164	0.244	–	–	–	–

Vitamin A, B_2, D, as in cow's milk. Vitamin C—four times the level of cow's milk.

Figure 18–73 A. An orphan white rhinoceros calf and companion sheep. B. An orphan zebra foal and companion horse.

Enteritis occurs in all species and is best controlled with a neomycin-kaolin-pectin combination.

Umbilical hernia occurs frequently in the exotic equine. Because of the relatively large hernial ring, polyvinyl foam should be employed for support in conjunction with restorative surgery.[213]

VACCINATION PROGRAM

In general, vaccination programs paralleling those for the domestic equine have been used in zoos. The exotic equines should be vaccinated against encephalitis and tetanus. Tapirs, rhinoceroses, and elephants should be vaccinated against encephalitis if they are in a high risk area; otherwise, they are usually not vaccinated. Elephants are usually vaccinated against tetanus.

SURGERY AND RADIOLOGY

Surgical procedures on zebras, tapirs, rhinoceroses, hippopotamuses, and elephants have included repair of lacerations, tail amputations, rectal and vaginal prolapse repairs, tumor removals, and fracture repair. Most procedures are carried out under general anesthesia. Many of the surgical and major medical events for the exotic equine, zebra, and pachyderm involve repairs of trauma to the soft tissue and skeleton.

The skeletal and muscular anatomy of the exotic equine and zebra is almost identical to that of the domestic horse.

The skeletal anatomy of the elephant is unique in its mass and structural adaptations (Fig. 18–74).

Castration of the zebra and elephant has been done to help reduce aggression. Zebras are castrated in the same manner as are domestic horses. Elephant testicles are abdominally located on a short stalk posterior and ventral to the kidneys. The testicles do not descend at any time during the life of the elephant, requiring intra-abdominal surgery for castration.

The surgical site of castration for the elephant is 45 cm ventral to the dorsal midline. A 25 cm incision is made directly over the last rib. The surgeon must operate within the abdominal cavity at arm's length. One testicle is excised during the original procedure. The second testicle should be removed in the same way 12 to 14 days later with the elephant lying on its opposite side.

Orthopedics

Joint and bursa *inflammations produced by trauma* occur with regularity in

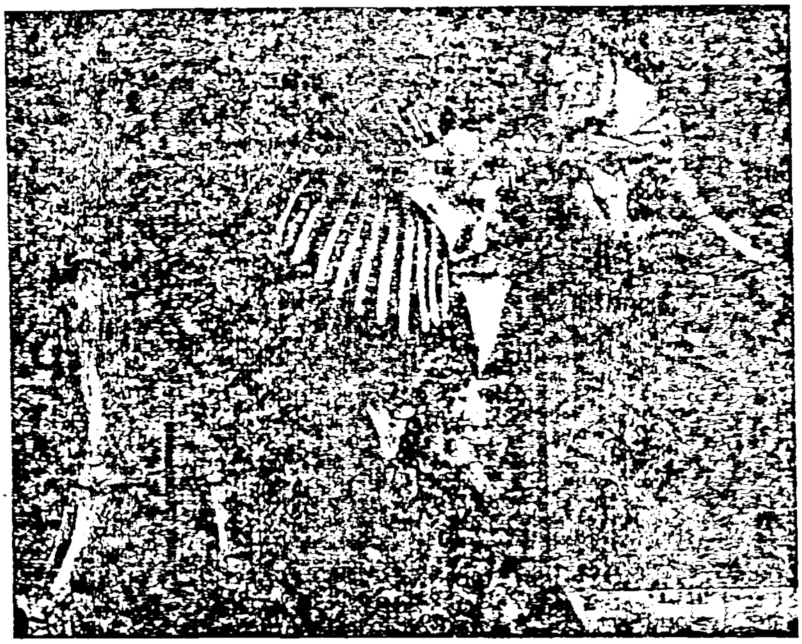

Figure 18–74 Skeleton of Asiatic elephant. (Courtesy of Smithsonian Institution, Washington, D.C.)

the exotic equine, zebra, and pachyderm. These traumatic syndromes are usually accompanied by soft, painless swellings. Close confinement and rest of the joint and limb will often relieve the inflammation.

In chronic cases of *bursitis* the accumulated fluid should be aspirated and cultured for pathogenic organisms. If infection has become established, the appropriate antibiotic should be injected into the bursa. If the lesion is sterile, a corticosteroid injection may be of value.

The oral administration of phenylbutazone at the rate of 0.5 to 1 gm per kg of body weight for three to five days will relieve the animal's discomfort and allow the joint and associated soft tissues to recover. Special corrective orthoses have been applied to elephant legs (Fig. 18–75).

Osteoarthritis occurs in the older equine, zebra, and pachyderm. The articular cartilage is usually destroyed, leaving a raw, painful bony surface. Diagnosis is usually made by clinical signs and a history of recurring lameness that becomes reduced as the animal "warms up."

The treatment of choice is rest and the oral administration of phenylbutazone as required at the rate of 0.5 to 1 gm per 100 kg of body weight. Luxations have occurred in elephants (Fig. 18–76). Degenerative arthritis has been described in the elephant, zebra, and black rhinoceros (Fig. 18–77), and even in a fossilized rhinoceros discovered in a middle miocene quarry.

Pedal rotation following laminitis is a common occurrence in the exotic equine and zebra.

Figure 18–75 Corrective orthosis applied to support and correct a joint lameness in an elephant. (From Siegel, I. M., J.A.V.M.A. *163*:544–545, 1973.)

Figure 18–76 Luxation of the carpal joint of an Asiatic elephant. (Courtesy of M. Fowler, University of California, Davis, California.)

Diagnosis is easily made by observing the characteristic clinical signs and is confirmed by radiographs of the foot.

The treatment of choice is trimming and lowering the heel, removing the excess toe material of the hoof, and padding the sole of the hoof to eliminate the dead space and produce more weight-bearing surface. If the animal can be placed on sand or soft earth, it is more desirable than hard surfaces.

Avulsion or *fracture* of the extensor process of the third phalanx occurs in the

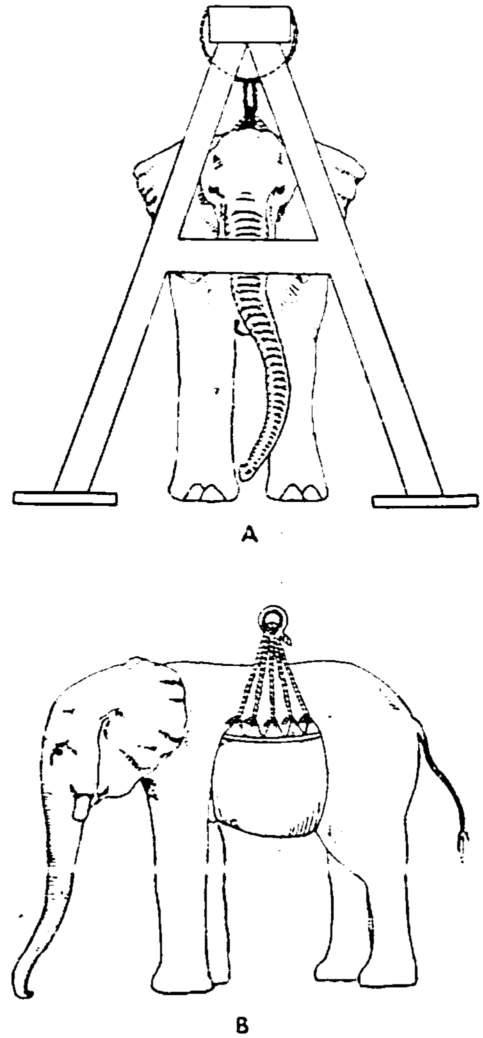

Figure 18–78 *A* and *B*, "A" frame used to lift and sling a convalescent elephant.

Figure 18–77 Head of femur of a black rhinoceros with degenerative arthritis.

exotic equine and zebra as a result of trauma to the anterior hoof produced by kicking door sills or water troughs protruding into stalls. The lameness is characterized by tender footedness; however, a radiograph will be required to specifically identify the lesion.

Surgical removal of the fragment is the treatment of choice.

The surgical approaches and techniques for pressure plating and intramedullary pinning of long bone fractures for the domestic horse should be used for the zebra, exotic equid, tapir, and pachyderm.[6, 36, 126] Thomas splints and walking casts covered with plaster have been used successfully for the exotic equid, zebra, and elephant.[74]

Second in frequency to limb fractures in the exotic equine and zebra are fractures of the mandible and facial bones. Lesions of the palate and molar teeth occur regularly but are inaccessible by conventional surgical approaches.

Mandibular symphsiotomy has been used in the domestic equine to gain access to the posterior oral cavity.[111] The same procedure is used in exotic equine. Occasionally, elephants and other animals in this group need to be in a sling. An I-beam A-frame has been used successfully. The sling is placed just behind the forelimbs and suspended 2 cm below the thorax of the standing animal (Fig. 18–78). In this manner, the animal can use the sling or stand on his own.

Radiography

Radiography of this group of animals is done in the same manner as with the domestic horse.

Increased milliamperage seconds and kilovoltage are required over the standard equine settings to obtain clear radiographs in the pachyderms. Where possible, grids should be used to reduce radiation scatter.

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