BISON, BUFFALO AND CATTLE ADVISORY GROUP

American Zoo and Aquarium Association

Husbandry Manual for Wild Cattle Species

AZA BISON, BUFFALO AND CATTLE ADVISORY GROUP

Husbandry Manual for Wild Cattle Species

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Table of Contents

Species Fact Sheets

American Bison 2
European Wisent 4
Gaur 6
Banteng 8
Wild Yak 11
Kouprey 13
Asian Buffalo 15
Anoa 17
Tamaraw 19
African Buffalo 21

Abiotic Variables

Temperature 24
Ventilation and Humidity 24
Illumination 25
Housing 25
Space 25
Substrates 25
Sanitation 26
Containment 26
Animal Safety 26

Social Considerations

Social Organization 27
Social Groups 27
Mixed Species Groups 28
Bachelor Groups 28
Introductions 29
Human—Animal Interactions 29

Health and Nutrition

Food and Water 30
Diet 31
Body Scoring 32
Medical Management 34
Post-Mortem Protocol 36
Pest Management 36

Reproduction

General Information 36
Contraception 38
Pregnant Animals/Neonates 38
Hand-Rearing Information 39

Management Practices

Capture and Restraint 40
Transport 43
Behavioral Management 44
Training 44
Enrichment 45

Selected References 46

Species Fact Sheet

AMERICAN BISON
(Bison bison)

Some scientists have combined the American and European bison into a single species, because they can interbreed and produce fertile offspring. However, there are clear differences in the physical characteristics between the two, and they have been geographically separated from one another for a long time. There are two species of American bison, the plains bison *(Bison bison bison)* and the wood bison *(Bison bison athabascae)*. The wood bison occurs only in Canada.

Conservation Status

The 2000 IUCN Red List classifies both the plains and wood bison as Lower Risk/Conservation Dependent. The wood bison is listed as Endangered by the U.S. Endangered Species Act and Appendix II by CITES. The plains bison is not listed by either the ESA or CITES.

Current Population Estimates and Distribution

The population of plains bison has been estimated at more than 75,000 and increasing, according to the 1995 CBSG Conservation Assessment and Management Plan. Their survival seems secure. According to the Canadian Wildlife Service (1999), there are approximately 3,500 wood bison (2,800 in the wild and 700 in captivity). Population trends suggest the numbers of wood bison are increasing. Today there are herds of wood bison in Alberta, British Columbia, Manitoba, Yukon, and the southwestern Northwest Territories.

Description

The bison is the largest of the terrestrial North American mammals. It is dark brown, with a massive head, a high hump on its large shoulders, and long shaggy hair on its shoulders and front legs. The bison's short legs end in rounded hooves. The short horns curve inward on the males, but are straight on the females. Males are much larger than the females and can weigh up to 2,200 pounds. The wood bison is generally taller and not as stocky than the plains bison. Bison are long-lived animals, living up to 40 years.

Habitat and Ecology

Wood bison are found in the open boreal and aspen forests with associated large, wet meadows, where they subsist mainly on leaves, shoots, and the bark of trees and shrubs. The plains bison eats prairie grasses and herbs in the summer, and feeds primarily on moss, lichens, and dried grasses in winter. All bison need drinking water and will also eat snow in the winter. Bison typically feed in the morning and at dusk and spend the bulk

of the day resting, ruminating, and grooming themselves by rubbing their heads, necks and flanks on trees. Herd size is typically 15-25 animals, but can grow to 350-400 animals during the breeding season. Herd are composed of maternal groups, with males at the edge of the group.

Captive Programs

There are four captive breeding herds of wood bison in Canada, totaling about 700 animals. There are approximately 500 plains bison in captivity in North America, according to the International Species Information System (ISIS). The plains bison is also well represented in the private sector and on federal lands. Both subspecies can be managed in captivity quite successfully, although facilities and space requirements must be commensurate with the size and power of these animals. Given enough space, bison can be housed with other species peacefully.

Threats

Diseases such as anthrax, brucellosis and tuberculosis and habitat loss through human development, agriculture, forestry and petroleum resource development (in the case of the wood bison) are the main threats faced by bison.

Conservation Measures

The wood bison is protected in Canada against such activities as capture, harassment, trade, and killing, with only a limited number of hunting permits being issued annually. The plains bison is well represented in the private sector and on federal lands and there are no immediate conservation concerns for this species. The Canadian Wildlife Service promotes a number of research, monitoring, recovery and release activities for the wood bison.

Species Fact Sheet

EUROPEAN WISENT *(Bison bonasus)*

Some scientists have combined the American and European bison (or wisent) into a single species, because they can interbreed and produce fertile offspring. However, there are clear differences in the physical characteristics between the two, and they have been geographically separated from one another for a long time.

Conservation Status

The European wisent is Endangered according to the 2000 IUCN Red Data List, based on an assessment by the Bison Specialist Group. This species is not listed by either the U.S. Endangered Species Act or CITES.

Current Population Estimates and Distribution

The most recent estimate of the wild (reintroduced) population of European wisent is greater than 3,200 and increasing, according to the CBSG European Bison Working Group (1995). The current range for European wisent includes Belarus, Kyrgyzstan, Lithuania, Poland, Ukraine, and the Russian Federation, previously the USSR.

Description

The European wisent is the heaviest terrestrial mammal in Europe. They are smaller and more long-legged than the American bison. Like the plains bison, the wisent is dark brown, with a massive head, a high hump on its large shoulders, and long shaggy hair on its shoulders and front legs. The short horns curve inward on the males, but are straight on the females. Males are much larger than the females and can weigh up to 1,800 pounds. Bison are long-lived animals, living up to 40 years.

Habitat and Ecology

European wisent prefer deciduous or mixed forest habitat with moist clearings, where they feed on grasses, herbs, foliage, shoots of shrubs and trees, bark and lichens. In the winter, wisent use their hooves to dig up food buried as deep as a foot. Their activity pattern consists of about 30% of their time feeding, 60% resting, and about 10% moving. Like other wild cattle species, wisent are gregarious and non-territorial. They assemble in maternal groups of up to 20 animals, consisting of adult cows, calves and juveniles two to three years old, and occasionally one or more adult males. Other males may form small bachelor groups or exist as solitary animals.

Captive Programs

European wisent have been successfully kept in captivity for many years. There is currently a large captive population worldwide, with the largest numbers

being held in the European Region (over 250 animals). The International Studbook Keeper is Dr. Jan Raczynski, of the Bialowieza National Park in Poland. The EEP Coordinator is Wanda Olech-Piasecka of the Institute of Biological Foundation in Brwinow, Poland.

Threats

The largest threat to this species is further reduction of their range due to human encroachment. Juvenile wisent are vulnerable to predation by wolves and lynx. Diseases, such as hoof and mouth disease and pasturellosis, and parasites such as the greater liver fluke have taken a toll as well.

Conservation Measures

Since 1980, more than 20 herds of wisent have been reintroduced into Poland and the former USSR. The conservation of this species is dependent on preserving its remaining and reintroduced ranges. Today, more than half of the living population of wisent occurs in conservation areas.

Species Fact Sheet

GAUR *(Bos gaurus)*

The IUCN Asian Wild Cattle Specialist Group recognizes three subspecies of wild gaur: *Bos gaurus laosiensis* (Myanmar to China), *Bos gaurus hubbacki* (Thailand, Malaysia), and *Bos gaurus gaurus* (India, Nepal). The taxonomy of the gaur remains a subject of ongoing genetic research, both *in situ* and *ex situ*.

Conservation Status

The gaur is listed as Vulnerable according to the 2000 IUCN Red Data List, Endangered by the U.S. Endangered Species Act, and Appendix I by CITES. The IUCN rating is based on an overall decline of at least 20% over the last three generations. The 1994 Asian Wild Cattle CAMP listed *Bos gaurus laosiensis* and *Bos gaurus hubbacki* as Critically Endangered.

Current Population Estimates and Distribution

The global population of gaur is estimated to be 13,000-30,000, with a population of mature individuals of 5,200-18,000. The overall population trend is declining. The current distribution of gaur includes the countries of: Bangladesh, Bhutan, Cambodia, China, India, Lao People's Democratic Republic, Peninsular Malaysia, Myanmar, Nepal, Thailand and Viet Nam. The geographical distribution of the present-day gaur approximately corresponds to the remaining large forested areas and the majority of the population is in India.

Description

The gaur is one of the most impressive of the wild cattle, with its muscular build and striking light eyes. Adult males are shiny black with cream-colored leggings and rump patches; young males and females are medium to dark brown with the same markings. The body of the gaur is massive (shoulder height 6 ft), with a large hump at the shoulders, sturdy legs, and a narrow dewlap under the chin and between the front legs. Gaur have huge heads with a bulging forehead ridge between the horns, which are approximately 30 inches in length in the males. Males can weigh up to 2,100 pounds and females 1,600 pounds.

Habitat and Ecology

Gaur inhabit tropical savannah woodlands, tropical monsoon and dry forests and lowland tropical rainforests. Their habitat is characterized by 1) large, relatively undisturbed forest tracts, 2) hilly terrain below an altitude of 5,000 to 6,000 feet (1,500 to 1,800 meters), 3) the availability of water, 4) an abundance of coarse grasses, bamboo, shrubs, and trees. Gaur feed primarily on dry grasses, young shoots, and the fruits of bushes and trees. Their normal pattern of activity is to rest until late morning, when they move into the open forest to graze. They feed in the afternoon and again at night. In between feedings, they rest and ruminate.

In areas of disturbed habitat, the gaur has assumed a more nocturnal lifestyle. Herds number from 6-20 animals and typically consist of a few old bulls, juveniles, and adult cows with calves.

Captive Programs

Gaur have been successfully kept in captivity for many years. There is currently a large captive population worldwide (approximately 250 animals), primarily in the European, North American and Southeast Asian Regions. The IUCN Asian Wild Cattle Specialist Group has recommended establishing captive programs with known subspecific populations. The North American captive population of gaur is currently managed under a Species Survival Plan. The TAG has recommended limited captive breeding of gaur pending clarification of outstanding subspecies issues, in accordance with the IUCN/SSC Asian Wild Cattle Specialist Group Action Plan (1995).

Threats

Hunting and the loss of suitable habitat are the most significant threats to this species. Diseases transmitted by domestic cattle, such as rinderpest and foot-and-mouth disease, pose potentially serious threats as well. Several subpopulations of gaur in India were nearly destroyed as a result of rinderpest in 1968. In addition, the trade in wildlife products, especially trophy horns, takes a toll.

Conservation Measures

Gaur are legally protected in all range states and occur in a number of protected areas. There are several ongoing field survey programs in the range countries, as well as both *in situ* and *ex situ* research programs.

Species Fact Sheet

BANTENG *(Bos javanicus)*

According to the taxonomy adopted by the IUCN/SSC Asian Wild Cattle Specialist Group, there are three subspecies of wild banteng: the Burma banteng *(Bos javanicus birmanicus),* the Javan banteng *(Bos javanicus javanicus),* and the Borneo banteng *(Bos javanicus lowii).* The question of how many (if any) subspecies should be recognized and/or included in captive breeding programs is still unresolved. There appear to be some phenotypic differences between the banteng on Java and the Asian mainland that would warrant classifying them as two different subspecies. There is a need to further assess the genetic and phenotypic variation within the global population of wild banteng in order to determine the validity of the three subspecies that are traditionally recognized.

Additionally, there are unresolved questions about the purity of the genetic status of the captive population. Many founder animals for the captive population were Bali cattle, which is the domesticated form of the wild banteng. Because banteng can interbreed with common cattle, there exists the possibility that zoo populations may contain genetic material from Bali cattle/*Bos taurus* crosses. Domestic and feral livestock are also a threat to the genetic integrity of wild banteng populations and may further cloud subspecies issues.

Conservation Status

Both the IUCN Red Data List and the U.S. Endangered Species Act classify the banteng as Endangered, based on an overall decline of at least 20% over the last three generations. The banteng is not currently listed by CITES, although the IUCN/SSC Asian Wild Cattle Specialist Group is seeking to have them listed as Appendix I and has identified the Burma banteng *(Bos javanicus birmanicus)* as being Critically Endangered.

Current Population Estimates and Distribution

The world population of banteng is unlikely to be more than 8,000 and is quite possibly fewer than 5,000 animals (2000 IUCN Red Data List). Their current range includes the countries of: Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia (Kalimantan; Java; Bali), Lao People's Democratic Republic, Malaysia, Myanmar, Thailand and Viet Nam. No subpopulations of more than 500 banteng are known and only six to eight subpopulations of more than 50 banteng are known to remain (five or six on Java and one or two in Thailand). The population trend on the Asian mainland is downward due to hunting and the trade in wild animal parts, especially horns. The population trend on Borneo is unknown. The banteng populations on Java are relatively stable, although there are

threats due to hunting, habitat destruction and diseases from domestic livestock.

According to Barry Lees of the Tipperary Sanctuary for Endangered Species, there is a large population of introduced banteng in the Northern Territory of Australia, reported to number up to 3,000-5,000 animals. However, these animals are believed to have originated from a British shipment of the domestic form of banteng, the Bali cattle.

Description

The banteng is considered to be one of the most beautiful of all wild cattle species. They are most likely the ancestors to the domestic cattle of Southeast Asia. Banteng are a sexually dimorphic species, with mature males being dark chestnut brown and cows and juveniles reddish brown. Both sexes have white rump patches and leggings. Both sexes carry horns, although they are much heavier and larger in the males. Banteng are smaller and more even of temperament than gaur. Adult males weigh between 1400-1760 pounds (625-785 kg), whiles adult females weigh between 1320-1500 pounds (590-670 kg). Their average lifespan in the wild is 11 years, although they have been reported to live up to 20 years of age. It is very common for captive banteng to live into their late teens or mid-twenties.

Habitat and Ecology

Banteng on the Asian mainland prefer open, dry, deciduous forests. Banteng on Java and Borneo prefer secondary forest resulting from logging and fires, while banteng on Burma inhabit mixed deciduous and evergreen forest. Banteng are grazers by preference, but also consume a lot of browse and fruits depending on season and availability. They feed primarily on grasses, bamboo, leaves, fruits and young branches of woody shrubs. Numbers of banteng within a herd vary, with about a one-third of herds containing ten or more individuals, one-third containing 6-9 individuals, and about one-third of the herds containing five or fewer individuals..

Captive Programs

European zoos imported captive banteng from collections in Indonesia as early as 1867. The North American population of captive banteng has all derived from animals imported from European collections by the Catskill Game Farm, Philadelphia Zoological Gardens, St. Louis Zoo and San Diego Zoo.

Banteng are easily managed in captivity, where they reproduce well and can live into their early twenties. There are about 2,000 animals listed in the historical International Studbook for Banteng with approximately 300 specimens in captivity at the present time.

Threats

The primary threats to banteng are hunting, habitat loss, and the degradation of the species' remaining habitat. Interbreeding with domestic and feral cattle threatens the genetic integrity of the remaining wild banteng in some areas. The number of banteng trophies reported for sale within Cambodia and the Lao PDR, along the Thai/Cambodia, Thai/Lao, and Thai/Myanmar borders would suggest that the banteng populations on the mainland are under considerable pressure from hunters.

Conservation Measures

The banteng is legally protected in all range states and occurs in a number of

protected areas. There are ongoing field survey programs in Indochina and a monitoring program in East Java. Large captive populations exist in North America, Europe and Southeast Asia.

Species Fact Sheet

WILD YAK *(Bos mutus)*

The yak is one of four living subgenera of true wild cattle in the genus *Bos*, along with gaur, banteng, and kouprey.

Conservation Status

The wild yak is listed as Vulnerable according to the 2000 IUCN Red Data List, Appendix I by CITES, and Endangered by the U.S. Endangered Species Act. The IUCN rating is based on an overall decline in the population of at least 20% in the last 20 years.

Current Population Estimates and Distribution

In 1996, the global population of wild yak was estimated at 15,000 (Schaller). It is possible that only about 10,000 remain today. Their distribution is China, India and Nepal, with the largest number of animals occurring in Tibet (~ 8,000). The overall population trend is declining.

Description

Wild yak are massively built animals with high-humped shoulders, short legs and broad hooves. They have thick, shaggy dark brown coats with white markings around the muzzle. There is considerable sexual dimorphism found in wild yaks with the cows being much smaller than the bulls. While males can weigh up to 1800 pounds, females weigh only about 700 pounds.

The domestic yak *(Bos mutus grunniens)* originated from the yaks living in the wild but is considerably smaller. They have been invaluable as pack animals as well as suppliers of meat, milk and wool, to the people of the Himalayas and neighboring mountain regions.

Habitat and Ecology

The wild yak is one of the least known species of wild cattle alive today. They occur largely in scattered ranges in the mountain tundra and ice desert of the Tibetan plateau at elevations of 12,800 to 19.200 feet. A migratory species, yak travel from the plateaus to the lower plains depending on the season. Wild yak exist under the harshest winter conditions and can withstand temperatures as low as –40 ° F. but are extremely heat-intolerant. During the winter, they subsist on mosses and lichens. Wild yak live in herds of 20 to 200 animals, consisting of females, young bulls and offspring. Adult bulls may form bachelor herds or lead an essentially solitary existence, only coming together with the maternal herds during the breeding season.

Captive Programs

There are no wild yak in captivity outside of China, where only small numbers are

being held. Captive yak outside of China are actually domestic counterparts of the wild yak. The AZA Bison, Buffalo and Cattle Regional Collection Plan has recommended that North American zoos phase domestic yak out of their collections in favor of cattle species of more conservation significance. The Cattle TAG further recommends supporting conservation programs for wild yak in their range countries.

Threats

Hunting, including commercial hunting for meat, is the most serious threat to wild yak. Interbreeding between domestic yak and wild yak also presents a threat to the remaining wild yak populations, as do diseases transmitted from domestic livestock to wild yak. In addition, there is low fertility in the wild yak population. It is not known whether reproductive failure in wild yak is due to diseases, such as brucellosis, which can cause spontaneous abortion or high levels of postpartum mortality.

Conservation Measures

This species has been fully protected under Chinese law since 1962, but legal protection is difficult to enforce in remote mountainous areas where the species occurs. In India, the species receives total protection under The Wildlife Protection Act of 1972.

Species Fact Sheet

KOUPREY *(Bos sauveli)*

The kouprey is one of four living subgenera of true cattle in the genus *Bos*, which also includes gaur, banteng, and yak.

Conservation Status

The kouprey is listed as Critically Endangered by the 2000 IUCN Red Data List, Endangered by the U.S. Endangered Species Act, and Appendix I by CITES.

Current Population Estimates and Distribution

The current population of wild kouprey is believed to be less than 250 and declining. Their presumed range is Cambodia, the Lao People's Democratic Republic, Thailand and Viet Nam. However, there were no kouprey seen during an aerial survey of Cambodia in 1994, and ground surveys of Cambodia, Lao and Viet Nam have failed to produce evidence of significant numbers of animals. Some sources believe the species is extinct outside of Cambodia. Wars in Indochina have contributed to the demise of the kouprey, which is now perhaps the most endangered large mammal in the world.

Description

Known also as the wild forest ox of Indochina, the enormous kouprey is the least known species of wild cattle alive today. No scientist has observed a kouprey at close range since 1957, when zoologist Charles Wharton studied and even filmed the animal in the wild. This study remains the sole source of ecological and natural history information on the kouprey. Grey to dark brown or black, kouprey's bodies are massive but narrow, their legs long, their backs humped. Males may stand two meters at the shoulder and weigh up to 2,000 pounds. Adult males have a pronounced dewlap, up to 16 inches long. Both sexes have curiously notched nostrils and long tails. The horns of the female are lyre-shaped with antelope-like upward spirals. The widespread horns in the male arch forward and upward.

Habitat and Ecology

What kouprey remain today probably live a skittish, nocturnal life in inaccessible habitats consisting of open deciduous forests, grasslands, wooded grasslands and patches of closed monsoon forest. Most live in areas receiving 40-80 inches of precipitation per year; there are indications that they move to higher elevations during the rainy season. Kouprey typically graze in open areas during the day, entering the forest for shelter from the sun, refuge from predators, and to seek food when the grasslands are dry. Like other wild cattle species, kouprey are primarily grazers but will browse as well and are active mainly in the late afternoon.

Captive Programs

The only known captive kouprey outside of the range countries was an animal brought to the Vincennes Zoo in Paris in 1937. Originally thought to be a gaur calf when it arrived from Saigon, it was determined to be an animal of an entirely new species as it grew to adulthood. The animal lived at the zoo in Paris for three years before dying of starvation during the German occupation of France. In 1964, Charles Wharton embarked on an ill-fated expedition to capture some kouprey but of the five animals captured, two died and three escaped. There have been no kouprey in captivity since Cambodia's Prince Sihanouk kept a kouprey calf on his palace grounds at Phnom Penh, likely sometime during the 50's. The IUCN/SSC Asian Wild Cattle Specialist Group Action Plan recommends investigating the potential for developing both *in situ* and *ex situ* programs in the range countries for this species.

Threats

Hunting, for subsistence and for trade (meat and body parts, especially horns and skulls) is the major threat to the conservation of this species. Habitat loss, due to cultivation, logging and human encroachment, and diseases from domestic/feral livestock are also contributing to the decline in numbers of kouprey. Additionally, land mines along the border of Cambodia have caused the deaths of some kouprey.

Conservation Measures

Kouprey are legally protected in all range states. There are several ongoing large mammal survey programs being conducted in Cambodia.

Species Fact Sheet

ASIAN BUFFALO *(Bubalus bubalis)*

The Asian buffalo is one of four species in the genus *Bubalus*, which also includes the tamaraw, lowland and mountain anoas.

Conservation Status

The wild Asian buffalo is listed as Endangered according to the 1996 IUCN Red Data List, when it was last assessed. This rating is based on an estimated continuing decline of at least 20% over the next 14 year. Asian buffalo are listed by CITES as Appendix III (Nepal); they are not listed by the U.S. Endangered Species Act. In 1994, the Asian Wild Cattle Conservation Assessment and Management Plan categorized the Asian buffalo as Critically Endangered in Thailand, Nepal, and Central China.

Current Population Estimates and Distribution

The total number of wild Asian buffalo is thought to be less than 4,000. It is possible that the actual number is far less than that. Some have even suggested that there may be no purebred wild Asian buffalo left. Assessment is hampered by the difficulty in distinguishing between free-ranging domestic buffalo, feral buffalo and truly wild buffalo, as well as hybrids (wild x other buffalo). The range of wild Asian buffalo is Bhutan, Nepal, India and Thailand, with the majority of individuals occurring in India.

The domestic water buffalo *(Bubalus arnee bubalus)* is a descendant of the wild Indian arna, from which it differs not only in temperament but also in its smaller size and less splayed horns. Unlike the wild form, which is restricted to Southeast Asia, the range of the domestic animals extends to many countries of the world. As a result of dispersal by humans, domestic buffalo reached North Africa and the Near East, as well as Australia, Brazil and Central America.

Description

The Asian buffalo is a massive and powerful animal; males can weigh in excess of 2,200 pounds, females 1,800 pounds. They are dark brown in color, with short, sparse hair and white markings under the chin. Their broad, long hooves are advantageous for walking in swampy areas. As with other wild bovids, both sexes bear horns (larger in the males; up to 78 inch spread). The broad, flat, notched horns are often used as mud shovels, with the buffalo dipping them in the mud with sideways motions of the head and then throwing the mud onto their backs.

Habitat and Ecology

Asian buffalo are very dependent on the availability of water. Their preferred habitats are low-lying alluvial grasslands, riparian forests and woodlands. Gregarious, but not territorial, they live in small groups consisting of one adult breeding bull, a few adult cows and their offspring. Asian buffalo are primarily grazers and, when not feeding, spend the majority of their day bathing and wallowing.

Captive Programs

There are probably no true wild Asian buffalo in captivity outside of the range countries. According to ISIS data (03/02), there are 4.4 animals in the Singapore Zoo. North American captive animals are all domestic counterparts of the wild Asian buffalo *(Bubalus arnee bubalus).*

Threats

Threats to the wild Asian buffalo include: 1) hunting, 2) habitat loss and degradation, 3) diseases and parasites transmitted by domestic livestock, 4) interspecific competition for food and water between wild buffalo and domestic stock, and 5) interbreeding with feral and domestic buffalo.

Conservation Measures

Wild Asian buffalo are legally protected in Bhutan, India, Nepal and Thailand. They are listed by CITES as Appendix III in Nepal. Apparently-wild buffalo occur in several protected areas.

Mountain Anoa Lowland Anoa

Species Fact Sheet

LOWLAND ANOA
(Bubalus depressicornis)
MOUNTAIN ANOA *(Bubalus quarlesi)*

The IUCN/SSC Asian Wild Cattle Specialist Group currently recognizes two species of anoa; the lowland anoa *(Bubalus depressicornis)* and the mountain anoa *(Bubalus quarlesi)*. More genetic research, both *in situ* and *ex situ*, is underway to elucidate outstanding taxonomic questions. Once thought of as a subspecies of the Asian water buffalo, the anoa developed as an independent island form.

Conservation Status

The 2000 IUCN Red Data List classifies both the lowland and the mountain anoa as Endangered. Both species are listed as Endangered by the U.S. Endangered Species Act and Appendix I by CITES.

Current Population Estimates and Distribution

The wild populations of lowland and mountain anoas are each estimated at 3,000-5,000 and declining, according to the IUCN/SSC Asian Wild Cattle Specialist Group Action Plan (2003, in prep). Anoas are endemic to the Indonesian island of Sulawesi, plus several small offshore islands.

Description

Anoas are the smallest of the wild cattle species. Both species are stocky, short-limbed and thick-necked. Adults are predominantly dark brown to black; the lowland anoa has white or yellowish stockings and a white throat crescent. While the lowland anoa has sparse, straight hair, the coat of the mountain anoa remains thick and somewhat wooly. Lowland anoa weigh up to 675 pounds; mountain anoa up to 340 pounds. As with other bovids, both sexes have horns. The lowland anoas have straight horns, triangular in cross-section and with a marked keel (males 11-15 inches, females 7-11 inches). The horns of the mountain anoa are shorter (6-8 inches in both sexes), conical and without an external keel.

Habitat and Ecology

Very little is actually known about the habitat preferences of these little-studied animals. Anoas reportedly have more of a requirement for undisturbed forest than the other species of wild cattle in South and Southeast Asia. Lowland anoas inhabit lowland forests including secondary formations and swampy areas and were once common along the coasts. Mountain anoas are reported to occur in mountain

forest up to 6,500 feet above sea level. Anoas have a varied diet and are known to eat grasses and other herbs, aquatic plants, leaves of shrubs and young trees, bark, and fruit.

Anoas have not been seen in herds, with most reported sightings consisting of lone animals or pairs, a female with a calf, occasionally a pair with a calf. As with other wild cattle species, anoas are not thought to be territorial. They are most active in the morning and late afternoon, spending the rest of the day resting and ruminating in the forest. Like other wild buffalo, anoas wallow and bathe in pools of water and mud.

Captive Programs

Although anoas have been kept in captivity for many years, primarily in European collections, the captive husbandry cannot be considered well-established for either species. Currently, there are about 50 lowland anoas in North American institutions, 50 in the European Region and only a handful in the Asian Region, according to available Regional Studbook data and ISIS information (03/04). There are fewer than 10 mountain anoas in European institutions and none in North America. An incomplete understanding of the husbandry of these species has hampered captive breeding efforts.

In their 1995 Action Plan, the Asian Wild Cattle Specialist Group recommended that the captive programs for anoas serve as a genetic reservoir for both species as an insurance policy against extinction and as a source of animals for reintroductions. They further recommended that captive programs assist genetic researchers to answer the outstanding taxonomic questions, which this TAG endorses.

Threats

Hunting, mainly subsistence, and the loss of suitable habitat are the most significant threats to these species. Diseases transmitted by domestic or feral cattle pose potentially serious threats as well. A lesser threat is the international trade in either live animals or body parts.

Conservation Measures

Anoas have been legally protected in Indonesia since 1931. There are a number of protected areas on the island of Sulawesi, many of which are believed to contain anoas. However, these areas are not all well managed and the level of protection accorded to their wildlife is uncertain.

Species Fact Sheet

TAMARAW *(Bubalus mindorensis)*

Once thought of as a subspecies of the Asian water buffalo, the tamaraw, like the anoa, developed as an independent island form. Recently discovered museum and subfossil remains suggest this species may be the last survivor of several species of dwarf buffaloes to have become extinct in the Philippines since human colonization of the islands.

Conservation Status

Of all wild water buffalo, the tamaraw is the one most threatened with extinction. The tamaraw is listed as Critically Endangered by the 2000 IUCN Red Data List, Endangered by the U.S. Endangered Species Act, and Appendix I by CITES.

Current Population Estimates and Distribution

According to the IUCN/SSC Asian Wild Cattle Specialist Group (2000), the total wild population of tamaraw is estimated to be between 30 and 200 individuals, with the number of mature individuals at 11-118. There is a projected decline of 25% over the next generation, 8-10 years. It is believed that tamaraw freely roamed the island of Mindoro in the early 1900's in numbers of about 10,000 from sea level to about 6,500 feet. Today there are thought to be only two remaining subpopulations.

Description

The tamaraw is the Philippines' largest land mammal and the national animal. As is characteristic of many island species, the tamaraw has a small build, only slightly larger than the anoa. Its color and skull dimensions are similar to that of the water buffalo on the Asian mainland, but the light markings on the head, neck and legs are reminiscent of the anoa. Overall, it has the appearance of being a cross between an anoa and a mainland water buffalo.

Habitat and Ecology

The biology of the tamaraw is largely unknown, having been observed in the wild only in isolated cases and for short periods. Similar to anoas, tamaraws appear to live primarily as solitary animals or in small groups. They inhabit open grassland, forest glades, thick bamboo jungle, marshy river valleys and upland forest. Tamaraws are primarily grazers and, when not feeding, spend the majority of their day bathing and wallowing.

Captive Programs

There are no captive tamaraws outside of Mindoro, where only a small number of animals are held. There are no current or future prospects for North American captive programs with this species. The IUCN/SSC Asian Wild Cattle Specialist Group Action

Plan has recommended investigating the potential for developing both *in situ* and *ex situ* range country programs for this species.

Threats

Hunting, both subsistence and sport, and the loss of suitable habitat are the most significant threats to this species. Mindoro has suffered a disproportionate (~ 92%) loss of forest cover. Diseases transmitted by domestic cattle and over-burning of pastures have also caused drastic declines in the tamaraw population. Many animals fell victim to rinderpest in the 1930's.

Conservation Measures

Tamaraws receive total protection under Philippine law. The larger of the two remaining subpopulations occurs in a national park. Mindoro has been recognized by the World Conservation Union (IUCN), the World Conservation Monitoring Centre (WCMC), Birdlife International (BLI), and other major international conservation agencies as one of the world's ten highest priority areas for conservation concern in terms of both numbers of threatened endemic species represented and degrees of threat.

At present, there are no effective protected areas. The tamaraw is a focal species in the Mindoro Biodiversity Programme, a project that seeks to promote ongoing and proposed conservation measures for more than 155 endemic species and subspecies in the areas of conservation education and community relations, applied research, monitoring, habitat restoration, threatened species recovery and sustainable development.

Forest Buffalo

Cape Buffalo

Species Fact Sheet

AFRICAN SAVANNAH (CAPE) BUFFALO *(Syncerus caffer caffer)* AFRICAN FOREST (CONGO) BUFFALO *(Syncerus caffer nanus)*

There are four recognized subspecies of African buffalo according to the 1998 African Antelope Database of the IUCN/SSC Antelope Specialist Group. The three forms of the African savannah buffalo are: West African savannah buffalo *(Syncerus caffer brachyceros)*, Central African savannah buffalo *(Syncerus c. aequinoctialis)*, and the southern savannah buffalo *(Syncerus caffer caffer)*. Of these, the southern savannah buffalo, often referred to as the Cape buffalo, is the most numerous and the form typically displayed in zoological collections. The fourth subspecies is the forest or dwarf buffalo *(Syncerus caffer nanus)*, sometimes referred to as the Congo buffalo. The savannah and forest buffalo will freely hybridize when their ranges overlap.

Conservation Status

The 2000 IUCN Red Data List classifies the African savannah buffalo as Lower Risk/Conservation Dependent and the forest buffalo as Lower Risk/Near Threatened. This means that they are the focus of a continuing conservation program that directly affects them, and that the cessation of the program would result in the taxon qualifying for one of the threatened categories. Neither subspecies is listed by the U.S. Endangered Species Act or CITES.

Current Population Estimates and Distribution

According to the 1998 African Antelope Database of the IUCN/SSC Antelope Specialist Group, there are approximately 830,000 African savannah buffalo (27,000 West African savannah buffalo, 133,000 Central African savannah buffalo and 670,000 southern savannah buffalo) and approximately 60,000 forest buffalo in the wild. Populations of both savannah and forest buffalo are declining.

In the past, the African buffalo inhabited most of Africa south of the Sahara from the East to the West Coast. Today, there are forms of African buffalo in varying degrees of abundance in the following countries: Angola, Benin, Botswana, Burkina Faso,

Burundi, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

The largest concentrations of West African savannah buffalo occur in the Ivory Coast and Senegal; of Central African savannah buffalo in Congo-Kinshasa and the Central African Republic; and of the southern savannah buffalo in Tanzania (245,000), Zimbabwe (37,300), Zambia (34,280), South Africa (28,470) and Uganda (20,220).

Today, the forest buffalo occurs mainly in the Ivory Coast, Cameroon, Central African Republic, Gabon, Congo-Brazzaville, and Congo-Kinshasa, but is not abundant anywhere.

Description

The African savannah buffalo is the largest of the African bovids, and one of the most successful African mammals in terms of geographical range, abundance and biomass. The average weight for male savannah buffalo is 1,500 pounds and for females 1,290 pounds (Estes, 1991). The smaller forest buffalo reaches a maximum weight of 675 pounds. The savannah buffalo are black or seal brown, whereas the forest buffalo are red-brown to brown. Both have heavy horns with a substantial boss.

The social structure of the African buffalo is rather typical of most other wild cattle species. They are gregarious, but not territorial. Savannah buffalo generally form large herds of 50-150 individuals, sometimes 350 animals or more. Forest buffalo congregate in much smaller herds, generally from 8-20 individuals. The basic units of buffalo herds are stable groups of presumably related cows that are arranged in a linear dominance hierarchy, to which are attached a number of adult and subadult bulls that are also ranked according to age and dominance status. Male reproductive success is based on dominance over other males, rather than over a particular site. This places a direct premium on size and power. Young males may form loosely organized bachelor herds, while older bulls not associated with a herd may essentially lead a solitary existence.

Habitat and Ecology

African buffalo occur in a variety of habitats, including lowland tropical rainforest, grassland, tropical savannah woodland, desert and semi-desert. They are primarily bulk grazers but do some selective browsing, especially when grasses are not abundant. Buffalo will generally graze in the early morning and again at night, and will spend the majority of the day wallowing, resting and ruminating.

Captive Programs

African buffalo have successfully been kept in captivity for many years. There are currently about 110 African savannah buffalo and about 100 African forest buffalo being held in captivity worldwide. The majority of these are in European collections, with less than 35 savannah buffalo and about 20 forest buffalo in the North American region (ISIS figures, 03/03).

Threats

Illegal hunting and the continuing loss of suitable habitat (primarily human induced by the expansion of settlement and agriculture) are the most significant threats to this species. Rinderpest continues to pose a major threat to these subspecies in some regions of Africa. On private lands, where the populations of African buffalo intersect with domestic livestock, diseases transmitted by domestic and feral cattle are a concern. African buffalo are also susceptible to drought, which caused substantial declines in some populations during the 1990's.

Conservation Measures

The future status of all subspecies of African buffalo is closely linked to the future of protected areas and well-managed hunting zones. Large, stable or increasing populations of the southern savannah buffalo occur in many protected areas in southern and eastern Africa but the current trend of the West and Central African forms of the savannah buffalo is towards near-threatened or threatened status. About 75% of the estimated total population of forest buffalo occurs in nominally protected areas. The level of protection afforded this subspecies will determine its future conservation status.

Abiotic Variables

TEMPERATURE

In general, cattle and related species are relatively heat tolerant and temperatures in excess of 100° F are tolerated as long as adequate water and sufficient shade to cover all herd members are provided. Many of the exotic cattle species will competitively exclude subordinate herd members from the most desirable spaces. Most species can be kept outside year-round in warmer parts of North America and only require shelter from prevailing winds or excessive precipitation. In colder climates where temperatures are expected to be below freezing, supplemental heat and adequate bedding should be provided in protected areas or barns. Temperatures below 15° F may result in frostbite on the ears, horns, or feet. Factors such as rain, snow, sleet and wind chill should also be considered in the decision to move animals into protected shelters.

In particular, gaur have shown great versatility in their ability to adjust to colder ranges of temperature. Although gaur occur naturally in tropical areas where temperatures exceed 100° F, they display no adverse effects in captivity when maintained outdoors at temperatures below freezing, as long as adequate windbreaks are provided. The wild yak, *Bos mutus*, is found at high altitudes and is extremely cold tolerant. Banteng and anoa tend to be more sensitive to cold, wet conditions and should be provided access to indoor quarters and/or supplemental heat when the temperature falls below 45° F. Water buffalo have a comfort range of between 50-75° F and show signs of physiological stress when the temperature falls below 45° F. African buffalo are more suited to dry climates than Asian buffalo but have similar temperature requirements.

Wild cattle kept inside can tolerate relatively high temperatures, with adequate ventilation, although most species should be protected from temperatures above 95° F if exposure is prolonged. For all species of cattle, it is recommended that appropriate shade/shelter structures be provided and that indoor stalls should have ample bedding for comfort and insulation during periods of cold or inclement weather.

VENTILATION AND HUMIDITY

Temperature, ventilation and humidity are related to the ability of these species to adapt to captive environments. Indoor ventilation systems for wild cattle should be able to:

- provide fresh air to meet the respiration needs of the animals
- control moisture build-up within the structure
- move enough air to dilute airborne disease organisms produced within the housing unit
- control or moderate temperature extremes

The recommended ventilation for cold weather housing of domestic cattle is 4-6 complete air changes per hour. For exotic species of cattle, a barn with forced air heat should be capable of maintaining 45° F and four air changes an hour. For hot weather conditions (above 90° F), the recommendation increases to 16-32 complete changes of air per hour.

ILLUMINATION

Because of their large size, wild cattle are typically kept outside where natural light is available, unless weather or other conditions dictate otherwise. When kept indoors for extended periods of time, skylights, fluorescent or incandescent lights are acceptable until the animals can be allowed outside again. Wild cattle may be diurnal, crepuscular or nocturnal in nature and have no specific lighting requirements, nor are their breeding habits associated with photoperiod length. They are best maintained on a 12 hour/12 hour light-dark schedule.

HOUSING

Space

As a minimum guideline for the larger, herding wild cattle species, outdoor enclosures must provide 1,000 square feet per individual animal. Visual barriers should be provided in the enclosure to allow subordinate herd members to escape or rest. Blind corners or places where individuals can be trapped by aggressive conspecifics must be avoided.

Holding areas where individuals can be temporarily isolated from herd mates should be accessible directly from the primary enclosure and arranged in a way to facilitate introduction of animals to the herd. Minimum enclosure size for these holding areas should be 400 square feet per individual animal.

No specific furnishings to accommodate locomotory or foraging behaviors are needed for these species.

These species are generally tolerant of stimuli (ambient noise, activity, etc.) external to their enclosures.

Substrates

A relatively flat, natural substrate of dirt and grass is preferred for outdoor enclosures.

Cement is the most commonly found surface for indoor quarters, due to ease of cleaning. Because ungulates can lose their footing and slip on cement surfaces, it is recommended that a broom-swept finish be applied to floors. This can also prove helpful in controlling excessive

hoof growth. Keeping large species of cattle on concrete floors for extended periods of time can cause lameness.

Some bedding materials such as grass hay or pine shavings can mitigate the effects of slick surfaces in addition to providing insulation from cold weather. The bedding layer must be sufficiently thick; a thin layer may exacerbate the hazards posed by slick surfaces.

There are several commercially-available synthetic flooring systems that are proving to hold up well to the foot traffic of large-bodied animals, urine contamination and the rigors of daily cleaning with disinfectant agents.

Sanitation

Indoor quarters with either cement or other poured flooring should be cleaned and disinfected daily. When possible, vertical surfaces should be cleaned with the same frequency. Portable water containers or automatic drinkers should also be cleaned and disinfected daily.

Feces should be removed daily from indoor and outdoor quarters. This prevents contamination of bedding and foodstuffs by feces. It is particularly important to remove fecal material from feed areas in order to break the fecal-oral contamination cycle common to most endoparasites. For this reason, elevated feed bunkers are preferred, rather than feeding on the ground.

Containment

Regulations may vary from state to state and all applicable regulatory agencies should be consulted to ensure compliance with regards to containment of wild cattle species.

For most wild cattle taxa, an eight-foot barrier is required. If a dry or wet moat is employed, the depth of the moat plus the height of any adjoining fence should combine to form an eight-foot barrier. Depending on the species, barriers may be constructed of block wall, gunnite, wooden stockade-type fencing in a steel frame, or heavy-gauge chain-link (9-gauge or stronger). Chain-link is not recommended for African buffalo.

ANIMAL SAFETY

Care should be taken to ensure that the animals' living space is free from hazards. The public should not have the sort of access that would allow them to share the same physical space as the animals, to make tactile contact with the animals, or to introduce foreign or hazardous objects into the enclosure.

Social Considerations

Social Organization

In the wild, cattle and buffalo species are both gregarious and non-territorial. Male reproductive success is based on dominance over other males rather than dominance at a particular site. This direct competition places a premium on size and power. Species such as African buffalo that migrate the open savannahs live in mixed herds where there is a dominance hierarchy among the males. Beta males breed only when two or more females are in estrus at the same time.

Social Groups

In captive settings, there is generally not space enough to allow for a mixed-herd structure with multiple males. The recommended age and sex structure of social groups for most captive cattle species is a herd composed of multiple females, their calves, and one breeding bull. Breeding groups of anoa should be smaller, typically consisting of a dominant bull, one female, female offspring under two years of age and/or male offspring under one year of age. Adult and sub-adult bulls of all species should be housed in individual stalls, separate from females.

Unless there is a great deal of space available, male calves of all species may need to be removed from the herd prior to one year of age, sooner if the bull begins to show signs of aggression. As with other bovids, adult bulls in these taxa may drive out young males when they begin to exhibit secondary sex characteristics (horn growth, coat color change, etc.). The timing of this "forced" emigration of male adolescents is somewhat dependent on enclosure size. In smaller enclosures, the adult bull tends to become intolerant of juvenile males at an earlier age. Male anoas are particularly intolerant of other males, and bull calves should be removed at about eight months of age.

For small enclosures, a trio of animals (1.2) with space for offspring is ideal. It is possible to keep bison, buffalo, banteng, and gaur in large herds consisting of one breeding male and multiple females. Depending on space available, a bull can breed 10-15 females or more. Breeding groups of anoa consist of a dominant male, one adult female and offspring. For all species, there should be enough space for animals to voluntarily separate themselves and visual barriers to allow subordinate animals safe areas to rest. There should not be any blind cul-de-sacs or other areas for animals to be trapped by conspecifics.

MIXED SPECIES GROUPS

It is possible to keep selected bison, buffalo, and cattle species in mixed-species settings. It is important not only to select compatible species, but also to provide adequate space for animals to voluntarily separate themselves when desired or necessary.

Banteng and Asian water buffalo have been peaceably exhibited with a number of other species, including multiple species of cervids and small antelope, as well as caprids, storks, cranes, pelicans, and waterfowl. Gaur have been exhibited with multiple species of cervids, small antelope and gazelles, Indian rhinos, caprids, and numerous avian species. There is at least one report of fighting between an Indian rhino bull and a particularly aggressive gaur bull. Bison species (both American and European), have been successfully exhibited with a variety of ungulate and avian species. Problems only seem to occur with bulls of other large wild cattle species. For space shared with avian species, it is best to establish the birds in the habitat first so that they become comfortable, know their boundaries, and have places of refuge. Anoas are best kept as a single-species display.

Asian species of buffalo and cattle should not be housed with or near wildebeest, due to the potential for transmission of malignant catarrhal fever (MCF). Although wildebeest do not exhibit clinical signs of this viral disease, they are carriers of the herpesvirus that causes the disease. Should MCF be transmitted to Asian or European ungulates, in particular, the resulting infection can be quickly fatal.

BACHELOR GROUPS

Depending on enclosure size and the proximity of female conspecifics, it is possible to keep small all-male groups. Bachelor herds can be assembled and are likely to be needed since breeding herds can typically only accommodate a single dominant male with a number of females. The primary disadvantage with bachelor herds is the potential for increased aggression and subsequent injury when the hierarchy in an established all-male herd is disrupted. This can occur when new males are introduced, when animals are removed from the group, or when dominant animals age or decline in condition. Competition and anxiety during feeding are some of the most likely factors contributing to intragroup aggression. Various strategies for reducing aggression during feedings include scattering food items, providing multiple feeding stations throughout the enclosure, or using different feeding devices that prolong feeding. It is recommended that at least some portion of the daily diet be fed to animals individually while separated from conspecifics.

There has been some success using hormonal compounds to mitigate aggression among individuals in an all-male group. In one study, melengestrol acetate (MGA) was used to moderate aggressive behavior in a bachelor herd of fringe-eared oryx. Treatment with oral MGA resulted in an apparent reduction of fecal testosterone levels after the first week of treatment. The decline in androgen excretion was accompanied by a significant reduction in several measures of agonistic behavior (Patton, 2001).

INTRODUCTIONS

To New Facilities

When introducing animals to a new facility, it is preferable to establish them in an off-exhibit holding area before releasing them into the new enclosure. During this acclimation period, the animal adjusts to its new surroundings and learns the daily routine. Animals should be allowed to "drift out" into the exhibit at their own pace; they should never be forced into new enclosures, as this may needlessly stress them. Initially, shift doors may be left open so that animals can return to the safety of the holding area as desired. The use of visual barriers, such as tarps or flags, may be used to assist animals in learning boundaries in their new outdoor enclosures.

To Conspecifics

New herd members should be given a period of time that allows them to gradually familiarize themselves with the existing group before progressing to full physical contact. Preliminary introductions should first include olfactory, visual and limited tactile access through protective barriers. In general, it is best to conduct introductions in a space that is adequate for animals to get away from one another and with gates or doors that offer shifting opportunities in the event the animals need to be separated from one another.

When introducing a male to a group of females, there is the potential for aggression and sparring. The bull will often pursue the lowest ranking females upon initial introduction. Introducing younger males into a female herd has proven more successful because they are less aggressive with the inexperienced or low-ranking females.

There appears to be some correlation between the physiological/hormonal condition of females and their temperament towards one another. Agonistic behavior among females is at the highest frequency during periods when the bull is removed and females are neither pregnant nor with calves. It may be advantageous to conduct female introductions at a time when the breeding male is present. It is also advantageous to introduce two or more females together as a group, rather than one at a time.

The formation of bachelor groups, or the introduction of new males into an existing group, must be carefully orchestrated in order to minimize aggression. When possible, it is preferable to introduce two or more males together to an existing bachelor group, in an effort to diffuse aggression. When animals are electively removed from the group, they should be removed from the low end of the social hierarchy so the rankings of the remaining animals are not disrupted.

HUMAN—ANIMAL INTERACTIONS

Although animals in these taxa can become quite habituated to having humans around and can give the appearance of being docile, it should be noted that any member of this group could become aggressive and dangerous. In particular, adult bulls of all species and female African buffalo have the propensity for being aggressive.

It is important that captive specimens be acclimated enough to humans to tolerate all aspects of their husbandry care but equally important that caretakers not take the disposition of their charges for granted, but rather respect their strength, power, and potential to injure.

Adult bulls of all species should be worked with a "protected contact" mentality; that is, caretakers should not share the same physical space with the animals without the benefit of some type of barrier. Caretakers should also be wary of working in close proximity to females, especially females with calves. As with other species, it is important to know your animals, be aware of any relevant special circumstances and of your surroundings, and to always have an escape route in mind if put into a dangerous situation. The level of caretaker contact with animals should be adjusted depending on the temperament of the species and the individual specimens. The larger the enclosure space, the longer a caretaker may be tolerated in that space.

Institutions should promote the public perception of these animals as wild, exotic species and not as domestics or pets.

Health and Nutrition

Food and Water

All species of wild cattle and buffalo are water dependent. In a captive environment, clean, potable water should be available 24 hours a day. Watering devices should be secure enough to prevent being tipped over and inadvertently emptied and should be shaped and positioned such that the animals' horns don't interfere with access to the water source. Multiple drinking sites may be necessary to ensure that all individuals have access to water. Automatic watering devices are suitable for most species. Where pools are used for drinking, there should be sufficient water flow to prevent the build-up of algae. Pools need to be thoroughly cleaned on a regular basis. A wallow or pool should be available for water buffalo and anoas to allow them to thermoregulate properly and to promote species-appropriate behaviors.

In nature, wild cattle are primarily grazers or intermediate grazer-browsers and have a digestive physiology that relies on a continuous intake of food material. A diet of good quality grass, Bermuda and alfalfa hays, supplemented with commercial herbivore concentrate pellets will provide adequate nutrition for most species. Whenever possible, the day's food ration should be broken down into at least two, and preferably three, feedings in order to promote normal digestive tract activity and to mimic more natural feeding patterns. Food items should be fed out in elevated feed pans or above-ground hay racks to avoid sand and gravel impaction and/or parasitic infections caused by fecal-oral contamination. Trace mineral and salt blocks should be available *ad lib*. When animals are housed together in groups, multiple feeding sites well spaced within the enclosure should be utilized to prevent dominant individuals from monopolizing feed. Selected seasonal browse species should be offered as available. Limited quantities of produce may be used as behavioral training reinforcement.

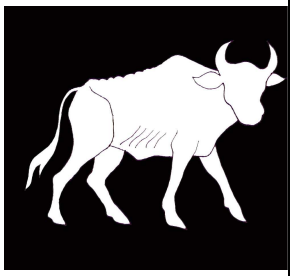
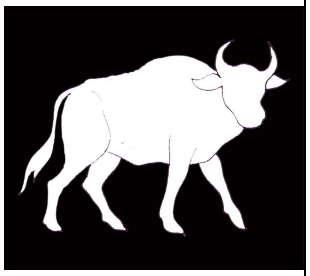
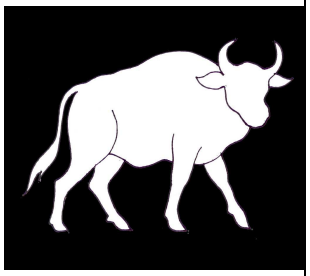
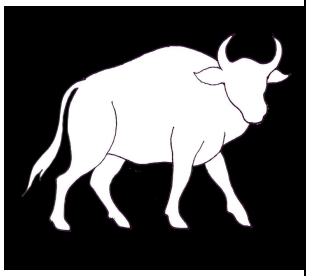
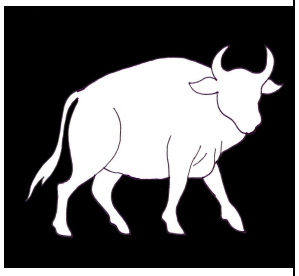
DIET

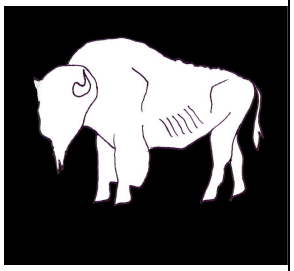
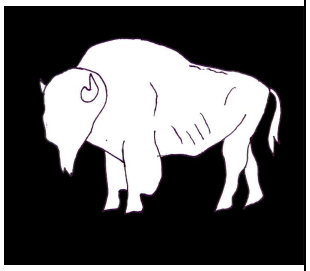
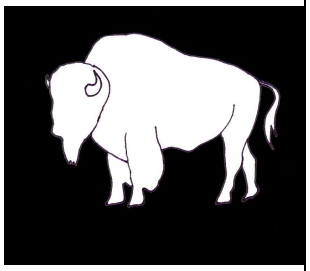
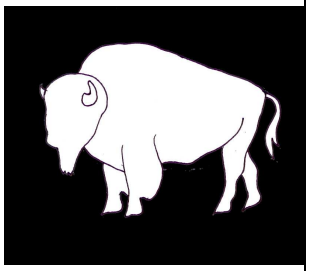
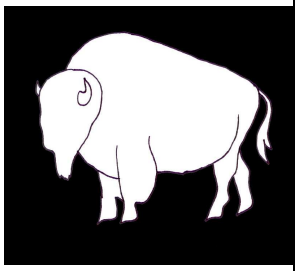
The extensive literature and known requirements for domestic cattle are broadly applicable to wild cattle species. Diets should be reviewed at least annually with an exotic animal nutritionist and diet components should be tested periodically.

Members of these taxa are primarily grazers. A diet of good quality grass and Bermuda hays should be offered for bulk, with alfalfa hay being offered only in small amounts, if at all. A commercially available herbivore concentrate pellet can provide most of the nutritional needs for these species. A high fiber, low protein pellet should be selected. It is important to offer hay and concentrates in proper proportions. Overfeeding and obesity may significantly reduce reproductive ability. If given the opportunity, animals may preferentially select for alfalfa hay over herbivore pellets. This can result in zinc and phosphorous imbalances. Selected seasonal browse species should be offered as available, but should not be offered in quantities that would discourage consumption of the full ration of pellets. If produce is offered for training purposes or for enrichment, it should represent less than 4% of the total diet. Fruits with significant sugar content, such as apples or bananas, should be avoided, as they can contribute to rumen acidosis.

The diet for pregnant females may need to be adjusted to provide more energy, depending on body condition, especially if the pregnant female is still nursing her previous calf. Calves and juveniles should be on a graduated diet, with sequential increases throughout the growth phase.

The natural history of these species is such that they spend several hours a day locating, consuming and processing their food. Their digestive physiology requires a continuous intake of plant material. The daily food ration should be broken into at least two feedings per day in order to promote normal digestive processes and also to simulate the amount of time they would spend feeding in the wild.

Score	1: Emaciated	2: Thin	3: Good	4: Fat	5: Obese
Outline Depictions					
Neck & Shoulders	• Emaciated • Bone structure is easily visible • No fat	• Neck is thin • Decreased girth	• Neck is thick • Shoulders are flat	• Neck is thick • Fat deposits evident • Shoulders slightly rounded	• Fat is evident along neck • Bulging fat • Neck is thick • Neck blends into shoulders • Shoulders are rounded
Withers	• Emaciated • Bone structure is easily visible • No fat	• Thin • Bone structure is evident	• Withers have fat deposits • Decreasing visibility of bone structure	• Fat deposits are evident	• Fat deposits make withers appear flatter/ less discernable
Loin & Back	• Emaciated • Spinous processes are easily identifiable	• Spinous processes are not individually identifiable, but spine is still prominent • Transverse processes faintly discernable	• Back is sloped to withers	• Fat deposits are present • Back appears flatter	• Wide back • Patchy fat • Back is flat
Tailhead & Hips	• Pelvic bones are very prominent	• Pelvis bones at the point of the hip are rounded, but still evident • Pelvic bones at rump may be slightly discernable	• Fat is present around tailhead • Pelvic bones are flat	• Hips are rounded	• Hips/thighs are very round
Ribs	• Emaciated • Rib spacing appears wide and depressed	• Ribs still discernable, but fat is discernable by touch	• Ribs are not visible, but discernable by touch	• Ribs are not visible • Fat deposits may be evident	• Fat deposits may be present, easily evident

Score	1: Emaciated	2: Thin	3: Good	4: Fat	5: Obese
Outline Depictions					
Neck & Shoulders	• Emaciated • Bone structure is easily visible • No fat	• Neck is thin • Decreased girth	• Neck is thick • Shoulders are flat	• Neck is thick • Fat deposits evident • Shoulders slightly rounded	• Fat is evident along neck • Bulging fat • Neck is thick • Neck blends into shoulder • Shoulders are rounded
Withers	• Emaciated • Bone structure is easily visible • No fat	• Thin • Bone structure is evident	• Withers have fat deposits • Decreasing visibility of bone structure	• Fat deposits are evident	• Fat deposits make withers appear flatter/ less discernable
Loin & Back	• Emaciated • Spinous processes are easily identifiable	• Spinous processes are not individually identifiable, but spine is still prominent • Transverse processes faintly discernable	• Back is sloped to withers	• Fat deposits are present • Back appears flatter	• Wide back • Patchy fat • Back is flat
Tailhead & Hips	• Pelvic bones are very prominent	• Pelvis bones at the point of the hip are rounded, but still evident • Pelvic bones at rump may be slightly discernable	• Fat is present around tailhead • Pelvic bones are flat	• Hips are rounded	• Hips/thighs are very round
Ribs	• Emaciated • Rib spacing appears wide and depressed	• Ribs still discernable, but fat is discernable by touch	• Ribs are not visible, but discernable by touch	• Ribs are not visible • Fat deposits may be evident	• Fat deposits may be present, easily evident

MEDICAL MANAGEMENT

Broadly speaking, the baseline of known medical and husbandry information available for domestic cattle applies to wild cattle species. This includes non-infectious as well as infectious domestic and foreign animal diseases.

Quarantine and Hospitalization

Animals may occasionally need to be hospitalized for treatment and, although all specimens should be tested prior to shipment, will require some type of quarantine isolation period after arrival at a new institution. Wild cattle species are social in nature and may be more anxious or aggressive when isolated for hospitalization or quarantine. Such separation may also lead to a disruption in herd stability, causing the animal to lose its relative position in the social hierarchy. In some cases a re-introduction process is necessary in order to reunite an animal with the herd. Medical or husbandry procedures that can be conducted while an animal remains in the herd, or that require only short separations, are preferable to removing an animal from its herd.

Diseases

Members of these taxa are known to be or are assumed to be susceptible to all domestic bovid diseases. Disease susceptibilities include:

Black leg	Necrobacillisis	Rinderpest
Paratuberculosis	Leptospirosis	Rift Valley fever
Tuberculosis	Anaplasmosis	Foot and mouth disease
Brucellosis	Vibriosis	Vesicular stomatitis
Haemophilus somnus	Actinobacillosis	Malignant catarrhal fever
Infectious bovine rhinotracheitis	Actinomycosis	Pasteurellosis
Parainfluenza	Salmonellosis	Blue tongue
Bovine viral diarrhea	Listeriosis	Paratuberculosis
Anthrax	Enterotoxemia	Contagious bovine pleuropneumonia

Within North America, blackleg and other clostridial diseases are probably most common with blackleg frequently occurring secondary to intraspecific aggression and bruising. Pseudotuberculosis is of serious concern due to the risk it poses to all hoofed stock within an institution and also from a regulatory perspective. Infectious bovine rhinotracheitis, parainfluenza and haemophilus somnus present a significant potential hazard for wild cattle species due to the presence of these diseases in domestic animal populations in North America and their potential for transmission. Malignant catarrhal fever presents a significant risk to wild cattle within the zoo setting due to potential transmission from wildebeest.

Annual vaccinations for common domestic cattle diseases, such as clostridial diseases, infectious bovine rhinotracheitis, parainfluenza, haemophilus somnus and bovine viral diarrhea, should prevent significant outbreaks in herd settings.

From a regulatory perspective, tuberculosis and brucellosis are of primary importance. Most states require tuberculosis and brucellosis tests prior to entry. Most states accept standard tail-fold tests

and serology as being valid for tuberculosis and brucellosis respectively. Foot and mouth disease, rinderpest, Rift Valley fever, and vesicular stomatitis are of regulatory concern when importing animals into the United States from other regions. Although blue tongue does not seem to clinically affect wild cattle species, it is of great concern when attempting to export animals out of the United States.

Pre- and post-shipment testing of individual specimens is important in preventing the transfer of infectious diseases between institutions. Many of the standard tests have not been validated for exotic species, but it is reasonable to assume that these tests are valid. The disease of greatest concern between institutions is paratuberculosis, or Johne's disease. Many facilities have a regular Johne's surveillance program in place that includes monitoring of all hoofed stock specimens. Testing procedures for Johne's disease are slightly suspect, with both false positives and false negatives occurring, and the timeframe for obtaining results is quite lengthy (8-12 weeks). However, the current fecal culture process is the best indicator of paratuberculosis at this time.

Wild cattle species in captivity are susceptible to both internal and external parasites. Commercially available cattle wormers (injectable, oral, and topical) work well in these species.

Hereditary diseases and anomalies, such as cleft palate or congenital heart defects, may occur in specimens of these taxa. Addressing these issues is primarily a management concern, from management of the individual specimen to considering the overall genetics of the species.

Annual Physical Exams

Some institutions elect to perform annual or semi-annual routine health exams on exotic cattle specimens, including a full physical exam, TB test, vaccinations, and routine blood work.

- Blood—a 100 ml blood sample may be drawn from the jugular vein. The whole blood sample may be divided as follows, depending on tests to be run:

  - ✓ 5 ml—EDTA or other anticoagulant for complete blood cell counts of red and white blood cells.
  - ✓ 85 ml—placed in serum tubes. This should yield 40-50 ml of serum. 10 ml of this serum can be used for serum chemistry analyses to assess the health of the animal. 10-20 ml of serum can be used for infectious disease testing purposes. 10-20 ml of serum may be placed in frozen storage for future or back-up testing as needed.
  - ✓ Following is a list of whole blood and serum chemistry tests that institutions may consider. This list is not intended to be all-inclusive for every situation but rather a routine screening baseline.

    Routine whole blood tests:

White blood cell count	Red blood cell count
Lymphocyte—absolute and %	Hemoglobin
Mean corpuscular volume	Hematocrit
Platelet count	Monocytes—absolute and %
Segmented Neutrophils—absolute and %	Eosinophils—absolute and %
Band Neutrophils—absolute and %	Basophils—absolute and %

Routine serum chemistry tests:

Total protein	Aspartate transferase (SGOT)
Albumin	Lactic dehydrogenase
Cholesterol	Triglycerides
Uric acid	Sodium
Creatinine	Potassium
Bilirubin	Chloride
Blood urea nitrogen	Calcium
Glucose	Phosphorous
BUN/CR	Total CO_2
Alkaline phosphatase	Anion Gap
Alanine transferase (SGPT)	Calculated osmolality

POST-MORTEM PROTOCOL

A thorough necropsy of each animal in the captive collection that dies can provide valuable information not only on the cause of death for that individual animal, but also on other concurrent medical problems. A review of necropsy records can uncover trends in mortality and morbidity that may prompt needed management changes. Often, underlying pathologies, parasitic infections, nutritional deficiencies or other disease processes are discovered that may have ramifications for other animals in the collection.

A straightforward ruminant gross necropsy with associated histopathology of major organs and significant lesions should be conducted for wild cattle specimens. There are often standing requests for biological samples or specimens made by researchers or museum personnel. Testes and ovaries can be collected from most species immediately after death and gametes can often be successfully recovered for long-term cryopreservation or in-vitro fertilization.

PEST MANAGEMENT

An active program of rodent and other vector abatement should be employed to reduce disease concerns.

Reproduction

GENERAL INFORMATION

With the exception of European wisent, members of these taxa are not seasonal breeders. Except as noted, males and females can be kept together year-round and calves are likely to be born any month of the year. There are no typical crèches or "nursery groups," but calves of similar age are

likely to consort with one another and the dams are quite tolerant of other females and calves that are not their own.

It is thought that all members of these taxa exhibit standard cattle mating behaviors. Copulation in all species is brief, but as a rule is repeated multiple times. The ovarian cycle has been well-documented in banteng and gaur and appears to be about 20 days in length with a post-partum interval of about 44 days.

Most wild cattle will safely calve in the herd with the exception of anoa, and there is no need to separate parturient females from the rest of the herd. Male anoa should be removed from the group prior to a female calving. The timing of this separation should be based on known breeding dates, signs of impending birth such as udder development, vulvar distention and other behavioral or physical signs of parturition.

Species	Gestation	Birth Weight	Weaning
Cape buffalo	~ 340 days	65-80 lbs	6 months
Banteng	285 days	45-60 lbs	6-9 months
American bison	270-300 days	66 lbs	5-6 months
European bison	254-272 days	59 lbs	6-8 months
Asian water buffalo	310-330 days		
Gaur	270-300 days	65-80 lbs	7-9 months
Lowland anoa	270-280 days		

ASSISTED REPRODUCTION

A significant amount of work on assisted reproduction has been done in both banteng and gaur. Banteng calves have been produced via artificial insemination at the Saint Louis Zoo and at the University of Queensland in Australia. As a result of collaboration between the San Diego Zoological Society and Advanced Cell Technology, Inc., two cloned banteng calves were produced in the spring of 2003. These calves, which were carried to term by domestic Holstein cows, were the result of the cloning of skin cells from a banteng bull. Gaur calves have been produced through *in vitro* fertilization, again with domestic cows serving as surrogate dams.

SEMEN COLLECTION AND EVALUATION

Semen from anesthetized wild cattle species can be collected by electroejaculation. Prior to beginning the stimulation procedure, the penis is externalized manually or by gentle traction with a cable loop. The penis can be maintained in a position external to the penile sheath by a hand-held loop of cotton gauze placed around it. A 5 cm diameter, three-electrode electroejaculation probe is inserted into the animal's rectum. A series of mild electrical stimulations is applied through this

probe to cause ejaculation into a warm, water-jacketed artificial vagina or collection vial placed over the tip of the penis. Some movement of the rear legs should be expected during stimulation. Semen has also been collected on non-anesthetized animals in a restraint chute via manual penile stimulation.

Semen should be evaluated immediately after collection for parameters such as total ejaculate volume, percent motility, concentration, and morphology.

CONTRACEPTION

Effective reproductive management of a captive species does not just mean successful breeding but also contraception when necessary and appropriate. Cattle species are generally very straightforward to breed. In situations where there is a limited outlet for surplus offspring, a focus on preventing propagation may be required.

Segregating the sexes, while 100% effective, can be difficult depending on the nature of an institution's facilities. Castration and vasectomy of males are both widely used to curtail propagation, but both should be considered permanent solutions. Reversing a vasectomy is challenging and results certainly cannot be guaranteed. For species that are part of a managed AZA conservation program, the program leader should be consulted before making the decision to permanently contracept an animal of either sex.

Melengestrol acetate (MGA) implants and oral MGA milled into herbivore pellets are techniques that have proved to be effective for contraception in the livestock industry for more than 25 years. Both techniques have been tested in exotic bovids and have also been proven both effective and reversible. Trials of this product at the Bronx Zoo and San Diego Wild Animal Park did not produce any deleterious effects, with the exception of an increased potential for obesity. Depo Provera shots are also effective, but expensive, and may have to be delivered via a dart. More detailed information on contraception options for these species can be obtained from the AZA Contraception Advisory Group. There is a contraception Advisory Group Forum located on the worldwide web at www.stlzoo.org/contraception.

MANAGEMENT OF PREGNANT ANIMALS AND NEONATES

Pregnant females should be monitored closely for condition. Overly conditioned or obese animals are at risk for dystocia or delivery complications. Females that are still nursing their previous calves may lose condition. Diet amounts may need to be adjusted as appropriate. Institutions should consider vaccinating cows for *E. coli*, corona virus, or other calf diseases in herds that have experienced these problems in order to afford calves a level of antibody protection.

When possible, a neonatal exam should be performed on calves at about 24 hours of age to assess health and confirm transfer of passive immunity. No interference with maternal care is likely to occur if the exam is carried out expediently and the calf is immediately returned to its dam. In addition to examining the calf for both congenital and non-congenital defects, vaccinations for

common calf infectious diseases (rota corona virus, *E. coli*, etc.) may be administered. In some cases, Vitamin E, selenium or prophylactic antibiotics may also be administered. Many facilities also take this opportunity to affix some type of permanent identification markers, such as ear notches, tattoos, ear tags or transponders. For calves that are in a compromised condition, glucose or natural or synthetic colostrum may be given. Colostrum can be administered orally, intravenously or by way of a stomach tube.

HAND-REARING

Hand-rearing cattle and buffalo neonates may be indicated in the following cases:

- Illness, injury, compromised health or death of a dam.
- Illness, injury, or compromised health of a calf.
- In rare cases, electively (e.g., if the animal is to be shipped and range capture would prove difficult). Hand-reared animals as adults are likely to be more aggressive towards and less intimidated by humans.

General Hand-Rearing Protocol

A general health exam should be conducted to assess the overall condition of the neonate, including; heart and lung auscultation, hydration, suckling response, temperature (hyper- or hypothermia), congenital abnormalities (cleft palate, angular limb deformities, heart defects, etc.), herniated umbilicus, blood values, and immunoglobin status. The umbilicus should be dipped in a solution of 3% iodine in order to prevent infection. Vaccinations/injections may given at this time, including; prophylactic antibiotics, Vitamin E, selenium, and calfhood disease vaccinations.

It is crucial to provide the newborn calf with immunoglobins, especially if it did not nurse from its dam prior to being pulled for hand-rearing. Bovine colostrum procured from Johne's-free commercial dairies or synthetic colostrum may be used. Colostrum only provides systemic immunity to a calf if given in the first 12 hours after birth. It can be administered orally, intravenously or via a stomach tube placed in the esophagus no further than the thoracic inlet. This positioning facilitates closure of the esophageal groove, directing the colostrum into the abomasum rather than the inactive rumen. After the first 12 hours, the colostrum will have a locally protective effect within the intestinal tract for potential disease problems.

Sample Feeding Regimen

First 24 hours	100% bovine colostrum
24-48 hours	50% bovine colostrum/50% formula
To one month of age	10% bovine colostrum/90% formula
To weaning	100% formula

There are a variety of formulas that have been used successfully with cattle and bison neonates, including whole cow's milk, evaporated cow's milk and pre-diluted Milk Matrix (a commercially available product). Commercial domestic cattle milk replacers can be used successfully but careful attention should be paid to fat content which is often minimized in these products. The fat content should be 6-10% in the diet as fed.

The following are guidelines for the number of feedings per day: 5 per day from 0-3 weeks of age, 4 per day from 3-6 weeks of age, 3 per day from 6-14 weeks of age, and 2 feedings per day from 14 weeks to weaning which is generally at 5-6 months of age. The standard for calculating the intake of formula is 10% of the body weight per day. This amount is flexible and should be adjusted according to multiple factors, including appetite, weight gain, formula tolerance, stool consistency and/or signs of digestive upset.

Typically, some type of vitamin supplement is provided for calves through weaning. Visorbin can be offered once a day at a rate of 0.15 cc/lb. Some facilities use a microbial powder (e.g., Probios TM), offered once a day through weaning. Probios microbial powder contains a source of live, naturally occurring microorganisms. Commercial calf-starter grain rations can be provided to calves as early as two weeks of age.

Management Practices

CAPTURE AND RESTRAINT

Chemical Immobilization

For most adult specimens in these taxa, capture and restraint is accomplished by chemical immobilization. Semi-synthetic morphine derivatives are the drugs of choice although successful procedures have been carried out with only alpha-2 adrenergic drugs such as xylazine and medetomidine at higher doses. Use of these alpha-2 drugs alone at high doses does carry greater risk of respiratory depression and of regurgitation, plus there is some significant risk of arousal by the animal during a procedure. Sedation of wild cattle for behavioral reasons or for shipping has been accomplished with xylazine, haloperidol and perphenazine.

These drugs include some extremely potent semi-synthetic morphine derivatives and must be handled with extraordinary caution. Human exposure to even small amounts of these drugs can result in the very rapid onset of respiratory arrest. The drugs can be absorbed through mucous membranes, such as the mouth and eyes, as well as by accidental needle puncture. Personnel must be adequately protected during dart preparation and handling of the animal after the administration of the dart. Adequate protection may include latex or rubber gloves, safety glass or full face shields, long sleeves and other precautions as appropriate. Every institution should have an accidental narcotic exposure response protocol in place and staff should be well-versed in its execution.

There can be a great deal of variation in the drug dose required to immobilize animals. This variation occurs as a result of differences in animal temperament, individual drug sensitivity,

excitability and whether or not they are captive or free ranging. Drug doses required are also affected by the space available for the animal to move about in after drug injection, and the amount of animal stimulation that occurs just prior to or after drug injection. The drug dose that will be required to immobilize an animal in a particular situation cannot be precisely predicted. Consequently, a dose range should be identified for each drug and each species. At the discretion of the veterinarian, supplemental drugs or methods may be used to maintain anesthesia, including gas anesthesia with or without intubation.

A sufficient number of personnel must be available to assist with the immobilization and move the animal once it is down. Immobilizations are carried out most safely and efficiently when a team approach is utilized. With most members of these taxa, the necessary personnel would include a veterinarian, a veterinary technician and approximately six support staff. Although the veterinarian has primary responsibility for the immobilization, safe positioning of the animal, monitoring of the animal's vital signs (respiratory rate, heart rate, temperature, percent oxygenation of the blood, etc.) and depth of anesthesia requires the cooperation of all team members. Safe immobilizations also depend on constant communication of critical information between team members.

Normal vital signs for wild cattle specimens:

- Pulse oximetry: saturation preferably above 90%. Consider administering drugs to stimulate respiration or reversing the animal if oxygen saturation falls below 80%.
- Heart rate: 44-72 beats per minute.
- Respiratory rate: 6-24 breaths per minute.
- Temperature: 99-101° F. Body temperature must be checked rectally.

As with other large bovids, the risks of regurgitation and inhalation pneumonia are great. Whenever possible, wild cattle and buffalo should be fasted for 48 hours prior to a chemical immobilization. Water should be removed 12 hours prior to immobilization if ambient temperatures permit. Animals should not be immobilized when ambient temperatures are 80° F or higher due to the risks associated with hyperthermia and muscle myopathy.

After the specimen becomes recumbent, it can be safely managed in either a lateral or upright (sternal) position; right lateral recumbency is generally preferable. The muzzle should always be directed towards the ground to allow any ingesta to flow out of the mouth. Individual pads may be placed around the metatarsal areas on each rear leg. Separate ropes can then be tied around each rear leg over the pads and secured to a solid object behind the animal (pole, tree, etc.). The front legs can be tied together and similarly secured in front of the animal. The rear legs can be tied together if there is nothing to secure them to, in order to reduce the likelihood of injury due to kicking. The duration of anesthesia for most large bovids should be limited to no more than 60 minutes due to the risk of pressure necrosis. Animals should be observed closely for evidence of bloat throughout all procedures.

The following equipment and drugs should be available for potential emergencies:

- **30 mm stomach tube**—bloat occurs very rarely in animals that have been fasted prior to immobilization. However, if it does occur, the stomach tube can be inserted through the

mouth, down the esophagus and into the rumen to release the accumulated gas. Significant bloating may require ending the immobilization procedure.

- **Doxapram:** 0.01 – 0.2 mg/kg intravenously. Doxapram may be used in situations where the respiratory rate is less than six breaths per minute. Handlers should anticipate the animal to surge when the doxapram takes effect.

- **Atropine:** 0.1 mg/kg intravenously. Atropine may be used in cases when the heart rate is less than 40 beats per minute.

- **Yohimbine:** 0.05 mg/kg intravenously. Yohimbine reverses the effects of xylazine. It may be used when the respiratory rate of the animal is less than six breaths per minute. Administration of yohimbine may require ending the procedure.

- **Epinephrine:** 0.02 – 0.03 mg/kg intravenously. Epinephrine is a cardiac stimulant and should only be administered in extreme emergencies such as cardiac arrest.

Once all necessary procedures have been completed, any restraining ropes should be removed from the animal's legs and non-essential personnel should leave the area. The immobilizing drug is then reversed with naltrexone or other antagonist as appropriate. An animal can either be left to get up on its own, or one or two handlers can remain to hold the head and steady the animal as it gains its feet.

Animals should be monitored for up to 48 hours post-immobilization for signs of renarcotization. This occurs when the immobilizing drug is still present in an animal's system while the reversal drug is being cleared to a level where it is no longer effective. An animal may exhibit signs similar to those of narcotic induction, including sedation, pacing, vocalizing, ataxia, head-pressing or even sternal recumbency.

Mechanical Restraint

Many institutions have had success working cattle and buffalo species through mechanical restraint devices or commercial cattle/bison handling equipment. Animals can be worked through this equipment by forcing or squeezing them into the device or by using a combination of partial restraint and training to get them to tolerate procedures. Procedures such as blood draws, TB tests, injections, minor wound care and/or hoof work can be accomplished in mechanical restraint devices. In some cases, a standing sedation can be used in combination with the restraint device to facilitate longer or more invasive procedures, such as castrations or resolving dystocia situations.

General acclimation techniques and principles of operant conditioning can be successfully used with all of these species.

TRANSPORT

Animals in poor condition or females in the late second or third trimester of pregnancy should not be shipped.

In general, a trailer is used for transport of wild cattle species such as bison, banteng, gaur, anoa, and Asian and African buffalo. Because of their large size, the use of a crate is generally not recommended except for transport of juvenile or sub-adult animals or for air transport. When transporting wild cattle in a trailer, animals should be singly-stalled and stalls should be partitioned in such a way that the animal has enough room to lie down and stand up, but not turn around. Too much space allows the animal to jump up, potentially injuring itself.

For transfer of cattle species in a crate, the animal must have enough room to stand erect with its head extended, even if horned. The size of the crate must sufficiently restrict movement so that the animal cannot turn around and, in so doing, trap or injure itself, or have space to kick and damage the container. Typically, the crate should be about 12" wider and 18" longer than the animal. The crate must be constructed of one-inch solid wood or metal parts, bolted or screwed together. For these particular taxa, metal bracing must be present around the whole container. The interior must be completely smooth, and free of potential hazards to the animal. Two rows of ventilation holes, approximately four per foot, with a maximum diameter of 2" should be present above eye level and below the level of the carpus on all four sides. Food and water containers must be provided such that they can be accessed from outside the crate. For more specific requirements and regulations regarding transport crate size and design, more information is available from IATA (International Air Transport Association), USDA (United States Department of Agriculture), or APHIS (Animal and Plant Health Inspection Service).

Food and water must be provided to animals during transit. Because animals are likely to be excitable or even aggressive, it is best to affix a water container in the trailer stall or crate ahead of time. A trap door or opening should be available to add water or food during transit. For obvious reasons, the entire stall or crate door should not be opened in order to provide water or food.

Bedding or other substrate should be placed in the trailer stall or crate in order to provide traction, warmth during cold weather, absorption of urine and feces, and to reduce abrasions. A grass hay is suitable for bedding; pine shavings are not recommended due to the risk of ingestion. Rubber mats or a thin layer of decomposed granite may be used to prevent animals from slipping. It is not generally possible to utilize a tray or floor slats in a trailer or crate floor for urine and/or feces to fall through. Bedding material to provide adequate absorption of urine is recommended.

Transport of wild cattle species in either hot or cold temperature extremes is not recommended. In addition to animal welfare concerns, winter transports in cold climate areas can be hazardous due to driving conditions. General temperatures permitted by airlines for live animals are 45-85° F. Individual airlines should always be contacted well in advance of a planned shipment to confirm all shipping regulations, including temperature guidelines and restrictions on crate dimensions.

While it is possible to ameliorate cold conditions by providing ample bedding in a trailer or crate, the transport of wild cattle should not be undertaken at prolonged temperatures below 40° F. It must be noted that even if ambient temperatures are not considered extreme, the temperature inside a

trailer or crate can be as much as 10° F. warmer. Transports should not be undertaken at ambient temperatures above 90° F. Crates or trailers should never be left immobile for prolonged periods of time in direct sunlight when ambient temperatures approach the heat extremes noted above.

A darkened trailer stall or crate is most appropriate for transport of wild cattle species, as this helps to reduce the effects of visual stimuli. Because capture and transport are among the most stressful events in an animal's life, ambient noise during transport should be minimized.

In general, wild cattle should be singly stalled in a trailer or crated individually. It is possible to place 2-3 female banteng in an appropriately sized trailer stall, or perhaps a cow and calf of selected species (gaur, buffalo, bison), depending on size and temperament.

Whether a crate or trailer is selected for transporting wild cattle specimens, it is important to consider the need for handler/veterinarian access to the animal during transport and for personnel to be able to clearly see the animal during transport in order to check its condition. A handler will need to have some type of port or other small opening in order to replenish water and/or food. Also, it may be necessary to administer drugs (narcotic reversal agents, tranquilizers, etc.) or medical treatment while the animal is confined.

In general, wild cattle specimens can tolerate a cross-country trip in a transport trailer of up to five days. Large cattle tend to lie down during transport and can develop lameness after lying for extended periods so it is important to encourage them to their feet 2-3 times a day. For animals confined to a crate, the transport time should be considerably shortened, probably two days at a maximum, because their ability to move about is much more restricted.

Following transport, a specimen is typically released into a small holding pen or barn stall, prior to being released into a large enclosure. This pen or stall should be free from visual and noise intrusions, so that the animal can acclimate gradually to its new surroundings. An enclosed stall or heavily-constructed chain-link (minimum 9-gauge) pen with privacy slatting are suitable for most specimens. However, newly confined or aggressive animals can be destructive to their barriers. African buffalo should not be contained with chain-link. Minimum stall or pen size should be 10 ft by 15 ft for most specimens; 20 ft by 20 ft for mature bulls of larger species. Whenever possible, this stall or pen should adjoin an outdoor pen so that the animal can have access to natural light and fresh air during the acclimation period. Any vertical barriers constructed of material that the animal can see through should be covered with a screening material or at least marked with flags to reduce the likelihood that the animal will try to go through them.

BEHAVIORAL MANAGEMENT

Training

Behavioral husbandry training has not been widely used with wild cattle specimens but can be an effective animal management tool. Animals can be target-trained for purposes of shifting, stationing, or for obtaining regular body weights on a platform-type scale. Most species in these taxa can be acclimated to some type of chute or restraint device. Commercially available cattle chutes designed for use with bison work well with the larger species, such as banteng and gaur.

A combination of partial restraint and operant conditioning can be used to accomplish many routine husbandry procedures. With an investment in staff training and animal conditioning, procedures such as blood draws, TB testing, injections, heart and lung auscultation, rectal temperatures, minor wound care and light hoof work can often be accomplished on non-anesthetized specimens.

Enrichment

Enrichment should be designed to elicit species-appropriate behaviors. Enclosures should be provisioned with objects such as trees, stumps, deadfall, rocks, and natural vegetation placed irregularly throughout the exhibit to enhance the daily routines of the animals. Many cattle species will enjoy a wallow or shallow water element. Provisioning the enclosure with browse, hidden food items, herbs and scents may increase the animals' activity levels, especially if replaced at irregular intervals during the day. Fruits with significant sugar content should be avoided, as they can contribute to rumen acidosis. Produce offered for behavioral training or enrichment purposes should not comprise more than 4% of the overall diet. Daily food rations should be divided between at least two feedings in order to better simulate the amount of time animals would spend feeding in the wild.

Selected References

Achuff, P. and Petocz, R. (1988) Preliminary resource inventory of the Arjin Mountains Nature Reserve, Xinjiang, People's Republic of China. WWF: Gland, Switzerland.

Ackerman, D.J., Reinecke, A.J.and Els, H.J. (1994) The ultrastructure of spermatozoa of African buffalo (Syncerus caffer) in the Kruger National Park. Animal Reproduction Science 36: 87-101.

Alikodra, H. (1987) The ecology of banteng (Bos javanicus) in the National Park of Ujung Kulon. Biotrop Special Publications 30: 161-167.

Anon. (1975) Kouprey in Thailand. Tigerpaper 2(3): 8-9.

Anon. (1979) Is it the last kouprey? Tigerpaper 7(2): 32.

Anon. (1982) Kouprey alert. Tigerpaper 9(3): 24.

Ashby, K.R. and Santiapillai, C. (1986) An assessment of the status of the banteng (Bos javanicus) with particular reference to its interaction with the water buffalo (Bubalus bubalis). Tigerpaper 13(4): 10-20.

Ashby, K.R. and Santiapillai, C. (1987) The life expectancy of banteng (Bos javanicus) and buffalo (Bubalus bubalis) in Baluran National Park, East Java, Indonesia. Biotrop Special Publications 30: 151-160.

Ashby, K.R. and Santiapillai, C. (1988) The status of the banteng (Bos javanicus) in Java and Bali. Tigerpaper 15(4): 16-25.

Baird, I. (1993) Wildlife trade between the southern Lao PDR provinces of Champassak, Sekong, and Attapeu and Thailand, Cambodia, and Vietnam. TRAFFIC Southwest Asia Field Report No. 3: Kuala Lumpur, Malaysia.

Baldwin. C.L., Malu, M.N. and Grootenhuis, J.G. (1988) Evaluation of cytotoxic lymphocytes and their parasite strain specificity from African buffalo infected with (Theileria parva). Parasite Immunology 10: 393-403.

Bamforth, D.B. (1987) Historical documents and bison ecology on the great plains. Plains Anthropologist 32(115): 1-16.

Baskin, Y. (1998) Home on the range: scientists are scrambling to understand the complexities of brucellosis in Yellowstone's bison. BioScience 48(4): 245-251.

Beekman, J.H. and Prins, H.H.T. (1989) Feeding strategies of sedentary large herbivores in East Africa, with emphasis on the African buffalo (Syncerus caffer). African Journal of Ecology 27: 129-147.

Belue,T. F. (1996) The Long Hunt: Death of the Buffalo East of the Mississippi. Mechanicsburg, Pennsylvania: Stackpole Books.

Berger, J. and Cunningham, C. (1994) Bison of the past, present, and future. In: (ed. Pearl, M.C.), pp. 24-41. Bison: Mating and Conservation in Small Populations. New York, New York: Columbia University Press.

Berger, J. and Cunningham, C. (1995) Multiple bottlenecks, allopatric lineages and Badlands bison (Bos bison): consequences of lineage mixing. Biological Conservation 71(1): 13-23.

Biondini, M.E., Steuter, A. and Hamilton, R.G. (1999) Bison use of fire-managed remnant prairies. Journal of Range Management 52: 454-461.

Blaszkiewitz, B. (1999) Africana 3: Two new open-air enclosures for African Cape and Forest Buffalo in the Berlin-Friedrichsfelde Zoo. Zoologische Garten 69(4): 225-230.

Blower, J.H. (1986) Nature conservation in Bhutan: project findings and recommendations. Unpublished report on project number FO: DP/BHU/83/022, UNDP/FAO, Rome, Italy.

Bowman, D. (1992) Banteng. Australian Natural History 24(3): 16.

Breining, G. (1992) Back home on the range: bison are stampeding back from the brink of extinction. Nature Conservancy, November/December 10-15.

Brown, J.L., Wildt, D.E., Raath, J.R., de Vos, V., Howard, J.G., Janssen, D.L., Citino, S.B. and Bush, M. (1991) Impact of season on seminal characteristics and endocrine status of adult free-ranging African buffalo (Syncerus caffer). Journal of Reproduction and Fertility 92: 47- 57.

Bunting, B.W. (1989) Strategy for environmental conservation in Bhutan: a WWF/RGOB cooperative program, July 1989. Tigerpaper, October-December: 5-12.

Burzyńska, B., Olech, W. and Topczewski, J. (1999) Phylogeny and genetic variation of the European bison (Bison bonasus) based on mitochondrial DNA D-loop sequences. Acta Theriologica 44(3): 253-262.

Butynski, T. M., Schaaf, C. D. and Hearn, G. W. (1997) African buffalo (Syncerus caffer) extirpated on Bioko Island, Equatorial Guinea. Journal of African Zoology 111(1): 57-61.

Byers, O., Hedges, S. and Seal, U.S. (eds.) (1995) Asian wild cattle conservation assessment and management plan workshop. Working document. IUCN/SSC Conservation Breeding Group, Apple Valley, Minnesota, USA.

Caboń-Raczyńska, K., Krasińska, M., Krasiński, Z.A, and Wojcik, J.M. (1987) Rhythm of daily activity and behavior of European bison in the Białowieza Forest in the period without snow cover. Acta Theriologica 32(21): 335-372.

Callo, R.A (1991) The tamaraw population: decreasing or increasing? Canopy International 16(4): 4-9.

Callo, R.A. (1996) Tamaraw habitat and ecology. In: (eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U.S.), pp. 125-135. Tamaraw (Bubalus mindorensis) Population and Habitat Viability Assessment. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Campbell, C., Campbell, I. D., Blyth, C.B. and McAndrews, J.H. (1994) Bison extirpation may have caused aspen expansion in western Canada. Ecography 17(4): 360-362.

Carbyn, L.N., Lunn and Timoney, K. (1998) Trends in the distribution and abundance of bison in Wood Buffalo National Park. Wildlife Society Bulletin 26(3): 463-470.

Chamberlan, C., Marechal, C. and Maurois, C. (1999) Estimation of the population of forest buffalo, (Syncerus caffer nanus) in Odzala National Park, Republic of Congo. Cahiers D'Ethologie 18(2): 295-298.

Choudhury, A. (1994) The decline of the wild water buffalo in northeast India. Oryx 28(1): 70-73.

Choudhury, A. (2000) The status of guar (Bos gaurus) in Mizoram, India. Tigerpaper 27(3): 30-31.

Condy, J.B. and Hedger, R.S. (1978) Experiences in the establishment of a herd of foot-and-mouth disease free African buffalo (Syncerus caffer). South African Journal of Wildlife Research 8: 87-89.
Conry, P.J. (1989) Gaur (Bos gaurus) and development in Malaysia. Biological Conservation 49: 47-65.

Cox, R., Laurie, A. and Woodford, M. (1992) Report of the results of four field surveys for kouprey (Bos sauveli) in Viet Nam and Lao. P.D.R. Unpublished report, Kouprey Conservation Trust.

Cox, R. and Woodford, M. (1990) A Technical Evaluation of the Philippine Tamaraw Conservation Programme. A Report to the Department of Environment and Natural Resources, Republic of the Philippines by IUCN, Zoological Society of London and Bristol, Clifton and West England Zoological Society.
Cribiu, E.P. and Popescu, C.P. (1980) Chromosome constitution of a hybrid between east African buffalo (Syncerus caffer caffer) and dwarf forest buffalo (Syncerus caffer nanus). Annales de Genetique et de Selection Animale 12(3): 291-293.

Czykier, E., Sawicki, B. and Krasińska, M. (1999) Postnatal development of the European bison spermatogenesis. Acta Theriologica 44(1): 77-90.

Danz, H.P. (1997) Of Bison and Man. Niowot, Colorado: University Press of Colorado.

Daubenmire, R. (1985) The western limits of the range of the American bison. Ecology 66(2): 622-624.

Davis, S. and Read, B. (1985) The status of North American captive herds of the banteng (Bovis javanicus). Zoo Biology 4(3): 269-279.

de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U.S. (eds.) (1996) Tamaraw (Bubalus mindorensis) Population and habitat viability assessment. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Desai, A.A. and Lic Vuthy (1996) Status and Distribution of Large Mammals in Eastern Cambodia: Results of the First Foot Surveys in Mondulkiri and Rattanakiri Provinces. IUCN/FFI/WWF Large Mammal Conservation Project, Phnom Penh, Camobdia.

Divekar, H.K. and Bharat Bhusan (1988) Status of wild Asiatic buffalo (Bubalus bubalis) in the Raipur and Bastar Districts of Madhya Pradesh. Technical Report of the Bombay Natural History Society of the Salim Ali Nature Conservation Fund, SANCF Report No. 3/1988.

Drager, N. and Paine,G.D. (1980) Demodicosis in African buffalo (Syncerus caffer caffer) in Botswana. Journal of Wildlife Diseases 16(4): 521-524.

Dresser, B.L. (1986) Embryo transfer in exotic bovids. International Zoo Yearbook 24/25: 138-142.

Duckworth, J.W. and Hedges, S. (1998) A Review of the Status of Tiger, Asian Elephant, Gaur, and Banteng in Viet Nam, Lao, Cambodia, and Yunnan (China), with Recommendations for Future Conservation Action. WWF Indochina Programme, Hanoi, Viet Nam.

Duckworth, J.W., Salter, R.E. and Khounboline, K. (compilers) (1999) Wildlife in Lao PDR: 1999 Status Report. IUCN, WCS and CPAWM, Vientiane, Lao PDR.

Duckworth, J.W., Timmins, R.J., Thewlis, R.C.M., Evans, T.D. and Anderson, G.Q.A. (1994) Field observations of mammals in Laos, 1992-1993. Natural History Bulletin of the Siam Society 42: 177-205.

Foggin, C.M. and Taylor, R.D. (1996) Management and utilization of the African buffalo in Zimbabwe. In: (ed Penzhorn, B.L.), pp. 144-162. The African Buffalo as a Game Ranch Animal. South African Veterinary Association Wildlife Group, Onderstepoort.

Foster, J.E. (1992) The metis and the end of the plains buffalo in Alberta. In: (eds. Foster, J.E., Harrison, D. and MacLaren, I.S.), pp. 61-77. Buffalo. Edmonton, Alberta: University of Alberta Press.

Frank, S., Eulenberger, K., Rohleder, M. and Meyer, H.H.D. (1997) Reproduction of anoa (Bubalus depressicornis) monitored by fecal progestin analysis. Zeitschrift fuer Saeugetierkunde, 62(Supplementum 2): 59-65.

Gates, C., Chowns, T. and Reynolds, H. (1992) Wood buffalo at the crossroads. In: (eds Foster, J.E., Harrison, D. and MacLaren, I.S.), pp. 139-165. Buffalo. Edmonton, Alberta: The University of Alberta Press.

Gebczyńska, Z., Gebczyński, M. and Martynowicz, E. (1991) Food eaten by the free-living bison in Białowieza Forest. Acta Theriologica 36(3-4): 307-313.

Geist, V. (1996) Buffalo nation: History and legend of the North American bison. Stillwater, Minnesota: Voyageur Press.

Gill, J. (1992) Seasonal changes in activity of some enzymes in the European bison (Bison bonasus). Acta Theriologica 37(3): 291-300.

Gill, J. (1992) Seasonal changes in the white blood cell count and blood cell sedimentation rate in the European bison (Bison bonasus). Acta Theriologica 37(3): 279-290.

Gill, J. (1993) Evidence for the need to protect European bison (Bison bonasus) living in modern environments. Proceedings of the International Union of Game Biologists Congress 21(2): 29-34.

Gill, J. (1998) Do the abiotic environmental factors influence the reproduction rate in the free-ranging European bison in Białowieza Primeval Forest? Acta Theriologica 43(4): 417-432.

Gompper, M.E., Stacey, P.B. and Berger, J. (1997) Conservation Implications of the Natural Loss of Lineages in Wild Mammals and Birds. Conservation Biology (11) 4: 857-867.

Hamblin, C. and Hedger, R.S. (1978) Neutralising antibodies to parainfluenza-three virus in African wildlife, with special reference to the cape buffalo (Syncerus caffer). Journal of Wildlife Diseases 14: 378-388.

Harris, R.B., Pletshcer, D.H., Loggers, C.O., and Miller, D.J. (1999) Status and trends of Tibetan plateau mammalian fauna, Yeniugou, China. Biological Conservation 87: 13-19.

Hartl, G.B. and Pucek, Z. (1994) Genetic depletion in the European bison (Bison bonasus) and the significance of electrophoretic heterozygosity for conservation. Conservation Biology 8(1): 167-174.

Hedges, S. (1996) Proposal for transfer of wild Asian buffalo (Bubalus bubalis) from CITES Appendix III to Appendix I. Proposal prepared for the IUCN/SSC Asian Wild Cattle Specialist Group, the IUCN/SSC Wildlife Trade Programme, and the Thai Government.

Hedges, S. (1996) Proposal for inclusion of Banteng (Box javanicus) in CITES Appendix I. Proposal prepared for the IUCN/SSC Asian Wild Cattle Specialist Group, the IUCN/SSC Wildlife Trade Programme, and the Thai Government.

Heinen, J.T. (1993) Population viability and management recommendations for wild water buffalo (Bubalus bubalis) in Kosi Tappu Wildlife Reserve, Nepal. Biological Conservation 65: 29-34.

Hendrix, S. (1995) Quest for the kouprey. International Wildlife 25(5): 20-23.

Heng Kimchhay, Ouk Kimsan, Kry Masphal, Sin Polin, Uch Seiha and Weiler, H. (1998) The Distribution of Tiger, Leopard, Elephant and Wild Cattle (Gaur, Banteng, Buffalo, Khting Vor and Kouprey) in Cambodia. Interm Report: July 1998. Wildlife Protection Office, Phnom Penh, Cambodia.

Hicks, M.V. (1995) Bison. Alaska Department of Fish and Game Division of Wildlife Conservation Federal Aid in Wildlife Restoration Annual Performance Report of Survey-Inventory Activities 24-3(9.0): 1-7.

Hicks, M.V. (1999) Bison. In: (ed. Hicks, M.V.), pp. 1-6. Alaska Department of Fish and Game Division of Wildlife Conservation Federal Aid in Wildlife Restoration Annual Performance Report of Survey-Inventory Activities, Alaska Department of Fish and Game.

Hoffmann, R.S. (1986) A new locality record for the kouprey from Viet Nam, and an archaeological record from China. Mammalia 50(3): 391-395.

Hunter, C.G. (1996) Land uses on the Botswana/Zimbabwe border and their effects on buffalo. South African Journal of Wildlife Research 26(4): 136-150.

Jahja, M.M. (1987) The possibility of breeding anoa in captivity: An alternative for conservation of the species. Biotrop Special Publications 30: 101-108.

Jedrzejewska, B., Jedrzejewski, W., Bunevich, A., Milkowski, L. and Krasiński, Z. (1997) Factors shaping population densities and increase rates of ungulates in Białowieza Primeval Forest (Poland and Belarus) in the 19th and 20th centuries. Acta Theriologica 42(4): 399-451.

Kakoi, H., Namikawa, T., Takenaka, O., Takenaka, A., Amano, T. and Martojo, H. (1994) Divergence between the anoas of Sulawesi and the Asiatic water buffaloes, inferrerd from their complete amino acid sequences of hemoglobin [beta] chains. Zeitschrift Fuer Zoologische Systematik und Evolutionsforschung 32(1): 1-10.

Kalita, H.C. and Chandramouly, K.N. (1997) Morphometry of the cardiac glands in Indian buffaloes. Indian Veterinary Journal 74(1): 46-50.

Kalita, H.C. and Prasad, R.V. (1996) Carbohydrate histochemistry and histology of the mucous neck cells in the abomasal glands of Indian buffaloes (Bubalus bubalis). Indian Veterinary Journal 73 (12): 1288-1289.

Kassim, H. and Baharin, K. (1979) Grazing behaviour of the swamp buffalo (Bubalus bubalis). Pertanika 2(2): 125-127.

Keiter, R.B. (1997) Greater Yellowstone's bison: unraveling of an early American wildlife conservation achievement. Journal of Wildlife Management 61(1): 1-11.

Khan, M.H. and Patnaik, B. (1978) Seasonal incidence of muscid flies associated with buffaloes at Izatnagar, Uttar Pradesh. Indian Veterinary Journal 55(11): 857-861.

Kikkawa, Y., Yonekawa, H., Suzuki, H. and Amano,T. (1997) Analysis of genetic diversity of domestic water buffaloes and anoas based on variations in the mitochondrial gene for cytochrome b. Animal Genetics 28(3): 195-201.

Kirikov, S.V. (1979) Distribution of European bison in the USSR territory in the 11th-20th centuries. In: (ed Sokolov, V.E.), pp. 476-487. European Bison: Morphology, Systematics, Evolution, Ecology. Nauka, Moscow.

Kobryńczuk, F. (1985) The influence of inbreeding on the shape and size of the skeleton of the European bison. Acta Theriologica 30(25): 379-422.

Kobryńczuk, F. and Krasińska, M. (1987) Taxonomic studies on skulls of European bison and domestic cattle hybrids. Acta Theriologica 32(12): 203-218.

Kobryńczuk, F. and Krasińska, M. (1991) Shape of the mandible in European bison and domestic cattle hybrids. Acta Theriologica 36(1-2): 171-177.

Kramer, B., Hattingh, J., Teixeira, M., Wolf, D. and Raath, J.P. (1995) The neuromuscular junction in the African elephant (Loxodonta africana) and African buffalo (Syncerus caffer). South African Journal of Wildlife Research 25(1): 14-16.

Krasińska, M., Cabon-Raczyńska, K. and Krasiński, Z. (1987) Strategy of habitat utilization by European bison in the Białowieza Forest. Acta Theriologica 32(11): 147-202.

Krasińska, M. and Krasiński, Z. (1995) Composition, group size, and spatial distribution of European bison bulls in Białowieza Forest. Acta Theriologica 40(1): 1-21.

Krasińska, M., Krasiński, Z.A. and Bunevich, A.N. (2000) Factors affecting the variability in home range size and distribution in European bison in the Polish and Belarussian parts of the Białowieza Forest. Acta Theriologica 45(3): 321-334.

Krasiński, Z.A. (1978) Dynamics and structure of the European bison population in the Białowieza Primeval Forest. Acta Theriologica 23(1): 3-48.

Krasiński, Z. and Krasińska, M. (1992) Free ranging European bison in Borecka Forest. Acta Theriologica 37(3): 301-317.

Krishnan, M. (1972) An ecological survey of the larger mammals of peninsular India. Journal of the Bombay Natural History Society 69: 322-349.

Krumbiegel, I. and Sehm, G.G. (1989) The geographic variability of the plains bison. A reconstruction using the earliest European illustrations of both subspecies. Archives of Natural History 16(2): 169-190.

Lad, P.M. and Gopal, R. (1992) The status of Indian guar (Bos gaurus) in Bandhavgarh National Park. Journal of Tropical Forestry 8(1): 84-95.

Larter, N.C. and Gates, C.C. (1994) Home-range size of wood bison: effects of age, sex, and forage availability. Journal of Mammology 75(1): 142-149.

Lawas, N.R. and de Leon, J. (1996) The tamaraw conservation program: past, present, and future thrusts and direction. In: (eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U.S.), pp. 119-123. Tamaraw (Bubalus mindorensis) Population and Habitat Viability Assessment. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Le Xuan Canh, Pham Trong Anh, Duckworth, J.W., Vu Ngoc Thanh and Lic Vuthy (1997) A survey of large mammals in Dak Lak Province, Viet Nam. Unpublished report to IUCN and WWF, Hanoi, Viet Nam.

Lic Vuthy, Sun Hean, Hing Chamnan and Dioli, M. (1995) A brief field visit to Mondolkiri Province to collect data on kouprey (Bos sauveli), rare wildlife for field training. Unpublished report to Canada Fund and IUCN.

MacKinnon, J.R. and Stuart, S.N. (compilers) (1989) The kouprey: an action plan for its conservation. Gland, Switzerland: IUCN.

Mahaney, W.C. (1987) Behaviour of the African buffalo on Mount Kenya. African Journal of Ecology 25: 199-202.

Martin, E.B. and Phipps, M. (1996) A review of wild animal trade in Cambodia. Traffic Bulletin 16(2): 45-60.

Mattison, R.G., Hanna, R.E.B. and Nizami, W.A. (1992) Ultrastructure and histochemistry of the protonephridial system of juvenile (Paramphistomum epiclitum) and (Fischoederius elongates) (Paramphistomidae: Digenea) during migration in Indian ruminants. International Journal for Parasitology 22(8): 1103-1115.

McCormack, P.A. (1992) The political economy of bison management in Wood Buffalo National Park. Arctic 45(4): 367-380.

Meagher, M. (1989) Range expansion by bison of Yellowstone National Park. Journal of Mammology 70(3): 670-675.

Melisch, R.(1995) Anoa threatened by souvenir trade in South Sulawesi, Indonesia. Oryx 29(4): 224-225.

Melton, D., Larter, N., Gates, C. and Virgl, J. (1989) The influence of rut and environmental factors on the behaviour of wood bison. Acta Theriologica 34(12): 179-193.

Miller, D.J. and Schaller, G.B. (1997) Conservation threats to the Chang Tang Wildlife Reserve, Tibet. Ambio 26(3): 185-186.

Miller, D.J., Harris, R., and Cai, G. (1994) Wild yaks and their conservation on the Tibetan Plateau. In: (eds. Zhang, R., Han, J. and Wu,J.); pp. 27-34. Proceedings of the 1st International Congress on Yak. Gansu Agricultural University, Lanzhou.

Minta, S. and Mangel, M. (1989) A simple population estimate based on simulation for capture-recapture and capture-resight data. Ecology 70(6): 1738-1751.

Misiak, J. (1979) Problems of animal introduction into Kampinos Forest. Memorabilia Zoologica 32: 159-167.

Mloszewski, M.J. (1983) The Behavior and Ecology of the African Buffalo. Cambridge, England: Cambridge University Press.

Mollel, C.L. (1979) The incidence of hernia in the East African buffalo. African Journal of Ecology 17: 45-46.

Momongan, V.G. and Walde,G.I. (1993) Behavior of the endangered tamaraw (Bubalus mindorensis huede) in captivity. Asia Life Sciences 2(2): 241-350.

Mustari, A.H. (1995) Population and behaviour of Lowland Anoa (Bubalus depressicornis) in Tanjung Amolengu Wildlife Reserve South-East Sulawesi, Indonesia. Unpublished M.Sc. thesis, Faculty of Forestry Science, Georg-August University, Göttingen, Germany.

National Research Council. (1983) Little-known Asian animals with a promising economic future. Washington, D.C.: National Academy Press.

Nudds, T.D. (1993) How many bison, (Bison bison), should be in Wood Buffalo National Park? Canadian Field Naturalist 107(1): 117-119.

Nutting, W.B. and Guilfoy, F.M. (1979) (Demodex cafferi) NSP from the African buffalo, (Syncerus caffer). International Journal of Acarologs 5(1): 9-14.

O'Brien, T.G. and Kinnaird, M.F. (1996) Changing populations of birds and mammals in North Sulawesi. Oryx 30(2): 150-156.

Okarma, H., Jedrzejewska, B., Jedrzejewski, W., Krasiński, Z. and Milkowski, L. (1995) The roles of predation, snow cover, acorn crop, and man-related factors on ungulate mortality in Białowieza Primeval Forest, Poland. Acta Theriologica 40(2): 197-217.

Olech, W. (1987) Analysis of inbreeding in European bison. Acta Theriologica 32(22): 373-387.

Olivier, R. and Woodford, M. (1994) Aerial surveys for Kouprey in Cambodia, March 1994. Gland, Switzerland and Cambridge, UK: IUCN/SSC.

O'Ryan, C., Harley, E.H., Bruford, M.W., Beaumont, M., Wayne, R.K. and Cherry, M.I. (1998) Microsatellite analysis of genetic diversity in fragmented South African buffalo populations. Animal Conservation 1: 85-94.

Pal, B.C. and Guin, D.P. (1986) Population structure of gaur herds at Garumara Wildlife Sanctuary, West Bengal, India. Proceedings of the Zoological Society, Calcutta. 35(1-2): 89-95.

Payne, J., Francis, C.M. and Phillipps, K. (1985) A Field Guide to the Mammals of Borneo. The Sabah Society, Kota Kinabalu and WWF Malaysia, Kuala Lumpur, Malaysia.

Peters, J. (1988) Osteomorphological features of the appedicular skeleton of African buffalo, (Syncerus caffer) (Sparrman, 1779) and of domestic cattle, (Bos primigenius). Z. Saugetierkunde 53: 108-123.

Petocz, R. (1989) Status of the tamaraw (Bubalus mindorensis). Asian Wild Cattle Specialist Group Newsletter, 2: 1-4.

Pitra, C., Furbass, R. and Seyfert, H.M. (1997) Molecular phylongeny of the tribe Bovini (Mammalia: Artiodactyla): alternative placement of the Anoa. Journal of Evolutionary Biology 10(4), 589-600.

Price Forbes Chair in Wildlife (1996) Bibliography of the African buffalo. In: (ed Penzhorn, B.L.), pp. 163-188. The African buffalo as a game ranch animal. South African Veterinary Association Wildlife Group, Onderstepoort, 163-188.

Prins, H.H.T. (1989) Buffalo herd structure and its repercussions for condition of individual African buffalo cows. Ethology 81: 47-71.

Prins, H.H.T. (1989) Condition changes and choice of social environment in African buffalo bulls. Behaviour 108(3-4): 297-324.

Pucek, Z. (1983) The European bison: current state and problems of management. Conservation, Science, and Society 2: 276-282.

Pucek, Z. (1984) What to do with the European bison, now saved from extinction? Acta Zoological Fennica 172: 187-190.

Pucek, Z., Udina, I., Seal, U.S. and Miller, P. (1996) Population and habitat viability assessment for the European bison (Bison bonasus). Wolinski National Park Miedzyzdroje, Poland. IUCN/SSC Conservation Breeding Specialist Group i-vi: 1-163.

Pytel ,S., Wegrzyn, M. and Kobryńczuk, F. (1988) Abnormal development of the caudal vena cava in European bison. Acta Theriologica 33(25): 361-365.

Quimbo, M.A. (1996) Tamaraw population: distribution and status. In: (eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U.S.), pp. -137-145. Tamaraw (Bubalus mindorensis) Population and Habitat Viability Assessment. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Rabinowitz, A., Schaller, G.B. and Uga, U. (1995) A survey to assess the status of Sumatran rhinoceros and other large mammal species in Tamanthi Wildlife Sanctuary, Myanmar. Oryx 29(2): 123-128.

Rabor, D.S. (1986) Guide to the Philippine flora and fauna. Natural Resources Management Centre, Ministry of Natural Resources and University of the Philippines.

Read, B. (1988) Throwing a lifeline to the endangered kouprey. International Zoo News 35(5): 26-29.

Read, B., Morris, D., Loskutoff, N. and Ellis, S. (1994) Prepatory Document for the Bovid Conservation Assessment and Management Plan: Participants' First Draft, 20 April 1994. IUCN/SSC Captive Breeding Specialist Group.

Read, B. (1996) An update on the bison, buffalo and cattle TAG. American Zoo and Aquarium Association Regional Conference Proceedings, 343-345.

Reeves, B.O.K. (1983) Six millenniums of buffalo kills. Scientific American 249(4): 120-135.

Reynolds, H. (1982) An endangered species program brings wood bison to Nahanni. Zoonooz 55(7): 4-8.

Ridpath, M.G. and Waithman, J. (1988) Controlling feral Asian water buffalo in Australia. Wildlife Society Bulletin 16(4): 385-390.

Salter, R.E., Bouaphanh Phanthavong, Sivannavong Sawathvong, Sanxay Souriyakan, and Khamphay Louanglath. (1990) An assessment of the current status of kouprey and other wild cattle in southern Laos. Unpublished report, Forest Resources Conservation Project Lao/Swedish Forestry Cooperation Programme, Vientiane, Laos.

Salter, R.E. (compiler) (1993) Wildlife in the Lao PDR. A Status Report. IUCN, Vientiane, Lao PDR.

Salter, R.E. (1983) Summary of currently available information on internationally threatened wildlife species in Burma. FAO Nature Conservation and National Parks Project. Field Document 7/83. Fo: BUR/80/006. FAO, Rangoon, Burma.

Sawicki, B. (1991) Ultimobranchial follicles and cysts in the European bison thyroid. Acta Theriologica 36(3-4): 349-356.

Sawicki, B., Siuda, S. and Kasacka, I. (1992) Microscopic structure of the thyriod gland in the European bison. Acta Theriologica 37(1-2): 171-179.

Schaller, G.B. and Gu, B. (1994) Ungulates in Northwest Tibet. National Geographic Research and Exploration 10(3): 266-293.

Schaller, G.B. (1967) The Deer and the Tiger. A Study of Wildlife in India. Chicago and London: University of Chicago Press.

Schaller, G.B. and Wulin, L. (1996) Distribution, status, and conservation of wild yak (Bos grunniens). Biological Conservation 76(1): 1-8.

Schreiber, A, Nötzold, G. and Held, M. (1993) Molecular and chromosomal evolution in anoas (Bovidae: Bubalus spec.). Zeitschrift fuer Zoologische Systematik und Evolutionsforschung 31(1): 64-79.

Schreiber, A. and Nötzold, G. (1995) One EEP, but how many anoas? In: (eds. Rietkerk, F. Brouwer, K. and Smits, S.), pp. 419-424. EEP Yearbook 1994/95. EAZA/EEP Executive Office, Amsterdam, The Netherlands.

Schreiber, A., Seibold, I., Notzold, G. and Wink, M. (1999) Cytochrome b gene haplotypes characterize chromosomal lineages of anoa, the Sulawesi dwarf buffalo (Bovidae: Bubalus sp.). Journal of Heredity 90(1): 165-176.

Shaw, J.H. (1995) How many bison originally populated western rangelands? Rangelands 17(5): 148-150.

Simonsen, B.T. Segismund, H.R. and Arctander, P. (1998) Population structure of African buffalo inferred from mtDNA sequences and microsatellite loci: high variation but low differentiation. Molecular Ecology 7: 225-237.

Skinner, S. (1991) Hunt on hold. Wyoming Wildlife 55(10): 12-15.

Solis, C.D., Kawamoto,Y., Tanaka, K., Masangkay, J.S. and Namikawa,Takao (1998) Transferrin polymorphism in the tamaraw (Bubalus mindorensis) and comparison among the Asian buffaloes using polyacrylamide gel electrophoresis. Philippine Journal of Veterinary Medicine 35(1-2): 37-40.

Spinage, C.A. and Brown, W.A.B. (1988) Age determination of the West African buffalo (Syncerus caffer brachyceros) and the constancy of tooth wear. African Journal of Ecology 26: 221-227.

Srifa La-Ong, Duangrat Pothieng and Bok Sakon. (1997) Survey on Wildlife Trading at the Frontier of Thailand-Cambodia and People's Republic Democratic of Laos. WWF-Thailand, Bankok, Thailand.

Srikosamatara, S. and Suteethorn, V. (1994) Wildlife conservation along the Thai-Lao border. Natural History Bulletin of the Siam Society 42: 3-21.

Srikosamatara, S., Siripholdej, B. and Suteethorn, V. (1992) Wildlife trade in Lao P.D.R. and between Lao P.D.R. and Thailand. Natural History Bulletin of the Siam Society 40: 1-47.

Srikosamatara, S. and Suteethorn, V. (1995) Populations of gaur and banteng and their management in Thailand. Natural History Bulletin of the Siam Society 43(1): 55-83.

Stuart, S.N. (1988) New hope for the kouprey. IUCN Bulletin 19(4-6): 9.

Sugiharta, A. (1994) Abundance and habitat characterization mountain anoas in Besoa, Lore Lindu National Park, Indonesi. Unpublished M.Sc. thesis, New Mexico State University, USA.

Suvanaborn, P. (1984) Status of kouprey in Thailand. Biotrop Special Publications 21: 33-38.

Syam, A. (1978) Study of habitats and population of anoa (Anoa depressicornis) H. Smith in Mount Tangkoko Batuangus Nature Reserve, north Sulawesi. Lembaga Penelitian Hutan (Bogor) Laporan 288, 1-47.

Taylor, R.D. (1988) Age determination of the African buffalo (Syncerus caffer) (Sparrman) in Zimbabwe. African Journal of Ecology 26: 207-220.

Teixeira, M. and Kramer, B. (1993) The adrenal gland of the African buffalo, (Syncerus caffer): a light and electron microscopic study. South African Journal of Zoology 28(1): 13-17.

Thomas, O. (1898) On the mammals obtained by Mr. John Whitehead during his recent expedition to the Philippines. Transactions of the Zoological Society of London 14: 377-412.

Thornback, J. (1983) Wild cattle, bison and buffaloes, their status and potential value. IUCN Conservation Monitoring Centre, Cambridge, UK.

Turbak, G. (1995) Where the buffalo roam: Each winter they wander out of Yellowstone Park and into trouble. Wildlife Conservation 98(6): 26-35.

Ullas, K.K. (1984) Interaction between gaur and tiger in Bhadra Wildlife Sanctuary. Journal of the Bombay Natural History Society 81(2): 460-461.

Van Camp, J. (1989) A surviving herd of endangered wood bison at Hook Lake, N.W.T.? Arctic 42(4): 314-322.

Van Vuren, D. (1987) Bison west of the Rocky Mountains: an alternative explanation. Northwest Science 61(2): 65-69.

Van Vuren, D. and Bray, M.P. (1985) The recent geographic distribution of Bison in Oregon. The Murrelet 66(2) 56-58.

Waghela, S and Karstad, L. (1986) Antibodies to brucella spp. among blue wildebeest and African buffalo in Kenya. Journal of Wildlife Diseases 22(2): 189-192.

Walde, G.I., Momongan, V.G. and Escalada, R.F. (1996) The behavioral pattern and some basic physiological parameters of tamaraws (Bubalus mindorensis heude) in captivity during the dry and wet seasons. In: (eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U.S.), pp. 173-204. Tamaraw (Bubalus mindorensis) Population and Habitat Viability Assessment. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Wenink, P.W., Groen, A.F., Roelke-Parker, M.E. and Prins, H.H.T. (1998) African buffalo maintain high genetic diversity in the major histocompatibility complex in spite of historically known population bottlenecks. Molecular Ecology 7: 1315-1322.

Wharton, C.H. (1957) An Ecological Study of the Kouprey (Novibos sauveli Urbain). Monographs of the Institute of Science and Technology, Monograph 5, Manila, Philippines.

Wharton, C.H. (1968) Man, fire and wild cattle in Southeast Asia. Proceedings of the Annual Tall Timbers Fire Ecology Conference 8: 107-167.

Whitten, A.J., Mustafa, M. and Henderson, G.S. (1987) The Ecology of Sulawesi. Yogyakarta, Indonesia: Gadjah Mada University Press.

Whyte, I.J. (1996) The management of large buffalo populations. In: (ed Penzhorn, B.L.), pp. 21-36. The African Buffalo as a Game Ranch Animal. South African Veterinary Association Wildlife Group, Onderstepoort.

Witkowska, A. and Kotik, T. (1987) Concentrations of creatine, creatinine and phosphorus in skeletal muscles of the European bison. Acta Theriologica 32(13): 219-228.

Wolfe, M.L. and Kimball, J.F. (1989) Comparison of bison population estimates with a total count. Journal of Wildlife Managemen, 53(3): 593-596.

Wolfe, M.L., Shipka, M.P. and Kimball, J.F. (1999) Reproductive ecology of bison on Antelope Island, Utah. Great Basin Naturalist 59(2): 105-111.

Wolff, J.O. (1998) Breeding strategies, mate choice, and reproductive success in American bison. Oikos 83: 529-544.

Wolk, E. and Józefczak, E. (1988): Serum biochemistry of free-ranging European bison. Acta Theriologica 33(4): 47-56.

Zhang, Y. (1985) Macroscopical anatomy of kidney of (Anoa depressicornis). Sichuan Journal of Zoology 4(3): 33.