Wallach & Boever
Diseases of Exotic Animals
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CHAPTER 18

PERISSODACTYLA (EQUIDS, TAPIRS, RHINOS), PROBOSCIDAE (ELEPHANTS), AND HIPPOPOTAMIDAE (HIPPOPOTAMUS)

The three taxonomic groups presented in this chapter are bound by the common denominator of husbandry, longevity, and disease problems. The zebra, rhinoceros, elephant, and hippopotamus are among the earliest of the large exotic species to have been kept in captivity and are synonymous with circuses and zoological parks. A great number of these animals are kept on private ranches and farms and in commercial safari parks and zoos because of their general appeal and hardy constitutions.

CLASSIFICATION

Perissodactyla is a diverse order containing odd-toed hoofed mammals.[15] Most of the animal's weight is carried on the middle toe of each foot. The tapirs have retained four toes on each front foot but have only three on each rear foot; rhinoceroses have three toes on each foot; and the zebra and other exotic equids have only one functional toe on each foot.

Equidae is a family containing wild horses, asses, and zebra.[25, 201]

The Mongolian wild horses (syn., Przewalski's horse, *Equus przewalski)* range from southwestern Mongolia to northeastern Sinkiang Province, China, roaming the semiarid steppes of this region.[15, 25, 201]

The Mongolian wild horse is a short, bulky animal whose weight may vary from 225 to 240 kg (Fig. A).[25, 201] They range in color from light tan to buckskin, with a narrow dark stripe coursing down the dorsal midline, and occasionally there are faint leg stripes. The lower legs, mane, and tail are black. The abdomen and muzzle are pale to buff. The head is large and exhibits a prominent "Roman" nose. The mane is stiff and upright with no forelock. Their gestation period is 330 days, and they live from 27 to 32 years.

Zebras (*Equus grevyi, E. burchelli,* and *E. zebra)* are abundant on the plains of Africa.[25]

Grevy's zebras *(Equus grevyi)* range from southern Ethiopia to northern Kenya.[15, 25, 201] They are the largest of the zebra and are characterized by sharp, narrow stripes extending to the hoof, a white belly, and large, rounded, furred ears (Fig. *B).* They range in body weight from 431 to 451 kg.[25] The gestation period averages 399 days, and they have a longevity of 29 to 35 years.[201]

The Burchell's group contains three races of zebras (Fig. C):[25, 201] Chapman's zebra (*E. burchelli antiquorum),* Grant's zebra (*E. b. bohmi),* and Selous zebra (*E. b. selousi).* The Burchell's zebras have wider stripes and are smaller than the Grevy's zebras.

Their gestation period averages 366 to 375 days, and they have a longevity of 22 to 28 years.[201]

The quagga (*E. quagga),* now extinct,

once roamed the plains and bush of the Cape of Africa. The last one died in 1883 in the Amsterdam Zoological Garden.[25, 201]

The mountain zebras *(E. zebra)* are smaller than the northern species.[25, 201] They are characterized by strong striping to the hoof, no shadow striping, and body stripes that do not meet the ventral midline. Short crossbars on the rump and tailhead join the upper flank stripes, forming a characteristic "grid." A fold of skin on the ventral midline of the neck forms a dewlap or bell.

The family Tapiridae is characterized by a stout, swine-like body, a fused nose and upper lip that form a short flexible proboscis, and a blunt, stubby tail.[25, 201] As a group the tapirs prefer heavy vegetation, swamps, and tropical mountains as habitat. All tapirs swim rather well and will take to water as an escape.

The Brazilian tapirs *(Tapirus terrestrus)* range from tropical South America from Paraguay to northwestern Colombia.[15, 25, 201] They are brown with a thin, white edge on their ears (Fig. *D*). Both sexes possess a prominent nuchal crest. They average 150 to 180 kg in body weight.

The Baird's tapir *(T. bairdii)* is similar to the Brazilian tapir, differing in the lack of a prominent nuchal crest.[25, 201] A stiff mane is characteristic.

The mountain, or woolly, tapirs *(T. pinchaque)* range the Andes of Columbia and Ecuador at around 2000 to 4000 feet.[25, 201] They have wiry black hair with prominent white ear and lip fringes. They range in weight from 110 to 115 kg.[25]

The Malayan tapirs *(T. indicus)* range from Sumatra northward through the Malay Peninsula to Burma and Thailand.[15, 25, 201] They are black with white ear tips and a large white saddle. They are the largest of the tapirs, ranging in weight from 260 to 315 kg.

The gestation periods of all species of tapirs range from 392 to 400 days.[25, 201] Newborn tapirs are marked with white to yellow spots and stripes that disappear by the age of four to six months.[201]

The family Rhinocerotidae contains the second largest of the land mammals, being smaller than only the elephant.[15, 25, 201] They are characterized by one or two horns on the skin overlying the nasal bones. The horns are composed of collagen fibers bound together by an amorphous collagen. The horn is often wrongly referred to as compacted hair. There is no bony core in the horn; it grows continuously and will be completely replaced in one to two years if knocked off. The Eastern belief that rhinoceros horn is an aphrodisiac had led to widespread destruction of rhinoceros populations.

As a group, rhinoceroses are entirely vegetarians; they enjoy wallowing in mudholes or swamps to cool themselves and to protect their skin from biting insects.

The white rhinoceroses (synonym, square-lipped rhinoceros) *(Diceros simus simus)* are indigenous to the central province of Natal in the Republic of South Africa (Fig. 18–1). Their skin color is charcoal to light gray when not covered with mud. They range in weight from 1500 to 2500 kg.[25, 201] The anterior horn length in the wild is from 75 to 155 cm. The posterior horn length rarely exceeds 25 cm.

The white rhinoceros is a social animal, living in large nursery groups and bachelor herds. There are old territorial bulls. The animal is a short grass grazer almost exclusively.

The black rhinoceroses (synonym, hook-lipped rhinoceros) *(Diceros bicornis)*

Figure 18–1 White, or square-lipped, rhinoceros *(Diceros simus simus)*. Courtesy of L. LaFrance, Chicago Zoological Society, Brookfield, Illinois.)

Figure 18–2 Black, or hook-lipped, rhinoceros *(Diceros bicornis)*. (Courtesy of L. LaFrance, Chicago Zoological Society, Brookfield, Illinois.)

are the most common rhinoceros of Africa, although their numbers have been depleted in modern times (Fig. 18–2).[15, 25, 107, 110, 201] Their skin color is darker gray to black when compared with that of the white rhinoceros. They are a smaller species than the white rhinoceros, being from 1.43 to 1.8 meters high at the shoulder and weighing from 1000 to 1400 kg. The anterior horn tends to be more recurved, averaging 62.5 cm. in length with a record of 132.5 cm.

Black rhinoceroses tend to be solitary animals in the bush; they prefer thick brush and are primarily browsers.[110] They have a longevity of 35 to 40 years.

The great Indian rhinoceroses *(Rhinoceros unicornis)* were once widely distributed from Kashmir to Indochina; they are now found only in game reserves in Bengal and Nepal and in zoological gardens.[15, 25, 201] At last count there were 400 in India and 300 in Nepal. Both the male and female have a single horn averaging 60 cm in length. They have heavily folded skin with knobby protrusions giving the impression of armor plate. They range in height from 1.5 to 1.62 meters at the shoulder and in weight from 1700 kg in the females to 2100 kg in the males.[201]

The Javan rhinoceros *(R. sondaicus)* once ranged from Burma through southeast Asia to Sumatra and Java.[25, 201] The males possess a characteristic stubby horn that grows only up to 25 cm in length. The males stand 1.68 meters at the shoulder.[25] There are only 30 to 40 living individuals at this time.[25]

The Sumatran rhinoceros *(Didermocerus sumatrensis)* is the smallest of the rhinoceroses, ranging from 1.1 to 1.3 meters at the shoulder and weighing about 1000 kg.[25, 201] They have long, wiry red hair that covers the body, and they have two horns. The anterior horn reaches lengths of 80 cm.

The family Hippopotamidae is actually placed taxonomically within the order Artiodactyla with swine, deer, and antelope. They have large, bulky bodies, a relatively large head, and prominent bristles about the lips, ears, and tail tuft. The eyes and nostrils are raised, and the nostrils are provided with valves to allow the hippopotamus to float submerged with the eyes and nostrils above water. Although credited with great ability to hold their breath, the average time the hippopotamus can remain submerged is four minutes.[21]

Figure 18–3 Pygmy hippopotamus *(Choeropsis liberiensis)*. (Courtesy of L. LaFrance, Chicago Zoological Society, Brookfield, Illinois.)

The river hippopotamus (synonym, river horse) *(Hippopotamus amphibius)* ranges from Africa south of the Sahara from the great lakes of east Africa southward to Rhodesia and the Republic of South Africa.[15, 21, 201] The males range in height from 1.2 to 1.5 meters at the shoulder and in weight from 2000 to 2800 kg.[21, 201] Large herds of hippopotamuses are made up of females and calves; the males generally live in bachelor herds or singly.

River hippopotamuses sleep in the shallows of rivers or lakes during the day and venture several miles inland at night to graze on grass and reeds.

The river hippopotamus commonly lives for 45 to 50 years.

The pygmy hippopotamuses *(Choeropsis liberiensis)* are indigenous to the forests of West Africa (Fig. 18–3).[15, 21, 156] The center of their range appears to be Liberia.[156] They are from 0.6 to 0.75 meter high at the shoulder and weigh up to 250 kg.

The pygmy hippopotamus commonly has a life span of 38 to 40 years.[21]

The order Proboscidea contains the family Elephantidae, the largest of the living land mammals.[26, 180] Elephants adapt well to captivity and have been used as domesticated beasts of burden in Asia and portions of Africa for thousands of years. Both species of elephant, the African and the Asian, possess tusks, large upper incisors adapted for digging and peeling bark off of trees. Both sexes have tusks; however, occasionally a tuskless elephant is reported. The tusks of the males are typically bulkier. The ivory is composed of a dense dentin and has been used by man for thousands of years for ornamentation.

The Asian elephant *(Elephas maximus)* ranges from India eastward through southeast Asia (Fig. 18–4).[15, 26, 180] The Asian elephant is a stout, bulky animal with a trunk, an elongated proboscis composed of the nose and upper lip.[180] The trunk is said to contain "40,000" muscles, which provide the organ with great dexterity and strength. The distal end of the trunk possesses a sensitive finger-like papilla on its dorsal aspect. The high point of the Asian elephant is located at the middle of the back. The Asian elephant has five toes on the front feet and four on the rear. They vary in height from 3.1 to 3.5 meters and in weight from 4000 to 5800 kg.[26, 180, 201]

The Asian elephant has a documented life span of 65 to 70 years, although claims of 100 years and more have often been made.

The African elephant *(Loxodonta africanus)* ranges from East Africa south and west and may be found in isolated populations throughout Central and South Africa.[15, 26, 180, 201] The high point of the African elephant is the peak of the rump.

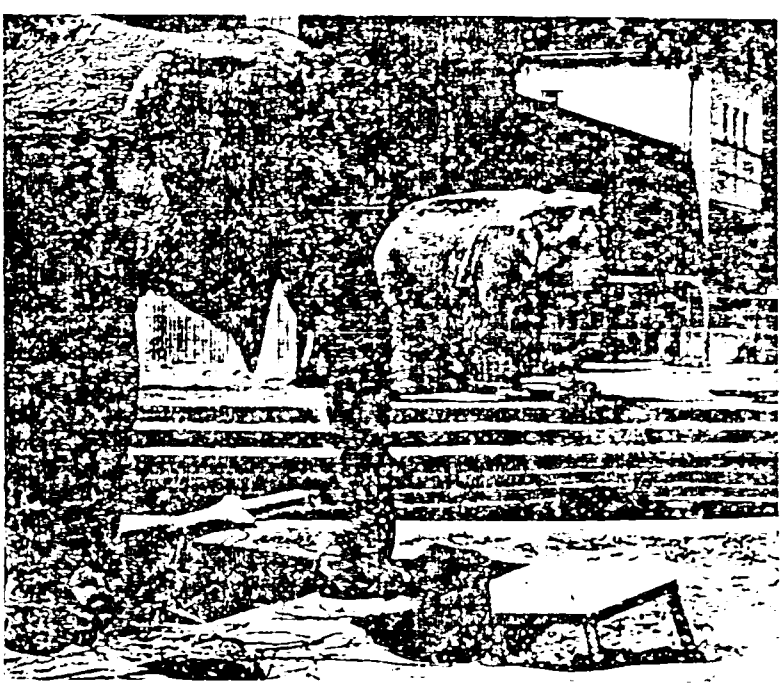

Figure 18–4 Asiatic elephant *(Elephas maximus)*.

TABLE 18–1 HEMATOLOGICAL VALUES OF THE ZEBRA, RHINOCEROS AND ELEPHANT[31, 97, 155, 165, 174, 175, 188, 189, 190, 223, 230]

ANIMAL	RBC (10^6)	HG (g/%)	PCV (%)	WBC (10^3)	NEUTRO. (%)	LYMPHO. (%)	MONO. (%)	EOSIN. (%)	BASO. (%)	MCV (μ^3)	MCH ($\mu\mu g$)	MCHC (%)
Grant's zebra	8.3–8.9	14.3–16.5	44	8.3–9.5	50–60	20–25	1–2	0–1	–	54	18.7	34.7
Horses	7.8–10.2	12.7–16.1	41–45.5	7.8–10.8	45–60	30–40	1–2	0–2	–	41.2–49.8	14.4–17.4	35.8–36.6
Burro	5.7–7.3	10.0–13.5	32.3–40.5	11.4–17.6	30–50	40–50	1–2	2–4	–	52.4–58.8	16.4–17.4	28.9–34.7
White rhinoceros	5.87–8.11	13.1–19.5	36.7–49.5	6.1–15.6	40–50	40	0–1	0–2	–	55.2–67.6	19.5–27.1	32.6–42.6
African elephant	2.9–3.8	13.6–14.5	39.6–48	9.5–16.366	40	58–77	0–1	0–1	–	–	–	–
Asiatic elephant	2.86–3.50	11.4–12.8	32.4–34.9	12.78–16.72	37.6–43.0	49.3–56.1	4.2–6.4	1.7–3.0	–	113.7–122.1	36.2–48.0	35.2–36.9

TABLE 18–2 BLOOD CHEMISTRY OF ZEBRA, RHINOCEROS, AND ELEPHANT[155, 165, 174, 175, 184, 190]

SPECIES	Na (mEq/L)	K (mEq/L)	Cl (mEq/L)	Total CO_2 (mEq/L)	Ca (mg %)	P (mg %)	Glu. (mg %)	BUN (mg %)
Grant's zebra	133–147	3.5–5.3	87–104	17–28	9.7–12.1	3.6–6.4	88–132	9–25
White rhinoceros	134–144	4.6–5.5	92–98	26.2–29.4	11.2–12.6	4.7–5.6	56–112	11–15
African elephant	128	6.4	88	–	7.4	3.5	53.23–199.72	31
Asiatic elephant	130	–	90.0	–	–	4.9	–	–

They have four toes on the front feet and three on the rear.[26, 180, 201] The African elephant ranges in height from 3.6 to 4.1 meters at the shoulder and in weight from 3500 kg in the females to 6000 kg in the males.[26, 180, 201]

The trunk of the African elephant has a flattened projection on the dorsoventral aspect of the distal trunk, giving it "two fingers" when compared to the Asiatic elephant's single dorsal "finger."

Both the Asiatic and African elephant graze and browse, eating grass, reeds, twigs, and the bark off of larger saplings, limbs, and tree trunks.

BIOLOGICAL DATA

Some of the hematological and serum chemical values of zebras, rhinoceroses, tapirs, elephants, and hippopotamuses are presented in Tables 18–1, 18–2, and 18–3. Many of the values are similar to those in the domestic horse, with a few notable differences. The elephant's RBC measures 9.5 to 9.6 μ in diameter. The total blood protein is greater than that of the horse (Table 18–4).

Blood collection on the elephant and rhinoceros is easiest from the large auricular veins (Fig. 18–5). Blood collection from the elephant is made easier by washing the back of the ear with warm water prior to collection to cause the vein to stand out. In the equids, blood samples are collected from the jugular vein, as in the horse (Fig. 18–6). Blood is collected from the femoral vein or the brachial vein of the hippopotamus and tapir (Fig. 18–7).

The heart rates per minute for the zebra, rhinoceros, and elephant are 55 to 81, 64 to 67, and 34 to 46 respectively.[8, 28, 180]

Figure 18–5 *A*, Collection of blood from auricular vein of a white rhinoceros; *B*, injection of intravenous medication via auricular vein of black rhinoceros.

TABLE 18–2 BLOOD CHEMISTRY OF ZEBRA, RHINOCEROS, AND ELEPHANT *(Continued)*

URIC A. *(mg %)*	TOTAL PRO. *(Gm%)*	CHOL. *(mg %)*	FIBRINOGEN *(mg %)*	SGOT *(IU)*	CPK *(IU)*	LDH *(IU)*	ALK. PHOS. *(IU)*	MG *(mEq/L)*
0.3–2.5	5.5–7.7	85–197	227–567	54–100	12–26	254–287	86–90*	–
–	7.1–9.8	68–110	470–573	39–55	60–126*	212–328	93–127*	–
0.38–0.82	8.0–9.3	121 (63.3–71.3 wild)	–	26.8–35	–	233.54–626.46	7.1 (K.A.U.)	3.4
–	–	–	–	39 (S.F.U.)	–	–	–	–

*These reported values are higher than normals for other species.

The electrocardiogram of the elephant has been recorded many times. The recordings are easily made at low voltage and are best recorded with Lead I (Fig. 18–8). The heart rate of the elephant increases to 60 beats per minute with strenuous exercise.

The respiratory rates for zebra, rhinoceros, and elephant are 10 to 18, 12 to 16, and 10 to 12 per minute respectively.[8] The sleeping respiratory rate of the elephant drops to four to five respirations per minute. Blood gas levels for the zebra and exotic equine have been reported (Table 18–5).

The normal rectal temperature of the zebra, rhinoceros, and elephant are 38.3 to 39.2°C, 29.4 to 35.0°C, and 36.0 to 38.8°C respectively.[8, 180] The rectal temperature will fluctuate slightly with the environmental temperature and will elevate with exercise and excitement.

The urine of a healthy elephant is straw colored and slightly acid.

More urine is passed by the elephant at night than during the day; the specific gravity is between 1.004 and 1.033. The average volume per void varies between 5 and 11 liters, with a total average daily volume of 50 liters.[8, 180] More than 2 kg of solids are excreted in the urine per day, of which 20 per cent is mineral and 80 per cent is organic material. About 5 mg of nitrogen is in each ml of urine, the total 24-hour excretion total being 235 gm. The daily excretion rate of NaCl in the urine is 160 gm.[8, 180]

Figure 18–6 Blood collection from the jugular vein of a Grevy zebra.

TABLE 18–3 SERUM LIPID AND HORMONE LEVELS FOR ZEBRA, RHINOCEROS, AND ELEPHANT[98, 180]

Species	Total Lipid (mg %)	Total Cholesterol (mg %)	Esterified Cholesterol (mg %)	Free Cholesterol (mg %)	Tri-glyceride (mg %)	Unesterified Fatty Acid (mg %)	Phospho-lipid (mg %)	Thyroxine (mg %)	Cortisol (mg %)	Testosterone (mg %)
Grant's zebra	–	85–197	–	–	–	–	–	2.75–3.25	9.2–10.8	–
White rhinoceros	–	47–131	–	–	0–25	–	–	2.1–3.5	0.36–1.36	17–145 M 5–77 F
African elephant	203–237	63.3–71.3	46.4–52.8	17.02–18.56	25.1–34.5	9.7–11.31	72.8–84.6	–	–	–
Asiatic elephant	–	–	–	–	–	–	–	–	–	20–140 normal 430–1370 musth

TABLE 18–4 BLOOD PROTEIN SPECTRUM OF GRANT'S ZEBRA, RHINOCEROS, AND ELEPHANT[144, 174, 175]

Species	Total Protein (gm %)	Albumin (gm %)	Alpha-1 Globulin (gm %)	Alpha-2 Globulin (gm %)	Beta Globulin (gm %)	Gamma Globulin (gm %)	A/G Ratio
Grant's zebra	6.43–8.95	2.39–3.39	0.88–1.88		1.17–1.93	0.89–2.73	0.48–0.76
White rhinoceros	6.1–9.1	2.1–3.1	0.06–0.22	0.17–0.53	1.35–2.51	1.75–3.19	–
Asiatic elephant	8.0	3.7	4.3	1.3	1.7	1.3	–

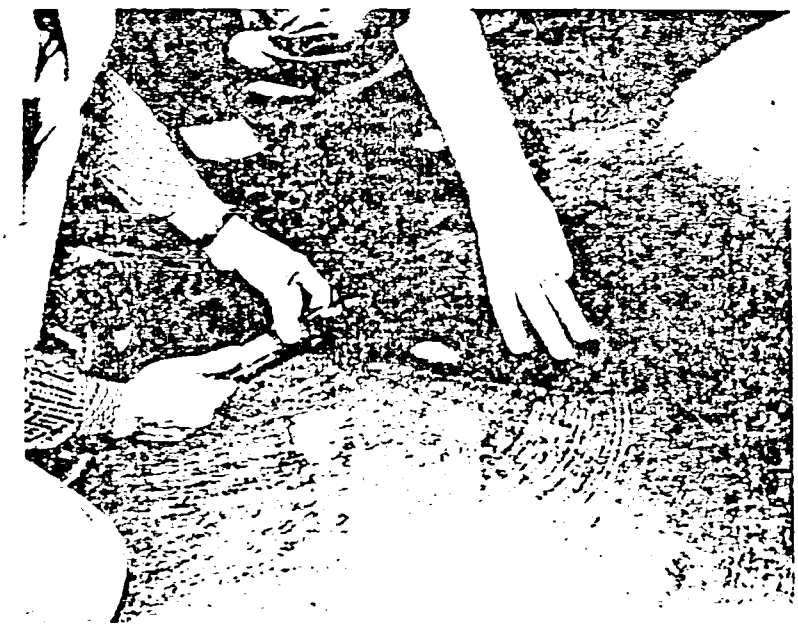

Figure 18–7 Collecting blood from a Malayan tapir.

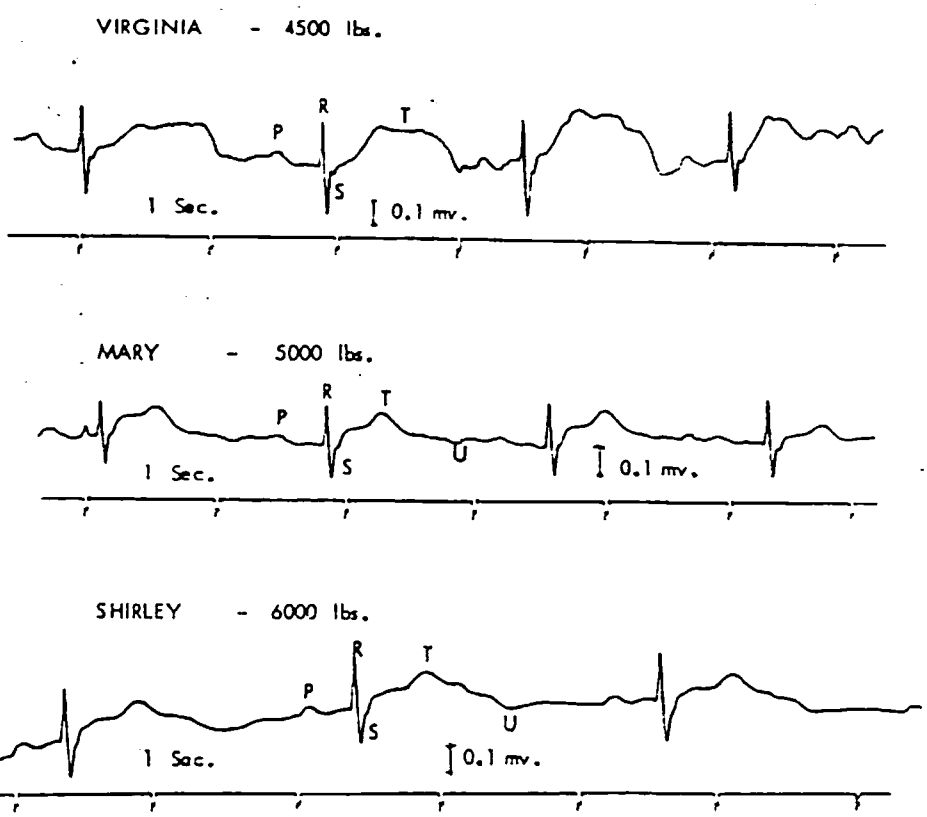

Figure 18–8 Electrocardiogram of three adult elephants (lead 1). (From Geddes, L. A., et al., Southwest. Vet. 20:211–216, 1967.)

TABLE 18–5 VENOUS BLOOD GAS AND pH VALUES FOR EXOTIC EQUIDAE[152]

	pH	Pco_2	Po_2	HCO_3	Total CO_2	Source	HG G %
Grant's zebra	7.5	60.4	59.9	20.0	21.9	Jugular vein	13
Onager	7.37	54.8	27.1	32.3	30.9	Jugular vein	19
Tarpan	7.42	49.4	36.1	31.2	35.2	Jugular vein	19.5

HOUSING

Basic housing for zebras, tapirs, rhinoceroses, elephants, and hippopotamuses includes a spacious yard and indoor stalls. All but the zebra need access to pools as well.

Chain link fencing, stockade fencing, or moated barriers may be used for tapir and zebra and other exotic equids. The chain link should be at least 6 feet high, and the wire mesh should be placed on the inside of the poles. The rhinoceros, hippopotamus, and elephant require a more substantial barrier. Two-inch steel bars with 20-inch centers have been used.

Utility poles sunk in concrete 6 feet in the ground to form a "stockade" fence have also been used. Concrete "box" moats 6 feet wide and 8 feet deep have been successful. Three to four strands of 1/2-inch to 5/8-inch steel cable may be used for outdoor and indoor enclosures for rhinoceroses (Fig. 18–9). The utility poles should be set 6 feet in the ground and placed in concrete. Indoor shelter is required for all of these species except in the most temperate climates.

Zebras will grow long hair and adapt well to cold weather, but the tapir, rhinoceros, hippopotamus, and elephant can only tolerate temperatures below 60°F (16°C) for brief periods of time while their inside enclosures are being cleaned. In temperatures below 40°F (5°C) and wet weather, the "pachyderms" should be kept indoors entirely.

Zebras and tapirs may be housed in individual wooden box stalls measuring 4 meters by 4 meters with sliding doors between stalls and the outdoors. The hay racks should preferably be hung on the outside of the stall to prevent head injuries (Fig. 18–10). The cement floors should be bedded with straw, grass hay, or wood shavings in one corner. The cement should be "broomed" prior to drying to obtain a high traction surface. Water troughs may be of the automatic type; they should be built into the wall to prevent fecal contamination and remove the physical hazard from the interior of the stall.

Rhinoceroses, hippopotamuses, and elephants are normally housed in concrete

Figure 18–9 Cable fence of rhinoceros enclosure.

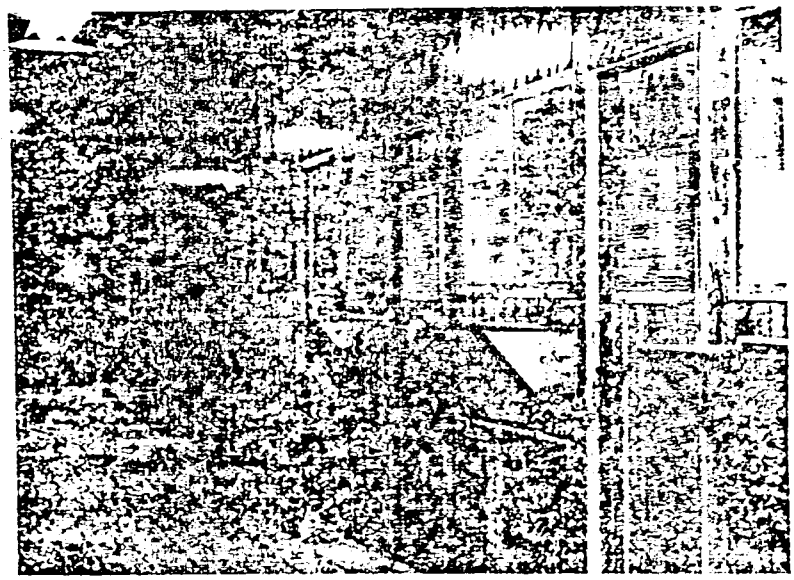

Figure 18–10 Connecting box stalls for ungulates. Note outside access to the hay rack, which eliminates protrusions into the stall.

structures. Wooden poles may be used to line the interior walls. Five meters by 6 meters is usually required for each individual. Hippopotamuses should have constant access to a pool that is a minimum of 1 meter deep. Even inside, tapirs, rhinoceroses, and elephants should have access to pools occasionally. The temperature of the pools should be maintained at 60°F (16°C) as above. Most filters will not keep the pools clean. As a result, most facilities drain and fill with fresh water daily. When access to pools is not possible, water showers will suffice.

Sunken water troughs should be used for the rhinoceros, as narrow high-walled concrete troughs physically prohibit drinking because of the horn. The water troughs should ideally be concave "pans" 3 feet in diameter.

Elephants should be *hand watered* indoors at least twice each day. The water may be placed directly into the mouth by a hose or be placed in a tub. Once the elephant's requirements are met, the indoor water source should be removed. Access to outdoor pools in warm weather provides the elephant with a good diversion.

Facilities for night chaining should be included in the elephant's stall. When a single elephant is kept, the animal may be chained by alternate fore or rear legs each night. When several elephants are housed together in the same barn or stall, they must be chained both in the front and rear to prevent them from getting tangled. In the latter example, the front and rear chains should be 3 to 4 feet long and be connected by a universal swivel to parallel front and rear "picket chains." Zebra, elephants, white rhinoceroses, tapirs, and river hippopotamuses are usually housed in small groups. Black rhinoceroses and pygmy hippopotamuses are usually housed individually or in pairs if compatible. Usually, two males of any of these species are not housed together unless space is not available.

RESTRAINT AND ANESTHESIA

Physical Restraint

Restraint of zebras, tapirs, rhinoceroses, hippopotamuses, and elephants is usually difficult because of their size. It is almost impossible to physically restrain an adult of one of these animals if they do not cooperate. Youngsters can be physically restrained with nets and ropes when they are very small. Adults can be worked with if they are trained. Many of the tapirs are docile enough to allow minor manipulations and physical examination in the stall (Fig. 18–11). Occasionally, rhinoceroses have been given superficial examination with no restraint.

Most elephants are trained to allow thorough examination and manipulation under the restraint of the handler's command. In contrast to the rhinoceros and tapir, the elephant can be trained to lie

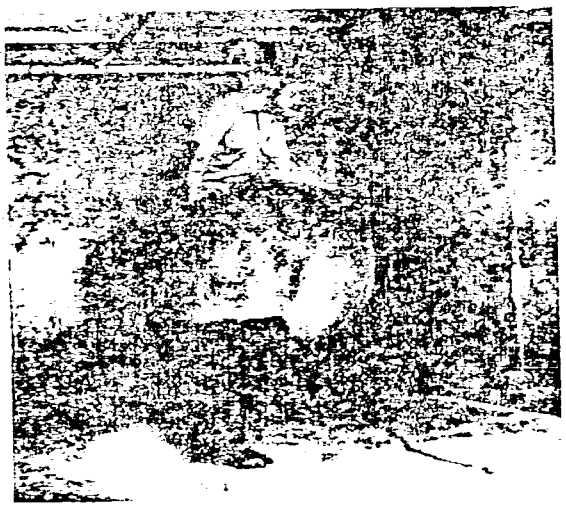

Figure 18–11 Physical examination of a Malayan tapir, using no restraint.

down, to pick up their feet for examination, and so on. Most hippopotamuses and zebra do not allow physical manipulations.

Chemical Restraint

Restraint of zebras, rhinoceroses, tapirs, hippopotamuses, and elephants requires chemical immobilization for most procedures, even to collect a blood sample or do minor procedures.

ORAL: Promazine hydrochloride (Sparine) has been administered orally in the form of alfalfa pellets mixed with feed or pills in bananas. As much as 2000 mg per day for one year was administered orally to a mature African elephant. 4.0 to 5.0 mg per kg of body weight has been used on hippos. The tranquilization produced is very minimal. It did allow for transferring and getting medication into a wound.

The use of promazine tranquilizers causes a relaxation of or transient "paralysis" of the penis of all animals in this group (Fig. 18–12).[209, 217]

Intravenous anesthetics are not used in this group of animals except to maintain anesthesia once the animal has been immobilized with intramuscular agents.

Intramuscular immobilizing agents are by far the most common agents used to restrain zebras, rhinoceroses, tapirs, elephants, and hippopotamuses. The drug is administered via the projectile syringe (see Appendix I) or by pole syringe or hand injection. Etorphine (M99) is the drug of choice.

M99 (etorphine HCl) by the IM or IV route is universally useful for immobilizing ungulates including the zebra, tapir, hippopotamus, rhinoceros, and elephant. M99 may be administered alone or in combination with a tranquilizer such as xylazine or promazine. The immobilizing activity of M99 is equal to 1000 times that of morphine and its analgesic activity is 6000 to 10,000 times that of morphine. M99 produces analgesia, tachycardia, and increased blood pressure, causes muscle stiffness (reduced by administration of tranquilizer), and lowers body temperature. In general, total doses of 1.0 to 6.0 mg are quite effective for immobilizing the zebra, tapir, rhinoceros, hippopotamus or elephant (Table 18–6).

M99 has been used to produce seda-

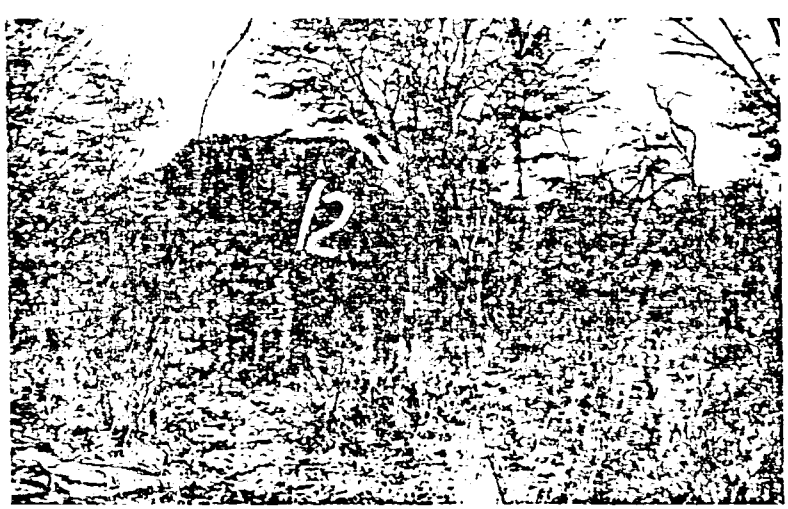

Figure 18–12 Free-ranging bull elephant showing partially relaxed penis caused by the administration of acepromazine.

TABLE 18–6 AGENTS FOR CHEMICAL IMMOBILIZATION OF ZEBRA, TAPIR, RHINOCEROS, HIPPOPOTAMUS, AND ELEPHANT*

SPECIES	AGENT	DOSE	REMARKS
Zebra	M99	2–5 mg total dose	Best drug for zebra. May be used in combination with acepromazine or xylazine. Induction 5–15 min. Has specific antagonist–M 50-50
Zebra	Succinylcholine	0.3–4 mg/kg	Induction in 5–10 min. No analgesia. Can be used only for nonpainful procedures. Some mortalities reported
Tapir	M99	1–3 mg total dose	Drug of choice for tapirs. Smooth induction and slow recovery. Has specific antagonist–M 50-50
Rhinoceros	M99	2–4 mg total dose	Drug of choice for rhinoceros 5–10 min. induction. Occasionally has to be pulled down to its side. Often used in combination with xylazine or acepromazine
Rhinoceros	Xylazine	0.3–0.7 mg/kg	Tranquilized animal sometimes ataxic. May be used in combination with M99
Elephant	M99	4–8 mg total dose	Drug of choice for elephants. Induction in 10–30 min. May be used in combination with xylazine or acepromazine
Elephant	Xylazine	0.08–0.15 mg/kg	Induction in 25–60 min. Only a tranquilizer. Allows for foot trim, blood collection, etc. May be used in combination with M99. Doses greater than 0.15 mg/kg are required for excited animals
Elephant	Fentanyl	10–40 mg total dose	Not recommended
Hippopotamus	M99	4–8 mg total dose	Induction 10–20 min. Must keep away from water
	Phencyclidine	0.6–1.1 mg/kg	Used in combination with xylazine or acepromazine

*References: 1, 37, 44, 47, 71, 73, 79, 82, 88, 91, 94, 114, 115, 116, 120, 121, 124, 133, 145, 148, 149, 152, 166, 199, 203.

tion and analgesia for castration, for minor surgery, for obtaining blood samples, for manual extraction of fetuses, for applying casts to fractures, and for hoof trimming and many other procedures. The use of DMSO as a solvent for M99 failed to increase the speed of induction following parenterally administered doses. It is essential that a sufficiently long needle be used (2.5 to 4.0 inches or 6.5 to 10.0 cm) to fully penetrate the thick skin and subcutaneous tissue of the pachyderms. Once the initial dose of M99 is given, the animal should not be excited, aroused, or disturbed in any way. Induction time is usually 10 to 15 minutes. During the induction some individuals will pace around in circles, eventually showing an exaggerated gait sometimes called high stepping. Elephants more typically sway back and forth during induction. Some individuals will move to a corner or side of the stall and brace themselves with their head while leaning into the corner or wall (Fig. 18–13).

The effects of M99 are additive. Should the initial dose be insufficient for the desired effect, a supplementary, post-injection dose may be administered after 20 minutes (Fig. 18–14).

Some animals will brace themselves against the wall and not fall over even though they are immobilized. If after 20 minutes the animal does not fall, it is pulled over on its side. Once on its side, it will stay immobilized.

Some elephants and rhinoceroses col-

Figure 18–13 *A*, Immobilized black rhinoceros leaning into corner. *B*, Pulling immobilized black rhinoceros onto its side.

lapse rather suddenly at the higher doses; therefore, the operators should stand clear until the animals are fully recumbent or are braced against the wall. The hippopotamus and tapir will seek the "safety" of their water pools as they begin to feel the effects of the M99; therefore, they should be kept clear of water during immobilization and recovery periods. Trained elephants can be commanded to lie on their side during the induction period or prior to injection to ensure that they are in the correct position.

The elephant can be safely guided into the correct position and direction during immobilization with casting ropes (Fig. 18–15*A-C*) or by chaining them in position.

Sternal recumbency of the elephant for long periods of time (Fig. 18–16) should be avoided, as its abdominal viscera presses against the diaphragm and thorax, preventing proper ventilation.

M99 induced anesthesia lasts 30 to 60 minutes before the animal starts to recover. Anesthesia can be maintained with intermittent intravenous injections of 0.5 mg of M99 when needed.[56, 57] Intravenous drips containing 4 mg etorphine per 250 ml of 9 per cent NaCl have been used on a one drop per second schedule established to deliver 1 mg etorphine every 15 minutes.[56, 57]

A reduction in respiratory rate down to four to six per minute occurs at the peak of M99 immobilization. If the respirations fall below four per minute or if apnea occurs, partial or full reversal with an appropriate antagonist should be instituted.

Care should also be taken to maintain

Figure 18–14 *A*, Administering supplemental dose of M99 to a partially immobilized free-ranging bull elephant. *B*, Recumbency is imminent; note original projectile in foreleg.

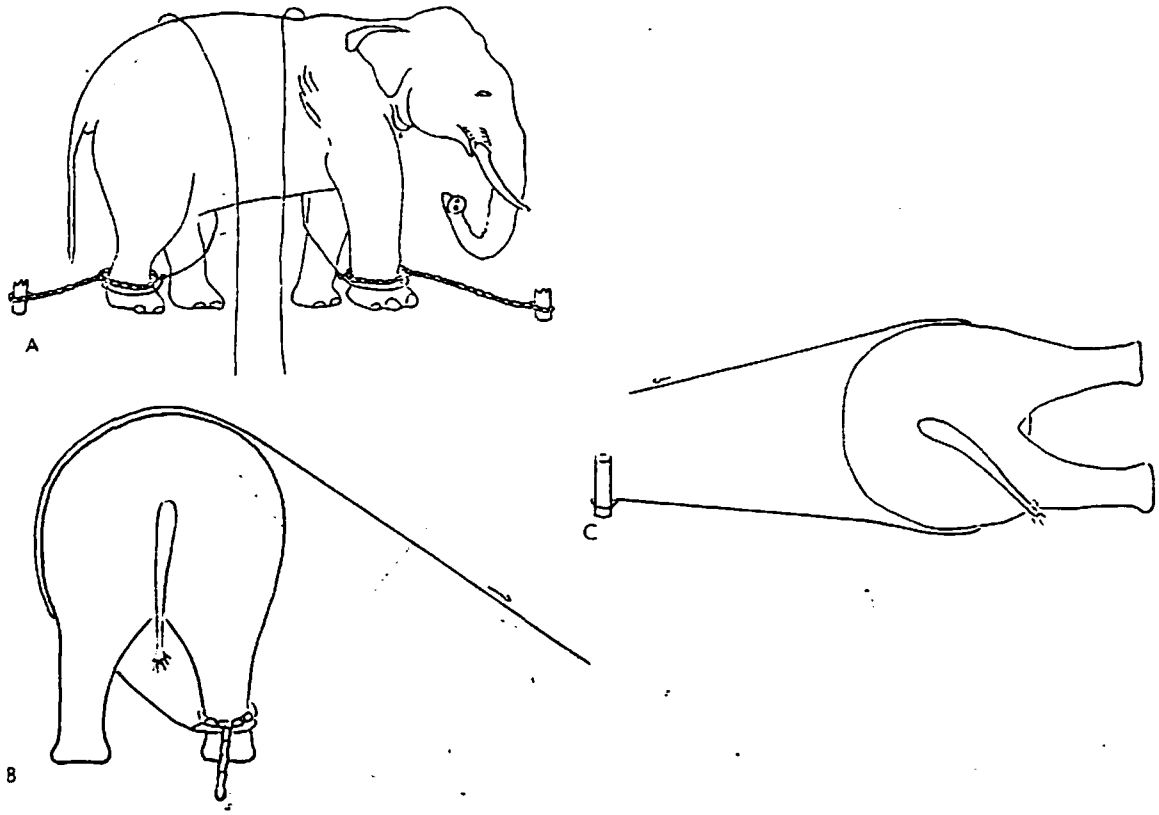

Figure 18–15 *A*, Lateral view of elephant with casting ropes, which are used to force the animal into right lateral recumbency. *B*, Rear view. *C*, An elephant or rhinoceros can be rolled from sternal recumbency to lateral recumbency or rolled over by using a parbuckle casting technique. (From Fowler, M. J. Zoo Anim. Med. 5:27–30, September, 1974.)

adequate temperature regulation during long procedures.

The immobilizing effects of M99 may be voluntarily reversed with antagonist diprenorphine (M 50-50) IM or IV at double the dose of M99 (Fig. 18–17*A-D*); e.g., a 1 mg dose of M99 would be reversed by 2 mg of M 50-50. Nalorphine at 50 to 500 mg of M285 at two times the M99 dose may also be used as an antagonist. The reversal of effects can occur very rapidly if the antagonist is given IV, so the operator should be prepared to handle a fully awake animal. The addition of tranquilizer or scopolamine to the immobilizing mixture slows the recovery time. Reversal with M 50-50 is normally three to 10 minutes.

M99 is the preferred drug for immobilizing this group; however, other drugs have been used.

Xylazine (Rompun) has been used alone or in combination with M99 in tapirs, rhinoceroses, and elephants (Table 18–6). An average of 0.08 to 0.11 mg per kg of body weight produced peak effects in 25 to 60 minutes when administered IM.[165, 166, 168] If the elephant is disturbed during induction, the total effect is reduced. Strong stimuli during induction will cancel out the sedative effects of xylazine.

Figure 18–16 Sternal recumbency in a chemically immobilized elephant forces abdominal viscera against the thoracic viscera, preventing proper ventilation.

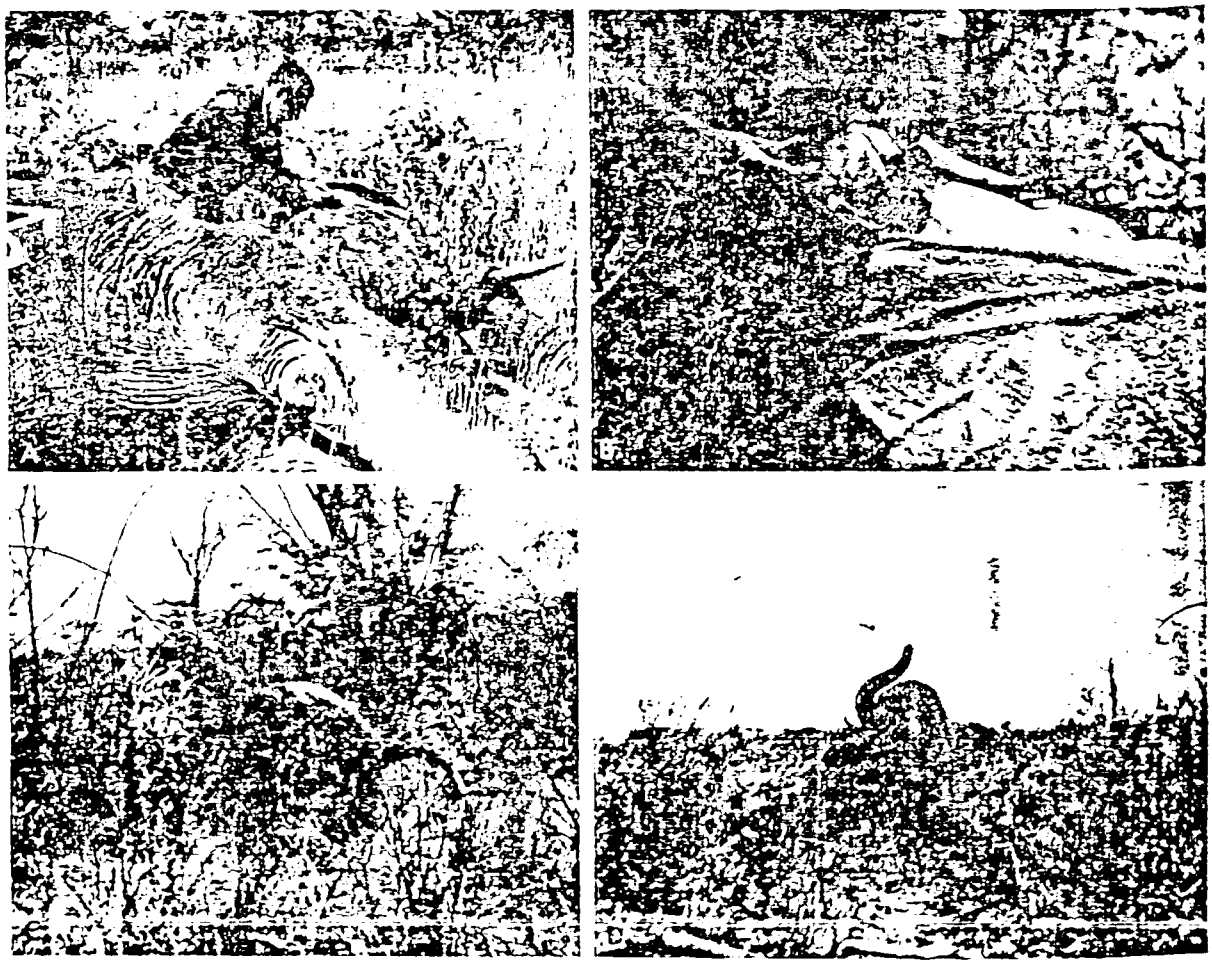

Figure 18–17 *A*, Administering M50-50 intravenously to an African elephant to reduce immobilizing effects of M99. *B*, Closeup of posterior surface of elephant ear and auricular veins. *C*, First stage of recovery. *D*, Return to sternal recumbency

The initial effect is a decreased ability to use the trunk and a decrease in alertness, which occurs at about 10 to 30 minutes after IM injection.[115, 166, 168] The maximum effects reached at 25 to 60 minutes last for 30 to 180 minutes.

During the peak effect of xylazine immobilization, the elephant appears to be in a deep stupor; regular, deep respirations occur and the elephant will prefer to lean against a tree or wall.[115, 166, 168]

There is ataxia, complete loss of trunk movement, and a relaxation of the penis or clitoris with some dribbling of urine. The pupils are dilated. The elephant may lie down but will rise immediately if disturbed by noise or pain. The sedated elephant is sufficiently anesthetized to tolerate steadily applied noxious stimuli. If only mildly aroused, it will soon return to the sedated state if left alone. Electrocardiograms of an elephant given 0.08 mg per kg showed an elongated P wave with a 1° heart block. Xylazine is contraindicated when cardiac and pulmonary disease are present.

Excited animals require a 25 to 50 per cent increase in the calculated dose.[143, 166, 168] Sick and exhausted animals lie down and sleep for several hours. Xylazine has been given daily for up to seven days; a 60 per cent decrease in food consumption occurred.

Succinylcholine chloride is used to immobilize the exotic equine and zebra for brief painless manipulation, e.g., marking, catching, etc. The animals are then released or transferred to gas anesthesia for maintenance.[86, 88]

Fentanyl has been used to immobilize rhinoceroses and elephants; however, it is

not recommended for elephants because of their tendency to recover temporarily under stimuli (Table 18–6).

Azaperone has been used with good results on a limited basis as a tranquilizer in African elephants for minor manipulations.[181]

Phencyclidine HCl in combination with acepromazine or xylazine has been successfully used to immobilize 19 hippopotamuses in a safari park (Table 18–6). Seventeen were injected while in water by projectile syringe. Eleven left the water after being injected; six floated to the surface and were safely roped and hauled to shore. The effects of the immobilizing mixture lasted for an average of 38 minutes. Immobilization in or near the water is usually contraindicated.

Inhalant Anesthesia

Anesthesia may be maintained by transferring the animal that has been immobilized with succinylcholine chloride, xylazine, or M99 to gas anesthesia (Fig. 18–18). A closed circuit, large animal, circle type gas machine is adequate.[101, 103, 178] This method has been successfully used on exotic equines, zebras, and tapirs.

An endotracheal tube may be passed in all species; however, the use of an oral speculum or gag will be required to visualize or manually palpate the larynx and glottis.

Elephants occasionally have difficulty in recovering from anesthesia, especially when drugs other than M99 are used. The elephant tries to get up prior to complete recovery and seems to wear itself out. As a result, it is not able to stand. The authors make it a practice to immobilize elephants in a cage where preparations have been made to hoist the animal when necessary. A block and tackle is attached to the support beam, and a belt is placed around the elephant just behind the front legs. This can be used to move the elephant if it does not become anesthesized in the right position or to help hoist the elephant if it cannot rise on its own. Once on its feet, the elephant recovers well and can usually support its own weight.

NUTRITION

Diet

The equids, rhinoceroses, elephants, and hippopotamuses are total herbivores. The tapir is basically a herbivore, but on occasion is omnivorous. In the wild these animals graze and browse on grasses and other vegetation.

In captivity this group is fed a diet of grass hay and commercial equine grain or pellets (Table 18–7).

Ten to 25 per cent of the grass hay may be substituted with mixed prairie or legume hay. All diets may be supplemented with

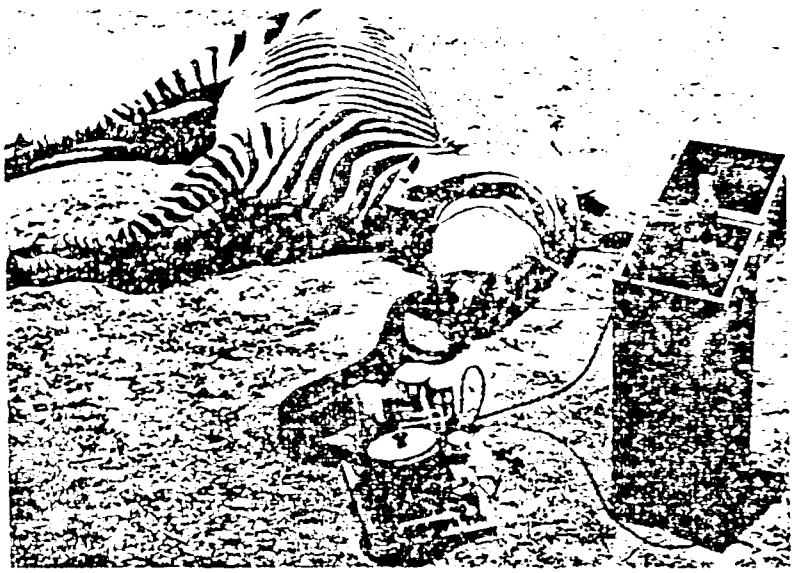

Figure 18–18 Zebra being maintained under deep gas anesthesia. (Courtesy of William York, Lion Country Safari, West Palm Beach, Florida.)

TABLE 18–7 DIETS FOR EXOTIC EQUIDAE, TAPIR, RHINOCEROS, HIPPOPOTAMUS, AND ELEPHANT

Zebra	Grass hay free choice
Exotic equidae	10–25% mixed prairie or legume hay Grain supplement – 50% equine pellets – 50% dairy conditioner } 2–6 liters Yellow vegetables, fruit – 0.5–1 kg
Tapir	Grass hay free choice 10–25% mixed prairie or legume hay Grain supplement – 50% equine pellets – 50% dairy conditioner } 2–4 liters Yellow vegetables, fruit – 0.5–1 kg Balanced meat supplement – 0.1–0.2 kg
Rhinoceros	Grass hay free choice 10–25% mixed prairie or legume hay Grain supplement – 50% equine pellets – 50% dairy conditioner } 4–6 liters Yellow vegetables, fruit – 1–2 kg
Hippopotamus	Grass hay free choice 10–25% mixed prairie or legume hay Grain supplement – 50% equine pellets – 50% dairy conditioner } 6–8 liters Yellow vegetables, fruit – 2–3 kg
Elephant	Grass hay free choice 10–25% mixed prairie or legume hay Grain supplement – 50% equine pellets – 50% dairy conditioner } 8–20 liters Yellow vegetables, fruit – 3–5 kg

yellow vegetables and fruit. The tapir diet may also be supplemented with 0.1 to 0.2 kg of a complete carnivore diet. A grass hay (i.e., timothy) should be available to these animals at all times during the day. The grain supplement and vegetables should be fed along with hay in the evening as an inducement to return to the stall.

Complete equine diets have been used successfully (Table 18–8).[198]

Requirements

The basic nutritional and dietary requirements of zebras, tapirs, rhinoceroses, hippopotamuses and elephants approximate those of the domestic horse.[1, 5, 150, 198, 207]

WATER: Water is consumed in relatively large amounts by animals presented in this section. Water should be provided *ad libitum* for all species kept outside and for all kept inside except the elephant.

The elephant should be hand watered indoors, keeping in mind the huge quantity required. The adult elephant will drink 130 to 160 liters of water per day.[180] There is a 40 liter loss of water in the urine; more than 20 liters are lost through vaporization from its lungs and skin.[180]

CARBOHYDRATES: Carbohydrates and starches provide the major source of energy for zebras, tapirs, rhinoceroses, hippopotamuses, and elephants.[1, 5] Both the domestic horse and the elephant require 12 to 13 calories per kg of body weight per day for the basic metabolic processes.[1, 5, 8, 180, 180] This value is probably also valid for the zebra, tapir, rhinoceros, and hippopotamus.

A failure to provide sufficient dietary calories in the growing equidae, tapir, rhinoceros, hippopotamus, and elephant will result in insufficient weight gains and stunted skeletal growth. Working animals, females in late pregnancy, lactating females, and weanlings require 50 to 100 per cent more energy over and above the basal metabolic requirements. Hay or good pasture alone are reportedly sufficient to provide

TABLE 18–8 COMPOSITION OF A COMPLETE EQUINE DIET[198]

EQUINE DIET–5 MM VIA PELLET	(%)
Corn cob	31.55
Yellow corn	20.00
Soybean meal (44% crude protein)	25.00
Alfalfa meal (17% crude protein)	5.0
Cane molasses	5.0
Wheat	10.0
Soybean oil	1.0
Trace mineral salt (0.8% Zn)	0.5
Ground limestone (38% Ca)	0.7
Mono-dical phosphate (18% Ca, 21% P)	0.8
Vitamin and Se premix*	0.25
Calcium propionate	0.20

COMPOSITION *Crude Protein*	*Ether Extract*	*Sol. Carbohydrate*	*Ash*	*Ca*	*P*	*Gross Energy*
16.1%	2.1%	34.1%	5.1%	0.65%	0.45%	4.04 KCal/gm.

*3300 IU vitamin A, 220 IU vitamin D, 44 IU vitamin E, 1.1 mg riboflavin, 5.5 mg niacin, 3.3 mg pantothenic acid, 13.2 μg B_{12} and 0.2 ppm Se per kg of diet.

enough calories for maintenance of a non-working adult animal.

PROTEIN: Dietary protein requirement levels range from 8 to 10 per cent of total intake in the mature animal for maintenance.[4,5] Thirteen to 14 per cent levels are required by growing animals and lactating females. The amino acid lysine is especially important to the animals presented in this section. A level of 0.6 to 0.7 per cent of lysine is required in the diet for proper bone matrix development.[90] Protein makes up 20 per cent of fresh bone weight.

Legume hays or pellets have adequate levels of protein and are high in their lysine content. Soybean meal contains more lysine than most other vegetable proteins.

Poor quality protein in the diet will result in poor hair coats in the equid and tapir. Excess protein in the diet may be responsible for abnormal rates of hoof growth and horn growth in the rhinoceros (Fig. 18–19).[207]

LIPIDS: The serum lipids of the elephant are found in the similar concentrations to those of the rat and the rabbit, suggesting similar systems of fat metabolism. Insufficient levels of essential fatty acids will produce dry, scaly skin.[4,5] Most grain supplements contain sufficient levels of the essential fatty acids.

VITAMINS:

Vitamin A. Avitaminosis A produces skeletal fragility, fractures, and deformities.[4,5,90] Vitamin A is required for the normal growth and development of the epiphyseal cartilage.

Early signs of avitaminosis A may include lacrimation, anorexia, progressive weakness, abscess of the sublingual glands, ataxia, birth defects, and persistent reproductive problems.[61,90]

Twenty-five IU of vitamin A per kg per day is sufficient for maintenance, but requirements increase to 40 IU per kg per day for growth and 50 IU per kg per day for pregnancy and lactation.[1]

Thiamine (B_1). A dietary level of 0.11 mg per 45 kg of body weight will maintain peak food consumption.[4,5] Thiamine deficiency produces anorexia, weight loss, ataxia, hypertrophy, and dilation of the heart. Consumption of Bracken fern or Equisetum produces thiamine deficiency in the domestic horse and probably in the exotic equids.[4,5]

Parenteral administration of 50 to 100 mg of thiamine daily will reverse the clinical course in one to three days.

Riboflavin (B_2). A dietary deficiency of riboflavin causes periodic ophthalmia, catarrhal conjunctivitis, photophobia, and lacrimation.[4,5] A level of 0.05 mg per kg per day will prevent and reverse clinical signs in the domestic horse.[1]

Figure 18–19 A, Trimming excessive hoof growth in a tarpan horse immobilized with M99. B, Normal horn of free-ranging white rhinoceros. C, Excessive horn growth in a captive white rhinoceros.

Niacin. A dietary deficiency of niacin rarely occurs in the equine; however, a dietary level of 0.10 mg per kg is recommended.[4,5]

Ascorbic Acid (Vitamin C). The ascorbic acid content of elephant milk is reported to be four times greater than the level found in bovine milk, giving rise to the theory of a large ascorbic acid requirement in the growing elephant. No dietary supplementation is necessary in adult diets, as normal intestinal flora are thought to produce adequate amounts.

Vitamin D. Avitaminosis D produces rickets.[4,5,200,207] Rickets has been reported several times in hand-reared elephants and will undoubtedly occur in all animals of this group not offered sufficient dietary levels of vitamin D.[207]

The classic lesions of rickets (enlarged articulations and widened epiphyses) have been reported in the hand-reared Asian elephant. Radiographic examination of the articulations of suckling animals will easily confirm the diagnosis of rickets.

Prevention and treatment of rickets require sufficient levels of dietary vitamin D. The vitamin D requirement for the equid is 220 IU per kg of diet.[4,5] These levels will also prevent rickets in the other species of the group.

Hypervitaminosis D has been reported in the domestic horse and should be considered a possibility when examining diets. Hypervitaminosis D is characterized by loss of weight, hypercalcemia, lameness, and extensive calcification of elastic tissue, including the elastic media of the aorta and the suspensory ligament system.

Vitamin E (α-tocopherol). Hypovita-

minosis E/selenium is recognized as a significant problem in both the domestic and exotic equine.[89, 207] Both nutritional myodegeneration and steatitis have been reported in the Grevy's and the Grant's zebra.[89, 207] One study revealed a seasonal fluctuation of liver concentrations of selenium in free-ranging exotic animals from a low of 625 $\mu\mu$g per gm dry weight in January to a high of 1000 $\mu\mu$g per gm dry weight in March.[80] There has been a great deal of discussion about "capture myopathy" in free-ranging ungulates, especially zebras. The clinical syndrome presented is very similar to that of azoturia in the domestic horse. One published report describes acute muscular dystrophy in the zebra as "azoturia" with myocardial infarction. The CPK and SGOT levels are elevated in capture myopathy, azoturia, and the myodegeneration syndrome produced by vitamin E/selenium deficiency.[84, 92, 113, 221] The acute or subacute collapse of the ungulate following exercise is typical of all three syndromes.

Clinical signs of vitamin E/selenium deficiency are characterized by weak or stillborn young, young unable to find the udder, weak pasterns in the front and rear limbs (Fig. 18–20), ataxia, sudden collapse following exercise, dyspnea, icterus, anemia, and rapid, weak pulse.[89] The normal CPK level for equines is 20 sigma units; increased levels of 400 per cent or more have been reported in zebras with muscular dystrophy following exercise.

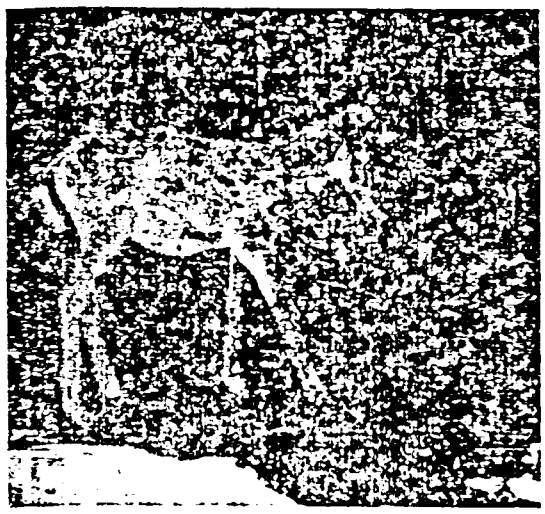

Figure 18–20 Onager foal showing limb and pastern weakness typical of selenium deficiency. (Courtesy of E. Maschgan, Chicago, Illinois.)

Gross pathology of hypovitaminosis E/selenium includes pale skeletal and cardiac muscles, especially the adductor muscles. Pale linear areas may be observed throughout the heart, the liver is enlarged, and there are hemorrhages of the adrenal cortex, subcutaneous and intramuscular edema, and cardiac ventricular septal defects.[89]

Microscopic lesions of vitamin E/selenium deficiency are characterized by hyaline and granular degeneration of the skeletal and cardiac fibers.[89] There is coagulation and fragmentation of the sarcoplasma. Mineralization of dystrophic fibers, muscle fibers separated by edema, formation of "retraction caps," and interstitial fibroplasia have been reported in zebras and domestic horses (Fig. 18–21).[89, 221]

The administration of one liter of normal saline with 1000 mEq. of sodium bicarbonate has been reported to be useful in alleviating the acute clinical signs of capture myopathy in a limited number of zebras following long chases.[51, 89] The parenteral administration of vitamin E-selenium during the acute phase of the syndrome; e.g, azoturia, capture myopathy, nutritional muscular dystrophy, has produced variable results. Dietary levels of 44 IU of vitamin E and 0.2 ppm selenium per kg of diet appear to meet the needs.[5]

MINERALS: The mineral requirements per kg of feed for the zebra, exotic equine, tapir, rhinoceros, hippopotamus, and elephant appear to be equal to those for the domestic horse.

Calcium and Phosphorus. Because of the large size of the animals presented in this section, the importance of dietary calcium and phosphorus throughout life cannot be overemphasized.[4, 5, 190, 207]

Nutritional secondary hyperparathyroidism (NSH) occurs frequently in young elephants and zebras raised on a high phosphorus, low calcium diet.

Clinical signs of calcium deficiency in young, growing zebras, tapirs, rhinoceroses, and elephants are characterized by pica, lameness, pathological fractures, limb and facial deformities, and reluctance to move (Fig. 18–22). Free-ranging elephants will eat the limestone brought into calcium deficient areas for road beds. Radiographic examination of calcium deficiency or nutritional secondary hyperparathyroidism is

Figure 18–21 *A*, Longitudinal section of skeletal muscle with extensive hyaline and granular degeneration of muscle fiber. (×100). *B*, Section of skeletal muscle with marked mineralization of dystrophic fibers. Note deposition of mineral along cross striations.

characterized by the "lipping" of an epiphyses of relatively normal width (Fig. 18–23), folding fractures, and fibrous osteodystrophy. The normal alkaline phosphatase activity for an Asian elephant is 4 to 15 KA units per ml; an elevation over 20 KA units per ml is significant (Fig. 18–24).

The dietary Ca:P ratio for all of the animals in this group should be 1:1. The NSH syndrome may be reversed by correction of the ratio to 1.4:1 until clinical recovery occurs, then returning it to 1:1. As a rule of thumb, 3.3 mg each of dietary calcium and phosphorus should be provided daily for each 100 kg of body weight.[90]

Copper. Deficiency of copper in the domestic equine and zebra, and probably in the other species presented in this group.

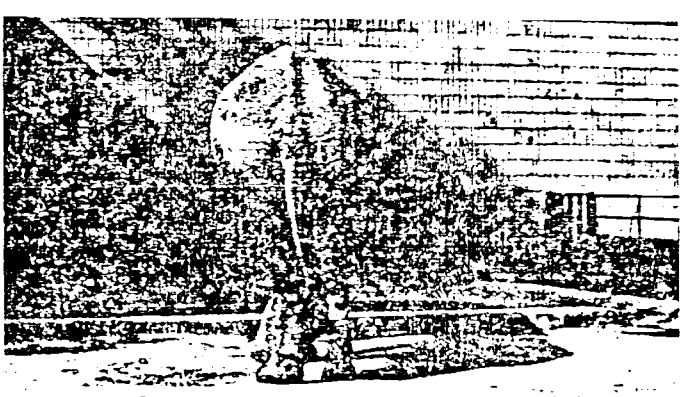

Figure 18–22 Deformity of leg in elephant with calcium deficiency.

Figure 18–23 Anteroposterior and lateral radiograph of right tibiotarsometatarsal area of an elephant with a deformity produced by calcium deficiency. (From Siegel, I. M., J.A.V.M.A. *163*:544–545, 1973.)

produces anemia, achromotrichia, spinal cord demyelination, myocardial fibrosis, and ricketts-like bone disorders.[90] Excessive dietary molybdenum causes a relative copper deficiency.

The equine dietary requirement for copper is 5 to 10 ppm per day.[4, 5, 90]

Iron. Iron is required in the domestic equine at the rate of 40 ppm.[4, 5] Most high forage diets contain sufficient iron.

Manganese. This is required for synthesis of chondroitin sulfate, an important constituent of cartilage and bone matrix. Deficiencies of manganese produce shortened, bowed limbs with enlarged joints and congenitally contracted tendons. Most high forage diets contain sufficient manganese.

Zinc. Zinc deficiency in the equidae produces poor growth, parakeratosis, and a lowered alkaline phosphatase. Growing horses fed 0.54 per cent zinc develop anemia, swelling of the epiphyses of the long bones, stiffness, and lameness; 40 ppm in the feed appears to meet the needs of the equine and probably the other animals in the group.[5, 90]

Selenium. This is an important trace mineral that is required for the health of skeletal muscle, cardiac muscle, liver, and fat. It is discussed with vitamin E. Excesses of selenium (5 to 40 ppm) in the diet cause loss of mane and tail hair and a ring of

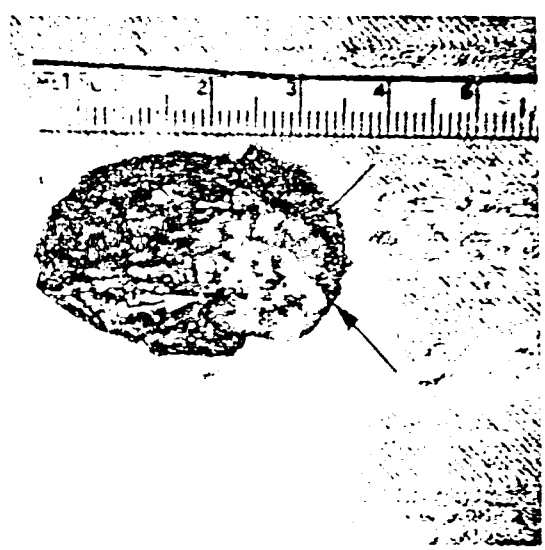

Figure 18–24 Thyroid gland and hypertrophied parathyroid gland (arrows) from a tarpan horse with nutritional secondary hyperparathyroidism

disturbed growth on the hoof below the coronary band. In severe cases, the hoof may slough off. Dietary levels of 0.2 ppm per kg of diet appear to be adequate.[5,138]

Iodine. Iodine deficiency results in abnormal growth rates, goiter, abortion, and brittle skeletal matrix. The requirement may be considered to be about 0.2 mg per day. Weekly oral doses of 1 gm of potassium iodide may be useful in iodine deficient areas.

Salt. Sixty to 85 gm per day or 0.5 per cent of the diet is required for the domestic horse and probably all animals in this section.[4,5]

BEHAVIOR AND TRAINING

Most of the equids, tapirs, rhinoceroses, elephants and hippopotamuses are social animals, living in groups. The black rhinoceros, the pygmy hippopotamus, and the older bull elephants are exceptions that normally live singly. In captivity, these animals should be kept in groups except the black rhinoceros and the pygmy hippopotamus, which are normally housed singly and are put together only for breeding. In captivity the zebra, exotic equid, tapir, rhinoceros, and elephant can become victims of a low quality environment with no occupational therapy. Stereotyped behavior such as pacing, walking figure eights or circles, swaying, rocking in place, coprophagia, "cribbing" (Fig. 18–25), anorexia nervosa, and self-mutilation (rubbing off of tusk or horn) (Fig. 18–26)[129] are all signs of behavioral disease.

The availability of grass hay ad libitum during the day, and especially while confined at night, will provide sufficient occupational therapy for most ungulates. Public feeding of zoo and circus elephants has been a pastime for hundreds of years, providing enrichment for both elephant and guest.

The placement of large "toys" in the form of edible reed baskets, pools, logs, and boulders (Fig. 18–27) will add quality to the outdoor enclosures. The "toys" provide intermittent outlets for occupational urges and social interactions.

Training sessions are useful, especially for the elephant, in providing routine occupational therapy.

Zebras raised on modern diets have been successfully trained to carry a man in a saddle and to work in a tandem hitch to pull a wagon (e.g., R. B. Rice Sausage Co., Lee's Summit, Missouri).

The Asian elephant has a long history of being trained to work for man either as a beast of burden or a performing animal. The African elephant has been trained less often; however, if they are procured at a young enough age, they will perform as well as the Asian elephant.

The training of the elephant is easiest on both elephant and trainers when it is begun at an early age. The most basic control of an elephant is the animal's respect for the human. When a single elephant is being trained, the animal should be tethered at

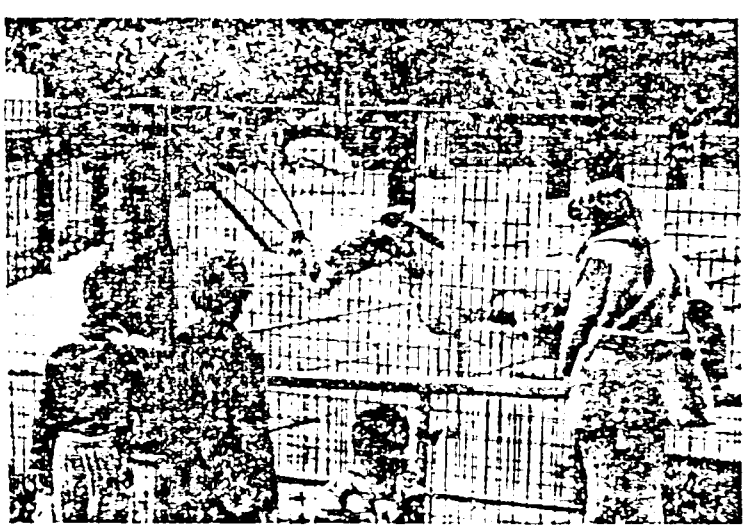

Figure 18–25 Cribbing barrier between territory of onager jack and that of closely approximated male oryx antelope. Behavior depicted is redirected aggression.

Figure 18–26 A, Groove worn in posterior aspect of anterior horn (arrow) in a white rhinoceros. This self-mutilation was produced by constant rubbing of the horn on a cable fence. *B*, Posterior horn mutilation caused by rubbing on concrete.

night by a front foot. If several elephants are in a picket line, they should be tethered by the front and rear feet.

Steel tether chains should be 3.3 to 4.0 meters long and attached to floor mounted rings or picket chains. The chain used to encircle the elephant's leg should first be passed through a rubber or canvas hose to protect the animal's skin. The chain should have a swivel in its middle to prevent twisting and should be secured around the elephant's leg with a lock.

Permanent water containers should never be placed in the night stall. The trainer or keeper should provide water two or three times per day inside the stall with the elephant chained. The grain and fruit supplement should be fed inside in the evening to ensure that the elephant will come in at night.

Once the elephant willingly accepts night chaining, the remainder of the training may begin. The elephant is then introduced to the elephant hook, or "bull" hook. The bull hook may be used to push or pull the elephant sufficiently to physically reinforce the voice command and should be applied to the rowdy elephant by the trainer as a father would use a hickory switch on a disobedient child. Care must be taken to

Figure 18–27 Grant's zebra using artificial termite nest as territorial reference point.

avoid sharpening the hook or spike portion of the bull hook too much and also to avoid poking the elephant in the eye.

Easy behaviors include "come up" (forward), back up, steady (stop), lifting the feet, trunk up, head down, and climbing onto tubs. All of these behaviors involve simple tugging or pushing at appropriate pressure points (Fig. 18–28*A-D*).

The more difficult behaviors, such as tub sitting, hind leg stands, and lie down, require the use of additional chains and a block and tackle (Fig. 18–29*A* and *B*). "Raking" an elephant, which is the manual removal of feces from the rectum, is performed by trainers to prevent defecation during performances (Fig. 18–30). A trained elephant is valuable and safe; a "spoiled" elephant is dangerous und usually winds up being given euthanasia after it injures or kills a handler.

MEDICINE

Medical procedures and principles of the domestic horse are applied to the exotic equines, tapirs, rhinoceroses, elephants,

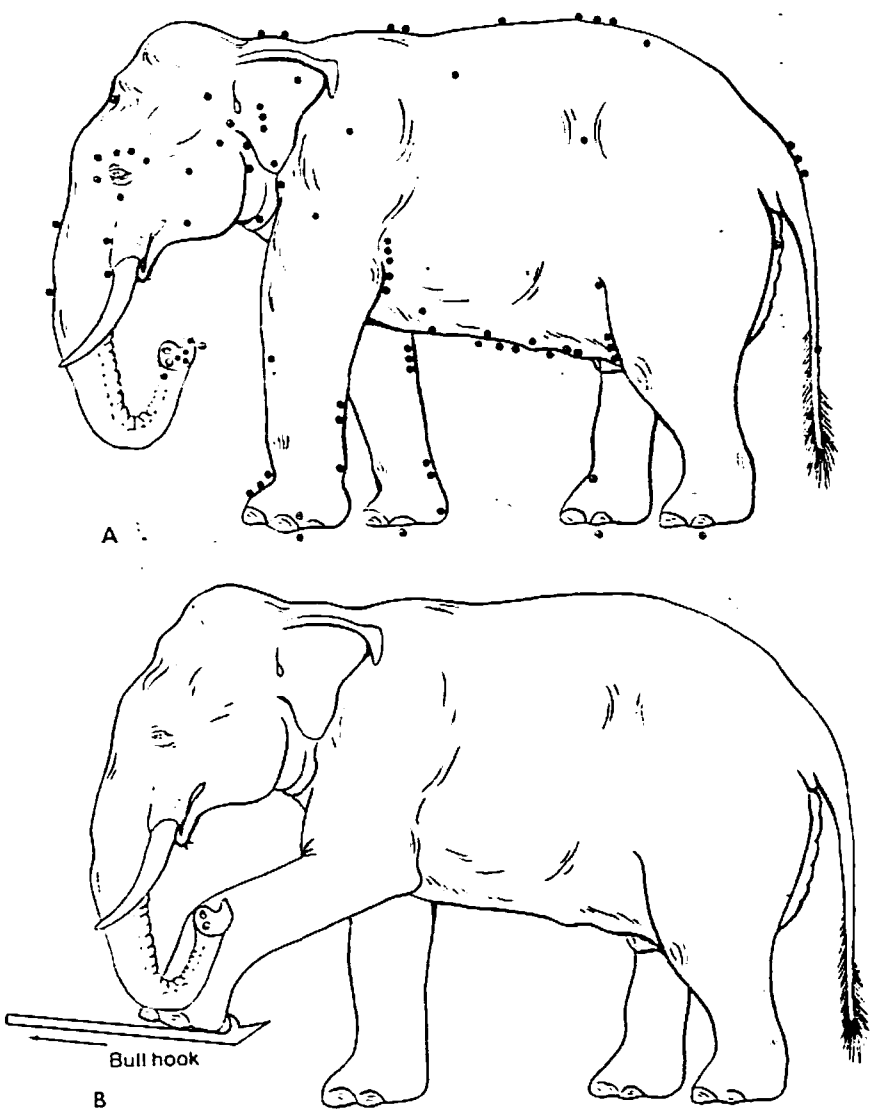

Figure 18–28 *A*, Locations of the sensory points on a domesticated Asian elephant. *B*, Simple foot lift: lift foot up and forward.

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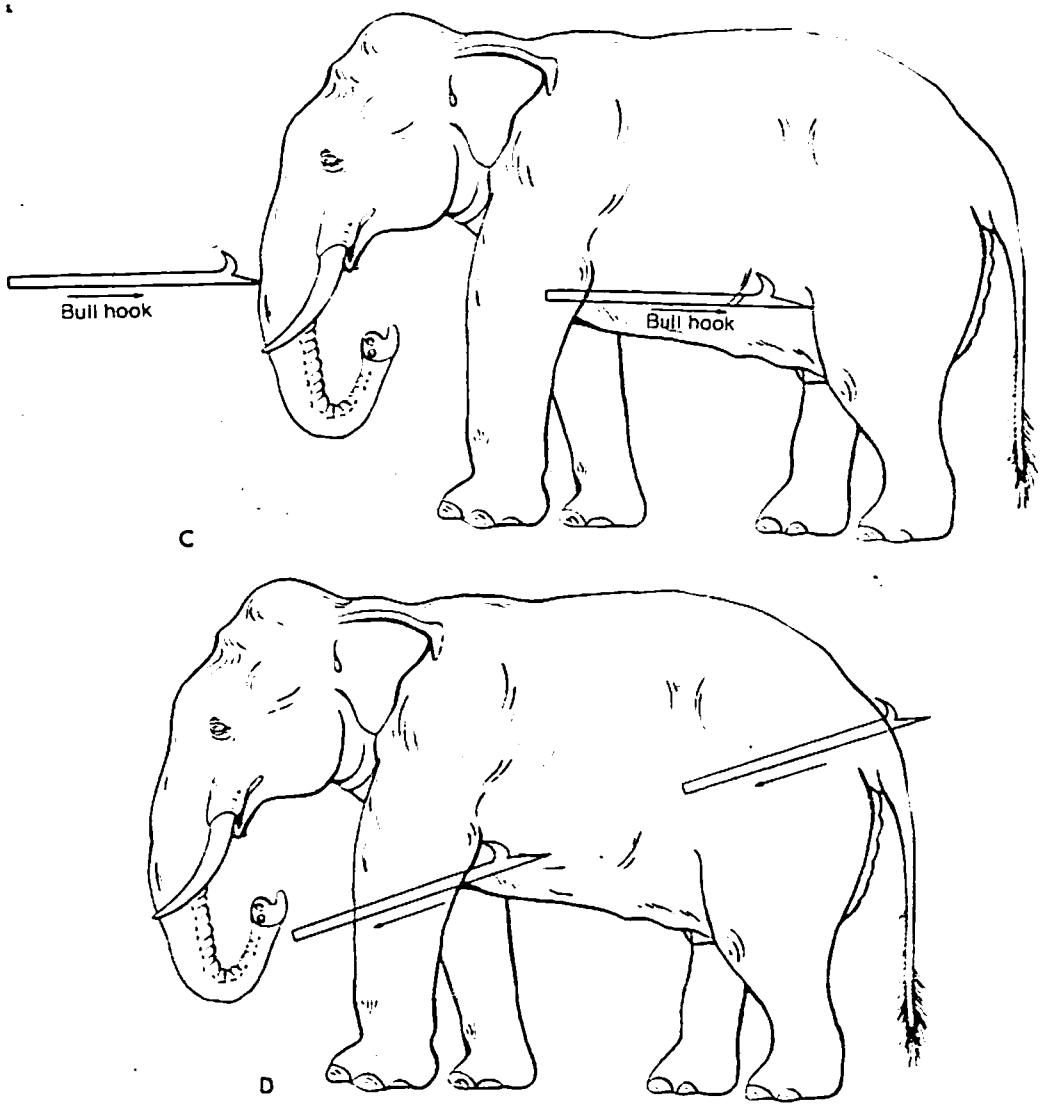

Figure 18–28 Continued *C*, Simple "back up"; apply steady, firm pressure. *D*, "Come forward"; apply steady pull. (From Deranygala. *In* Sykes Natural History of the African Elephant.)

and hippopotamuses. The pharmacological principles are the same, and the drug dosages used parallel those used for the domestic horse, on a by-weight basis.[167] Drugs are administered topically by the use of a water gun or spray bottle. Intramuscular drugs are administered via the dart gun (Appendix 00), pole syringe (Appendix 00), or hand syringe. Oral medications are mixed in the vegetables or mixed with molasses before being put in the grain.

INFECTIOUS DISEASES

The zebra, exotic equine, tapir, rhinoceros, hippopotamus, and elephant are susceptible to many of the infectious and contagious diseases of the domestic horse.

STREPTOCOCCOSIS (*β-hemolytic Streptococcus* spp.): This has occurred in zebra foals and tapirs.[102] The syndrome is characterized by submandibular abscesses, purulent arthritis, navel ill, and septicemia (Fig. 18–31 and 18–32).[158]

Clinical signs of streptococcosis include depression, hot, enlarged joints, anorexia, draining submandibular abscesses, navel ill, and death. The exudate is usually a creamy gray color.

Diagnosis of streptococcosis requires finding the organism in stained smears of the exudate or culture of the gram-positive

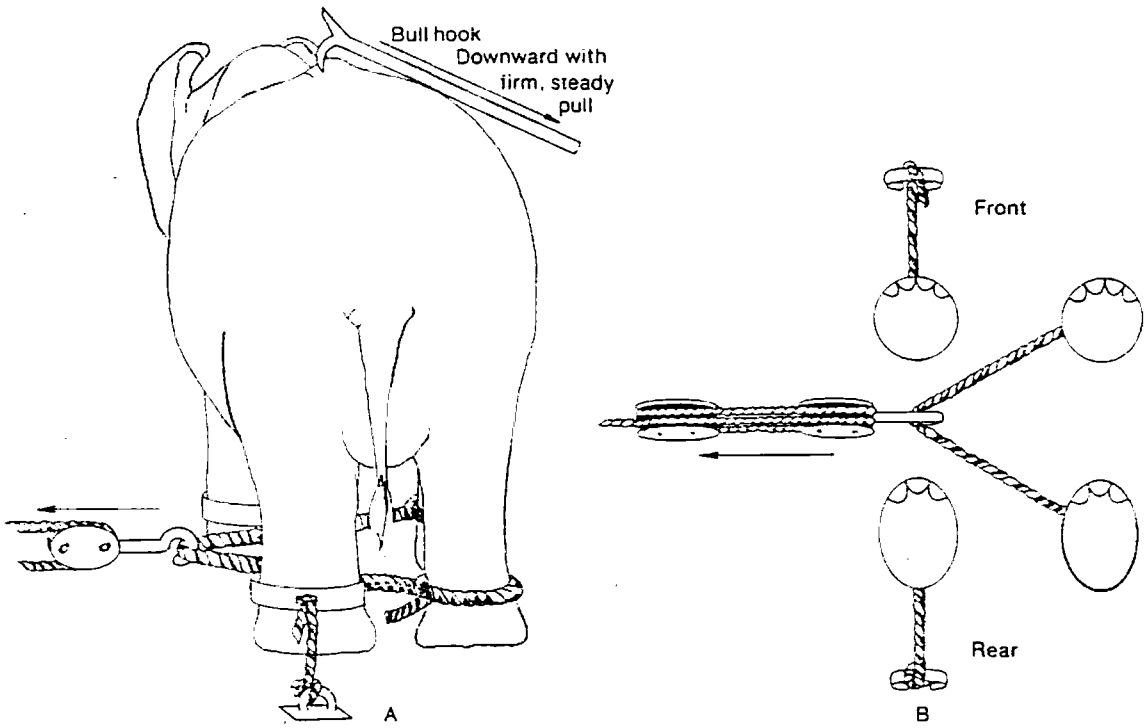

Figure 18–29 *A* and *B*. Block and tackle rigging for "laying down" an elephant.

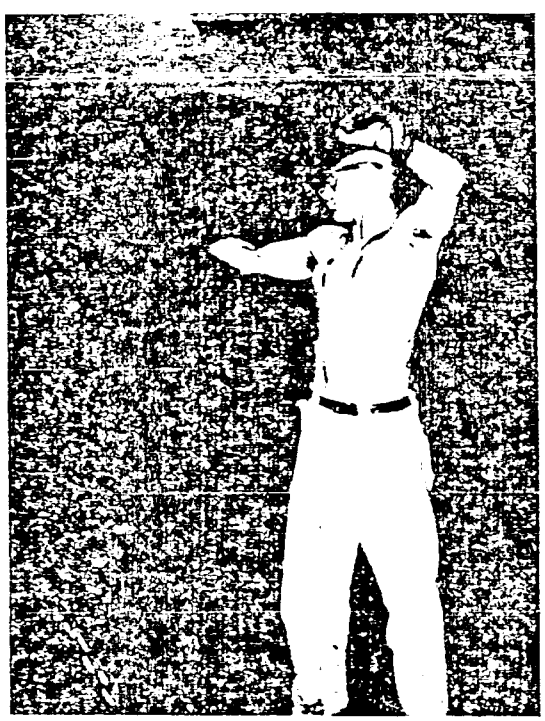

Figure 18–30 "Raking," or manually removing feces from an elephant prior to a performance to prevent bowel discharge during performance. (Courtesy of Floyd Smith, St. Louis Zoological Gardens, St. Louis, Missouri.)

cocci. Blood agar is required; growth of streptococcus will occur in 24 hours when incubated at 37°C.

Treatment of streptococcosis should include the parenteral administration of penicillin or other effective antibiotics.

ANTHRAX (*Bacillus anthracis*): Anthrax has been reported in the zebra, Asian elephant, African elephant, and hippopotamus.[21] The etiologic agent, a large gram-positive bacteria, ranges in size from 5 to 8 μ in length by 1.0 to 1.25 μ in width.[21] Anthrax is transmitted by predators, scavengers, and airborne dust.

Clinical signs of anthrax include peracute to acute onset, septicemia, and rapid death. In the subacute form, lameness, ataxia, and bloody discharge from the nostrils and anus precede death. In the chronic form, Asian elephants have shown cervical swelling very similar to that reported in swine.[21]

Diagnosis of anthrax may be made by finding the large gram-positive bacilli in blood smears made from peripheral blood. Care must be taken while collection of the sample is being made, as other animals and man are very susceptible to the disease.

Figure 18–31 Two-month-old river hippopotamus with an abscess on its shoulder.

Postmortem lesions of anthrax include a generalized rapid decomposition, subcutaneous edema, blood oozing from natural body openings, failure of blood to clot, hepatic congestion, and splenomegaly.

Treatment of anthrax should include the parenteral administration of penicillin. Avirulent spore vaccines are available from the Republic of South Africa.

MANDIBULAR ABSCESSES *(Corynebacterium pyogenes):* These have occurred with great frequency in both the South American and the Malayan tapir.[2]

The clinical signs of corynebacterial mandibular abscesses parallel those of streptococcosis.

Diagnosis of corynebacterial infection may be suggested by the appearance of the grayish-yellow purulent exudate but can be confirmed only by culturing the gram-positive bacilli from the exudate. The organisms grow somewhat slower on blood agar than do *Streptococcus* spp., appearing within 24 to 48 hours. The ivory-white colonies do not exhibit hemolysis.

Treatment of *Corynebacterium* mandibular abscesses should include the parenteral administration of penicillin or other sensitive antibioties and local therapy to establish drainage. Flushing with saline or Betadine, then instilling sulfonamides will produce dramatic results.

SALMONELLOSIS (*Salmonella london, Salmonella* spp.): This disease has been reported in the Asian elephant, rhinoceros, and tapir.[82, 159, 219]

Clinical signs of salmonellosis parallel those in the domestic species: gastroenteritis, loss of body weight, enophthalmia, anorexia, and dehydration.

Diagnosis of salmonellosis may be made by fecal culture or serological investigation. Salmonella bacilli are gram-negative nonlactose fermentors that can be grown on S. S. agar incubated at 37°C.

Treatment of salmonellosis is difficult at best. Dehydration and electrolyte imbalance should be corrected while antibiotic therapy is being conducted. Sulfonamides, tetracyclines, and chloramphenicol may be considered in dosages calculated at the standard levels recommended for the equine.

PASTEURELLOSIS *(Pasteurella multocida, P. pseudotuberculosis):* Pasteurellosis has been reported in the elephant and has been cultured by the author from the zebra and tapir.[30, 159, 216] Pasteurella organisms have a worldwide distribution and are usually passed through food contaminated by infected mice.

Clinical signs of pasteurellosis in the zebra, tapir, and elephant include hemorrhagic septicemia, pleuropneumonia, dyspnea, gastroenteritis, and depression.

Figure 18–32 Malayan tapir with a lanced abscess on its leg.

Diagnosis is usually made by correlating the history and the clinical picture, and by identifying the specific causative organism. The gram-negative coccobacilli range from 0.3 to 1.25 μ in length and will grow on most nutrient agars when incubated at 37°C.[159]

Postmortem lesions of pasteurellosis include splenomegaly, hepatic congestion, hemorrhage of lymph nodes, and petechial hemorrhages on lungs, epicardium, kidneys, and adrenals. Upper respiratory infections including tracheitis and red hepatization of the lungs are common findings. Pseudotuberculosis is characterized by miliary abscesses scattered throughout the tissues, including the spleen, liver, and lymph nodes.

Treatment of pasteurellosis should include the use of tetracyclines and sulfonamides. Commercial bacterins are available when a chronic problem occurs.

BIG HEAD (*Clostridium sordelli*): This has been reported in an adult black rhinoceros.[9] Big head is characteristically an infectious disease of young rams caused by the large anaerobic gram-positive bacilli *C. sordelli*, *C. novyi* or *C. chauvoei*. The infective organisms enter the broken skin following trauma. The traumatized subcutaneous tissues are ideal for clostridial growth.

The characteristic clinical sign of big head is edematous swelling of the head, neck, or shoulders. Ataxia and anorexia are commonly observed.[3]

Diagnosis may be made from the clinical appearance of the animal in conjunction with a history of peracute onset and of fighting or self-injury prior to infection.

The characteristic postmortem lesions are clear edematous swellings without the presence of gas or hemorrhage.

Treatment of big head should include large parenteral doses of penicillin.

TETANUS (*Clostridium tetani*): Tetanus has been reported twice in Asiatic elephants and should be considered in the differential diagnosis of nervous system and musculoskeletal disorders of zebra and other exotic equids.[14, 66] As with the domestic species, the signs of tetanus are caused by the exotoxin produced by the large gram-positive bacillus, *C. tetani*. The organism does not grow in healthy tissue, usually finding a deep puncture wound with a low oxygen tension as a growth site.

The characteristic clinical signs of tetanus in the elephant are nervous system and musculoskeletal abnormalities. A stiff gait, muscle rigidity, difficulty in prehension and swallowing, and increased sensitivity to loud or physical stimuli are common findings. Anorexia, adipsia, lameness (site of puncture wound), reluctance to open the mouth, pressing of the head against a wall, enophthalmos, and physical collapse were the terminal sequences of reported events.

The diagnosis of tetanus in the elephant is made on the basis of the characteristic clinical signs.

Postmortem lesions of tetanus are limited to the original puncture wound (Fig. 18–33) and dehydration.

Treatment and prophylaxis of tetanus in

Figure 18–33 Nail in the foot of an Asiatic elephant that died of tetanus. (Courtesy of Thomas Burke, University of Illinois, Urbana, Illinois.)

Figure 18–34 Performing an intradermal tuberculin test in the tail fold of an elephant. (Courtesy of M. Fowler, University of California, Davis, California.)

the exotic equine and the elephant parallel those used for the domestic horse.[53] Tetanus antitoxin (TAT) should be administered at the rate of 200,000 to 250,000 units every six hours, or as needed; in addition, 30 million units of procaine penicillin should be administered IM every six hours. The original wound should be identified, the foreign object removed, and drainage established. One of the two reported elephants died; it received only 30,000 units of TAT. Reestablishment of good hydration and electrolyte balance along with good nursing care will hasten recovery.

TUBERCULOSIS (*Mycobacterium bovis, M. tuberculosis*): This has been reported in the South American tapir, Malayan tapir, woolly tapir, black rhinoceros, Asiatic elephant, and African elephant.[65,117,150,153,180,222]

Clinical signs of tuberculosis in the zebra, tapir, and pachyderms include lameness, depression, emaciation, dyspnea, and coughing.

Diagnosis of tuberculosis in the zebra, tapir, and pachyderm requires the use of an intradermal tuberculin test. The site of choice is the caudal skin fold (Fig. 18–34). The test is performed in the standard manner, by injecting 0.1 ml of tuberculin (Jensen-Salsberg Laboratory) intradermally. The test site should be visually and physically examined at 24, 48, and 72 hours post injection. Further diagnostic tests include those of tracheal and gastric washings (Fig. 18–35).

Postmortem lesions of tuberculosis in the tapir, rhinoceros, and elephant have been characterized by abscesses or granulomas in the pelvic cavity, lungs (Fig. 18–36), lymph nodes, and spleen.

Microscopic lesions of tuberculosis were characterized by the typical tubercle formation; however, no giant cells were recorded in the tissues of the African elephant.

Figure 18–35 Using a bronchoscope on an Asiatic elephant to examine the trachea and bronchi for tuberculous lesions and to obtain tracheal washings.

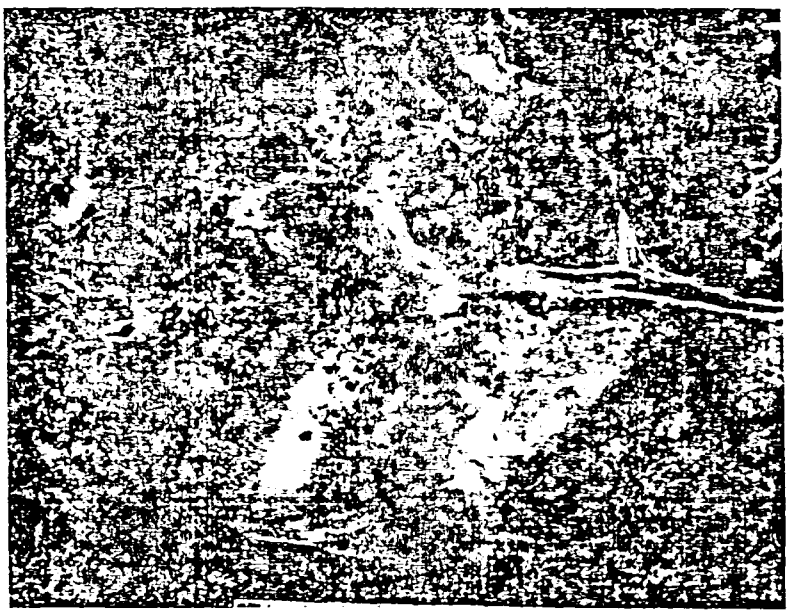

Figure 18–36 Lung of a black rhinoceros with tuberculosis. Cavitation and tubercles characterize infection with *M. tuberculosis*. (From Powers, R.D., and Price, R.A., J.A.V.M.A. *151*: 890–892, 1967.)

Treatment of tuberculosis has not been reported in the zebra, tapir, rhinoceros, hippopotamus, or elephant. Tuberculosis is a reportable disease; euthanasia should be recommended. If treatment is deemed necessary because of the rarity of the animal, isoniazid should be considered.

FOOT AND MOUTH DISEASE: This disease has been reported in the South American tapir, Malayan tapir, and Asian elephant.[34] The foot and mouth virus is a picornavirus that is resistant to environmental changes for one year. Transmission occurs by ingestion of contaminated feed. The virus is shed in all excretions of sick animals, including urine, feces, saliva, milk, and semen. The virus of this disease is shed before the animal becomes clinically ill, and saliva can be infective for up to six months following clinical recovery.

Clinical signs of foot and mouth disease include elevated rectal temperature, depression, anorexia, acute painful stomatitis, excessive salivation, ulcerations, and vesicle formation on the buccal mucosa, hard palate, and tongue. The vesicles rupture 24 hours after they appear, leaving raw, painful ulcers. Vesicles appear on the feet, in the area of the coronary band, two to three days later in survivors. Full clinical recovery may take as long as six months.

Diagnosis of foot and mouth disease may be made from the typical clinical appearance of the affected animal. Confirmation of the diagnosis requires employment of the complement fixation test or the intradermal injection of oral vesicle fluid into the foot pad of a guinea pig. Vesiculation will occur in one to seven days in positive cases; secondary oral vesicles appear one to two days later.

Postmortem lesions of foot and mouth disease parallel those seen during the clinical course of the disease.

Microscopic lesions are characterized by ballooning of the cells of the epithelial stratum spinosum, which slough, the nuclei become pyknotic, and the cytoplasm becomes eosinophilic. Edema and neutrophilic infiltration follow and are accompanied by liquefaction necrosis, resulting in the formation of vesicles.

Treatment for foot and mouth disease has not been reported. It is a reportable disease of great importance to the domestic livestock industry.

RINDERPEST: Rinderpest has been reported in the zebra, hippopotamus, and Asian elephant.[172] The etiologic agent is a myxovirus related to human measles and to the canine distemper virus. Rinderpest is primarily a disease of ungulates, especially the artiodactyla (cloven-hoofed species). Transmission occurs through airborne contamination of feed or direct contact with infected animals or carcasses. Clinically

normal animals shed virus in the early stages of rinderpest. The incubation period can be from three to 15 days.

The characteristic clinical sign of rinderpest is a sudden onset of elevated rectal temperature that lasts for two to three days.[172] Behavior alters from shyness to aggressiveness, and a profuse ocular discharge commonly occurs. Three to four days later, shallow erosions and ulcers appear on the mucosa of the vagina and oral cavity, and there is profuse salivation. Diarrhea appears one to two days after the appearance of the oral and vaginal lesions. Emaciation and precipitous dehydration occur in chronic areas.

Diagnosis of rinderpest can be made following observation of characteristic clinical signs and by postmortem findings. A leukopenia occurs initially but is quickly followed by a marked leukocytosis.[172] Hemoconcentration parallels the dehydration observed clinically. Serology must be used to confirm the diagnosis. Rinderpest is a reportable disease in most countries.

Postmortem lesions of rinderpest parallel the lesions seen during the clinical course of the disease.

Treatment is usually not attempted. Survivors have life-long immunity. Attenuated virus vaccines are available in Europe and Africa.

ENCEPHALITIDES: The equine encephalitides have not been reported as clinical diseases in the zebra, exotic equine, tapir, or pachyderm; however, routine vaccination for equine encephalitis with commercial vaccine is practiced in many zoos and private collections.[17]

Encephalomyocarditis virus has been isolated from four African elephants.[183] Clinical signs were limited to anorexia, listlessness, and moderate dyspnea followed by death in 24 hours. Postmortem lesions included epicardial hemorrhages and severe myocarditis. Diagnosis was made by inoculating tissue suspensions from the elephants into three to four week old mice and into cell cultures.

Encephalitis and myocarditis developed in the mice, and the cell cultures were destroyed in 24 to 72 hours. Intracytoplasmic viral inclusions were observed. The viral agent was neutralized by known antiserum to encephalomyocarditis virus.[183] No treatment is known.

PARASITIC DISEASES

In general, the parasites encountered in zebras, exotic equines, tapirs, and pachyderms are quite similar to those found in domestic equines. The identification and treatment methods are also similar to those used for domestic equines.

Internal Parasites

Babesiosis (synonym, piroplasmosis, *Babesia* spp.) has been reported in the zebra, rhinoceros, and African elephant: *Babesia* spp. in the black rhinoceros, white rhinoceros, and elephant; *B. equi* in the Grant's zebra and Grevy's zebra.[50, 118, 139, 180] The infection is characterized by a hemolytic anemia. Experimental transmission from zebras to horses has been successful.

The characteristic clinical signs of babesiosis in the zebra and pachyderms are hemolytic anemia, icterus, hemoglobinuria, diarrhea, tachycardia, and dyspnea brought on by minor exertion.[50, 125, 139]

Diagnosis may be made by finding the typical paired bodies in the erythrocytes on a stained blood smear or by means of a CF test.[125]

Postmortem lesions of babesiosis include hemolytic anemia, enlarged liver, splenomegaly, icterus, and hemoglobinuria.[50]

Treatment should include a blood transfusion and quinuronium sulfate (Acaprin) administered intramuscularly or subcutaneously at a rate of 1 ml of a 5 per cent solution per 50 kg of body weight.[125, 163, 139]

Trypanosomiasis has been reported in the Asian elephant, the African elephant, and the black rhinoceros: *Trypanosoma evansi* in the Asian elephant and *Trypanosoma* spp. in the African elephant; *T. brucei* and *T. vivax* in the black rhinoceros.[139, 150, 204, 215] Great slaughter campaigns have been carried out against the elephant, hippopotamus, and rhinoceros in early attempts to rid Africa of sleeping sickness by reducing the numbers of reservoir hosts. Field workers could not easily differentiate between *T. evansi* and *T. gambiense* and *T. rhodesiense*.[215] Trypanosomiasis is transmitted by tabanid flies and tsetse flies.

The clinical signs of trypanosomiasis include acute clinical onset, anemia, subcutaneous anemia and emaciation. Chronic and carrier states occur.