Elephant Husbandry Resource Guide

Edited by Deborah Olson

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American Zoo and Aquarium Association Elephant Taxon Group

Elephant Managers Association

International Elephant Foundation

Preface

Elephants were brought to North America 200 years ago and almost immediately gained celebrity status. The same is true today. Elephants have become the flagship species in conservation programs around the globe.

Assessing welfare status is a growing area of concern as ethical questions are raised about the psychological and physical well-being of elephants maintained in North America. At the same time, populations of free-ranging elephants are diminishing, emphasizing the need for captive breeding programs, further scientific investigation, and a heightened level of conservation education focus.

Approximately 500 Asian and African elephants live in North America. Half of this population reside in AZA institutions and the other half of our North American elephants are owned by circuses, non-AZA zoos, private individuals, sanctuaries, and corporations. The *Elephant Husbandry Resource Guide* is an attempt to address the husbandry issues faced by all elephant managers, handlers, and owners represented by these different types of facilities. The authors stress that common sense should be used at all times and that individual facility differences and goals must be considered in conjunction with these guidelines. It is the authors' intent that each facility adopt—from the many options presented—a program that most fits the needs and physical capabilities of their facilities. At the same time the emphasis is on raising the standards of elephant care throughout North America.

From the historical perspective of keeping both Asian and African elephants in North America, both species appear to share the same needs, therefore at this time these management and husbandry guidelines are for both species. Although many assumptions are based on the behavior of wild populations of elephants, it must be understood that the behavior and management of elephants in North America will be different and must be thought of in terms of restriction of space and intensive management versus the ability of the elephant to free-range. These different needs emphasize the importance of assessing the training and management programs for elephants in human care and evaluating the adequacy of environmental and husbandry conditions to produce the optimal behavior, health, and reproduction in North American elephants.

A great deal of information was collected and a large number of people contributed to the preparation of this document. The authors accept that these guidelines are far from complete and encourage readers to seek more specific information that is available in the literature. The authors acknowledge that our attitudes of what elephants require may change with time. Elephant management is a dynamic process and will change as more is learned about elephants. Regular review of these guidelines will be necessary to incorporate advancements and information that will benefit the elephants and their handlers.

These guidelines recognize the established standards of the United States Department of Agriculture (USDA), Elephant Managers Association (EMA), American Association of Zoos and Aquariums (AZA), and the International Elephant Foundation (IEF) as they apply to elephants.

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Contents

Natural History

African and Asian elephants are two distinct species, which belong to separate genera. They are generally similar in size, appearance, physiology, and social behavior (Eltringham 1982; McKay 1973).

The African elephant is the largest land mammal with the Asian elephant coming in as a close second. Males are larger than females, and both sexes continue to grow throughout their entire lives. Some of the most unique features of both species of elephant are the ears, tusks, trunk, and feet. The African elephant has larger ears than the Asian. In both species the ears are used for communication—behavior (see Behavior Ethogram, p. 103) and auditory—and in regulating body temperature. The tusks are upper incisors that grow throughout the elephant's life. Both male and female African elephants can have tusks, while it is usually only the male Asian which carries large tusks. The female Asian elephant's tusks seldom extend beyond the upper lip. These tusks are called "tushes." In both species, "tuskless" elephants have been observed.

Both the African and Asian elephant have trunks. The trunk is an elongated nose, the upper lip and nose combined. The elephant uses its trunk to breathe, explore its environment, communicate to and about conspecifics, pick up, push, carry, and to drink water or give itself a shower of water, mud, or dirt. It is essential to the survival of the elephant (although some elephants are able to successfully adapt their feeding and drinking behavior after severe trunk injuries). The tip of the trunk of the African elephant has two finger-like projections while the Asian elephant's trunk tip has only one.

The feet of both species of elephants are round with a large circumference in relation to the legs. The elephant's weight rests on a pad, which cushions the toes. This pad grows continuously and is worn down by the natural movement of the elephant. The number of toenails on both species of elephants appears to vary from individual. (Csuti et al. 2001, Eltringham 1982). Typically Asian elephants have five toenails on each forefoot and four on each hindfoot. The African elephant has four toenails on each forefoot and three or four on each hindfoot.

The Asian elephant is considered to be a single species, *Elephas maximus* with four extant subspecies, *E.m. hirsutus* (Malayan elephant), *E.m. indicus* (Indian elephant), *E.m. maximus* (Sri Lankan elephant), and *E.m. sumatranus* (Sumatran elephant). The African elephant is considered to be a single species, *Loxodonta africana* with two subspecies, *L.a. cyclotis* (forest elephant) and *L.a. africana* (savanna elephant). Some recent genetic research has suggested that

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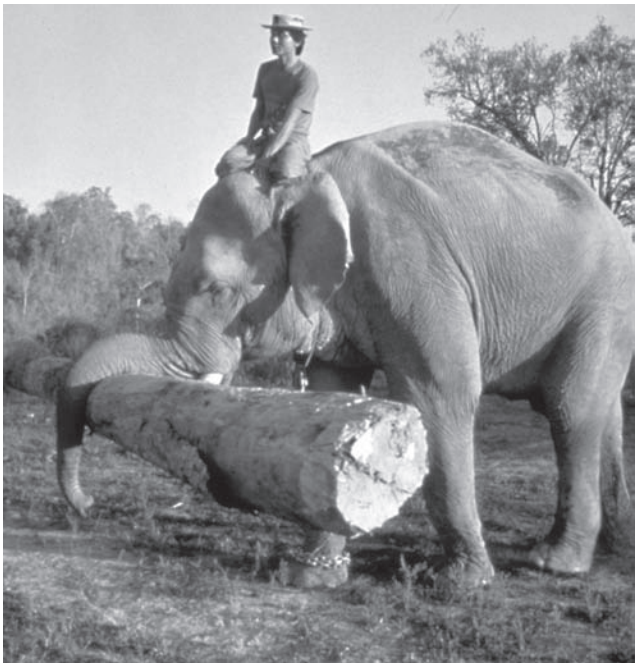
Jill Sampson

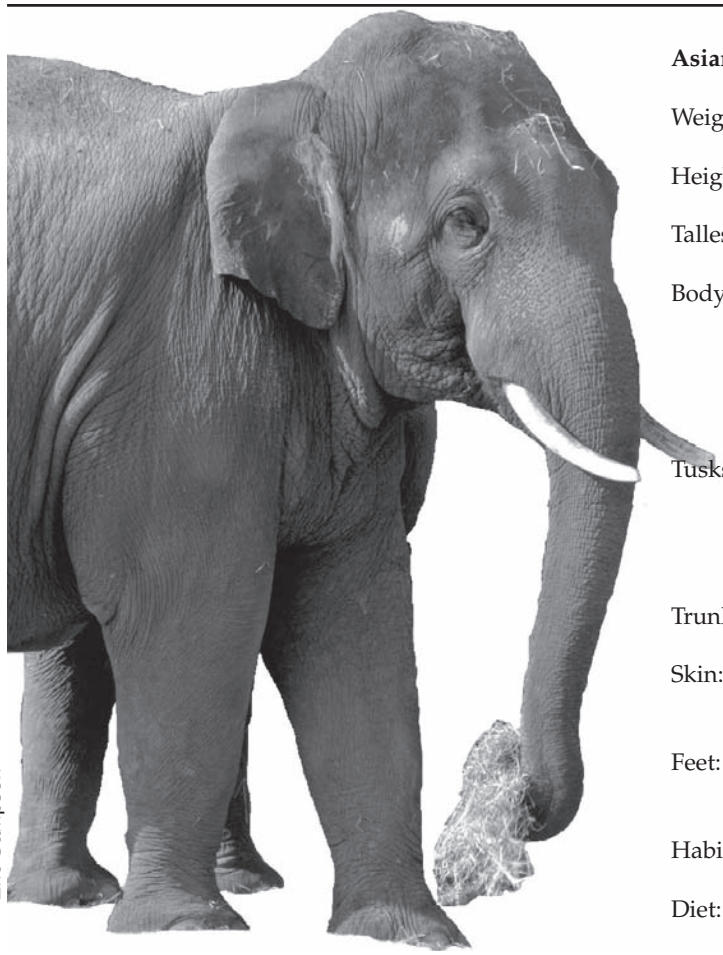
Savannah elephant of East Africa.



Heidi Riddle

Working elephant in Burma.

Comparison of the Two Elephant Species

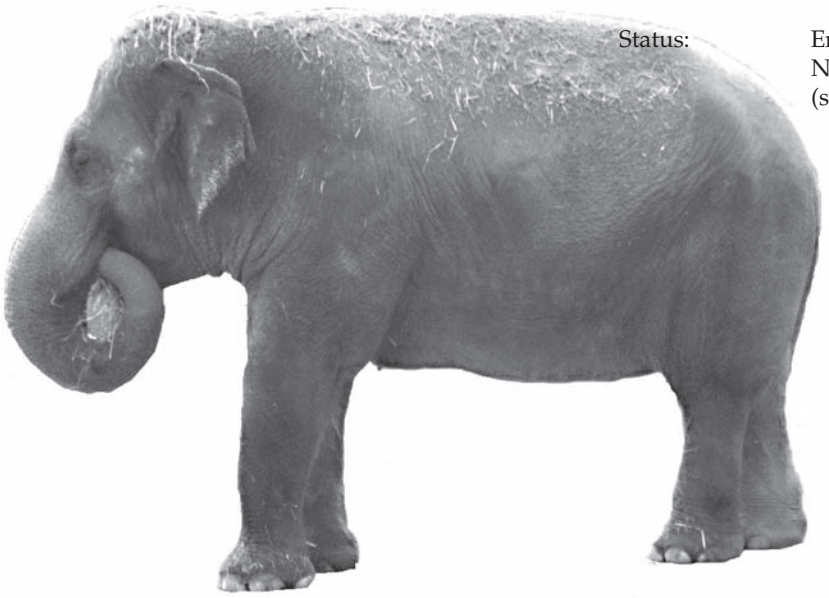


Eric Sampson

Male Asian elephant.

Asian elephant (*Elephas maximus*)

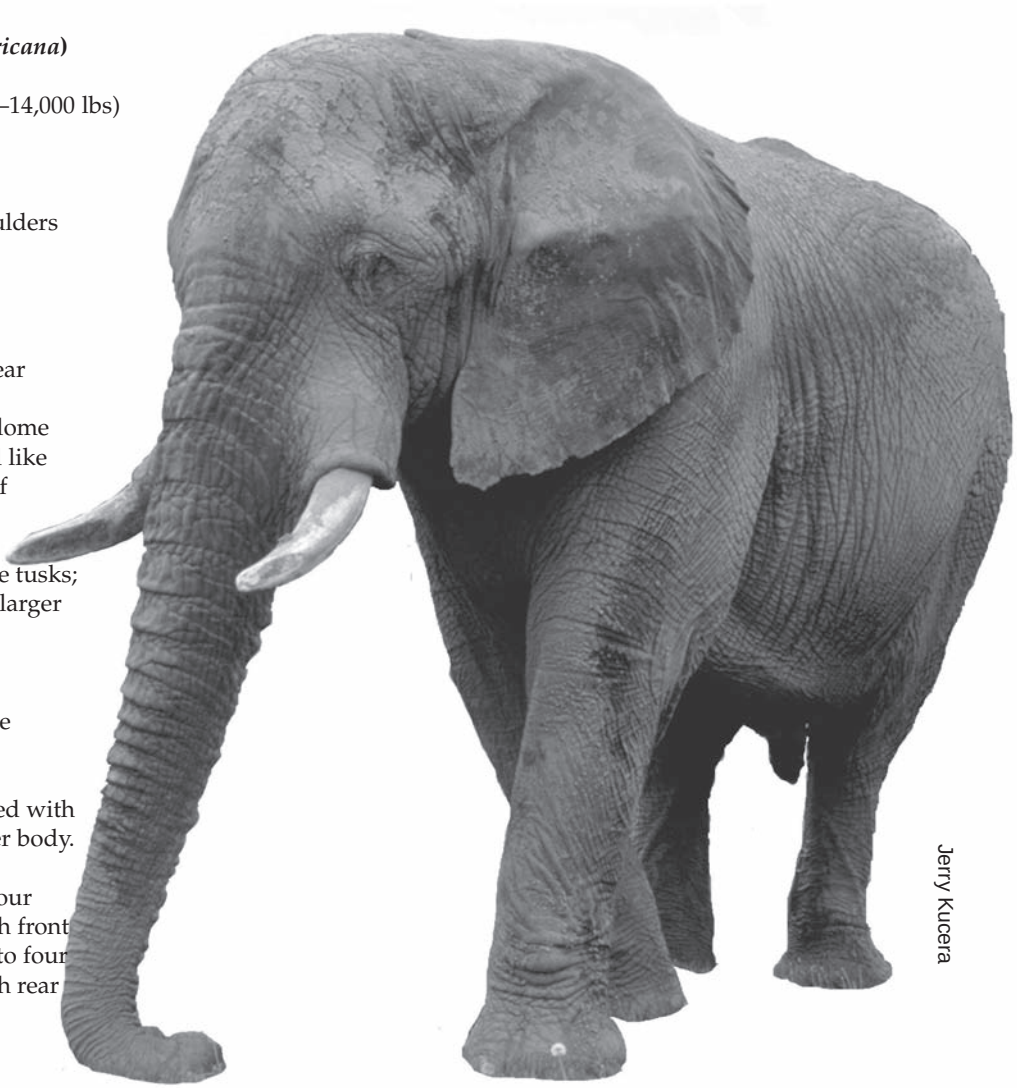
Weight:	3–7 tons (6,000–14,000 lbs.)
Height:	7–12 feet
Tallest point:	Top of the head
Body shape:	
Back	Rounded
Belly	Level or slopes to middle
Head	Two domes
Ears	Small and rectangular
Tusks:	Some males have large tusks. Females and some males have tusks called "tushes" which seldom extend beyond the upper lip.
Trunk:	Tip of trunk has 1 finger-like projection
Skin:	Lightly wrinkled with sparse hair over entire body
Feet:	Usually have five toenails on each front foot and four on each rear foot
Habitat:	Forest of Southeast Asia
Diet:	Primarily a browser
Social life:	Female family groups. Adult males are solitary or form loose social relationships.
Gestation:	659 days ± 30 days
Interbirth interval:	3–5 years
Status:	Endangered due to loss of habitat. Numbers are currently around 30,000 (see map).



Female Asian elephant.

African elephant (*Loxodonta africana*)

Weight:	4–7 tons (8,000–14,000 lbs)
Height:	8–14 feet
Tallest point:	Top of the shoulders
Body shape:	
Back	Concave
Belly	Slopes down from front to rear legs
Head	One rounded dome
Ears	Large, "shaped like the continent of Africa"
Tusks:	Both sexes have tusks; male tusks are larger and heavier.
Trunk:	Tip of trunk has 2 finger-like projections.
Skin:	Deeply wrinkled with sparse hair over body.
Feet:	Usually have four toenails on each front foot and three to four toenails on each rear foot.
Habitat:	Grasslands, scrub, and forests of Africa.
Diet:	Primarily a grazer
Social life:	Female family groups Adult males are solitary or form loose social relationships.
Gestation:	659 days ± 30 days
Interbirth interval:	3–5 years
Status:	Endangered/Threatened due to loss of habitat and poaching. Numbers are currently around 500,000 (see map).



Jerry Kucera

Columbus Zoo

The forest elephant (*L. cyclotis*) shows more rounded ears than the savannah elephant (*L. africana*).

the forest elephant are genetically different from the savanna elephant and represent a separate species of elephant (Comstock et al. 2002). In the Statement on the Taxonomy of Extant *Loxodonta* published February 2002, the IUCN/SSC African Elephant Specialist Group recommends that further genetic and morphological research be conducted before dividing elephants from Africa into two separate species. Ongoing and future genetic studies of elephants throughout Africa will ultimately determine their classification.

Status of Wild Elephant Populations

Populations of both elephant species continue to decline in the wild. Human encroachment, habitat loss, and poaching pose major threats to the extant populations. Conflicts are frequent as the population of humans increases and suitable habitat for elephants decreases. Human or elephant fatalities are often the result.

Elephas maximus is listed as an endangered species with the United States Fish and Wildlife Service (USFW) and classified under Appendix I with the Convention for International Trade on Endangered Species (CITES). *E. maximus* once occurred from the Tigris-Euphrates in western Asia, east through Iran and south of the Himalayas; throughout south and southeast Asia including the islands of Sri Lanka, Sumatra and Borneo, and into mainland China northwards at least as far as the Changkiang (Yangtze river).

Elephants have disappeared entirely from western Asia, Iran, and most of China. They currently occur in the following regions and countries although they are usually restricted to hilly and mountainous areas: a) Indian subcontinent: India, Nepal, Bhutan and Bangladesh, b) Continental southeast Asia: China, Myanmar, Thailand, Cambodia, Laos, Vietnam, and Malaysia, c) Island Asia: Andaman Islands (India), Sri Lanka, Sumatra (Indonesia), and Borneo (Malaysia and Indonesia) (Sukumar 1994).

It is estimated that at the turn of the century there were more than 100,000 elephants in Asia (Santiapillai and Ramono 1992). The actual number of elephants found in the wild then and now can be only rough estimates. The surviving population of Asian elephants is estimated between 30,000–50,000, one-tenth of the population of

Table 1. Current Estimates of Wild Populations of Asian Elephants.

Country	Minimum	Maximum
Bhutan	60	150
Burma (Myanmar)	5,000	6,000
Cambodia	1,000	2,000
China	250	350
India	20,000	24,000
Indonesia	2,500	4,500
Lao PDR (Laos)	1,000	3,000
Malaysia – Peninsular	800	1,000
Borneo	500	2,000
Nepal	50	85
Sri Lanka	2,500	3,000
Thailand	1,500	3,000
Vietnam	300	400
Total	**35,460**	**49,485**

Sources: IUCN's SSC Asian Elephant Specialist Group

Asian elephant (*Elephas maximus*) populations and ranges

African elephants. The process of trying to systematically census the densely forested regions of Asia is extremely difficult. In many countries, unfavorable political conditions hamper or prevent census work. Current estimates of the wild populations are shown in Table 1.

The loss of habitat has been the primary reason for the decline of *E. maximus.* About 20 percent of the world's human population lives in or near the present range of the Asian elephant. With human numbers increasing at a rate of about 3 percent per annum in most countries, this could mean a doubling of the human population in 23 years. The elephants' forest home has been reduced to a fraction of its former range. India's extensive forests, where elephants roamed widely, now cover less than 20 percent of the country, and barely half of that is suitable habitat for elephants. The central India elephant population has been seriously fragmented. Thailand has cleared almost all its lowland forest, creating a huge void of wildlife habitat in the heart of the country. On the Indonesian island of Sumatra, vast areas of forest are being cleared to accommodate millions of people resettled from the crowded islands of Java, Bali, and Madura. Indo-China's forests were seriously damaged during 30 years of constant warfare. More forest land, however, has been cleared since the

The population numbers used for the African and Asian elephant range maps are courtesy of the Elephant Research Foundation and can be found in *Elephant* (vol. 2, no. 4, pp. 11–12, © 2000). The African elephant population estimates and distribution were compiled by Gary H. Marchant, Eleanor C. Marsac, and Jeheskel Shoshani using their 1999 data from a few countries and data from Douglas-Hamilton and Michelmore (1996) and updated figures of Said et al. (1995). The elephant numbers indicate minimums and maximums for each country with a total ranging from 278,205 to 637,599 elephants. The minimum number for each country is the "definite" estimate and the maximum estimate includes the sum of "definite," "probable," "possible," and "speculative" estimates from Said et al. (1995). The Asian elephant population estimates and distribution were compiled by Gary H. Marchant, Eleanor C. Marsac, and Jeheskel Shoshani using their 1999 data from a few countries and data from Raman Sukumar and Charles Santiapillai (1996). Again, the numbers provide a minimum and maximum estimated number of Asian elephants with a total ranging from 36,450 to 50,250.

African elephant (*Loxodonta africana*) populations and ranges

Table 2. Current Estimated Wild Populations of African Elephants

Region	Definite	Probable	Possible	Speculative
Central Africa	7,322	27,104	30,027	63,469
Eastern Africa	82,357	24,111	18,772	1,495
Southern Africa	181,339	32,563	38,129	190
West Africa	2,309	824	6,408	3,442
Total	**273,327**	**84,602**	**93,336**	**68,596**

Source: Barnes et al. 1999

Vietnam War ended than during it. In Sri Lanka, the vast Mahaweli River Valley Project for settlement, crops, and irrigation cuts a wide swathe through the heart of elephant country. Myanmar (formally Burma), Cambodia, and Laos still have considerable forest cover, but this is suffering from unmanaged and unsustainable logging.

The fragmentation of the elephants' forest habitat is particularly deleterious. To find the best feeding areas, elephants migrate with the seasons. Now that migration routes have been disrupted and herds are confronted by new settlements and agriculture, conflicts with humans are inevitable. World Wildlife Fund estimates that there may be only 10 Asian elephant populations of more than 1,000 animals in the 13 countries where they are currently found (WCMC and WWF International 2001).

Other factors affecting the wild Asian elephant population include mortality during capture and poaching for ivory.

Loxodonta africana currently occur in sub-Saharan Africa, with the majority of the population living in the savanna of southern, western, and eastern Africa and the forest of the Democratic Republic of the Congo (Zaire) (Spinage 1994). Much of the extant population is fragmented by human activities disturbing traditional migratory routes. One of the highest projected human population growth in the next 25 years is expected in sub-Saharan Africa. The total fertility rate for African women remains high at nearly six live births per woman. To avoid malnutrition, sub-Saharan Africa will need to increase its food production three-fold, turning existing elephant habitat into cropland, exacerbating the problem of declining elephant populations and habitat fragmentation.

L. africana once ranged throughout Africa. By the middle ages, the species became extinct in northern Africa primarily due to the ivory trade (Scullard 1974).

Overhunting during the 18th and 19th centuries depleted elephant numbers in Southern Africa (Hall-Martin 1992). Controlled hunting, a drop in the price of ivory, and the development of wildlife preserves following World War I saw the population of elephants once again increase within Africa.

In the 1970s, the increase in the price of ivory reignited the poaching of elephants. The population, estimated to be at about 1.3 million in the early 1970s, dropped by more than half by 1995. Due to uncontrolled poaching, in 1989 the African elephant was listed as Appendix I (endangered) by CITES which placed an international trade ban on elephants and elephant products. In 1997, the African elephant was downlisted to Appendix II in some southern African countries by CITES due to rebounding populations and protection programs. This remains the case today. Appendix II classifies these populations as threatened and allows some limited trade in elephant products with certain restrictions, quotas, and permits.

Currently, some elephant populations in Africa are still subject to poaching and being hunted for bushmeat. The forest elephant is particularly susceptible, increasingly so as the forests are being logged, attracting more people and making elephant habitat more accessible by building roads. In contrast, some African countries insist they have too many elephants. They demonstrate an excess of elephants by increased elephant-human conflicts and elephant-influenced habitat modification, which adversely affects population numbers of other species. These countries are looking for ways to reduce their elephant numbers through translocation programs, birth control, and culling.

Today the population is optimistically placed at near 500,000 but census analysis done by the IUCN African Elephant Specialist Group suggests the true numbers are lower. The group suggests that the estimates are misleading due to several factors influencing census work including the vast forests where elephants inhabit, political unrest in some of the range countries, and inconsistencies of survey methods. To better understand the wild numbers, the African Elephant Database 1995 describes five levels of survey types.

1. Aerial total counts and ground total counts where a definitive population can be considered.
2. Sample aerial counts and ground samples with 95 percent confidence limits where a lower (*definite*), *probable*, and higher (*possible*) number is derived from the sampling.
3. Dung counts with 95 percent confidence limits where no *definite* number is established due to the lack of direct observation, but dung inspection provides a *probable* figure and a higher *possible* figure.
4. Informed guesses where expert opinion along with other non-methodical survey systems provide a *possible* number or a *speculative* figure.
5. Other guesses where only *speculative* numbers are provided.

Based on these definitions, Table 2 summarizes the current estimated wild populations of African elephants.

Personnel

Each elephant holding facility should have written, established goals for its elephant management program. These goals should guide the development and direction of the elephant management program. In addition, each facility should have a written elephant management protocol approved by the director/CEO/owner that specifically addresses elephant management and serves as a guide to all facility staff involved in the care of the elephants. These documents should be subject to periodic, and at least annual review.

The elephant management protocol should communicate clearly the mission, expectations, directives, and policies of the facility. A protocol is an effective training tool, as well as a means to verify staff understanding of the facility's adopted elephant management plan. Inclusive in the document and appendixes should be:

- a mission statement and goals;
- definition of responsibilities for all personnel involved in the elephant management program including the chain of command;
- guidelines for all elephant management and handling activities, such as elephant training, staff training, husbandry procedures, safety guidelines and rules;
- standard operating procedures;
- management policies;
- emergency response protocol;
- each individual elephant's behavior profile;
- the behavioral enrichment and exercise programs;
- definitions of training terminology used; and
- incident reports.

Sedgwick County Zoo

Handlers are responsible for maintaining individual elephant records and daily activity reports.

Other topics suggested for inclusion in the Elephant Management Protocol are:

- evaluation of personnel;
- description of the daily routine;
- protocol for dealing with public complaints;
- equipment used;
- protocols for demonstrations, shows, and rides;
- natural history of the elephant;
- and history in captivity of each elephant.

The elephant management protocol should be a living document that is reviewed at least annually by the entire elephant management team. The elephant management team should consist of the facility's director, manager or curator, veterinary staff, and elephant handlers. This document should be continually upgraded and improved to reflect the facility's current elephant management policy. New elephant staff should be given a copy of the protocol prior to their first day of working with the elephants, and all elephant staff should have full access to the most recently updated version of the document at all times.

All elephant holding facilities should make safety the highest priority. Although safety should be a constant consideration and routinely evaluated, it is recommended that a formal safety assessment program be established and a safety inspection occur at least twice a year. It is recommended that a safety committee be formalized to undertake these assessments. Committee members should include the elephant manager (see Personnel, p. 9), selected elephant management staff, veterinarian, and individuals representing facility administration and maintenance. Areas that should be included in all safety reviews are the elephant enclosures, facility maintenance, elephant husbandry and training program, elephant behavior toward staff and conspecifics, elephant care staff, and corrective measures that should be implemented in response to identified problems. A written record should be kept detailing each meeting, inspection proceedings, actions to be taken, priority, and date the changes are to be completed.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "All elephant-holding institutions must undertake at least a semi-annual elephant facility and program safety assessment, identify safety needs, and fully implement any corrective measures. Each facility shall establish a safety assessment team. The team may include elephant staff, management staff, animal health care staff, and experts in the area of risk management and safety. Each facility should establish the make-up of the team based on its own needs and resources. A written record must be kept for each inspection and that record be reviewed and its recommendations acted upon."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Each AZA member institution and related facility that holds elephants must have a written elephant management policy. This policy must be consistent with AZA standards for elephant management and care, and must, at minimum, include a description of the institution's:

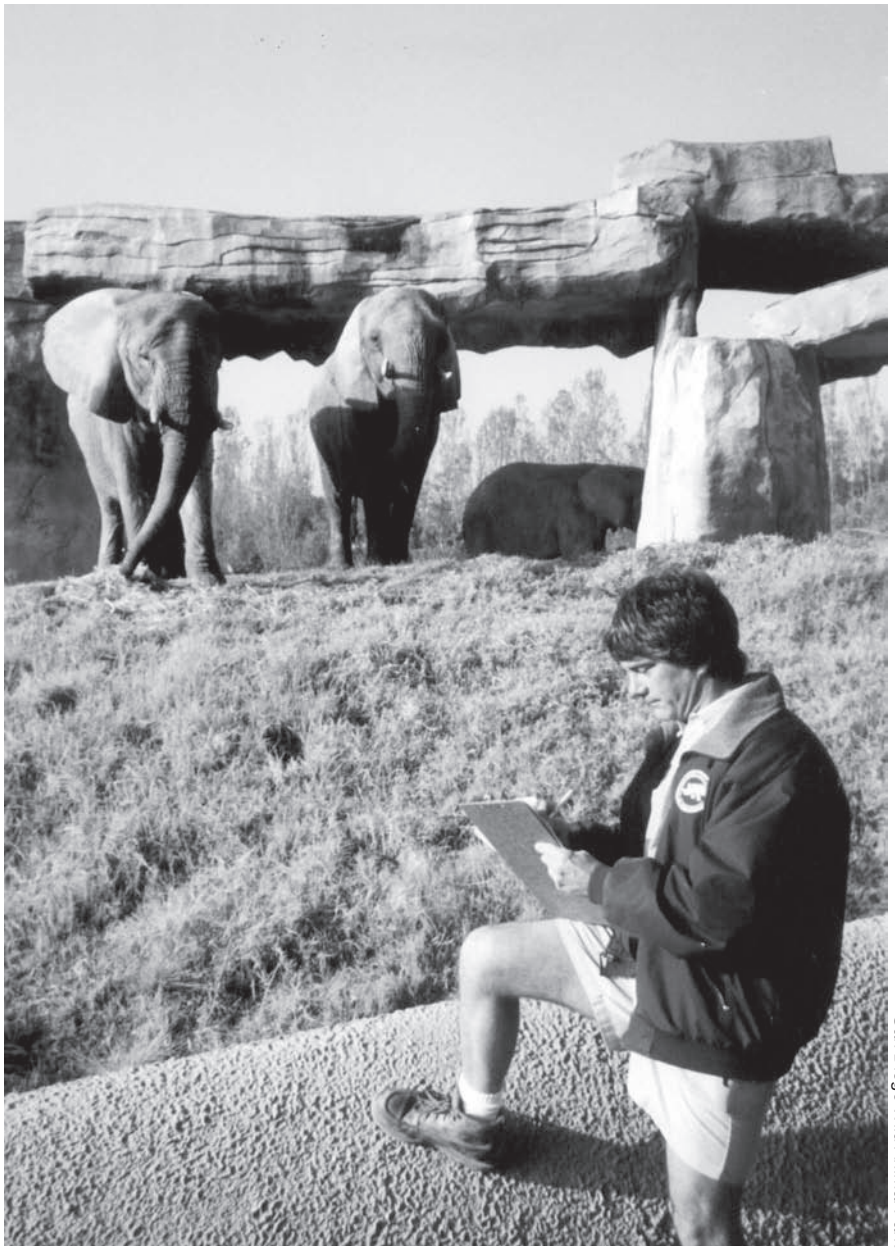
a. Elephant management program's mission and goals.
b. Elephant management policies, including guidelines for handling, training, and translocation.
c. Plan to separate animals from each other, safely manage elephants that are aggressive toward other elephants, safely move elephants from one location to another, and safely manage elephants that are aggressive toward humans.
d. Staff management policies, including guidelines for keeper safety.
e. Individual elephant profiles and incident reports for all cases in which elephants show aggression toward keepers or the public, regardless if any injury actually resulted.
f. Emergency response protocol. Institutions should be able to demonstrate readiness to respond to an emergency situation, such as an elephant escape or keeper injury."

An up-to-date Elephant Profile should be kept on file for each elephant maintained by a facility. The purpose of an elephant profile is to track a specific elephant's history, record training data, provide reproductive information and, most importantly, identify behavior trends in relation to the elephant's human handlers, and male and female conspecifics. This information is critical to evaluate the elephant management program, predict future elephant behavior, and for scientific investigation correlating elephant behavior to medical, reproductive, and behavior issues.

It is suggested that each facility develop a record sheet for this purpose. The completion of this record should be overseen by the elephant manager and updated after any change in the elephant's status, training and significant incidents of aggression or alterations in behavior. Minimally, this record should be updated annually. In addition, this record should be readily available to all elephant handlers and administrative staff.

Suggested topics that should be addressed in an elephant profile:

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "A behavioral profile must be maintained for each individual elephant and updated annually."



San Diego Wild Animal Park

A current elephant profile should be kept on file for each elephant.

- date last updated;
- name of the person recording the information;
- scientific name;
- common name;
- house name;
- local ID #;
- studbook #;
- acquisition date;
- sex;
- birth date;
- height;
- weight;
- captive born/wild caught—location;
- description of current management program;
- transaction history;
  - date moved
  - from
  - to
  - known as
  - description of management program at former institutions
- socialization/temperament, social comfort level, dominance status, behavior history toward elephant staff, and male and female conspecifics;
- trained behaviors;
- effective training tools and techniques;
- current medical problems and physical condition;
- past or recurring medical problems or physical conditions; and
- reproduction
  - male/female endocrine profile results
  - reproductive assessment results
  - breeding attempts/results
  - offspring
  - current breeding recommendation

Each facility should have a person directly in charge of the daily care and training of the elephants and supervision of related personnel. In AZA facilities, this position is called the Elephant Manager. Other facilities may have different titles for this position, and the position may have additional animal management responsibilities.

The manager in charge of the elephant program should have verifiable elephant management experience and proven leadership abilities. It is essential that the elephant

An Elephant Incident Report is a tool used to communicate a specific elephant's behavior to other elephant handlers and facility management. The report should be updated after every atypical event involving the elephant, and/or at least annually. Each event should be reviewed by the elephant management team, and recommendations made and acted upon.

SAMPLE ELEPHANT INCIDENT REPORT

Date:
Time:
Location:
Elephant involved:
Staff involved:
Details of the incident:
Diagram of the facility to pinpoint exact location of incident:
Precursors, warning signs:
Additional comments:
Completed by:
Review date and plan of action:

manager possess knowledge and experience in all facets of elephant husbandry, training, natural history, and personnel safety. This experience should include time spent working directly with elephants in professionally operated zoological collections, circuses or private facilities.

The management of the facility should check the references of any serious applicant to the elephant manager position to verify the applicant's work experience. If for some reason an inexperienced individual is placed in the elephant manager's position, the facility must provide appropriate training within six months of the individual's hiring date in order that the new elephant manager can do the job effectively and safely. It is highly recommended that each facility encourage and support the elephant manager and all of the elephant handlers to attend the AZA Principles of Elephant Management course, as well as other established elephant handling schools.

The elephant manager should be responsible for instructing the staff in the standard methodology of elephant training and husbandry as described by each facility's elephant management protocol. Minimally, the elephant manager, his or her direct supervisor, facility manager or curator, elephant staff, and the facility's veterinarian, should be involved in the development of the management protocol or training regimen. The elephant manager should also be responsible for maintaining up-to-date individual elephant profiles, daily individual elephant records, and training protocols.

The elephant management team should meet regularly to discuss relevant issues such as training, husbandry, enrichment, facility maintenance, veterinary concerns, safety issues, etc. Minutes of the meetings should be taken to document any training and behavior issues or management changes. Proper communication within the elephant staff and management team is essential for a good working environment and an effective elephant training program. Regular meetings encourage communication, dissemination of information, further development of the elephant management protocol, opportunities to evaluate training progress, team building, safety, and consistency.

Facilities must have enough trained elephant handling staff to meet the basic needs of the elephants, and to meet the facility's goals for the elephant program. Job descriptions should be developed for all levels of staff that work with elephants. Staff hired specifically as elephant handling staff should be interviewed by the management authority, including the elephant manager. Elephant handlers should be evaluated regularly to aid in the development of personal goals and to gauge each individual's progress, training proficiency, husbandry care, public interaction, safety, etc. A good elephant handler should have:

- knowledge about the natural history and behavior of elephants;
- knowledge about the individual history of each elephant in the collection;
- knowledge about the constraints/limits of the exhibit and holding facility;
- a positive attitude, a commitment to the program, and a strong work ethic;
- the ability to accept and follow instructions;
- the ability to work as a team member;
- the ability to correctly interpret elephant-elephant interaction;
- the ability to correctly interpret elephant-human interaction; and
- knowledge of the training program and criteria for each behavior.

It is strongly recommended that two qualified elephant handlers be present at all times when working with an elephant. A qualified elephant handler is a person the facility acknowledges as a trained, responsible individual capable of, and experienced in, the maintenance of elephants. Each facility must determine the level of training and experience required of those who work with

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Each institution must have one person, designated as the elephant manager. This individual is responsible for (1) staff training; (2) developing and maintaining the program; and (3) communicating with others about the elephant program. The elephant manager must also demonstrate knowledge about all emergency protocols and continually improve elephant management techniques as the industry standards evolve."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "All elephant managers should attend the AZA Principles of Elephant Management Course within 18 months following acceptance/promotion to the position. In addition, every elephant keeper is encouraged to attend this course."

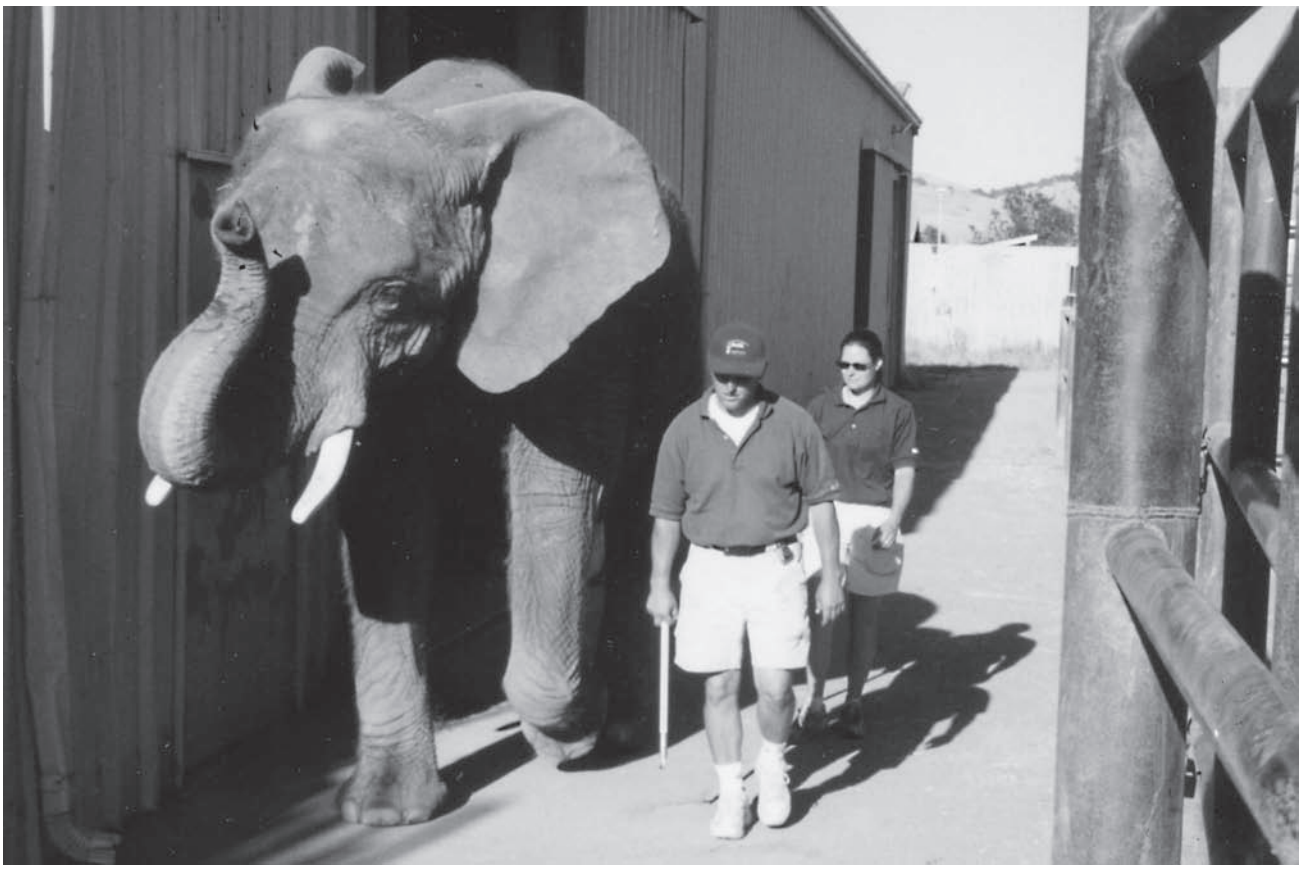
elephants and update those requirements as necessary. Each facility should develop a qualification program that quantifiably assesses each handler's knowledge of the institution's training practices, all elephant commands and associated responses, each elephant's behavior toward conspecifics and handlers, and husbandry requirements.

It is important that all new elephant staff be aware of the job requirements, program expectations, potential of danger, necessity of safe conduct, and have read and understood the facility's elephant management protocol indicated by their signature. A training plan should be established for new employees, both experienced and inexperienced. When training new personnel to handle elephants, only those staff members experienced in working with and training elephants should be giving instruction. The training procedure should consist of one-on-one training opportunities with an experienced handler until the new handler is comfortable with the elephant management program and confident in their ability to perform their duties as outlined by the facility's elephant management protocol. The training procedure should make use of the daily routine to familiarize the new handler with his or her duties, in addition to other instructional materials and resources.

Each facility should have established guidelines for the removal of an individual from the elephant program. The guidelines should be consistent with the facility's personnel or union policies. The guidelines should allow for the removal from the elephant department to be immediate and permanent if it is warranted. Some reasons for the removal of an individual include:

1. failure to follow the elephant management protocol;
2. failure to work with other handlers in the program, therefore destroying the team concept and eroding consistency;
3. disregard for safety;
4. aggression toward the handler by an elephant; and
5. inappropriate treatment of the elephants.

It is important that the elephant manager and facility



Six Flags Marine World

It is strongly recommended that two qualified elephant handlers be present at all times when working with an elephant.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "A minimum of two qualified elephant handlers must be present during any contact with elephants. A qualified keeper is a person the institution acknowledges as a trained, responsible individual, capable of and specifically experienced in the training and care of elephants."

management be vigilant and be able to determine when a handler's personal safety is compromised. In addition, an elephant handler should be able to request an immediate removal from the elephant program and have the request immediately considered. Each individual working with elephants is the best judge of their own comfort level with the elephants. It is recommended that no individual be forced to work with elephants if they feel it is unsafe or they are not confident with their ability.

In North America, elephants in human care are afforded the highest standard of treatment. Elephant holding facilities should maintain strict policies regarding their standards of elephant care, and provisions should be made in the event these standards are compromised. Alleged mistreatment should be investigated and addressed immediately.

Depending on the circumstances, the disciplining of the accused handler should follow the facility's standard personnel practices and disciplinary procedures. In addition, corrective steps must be immediately implemented. These steps may include facility modification, program review, outside consultation, and further staff training, transfer, or termination.

The following is a sample staff qualification program outlining the training procedure that could be used for both current and new elephant staff. A staff member can be moved up or down a level depending upon their consistency and ability to perform the required tasks. The elephant manager has the primary responsibility for coordinating and implementing the training of the elephants and the staff and decides when a trainee is able to advance.

Level 1 (entry level): Duties include clean up and other related elephant care duties, familiarity with the operation of the enclosure, and with established facility and elephant protocols. Trainees have contact with the elephants only with permission from, and in the presence of, two qualified elephant handlers. Trainees receive a weekly verbal progress evaluation from the elephant manager and a written progress evaluation every two weeks. Once a trainee shows proficiency in the assigned tasks, he/she should receive a final written progress evaluation from the elephant manager before the trainee moves to the next level. Trainees must demonstrate the following in order to move to the next level.

1) Be familiar with
   - A) elephant management policy
   - B) elephant and facility safety protocols
   - C) elephant and facility emergency protocols
   - D) radio use protocols and emergency codes
   - E) elephant natural history and behavior

2) Hydraulic door operation
   - A) ability to operate all doors safely in order to avoid injuries to elephants and/or handlers
   - B) ability to demonstrate proper operation of doors in order to prevent any damage to the hydraulics system

3) Must know the location of
   - A) indoor and outdoor lights and switches
   - B) circuit breakers
   - C) alarms
   - D) fire extinuishers

4) Pool maintenance
   - A) How often the pool is cleaned
   - B) how to drain and refill the pool

5) Daily routine
   - A) cleaning, feeding, watering, enriching, training, medicating, etc.
   - B) assistance with restraints for husbandry procedures

6) Record keeping system
   A) daily keeper logs
   B) behavioral profiles for the facility's individual elephants
   C) incident reports for the facility's individual elephants

7) Restraint device operation
   A) ability to operate chute controls for doors and gates safely
   B) ability to work safely around an animal restrained in the chute

The following areas will also be evaluated:
1) Judgment
2) Initiative
3) Quantity of work
4) Quality of work
5) Communication
6) Dependability
7) Job knowledge
8) Elephant knowledge (individual and species)

Level 2. Trainees have contact with the elephants only with permission from, and in the presence of, two qualified elephant handlers. Duties include husbandry care such as feeding, watering, bathing, and training the bull. Trainees are expected to learn the commands and consequences/reinforcements used by the handlers during these sessions for all elephants. Trainees begin giving the elephants commands beginning with the least difficult elephants to handle and progressing to the more difficult elephants. Trainees receive a verbal progress evaluation from the elephant manager immediately following every instance of working with an elephant. Written progress evaluations, prepared by the elephant manager, are given every two weeks. Once a trainee shows proficiency in the following assigned tasks, he/she should receive a final written progress evaluation from the elephant manager before the trainee moves to the next level.

1) Works safely around the elephants while performing husbandry care.

2) The trainee must demonstrate the ability to shift an elephant into and out of the elephant restraint device.

3) The trainee demonstrates elephant restraint techniques

4) The trainee must be able to successfully walk an elephant for a minimum of 20 minutes, using the appropriate commands.

5) The trainee demonstrates the ability to give commands properly, gain compliance from the elephant, and demonstrate the correct method for gaining compliance.

6) The trainee demonstrates an ability to correctly understand elephant behavior.

Level 3. Trainee must have two qualified elephant handlers present until they demonstrate that they are proficient handling individual animals. Level 3 demonstrates proficiency with all aspects of elephant care, including foot care, skin care, etc. Level 3 staff receives a verbal progress evaluation from the elephant manager immediately following every instance of working with an elephant. Written progress evaluations are given on a monthly basis, depending on the trainee's progression/regression. A final satisfactory progress evaluation and a recommendation from the elephant manager are required before the trainee moves to qualified handler status. Trainees must accomplish the following in order to move to qualified handler status:

1) Trainee demonstrates the ability to give commands properly, consistently gain compliance, and use the established method to correct noncompliance while handling all elephants in daily husbandry and training routines.

2) Trainee demonstrates the ability to consistently and correctly perform and implement all husbandry routines with little or no direction from the elephant manager.

3) Trainee presents correct and appropriate information to the public, volunteers, and donors in a professional and courteous manner.

4) Trainee demonstrates the ability to consistently work safely and efficiently around the elephants in a calm and professional manner.

5) Trainee demonstrates the ability to identify behavioral and/or medical abnormalities in the elephants and perform corrective actions after consultation with appropriate staff, e.g. the elephant manager, veterinarians, curator.

6) Trainee demonstrates the ability to participate in and sustain approved research activities in the elephant facility.

7) Trainee demonstrates the ability to problem solve, when faced with any situation that they have not previously encountered.

SAMPLE CHECKLIST OF TRAINEE'S PERFORMANCE OF BASIC BEHAVIORS

	YES	NEEDS IMPROVEMENT	
1) Get over	Y	NI	
2) Move over	Y	NI	
3) Come here	Y	NI	
4) Foot	Y	NI	
5) Move up		Y	NI
6) Back	Y	NI	
7) Lie down	Y	NI	
8) Get around	Y	NI	
9) Tail	Y	NI	
10) Come in line	Y	NI	
11) Trunk	Y	NI	
12) Stretch	Y	NI	
13) Steady	Y	NI	
14) No	Y	NI	
15) All right	Y	NI	
16) Easy	Y	NI	
17) Go play	Y	NI	
ADVANCED BEHAVIORS			
18) Head down	Y	NI	
19) Bow		Y	NI
20) Cross	Y	NI	
21) Salute	Y	NI	
22) Sit	Y	NI	
23) Front leg	Y	NI	
24) On your head	Y	NI	
25) Pick it up	Y	NI	
26) Push	Y	NI	
27) Waltz	Y	NI	
28) Ear	Y	NI	
29) Wave	Y	NI	
30) Speak	Y	NI	
31) Shake it	Y	NI	
32) Pull	Y	NI	
33) Stand up	Y	NI	

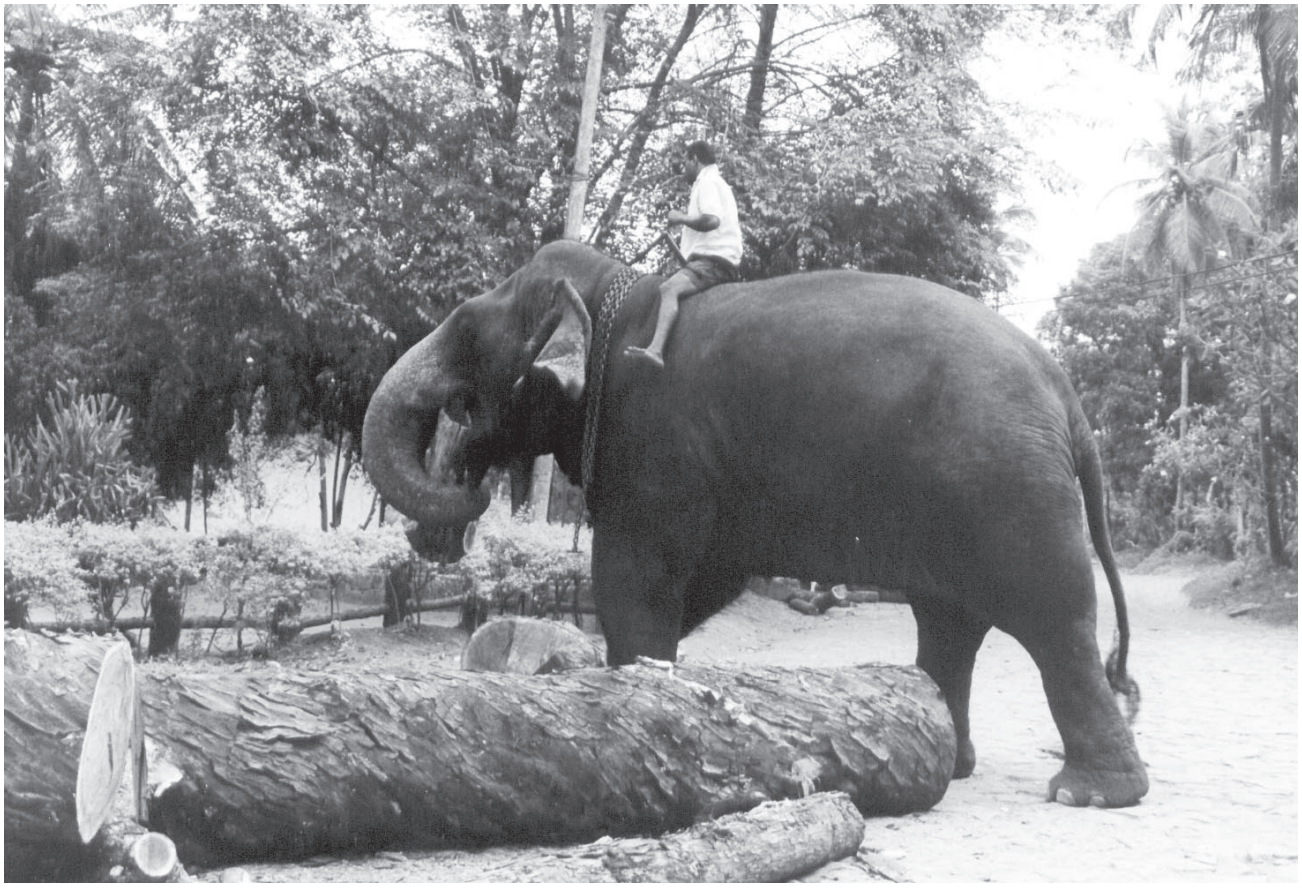
Rosamond Gifford Zoo at Burnet Park

Management

The history of elephant care and training dates back several thousand years. Humans and elephants have worked together since before the time of Alexander the Great, in forests of Southeast Asia from China to the Middle East, and Africa. In modern times, African elephants were successfully trained in the Belgian Congo at the beginning of the 20th century. Human interactions with elephants continue today throughout the world.

The management of elephants in North America has evolved in recent years as elephant handlers develop new ways—or modify old techniques—to improve the care provided to each individual elephant. Given the wide range of facilities that house elephants, each must develop its elephant management program based on its specific set of circumstances. When a facility develops its elephant management program, it should consider its goals in regard to the elephants; the design of the enclosure; experience and ability of the handlers; the number, age, gender, and demeanor of the elephants; finances; administrative directives; and education, conservation, and research. The elephant management style(s) used by a facility must be carefully studied and all ramifications considered. Protocols and action plans need to be developed to reflect the elephant management styles that are adopted. To provide the best care possible for the elephants, it is important that the method of elephant management selected is appropriate for the facility, staff, and elephants involved, and not simply a decision of convenience.

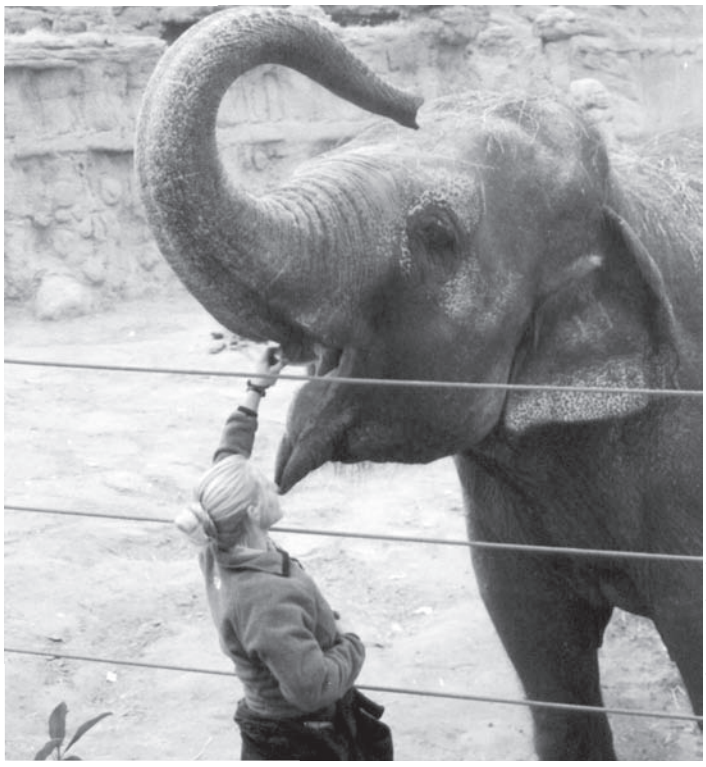
It was recently recognized that approaches to elephant management and behavior training have developed into a continuum of management techniques. These range from the handler working immediately next to the elephant, to the handler working the elephant only through or from



Kim Whitman

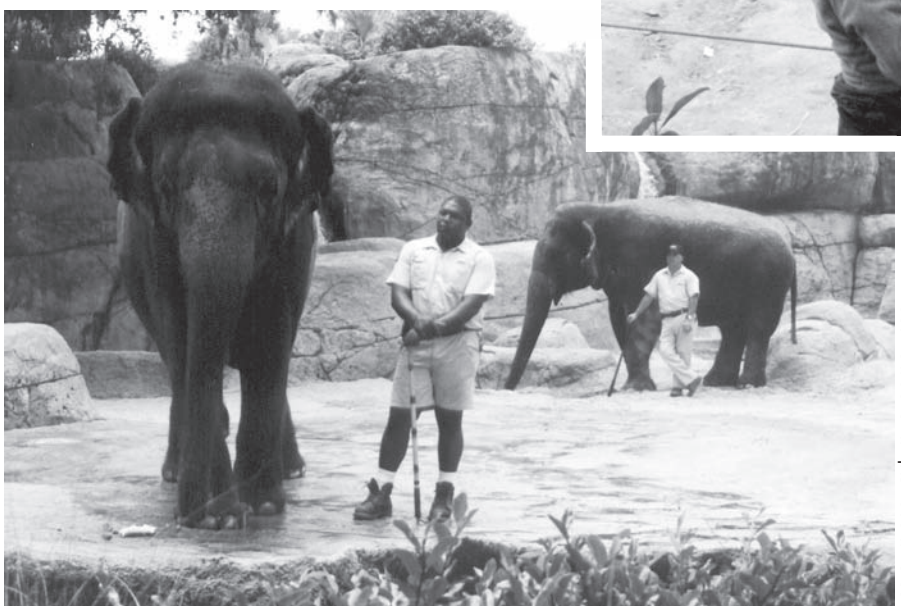
Elephants, similar to this one in Sri Lanka, have been living and working with humans for thousands of years.

Houston Zoo, Anita Schanberger



Albuquerque Biological Park

Above: On one end of the management continuum is the handling of an elephant through or from behind a barrier. Right: In the middle of the management continuum, the elephant can make physical contact with the handler to differing degrees. Below: The other end of the management continuum puts the handler in immediate contact with the elephant.



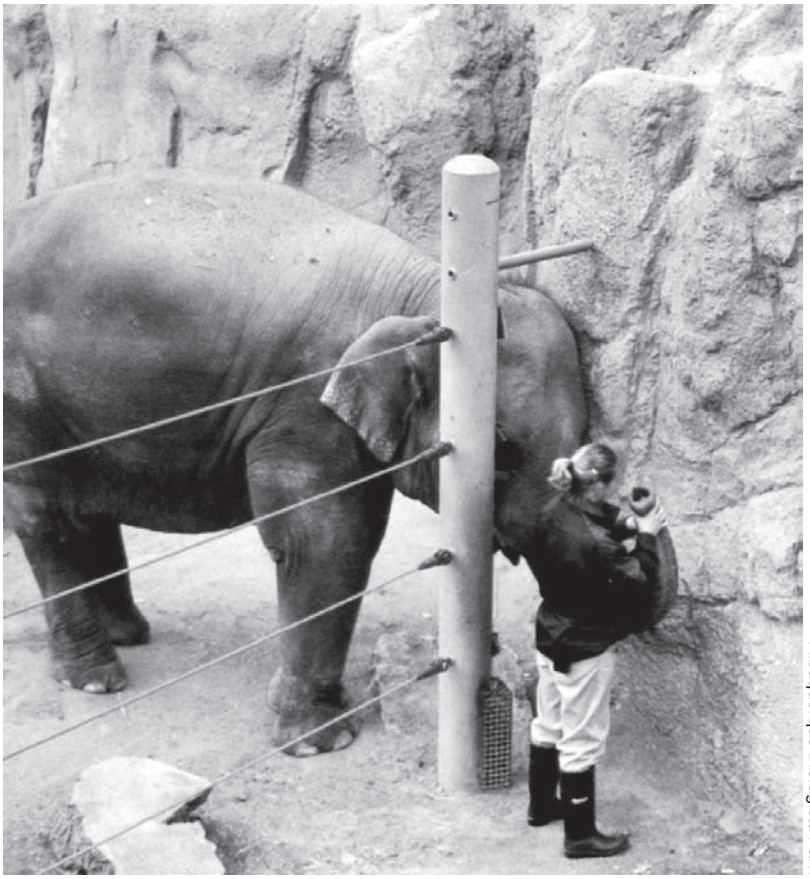
Busch Gardens Tampa/Deborah Olson

behind a barrier, to a large array of techniques in between with a varying amount of direct, or potentially direct, physical contact between the elephant and handler allowed. Within a single facility, different variations of this elephant management continuum may be used based on each elephant's disposition or the handler's level of training. For example, the elephant handlers may manage the cows and calves directly, but only manage an adult bull from behind a protective barrier or confined in a restraint device. Or, the handlers may choose to manage one or more of the cows from behind a barrier. The management technique or techniques within the continuum that a facility uses to attain its goals should be a means to an end so that the handlers are able to safely meet or exceed the established minimum standards of elephant care (see Husbandry, p. 37).

As stated previously, on one end of this management continuum is the handling of an elephant through or from behind a barrier, and by very careful handler positioning relative to the elephant. The handler is positioned so that the elephant cannot grab, tusk, kick, or contact the handler in such a way as to cause injury. Physical contact between the elephant and handler is restricted to very specific and limited locations used for the elephant to extend a foot, ear, or trunk at the handler's request. The elephant is not physically confined except for the fact that it is in its enclosure, which allows the elephant to refuse to respond to commands given and leave the presence of the handler. The elephant is trained to respond and change location or position through the use of targets, cues, guides, and reinforcements (see Training, p. 21, and Tools and Equipment, p. 61). This is the technique recommended for use with adult male elephants and female elephants that do not respond reliably, in order to safely work more closely with the handler.

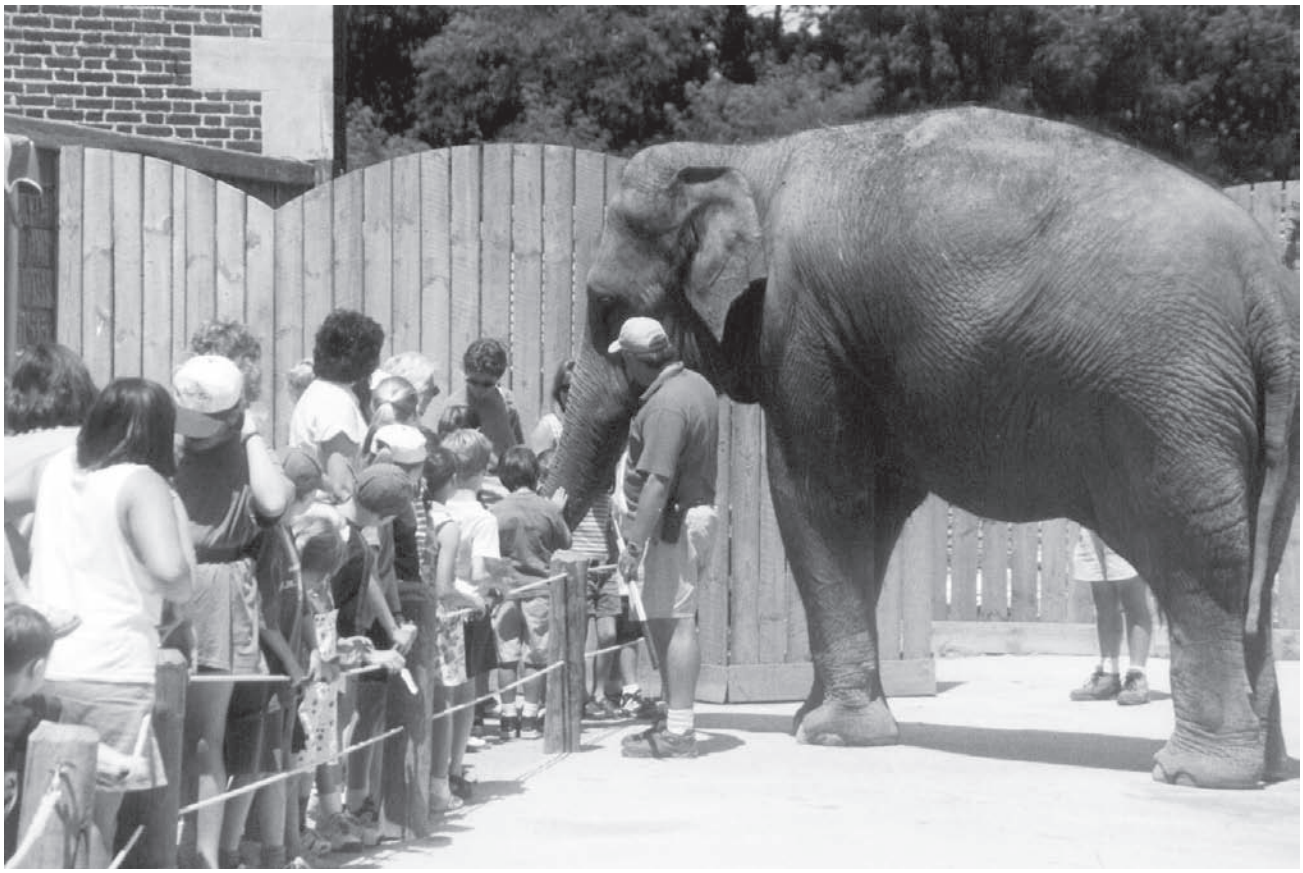
The level of safety afforded the handler is directly related to the design of the barrier and the positioning of the handler in relation to the elephant and the barrier. Used correctly, the barrier does provide an increased level of protection for the handler, but it does not prevent all chance of injury. The handler must take care to understand the

Lee Richardson Zoo



Albuquerque Biological Park

Above: The elephant is not confined except for its enclosure and there is no contact with the handler. Below: Handler has limited contact with elephant.



Buffalo Zoo

This end of the management continuum provides more opportunities for elephant-public interaction.

potential for an injury, the limitations of the barrier, the behavior and demeanor of the elephant during the training session, and their position in relation to the elephant's body, especially the head, trunk, tusks, and legs.

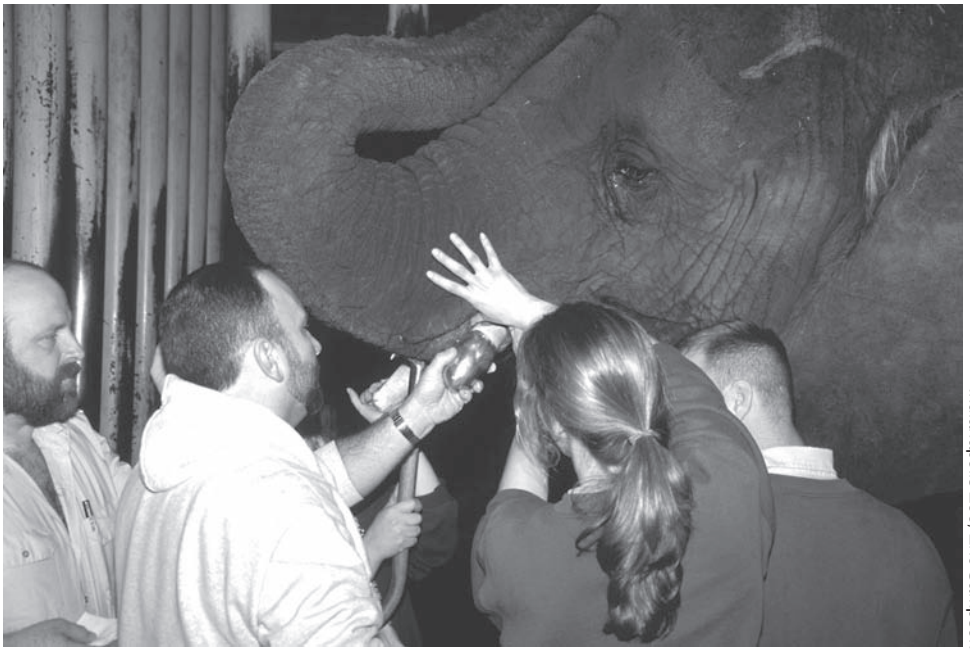
In the middle of the management continuum are the facilities that have barriers through which the elephant can physically contact the handler to differing degrees during the training and husbandry care process. In some cases, the elephant may be trained to interact physically with the handler. The reasons many management systems have maintained the contact between the elephant and the handler are: 1) the temperament of the elephant; 2) the increased control of the elephant and the use of additional techniques and tools for behavior modification; 3) a greater opportunity for the elephant and handler to physically interact; 4) an additional means to participate in research and education programs; and 5) to reduce the amount of facility modification required. However, it must be cautioned that working with the elephant in this range of management systems compromises the safety of the handler to varying degrees. Although the elephant is behind a barrier, injury to the handler can still occur if the elephant is not trained adequately to be respectful of the handler's space, or if the handler is inexperienced or careless in "reading" the elephant's behavior.

A common misconception by some practicing this range of systems within the continuum of elephant management is that the elephant will not act aggressively, if the handler uses predominately positive reinforcement in the training process (see Training, p. 21)**.** Therefore some handlers put themselves in potentially hazardous positions believing they are safe from injury. There are no data that would support this belief, and unfortunately the injuries caused and/or aggressive actions demonstrated by elephants toward their handlers underscores the necessity of following strict safety and training protocols.

The other end of the management continuum puts the handler in immediate contact with, and next to, the elephant. The handler carries a guide to cue and direct the elephant. Being in close contact with the elephant requires a high level of skill and ability from the handler. The elephant is trained not to push, strike, or displace the handler with any part of its body. In addition, the handler in this management system cannot ignore incorrect behaviors, or allow the elephant to walk away without being released through the trainer's command.

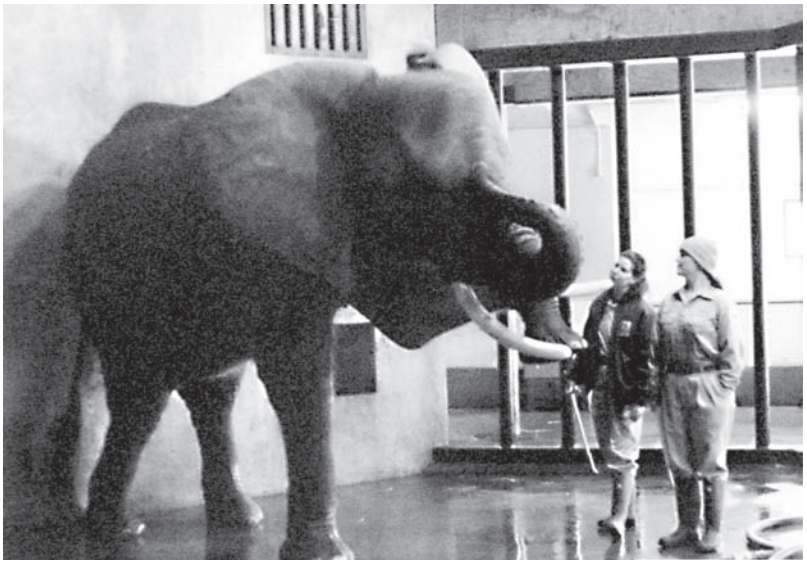
At this point in time and with our current level of understanding of elephant training and management, if both the elephant and its handler are properly trained and suitable for the endeavor, a wider range of behaviors and activities can be accomplished from this end of the continuum. Training protocols can be used to develop

highly tractable elephants that can be easily moved from location to location, exercised in a wide variety of ways, cared for, examined, and treated intimately and on demand. This end of the continuum provides a substantial degree of flexibility in the management of the elephant, and greater opportunities for the elephant to experience spaces outside of their exhibit, interact with the public, and participate in scientific investigation, education, and entertainment-based activities. But it must be cautioned that working with the elephant in this system compromises the safety of the handler to a greater degree.



Indianapolis Zoo, Eric Sampson

The management continuum that puts the elephant in immediate contact with the handler allows greater flexibility for husbandry procedures. Here, an unsedated cow is fitted with a tusk cap.



Sedgwick County Zoo

Left: Regardless of a facility's management technique, staff training is essential for a successful program. Below: Videotaped training sessions help trainers improve and refine methods.

Sedgwick County Zoo

Therefore, it is critical that facility management and the elephant manager understand the need to develop a well-trained, qualified staff and a consistent elephant training program prior to deciding on this end of the continuum. The elephant must be trained to be responsive to all commands given, and the handler must have the ability to obtain a reliable response from the elephant at all times. Due to the need for behavior control of the elephant, an elephant that is repeatedly noncompliant or aggressive should not be handled in this manner.

Rosamond Gifford Zoo at Burnet Park, Michele Delperuto

This male elephant made a successful transition from one end of the management continuum to the other. Initially, he was handled directly and trained to respond to a wide variety of commands.

Though there are a diversity of approaches, all of the methods within the management continuum have many qualities in common such as:

- The training process uses both classical and operant conditioning (See Training, p. 21).
- The elephant's behaviors are shaped through the use of consequences/reinforcements.
- The training techniques and tools are interchangeable throughout the continuum.
- The success of a facility's management program is dependent upon a comprehensive program of staff training, an understanding of elephant behavior, and proper elephant husbandry techniques.
- A good elephant program involves all of the handlers working as a team with consistency being the foundation. Consistency helps remove confusion and enhances the communication on the part of the elephant and the handlers. Consistency improves the elephant's ability to be successful in its response to a command, therefore increasing its responsiveness and tractability, while making contact with humans a positive, rewarding experience.
- All approaches to training have their advantages and disadvantages. It is the responsibility of the facility management to have thoroughly discussed these circumstances in the development of the elephant management program.
- All aspects of a management system within the continuum must be constantly evaluated, including the handler and the elephant.
- Every facility should have an elephant restraint device (see Tools and Equipment, 61).

Elephants handled in a method at one end of the management continuum have been transitioned successfully to another method within the continuum when the facilities are appropriate and the handlers are well-trained and experienced. However, it has been reported that serious noncompliance issues (unresponsiveness, aggression, etc.) on the part of some elephants have occurred at several institutions, making the transition from direct human handling without a barrier to handling through a barrier. Conversely, some elephants have thrived. In other instances, the social hierarchy of the elephant herd changed, resulting in increased aggression between elephants that previously had been compatible.

Possessing a good foundation and understanding of the commands and their associated behaviors has helped many elephants and handlers make this transition. It is strongly recommended that all young elephants, especially bulls, be taught the basic behaviors using direct handler contact without barriers to maximize their potential should barriers be introduced in the future.

Training

Elephants are trained for a variety of reasons, including husbandry, education, research, work, and entertainment. Effective training enhances our ability to care for elephants; for example, an elephant that is trained to stand patiently and quietly, or to enter a restraint device without hesitation, will enjoy better health as a result of the training.

People have been training elephants for centuries, but in the last 10 to 15 years there have been dramatic improvements in training practice and knowledge of training theory. It is the responsibility of today's elephant handlers to learn the accepted/recommended practices and to pass this skill on to subsequent generations of handlers.

For the training of elephants to be as successful and efficient as possible, the elephant handler must be familiar with training theory, the advantages and disadvantages of various tools and methods, and the terminology associated with training. The following review is a small sampling of the information available, and is not meant to be a comprehensive discussion of elephant training. It is meant instead to stimulate greater interest in, and discussions about, training.

Elephants, like all animals, continually gather information and respond to it. This process may be described as learning. Learning can also be described as changes in behavior that occur as the result of practice or experiences (Dewsbury 1978). When humans dictate that practice, the process is called training (Mellen and Ellis 1996). Given this very broad definition, virtually every direct and indirect interaction that handlers have with their elephants can be viewed as a form of training.

In the middle of the 20th century, psychologists (such as B.F. Skinner) suggested that the mechanisms of learning were the same in all animals ("learning is learning"). However, as comparative psychologists and ethologists, led by Keller and Marion Breeland, studied learning throughout the 20th century in a broad range of species,

Six Flags Marine World

Training—for husbandry procedures, for enrichment, and for exercise—is critical to the success of an elephant program.

Six Flags Marine World

Log work can be a good training exercise, using both classical and operant conditioning to train the behavior.

they discovered that while the basic concepts associated with learning were very similar, the natural history of an animal strongly influenced how that animal learned. This was called "constraints on learning" or "preparedness to learn" (Dewsbury 1978; Mellen and Ellis 1996).

In order to select the most effective and appropriate techniques to train (shape) elephant behavior, it is necessary to consider three things:

1. the elephant's natural history—it is important to consider the elephant's predispositions. For example, it may make more sense to ask an arboreal animal to position itself or "station" on a perch off the ground. This may be simplistic, but it makes no sense to try to train an elephant to jump.
2. the elephant's individual history—it is important to consider the early rearing/life experiences of the elephant being trained. For example, a captive-born elephant raised in close contact with humans may be trained substantially differently than a wild-caught elephant brought in as an adult.
3. the elephant's function or "role" at the facility—the type of training and the level of interactions with an elephant may differ depending on the function that the elephant serves. For example, young bulls are often trained to give rides. This, at some point, generally ceases as the elephant gains maturity and develops into an elephant whose primary role is breeding (Sevenich, MacPhee, and Mellen 2002).

Learning, or conditioning, for all animals (including humans) is generally described as either classical or operant. In fact, however, learning is almost always a combination of both.

In very simple terms, *classical conditioning* is the process through which a stimulus that formerly had no effect on a particular reflex acquires the power to elicit that reflex. The best known example of classical conditioning is Pavlov's dogs, where the sound of a bell was paired with a food reward until the bell by itself stimulated salivation in the dogs. The important thing to remember is that the response is reflexive; the animal has no control over its response.

In animal training, classical conditioning is commonly used to establish a *bridge* (or *bridging stimulus*). A bridge is a term for the association between the stimulus, such as a whistle, clicker, or the word "good," and a tangible reward, a *primary reinforcer*, such as food. The bridge is a stimulus that pinpoints in time the precise moment of a desired behavior and bridges the gap in time between that point and when the animal may receive reinforcement. Creating a bridge is very important as often times it is very difficult to present the actual reinforcment at the correct time in order to reinforce the desired behavior. The bridge is a secondary or conditioned reinforcer because it acquires

its effectiveness through a history of being paired with primary reinforcement.

Therefore, a very simple example of classical conditioning is an elephant learning to associate the sound of a clicker with food. Elephant handlers establish a bridge by presenting a stimulus (e.g., the whistle or clicker) while simultaneously offering a food reward. Initially, the stimulus is meaningless, but when paired with the food it will become a reinforcer itself over time. When the bridge is correctly conditioned, it is used to reinforce correct behavior. At the same time, overuse of a bridge or reinforcement will diminish its effectiveness by desensitizing the elephant to its use.

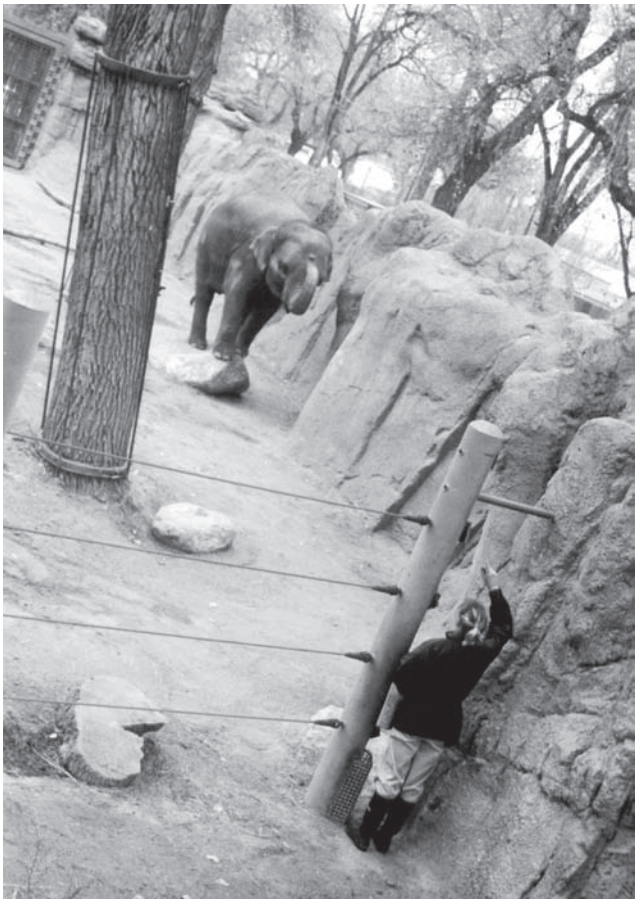
Operant conditioning (also known as *instrumental conditioning*) occurs when the frequency of behavior is modified by the consequences of the behavior. The fundamental principle of operant conditioning is that *behavior is determined by its consequences*. In other words, when the consequences that immediately follow a behavior are something that the animal seeks to encounter (reinforcement), the likelihood of that behavior being repeated increases. For example, the elephant enters a holding area and the elephant receives a food reinforcement. After making this association, the elephant is more likely to enter the holding area at its next opportunity. Conversely, when the consequences following a behavior are something that the animal seeks to avoid (punishment), the likelihood of the behavior being repeated decreases. The elephant that reaches for a tree limb protected by "hot wire" (see Tools and Equipment, p. 61) is punished by the electric shock and typically will not repeat the behavior. This type of learning is called operant because the animal "operates" on its environment.

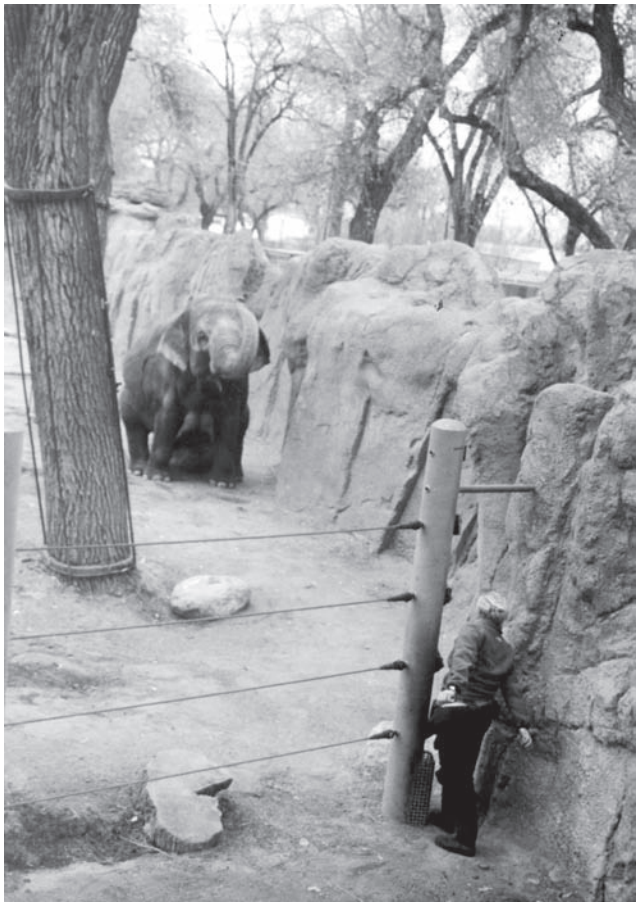
It should be understood that all animals learn through a combination of reinforcement and punishment. When the lion catches the gazelle, the lion has been reinforced and the gazelle punished. On the other hand, when the gazelle escapes, it has been reinforced and the lion has been punished. Reinforcement and punishment are closely intertwined, and one cannot exist without the other.

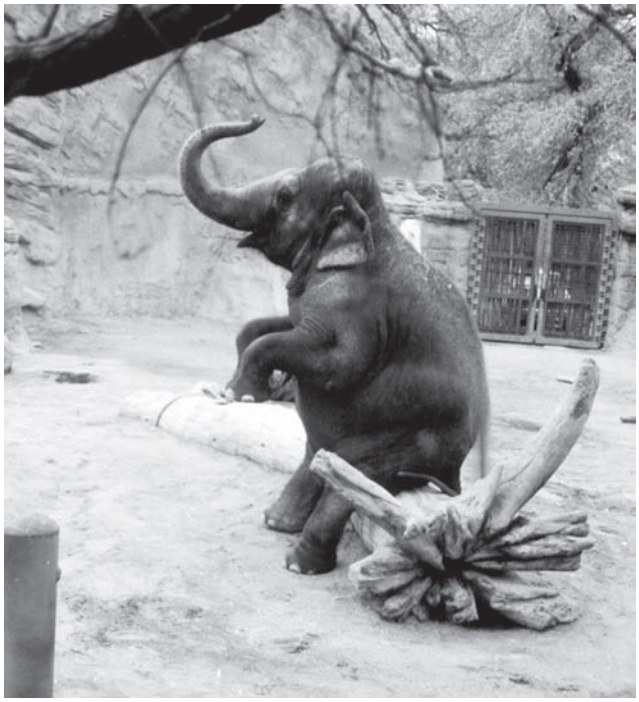
Some scientists use the term *complex learning* as a "catch-all" category for types of learning not described by classical or operant conditioning. One such example is observational learning, where one animal learns how to perform a particular behavior simply by watching another animal; or latent learning, where rats ran through a maze faster if they had been allowed to first explore the maze. This can also be true for elephants. Many young elephants learn their behavior and routines through watching their mother and herd mates. They are probably watching very closely everything that goes on, including how their dam interacts with handlers and how their dam approaches

North Carolina Zoological Park

Using targets (see Tools and Equipment, p. 61) as a cue, the elephant is trained to stand alongside this barrier allowing for inspection of its skin.







Albuquerque Biological Park

Working from behind a barrier, the trainer asks the elephant to "stand" on a rock (top left); "sit" top right; and "tub up" (bottom right).

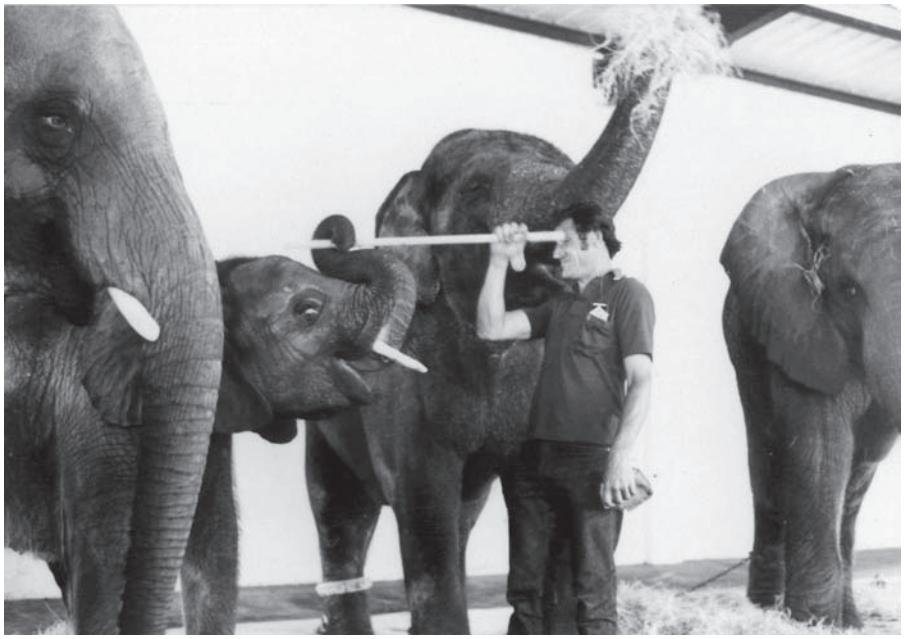
situations such as entering a restraint chute. Thus, a young elephant may learn to enter a restraint chute by imitating the behavior of its mother.

Habituation is the declining or waning of a behavior as the result of repeatedly presenting a stimulus. An example is an elephant that is initially startled by a loud noise. If that loud noise is repeated many times, the elephant's reaction to the loud noise can become imperceptible. In this example, the stimulus (loud noise) went from being aversive to the elephant to being neutral. In the case of an elephant learning to enter an elephant restraint device, some handlers have experienced success in establishing this behavior by simply allowing the elephant access to the restraint device. The elephant enters at its leisure, investigates, smells, plays with the hardware and so on, thus gaining familiarity and confidence with this "furniture" in its environment. Comparing this type of learning with operant conditioning, this process is passive and may take a great deal of time depending on the elephant, where operant conditioning can be considered a more active process. With operant conditioning techniques, or *desensitization*, the elephant handler has the opportunity to create a positive association with the restraint device through the elephant's positive affinity for food and/or attention. More specifically, the elephant might be offered certain positive reinforcement only in the restraint device and thus, with repetition, the elephant comes to make a positive association with the device. In this example, the elephant handler is proactive in creating the opportunity for a positive

association to occur.

In reality all, or several, of the above types of learning are probably functioning at any one time. It is difficult, even in a laboratory setting, to know what is happening inside an animal's mind; therefore, one cannot assume that one type of learning is functioning exclusively. There are simply too many variables to consider, including the animal's individual history and experiences (Sevenich, MacPhee. and Mellen 2002).

Training is an ongoing, fluid process involving two-way communication. It is problem-solving through associations. The elephant must figure out what the handler is requesting, and the handler must figure out how to communicate the request. The clearer the handler can communicate the goals to the elephant, the quicker the goals can be obtained. But remember, communication can be both verbal and nonverbal, so effective communication is not only what the handler is displaying but also what the elephant perceives**.** By studying and understanding the elephant's behavior, it is possible for a handler, in effect, to "listen" to messages the elephant is sending in response to their request. It is then also possible for a handler to communicate clear messages about their expectations back to the elephant**.** The handler and the elephant are always learning from each other, adjusting to each other's actions with every interaction.



Michael Fouraker

Franz Tisch of Circus World training Hillary, the second African elephant born in North America. A loaf of bread is being used as reinforcement.

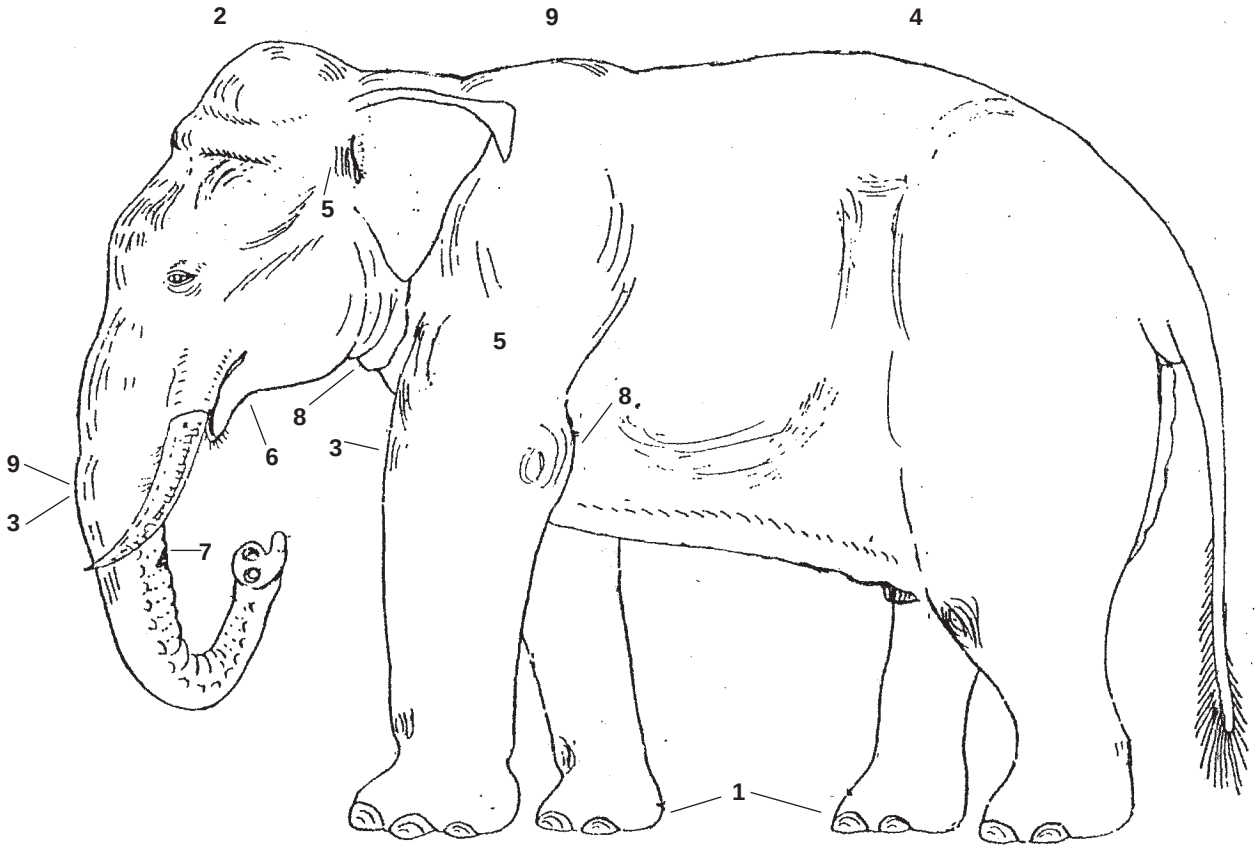
Some elephant handlers have a highly developed ability to interpret elephant behavior accurately**.** Every opportunity must be taken to identify these individuals, and efforts should be made to encourage these handlers to consider elephant management a long-term career choice. At the same time, emphasis must be placed on developing these qualities in all elephant handlers. New and inexperienced handlers should be given time to watch the elephants, provided with relevant reading material, and instructed to spend as much time as possible with experienced handlers in order to develop an understanding of the nuances and subtleties of elephant behavior and training.

The key to an optimal training program is to facilitate the elephants' opportunities to make associations through consequences that enhance their understanding of the handler's requests. Behavior does not occur as isolated and unrelated events; the consequences that follow the actions of an elephant, whether good, bad, or indifferent, will have an effect upon the frequency with which those actions are repeated in the future.

All reinforcement increases the likelihood of a behavior being repeated. By definition, *reinforcement* is the presentation of a stimulus, the result of which will *increase* the frequency of a desired behavior. A *positive reinforcer* is something that an organism seeks to encounter—food to an animal, good grades to a student, a paycheck for the worker. Behavior that produces desirable consequences is reinforced and, thus, repeated. By offering an elephant an apple after it raises its trunk, the likelihood of it raising its trunk again will increase.

Positive reinforcers can be many different things and can vary from elephant to elephant. Although we can never really know what an elephant "likes" or "does not like," we can know what stimuli they respond well to and those that they do not. Some positive reinforcers might have more value to one elephant than to another and, thus, may prove very useful in training circumstances where that particular elephant is demonstrating reluctance or seems to be having difficulty making an association. It is also important to remember that each elephant is different; thus, different training tools and reinforcers may have different value and impact. All of this information is vital in putting the elephant in a position to be successful.

The handler uses positive reinforcement to teach an elephant a behavior by providing something the elephant desires when the elephant executes the behavior requested by the handler. The presentation of the reinforcement must be given to the elephant at the exact moment the elephant performs the behavior in order to communicate to the elephant that the behavior was the one being requested. Timing of the reinforcement is one of the most important aspects of the communication process. Presenting reinforcement too early or too late communicates to the elephant that the behavior they were performing at the moment of receiving the reinforcement was the desired one; not the behavior the handler was attempting to acquire. Therefore a bridge is used to communicate to the elephant the behavior was correct as it is faster than the presentation of the food reinforcement.



Ken Johnson, Have Trunk Will Travel

Suggested guide placement for tactile commands.

1. Foot
2. Head down
3. Back up
4. Down
5. Get over
6. Come here
7. Trunk up
8. Move up
9. Stretch

A second form of reinforcement is known as *negative reinforcement*. This term often creates great confusion, particularly in the lay community, because the words "positive" and "negative" have a common connotation of meaning "good" or "bad." When we are speaking operantly, however, the words "positive" and "negative" should be thought of in terms of arithmetic—as the "addition" or "subtraction" of a stimulus from the elephant's environment. Therefore, a *negative reinforcer* is any stimulus that when removed, reduced, avoided, or prevented increases the probability of a given response over time. A great example of a negative reinforcer in our daily lives is the seat belt buzzer in our car. Buckling up (the desired behavior) is negatively reinforced by the termination (removal) of the annoying buzzer (an aversive stimulus). Common examples of negative reinforcers in animal training include a bit and bridle on a horse, a collar and leash on a dog, or a guide (see Tools and Equipment, p. 61) in elephant training. Each of these tools, when used properly, applies pressure to a part of the respective animal's anatomy. By the animal moving in the proper direction, the pressure is reduced or eliminated, and the animal is negatively reinforced for responding correctly.

To clearly distinguish between positive and negative reinforcement, remember the following: Both positive and negative reinforcement *increase* the probability of the response that precedes them. Positive reinforcement increases response probability by the presentation of a positive stimulus following a response; negative reinforcement does the same in reverse—through the removal, reduction, avoidance, or prevention of an aversive stimulus following a response.

Consider a simple scenario to demonstrate the difference between positive and negative reinforcement. In this example, the elephant handler wants the elephant to move from stall A to stall B. There are many techniques that will achieve the desired result. One might entice the elephant to move from stall A to B by offering a food item the elephant prefers (a positive reinforcer) only in stall B. The elephant moves into stall B based upon its motivation to obtain the

North Carolina Zoological Park

Whistles, clickers, or the word "good" are often used as bridges—they are used to indicate the instant at which an elephant successfully completes a desired behavior.

positive reinforcement. Done consistently over time, the elephant soon makes the association that moving to stall B gains access to something good. Alternatively, negative reinforcement can also be used. In this example, the goal is to make the environment in stall A less appealing, perhaps by adding a cold water shower in stall A. The elephant is seeking to avoid the cold water (the negative reinforcer or aversive stimulus) and moves to stall B. Both methods increase the occurrence of the desired behavior, moving from stall A to stall B. *It should be noted that many elephants may not see the cold water shower as aversive, and in fact would find it reinforcing. This demonstrates the importance of understanding the particular elephant that is being trained and the stimuli it responds well to and those it does not.*

Let's consider another scenario. Here, the guide is the aversive stimulus, and the forward leg movement is the target behavior. A handler applies pressure when placing the tip of the guide against the back of the elephant's leg to communicate to the elephant to move its leg away from the pressure. When the elephant moves its leg forward, it avoids the aversive stimulus and the behavior is negatively reinforced. This action can then be reinforced with food and praise (positive reinforcement) further communicating to the elephant that the behavior of moving its leg forward was correct.

Contrary to reinforcement is *punishment*. Punishment is an aversive consequence that follows a behavior, the effect of which will be to decrease the frequency of that behavior. As with reinforcement, punishment can be either positive or negative. *Positive punishment* is the addition of an aversive stimulus—something the elephant seeks to avoid—to the elephant's environment following a response, thereby decreasing the frequency of that response. For example, the elephant in moving from stall A to B has the opportunity to choose stall C. The goal is that the elephant goes to stall B and never goes to stall C. In this instance, the elephant chooses stall C. While the elephant is in stall C, the handler sprays the elephant, which "dislikes" cold water, with a cold water shower. Because the shower is added after the elephant is in stall C, the elephant is being punished for choosing stall C.

Negative punishment is the removal of a positive stimulus—something the elephant seeks to encounter—from the elephant's environment following a response, thereby decreasing the frequency of that response. The most commonly used form of negative punishment is a *time out*. The technical definition of a time out is a form of punishment in which all reinforcement is withheld, including personal contact, with the intent of reducing or eliminating the frequency of occurrence of an undesired behavior. It requires removing the situation in which an elephant can get reinforcement, and is used to suppress incorrect responses correlated with nonreinforcement. A time out can also be thought of as a nonreinforcement training strategy whereby a training session is temporarily paused, and attention is removed from the elephant for a short period of time in order to elicit desirable behavior when the session is restarted.

The reality of training—or learning—is that reinforcement and punishment are occurring all the time, sometimes concurrently, sometimes sequentially. As an example, let's consider the following example: An elephant that has previously been conditioned to move from stall A to stall B on command is given the cue to do so. The elephant does not shift. The handler then takes a water hose and showers the elephant with cold water. In an attempt to escape the water, the elephant shifts from stall A to stall B. The handler gives the elephant a carrot.

What has occurred here is positive punishment, followed by negative reinforcement, followed by positive reinforcement. The first behavior that the elephant demonstrated was not shifting; the consequence of that behavior was being showered by cold water. Assuming that the elephant was not looking forward to being showered with cold water, the water was an aversive stimulus that was added to the elephant's environment as a consequence of its not moving; it was, therefore, positive punishment. When the elephant finally does move from stall A to stall B, it is negatively reinforced for escaping from the cold water. Finally, when the handler gives it a carrot for moving into stall A, the elephant has been positively reinforced.

Handlers must fully understand the application and

Punishment, Negative Reinforcement, and Discipline

Animal training, especially in zoos, is often referred to as "positive reinforcement training." This is misleading as all training programs involve a combination of positive reinforcement, negative reinforcement, and punishment.

Any discussion of punishment and negative reinforcement would be incomplete without discussion about some common misconceptions. The general public most likely thinks of "punishment" as something applied to people as a result of breaking rules, committing a crime, and/or other behavior deemed improper. These "consequences" are applied and determined by governments, people, police, and so on, as a means to inhibit law violation and inappropriate behavior. For example, jail terms, tickets for traffic violations, or even expulsion from the facility for feeding the animals, are all familiar forms of punishment. In this most common context, punishment has a moral component and is perceived as something deserved. The punishment can take on an element of retaliation. Thus, many people perceive any application or certain types of "punishment" of animals as inherently wrong. With punishment taking on moral and ethical qualities, judgments get made regarding the nature of punishment or the use of any punishment at all.

In contrast, the term "punishment," as defined in the field of animal learning and in the psychology literature where concepts of animal learning were developed, simply refers to a process where the application of said punishment results in a decrease in the occurrence of a particular behavior. Also included in this consideration is the term "negative reinforcement." Because of the word "negative," and simply through extrapolation and association, most people think of "negative reinforcement" as bad and positive reinforcement as good. Some might even go so far as to consider "negative reinforcement" and/or punishment as inappropriate techniques when training elephants (or any animal) when, in fact, they can be used effectively.

There is also confusion in using the term "discipline." Webster's lists several possible meanings including, but not limited to, punishment. Using the term "discipline" is thought by some to soften the fact to the public that the handler used punishment as the tool of choice for a particular training event. Unfortunately, choosing the term "discipline" only adds to the confusion and misinterpretation. Punishment, its meanings, uses, pitfalls, and strengths is abundantly referenced in literature discussing behavior modification. Discipline is not commonly used in these same discussions; therefore, it is not recommended to use the word "discipline" when discussing training terminology.

Uninformed people do and will continue to make judgments and place moral and ethical values on words, and unfortunately, this is unlikely to change. Elephant handlers must make every effort to familiarize themselves thoroughly with the technical use of the terms "punishment" and "negative reinforcement," how they work, the pros and cons, and how to explain how and when such training tools are used. Elephant handlers must choose their words carefully and accurately so as to avoid contributing to these common misconceptions.

Thus, a certain competence around terminology and training theory may be developed in the general public over time.

consequences of punishment, both positive and negative. Although the intent of punishment is to decrease unwanted behavior, and despite the fact that punishment occurs naturally and frequently in nature, in the training situation it is often less than effective and there are other, more effective methods to decrease behavior that are more effective than punishment. Good handlers understand that an elephant should never be punished for not understanding what the handler wants it to do. Nor should an elephant be placed on a time out simply because the handler is frustrated. Punishment, when it must be used, should enhance or create a situation of benefit, such as increasing safety, to both the elephants and humans involved.

It is common to hear elephant handlers claim that they use only "positive reinforcement" techniques when they train. However, it is impossible that this training technique is the only one used. The terms "positive reinforcement" and "operant conditioning" are also frequently used as if they were interchangeable. This is incorrect. Techniques used to modify a behavior through the use of positive reinforcement, negative reinforcement, and punishment may vary from handler to handler, from management program to management program, but this form of training is still operant conditioning. All forms of reinforcement and punishment should be used carefully and judiciously, and when used properly, they are effective and appropriate tools within the definition of operant conditioning.

Training a behavior is accomplished by breaking the behavior into small increments. This is called *shaping* or *successive approximation*. This allows the handler to build upon what the elephant already understands, going from the familiar to the unfamiliar until the desired behavior is achieved. These small successes provide the elephant the confidence and interest to try solving more difficult problems. An example is training an elephant to come when it is called.

1. The handler first calls the elephant's name when the elephant is standing very close to the handler. The elephant is then reinforced for simply turning to look at the handler.

2. When that behavior is understood, the next step is for the handler to withhold the reinforcement until the elephant takes a step toward the handler.
3. When the elephant clearly understands it is to move toward the handler when it hears its name, the elephant is then required to take multiple steps toward the handler before the reinforcement is offered.
4. This process continues until the elephant comes to the handler each time it hears its name.

Through gradually building on what the elephant knows and increasing the handler's expectations, a behavior is trained. When the elephant becomes confused or anxious, the handler returns to behaviors the elephant is comfortable with and starts the building process once again. Retracing the steps of the shaping process will assist in developing the elephant's ability to learn.

Many situations and opportunities occur throughout each day for handler interaction with elephants. Some are planned and some are not. But every interaction results in the elephant associating an action with a consequence—or learning. Some associations may be learned passively; the elephant might be watching from a distance. Or, the elephant may be directly engaged. In any case, learning is ongoing. The elephant is gaining information and making associations. Elephant handlers must remain ever focused and vigilant with regard to the behaviors they are actively and passively shaping.

When the trainer is aware of what they are teaching or training, they make a conscious effort to achieve their goal. However, all too often trainers are unaware of the effects of their own behavior on the animal. It is not uncommon for a handler to influence or train a behavior inadvertently through their actions, their husbandry routines, or through other stimuli present in the environment. Therefore, the elephant handler must be conscious of, and to take responsibility for, their actions and activities, as well as the routines they put in place to care for their elephants. An example of inadvertent training might be the elephant that throws feces. One day the elephant finishes its hay and standing near its stall are two handlers engaged in a discussion. The elephant, perhaps seeking attention, or more hay, randomly picks up some feces and throws it in the direction of the handlers, who scatter and shout. One of the handlers then goes and obtains a few flakes of hay for the elephant. A behavior is born. It is that simple. The handler has just inadvertently rewarded the elephant for throwing feces.

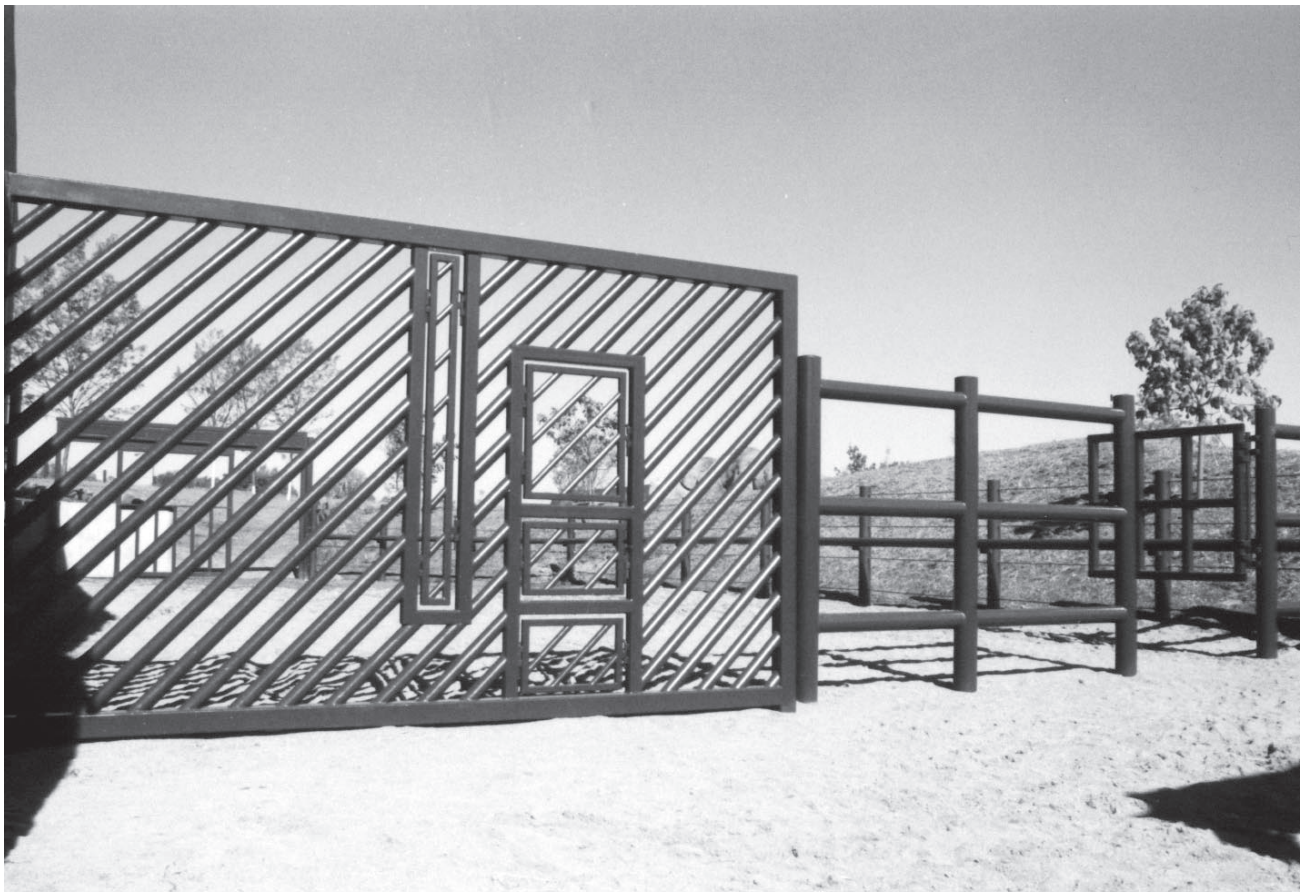
Training is often a challenge, as it completely relies on the effective communication process between the elephant and human using the language of actions and consequences as explained in detail earlier. This type of communication can lead to mistakes and errors in judgment. A common mistake made is in the timing of the presentation of the reinforcement, but other errors are also often made. For example, a handler reinforces one behavior, which could cause the elephant to believe it is being reinforced for another, a *superstitious behavior*. By way of illustration, consider an elephant that acts aggressively towards another elephant when it is coming toward the handler after being called. The handler still reinforces the elephant for coming, but has also reinforced the elephant for acting aggressively even though that was not the handler's intent. Therefore, the elephant believes it is being reinforced for the aggression and will then repeat the aggression either by itself or in concert with the correct behavior.

Six Flags Marine World

A handler uses the guide to train the "foot" command.

Or consider the following example: The elephant that has been previously conditioned to shift from stall A to stall B on command is given the cue to do so. The elephant does not shift. The handler gives the cue again; the elephant still does not move. The handler repeats the cue, this time with more emphasis, and the elephant finally shifts into stall B. The handler rewards the elephant with a handful of carrots. The elephant has learned in this situation that it is not expected to shift the first time it hears (or sees) the cue, but rather on the third time. The handler has inadvertently trained the elephant to criteria totally different than what was desired.

There are many variables that affect an elephant's response while being trained. Some of these variables are the social structure of the herd, the surroundings where the handler is working, the number of handlers training a behavior, the elephant's health, and its behavior, to name a few. Recognizing these variables is crucial to success.



Deborah Olson, Indianapolis Zoo

A training wall expands training opportunities and should be considered in any new construction.

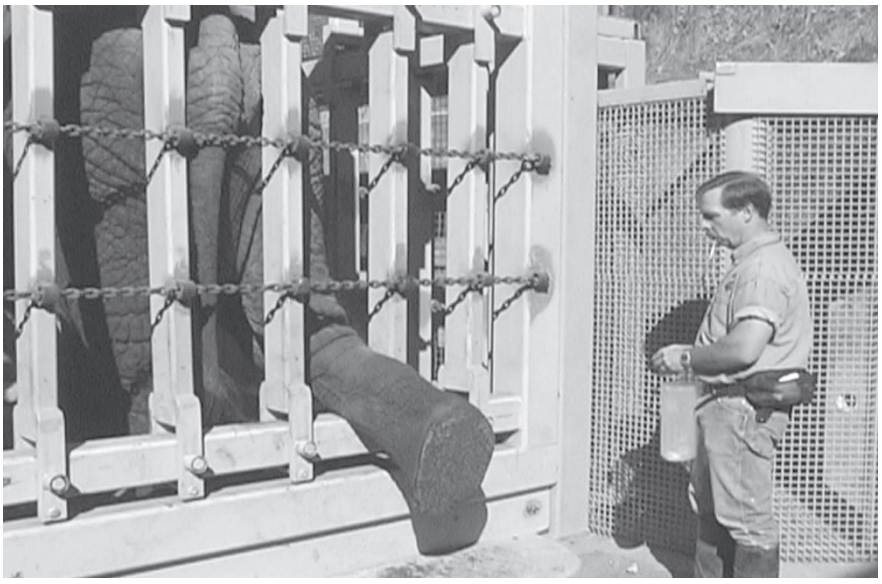
Training can be more productive if some of the variables are eliminated or controlled. For instance, making sure the basic behaviors are well understood by the elephant before training more difficult behaviors will enhance success. Not only will training basic behaviors build confidence and create a pattern of learning, but if the basic movements, such as steady, move forward, back up, move to the left or right, are not established first, then the trainer and the elephant will be distracted by just keeping the elephant in position.

Although it may not always be able to be controlled, a variable that can help is having only one elephant in the enclosure when initially training the elephant to come when it is called. This will eliminate the problem of other elephants affecting its response. The size of the enclosure could also have a direct effect on the handler's initial success. Training inside the confined space of a single stall might be easier than in the significantly larger exhibit yard.

One variable that can—and should—be easily controlled is the number of handlers training a behavior to an individual elephant. It is highly recommended that only one handler be given the responsibility of training a new behavior. A handler must have knowledge of every aspect of the training process, the elephant's demeanor, its daily response to training sessions, its response to the shaping procedure, and its day-to-day level of understanding of the training process. Using more than one handler to train may introduce inconsistencies to the training process, which may unintentionally cause confusion and anxiety on the part of the elephant. A single handler will have intimate knowledge of every aspect of the training process and the elephant's behavior, making it easier for the elephant to succeed. Once the behavior has been trained, other handlers can be instructed as to the cues and reinforcements of the behavior.

A critical aspect in training is knowing when to stop the training session. Too often a handler making progress on a behavior goes for "just one more," only to have everything fall apart. In this case it is often beneficial to go to another, already established behavior. By doing so, the handler takes the elephant back to something it understands and creates an opportunity to positively reinforce the elephant. Ultimately, it is more beneficial to stop on a successful note and leave the elephant wanting more than to satiate the elephant's interest or lose its motivation. Likewise, knowing when to discontinue a "time out" or other punishment is equally important. Punishment must be timely and it must end when the unwanted behavior ceases.

Successfully training an elephant not only requires a handler of experience and skill, but also a well thought out elephant management program. A training protocol—or a



North Carolina Zoological Park

Use of an elephant restraint device (ERD; see Tools and Equipment, 61). Above: The elephant is asked to enter the ERD. Bottom: Elephant presents a hind foot. Note the trainer's whistle.

plan of action outlining the steps to be taken when training or shaping a behavior—should be established for every behavior. Each protocol should consider variations to the shaping of the behavior, but stepping outside of the protocol can create confusion and undermine the elephant's learning. A plan of action helps the handler evaluate their progress in reaching the goal behavior. Recording the incremental steps in the shaping of a behavior allows the handler to constantly evaluate the behavior, comparing what it is to what the handler wants it to become.

Measuring and duplicating success is more likely to take place if records are used to document training efforts. Often subjective references are made to what is witnessed in a training session days, even weeks or months, in the past. These subjective recollections can be accurate; however, they often leave out important details. Therefore, it is recommended that handlers maintain records in personal journals or training logs. Each handler should record and track the effectiveness of their training daily so that they are better able to repeat success and avoid repeating unsuccessful efforts. But if these records are going to be useful, care must be taken by the handler to accurately describe their activities using correct terminology. This accuracy will allow their actions to be duplicated by others and prevents others from interpreting the records incorrectly. The types of records kept and the types of information

Ending a Session on a "Good Note"

Much has been written about how trainers should always try to end their training sessions on a "good note." That is, the trainer should stop after the animal has responded correctly and quit before the animal is satiated either with the reinforcement or the training itself. This philosophy creates a true irony. By definition, when an animal's opportunity to gain reinforcement is prevented, removed, or reduced, the animal is being negatively punished. Therefore, if the animal is not satiated with a training session and is still interested in continuing, then stopping the session becomes a time out, or more accurately, a negative punishment. Unless it is done propitiously, ending a session in this manner could have the unwanted effect of decreasing the frequency of the last emitted behavior. Good trainers are aware of this conundrum and are very careful about how and when they conclude a session.

Frequently Used Commands in Elephant Management

Back up	-	move back in straight line
Steady	-	freeze
Come here	-	move to handler
Move up	-	move forward in straight line
Lean in	-	position body parallel to, and in contact with, barrier
Turn	-	pivot in circle (right and left)
Trunk (up)	-	curl trunk up to touch forehead
Trunk down	-	drop trunk straight down to ground
Foot	-	front leg/wrist to elbow parallel to ground; rear leg/foot to knee parallel to ground or move foot into foot hole, tub or present foot for chaining
Target	-	move toward target; respond to target by touching appropriate body part to it
Stretch	-	sternal recumbency
Lie down	-	lateral recumbency
Open	-	open mouth wide for visual and tactile inspection
Go	-	leave handler and move to desired place
Ear	-	present ear(s) forward or through ear hole
Give	-	hand object to handler
Line up	-	stand facing handler; elephants stand in order of hierarchy
Come in	-	laterally move toward handler
Get over	-	laterally move away from handler
Alright	-	release from previous command
No (quit)	-	stop unwanted behavior
Leave it	-	drop whatever is in trunk
Tail	-	grab and hold tail of another elephant
Pick it up	-	lift object with trunk
Push	-	push object with head
Salute	-	raise trunk and foot simultaneously

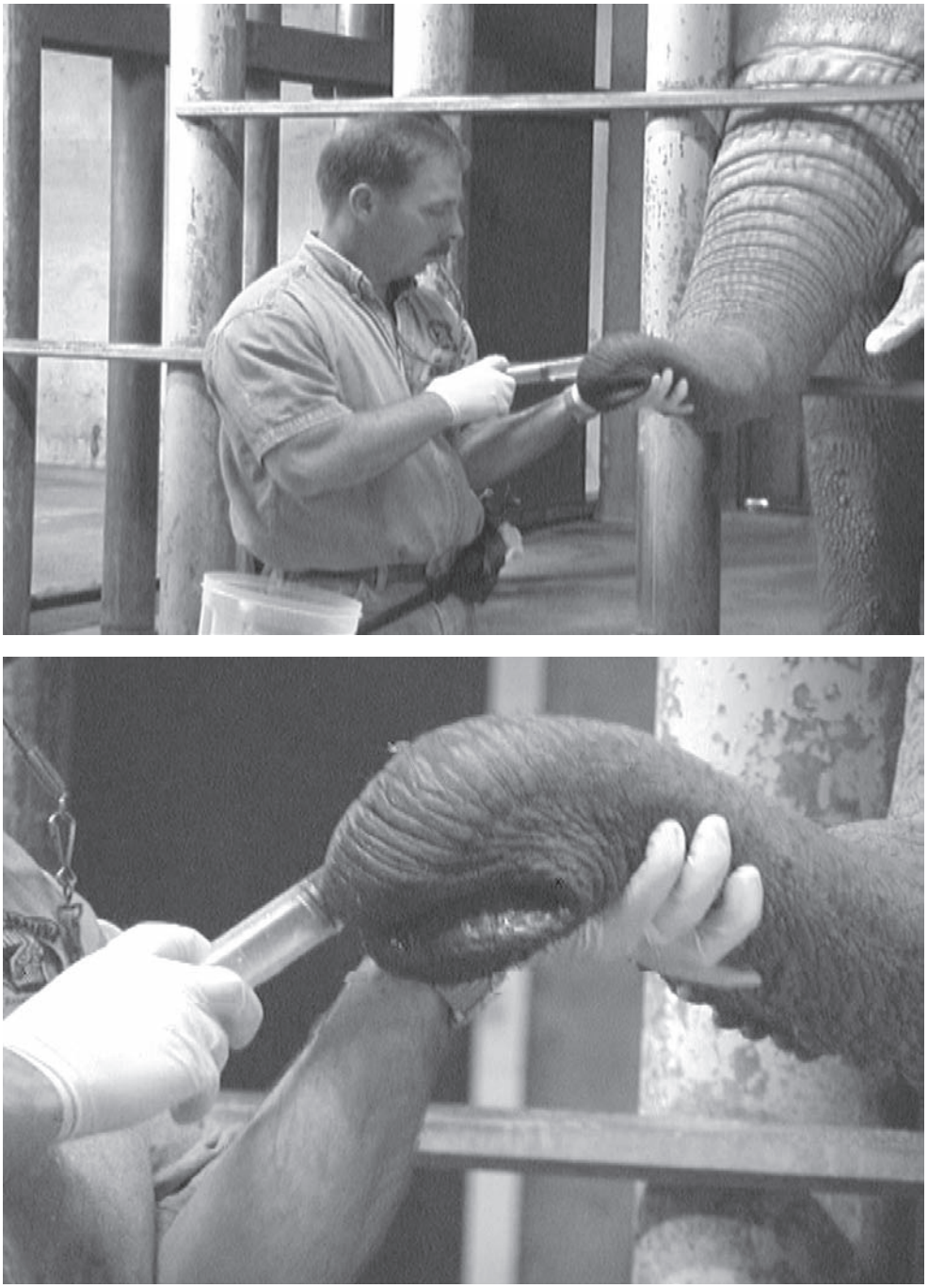
recorded will vary at each facility. Although similarities are abundant, no two training record keeping programs are going to be exactly alike, since no two elephant management programs are alike.

Daily training sessions are strongly recommended, as they are an effective and reliable means of maintaining behaviors. Most elephants respond well to training sessions, and they appear to look forward to the process and the attention that they receive. If this is not the case, then something may have gone wrong in the training process, and the elephant manager should review their program.

The benefits of a daily training session are many. The daily training session becomes a constant in the relationship between the handler and the elephant. It is also another opportunity to evaluate the general health of the elephant. Daily training sessions can also be a scheduled time to reinforce to all of the handlers the criteria of a behavior and to make sure that it is consistent from individual to individual. *Criteria of the behavior* is the quality or level of performance of the behavior, including the timeliness of the response. For example, every handler should have the same exact expectation of how high the elephant should pick up its foot, as well as how quickly it responds to the cue to lift the foot. It is confusing to the elephant to have to adjust constantly to varying expectations from different handlers. Establishing clear criteria for each behavior helps train new behaviors, as well as maintain previously learned behaviors.

Flexibility in the elephant program and in the training sessions is equally important. The elephant and handler should be confident enough in the training program and each other that changes or deviations do not adversely affect the elephant's response. It is very important that the elephant is used to and comfortable with a variety of situations so that it can cope with both planned and unplanned variations. This is accomplished by developing a consistent, sound foundation. Once that foundation is established, then it can be built upon by changing individual aspects of the program. For example, the elephant is taught to lie down in the barn consistently. Once this behavior is reliable, then the handler can ask the elephant to lie down in another part of the barn, then outside of the barn, and then anywhere that the handler has need of the behavior.

Many facilities use the daily training session as an opportunity to introduce a new staff member into the elephant program in a stable environment. Having a novice handler succeed in their initial encounters with the elephant is extremely important. For example, during the daily bathing routine the elephant is familiar with the tasks it is to perform in order for the bath to occur. The novice handler can observe the behaviors and know what



North Carolina Zoological Park

The handler is shaping or successive approximation of one portion of the trunk wash behavior (see Medical Management, p. 159) from behind a barrier.

to expect from the elephant prior to their attempts to accomplish the routine. The elephant manager can evaluate quantitatively the work of the apprentice while bathing the elephant—the commands, the behaviors related to the commands, the movements of the elephant in the accomplishment of the behaviors, and if those movements meet the criteria. Finally, the elephant manager has a benchmark to evaluate and critique the progress of the new employee.

A novice handler benefits greatly by working with an experienced handler. It is strongly recommended that a novice handler learn to work only one elephant at a time, starting with the most easily handled and well-trained elephant. It is also strongly recommended that novice handlers *do not* learn how to handle elephants by working with an untrained elephant. This is counterproductive to achieving a well-trained elephant, and it increases the risk to the novice handler. It is highly recommended that only an experienced handler be responsible for, and guide the handling of, an untrained elephant. Sometimes this might require contracting with an experienced handler outside the elephant facility. This gives the elephant a good start in

Sedgwick County Zoo

Training the elephant to hold the tail of the elephant in front of it prevents the elephant from performing the incompatible behaviors of walking in a different direction or reaching out to grab things with its trunk.

its training and the experience can be used to teach the less-experienced staff.

Often times the level of performance and/or training skills deteriorate unbeknownst to the handler, even the most experienced of handlers. Habits sometimes develop that are not always noticed by self-evaluation. This deterioration can be corrected by periodic evaluations by another experienced handler. It is recommended that each institution arrange to have their elephant management program and handlers evaluated, either formally or informally, on a regular basis by an outside elephant handler.

It is unacceptable to the goals of training to use inappropriate training methods. Inappropriate training methods destroy the bond of trust between the handler and the elephant, and risk the general physical and psychological health of the elephant. *At no time should the basic needs of the elephant be neglected, nor should the training risk permanent injury to the elephant.*

Terminology

Terms associated with training seem to be a source of confusion, frustration, and in some cases, incentive for debate. Ideally, terms can be used to provide a common language, facilitate good communication, and enhance the handler's ability to train elephants. Unfortunately many new handlers seem to get bogged down by the terminology. To add to the confusion, animal trainers who work in a much more complex environment than the laboratory have developed an additional set of terms that are used to describe the nuances of training. This jargon includes "bridge," "cues," and "desensitization" (Sevenich, MacPhee, and Mellen 2002).

It is suggested that elephant handlers focus on understanding broad concepts, the most important of which is that training is a process where elephants are making associations. It is the handler's job to facilitate the elephant making those associations.

The following list of training terms and definitions is a collaborative effort of the American Association of Zookeepers, Inc. (AAZK), Animal Behavior Management Committee and the American Zoo and Aquarium Association (AZA) courses for Principles of Elephant Management (PEM) and Managing Animal Enrichment and Training Programs (MAETP). This list is by no means intended to be comprehensive in nature, and the definitions of the terms are a distillation of many definitions found in the literature. The goal is to provide a basis for common language and thus clarify and enhance communication. It is strongly encouraged that each handler seek a more comprehensive discussion of terminology. The literature offers ample opportunity to debate the nuances and interpretations of terms.

Approximation—One small step, in a series of progressive steps, that leads to the behavioral goal; see *Shaping*.

Behavioral criterion—The level of behavioral response that must be met to earn reinforcement.

Bridging Stimulus—A stimulus that pinpoints the exact moment that the behavioral criterion (for that approximation) is met. The "bridge," as it is often referred to as, (often a clicker, whistle or word) communicates to the subject that it has performed correctly and often signals that additional reinforcement is on the way. It "bridges" the gap between the time the correct response is given and the time the additional reinforcer is delivered.

Capture (Scan)—The process of placing a behavior that is initiated by the subject under stimulus control by reinforcing the behavior as it spontaneously occurs.

Classical conditioning—A basic form of learning in which

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA standards for Elephant Care and Management adopted March 21, 2001, states, "Elephant training terminology and description of specific behaviors are outlined in the AZA Schools for Zoo and Aquarium Personnel Principles of Elephant Management (PEM) Course Notebook. Trained behaviors should allow the elephant staff access to the animal in order to accomplish all necessary animal care and management procedures and permit institutional consistency. The PEM-recommended list of commands and their corresponding behaviors are ones that every elephant and elephant keeper must know so that basic husbandry and verterinary practices can be accomplished. Behaviors should be reinforced so that all elephants attain close to 100% compliance upon request of the elephant staff.

Appropriate elephant training may employ several training aids or "tools" (see PEM Course notebook for a list and description of some elephant training tools and procedures). The goal of a good trainer is to be able to reduce the amount of time any particular training aid is used.

The AZA considers the following training tools/techniques to be inappropriate for use at member institutions:

a. Insertion of any implement into any bodily orifice, unless directed by a veterinarian specifically in connection with training for a medical or reproductive procedure.
b. Striking an elephant with anything more substantial than a guide.
c. Striking an elephant with any sharp object, including the hook of a guide.
d. Striking an elephant on or around any sensitive area, such as the eyes, mouth, ears, and genital region.
e. No tools used in training should be applied repeatedly and with such force that they cause any physical harm to the animal (i.e., breaking the skin, bleeding, bruising, etc.)
f. Withholding or reducing an animal's daily-recommended amount of food and or water.
g. Withholding veterinary care for any reason.

If properly executed training procedures are ineffective in eliminating aggressive or inappropriate behavior in a given animal, institutions should consider other alternatives, including transfer to a facility with more experienced staff or a different management system. Protracted and repeated use of corporal discipline in training is of serious ethical concern and AZA considers abusive training practices to be unacceptable. Further, elephants that are untrained, unexercised, or unable to complete minimum behavioral requirements may be considered neglected and thereby abused.

a neutral event (unconditioned stimulus) initially incapable of evoking certain responses acquires the ability to do so through repeated pairing with other stimuli that are able to elicit such responses. This type of conditioning does not involve any voluntary choices by the animal; the response or reaction is reflexive (e.g., blinking or salivating) and not dependent on operant learning.

Continuous reinforcement—A schedule of reinforcement in which the desired response is reinforced every time it occurs. Trainers typically use a continuous reinforcement schedule when the animal is in the process of learning a new behavior.

Conditioned response—A type of learned response that occurs through association with a specific stimulus.

Conditioned stimulus—A signal that will elicit a specific response as a result of a learned association between that stimulus and that response.

Cue—A stimulus that precedes a behavior, signaling that a specific response will be reinforced if emitted correctly. The result is that the stimulus will consistently elicit only that particular response.

Desensitization—The process of modifying an animal's response to an event (usually negative), such that its response will decrease in strength and /or frequency over time (generally through pairing with positive reinforcement).

Extinction—A method of eliminating a behavior by no longer reinforcing it.

Extinction burst—A short-term increase in the frequency and intensity of a response during the extinction process, due to a lack of reinforcement.

Generalization—The lack of discrimination between two stimuli. An animal that has been conditioned to respond to a specific stimulus may offer the same response in the presence of a similar stimulus.

Habituation—The declining or waning of a behavior as the result of repeated presentation of stimulus; the process of gradually getting an animal used to a situation that it normally avoids, by prolonged exposure.

Incompatible behavior—A behavior that is impossible to perform at the same time as another specific behavior.

Intermittent reinforcement—A schedule of reinforcement in which not every correct response is reinforced. Any schedule of reinforcement that is not continuous (i.e., variable ratio, variable interval, fixed ratio, fixed interval).

Jackpot or Bonus—A positive reinforcer that is much larger than usual, and usually unexpected.

Magnitude of reinforcement—The size and duration of the reinforcement following a behavior.

Negative reinforcement—A process in which a response

increases in frequency due to the avoidance, escape or removal of an aversive stimulus from the animal's environment. Not to be confused with punishment.

Observational learning—A type of learning in which the behavior of another organism is observed and imitated.

Operant conditioning—A type of learning in which behavior is determined by its consequences. (Strengthened if followed by reinforcement [positive or negative] and diminished if followed by punishment). The animal "operates" on the environment, leading to a desired outcome; the animal's behavior is instrumental in acquiring the desired outcome.

Primary reinforcer or Unconditioned reinforcer—A reinforcing event that does not depend on learning or previous experience to achieve its reinforcing properties (e.g., biological need: food, water, warmth, sex).

Positive reinforcement—The process of following an action or response with something that the subject wants, thereby causing an increase in the frequency of occurrence of that behavior.

Punishment—An act that occurs immediately *after* a behavior it is meant to affect, and causes a *decrease* in the frequency of that behavior.

Regression—The state of a conditioned behavior reverting back to a previous stage in the learning process.

Reinforcer—Anything that occurs immediately following a behavior that tends to increase the likelihood that the behavior will occur again.

Schedules of reinforcement—The conditions under which reinforcement is delivered; see *Continuous reinforcement* and *Intermittent reinforcement*.

Secondary reinforcer or Conditioned reinforcer—An object or event that initially may mean nothing to the animal but becomes reinforcing through pairing with a primary reinforcer.

Selective or Differential reinforcement—The act of reinforcing specific criteria of desirable responses to shape a specific behavior; the reinforcing of selected responses of higher quality to improve performance.

Shaping or Successive approximations—An operant conditioning method of taking an action or tendency and shifting it, one approximation, or step, at a time toward the final behavioral goal; building of a behavior by dividing it into small increments or steps and then teaching one step at a time until the desired behavior is achieved. Steps become a series of intermediate goals.

Stimulus—Anything that elicits or affects a behavioral response; see *Unconditioned stimulus* and *Conditioned stimulus*.

Stimulus control—A different form or frequency of behavior in the presence of one stimulus that does not occur in the presence of other stimuli.

Superstitious behavior—A behavior that is unrelated to the behavior being conditioned but has inadvertently been reinforced often enough that it becomes fixed in the subject's mind as necessary for reinforcement.

Time-out—A type of punishment in which all opportunities to obtain reinforcement is removed immediately following an inappropriate or undesirable response and is generally short in duration.

Unconditioned stimulus—In classical conditioning, a stimulus that elicits a particular response without any prior association, that is, it is not a learned association; a reflex.

Suggested Reading

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Wilkes, G. (1994), *A Behavior Sampler*, North Bend: Sunshine Books, Inc.

Husbandry

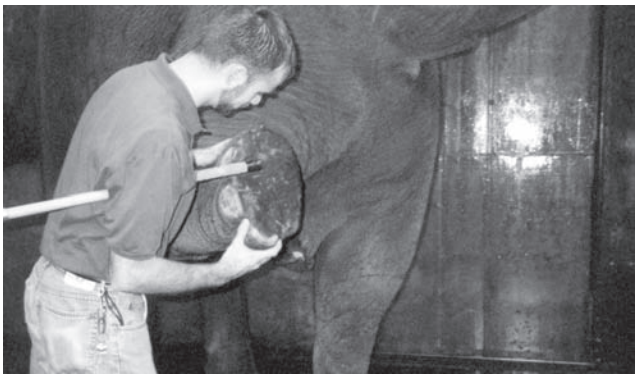
Both species of elephants in human care share many of the same needs. This manual considers the management and husbandry needs of the African and Asian elephant to be the same. As elephant breeding programs develop, subtle differences may begin to appear. Those who work with elephants or oversee elephant programs must stay abreast of new discoveries, and be able to adjust their elephant management accordingly.

Proper elephant husbandry management includes:

- a complete daily check of the elephant's physical condition;
- regular care of the feet and skin;
- monitoring reproductive capabilities;
- medical examinations;
- the ability to treat injuries and illnesses with minimal need for immobilization/sedation;
- providing sufficient exercise; and
- providing activities that stimulate mental processes and encourage species appropriate behavior.

Handlers should inspect each elephant first thing every morning. A general assessment of its physical condition should be noted daily in an elephant record or log. The report should also include atypical observations of urine, feces, eating, and drinking patterns; administration of medication; general condition; notable social interactions with conspecifics; physiological conditions (i.e., musth); training benchmarks; and behavior. In addition, all unusual daily activities of the elephant should be recorded.

Each elephant should be trained to perform daily controlled behaviors as a means of allowing the handler to provide foot, mouth, eyes, ears, and skin care; exercise; and



Rosamond Gifford Zoo at Burnet Park

Each elephant should be examined every day. Top left: Handler checks elephant's feet for problems. Above: An oral examination helps handlers spot a wide range of problems before they require dramatic measures. Bottom left: Handler examines the eyes and ears.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephants must be visually inspected on a daily basis. A general assessment must be made and any unusual activities should be recorded in the daily log at each inspection. Specifically, reports should include observations such as condition of urine and feces, eating and drinking patterns, administration of medications (if any), and general condition and behavior."

medical examinations and treatments. Examples of trained behaviors used daily to assess and care for the elephant include presenting each foot, presenting both ears, opening the mouth, allowing the eyes to be examined, laying sternal, and laying on its side. The elephant should maintain each trained behavior as long as it takes the handler and/or veterinarian to complete the assessment and care.

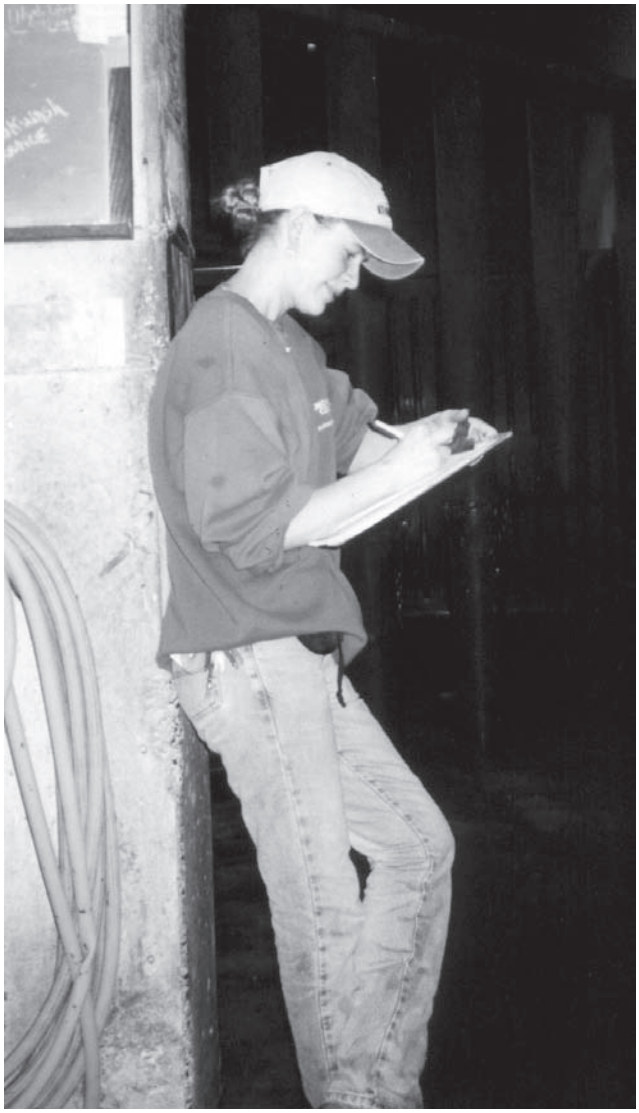
Male elephants in musth will often not cooperate with the handlers as musth alters the behavior and attitude of the male elephant (see Reproduction, p. 123). Every male elephant is different and every musth period of the same male may be different, therefore the male elephant management program must be adaptable in order to provide the musth male the best possible care. Although every attempt must be made to provide the musth male with daily care, it is acceptable to leave him undisturbed if he reacts aggressively to the handlers or the training.

The following list of behavioral components is the current standard of acceptable elephant care and management. Being able to achieve this list is essential for every elephant program. All elephants should be trained or managed in such a manner to consistently attain compliance in performing these behavioral components at the will of the elephant handlers. Elephant handlers who cannot meet these standards with an elephant should seek assistance from other handlers and facilities. A written plan of action that lists long- and short-term goals, and timelines to accomplishing those goals, should be developed to guide the training of the noncompliant elephant.

Established Minimum Standards of Elephant Care

Elephant handlers must be able to:

1. provide daily skin care;
2. perform a complete daily body exam;
3. perform daily foot inspection and provide regular care, including trimming and foot x-rays as needed;
4. perform daily eye examination;
5. perform daily ear examination;



Rosamond Gifford Zoo at Burnet Park Zoo

A general assessment of the elephant's physical condition should be noted in an elephant record or log.

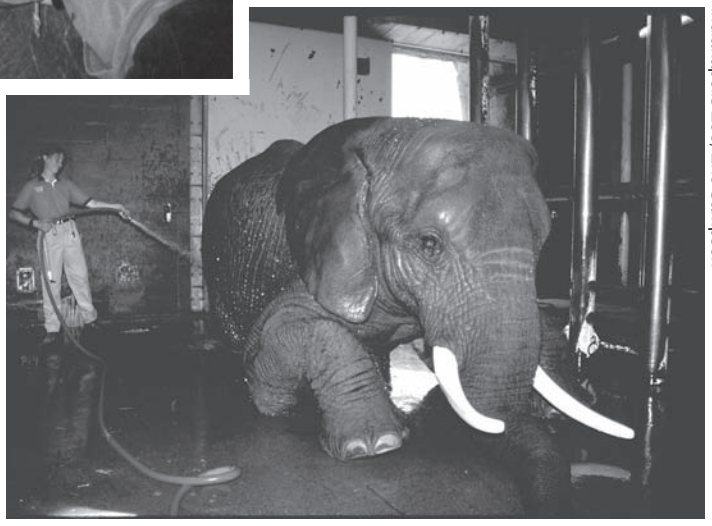
6. perform daily open mouth and tongue examination;
7. perform daily teeth examination;
8. perform daily tusk examination and the ability to trim tusks;
9. collect the following biological samples as needed without the need for sedation:
   a. urine
   b. feces
   c. saliva
   d. skin biopsy
   e. temporal gland secretion
   f. trunk wash for tuberculosis culture
   g. milk from lactating females

Buffalo Zoo

Sedgwick County Zoo

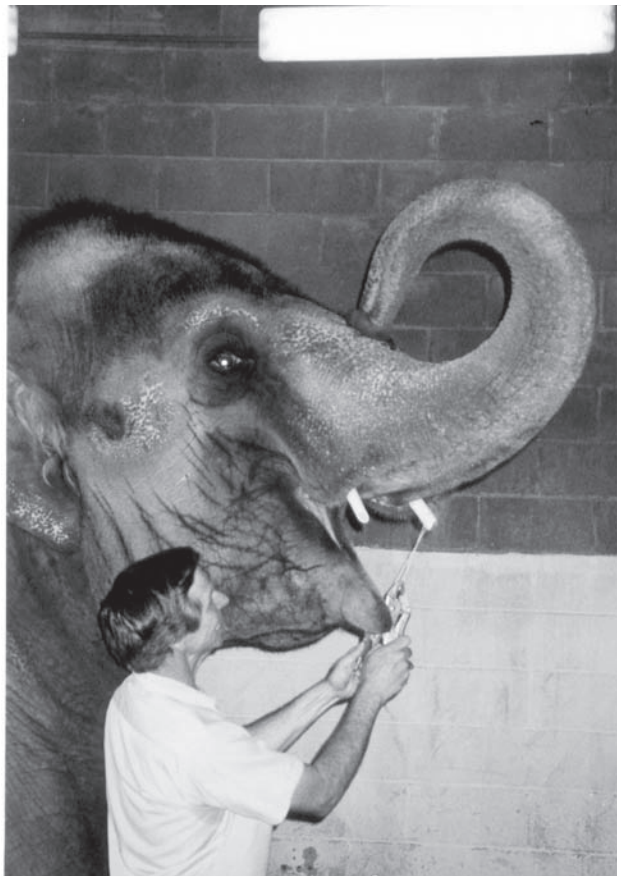
Wildlife Safari

Training and husbandry go hand-in-hand. Clockwise from top left: Giving an injection; performing footwork; giving a bath; taking blood from an ear vein.

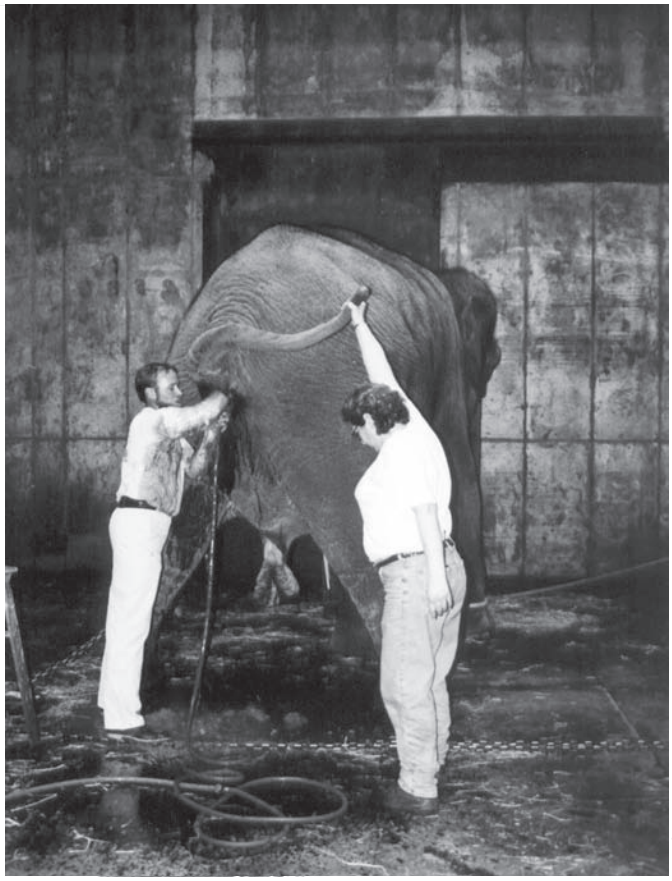


Indianapolis Zoo, Eric Sampson

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephants must be trained to permit a complete body daily exam (including feet, eyes, ears, open mouth and tongue, teeth and tusks) for any sign of abnormalities. Results should be recorded."



Sparks Nugget, Michelle Stinson



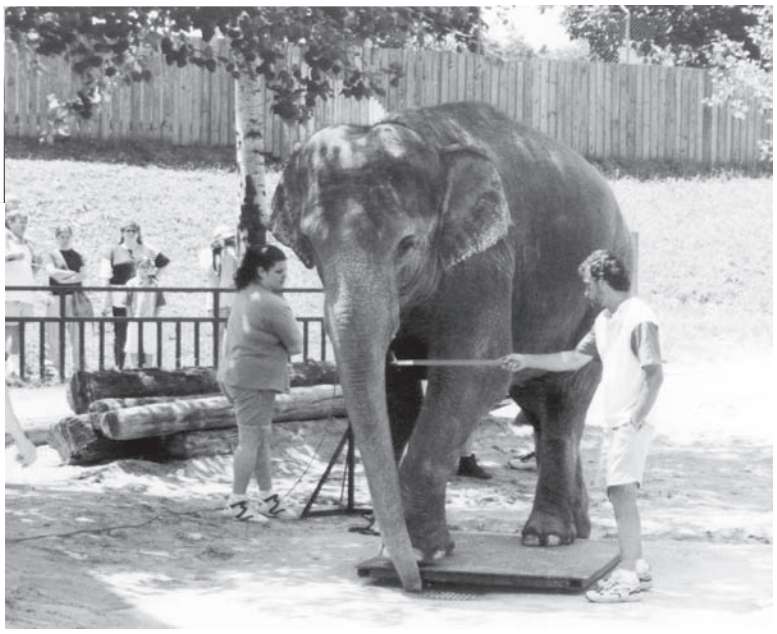
Rosamond Gifford Zoo at Burnet Park, Karen Marzynski

Have Trunk Will Travel, Kari Johnson

Above left: Handlers trim a ragged tusk. Above right: Handlers train the elephant to accept an enema, which is useful for both reproductive assessment and administering medication rectally. Bottom: Handlers use a bite block to administer medication orally.

Wildlife Safari

Houston Zoo, Anita Schanberger



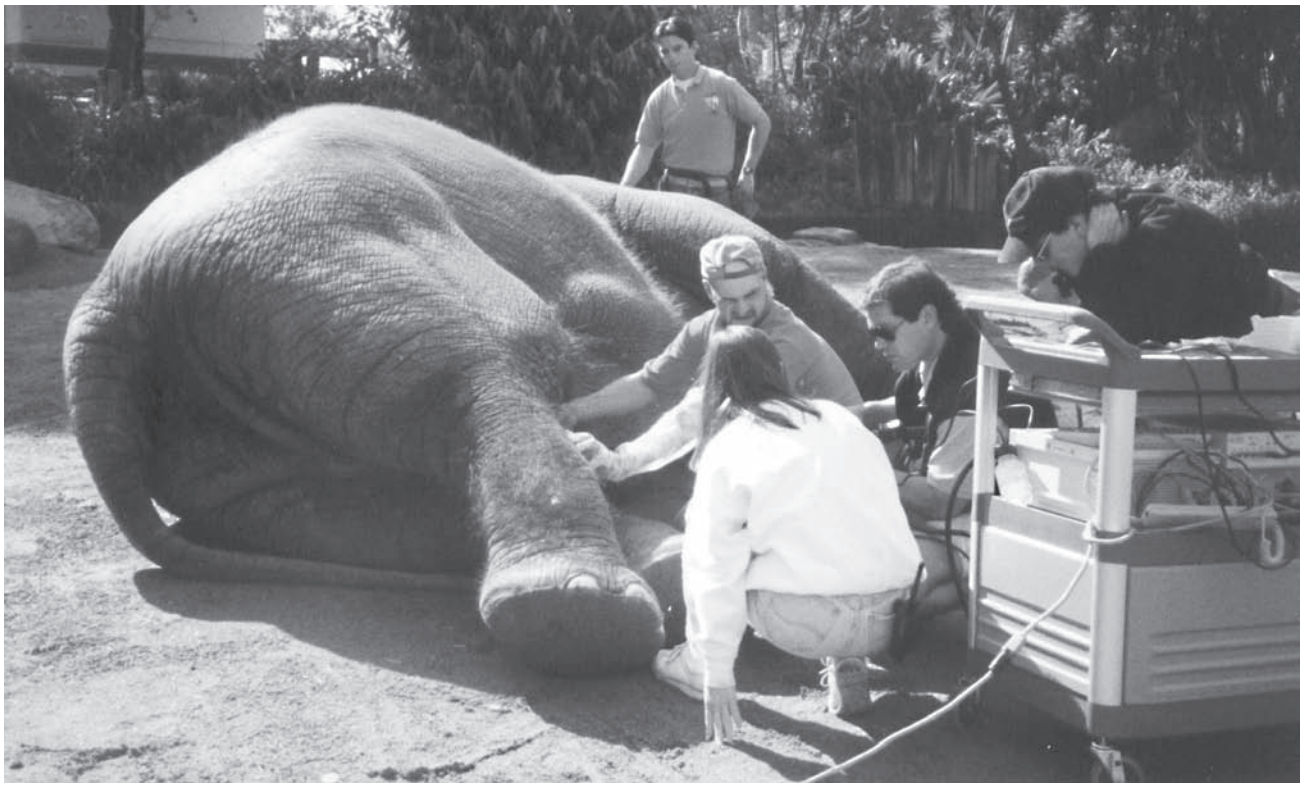
Rosamond Gifford Zoo at Burnet Park

Above: A handler performs a tusk and mouth exam. Center and bottom right: Recording an elephant's weight is an important component in tracking its health. Center: this bull has been trained to step on a scale with commands from behind a barrier. Right: An elephant is weighed as part of a public demonstration.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "For management purposes, all elephants must be trained to accept injections, oral medications, insertion of ear or leg vein catheters, treatment of wounds, enemas, and urogenital examinations."

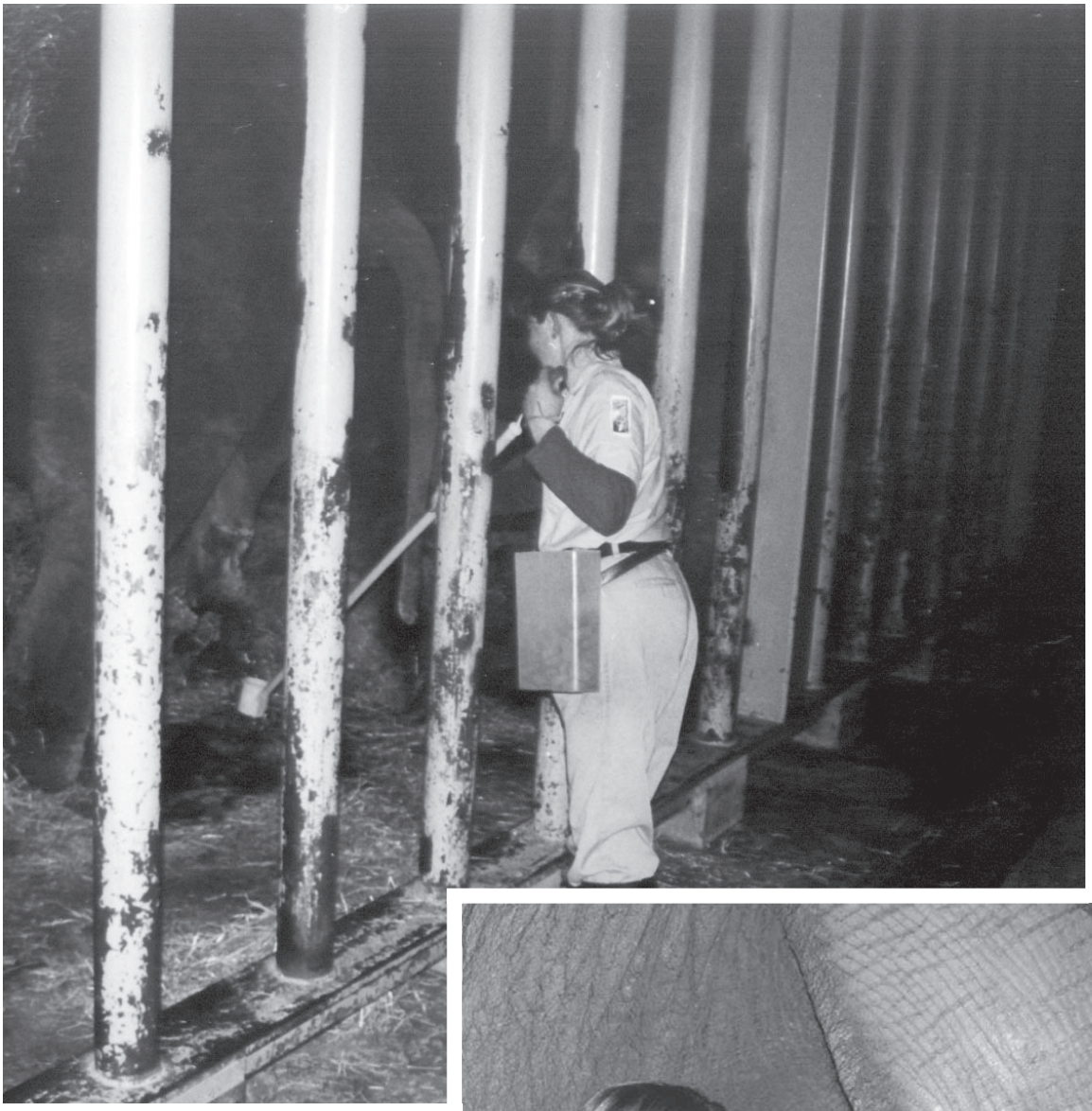
10. give the elephant injections as needed without the need for sedation;
11. train the elephant to accept oral medications;
12. train the elephant to accept ear or leg vein blood collection;
13. treat wounds;
14. train the elephant to enter and stay in the restraint device for:
    a. husbandry procedures,
    b. veterinary procedures, and
    c. for reproductive procedures;
15. demonstrate a method of restraint if no restraint device is present for:
    a. husbandry procedures,
    b. veterinary procedures, and
    c. reproductive procedures;
16. weigh the elephant;
17. train the elephant to accept an enema;
18. train the elephant to accept transrectal ultrasound examination;
19. train the elephant to accept transabdominal ultrasounds;
20. train the female elephant to accept an urogenital examination;

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephants must be trained to accept regular collection of blood, urine, feces, saliva, semen skin biopsy, and temporal gland secretion. Biological specimens should be stored according to the SSP Veterinary Advisor's guidelines on biomaterials collection."

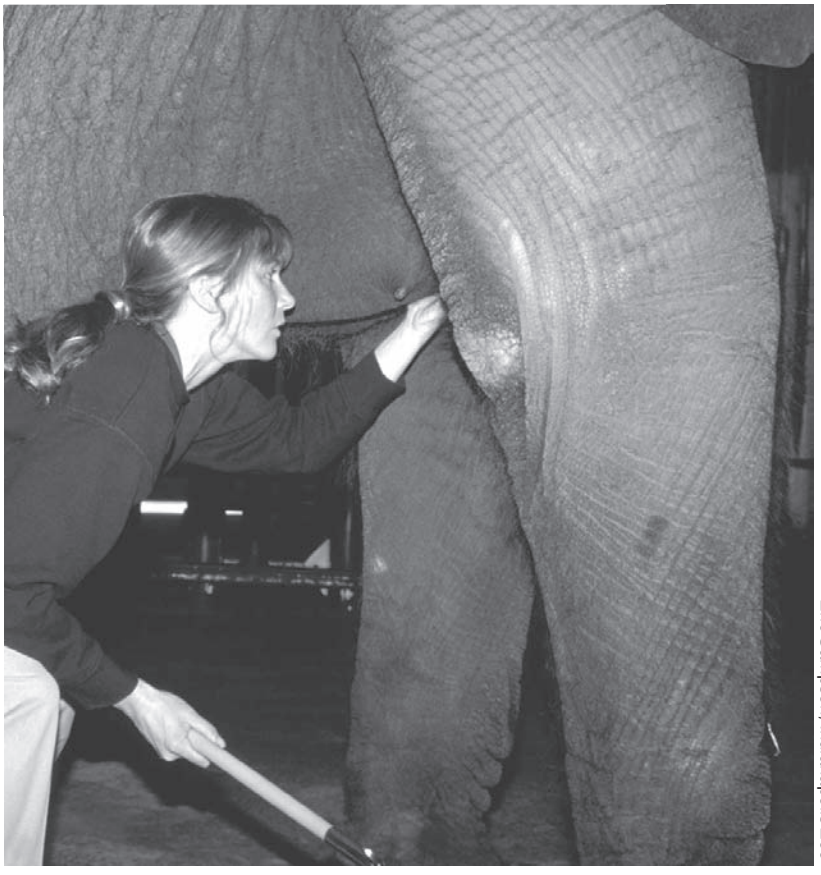


Santa Barbara Zoo

A female elephant receives a urogenital examination.



Albuquerque Biological Park



Eric Sampson, Indianapolis Zoo

Above: Above: A handler collects urine from behind a barrier. Right: A pregnant cow is trained to accept breast manipulation prior to parturition.

21. train the male elephant to accept semen collection;
22. train the elephant to accept radiographs and thermographs; and
23. load and ship an elephant for translocation.

Elephant handlers should be able to address elephant social issues by:

1. managing social compatibility;
2. managing dominance and aggression;
3. managing introductions with conspecifics:
   a. new female to herd,
   b. females to males for breeding,
   c. new born calf to its mother, and
   d. new calf and mother to herd;
4. being able to separate animals for periods of time.

Elephant handlers must be able to address psychological and physiological welfare by providing:

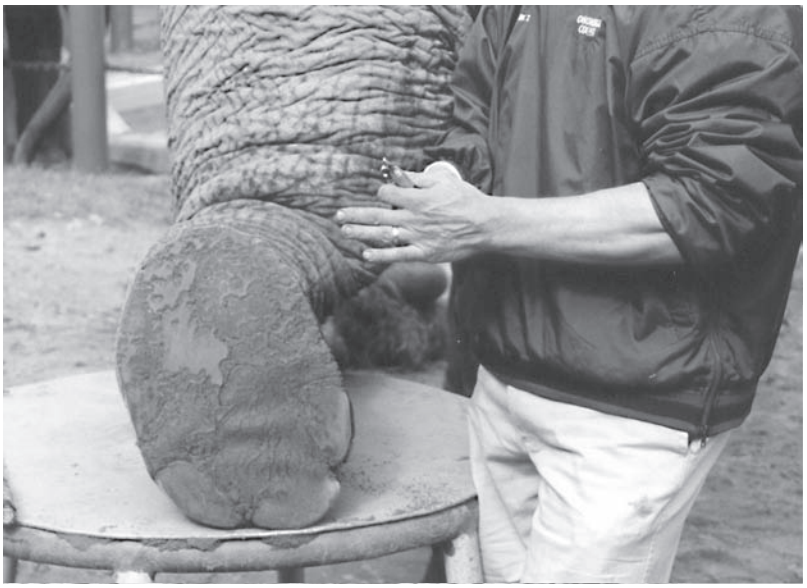
1. sufficient mental stimulation, and environmental and behavioral enrichment to promote activity and proper social behavior;
2. sufficient physical exercise to produce muscle tone, flexibility, agility, and stamina and promote a healthy weight; and
3. providing tactile contact with other elephants.

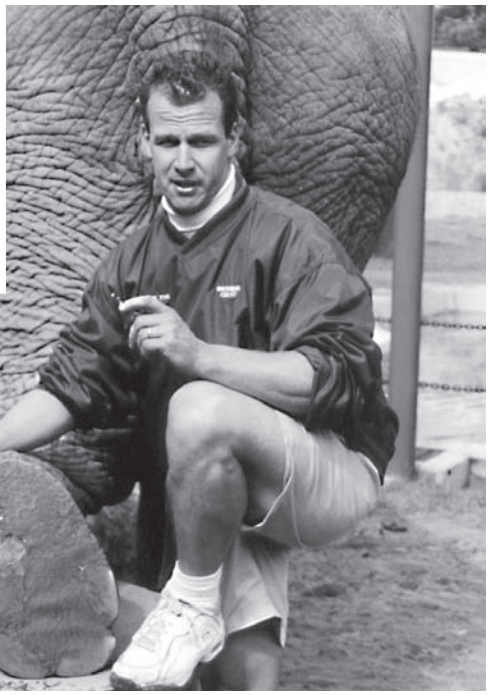
Foot Care

Infections involving the pad, nail, or skin of the foot are some of the most common medical problems in captive elephants (Mikota et al. 1994). It is hard to determine what is normal for the foot pad or nails of wild elephants, due to differences between the species, differences in individual elephants, and the wide range of habitat occupied by elephants. It is believed that, since elephants in the wild are frequently on the move, overgrown pads and nails are naturally worn down, while the substrate prevents excessive moisture and fungus from becoming a problem. In captivity, elephant feet require daily inspection and regular care in order to prevent overgrown soles; foreign body penetration; overgrown, cracked, or ingrown nails; overgrown cuticles; abscesses; and foot rot. Failure to prevent or treat any of these conditions can lead to pain,

Rosamond Gifford Zoo at Burnet Park

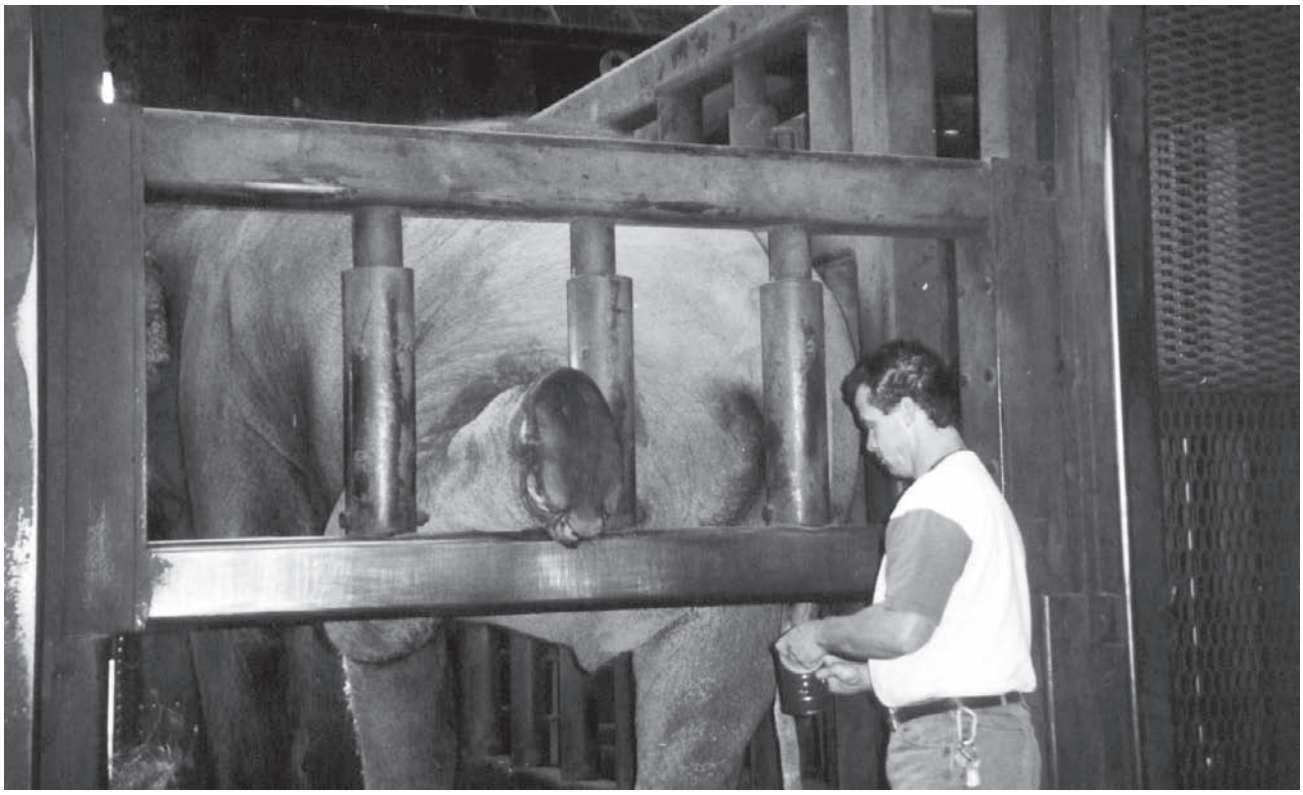
Foot care is a critical component to any elephant program.





Rosamond Gifford Zoo at Burnet Park, Kenneth Gilbert

Top left: A foot in need of a trim. Top right: An X-acto knife is used to trim foot pad. Bottom right: A rasp is used to smooth edges and file nails. Bottom left: A handler uses the knife to open and smooth a crevice.



Rosamond Gifford Zoo at Burnet Park

A handler performs foot care from behind a barrier.

lameness, local infection, tissue destruction, and, ultimately, systemic infection and death.

In captivity, some of the alleged causes of foot problems have been identified as the lack of exercise, excessive moisture, and improper substrate. Although no scientific studies have been conducted to date, anecdotally, elephants that are given plenty of opportunity for natural wear on their feet through regular exercise appear to need less foot care than those that do not have a chance for natural wear. In addition, the captive African elephant appears to require far less foot care than the captive Asian elephant.

Proper foot care depends on experienced staff, trained elephants, access to the feet, appropriate foot care equipment, facility design, and time. It is recommended that each elephant facility have a written protocol for routine foot care and show evidence of implementation, such as a written record of foot care activities. This protocol should include daily cleaning and inspection of the elephant's feet, as well as trimming the foot for the activity level the elephant is going to experience.

Each elephant's foot should be inspected daily for anything that may lodge in the pads of the feet or any potential problem sites indicated by soreness, discoloration, crevices that can harbor bacteria, cracks in the nails, and so on. The handler must train the elephant to remain standing in place and hold each of its feet, one at a time, on a block, pedestal, or identified section of a training wall. The elephant should present each foot until such time as the handler has completed inspection and/or care of it.

Tools used for elephant foot care are generally the same as those used by farriers in the equine industry (see Tools and Equipment, p. 61). When the foot is trimmed and filed, any crevices in the pad should have all edges smoothed to eliminate dirt and bacteria. Ideally there is no direct contact between the nail and the ground, and the nails are separated by spaces. The excess growth of the cuticles that could trap dirt and bacteria and could lead to infection needs to be pared back.

Elephants have very individualized needs in the area of foot care. Some elephants have skin—including nail and pad—that is fairly thin. Care should always be taken to work on each foot by increments. It is important to not injure the elephant by cutting too deeply into the tissue,

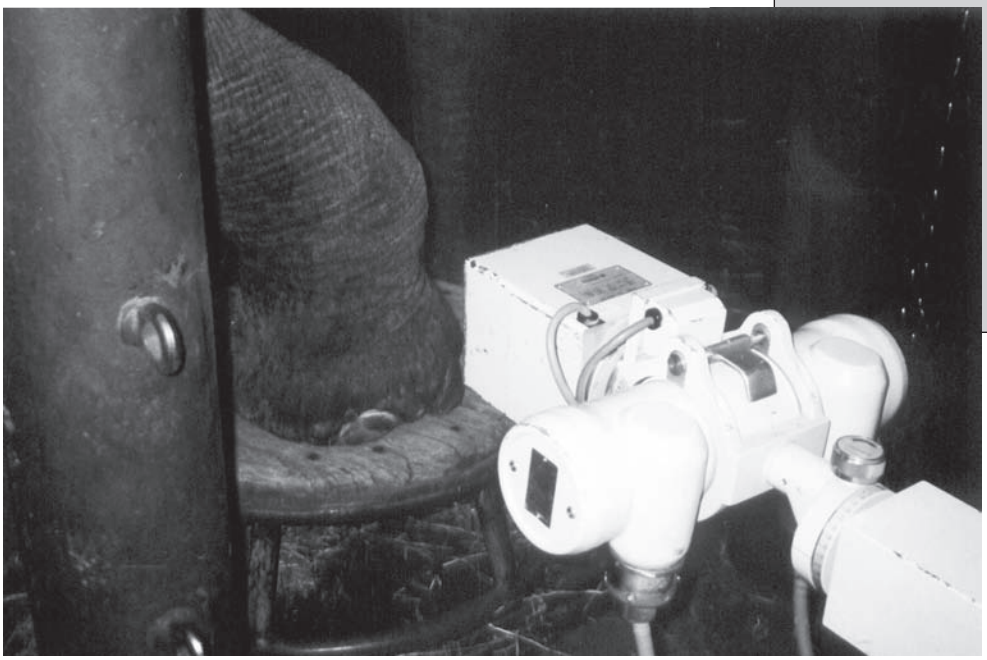
For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Each elephant facility must have a written protocol for routine foot care and show evidence of its implementation. This protocol must include daily cleaning and inspection of each elephant's feet."

Albuquerque Biological Park

Sedgwick County Zoo

Left: A handler trims the foot using an X-acto knife. Above: When the foot is trimmed, there is no direct contact between the nail and the ground. Below: A handler takes a radiograph of the front feet.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Baseline foot radiographs or thermographs of all adult elephants must be taken and kept on file. In some facilities, it may be appropriate to annually monitor selected elephants (i.e., those that have a history of chronic foot problems)."



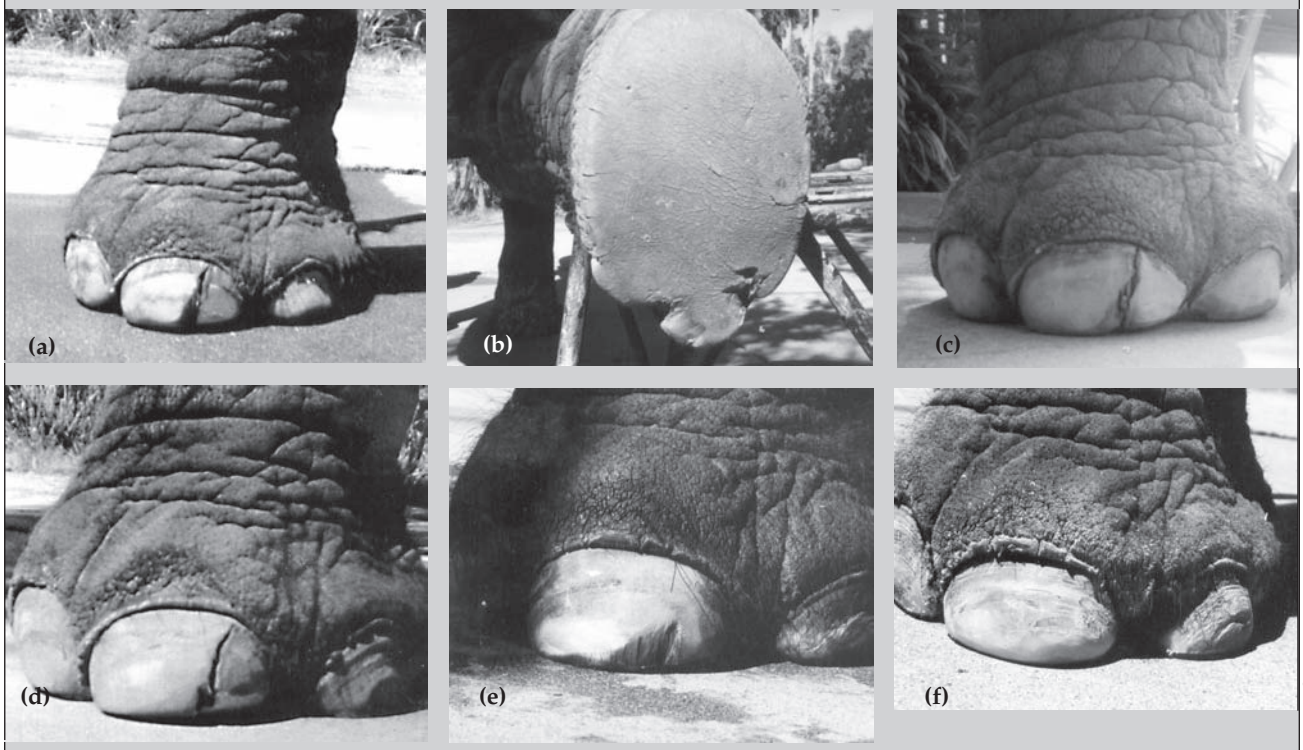
Rosamond Gifford Zoo at Burnet Park

Foot Care: A Case Study

A cracked toenail was located on the right hind foot of a 57-year-old female Asian elephant. The crack extended from the bottom of the nail up through the cuticle and effectively divided the nail into two separate pieces; these were observed to move independently of each other when the animal put weight on the foot. The crack would spread open each time the elephant put weight on the nail while walking.

The bottom of the nail was trimmed on the smaller of the two pieces to prevent it from receiving the force of the weight when the elephant walked. As much as possible of the bottom of the smaller nail was removed. The rest of the pad and the face of the nail was not trimmed. The trimming of the nail was accomplished by the use of a hoof knife followed by a rasp. The remaining larger portion of the nail then carried the weight of the elephant.

This trimming took place the first week of each month for the next year, until the crack was gone. At four months, the first signs of improvement were noticed. After six months of this regimen the entire pad was trimmed with care given to keep pressure off of the smaller side of the cracked nail. During the treatment period, the crack improved starting at the cuticle and slowly migrating down the nail, while the nail grew. The time taken to trim the nail each month was less than 15 minutes. In one year the crack was completely gone. This procedure has worked on similar nail cracks, which have healed without reoccurrence for more than six years.



Six Flags Marine World

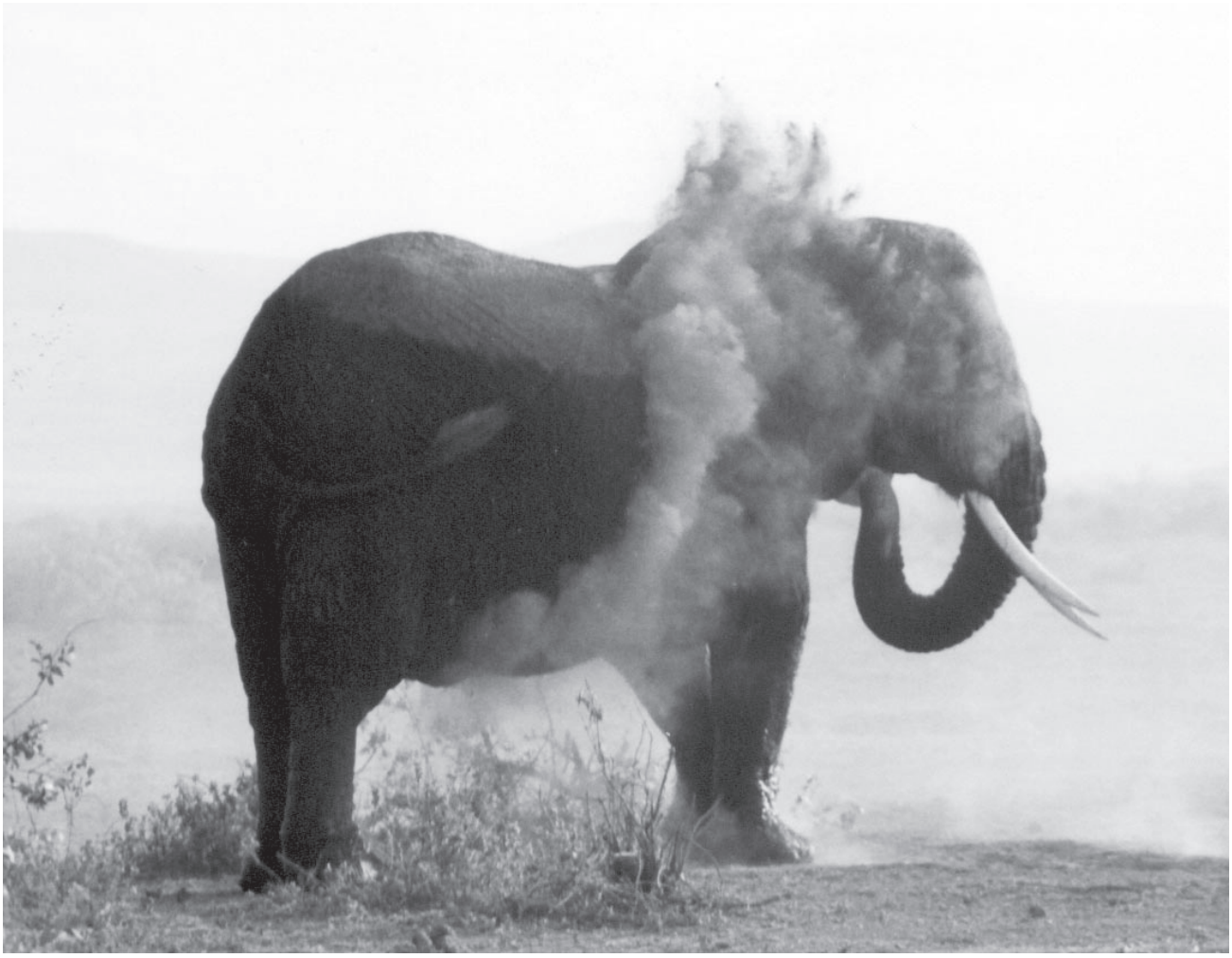
This series of photos (a)–(f) shows the progress of a badly cracked toenail as it underwent treatment.

which therefore can create damage or discomfort to the elephant. An experienced handler should always be present to oversee this work and lend assistance.

Medically based foot problems must be under direct veterinary care. Wounds and abcesses should be flushed well and treated with antibiotics. Any necrotic tissue should be removed. Lesions should be soaked and bandaged. New techniques in radiography support the recommendation of taking baseline foot radiographs of all adult elephants. It may be appropriate to radiograph certain elephants annually.

Skin Care

In the wild and in North America, elephants enjoy submerging their bodies in water, wallowing in mud, scratching against trees, rocks or other objects, and covering themselves with dirt or sand. It is assumed that elephants employ these behaviors to take care of their skin. Therefore, every captive elephant should be provided ample opportunity to indulge in these natural behaviors on a daily basis. Elephants should be provided with dusting material such as dirt, sand, straw, hay or sawdust (see Facility Design, p. 75).



Amboseli National Park, Deborah Olson

Elephants use dust as a natural means of skin care.

Opinions vary as to the best way to care for an elephant's skin. One of the reasons for this is that skin characteristics of elephants vary from species to species, from elephant to elephant. Elephant managers agree that captive elephants should be bathed on a regular schedule, and many handlers bathe their elephants daily. All areas of the elephant's body should be scrubbed with a stiff bristle brush to remove dirt, fecal stains, and dead skin. A mild soap is sometimes used to help remove stains and to keep the elephant's skin moist; however, some soaps can dry the skin. Pressure sprayers have been found to be useful when giving elephants a bath, although care must be taken when using the sprayer around the elephant's eyes, ears, and mouth. In addition, the handler should be aware of the pounds-per-square-inch (PSI) capabilities of the unit and the type of sprayer head used.

In colder climates, elephants may exhibit dry skin from the lack of humidity in the air. In that case, the elephant's entire body can be covered with mineral oil, or similar nontoxic conditioning oil or lotion. The oil should be allowed to penetrate the elephant's skin for a few days, after which the bathing schedule can be resumed. During this period the elephant should be protected from excessive sun to prevent the skin from burning. The ears of the elephant can also become dry and may chafe in winter. Nonpetroleum-based Vaseline or bacteria-resistant ointment can be applied to the backs of the ears and rims as needed.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephants' skin must be thoroughly inspected on a daily basis and cared for as needed through bathing, removal of dead skin, and treatment of dry skin or other skin problems.

Mouth Examination

Each elephant should be trained to open its mouth daily on command in order for the handler to inspect the

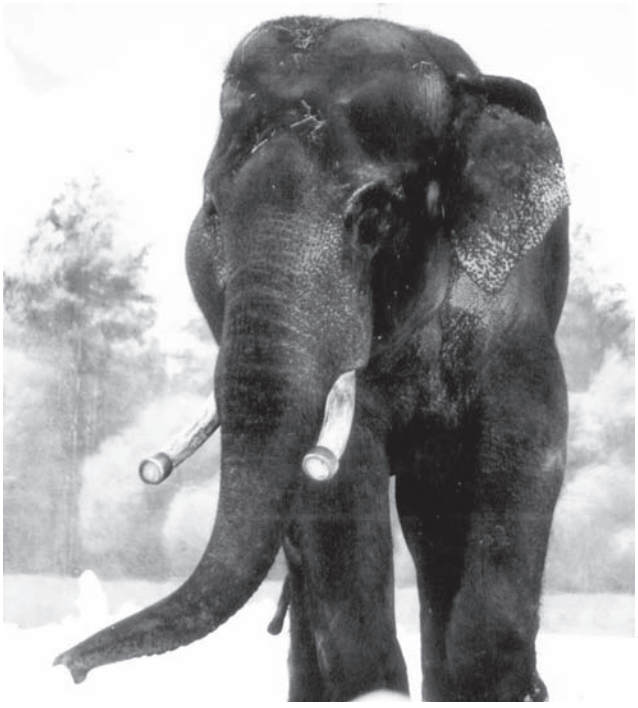
Indianapolis Zoo

A complete mouth inspection can reveal a number of problems, or as in this case, a healthy mouth.

elephant's tongue, gums, sulci, and teeth. The teeth should be inspected for alignment, abscesses, foreign bodies, and any unusual smell around the mouth. The inside of the mouth should be inspected closely. This is extremely useful in the detection of the early signs of the elephant herpes virus. An early indication of this virus infection is ulcerations around and on the roof of the mouth and a blue discoloration of the tongue. Problems should be reported immediately to the veterinarian for closer inspection, diagnosis, and treatment.

Tusk Care

Elephants in captivity may experience some form of tooth- and/or tusk-related problem. Each elephant should be trained to hold its head still and present its tusks for inspection, treatment, or trimming. The sulci and the base of the tusks should be examined for cracks or problems caused by normal tusk use, trauma, or constant rubbing. The ends of broken tusks should be trimmed and



Rosamond Gifford Zoo at Burnet Park, Michele Delperuto

Problem areas on the tusks can be protected with removeable metal bands.

smoothed to prevent the elephant from injuring itself or another elephant. Trimming can also help prevent the tusk from splitting further and causing other problems for the elephant. Trimming can be accomplished by removing small increments of ivory so as not to cause injury to the elephant. A radiograph of the tusk can also be taken to determine the length of the nerve cavity, and therefore where it is safe to trim the tusk. A tusk broken in such a manner as to leave the nerve cavity exposed needs immediate medical/dental attention to prevent infection. If an infection forms or if the tusk is left untreated, the elephant could lose the tusk and ultimately its life.

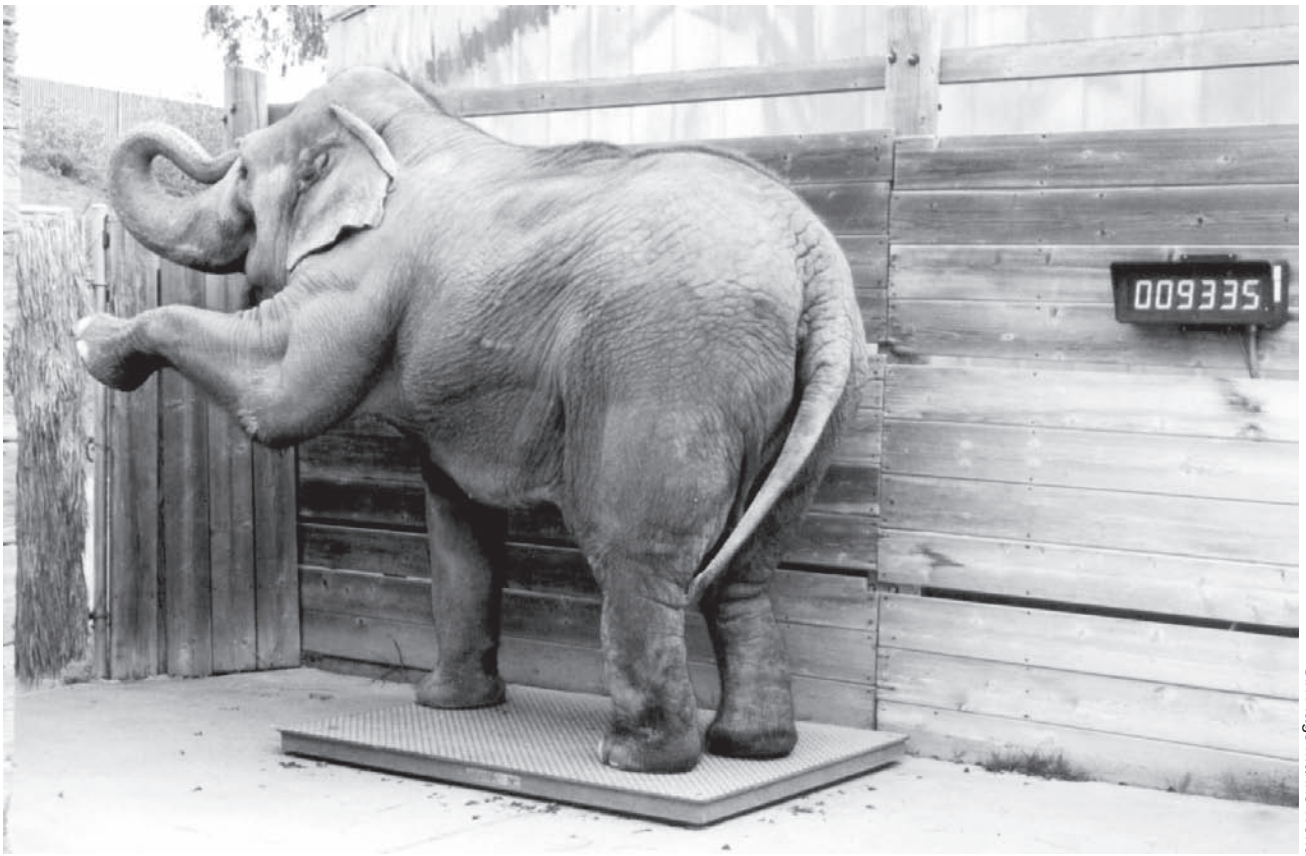
Problem areas on the tusks can be protected with removable metal bands that prevent an elephant from causing further damage when rubbing or using its tusks. The tusk tips can be covered with a metal cap if the elephant has cracked or broken the tusk close to the pulp (nerve) cavity. Bands or caps can be held in place by glue and small set screws, but care must be taken that the screws are short enough not to enter into the pulp cavity. Bands and caps should be removable so that they do not prevent the tusk from continuing its natural growth.

Body Weight

Elephants in North America and Europe tend to weigh more than their same-age wild counterparts. This can easily be explained by the regular provision of quality

Deborah Olson, Indianapolis Zoo

An elephant weigh-in can also be used as a public demonstration.



Six Flags Marine World

A 10,000- or 20,000-pound platform scale large enough for an elephant to comfortably stand on is the preferred method to weigh an elephant.

nutrition in more-than-adequate quantities, regular veterinary care, and the reduction of physiological stressors such as parasites, weather, and searching large distances for sufficient food and water. Unfortunately, elephants carrying excess weight are at risk for health and reproductive problems (see Reproduction, p. 123, and Nutrition, p. 209). Weighing an adult elephant regularly can help to determine its proper maintenance weight. Weights of young animals should be taken as frequently as possible to verify proper growth—both too little and too much weight loss or gain (see Calf Training and Weaning, p. 143). Every effort must be made to regularly weigh each elephant at least twice a year, although more frequently is preferred. See Tools and Equipment (p. 61) for a description of scales used to weigh elephants.

Body Measurements

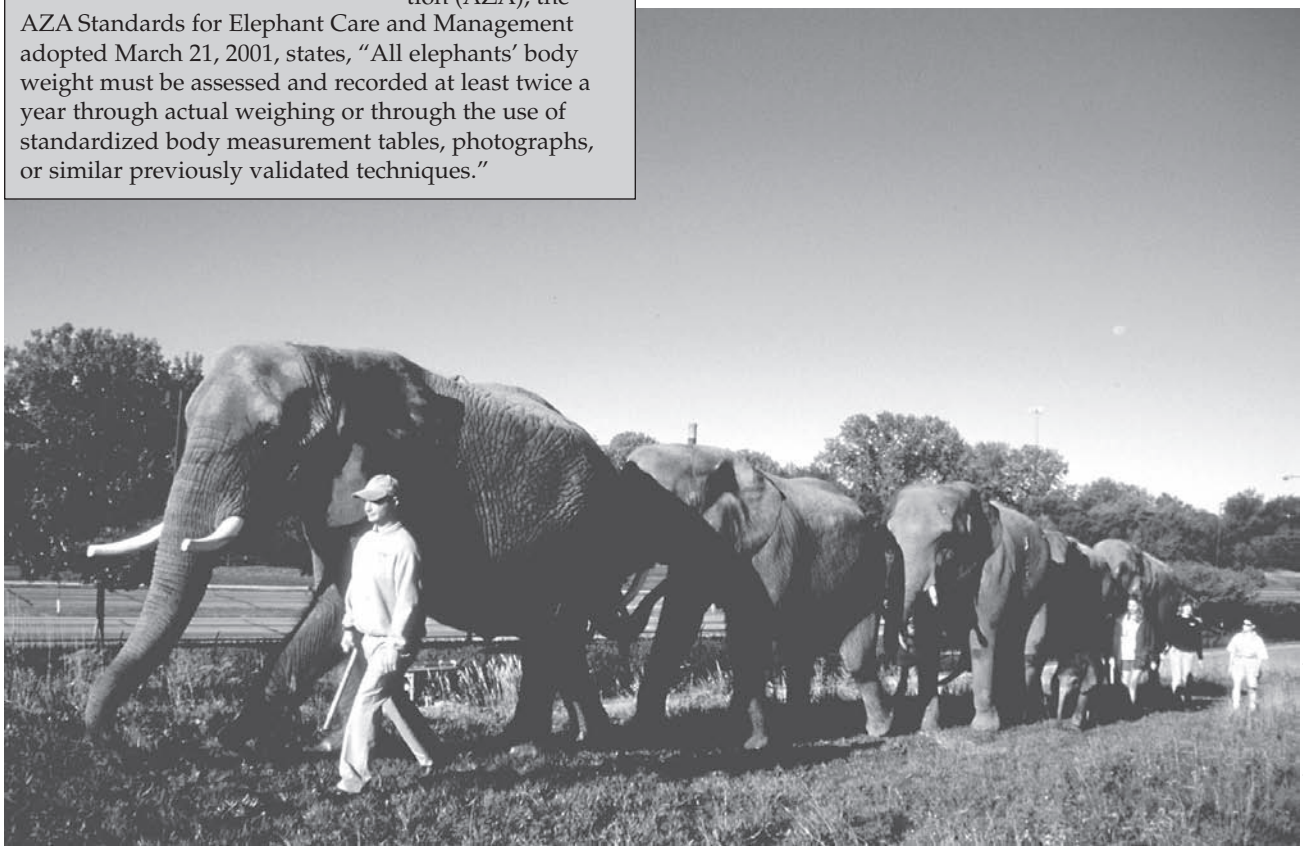
Body measurements of all elephants should be recorded annually. Measurements (height at the shoulder, girth, and length) of all young elephants should be taken as often as possible to verify proper growth and to add to the limited amount of data available on growth in elephants (see Nutrition, p. 209).

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephants' body weight must be assessed and recorded at least twice a year through actual weighing or through the use of standardized body measurement tables, photographs, or similar previously validated techniques."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "A written daily exercise program for each individual animal must be designed and followed. The program should be developed in consultation with the elephant manager, elephant handlers, and the staff veterinarian(s)."

Exercise and Enrichment

The elephant is physically built for walking and thrives on exercise. Elephants in the wild have been repeatedly documented traveling great distances in a day to find food, water, safety, or mates. Handlers must take measures to promote physical activity and affiliative behavior toward handlers and conspecifics by routinely occupying each



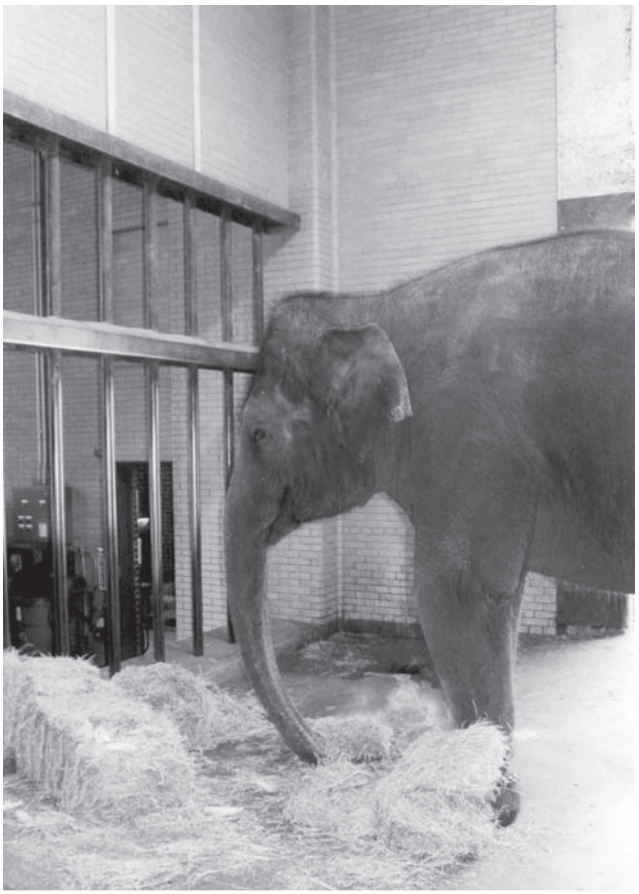
Eric Sampson, Indianapolis Zoo

Daily walks are an excellent form of exercise and enrichment.

elephant with physical exercise and mental stimulation in various forms.

As in humans, good physical conditioning is essential for a long, healthy life and reproductive success. It is essential that means are found to exercise all elephants, especially those that are unable to leave the exhibit area due to training or management limitations. The handler should provide sufficient physical exercise to produce muscle tone, flexibility, agility, and stamina in the elephant. Walking and performing trained behaviors that cause the elephant to use their abdominal, chest, and shoulder muscles, and increase heart and respiratory rates are excellent ways to improve the elephant's physical condition. These supplementary trained behaviors are also important as they further enhance the handler's ability to provide an elephant with the care that is so vital for its welfare. A written enrichment and exercise program implemented on a regular schedule is strongly recommended.

Walking in areas other than the exhibit, teaching new behaviors, providing novel means of presenting food, and providing the elephant with an object to use as a toy, are just some of the means of providing mental stimulation through enrichment activities. This is an emerging field in captive animal management and there is a great deal to learn about what is enriching, how long an item maintains an elephant's interest, and how often the item should be presented to maintain the highest level of interest. To understand enrichment, each item presented for enrichment should be monitored for effectiveness on a regular basis. It is not enrichment if an item remains with the elephant long after the elephant has become bored with it (see Environmental Enrichment, p. 227).



Buffalo Zoo

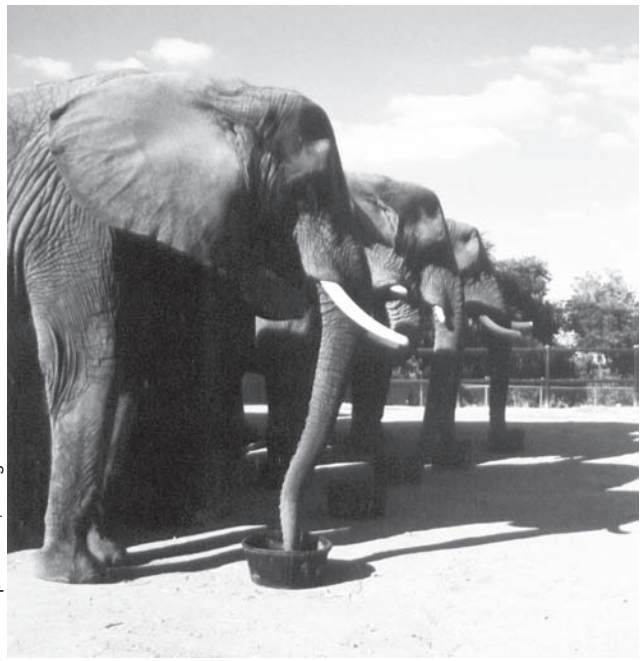
Michael Hutchins

Above: Good quality hay should be the basis for any feeding program. Below: Browse is also an important feed component.

Feed

Elephants should be fed repeatedly throughout the day with good quality fodder (see Nutrition, p. 209). This fodder should include hay, browse, and pellets or processed feed supplements. Hay should be fed in ample amounts to provide proper nutrition, bulk, and to stimulate activity. Feed supplements should be in the proper formulation to sustain the elephant in good health and weight.

The amount of food offered should be



Indianapolis Zoo, Craig Cook

It is recommended that elephants be fed their grain in individual tubs while under supervision.

monitored closely and adjusted regularly depending on whether the elephant is overweight or underweight. The elephant handler should watch diet consumption and report any variations immediately. An elephant's lack of interest in food can be an early indication that it is not feeling well. It is recommended that elephants be fed their grain in individual tubs under supervision. This allows the elephant handler to monitor consumption, make it more difficult for an elephant to consume the diet of another, and limit ingestion of dirt and sand which can cause colic.

It is recommended that a nutritionist be consulted when choosing the amount, the feed supplement, and hay type, even when choosing a commercially prepared elephant diet. From year to year, hay quality changes with species of grass and the location where the hay is grown. Hay should be analyzed before the product is accepted by the facility. Diets similar to those commercially manufactured for elephants can be formulated in-house.

Water

It is paramount that the elephant receives enough water for hydration and physical comfort. Elephants should be given ample opportunity to drink their fill of fresh, potable water daily, but water free-choice is not a requirement. It is recommended that water be offered at least twice a day and drinking opportunities should be increased based on

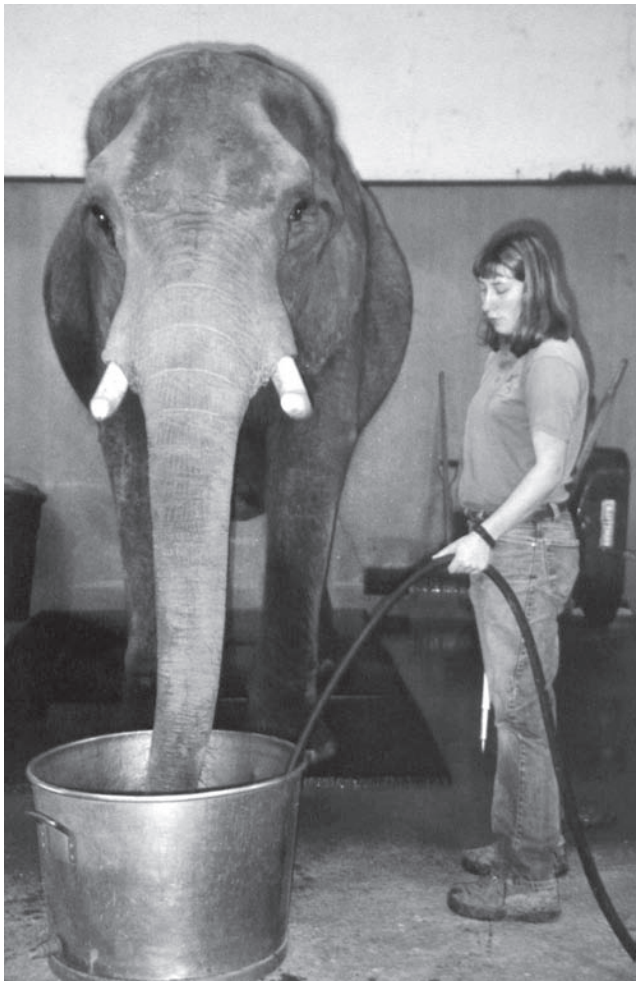
Elephants should be given ample opportunity to drink their fill of fresh, potable water daily.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Elephants must have access to clean, fresh drinking water. When water containers are used, they must be cleaned and refreshed at least twice daily. Containers must also be cleaned daily."

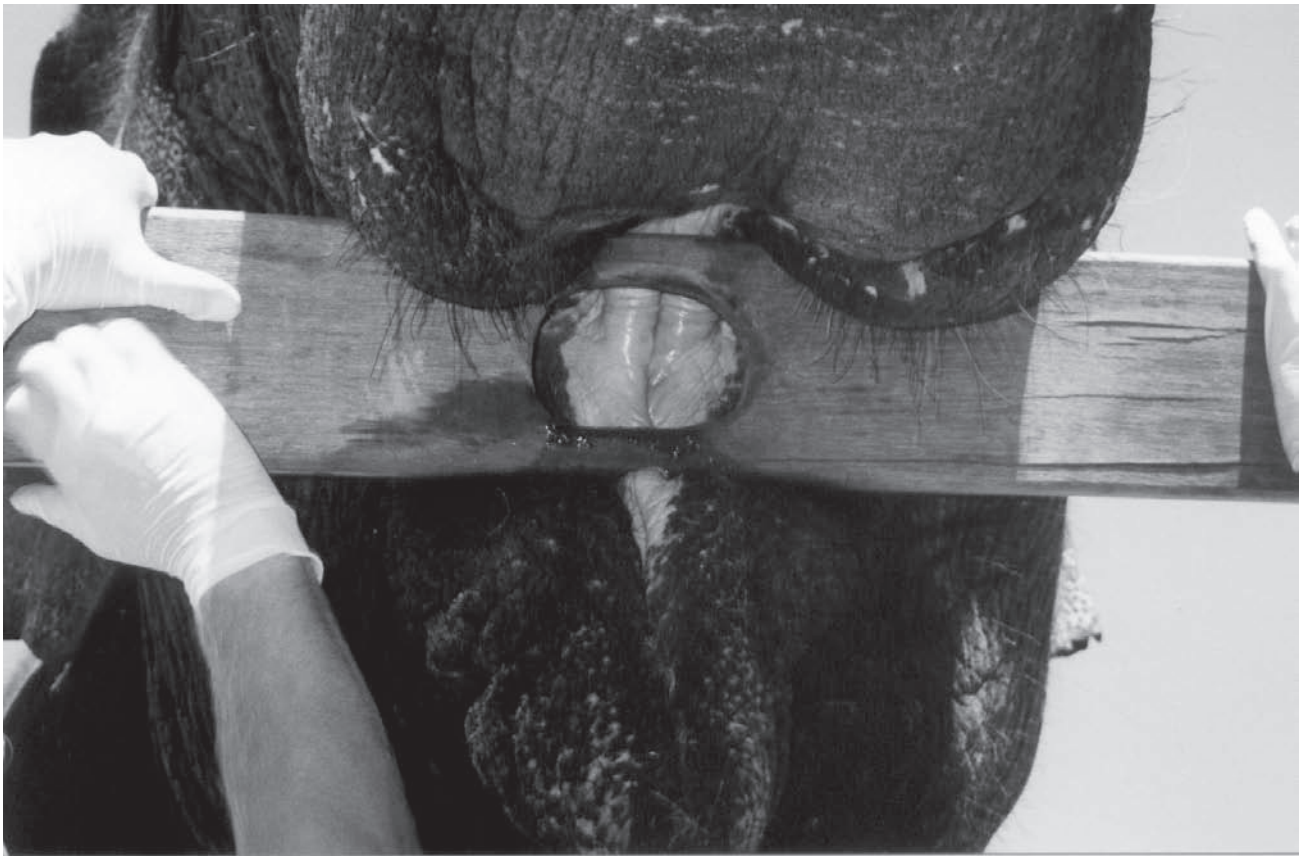
temperature, humidity, and the amount of exercise the elephant receives. The amount of water the elephant drinks is an indicator of health and should be monitored closely. Elephant handlers should report any variations in water consumption immediately.

Oral Medication

Elephants can be difficult animals to medicate due to their extremely well developed sense of smell and taste. Sometimes medication such as pills or powder can be disguised in favorite foods such as bananas, apples, peanut butter, bread, etc. and hand fed to the elephant. Elephants can also be trained to accept and swallow bad tasting, oral



Wildlife Safari



Have Trunk Will Travel, Kari Johnson

One method of providing oral medication is to train the elephant to hold a mouth/bite block. The block is free of sharp edges and has a hole in the middle large enough for a handler to pass through either a syringe or a hand.

medication. This is done by feeding the elephant the medication, and immediately reinforcing the act of swallowing with a favored food treat. The medication should not be disguised but fed in small enough amounts, with large enough rewards, to make it worthwhile for the elephant to comply.

Another method of providing oral medication is to train the elephant to hold a mouth/bite block so that it can be medicated by squirting medicine down the back of its throat. Mouth blocks are made out of wood. It is important to use a nontoxic, nontreated wood. The block is one piece and consists of an oblong shape with two handles extended on either side. A large hole is cut in the middle of the oblong block so that the handler can safely pass a hand through.

The block is placed in the elephant's mouth by the handler, who holds the block by the handles and asks the elephant to open its mouth, then inserts the block and tells the elephant to "hold it." The block should be held by the elephant in such a manner that the handler can administer the medication by passing either their hand or a syringe through the hole in the middle of the block.

Rectal Medications

Under the direction and with the instruction of a veterinarian, an elephant can be effectively medicated rectally, depending on the medication. All fecal material is removed from the elephant's rectum. When the rectum is clean, a suppository can be inserted by filling a large syringe with the medicine, connecting it to a tube similar to a horse worming tube, then placing the tube in the rectal tract at about arm's length (approximately 2 feet). The handler maintains the tube in place but withdraws his/her arm from the rectal tract. The plunger is depressed, and then the tube is removed. Elephants can be trained to hold their tails out of the way during such a procedure, but it should be cautioned that if this is a new procedure for the elephant, the tail may need to be restrained. With its tail, an elephant can quite effectively clamp its rectum closed or strike the human standing behind it with significant enough force to cause injury.

Blood Sampling

It is strongly recommended that blood serum be collected from each elephant on a weekly basis for diagnostic and research purposes. All elephants should be trained by at least 6 months of age—sooner, if possible—for this procedure. This will allow greater accessibility to the calf in the event of an illness, and to monitor the onset of reproductive capability. Female calves as young as 3 years of age have been known to conceive and carry offspring of their father or brother (see Reproduction, p. 123).

Taking regular blood samples from each elephant should be part of the elephant husbandry program and not neces-

Indianapolis Zoo

An 18-month-old calf is trained for blood collection from an ear vein.

Training for Blood Collection

Training the elephant is always easier if the elephant has had no previous negative history associated with the desired behavior. If the elephant has a conditioning history with aversive associations, each of these associations must be identified and then neutralized through desensitization. The sight of veterinarians, white lab jackets, special equipment, the smell of alcohol, etc. could stand out in the elephant's mind as a precursor to a negative event and, therefore, must be extinguished.

The first reinforcements are given as the elephant simply relaxes its body posture. Only after the elephant is totally relaxed with each stage does the trainer proceed on to the next new stage. The handler must determine the optimum site for blood withdrawal and begin to reinforce the elephant for allowing access to the general region. The handler begins to focus attention on the specific area where blood vessels are close to the surface. Desensitizing the elephant to the smell and feel of alcohol can be done at the same time increased blunt pressure is being applied with a thumb to the region. Again, the elephant is only reinforced for relaxation or non-responses to the sensation of pressure being applied and the evaporation of the alcohol on the skin.

Once the elephant willingly tolerates the application of pressure and alcohol without response, it is ready for the final phase where a mildly uncomfortable stimulus is introduced. Only those same relaxed responses are reinforced. Some handlers use the edge of a fingernail to simulate the prick of a needle; others use the pressure of a blunted hypodermic needle, while others prefer the snap of a rubber band. The end result should be the same, a willing tolerance to a minor level of discomfort for the exchange of a food or social reinforcement.

As with all training, a written training plan that breaks the behavior down into specific, incremental steps will increase the chances for success.

Six Flags Marine World

A handler collects blood from a leg vein.

sarily a veterinary procedure. Elephant handlers should be trained by the veterinarian in the proper manner to collect and handle the blood.

The blood is collected via the ear vein or rear leg vein. If the ears are used, it is recommended to alternate ears and veins on the ears at each collection. Records should be kept describing the ear and location used for each collection.

Facility Maintenance

Elephants by nature produce vast amounts of waste, and it is important for the elephants' health to remove waste on a regular basis. Keeping the holding facility, outside enclosure, and tools and equipment used with the elephants clean (and in some cases, regularly disinfected) is as important as the care of the elephant itself. The elephant stall floors, walls, and containment barriers should be cleaned of excrement, uneaten food, and hosed each morning and disinfected at least once a week. Additional cleaning of the holding enclosures should occur throughout the day if the elephants are confined in them for any length of time.

Outside elephant enclosures should be cleaned of manure and uneaten food at least daily. Depending on the number of elephants in the herd, the size of the enclosure, and the elephant management policy, the outside areas may need to be cleaned of manure much more frequently.

Rosamond Gifford Zoo at Burnet Park

Keeping the outside enclosure clean is as important as the care of the elephants themselves.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Enclosures must be cleaned of excrement daily. Frequent daily manure removal is recommended and may be necessary for the maintenance of both sanitary and esthetic conditions."

Since elephants use pools to drink, shower, and bathe, it is important to maintain pools and mud wallows free of manure, excess algae, and bacteria.

Due to parasitic reinfestation, the elephants should not be fed where manure is present. Hay and browse that has been fouled with urine or feces should be removed. This may require additional cleaning prior to food presentation. Manure, food, and browse removed from the elephant enclosure and holding areas should be contained in a dumpster and removed to a location as far away as possible from the elephants or placed in an appropriate recycling system.

Pest Management

Elephant holding areas give pests the perfect habitat due to high ceilings, exposed girders and supports, large openings to enter and exit, and an abundance of food and water. Because the invasion of pests can be anticipated, pest controls and prevention are important. Pests can spread disease to both animals and humans, can offend visitors, and cause inspection problems.

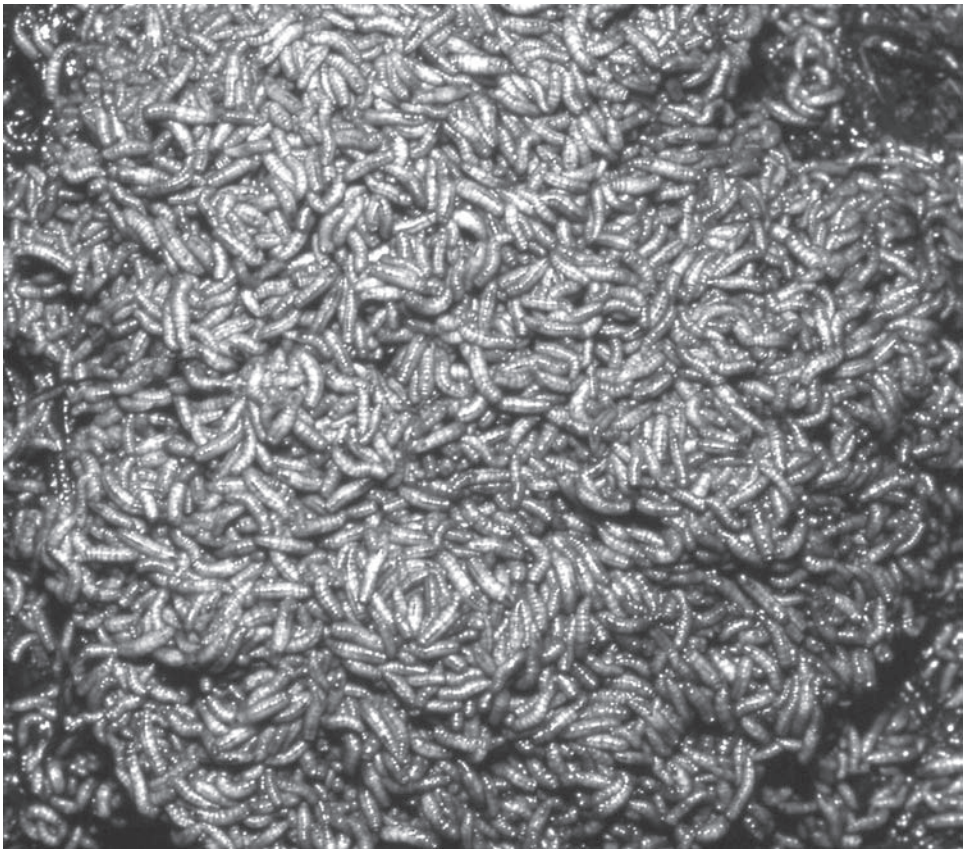
It is more difficult to eliminate a pest population once it has reached high levels than to have a system in place that is designed for prevention. When dealing with a pest problem, an integrated approach of chemical control, mechanical control, sanitation, exclusion, and record keeping should be used.

Neatness and cleanliness is the obvious means of preventing and eliminating pests. Keep all feed off the floor in sealed containers. Plastic and metal garbage cans work well, providing lids are tight and kept in place. Spillage should be swept up. Putting the cans on wheels allows them to be moved easily for cleaning. If hay is to be stored within the area, it should be kept well away from the wall. Maintaining a distance away from the wall will allow for better inspection, provide an area to place a rodent control device, and make sanitation easier to maintain. Any standing or leaking water source should be eliminated. Outside, weed growth around the perimeter of the building should be kept to a minimum. Tall grass, weeds, and clutter provide excellent cover, food, and nesting material for rodents. Timely manure removal and cleaning will deter many unwanted pests. Cleaning of the animals themselves daily will eliminate odors that will attract flies, especially biting flies. All tack, equipment, tools, and garments should be cleaned and disinfected daily.

Most flies need decaying organic vegetation, animal excrement, animal carcasses, or garbage for larval develop-

Six Flags Marine World

Sanitation is the best—and most obvious—means of eliminating pests.



Eric Sampson

Managers should be on the lookout for maggot (fly larvae) infestation. Eggs are laid and hatch quickly, and infestations can grow exponentially.

ment. The better the source the quicker the flies can populate an area. With many species it may be as little as six days for eggs to reach adulthood. Removing those needed sites will greatly reduce the fly population. Removal of breeding locations must be an ongoing, daily practice. Flies will always be attracted to the area because of the smell of food, decaying organic matter, and excrement. However, timely removal will break the complete life cycle and eliminate direct breeding within or next to the area.

Pesticides should be rotated on a regular basis. Some insects—most notably flies—develop resistant strains to a given pesticide in a matter of months. These fly strains will mate with one another, making a resistant population that easily survives application of chemical control. The end result is increased frequency of applications, increased material costs, high fly activity, and increased pesticide exposure for humans and animals. Before using any pesticides and insecticides, elephant managers should be sure that there are not protected bird species in the area and check with the facility's veterinarian, and all appropriate local, state, and federal agencies for restrictions. The label instructions for mixing, applying, and disposing of any chemical should always be read and followed. Reactions with exotic animals may not be known, so extreme caution must be used.

Exclusion is helpful and can be accomplished by adding door sweeps and thresholds, replacing damaged windows and screens, caulking, weather stripping, and inspecting incoming hay and straw. A diligent effort is required to exclude pests from the building. Harborage directly outside of the building will invite "walk-ins" and should be eliminated.

Tools and Equipment

The management of elephants encompasses a variety of methods and means of training. The following are "tools in the toolbox" of elephant management. This list is not all-inclusive, as the different tools are simply too numerous to list. As components of elephant training and management, all tools and equipment should always be well cared for, placed in a designated location when not in use, kept clean, and used only for their intended elephant management purpose. All new handlers should be instructed and knowledgeable in the use of each tool prior to working with an elephant.

Elephant Restraint Device (ERD)

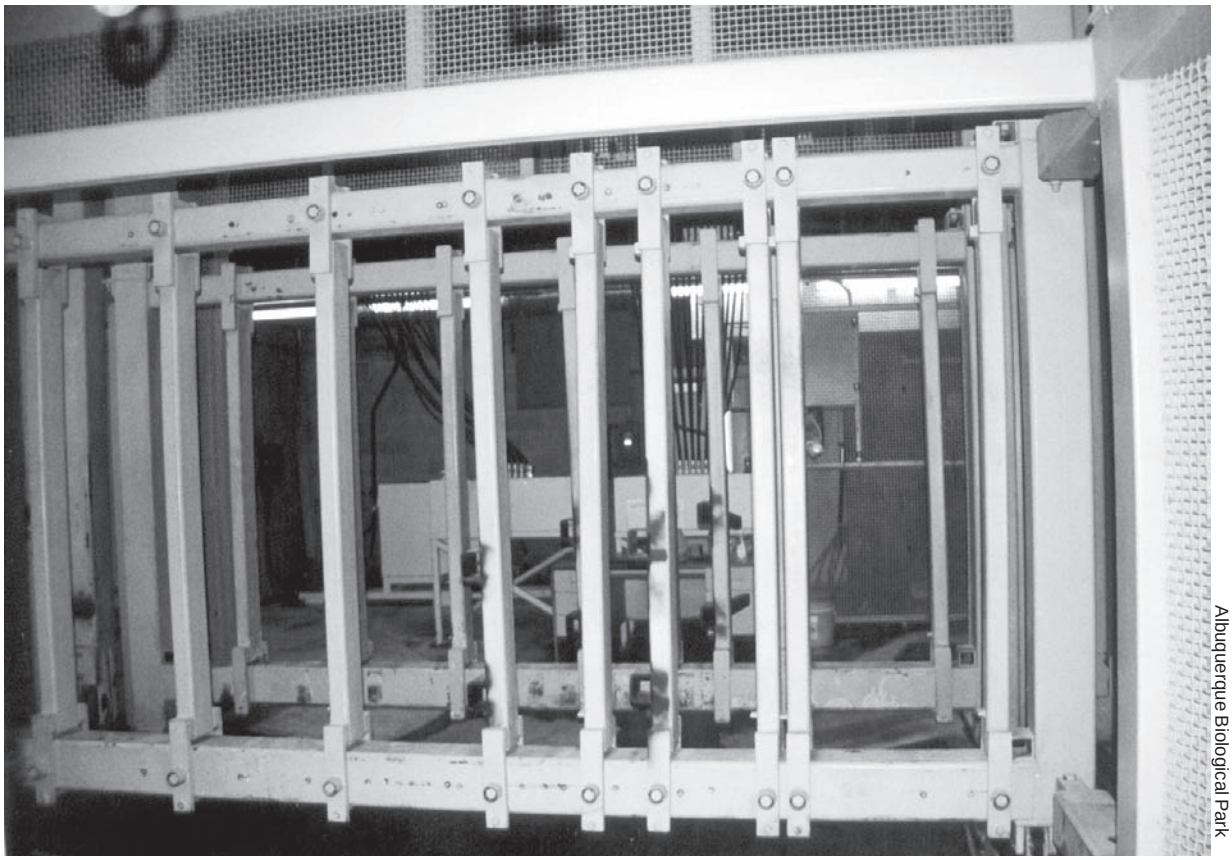
An ERD restricts the elephant's movements while allowing handlers access for routine husbandry and medical care. An ERD restricts most—but not all—of the elephant's mobility. Movement of the trunk, feet, and tail is limited, but these extremities can still be used aggressively. Although the access for husbandry and medical care is safer, it is not risk-free and handlers do come into contact with the elephant. Handlers always need to exercise caution when working in areas where contact could cause injury. There are many varieties of ERDs, from a simple aisle reducing the elephant's space side-to-side, front, and rear, to an elaborate device with movable walls and gates.

The basic idea of the ERD has existed for more than 1,000 years. In Asia, ERDs have been standard equipment for the training of elephants for generations (Sanderson 1960).

Sanderson described these devices as a cage-like apparatus made of round timbers lashed together just large enough to admit the elephant. Built against and lashed to the base of a large tree, the ERD consisted of four upright posts and three long horizontal bars on each side.

Kansas City Zoological Park

ERDs may be hydraulic, electric, or manual. Some even have the ability to lay an elephant on its side.



Albuquerque Biological Park

Top: Elephant restraint device (ERD) as viewed from the side. Bottom left: ERD in open position as elephant would enter it. Bottom right: ERD in closed position.

Kansas City Zoological Park

A handler secures the leg straps to further restrain a male in the ERD.

Other bars were placed horizontally across the inside at various levels.

The modern ERD evolved from these Asian devices. In order for the ERD to be applicable in the zoo setting, modifications were needed. In 1980, the Oregon Zoo took on the task of designing and implementing the first ERD outside of Asia. This device was designed so that it could accommodate sexually mature males and aggressive females. The design uses two steel bar walls placed 8 feet apart, one on a center pivot and the other completely movable (Greenburg 1978). The pivot wall creates an angle to fit an elephant regardless of the direction the elephant is facing, and the movable wall closes to within close proximity of the pivot wall. Remote hydraulic controls allow the handler to move an elephant safely into the ERD.

As of the writing of this manual, there are more than 50 ERDs in operation in North America, and many more ERDs are in the design phase. With the increased number of ERDs currently being constructed, and multiple companies specializing in their design and fabrication, a variety of designs and construction materials have been used. ERDs may be stationary or movable; hydraulic, electric, or manual; and some even have the ability to lay an elephant over on its side. The design of each ERD will be different based on the institutions needs, goals, and availability of funds.

Despite the many variations in design, there are basic elements shared by all ERDs. An ERD should allow access to all four feet, tusks, trunk, face, ears, both sides, hindquarters, and back by moving the animal or parts of the ERD. The ERD must easily and quickly open to free an elephant that has collapsed. It should also be able to comfortably contain an elephant for extended periods of time should the need arise for an ongoing or long-lasting medical or husbandry procedure. Most importantly it must be able to contain the facility's largest elephant safely; therefore, it is recommended that new ERDs are built to manage a male elephant weighing up to 7 tons.

Ideally, the ERD should be constructed in such a way as to provide enough space for staff to safely work on all sides of the ERD when an animal is entering it and when it is confined. The ERD should be located in an area of the holding facility easily accessible to the elephant and where it can be used 365 days a year regardless of weather conditions. Preferably, the ERD should be placed in an aisle, so the elephant must go through the ERD as a part of its daily routine in order to access its outside yard or another space within the facility. A by-pass must be available in the event another elephant is confined in the ERD for an extended length of time. Daily desensitization by moving through and spending time in the ERD accompanied by reinforcement will aid in the process of training the animal to enter the device on command. In order to ensure the continued successful use of the ERD, it should be used daily and routinely, not solely for uncomfortable procedures.

It is important that the handlers completely understand the fundamentals of elephant behavior training and the operation of the ERD. An ERD is a tool to complement a sound elephant management program. An ERD should never be viewed as a substitute for a poor elephant management program or a poorly trained staff.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All elephant holding facilities should install an Elephant Restraint Device (ERD). However, all bull-holding facilities, as well as those that manage elephants behind a barrier, must have an ERD. Use of the ERD should not be weather dependent."

"Each elephant must be trained to enter and stay in the ERD, if one is available, for husbandry, veterinary, reproductive assessment, and other procedures to occur in a safe and efficient manner."

"If a facility does not have an ERD, staff must demonstrate a method of restraint that allows necessary husbandry, veterinary, and reproductive procedures to occur in a safe and efficient manner."

Albuquerque Biological Park

ERD with elephant inside.

In order for an elephant to enter an enclosed space, it needs time to feel secure. This can be accomplished by leaving one gate to the ERD open so the elephant can enter and leave at its own pace, habituating the elephant to the device. The handler then trains the elephant to enter on command with the doors shut. If the elephant is allowed to always go directly through the ERD without stopping, it may refuse when the door or gate is closed. Or, the handler can opt to train the elephant to enter the ERD on command from the beginning. In this case, the handler can reinforce the behavior to enter the ERD in small increments, or for small amounts of time, with food or verbal rewards. An elephant that has been trained to walk next to its handler can be led into and/or through the restraint and asked to stand in an ERD. The handler can command the elephant to stand still in the restraint with the doors open, and to stay still while the doors close. With all of these methods, once the elephant is comfortable in the ERD, the handler

The elephant's experience in the ERD should be as enjoyable as possible. For example, a male elephant at the Oregon Zoo injured the end of his trunk and required prolonged medical treatment. He spent 30 days in the ERD while handlers kept the wound clean, medicated, and hand-fed him. The staff realized the importance of making his stay in confinement as positive as possible. When the male elephant was finally released from the ERD, there was concern about whether he would reenter it. The male elephant did so without hesitation on the same day, as he presumably did not perceive the ERD as a negative experience.

All bull-holding facilities, as well as those that manage their elephants through a barrier, must have an ERD in the event of an elephant being unresponsive to training methods, or in the case of having to administer an unpleasant medical procedure. Without an ERD, staff might not be able to gain an elephant's compliance reliably, and necessary treatments would be impossible. Although there is a less obvious application for an ERD when the elephant is handled directly, it is strongly recommended that any facility housing elephants have an ERD—*regardless of how the elephants are managed*. Changes in elephant behavior, newly acquired elephants, herd dynamics, and personnel, along with the potential of a catastrophic illness or injury, make an ERD a necessary piece of equipment.

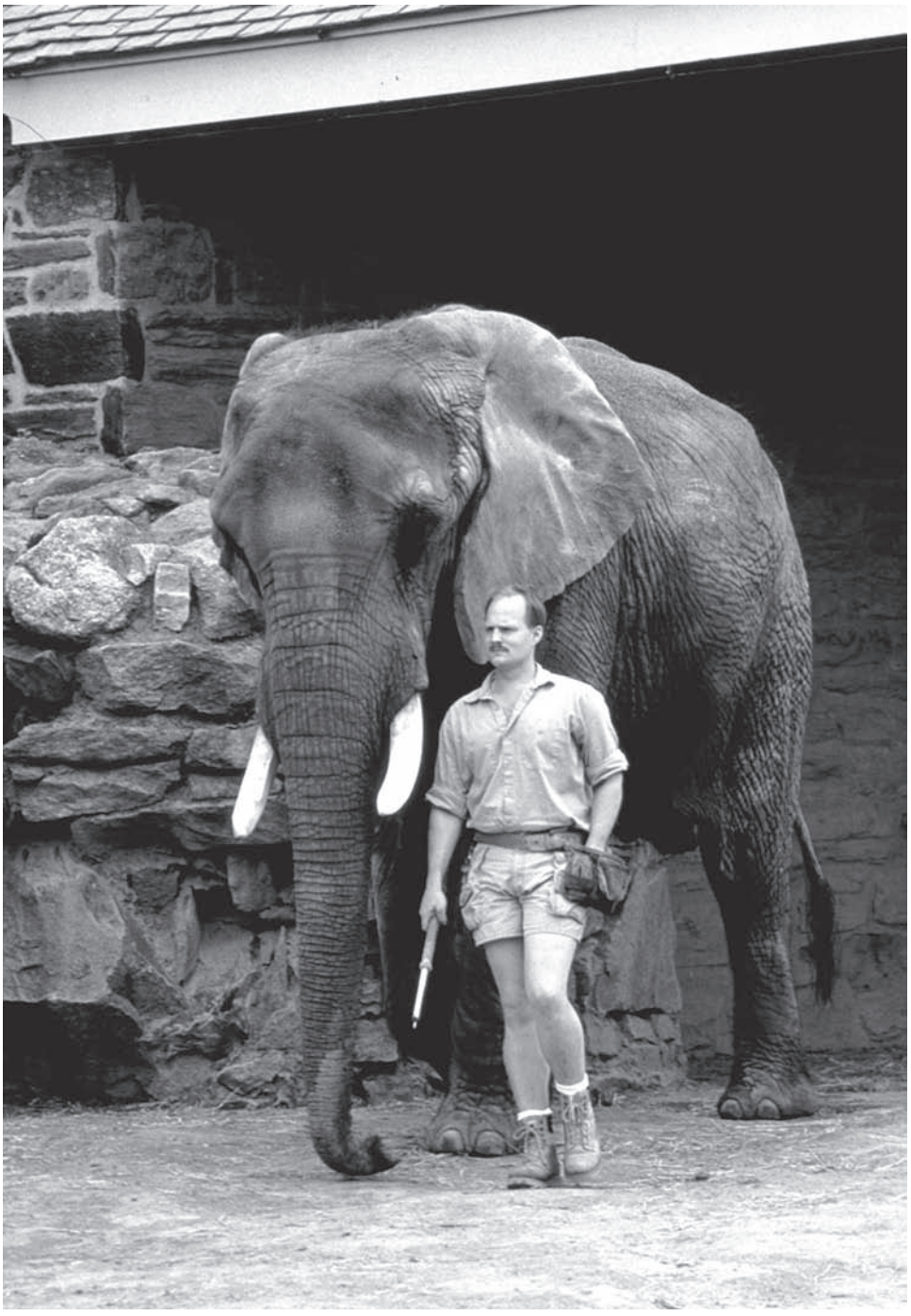
can then ask for a previously learned behavior, cue if necessary, and reward the elephant's correct response. It takes very little time for the elephant to realize that doing behaviors in an ERD can be very rewarding. As in any elephant behavior training, goals should be clearly defined at the outset, and the handler must know how to proceed after each previous step is attained.

After the elephant feels secure entering and standing in the ERD on request, this behavior must be maintained. It is also important that the elephant be conditioned to remain in the ERD for extended periods of time. One easy means of accomplishing this is to feed the elephant in the ERD with the doors closed. The elephant soon associates the ERD experience as a rewarding one. It is also important to vary the timing of the ERD training. Establishing an ERD routine can facilitate baths, foot care, veterinary procedures, and other routine management activities.

Guide

A guide is a tool used in the behavior modification of elephants. In the past in North America, the guide has been called an ankus or bullhook. Those names are outdated and do not provide an appropriate explanation for the proper use of the tool. The terminology has been changed for a number of reasons. Ankus is inappropriate as a descriptor as it is unclear where the term originated or what tool it actually represents as they vary throughout Asia. Most tools used in Asia to work with elephants do not resemble our guides, nor do most mahouts in Asia use the term ankus. A bullhook is also nondescriptive as to the tool's actual use and in fact is a misnomer; the term was coined more than 100 years ago by men who called all elephants, regardless of sex, bulls. Elephant management has evolved, and its tools and their uses have evolved as well. Evolution demands that our terminology change to keep up with the times. Flying machines are now called airplanes; iron horses are now called trains. It is not only necessary, but appropriate that the term guide be added to the elephant handler's vocabulary in place of the outdated, misunderstood, and misnamed ankus/bullhook.

The guide is a tool that is used to teach, guide, and direct the elephant into the proper position or to reinforce a command. This is accomplished by adding a physical cue to a verbal command. The ultimate goal of the elephant



Philadelphia Zoo

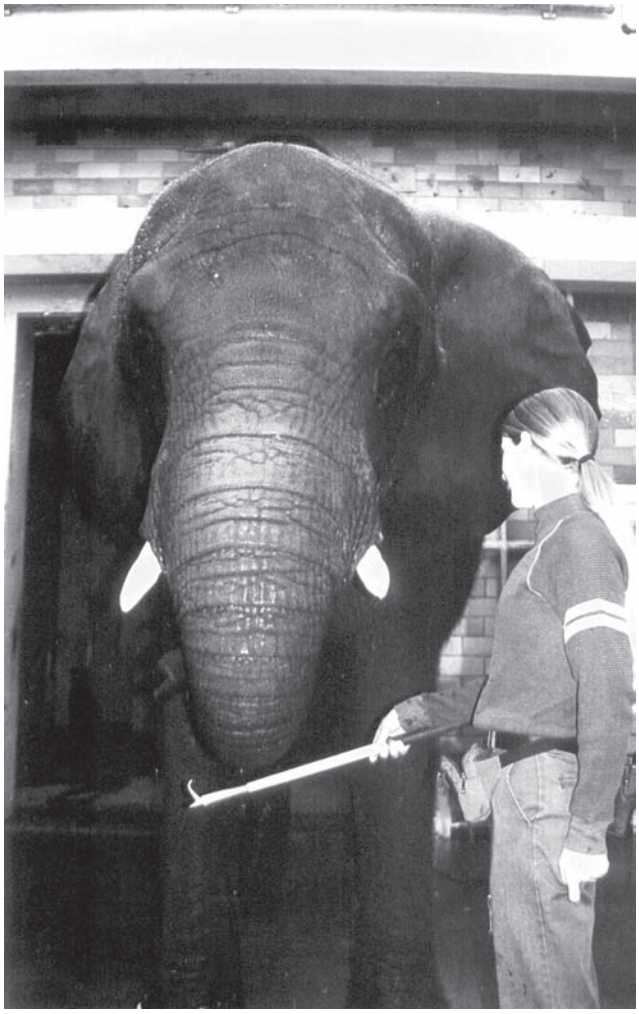
The ultimate goal of the elephant handler is to have the elephant respond on verbal commands alone, using the guide as little as possible.

handler is to have the elephant respond to verbal commands alone, using the guide as little as possible.

The guide is used in many facilities throughout the elephant management continuum. The guide can be used to move the leg of the elephant closer to the straps of a restraint device, or indicate to the elephant to lean into the bars of the holding stall to allow greater access for the keeper standing outside of those bars. It is also used by the handler to teach an elephant to lift a leg, move forward, move backward, and the list goes on and on.

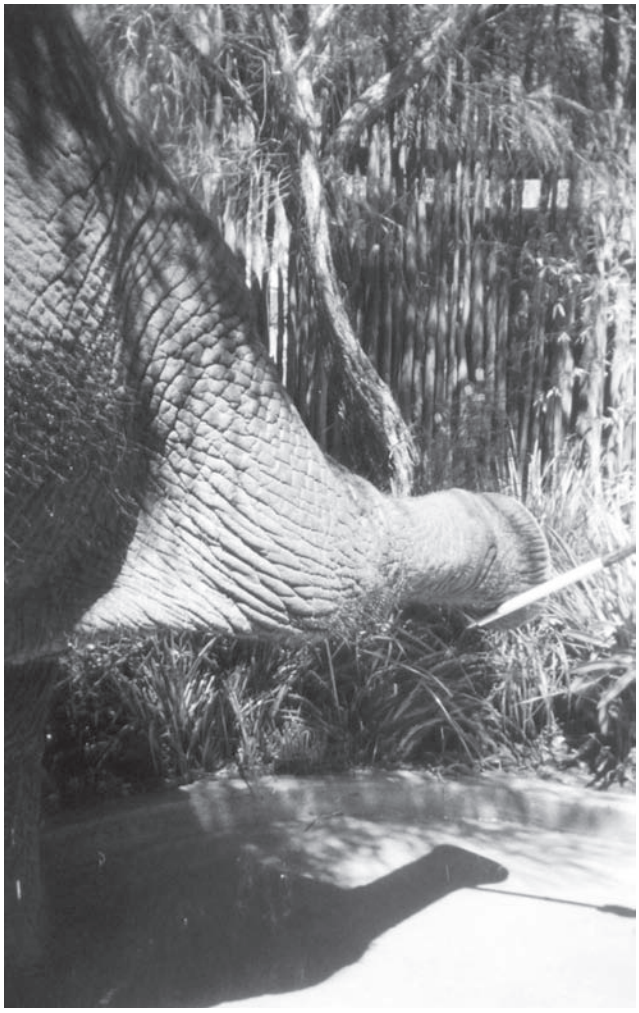
A guide consists of a hook (preferably stainless steel) mounted on one end of a fiberglass, wood, lexon, or nylon shaft. The design of the hook allows for the elephant to be cued with either a pushing or pulling motion. The ends on the hook are tapered to efficiently elicit the proper responses from the elephant with the handler exerting very little pressure. The ends of the hook should catch but not tear or penetrate into the skin. On a rare occasion, superficial skin marks may result but generally do not require medical attention.

On rare occasions, the shaft of the guide may be used as punishment after the elephant acts in an inappropriate or aggressive manner. Contact between the elephant and the shaft of the guide should be immediate, in response to the incorrect behavior, and should stop immediately upon the elephant demonstrating appropriate behavior (see Training, p. 21).



Seneca Park Zoo, Sue DeFalco

The guide is a tool for teaching, guiding, and directing the elephant.



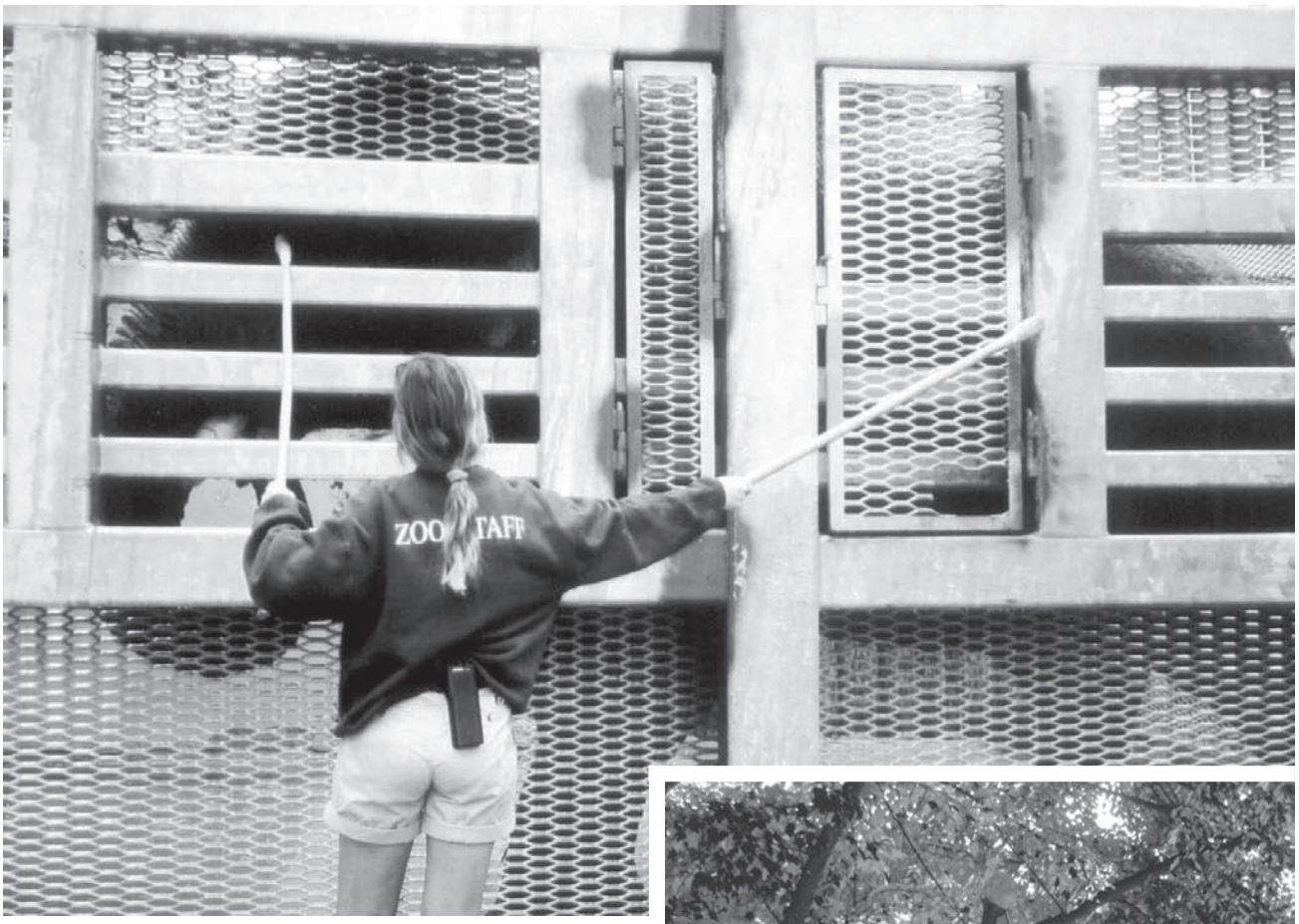
Six Flags Marine World

The guide's design allows for the elephant to be cued with either a pushing or pulling motion

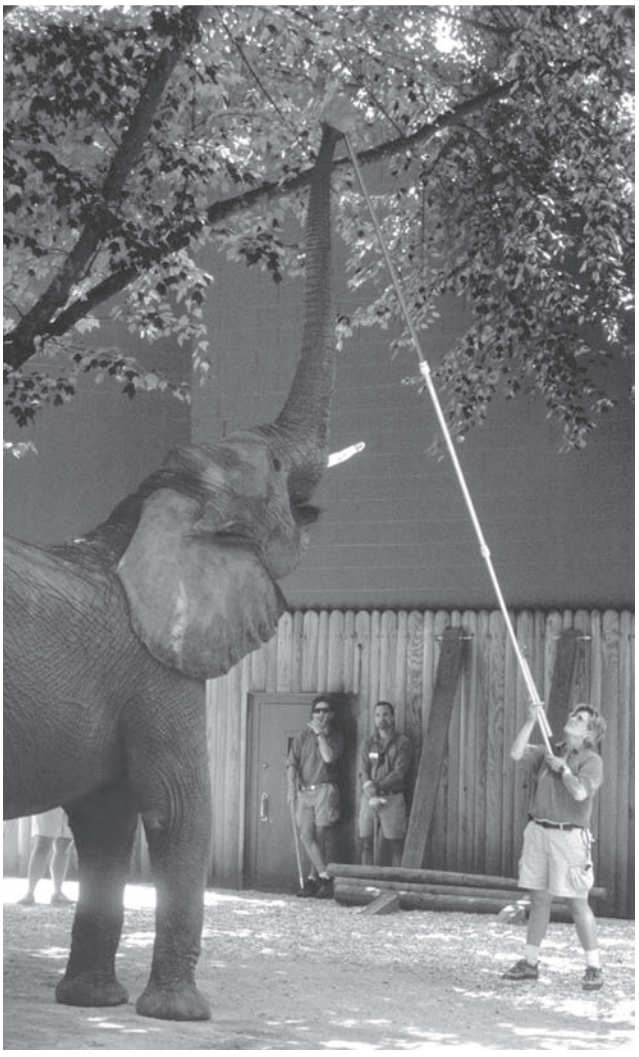
All new handlers should be instructed and knowledgeable in the proper use of the guide prior to working with an elephant so that the guide is not used improperly. As new handlers must learn the use of the guide, so must the elephant learn what is expected from the cues of the guide. An untrained elephant does not understand the "language" of the cues, similar to a dog that has not been taught to walk on a lead and pulls its owner.

Target

A target is used primarily, but not exclusively, when managing an elephant behind a barrier. It can be an effective method of moving an elephant to a specific location or positioning the elephant to a "mark" if the elephant is motivated. Multiple target poles can be used to position or direct the elephant to perform more complex behaviors.



Houston Zoo, Anita Schanberger



Zoo Atlanta, Eric Sampson

Above: A handler uses multiple targetpoles to position or direct an elephant. Right: A handler uses targets in a direct-contact setting.

A target can be any length and made of a number of different materials. Commonly, a bamboo pole or other lightweight material 8 to 10 feet in length is used to extend the handler's reach. Short target poles can be made of wooden sticks such as handles from rakes or brooms, or PVC pipe. On one end of the pole, a water buoy, bundle of rags or paper towels, or other such object is permanently fixed. Because the target can be grabbed and potentially consumed by the elephant, consideration should be given to the material selected to be used as the target.

Leg Restraints

Leg restraints or tethers are an acceptable and necessary tool in the management of captive elephants. Tethers provide a means to limit an elephant's movements and permit the safe handling of the elephant. Limiting the elephant's movement can facilitate foot work, feeding, veterinary procedures, elephant transports, elephant introductions, parturition, scientific investigation, training new handlers, training new behaviors, preventing fighting, protecting facilities, as well as fulfilling many other management and husbandry needs.

Tethering is just one component of an elephant management program. The decision to tether should take into

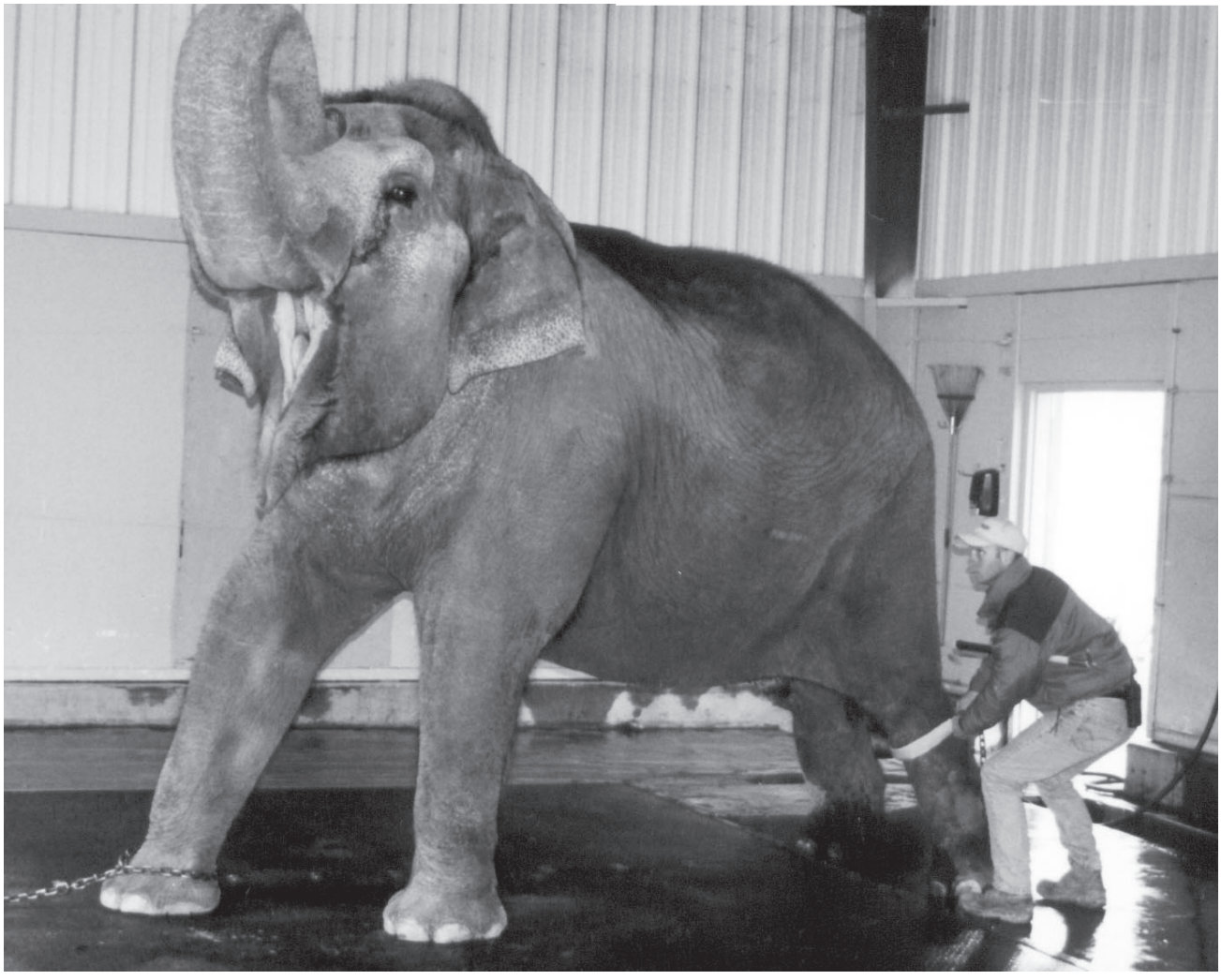
consideration the best interest of the elephant in the given circumstance. For instance, limiting the elephant' s movement at night is a viable alternative to keeping elephants in single stall accommodations. Under normal circumstances, elephants should not be tethered continuously for more than 16 hours without exercise. Elephants under medical care or other special circumstances, such as a mother demonstrating aggressiveness towards her new baby, may require longer tethering periods.

When tethering an elephant is determined to be necessary, the elephant should be tethered by one front leg and the rear leg on the opposite side or, in short-term circumstances, by one front leg only. The tethers should be rotated on alternate legs every other night to prevent possible injury, and the elephant's legs should be inspected daily. In some situations, elephants should be tethered on all four legs, such as for transport, parturition, certain procedures in an elephant restraint device, etc.

Elephants should be tethered on a clean level surface, which preferably slopes to a drain. For short-term use, tethers can be made of rope or nylon straps. For long term or overnight use, chains are the preferred method of restraint. Tethers made of absorbable material must be

Seneca Park Zoo

Right: Handlers secure the front leg tether.
Below: Handler secures the rear leg tether.



Six Flags Marine World

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Chaining is acceptable as a method of temporary restraint. However, elephants must not be subjected to prolonged chaining (for the majority of a 24-hour period) unless necessary for veterinary treatment or transport. Institutions that regularly use chains for some portion of the day must alternate the chained foot on a daily basis. All new construction and major renovations must be constructed in a manner that minimizes or eliminates the need for chaining.

**Note: If AZA policies on chaining require new construction, rather than procedural changes, then institutions will have five years to comply with this requirement. Plans must be in place within three years and institutions must apply for a variance from the AZA Accreditation Commission."

cleaned daily and given an opportunity to dry before their next use. The tethers should be long enough to allow the elephant to lie down and get to its feet easily, but not too long to allow the elephant to turn and become entangled in them.

Indianapolis Zoo

Soft cotton rope used as restraint.

Ropes are especially useful in limiting and guiding the direction of the elephant's movement. Ropes can be used to make hobbles to limit the movement of an elephant or a harness for a new baby being introduced to its mother for the first time. Ropes are often used when training an elephant and assisting an elephant that is unable to rise. Ropes used in elephant management should be of appropriate strength, thickness, and material so as to not cause

Example of chains and rope used together.

injury or abrasions under normal circumstances. Cotton braided, or natural fiber rope of 1 ¼" thickness, is often recommended but not in all cases.

Elephant handlers should be well-versed in the various and proper uses for ropes. It is also recommended that handlers be acquainted with rope splicing and knowledgeable about tying appropriate knots. For the protection of the elephant and handlers, a sharp knife should be on hand any time rope is used.

Elephant handlers should be well-informed about the types of chain and hardware used to tether an elephant, as well as appropriate chain construction and proper fit to the elephant's leg. The front leg chain should be loose on the foot below the ankle joint but with no chance of slipping off. The chain on the hind leg should fit snugly and be placed higher on the leg between the ankle and the knee (or stifle joint). Front leg bracelets are commonly connected using brummel hooks or clevices. Front leg chains should have at least one swivel added so the chain does not twist. Rear leg bracelets are usually connected with quick links, hooks, or clevices. Some facilities cover the leg bracelets with soft material such as rope or fire hose. Padded chains, straps of leather or nylon, or anklets made of cotton rope have all been used successfully, and are recommended for very young elephants and for extended periods of tethering of adult elephants.

All tethers should be checked routinely by the handlers, and any tethers showing signs of wear should be immediately replaced. Tethers need to be secured by rings imbedded in a concrete wall, floor, concrete "deadman," or other immovable anchor and placed about 18 feet apart. The placement of the rings, or attachment, is dependent on the enclosure and the facility's elephant management protocol. When acquiring the proper size chain and hardware, it is a good idea to check with a company specializing in hoisting or chaining equipment as not all chain is built for the amount of pressure an elephant can exert. The choice of what chain tensile strength to use should be based on the age, size, and weight of the individual elephant.

All facilities should develop a tethering protocol so that each elephant handler is familiar with the tethering procedure. This will ensure that the tethers are used correctly, efficiently, and humanely. For example, untethered and unsupervised elephants should not have access to tethered elephants as they can cause injury to their tethered stallmates. In addition, every handler in the facility should put all tethers on exactly the same way each time, that is, right to left, all hooks facing up, etc. In the case of an emergency, this reduces questions or mishandling of the hardware in tethering or untethering the elephant. For this reason, brummel hooks or similar closures are recommended over clevises that require pliers to get on and off.

Tethering Procedure at the Indianapolis Zoo

Untethering an elephant

Elephant should stand steady with trunk raised.

The handler removes the back leg first while the elephant is resting all four feet on the ground.

Handler then removes the front leg tether with the elephant standing steady but with the foot raised to level of the handler's waist so the handler is standing during the procedure.

Tethering an elephant

The elephant should stand steady with the trunk raised.

The handler places the front leg tether on first with the foot raised to level of handler's waist, so the handler can stand erect.

The handler places the rear leg tether on with the elephant standing steady with all four feet on the ground. The tether is placed snugly on the diagonal rear leg just below the stifle joint.

For AZA member institutions, it is stated in the AZA Standards for Elephant Management and Care adopted March 21, 2001, that "Electrical devices designed for use on livestock, such as commercially manufactured electric prods and shocking collars/belts, are prohibited as routine training tools or for handling animals during exhibition. Electric prods are permissible only as an emergency safety device; however, their use is restricted to situations in which keepers feel the imminent need to defend themselves against elephant attacks, or to protect an elephant from possible injury."

Bolt Cutters

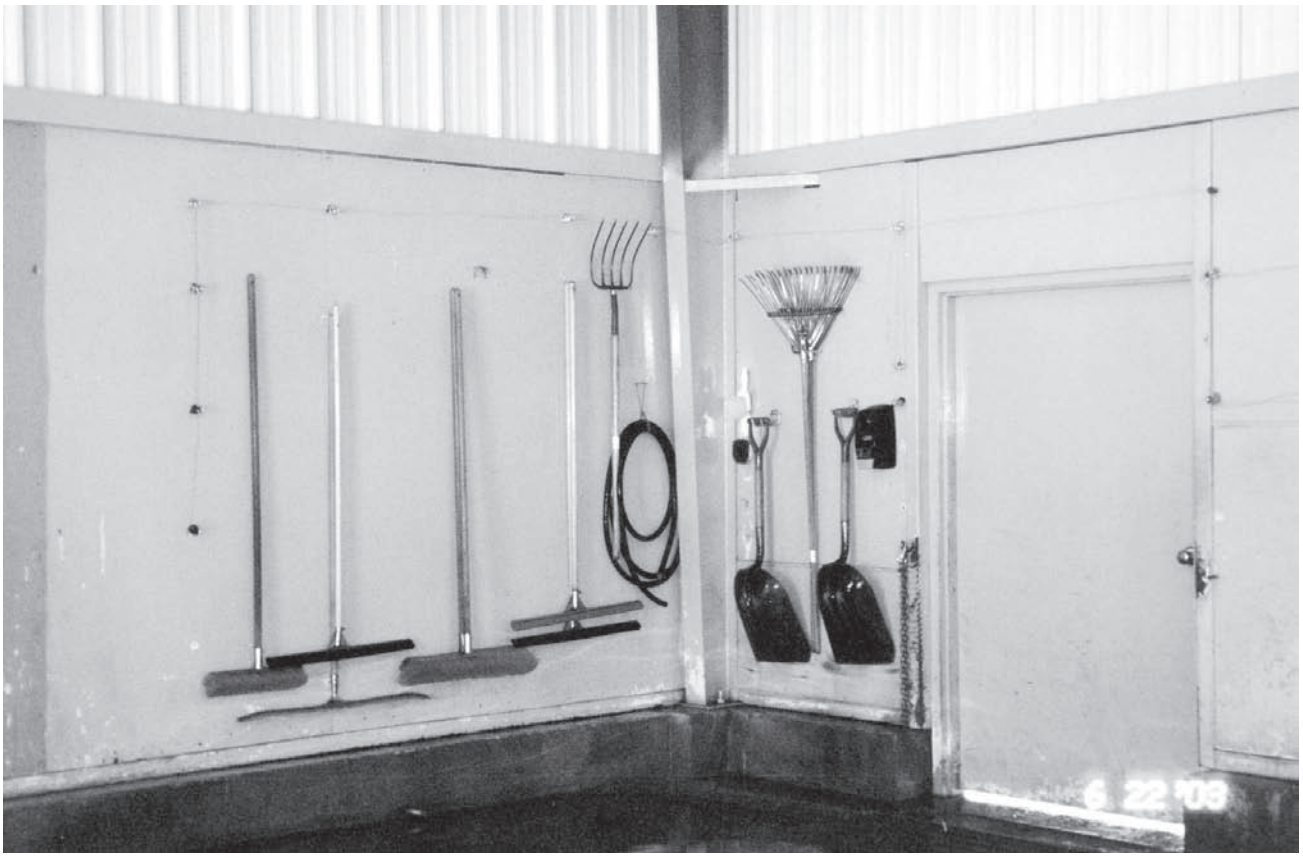
Bolt cutters of sufficient size and strength that are in good working order should be easily accessible to the elephant handlers at all times. Bolt cutters are invaluable when needing to free an elephant quickly from physical restraints or if entangled in cable fencing or electric wire.

Mechanical Assistance

There are a number of devices that aid handlers, especially in emergencies. These devices include a winch, come-a-long, and block and tackle. This equipment should be of sufficient size and strength to support an elephant, in good working order, and should be easily accessible to elephant handlers at all times. This equipment can help position an elephant, or assist in lifting an elephant that is sick or injured and unable to get to its feet by itself. It must be stressed that handlers lacking the knowledge or experience of using this type of equipment must get assistance in order to prevent injuries.

Electric Tools

The only form of electricity acceptable for use with managing elephants is a commercially manufactured cattle prod and electric fencing (see Facility Design, p. 75). The cattle prod should be used only for handler protection, or when the safety of the elephant is compromised, such as in fighting with another elephant. It is not appropriate that an



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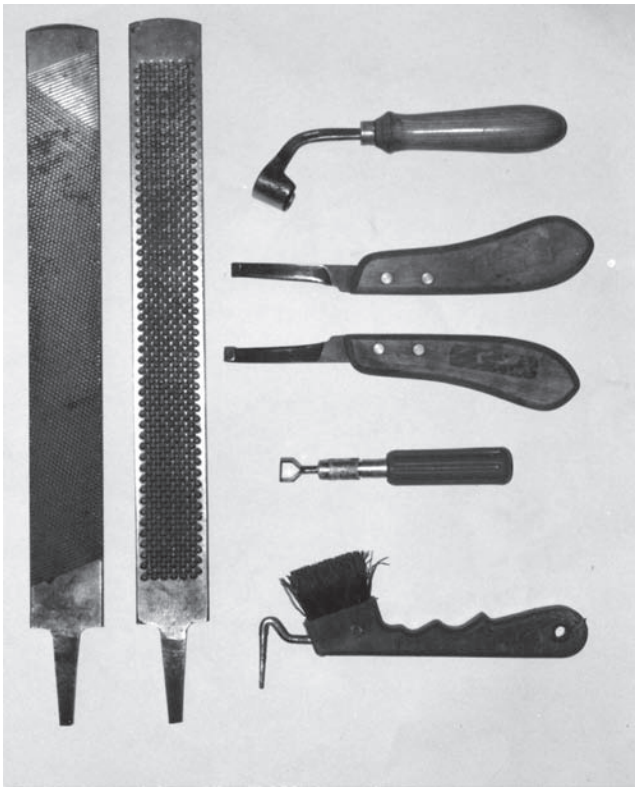
Facility cleaning tools.



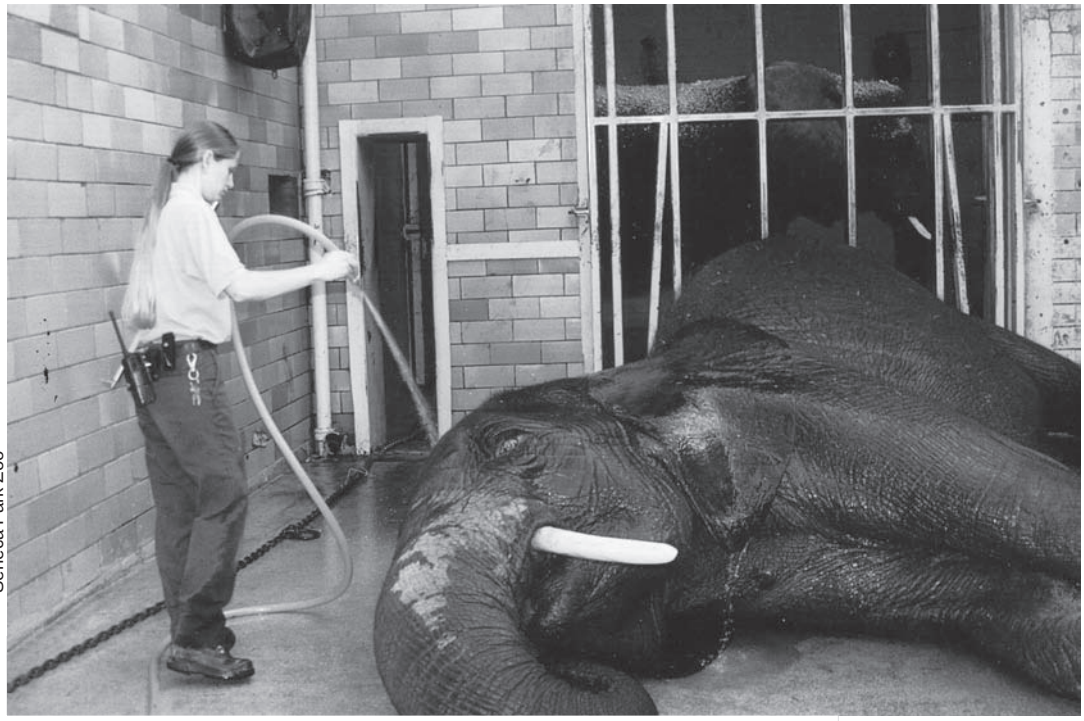
Six Flags Marine World

Elephant foot care tools.

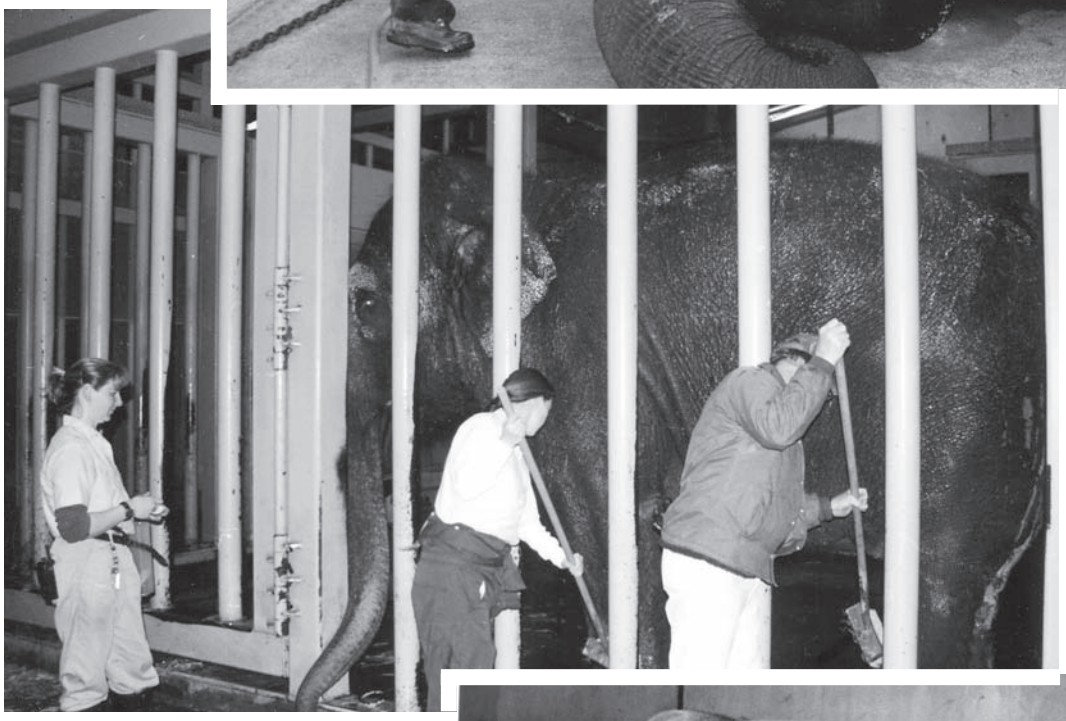
electric prod be used as a routine training tool. When the use of a prod is deemed necessary, the institution's elephant management team should review the application and develop an action plan, as any use of this tool will be closely scrutinized.

Foot Care Tools

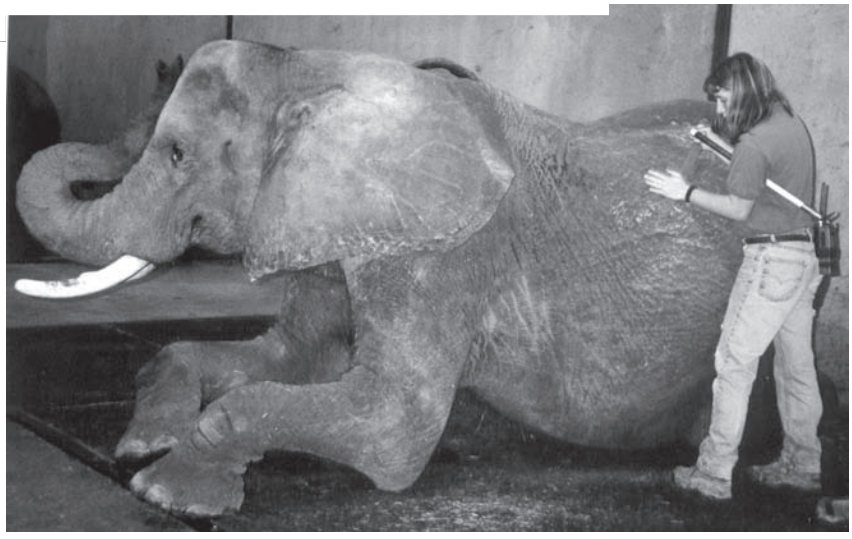
Elephant foot care is mandatory for those elephants held in North America (see Husbandry, p. 37). Over the years various tools have been used and found to be successful in the cleaning and trimming of the elephant's pad and nails. The most commonly used tools are hoof knives and rasps used by farriers in the equine industry. A rasp is used to file and trim nails. Nail nippers may also be used for the same purpose. A hoof knife may be used to trim excess growth of the elephant's footpad and overgrown cuticles. X-acto knives, drawblade, Dremmel tools, and electric grinders have also been used successfully to trim pads and shape the nails. Like hoof knives, X-acto blades come in different sizes providing a broad range of applications. With experience, an electric grinder can be used to trim pads, cuticles, and nails. Since an electric grinder makes noise, it is important that the elephant is desensitized to the sound, odor, and touch prior to its use. In addition, care must be taken when using an electric grinder as it can build up heat and reduce the pad and nail very quickly, potentially causing injury or discomfort to the elephant. It is important that all tools used in elephant



Seneca Park Zoo



Albuquerque Biological Park

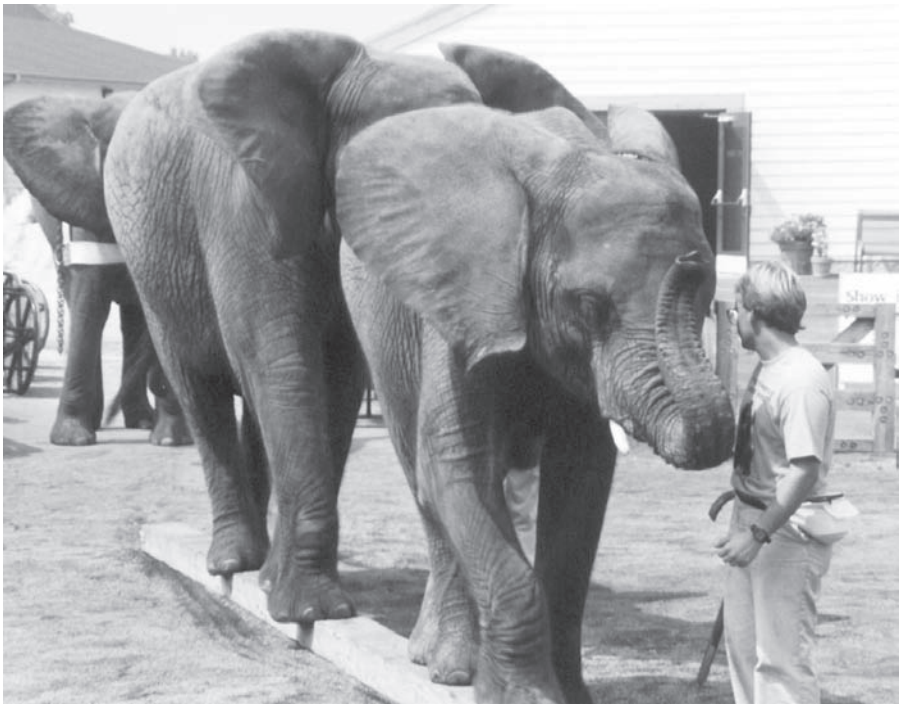


Wildlife Safari

Elephant skin care is an ongoing husbandry task. Above: A hose is used to remove dirt and dead skin. Center: Stiff brushes are used to scrub every part of an elephant's body. Below: A rasp can be used to remove dead skin.

foot care are cleaned and disinfected after each use. It is also encouraged that elephant handlers explore new tools and techniques in an effort to continually improve elephant foot care.

A foot stand provides comfort for the elephant and enables elephant handlers to easily clean, trim, or medicate all areas of an elephant's foot. Although a foot stand can be designed in various ways, it must be strong enough to support the weight of an elephant resting a leg on it, and stable enough to continue to support the elephant's leg even if the elephant moves.



Indianapolis Zoo

Elephants stand on a balance beam.

Scale

Each elephant facility should acquire a scale to routinely weigh the elephants to attain accurate weights, monitor growth, and provide a precise means of dosing medications. Scales come in different sizes, with and without platforms, portable and built-in. A 10,000- or 20,000-pound platform scale large enough for an elephant to comfortably stand on is the preferred method to weigh an elephant, but truck scales have been used successfully. The choice of scale should be based on the institution's elephant program and enclosure.

Facility Cleaning Tools

Elephant barns, holding areas, and exhibit yards should be kept clean of urine, feces, and old feed. These areas should be cleaned at least once a day, more often when needed. Tools that should be available to elephant care staff include a broom, shovel, rake, pitchfork, squeegie, and some type of waste conveyance, such as a wheelbarrow. Indoor holding areas should be scrubbed and hosed of all waste daily. A pressure sprayer is helpful in cleaning elephant holding areas, especially in those facilities that have low water pressure. All tools should be kept easily accessible and in good repair. Tools should be thoroughly cleaned after each use to reduce attracting flies and other pests, and placed or hung out of reach of the elephant.

Six Flags Marine World

Left: Elephant tub. Right: Spindle.

Elephant Bathing Tools

Bathing the elephant daily is recommended using a deck brush, scrubbing mitt, or other type of scrubbing device to remove dirt, feces, and dried skin.

Elephant Tub

An elephant tub is a circular metal table strong enough to support the elephant sitting or standing. An elephant tub is an excellent means of providing exercise. Various behaviors such as standing on the tub, sitting, or other behaviors strengthen the leg and abdominal muscles and can be used to demonstrate the athleticism of the individual elephant. The elephant tub is also useful as a foot rest during foot husbandry care. The elephant tub should be of proper height and diameter for each individual elephant (determined by the use of the tub) and in good repair.

Balance Beam/Spindle

The balance beam and spindle are just two examples of training equipment used to exercise an elephant and demonstrate its physical dexterity and agility. All training equipment must be of proper dimensions, kept in good condition, and strong enough to support the individual elephant.

Six Flags Marine World

Elephant harness.

Harness

A properly constructed harness fits an individual elephant. It is made of a breast band attached to a back strap by steel rings and plates. The harness should be made of material strong enough for the job, but it should not rub or cause abrasions. A harness allows an elephant to use its strength to pull heavy objects and other useful work. This is good exercise for the elephant and a good enrichment opportunity, as many handlers report that most elephants appear to enjoy the physical effort and exercise produced while pulling in harness.

Saddle /Howdah

Elephant rides are popular with the public and are a good form of exercise for the elephant. The elephant ride saddle should be fitted to the individual animal, well padded, and in good repair. Girth straps should be made of material that can be easily adjusted but will not slip. Girth straps should be in good condition, showing no signs of excessive wearing or fraying. Saddle blankets are recommended for the comfort of the elephant and the rider. Neither the saddle nor the girth straps should cause skin abrasions or sores.

Facility Design

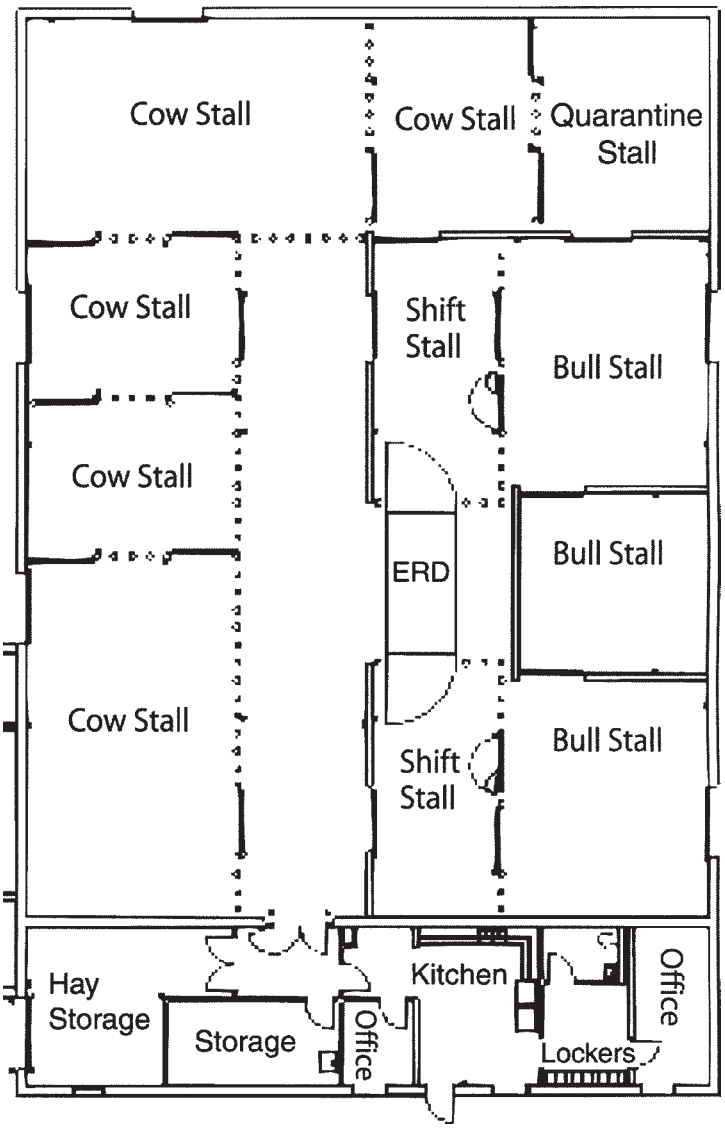
Elephants need contact with other elephants to develop correct social behavior, sufficient space to interact with conspecifics, and means to exercise. The enclosure must include these considerations, as well as be appropriate for the climate, provide protection from the elements, secure the elephants safely, meet the goals and needs of the elephant training program, and provide for the safety of the elephants and staff.

Design for a breeding facility should include at least one outdoor primary enclosure for females, at least one outdoor primary enclosure for males, indoor holding spaces that isolate males from each other and females from males, an ERD (see Tools and Equipment, p. 61), and holding space for calves of either sex through adulthood. In the future, depending on space and the North American elephant population, some institutions may be categorized as exhibit only. Exhibition only facilities should have an outdoor primary enclosure and indoor holding areas as well as an ERD. It is recommended that exhibit-only facilities maintain only post-reproductive individuals of a single sex, castrated animals, or those too young or too old to reproduce. Both types of facilities must have the ability to separate and isolate individual elephants in the event of behavioral concerns, illness, reproductive considerations, parturition, and medical and husbandry purposes.

Under normal circumstances, females and younger males should not be housed alone permanently but maintained instead in groups. Properly socialized elephants may integrate into new situations quicker, permitting greater success with introductions to a bull or a larger herd, than elephants that have had only limited or no social contact with conspecifics. Minimum space requirements of enclosures should be based on no less than two elephants and preferably a minimum of three, in order to assist the development of species appropriate behaviors. Minimum space requirements should allow for proper social interaction in a safe manner while the elephants are unrestrained.

It is recommended that all facilities maintaining elephants provide enclosures for male elephants. The North American population of both the Asian and African elephant is not self-sustaining and increased breeding efforts are needed. Increased efforts require many more facilities to house adult male elephants for breeding, as well as space to house male calves that will result through increased reproduction. In addition, all facilities should have enclosures, or plans for enclosures, for male elephants prior to breeding their females in the event a male calf is born.

Wild male elephants maintain loose social relationships with other males or are solitary. Therefore, males (as early as 5 or 6 years of age



Detail of an elephant holding building.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "All facilities must have the ability to separate and isolate animals to address behavioral concerns or allow veterinary procedures to occur."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "If the AZA Elephant SSP-managed population is to become sustainable, it is necessary to create housing for many more adult males. All institutions considering new construction for elephants should include holding space for adult males. Institutions modifying existing facilities should also make provisions for bull housing."

due to the onset of early puberty) may be, and often are, housed separately from females, although total isolation from other elephants should be avoided.

Adult bull elephants must be housed in facilities that are capable of dealing safely with their aggressive behaviors, especially during their intermittent or seasonal *musths*, which usually produce erratic, unresponsive, and aggressive behavior (see Reproduction, p. 123). During this time bulls are a threat, not only to their keepers but also potentially to other elephants. Because of this, adult male elephants should not be kept in situations where direct human contact is the only means of control. Enclosures built to house more than one adult breeding age bull must include the ability to keep the bulls separate at any time, especially during musth.

Physical separation of bulls for long periods of time may be necessary for management purposes. New studies into olfactory and infrasonic communication indicate these forms of contact are possible means of avoiding complete isolation. For example, a bull may not have physical contact with other elephants, but because he may share the same holding building, or use the same exhibit or holding spaces, there is still an olfactory and auditory link.

Indoor Housing

Every elephant holding facility is required to have indoor housing of some type. For those institutions in warm latitudes, shelter from the elements is sufficient; but for those facilities in colder latitudes, a heated building free from drafts is critical. Indoor facilities should be capable of providing adequate shelter and heat for the elephant's health and comfort. Facilities should be able to maintain an indoor temperature of at least 55° F (12.8° C) during cold weather. For the very young, sick, and/or debilitated animals, at least one room of the indoor facility should be able to maintain 70° F (21.1° C).

Typically indoor space for elephants is designed one of two basic ways. Indoor space can be designed as large community stalls in which the elephants live together as a group if they are socially compatible. Elephants housed in large community stalls may also be tethered if instances of aggression or serious competition between elephants are observed. In this situation, if one elephant must be tethered, then all of the elephants in the stall must be tethered. No elephant should be left untethered due to the potential of its injuring a tethered herdmate. The elephants are usually tethered side-by-side, close enough to interact but far enough apart that each elephant has sufficient space to lie down, and all can lie down at the same time.

Indoor space can also be designed as individual stalls. Each stall should provide adequate room for the elephant to move about freely and lie down without restrictions. Since the size of the holding area is just one aspect of a complete elephant management program, there is a large range of stall sizes currently being used successfully in North America. No scientific studies have been conducted to help determine the best stall sizes for elephants, and a study of this type would be difficult to undertake due to the differences in elephant management programs. For instance, some facilities are able to leave their elephants outside in the exhibit or holding yards at night all or part of the year depending on weather conditions; some facilities provide their elephants a significant amount of exercise during the day reducing the need for the elephant to bed down in a large area; and some facilities in colder regions lack both access to exhibit yards and exercise programs during much of the winter requiring larger than normal stalls or inside exercise areas. Therefore each facility must take into consideration its climate, herd composition and compatibility, and its elephant management program when determining the stall sizes most appropriate for their elephants. It is recommended that all new elephant holding facilities are designed so that a single female elephant stall size be a minimum of 400 square feet (39.2 sq. meters), approximately 800 square feet (74.3 sq. meters) for two adult female elephants, and so on.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Door and gate design is extremely important to ensure the safety of both elephants and keeper staff. Both doors and gates must be engineered to withstand extreme force. If mechanical opening devices, such as hydraulic or electrically powered drives are used, they must be able to be operated manually or with a backup generator in the case of power failure."

Six Flags Marine World

Indoor space can be designed as large community stalls.

Male elephant stalls are recommended to be a minimum of 600 square feet (55.7 sq. meters).

If individual stalls are designed for females, the use of solid walls between elephants should be minimal. It is important that females be able to see and interact with each other in order to maintain their social behavior and structure. However, see-through barriers that eliminate physical contact should be used for elephants with a history of aggressive behavior toward other elephants.

Elephants new to a facility can be difficult to quarantine due to their social nature, size, and containment needs. Due to some communicable diseases of elephants, it is advised that one stall in the indoor holding be able to be modified as a quarantine/hospital stall. A separate,

Carson & Barnes Circus

This individual stall is constructed of schedule 80 steel pipe.

isolated stall can decrease the transfer of pathogens to the resident herd. This may be of great importance when female elephants are moved into an institution for short-term breeding arrangements. At that time, introducing her to resident female elephants may not be medically or behaviorally advisable.

Primary containment walls, barriers, and doors and their attachments should be engineered for the maximum force (approximately 14,000 pounds at 20 miles per hour; 4,538 kilograms at 32 kilometers per hour) an elephant can exert. Schedule 80 steel pipe is often used for stalls and fences. Steel-framed doors filled with concrete and solid steel doors have proven to be successful in elephant holding barns. Solid doors made of concrete provide less surface area for corrosion from urine and water, but metal doors are often lighter in weight. Doors of framed steel vertical posts have been used between elephant stalls with good results, although the vertical posts may need reinforcement with horizontal members if they take a lot of abuse.

It is recommended that most doors be sliding in

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Indoor space must provide adequate room for animals to move about and lie down without restriction. A minimum of 400 sq. ft (37.2 sq. m) is required for a single animal, approximately 800 sq. ft (74.3 sq. m) for two animals, and so on (AZA 1997). Because of their size and space requirements, bulls or cows with calves must have a minimum of at least 600 sq. ft (55.7 sq. m). Outdoor yards must have at least 1,800 sq. ft. (167.2 sq. m) for a single adult individual and an additional 900 sq. ft (83.6 sq. m) must be added for each additional animal (AZA 1997). If this space is the only location for exercise, then it is recommended that the space per elephant should be even greater.

** Note: Institutions can petition for a variance from the current minimum indoor or outdoor space standards. The applicant must explain why their facilities are adequate, even though they do not meet the minimum size standard. Accreditation inspectors will take a holistic approach to accreditation inspections, rather than focusing on specific size measurements. Context is particularly important. For example, it may not be a problem that the indoor space requirements are under the standard by a small amount if a zoo is located in a warmer climate and the animals are outside most of the time. If, however, the zoo is located in a cooler climate and the animals are kept inside for many months during the winter, then the indoor space requirements must be met or, preferably, exceeded. Environmental enrichment programs should also be taken into consideration when evaluating space available."

Indianapolis Zoo

Albuquerque Biological Park

Above left: Individual stalls for females should use a minimum of solid walls. It is important that females be able to see and interact with each other. However, see-through barriers (left) that eliminate physical contact should be used for elephants with a history of aggressive behavior toward other elephants.

Six Flags Marine World

Concrete can act as a heat sink, chilling elephants that lie directly on it. Rubber mats and/or bedding of straw or sawdust can be used to keep the elephants more comfortable.

operation with stops for safety. Sliding doors can present a hazard to the handler if the elephant gains access to the door while it is in operation, and a stop or a mechanism to control the rate the door is opening or closing is not used. Use of swing operating doors can be hazardous and should be investigated before including them into the design of the enclosure. Potential hazards include the arc of opening, speed at which they close, and ability of the elephant to injure handlers or other elephants if they gain access to the door while it is in operation.

Because of the great weight of doors used to contain elephants, some type of power device can be used, such as electric or hydraulic drive. All mechanical doors must be able to be operated manually or with a backup generator in the event of a power failure. The location of the door controls must be well placed for keeper safety, and proper and efficient operation. Keepers must have visual access to the operation of the doors and be trained to use extreme caution when operating the doors. Serious trunk and tail injuries can occur when caught between the doorframe and the closing door. Positioning the elephant far away from the operating door is another means of preventing this type of injury. Manually operated doors are less expensive and less likely to fail due to the operating mechanism. Door-locking mechanisms should be attached to each door, and protected and secured away from the elephant.

Floors should be impervious to water, drain rapidly, and dry adequately to prevent chronic damp conditions or standing water. A recommended slope is 1/4″ per foot which is equal to 5″ of slope per 20 feet of floor (.63 centimeters per .15 meters which is equal to 12.7 centimeters per 3 meters of floor). Minimum recommended drain pipe circumference is 8 inches (20.32 centimeters). The surface of the floor should be smooth but not so smooth as to become slippery when wet. Roughed floors can cause excessive wear to footpads and skin abrasions as the elephant attempts to lie down. Recently—and with varying degrees of success—some facilities have installed newly developed rubberized compounds or polymer aggregate topping over the concrete floors to add cushioning and insulation.

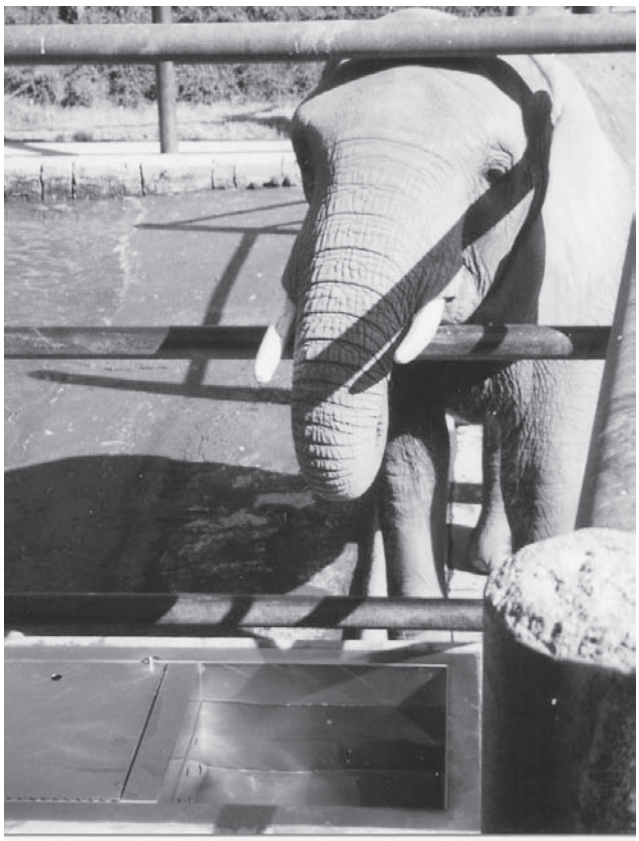
Concrete can act as a heat sink, causing elephants lying directly on the concrete to chill in cold weather if not provided a rubber mat or a bed of straw or sawdust. The majority of elephant holding buildings built in the last 5 to 10 years have installed heating systems underneath the floor. Hot water pipes laid in the concrete floor have

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Standing water in indoor floor areas can cause foot problems and become a breeding ground for bacteria. Floors must therefore be impervious to water, quick to dry, and sloped to a drain. Floor surfaces must be relatively smooth, but not enough so that they become slippery when wet. Conversely, very rough surfaces may cause excessive wear or irritate footpads."

proven the most successful. Floor areas should be available without the heating components to allow the elephants to move away in case of overheating.

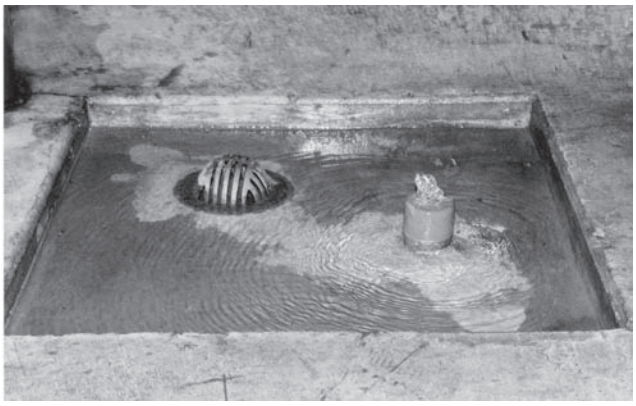
Fresh, clean, potable water must be provided to the elephants at least twice a day. Many facilities choose to provide water in troughs. Troughs can save time and labor, but improperly designed troughs can cause wet floors and unhygienic conditions through food, dirt, or feces contamination. Water troughs should be in a location where the elephant is unable to defecate or urinate in them. The water must be changed daily or be supplied from an automatic-fill or continuous flow device. Cleaning and disinfecting of the water container should occur daily to inhibit the growth of algae and bacteria.

Normal light cycles are appropriate for elephants. Indoor areas should be well illuminated during daylight hours followed by a dark period. Good lighting in the elephant stalls and staff workspace is required for both elephant comfort and handler safety. Natural lighting provided by an ample number of skylights and/or windows in concert with artificial lighting that provides a broad spectrum of illumination is recommended for use in indoor holding areas. Because many facilities work with elephants at night or in low-light conditions, high-quality night lighting is necessary to enhance staff safety. If an elephant is to be held indoors for more than 12 hours (e.g., winter in cold-climate institutions, medical or husbandry condition, birth of young), facilities should provide artificial or natural light sources to simulate natural cycles.



Six Flags Marine World

The bathing pool should not be the only source of drinking water.



Adam Cheek, Indianapolis Zoo

Continuous-flow watering device

Proper ventilation is very important for the health of the elephant. Because elephants produce substantial quantities of urine, feces, gases, and heat, it is important that there is good air circulation. Ventilation should be such that it will exchange the heavier humidified air quickly, maintain a constant temperature at all heights of the building, eliminate some of the odor, and not promote drafts. Indoor facilities should be maintained with a negative air pressure, and ventilation should be provided to accommodate at least four air exchanges per hour (USDA recommendations for a cold-weather heated barn). Facilities are encouraged to check with their local authorities for air-exchange requirements when the public occupies the facility. Humidity should be maintained at a comfortable level for both elephants and staff.

Mature elephants are athletic, strong, inquisitive, and

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Mature animals can reach a vertical height of 20 ft (6.1 m). Consideration of this must be given with regard to ceiling heights and fixtures (e.g., lights, heating units, plumbing, etc.) so that animals do not harm themselves or the facility."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Outdoor yard surfaces must consist primarily of natural substrates (e.g., soil, sand, grass) that provide good drainage and have a cleanable dry area for feeding."

Have Trunk Will Travel, Kari Johnson

Skylights are recommended for indoor holding.

intelligent, and can have a horizontal and vertical reach of 20 feet (6.1 meters) and more. Consideration of this must be given with regard to ceiling heights, fixtures (i.e., lights, heating units, plumbing, etc.) so that elephants do not harm themselves or damage the facility.

Other things to be considered in the design of an elephant holding building are the ability to install a video monitoring system, built-in scales for weighing elephants, hoist capabilities over each stall, an elephant restraint device, ability to access the stall area with an elephant transport trailer, and vehicle access to and into the indoor facility and outside exhibit yard.

The comfort and work needs of the elephant handlers must also be taken into consideration. All elephant holding barns should provide the handler visual access into the elephant holding area prior to physical entrance. Separate areas are needed to store foodstuffs in sanitary conditions, and tools and cleaning supplies away from food to avoid contamination. Areas should be designated for the handlers to store personal gear and training equipment. A comfortable and efficient workspace should be designated for staff meetings, the recording of daily elephant data, and the maintenance and storage of elephant documents.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Natural daylight cycles are adequate for elephants, even in temperate regions. Indoor areas must be well illuminated during daylight hours, followed by a period of darkness. Fluorescent lighting provides a sufficient spectrum of illumination; skylights, in addition to interior lighting, are highly recommended. Ample interior lighting must be available, as it is especially important to maintain staff safety."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Indoor holding areas must be ventilated, and heated to a minimum temperature of at least 55 degrees F (12.8 degrees C) at all times of the year. One room must be capable of maintaining a temperature of at least 70 degrees F (21.1 degrees C) and be free of drafts, for accommodating sick or debilitated animals."

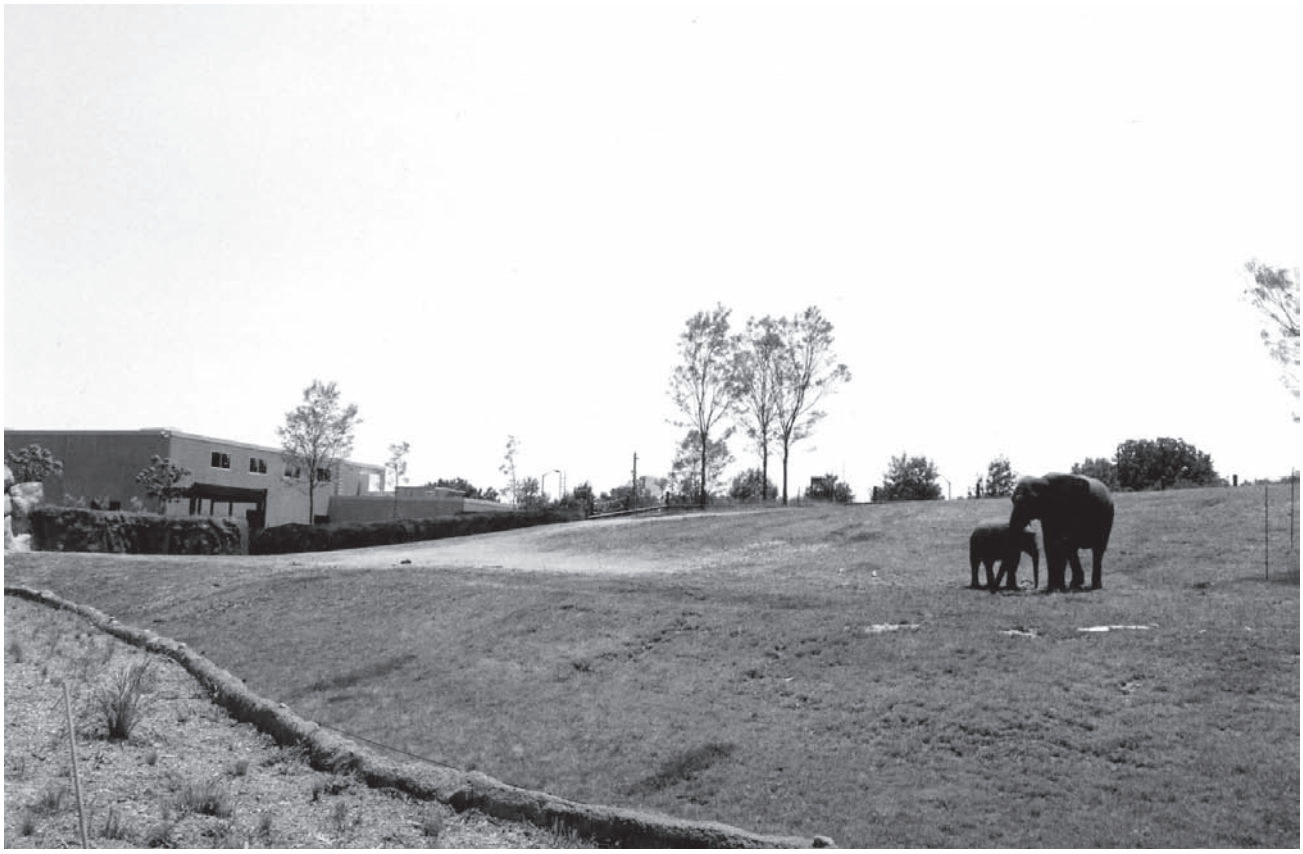
Outdoor Housing

The design of outdoor enclosures should incorporate the most current information available on the captive management and husbandry of same sex and multi-sex groups of elephants. It is recommended that each facility have a large communal yard for female elephants to encourage species-appropriate behaviors and stimulate exercise, and a separate enclosure for mature male elephants. An additional holding yard or yards should be available, preferably adjacent to the large communal yard, in case there is need to separate elephants due to aggression, illness, introductions, or a female with a new calf.

Outside yards should be as large as possible. It is recommended by most elephant managers that a minimum space of 1,800 square feet (167.2 sq. meters) per elephant be provided, so the elephant can move about freely and allow individual elephants to separate themselves from the herd if they desire. Many elephant managers believe that unless the elephant is out of the enclosure for exercise on a daily basis, the space per elephant should be even greater. In breeding situations, where the male is maintained with the

Albuquerque Biological Park

Video monitoring systems can be useful additions to a facility.



Indianapolis Zoo

North Carolina Zoological Park

Outside yards should be as large as possible, and most managers recommend a minimum of 1,800 square feet per elephant. Enclosures should be designed for no less than—and preferably a minimum of—three elephants.

females much of the time, yards should be significantly larger to allow the females to maintain a distance from the male, and for natural courtship and breeding behavior to occur.

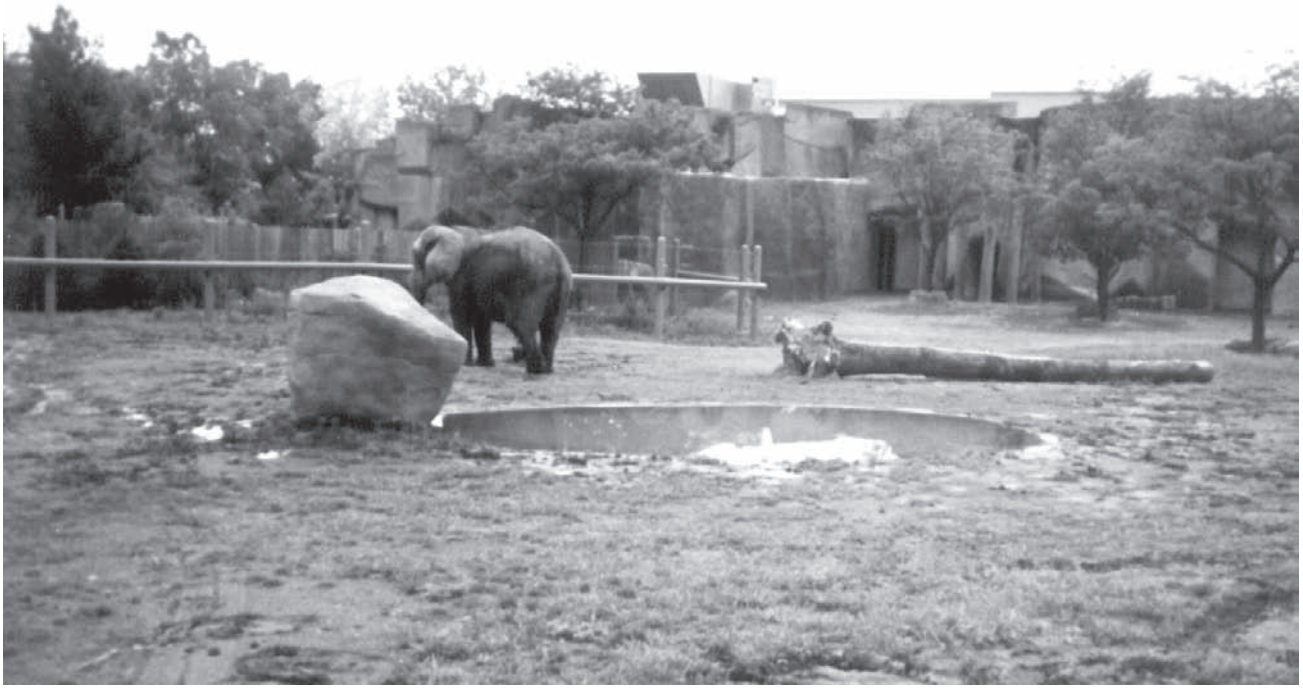
Yard elevation should provide drainage but not be so steep that the elephants have difficulty walking or using the entire area. Yard surfaces must be of a natural substrate such as grass, dirt, clay, or a coarse sand-type material that provides good drainage and adequate footing with a cleanable, dry area for feeding. Yards that are completely asphalted or concrete are not appropriate due to the belief (although unsubstantiated) that the lack of "give" of the compound can cause foot and joint problems.

Some additional required enclosure characteristics are shade, furnishings, a water feature, visual barriers, and the availability of escape routes from conspecifics. In addition, activities that provide behavioral enrichment should be considered in the design of the outside yard. It is also recommended that enclosures be designed so that elephants can be kept outdoors as much as possible within temperature, husbandry program, and local community constraints. These enclosures must be secure for the elephants and to prevent human trespassers from having easy access to the elephants.

Elephants in range countries are very hardy and have been found in a variety of habitats and climates from deserts to mountains. Elephants in North America are also adaptable to a wide range of temperatures as long as great care is taken to acclimate them properly, and the handlers regularly monitor the physical condition of the elephants and/or provide them access to shade or a heated structure. Elephants have a low surface-to-volume ratio; therefore,

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Outdoor yards must have at least 1,800 sq. ft. (167.2 sq. m) for a single adult individual and an additional 900 sq. ft. (83.6 sq. m.) must be added for each additional animal. If this space is the only location for exercise, then it is recommended that the space per elephant should be even greater.

** Note: Institutions can petition for a variance from the current minimum indoor or outdoor space standards. The applicant must explain why their facilities are adequate, even though they do not meet the minimum size standard. Accreditation inspectors will take a holistic approach to accreditation inspections, rather than focusing on specific size measurements. Context is particularly important. For example, it may not be a problem that the indoor space requirements are under the standard by a small amount if a zoo is located in a warmer climate and the animals are outside most of the time. If, however, the zoo is located in a cooler climate and the animals are kept inside for many months during the winter, then the indoor space requirements must be met or, preferably, exceeded. Environmental enrichment programs should also be taken into consideration when evaluating space available."



Columbus Zoo and Aquarium

Yard surfaces must be of a natural substrate, such as grass, dirt, or coarse sand.

Deborah Olson, Indianapolis Zoo

Off-exhibit yards offer added space and flexibility.

Temperatures can drop as low as 32° Fahrenheit (0° C) and create little discomfort for healthy elephants. Elephants in northern areas appear to enjoy snow.

Jerry Kucera, Six Flags Great Adventure

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Elephants must be kept outside on natural substrates as much as possible. Institutions should consider designing exhibits that allow elephants outdoor access twenty-four hours a day—weather, health, and safety permitting. During daylight hours, elephants kept outdoors can tolerate moderate temperatures extremes. Provisions must be made to protect animals from adverse weather, including intense sunlight, chilling rain, sleet, etc. Animals kept outdoors must be monitored frequently at temperatures below 40 degrees F (4.4 degrees C). Facilities may install outdoor heat sources to extend the amount of time the animals are able to remain outside."

they lose body heat slowly. Temperatures can drop as low as 32° F (0° C) and create little discomfort for healthy, acclimated elephants, indicating that elephants can tolerate much colder temperatures. Elephants in northern climates even appear to enjoy spending time in the snow. Other factors—such as precipitation, wind chill, and amount of sunshine, as well as the elephant's health and activity level—will also have an effect on the tolerance levels of an individual elephant.

The elephant's comfort must be given consideration in hot weather as well. Little body heat is lost by radiation due to the elephant's low surface-to-volume ratio and the fact that they do not have sweat glands over much of their body. Access to shade is a mandated requirement under the Animal Welfare Act, and all facilities must make shade available. A variety of both natural and constructed options are possible such as trees, sunscreens, tarps, and access to the holding building. It is recommended that multiple shade options be provided to prevent a dominant elephant from monopolizing the shaded area.

Elephants need access to mud wallows and dusting material such as sand or dry soil, for skin health, protection from sun, insects, and to promote natural behaviors. The size of mud wallows and sand piles should be gauged by the number of elephants in the exhibit so as to allow ample room for multiple elephants to use the area at the same time. It should be noted that elephants may construct their own mud wallows. Mud wallows should be cleaned regularly and renovated periodically to prevent contamination.

Additional furnishings for the outdoor exhibit should include scratching posts, which may be particularly effective if placed near mud wallows or pools. Post material must be nontoxic and strong. Several facilities have buried deadfall trees or logs upright in concrete sewer culverts, which are kept in place with gravel. This allows the posts or logs to be replaced when damaged or rotted. Artificial and natural rockwork can be very attractive, as well as strong and effective rubbing and scratching surfaces.

It is recommended for permanent public display purposes, enrichment, and physical activity that outside holding yards provide a water feature that allows the elephant to cool and bathe. The pool should be large and deep enough for the elephants to lie over in and be partially submerged, and it is strongly encouraged that the pool be deep enough to provide the elephant the opportunity to completely submerge itself. Suggested pool size is

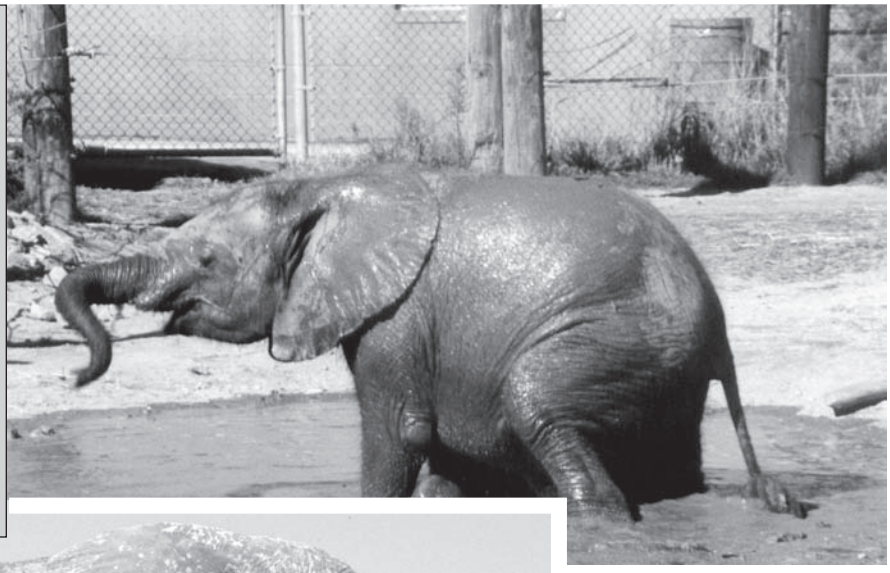
Karen Marzynski, Rosamond Gifford Zoo at Burnet Park

Elephants should have access to shade.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "While outdoors, all elephants must have access to shade during daylight hours in temperatures above 80 degrees F (27 degrees C) when they are exposed to direct sunlight."

Jerry Kucera, Six Flags Great Adventure

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, " While outdoors and weather permitting, elephants must have regular access to a water source, such as a pool, waterfall, misters/sprinklers, or wallow that provides enrichment and allows the animals to cool and/or bathe themselves."



Jerry Kucera, Six Flags Great Adventure

From top: Water features, mud wallows, and scratching areas are all important to elephant enclosures.

Deborah Olson, Indianapolis Zoo

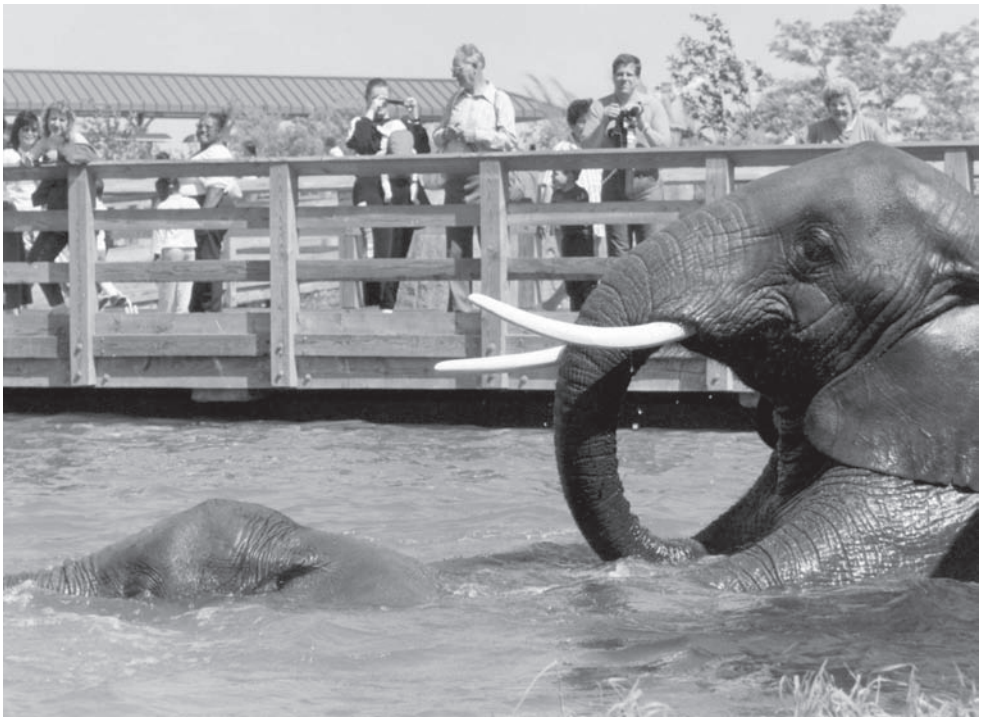
Sand piles provide a great source of enrichment. The size of the piles should be gauged by the number of elephants on the exhibit.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "While outdoors, elephants must have access to sand or soil at all times for dust bathing. Rocks, tree stumps, or large sturdy objects must be provided in the exhibit so that animals may use them for rubbing and scratching."

at least 30 feet x 30 feet (9.1 meters x 9.1 meters) so multiple animals can bathe at once. The bathing pool should not be the only source of drinking water. Pools, even when cleaned regularly, can become quickly fouled when used by elephants.

The drain, filtration system, slopes and steps, and handler access for cleaning should be considered in the design of the pool. For the elephant's entry into the pool, a slope or gradual steps are preferred. Areas of egress should occur in at least two to three locations around the pool to ensure safe access in and out of the pool for all elephants. Note that multiple entries to a pool prevent it from being a "dead end" in the enclosure. The pool substrate should be at least the texture of broom-swept concrete for traction but not so rough that it causes skin abrasions.

Care should be taken when a new calf is in an enclosure with a pool. Although many calves exhibit a natural ability to swim, consideration should be given to modifying or partially draining the pool until the calf is comfortable and experienced with swimming.



John Tobias, Indianapolis Zoo

It is strongly encouraged that the pool be deep enough to allow the elephant to completely submerge.

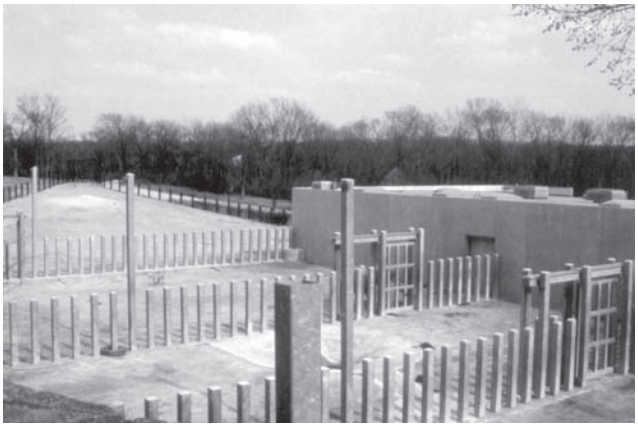
Columbus Zoo and Aquarium

Above: This tree's trunk and the grass around it is protected by electrified wire disguised as grass. Left: Tree root ball is protected by a concrete sewer culvert; its limbs are protected by electrified wire.

Visual barriers may help to decrease aggression when elephants are maintained together in a herd situation. Visual and physical barriers may be naturalistic or architectural as long as they are large and high enough to provide "safe zones" that allow an elephant to pass from another's sight partially or completely, or allow elephants to separate themselves from others, if necessary, during introductions or in a group situation. Some naturalistic types of visual barriers include deadfalls, logs, boulders, trees, and natural plantings. Fence barriers should be designed with corners greater than 90 degrees, which prevent the pursued elephant from being trapped. Gates to adjoining yards may be used as escape routes, provided that care is taken to prevent dead-end corners, and the gates create a "run-around" so that an animal can enter or leave the yard without an aggressor blocking or guarding the exit.

Live trees provide shade and have been successfully maintained in elephant exhibits. Stripping of the bark and/or root ball compaction usually causes the death of a tree. Corrals made of commercially manufactured electric livestock fencing, electric fencing simulating stands of grass, boulders, concrete pipe, or other fencing materials keep the roots from being compacted by the elephants' weight, and in some cases keep the elephants far enough away from the tree itself to cause it no harm. Electrified wire can be attached directly to or hanging from tree trunks and limbs, with extremely effective results, encour-

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Elephant containment barriers must be in good condition and able to prevent elephant escapes. A wide variety of building materials can be used as long as they are able to withstand the elephant's strength, contain the elephant in a specific space, and prohibit direct contact between the elephants and the public."



Kansas City Zoo

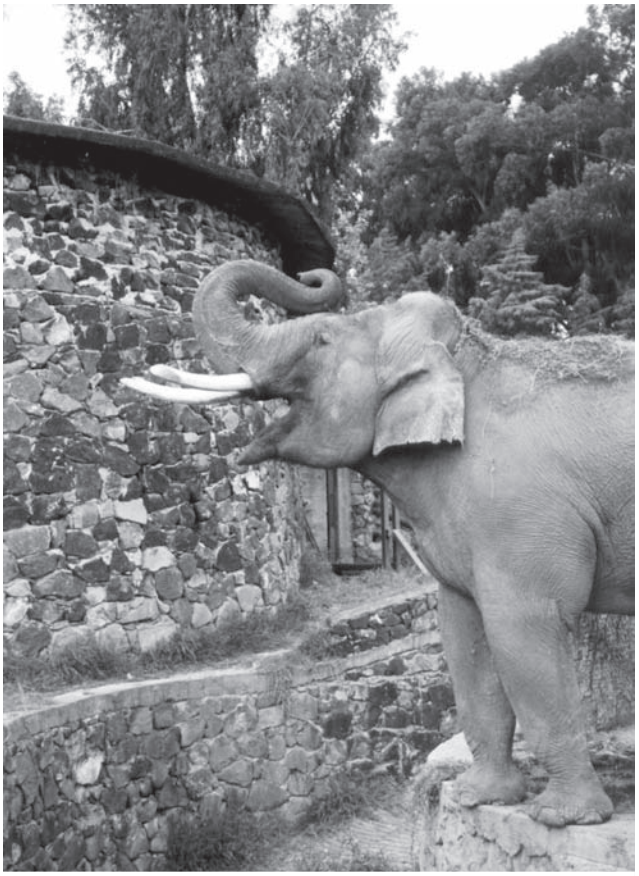
Vertical pipes set in concrete form an effective, off-exhibit holding.

aging the elephants to leave the tree intact.

Barriers

Retaining barriers such as walls, moats, posts, and railings must be constructed with the elephants' strength and reach potential in mind. Generally, 10 to 12 feet (3 to 3.6 meters) should be allowed for a safe zone between the elephant barriers and unprotected areas if the elephant is unable to extend its head beyond the barrier. Recommended heights of walls and horizontal railing as primary containment for adult female elephants is 6 to 7 feet (1.8 to 2.1 meters) . Recommended height for male elephants is at least eight feet (2.4 meters).

Facilities have used many types of primary



Deborah Olson, Tuluca, Mexico

Deborah Olson, Indianapolis Zoo

Top right: Unprotected dry moats pose a substantial threat to elephants. Center: A pipe barrier provides protection from the moat. Below: A dry moat that uses electrified grass and change of substrate makes an attractive, safe exhibit.

Deborah Olson, Indianapolis Zoo

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Dry moats can pose a substantial threat to elephants and their use must be limited with the ultimate goal that they are eventually phased out. Moats that are deep, narrow-sided, and hard-bottomed can be particularly dangerous. Although there should be no risk of animals falling or being pushed into the moat, written animal extraction protocols must be in place for any moat that is more than 3 ft (1m) deep, less than 10 ft (3 m) wide, and/or hard-bottomed."

barriers successfully such as walls, fencing, dry moats, and water. Barriers can be made of a wide variety of materials as long as the barrier is able to withstand the force of an animal that can weigh 7 tons, is suited for outside containment, and is nonclimbable. Elephants are surprisingly agile and have proven this ability by climbing fences, rocks, logs, and other objects meant to contain them. Horizontal rail fences must be carefully designed; otherwise, the rails may act as a ladder, helping the elephant slip over the top.

Recommended materials for barriers include solid concrete or rock walls, vertical posts set close enough together to prevent an elephant from passing through, and horizontal steel rails, pipe or cable spaced 18 to 24 inches (45.72 to 60.1 centimeters) apart attached to vertical posts spaced 8 to 10 feet (2.44 to 3.05 meters) apart. Whenever possible, bare steel cable should be covered with a non-abrasive material or inserted through plastic pipe or hose to prevent unwanted tusk wear. It is also important to consider fence spacing and keeper access/egress in the event of an emergency. Attention should also be given if calves will be present and adjustments made to prevent them from escaping containment.

Deborah Olson, Cincinnati Zoo

Attention should be given to horizontal rail spacing when calves are present.

The primary barrier between the elephants and humans in a public display situation, such as a zoo, is a critical element in the design of an outdoor exhibit. A permanent primary barrier should allow a clear view of the animal from a safe location. The public and elephant should not be able to reach out and touch each other, nor should the public be able to gain access into the elephant yard.

Poorly designed dry moats when used as primary barriers can pose a substantial threat to elephants. It is strongly recommended that their use be limited and/or phased out over time. Elephants can be injured or killed if they are pushed or fall into a deep, dry, narrow-bottom moat with a steep drop from the elephant yard. Elephants have been known to fall into the moat upside down and have been prevented from righting themselves due to the narrowness of the moat. Elephants have also been seriously injured in the fall. Correct moat design includes a slope to the wall, a cushioned bottom, and a floor of the moat wide enough for the elephant to gain its feet from any position. Easy elephant egress out of the moat back into the elephant facility by walking is required. If moats that are deep, narrow-sided, and hard-bottomed must be used in an elephant facility, then a fence or other barrier should be used as the primary barrier, and the moat should become the secondary barrier.

A gradual decline of the exhibit substrate down to a solid wall can be used to create a dry

Deborah Olson, Point Defiance Zoo and Aquarium

Horizontal cable attached to vertical posts as containment.

Jay King, Riddle's Elephant and Wildlife Sanctuary

Above: Electric fences should only be used as the primary containment when an elephant is attended. Right: Commercially available electric livestock fencing has proven to be safe and effective as a means of containment.

moat effect. The use of a dry moat effect requires the vertical wall be of necessary height and distance away on the public side to prevent elephant and human contact, since without additional barriers, the elephant can gain some access to the moat.

Commercially manufactured livestock electric fencing has proven to be a safe and effective means of secondary containment for training an elephant to remain within a restricted area defined by the electric fencing and to prevent physical contact to an area. Electric fence should never be used as the primary containment when an elephant is left unattended, as the electric fence could experience electrical or mechanical problems. Tusks do not conduct electricity, and both African and Asian elephants with long tusks can easily break the wire. In addition, any elephant can break the wire if they so desire or if they are frightened or pushed. If an elephant is contained by an electric fence with no other physical barriers present, the elephant must be closely monitored by the handlers to ensure the elephant's safety and continued confinement. Traveling public displays of elephants have recently begun to use electric and portable fences with great success. Those facilities that use this system have at least one handler that supervises the elephants at all times.

Water has been used as a secondary barrier successfully and attractively, although it may carry a small risk of drowning of very young or infirm animals. The pool should be built in such a way as to provide containment even when empty. For example, a cable-and-post fence embedded in the pool floor will separate the animal from the outer containment barrier, or a vertical wall at the deepest point of the pool will prevent the elephant from climbing out.

Effective November 17, 1999, the USDA's Animal and Plant Health Inspection Service (APHIS) adopted requirements for perimeter fences placed around outdoor housing facilities of elephants. The ruling states that the perimeter fence should act as a secondary containment system for the elephants, to reasonably restrict unwanted animals and unauthorized persons from entering the facilities or having contact with the animals, and to prevent exposure to diseases. Under this rule, a perimeter fence is not required where appropriate alternative security measures are employed and the Administrator provides written approval. If a facility wishes to use a perimeter fence that does not meet the requirements of this rule, or if a facility wishes to use alternative security measures, the facility must obtain written approval from the facility's inspector, the regional director for APHIS-Animal Care in the area the facility is located, or the Deputy Administrator for Animal Care.

Behavior Management

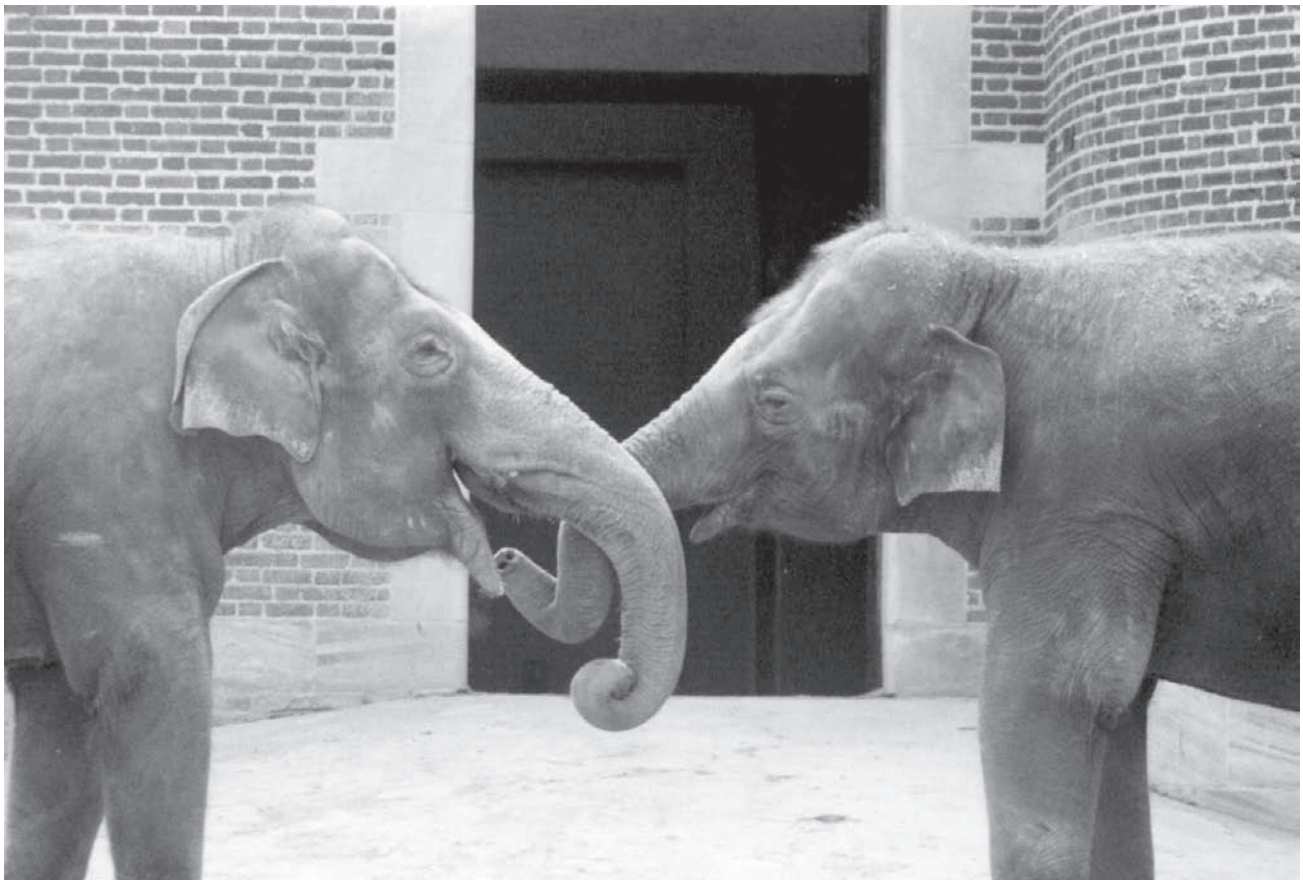
In recent years, a significant amount of information regarding the social structure of wild African elephants has been published. This information has painted a fairly complete picture of the social nature of elephants in Africa. Less information is available on the Asian elephant, as their social behavior is much more difficult to observe due to their fewer numbers and habitat of dense forests. Based on limited existing data, indications are that the social behavior of the Asian elephant appears to be similar to that of the African elephant.

Female elephants are social animals, spending much of their time rearing calves. In the wild, the family unit averages five to eight females and their offspring, although there are large variations in family size. Most females stay within the family group into which they were born, splintering into smaller subgroups when the family becomes too large. Family groups make up clans that fluctuate in size as family segments come and go, often depending on the availability of food and water. Male elephants leave the family as they enter their teenage years. Adult males spend a majority of their time away from females except during breeding opportunities. Males, once separated from the natal group, will form loose associations with other bulls except while in musth, at which time they are solitary (Douglas-Hamilton 1975; Moss 1988).

The establishment of comparable social groupings for public display has been difficult due to the mode of acquisition of elephants, the size of exhibits built more than 20 years ago, and the lack of captive reproduction. In North America, the average herd size in most zoological institutions is gradually increasing. Circuses and many private facilities house larger number of female elephants together. To encourage larger elephant groups, bigger exhibits are being constructed, some with bull-holding capabilities; and greater emphasis is being placed on

Jerry Kucera, Six Flags Great Adventure

Female elephants are social animals.



Buffalo Zoo

Elephants need social interaction.

breeding and encouraging the species-appropriate behaviors of calf rearing.

Due to the social nature and behavior of elephants, it is recommended that elephant holding facilities maintain a minimum of three same-species females, and all facilities establishing new groups of elephants should strive for groups of the same species. It is acceptable for elephants to be managed as individuals if they have been raised alone and will not socialize with other elephants, or in the case of working elephants that are temporarily required to be removed from the herd in order to perform their work.

When male elephants start to reach puberty (as young as 5 years old) their "play" mounting behavior may begin to develop into serious breeding activity. If not prohibited, the results could be an unwanted pregnancy. Additionally, the adult females may physically attack and seriously injure a young male who shows sexual interest in the herd. This aggression is similar to what occurs in the wild when a young male is forced by the adult females to leave the herd. If the young male is maintained in the herd and the harassment is allowed to continue, it may have long term effects on his health, behavior, and future reproductive capabilities.

Moving a young male from his natal group and introducing him to other young males or unfamiliar females as he matures more closely mirrors the experiences of elephants in the wild and may stimulate species-specific male behavior and reproductive capabilities. In addition, the species-appropriate reproductive behavior and ability of the young and adult breeding male may be enhanced by

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "When forming new herds, Asian and African elephants should not be placed together in the same enclosure. Herpes viruses endemic to one species can be fatal in the other. In addition, there is concern that behavioral differences between the two species may lead to problems with dominance and aggression."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Institutions must provide an opportunity for each elephant to exercise and interact socially with other elephants."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March, 21, 2001, states, "Zoos should make every effort to maintain elephants in social groupings. It is inappropriate to keep highly social female elephants singly. Institutions should strive to hold no less than three female elephants wherever possible. All new exhibits and major renovations must have the capacity to hold three or more female elephants.

**Note: It is understood that obtaining additional elephants for zoo exhibits can be difficult at this time. Temporary variances will therefore be considered regarding group size requirements. Institutions that do not currently meet the group size standard should demonstrate that they have requested assistance from the SSP in obtaining additional animals.

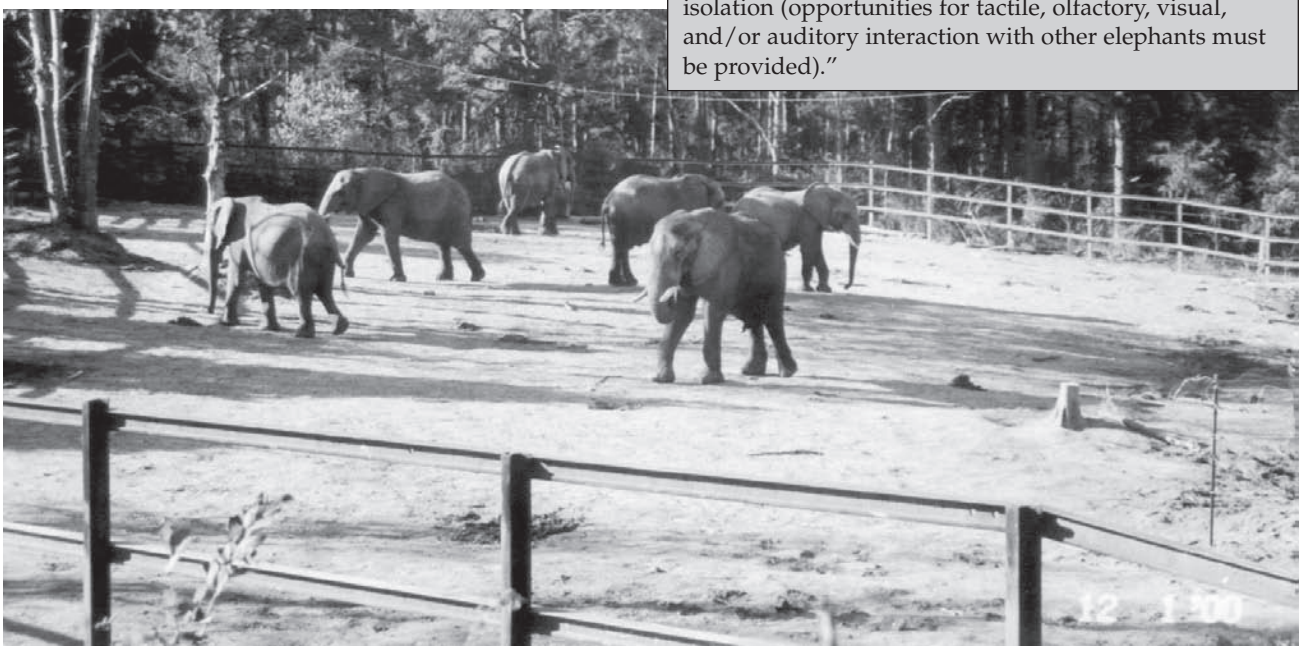
It is recognized that some socially aberrant adult females currently exist and these elephants can be managed singly if the institution has made every effort to introduce them to a social group and the SSP agrees that the anti-social behavior is not correctable."

the introduction of different females than the cows with which he has been raised or with which he is permanently housed. It is also unknown if the reproductive capacity of males is stimulated or suppressed if maintained with or in proximity to another bull. In the case of African elephants, one private facility currently maintains multiple males, in their early 20s, together in a large paddock indicating bachelor groups are feasible and need to be investigated further.

Elephant facilities should make every reasonable attempt to replicate the natural social behavior of elephants in order to enhance compatibility, longevity, and reproduction and calf rearing success, especially in nulliparous females (females that have yet to have a calf). In some species, management difficulties can be traced to the behavioral impact of the current environment. It should be noted that numerous variables affect the probability of success with any social group, including the elephants' dispositions, age, physical health, reproductive experience, past social experience, and the size of the holding space. In elephants, more research is needed on captive behavior of individuals and groups, especially in breeding herds. Objective comparisons of the behavior of wild herds to individuals born in captivity and maintained in their natal group, and of herds established from unrelated, same-aged orphan calves may provide important information. It is recommended that all facilities initiate and cooperate in studies that provide this information. The resulting data, combined with preliminary analyses of factors affecting reproductive success in captivity, may be used to generate recommendations regarding optimal social groupings in the future.

To facilitate natural breeding and manage genetic diversity, moving elephants from one established social grouping to another is sometimes required. This necessitates introductions to new animals, including bulls. Changing social groupings requires great care. Introductions can often result in aggression, and it should be noted

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Adult males (six years and above) may be housed alone, but not in complete isolation (opportunities for tactile, olfactory, visual, and/or auditory interaction with other elephants must be provided)."



Steve Johnson, Riddle's Elephant and Wildlife Sanctuary

One private facility is currently maintaining male African elephants in a group, indicating that bachelor groups are feasible.

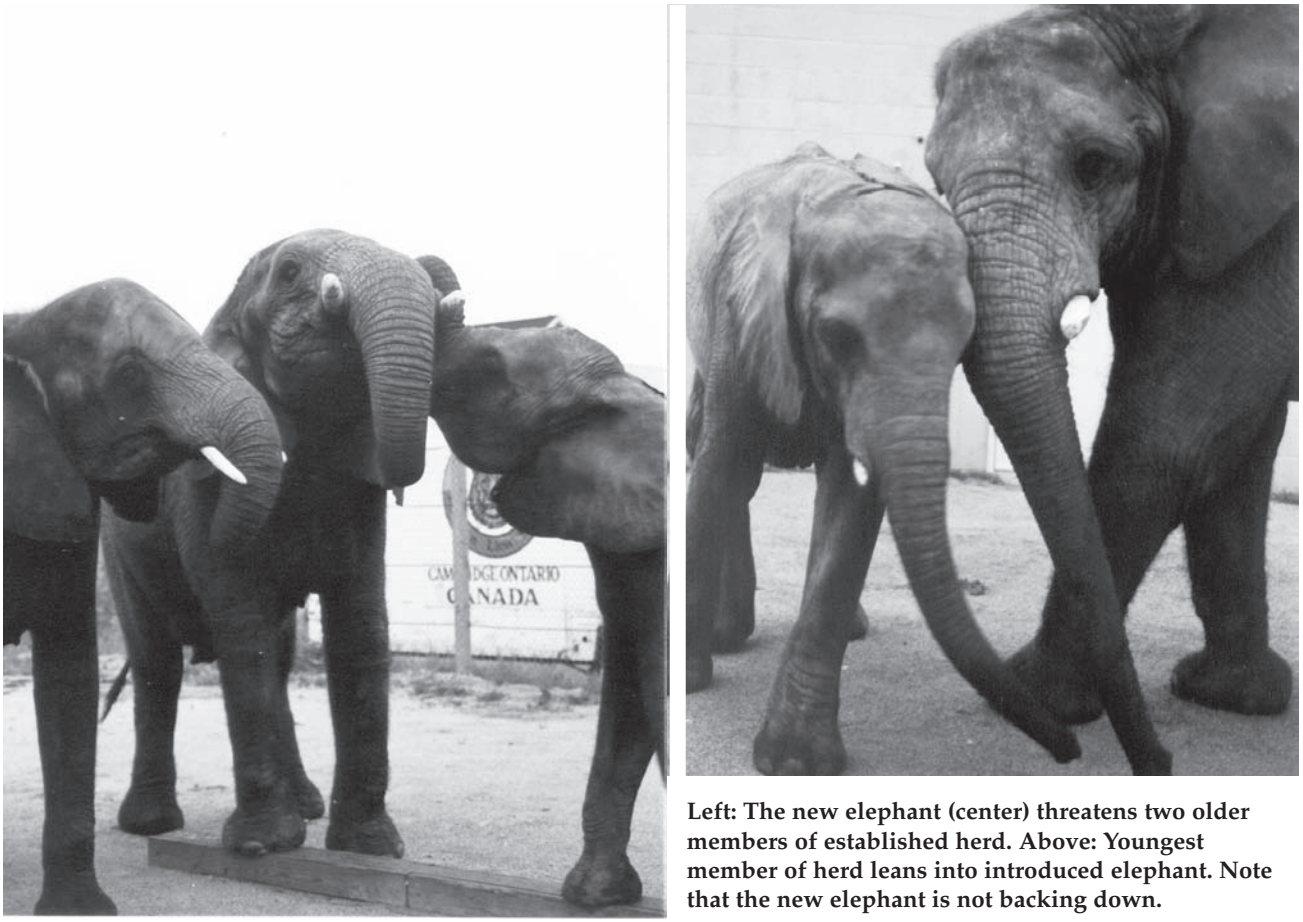
New Elephant Introduction

Deborah Olson, Indianapolis Zoo

Top left: Introduction of a new herd member—without barriers—should be done very carefully and under the supervision of handlers. Center: The youngest member of herd (left) shoves new elephant. Left: The new elephant responds with mild threat gesture.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Staff must be aware of each animal's social compatibility and the dominance hierarchies of the herd."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Institutions must have the ability to manage social compatibility as well as dominance and aggression among an elephant group."



Deborah Olson, Indianapolis Zoo

Left: The new elephant (center) threatens two older members of established herd. Above: Youngest member of herd leans into introduced elephant. Note that the new elephant is not backing down.

that elephants of both sexes have been the aggressors. Variables that must be considered in any introduction include individual animal personalities, staff experience and confidence level, enclosure type, and the facility's elephant management protocol.

Circumstances will vary with the age of the elephants, prior experiences, and herd cohesiveness, but proper introduction procedures can minimize injury from conflict and aggression. Introductions may be uneventful with all elephants immediately accepting each other. This frequently occurs when there is a large disparity in size between the elephants or there is a significant difference in the personalities of the individuals involved—one clearly dominant and the other without apparent concerns about its position in the group. This also frequently occurs in herds of elephants habituated to a changing group composition as in circuses, private facilities, and active breeding programs where the male is used to service females outside of the institution.

Aggression can be exhibited in ritualized confrontations, in which two elephants approach one another with head held high and ears flared but stop prior to any contact. Aggression can be exhibited in subtle behaviors that show dominance such as placing the head and trunk on or over the head and back of the other elephant, physically displacing an elephant, and/or grabbing the other elephant's trunk and not releasing it.

More intensive conflicts may involve head butting, kicking, trunk swatting, forceful physical displacement, tail-biting, head-on charges, and the infliction of injuries by tusking or ramming. This can continue until one elephant becomes submissive and turns its rear to the other. It is important to note that elephants are extremely powerful animals, many times the size of humans. Taken out of context or compared in human terms, what is often perceived as serious or dangerous aggression between elephants can be normal behavior requiring no intervention of any kind. Along with the increased body size and thick skin comes decreased vulnerability compared with many other animals. Stopping an introduction too soon will not lessen aggression during subsequent introduction attempts. Elephants that are allowed to "settle their differences" will establish their roles within the hierarchy and will usually not engage in serious aggression again. An important aspect of any introduction is to know at what point to intervene to prevent aggression from reaching the point of injury to one of the elephants.

In some cases, continued aggression has been observed after one elephant has submitted to the other. At this point, elephant handlers should intervene to prevent serious injury. Guidelines for intervening will vary from facility to facility due to their elephant management protocols. Most importantly, the means of separation must be well understood by all participants in advance of the introduction.

Deborah Olson, Indianapolis Zoo

Introductions through barriers. Above left: Females sniff genital area of new elephant. Above right: The new member's mouth is explored. Left: Mild threats from both elephants. Below: Mild threat toward new elephant.

Some of the methods of separation that have been used have been as simple as calling each elephant to attention, to physically separating elephants with remote operating gates, or using noisemakers, water, fire extinguishers, etc. to distract the elephants.

All appropriate personnel should be present at the introduction with accessory personnel on standby. The elephant manager and enough qualified handlers, especially those most experienced and familiar with the elephants, should be present. The facility's senior officials should be notified. A veterinarian with medical and immobilization equipment must be available and on standby. It is strongly recommended that all observations be documented to increase the behavioral database and as a guide to others.

The introduction process requires much planning and cooperation. Elephant personality should be considered in all introductions. This is an excellent reason for keeping behavior profiles and histories on each individual elephant. From the elephant's profile, decisions can be made, such as the facility staff may choose to forgo or greatly reduce the quarantine period (see Transportation, p. 219), introduce the subordinate elephant to a more dominant elephant, introduce the new elephant to the most dominant elephant, or to the next most subordinate animal, and so on.

At facilities where the elephants are handled directly with no barrier between the handler and the elephant, the initial introduction can be controlled, and the elephants are prevented from causing serious injury to one another, though caution must be used so that staff safety is never put in jeopardy. Typical introductions of female elephants handled without a barrier may be similar to the following scenarios after considering the personality of the individual elephants and the hierarchy of the group. In each case the amount of handler observation time decreases as the elephants adjust to each other.

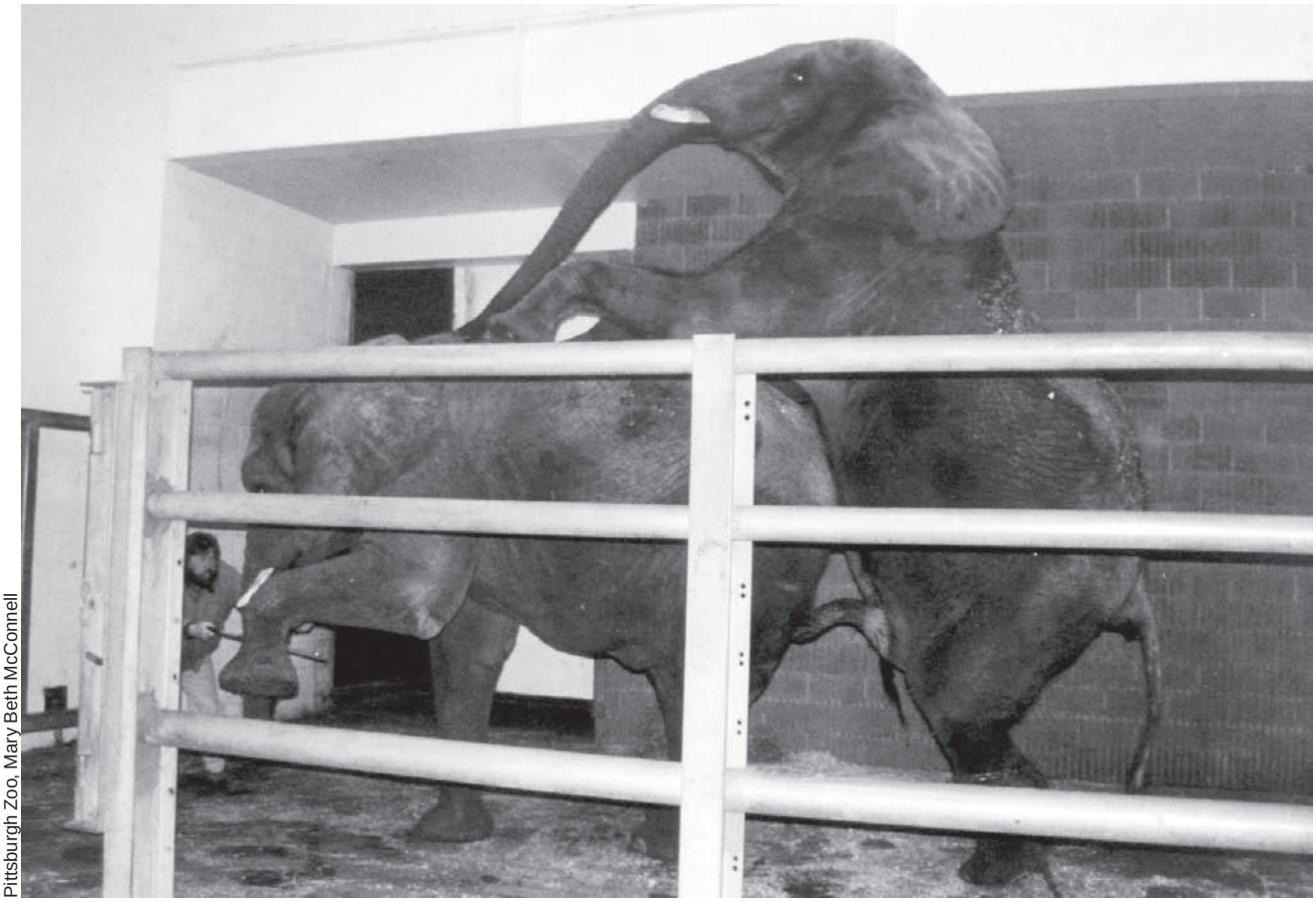
- Tether the new elephant next to another female. They should be close enough to be able to touch but not close enough to injure each other. The elephants will soon demonstrate their acceptance or lack of tolerance of each other. Inappropriate behavior should be controlled or eliminated by the handler.
- Elephants can be introduced in individual stalls where they can have visual and tactile contact. Again, inappropriate behavior should be controlled or eliminated by the handler.
- Without tethers or stall barriers, but under the control of the handlers, introduce the new elephant to one female at a time and allow the elephants to interact. Only positive interactions are allowed. As each subgroup becomes compatible, additional females can be introduced.
- Release both elephants into a stall or paddock, whichever area is best suited for this purpose, under close observation of the handlers. The handlers should be able to recall each elephant back under control if severe aggression would occur. At this time elephants are allowed to exert dominance and establish their hierarchy.
- Handlers work both elephants so that the elephants concentrate on the commands given and not on each other.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Institutions must have the ability to manage introductions and separations of a new female to a herd and, if the institution is a breeding facility, females to males for breeding, newborn calf to its mother, and calf and mother to the herd."

Elephant introductions at facilities at which elephant management protocol requires barriers between the elephant and handler can be more challenging. Female elephants should be introduced in individual stalls where they have visual and tactile contact. Sometimes elephants appear to realize that the other elephant is physically separated and can become more aggressive or antagonistic toward each other. This can cause problems when the elephants are eventually released together in the same space. For this reason caution must be taken in evaluating the success of each step, and introductions through barriers should not be too lengthy.

When confident that both animals are comfortable with the other, the elephants can be introduced to the same area. Because direct handler intervention is not possible in case of aggression, the actual introduction should be attempted in the area most appropriate to facility's situation, the elephant's personalities, and the plan of distraction and separation. The largest available enclosure allows for elephants to move some distance away from each other sometimes lowering aggressive interactions. In this case the area should be large enough to allow ample space for chasing, defense, and retreat. The enclosure should contain visual barriers as oftentimes elephants cease aggression if they are out of sight of each other. But in very large areas, elephants are prone to chasing one another for extended periods of time. Smaller enclosures with multiple doors and gates may be preferred in case the elephants need to be separated quickly. In both situations the enclosure should not contain dead-ends in which an elephant may become trapped by an aggressor.

Elephants that have been raised in isolation from other elephants have been integrated into herds. This integration has been and continues to be very difficult as the socially isolated elephants do not learn normal elephant social behavior and tend to exhibit inappropriate behaviors toward conspecifics. This lack of social learning causes the naïve elephant to react inappropriately to other elephants' advances often leading to aggression from the other elephants. This only exacerbates the problem. It is recom-



Pittsburgh Zoo, Mary Beth McConnell

Breeding elephants in a controlled situation. The female is under control of handler and the male is tethered by one rear leg.

mended that introductions of this type occur in facilities with elephant management protocols that allow handlers to work directly with the elephants without a barrier in between. But in any program, the individual elephant's interactions with conspecifics must be closely monitored and controlled.

The naïve elephant should be slowly introduced to the other elephants and allowed to interact with them as it feels comfortable. The handlers should not allow the other elephants to overwhelm or frighten the naïve elephant through too much investigation on their part. Over time as the elephant learns proper social behavior, the handlers should control the herd less and less so as to allow normal actions to occur. Ultimately, some socially naïve elephants may never fully adjust and be comfortable with conspecifics. In this case, it may be in the best interest and welfare of the individual elephant to be housed alone.

Although the experience of the captive community is limited in managing male elephants, it has been found that all males react differently from day to day, from musth period to musth period, from female to female. Therefore there is not "one way" to introduce male elephants to females, rather many ways, based on individual reactions of the bulls, observations of the handlers, and past experience.

The introduction of a female elephant to an adult breeding male is usually done with the elephant handlers behind a protective barrier, as direct handling of the male is not recommended. If the male is to be housed in the same enclosure as the females, the male should be introduced to the entire female group so his attention will be less likely to be focused on just one individual. For a female that has never been with a bull, the introduction should take place prior to her being receptive for breeding (see Reproduction, p. 123). Naïve cows are likely to be nervous by the mere presence of the bull and could become overly frightened by the bull's advances for breeding. It is important that she socializes with and is comfortable around him so that when she is in estrus she will be more likely to permit breeding.

Several facilities have observed that females that have a lot of experience with males, perhaps grew up around them, are more comfortable and receptive to male attention. This in turn may influence not only male preference but also problems with male aggression toward females. Increasing the exposure that immature females have with breeding bulls may be valuable to long-term breeding success.

If the male is housed with the cows only for breeding, the following strategy is an option. The handlers place the

Jerry Kucera, Six Flags Great Adventure

It is generally thought that females exposed to males on a regular basis are more comfortable with and receptive to male attention.

Jerry Kucera, Six Flags Great Adventure

A large group of females interacts with each other and a bull.

male elephant in a small stall or the elephant restraint device. The female elephant should be released in an adjacent area large enough for her to maintain a distance from the male if she is uncomfortable around him. The handlers observe the female elephant's reaction. If she appears frightened, the handlers continue this introduction process until she is more comfortable. If she is very interested in the bull and accepting of his advances, then she should be placed in a larger enclosure with which she is familiar. The bull is then released into this enclosure. The handlers should observe all interactions and be prepared to cause distractions if severe aggression should occur.

Generally, breeding behavior is observed in mature elephants during a two- to four-day period of the female's estrus. Estrus females do not exhibit visible physical changes, although behavioral changes have been observed including wariness of the male and a characteristic posture and gait. In the presence of a male, an estrus female typically holds her ears partly out, her head raised, and walks quickly swinging her head from side to side to look behind her. Female elephants may also solicit or demonstrate submissive behavior by backing up to the male.

Male behavior usually changes as he ages. Young males often will attempt to breed at any opportunity, whether the female is receptive or not. Some older and more experienced males show little interest in the female if she is not receptive. However, recreational breeding is also observed in adult male elephants. In all male elephants courtship behavior may include some of the following: chasing, pushing, raking manure from the anus; dominance activities, including head displays, threat displays, and tusking, and increases in flehmen activity directed at the genitals and urine.

Male courtship behavior can be very assertive. Typically, breeding activity begins with the male following the female with his penis erect or the penis becoming erect during the pursuit. Following becomes chasing and, depending on the female, can continue for a few minutes or indefinitely. At this point a successful copulation is dependent on the female stopping and standing still so the male can mount, or the male cornering the female forcing her to allow him to mount. In cases where the female won't stand, the male may get tired and stop the pursuit or become aggressive towards the cow.

Once the female stops, the male stands behind her. She may back up to him and allow him to mount, or he may position the female with his head and tusks and/or by kicking her hind legs. Using his head to help raise himself, he mounts the female with a full erection, placing his front legs on either side of her spine. The "S" shaped penis probes against the underside of the cow until it penetrates the vulva. Copulation takes from a few seconds to a minute. Once copulation is over, the female is joined by the other females in the herd. The entire group may become very excited. Trumpeting, roaring, defecating, urinating, increased temporal drainage, heads held high, and lots of physical contact are all a part of a post copulatory phenomenon known as mating pandemonium (Poole 1996). However, in some cases breeding takes place with no fanfare and can go unnoticed by the staff. The importance of routine blood analysis to monitor the cow's progesterone cycle cannot be overemphasized (see Reproduction, p. 123).

Copulation may occur every few hours or just a few times over the next two to three days. During this period the male usually stays within reach of the female. If facility design, weather, and the male's temperament permit, it is preferable to keep them together 24 hours a day over the period of courtship. This will maximize the number of copulations and ease the management of the bull. Separating the pair during this period can be difficult because the male often aggressively and vigilantly guards the female preventing her from shifting into an enclosure away from him. Once the male begins to allow some distance between himself and the breeding cow, the courtship is coming to an end.

Ethogram of Elephant Behaviors

To manage captive elephants effectively, it is important to describe their behaviors accurately. One useful tool is an ethogram—a list of the behaviors typically exhibited by individuals of a particular species. The following ethogram provides a comprehensive list of the elephant behaviors observed over many years by numerous researchers and elephant handlers. It describes the behaviors of both captive and wild elephants of both the African (*Loxodonta africana*) and Asian (*Elephas maximus*) species. Except in a few cases, the current version of the ethogram does not distinguish between behaviors exhibited by Asian or by African elephants. That distinction will occur in a future version. It is anticipated that the ethogram will be modified as the understanding of elephants' behavior improves.

The main purpose of the ethogram is to provide elephant handlers with a consistent, systematic set of labels for describing behavior. It is hoped that this ethogram will assist in communication among handlers at different facilities and will, therefore, improve the day-to-day management of elephants. It is important to remember that communication is multi-modal (Partan and Marler 1999; Rowe 1999)—for example, visual, acoustic, and olfactory signals may occur simultaneously. Although researchers often focus on one modality (visual, acoustic, etc.) to simplify their studies, this should be recognized as artificial.

A brief description of the terminology will aid in using the ethogram. Behaviors are defined using descriptive terms, to aid in identifying and remembering them. Behaviors have been categorized by the body part (e.g., trunk) or the physical activity involved (e.g., locomotion). The major categories are "Whole body", "Whole body—Locomotion", Ear, Foot, Head (and forequarters), Tail, Trunk, Tusk, and Vocalization. It is recognized that physically similar behaviors (e.g., head-shake) may occur in more than one context (e.g., reproduction, play). The ethogram uses "functional" descriptions of these contexts: Agonistic [Aggressive/Submissive] (A), Boredom/Anxiety (B), Comfort/Grooming (C), Exploratory (X), Foraging (F), Locomotion (L), Maternal/Nurturing (M), Play (P), Reproductive/(R), and Social Contact/Greeting (S).

Behaviors may be exhibited by a solitary elephant (a = alone), or in a group context (g = group), meaning within one body length [about 5 meters] of another elephant. The ethogram distinguishes between social behaviors (which are directed at another elephant) and behavior in a group (when one elephant is within one body length [about 5 meters] of another elephant but not interacting with it). For example, wallowing in the mud with another elephant less than a body length away would be "Wallowing" (Cg); eating hay alone would be "Eating Hay" (Fa). Running after another elephant would be "Pursuit" (A), a social behavior, since the behavior is directed toward another elephant. Social behaviors are indicated by reference to another elephant in the definition of the behavior. Behaviors may be unique to male (m) or female (f) elephants. Thus, "Erection" would be designated (mR) and "Nursing" would be designated (fM). Behaviors exhibited by calves, such as Suckling (cM), are designated with a "c." A calf is defined as an elephant below the typical age of weaning in the wild (4 years old). The term "animal" is used to refer to any species other than elephants.

The main sources for this ethogram are Abramson and Carden 1998; Adams and Berg 1980; Berg 1983; Chevalier-Skolnikoff and Liska 1993; Dale, Jordan, Noble, Beach, and Kinnett 2000; Douglas-Hamilton and Douglas-Hamilton 1975; Estes 1997, 1999; Friend and Parker 1999; Hawley 1994; Horwath 2002; Kahl, unpublished manuscript; Kahl and Armstrong 2000a, 2000b, 2002; Kuhme 1963; Langbauer 2000; Moss 1988; O'Connell-Rodwell, Arnason, and Hart 2000; Partan, Ortolani, Leong, Burks, Mellen, and Savage 2000; Partan, Watkins, Naelitz, Streeter, Burks, and Lehnhardt 2000; Poole 1996; Poole, Payne, Langbauer, and Moss 1988; Rasmussen and Krishnamurthy 2000; Riddle, Riddle, Rasmussen, and Goodwin 2000; Shyan 1994, 1995; Shyan and Barton, unpublished manuscript; Stoinski, Daniel, and Maple, 2000). See the reference list at the end of this section. *All photos by Robert Dale unless noted otherwise*.

Elephant Ethogram

1. WHOLE BODY

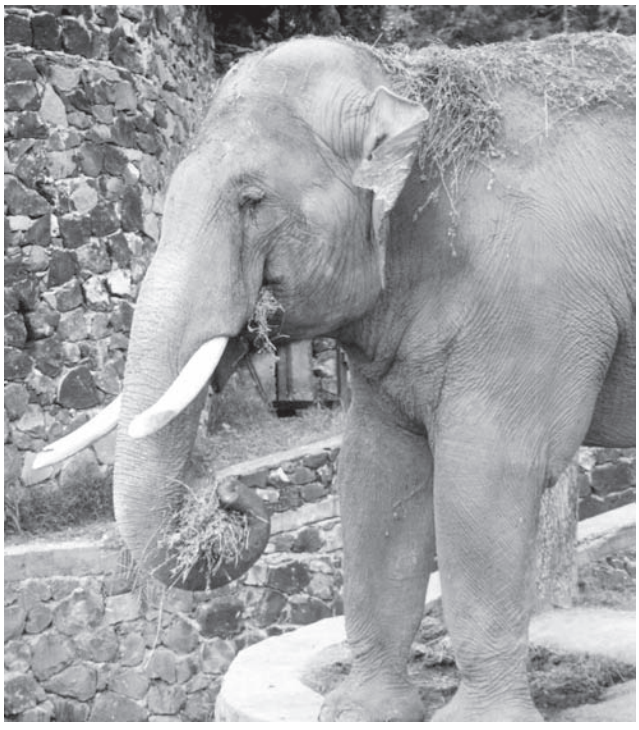
Behavior	*Definition*
Aggregation, Male	Loose associations with other males. (mS)
Aggression, Redirected	Aggressive behavior towards one elephant during an agonistic interaction with another elephant. (A)
Alert Posture	Standing with the head raised, ears spread, tail raised, trunk raised or turned in a "Sniff" position. (X)
Allomothering	A non-maternal female "baby-sits" a calf. That is, performs the

Allomothering.

	behaviors typical of a mother. (fM)
Back Arch	Seen in Asian elephants. Possible indicator of fear. (A)
Bathe	Standing, lying in deep water. (C) (P)

Bathe.

Blocking (Resource Holding)	Stationary elephant places its body between a resource, typically food, and an approaching elephant. Resource holder usually turns its rump toward the approaching (or dominant) elephant. (A)
Body Hoarding	Storing food on top of body, then eating the food.(Fa)



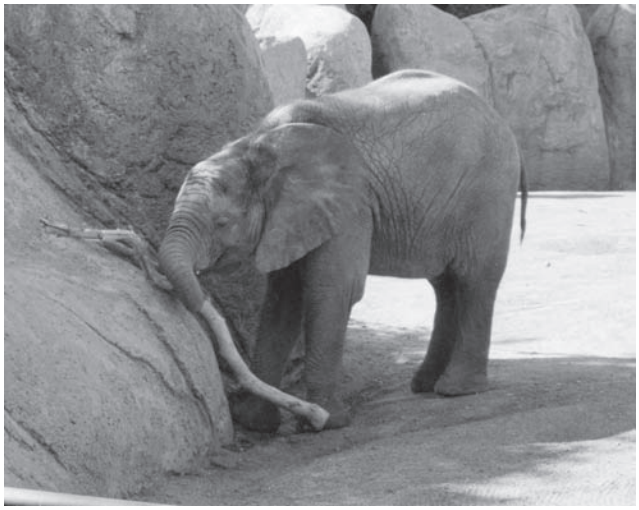
Deborah Olson, Tuluca, Mexico

Body hoarding.

Body Shake	Shakes body, apparently to remove dead matter or insect. (C)
Body Touch	Continuous head or body contact with another elephant, other than touching it with the trunk or tusks. (S)

Body touch.

Browsing	Eating branches, bushes, bark, other leafy plants. Includes intact plants and deadfall. (F)



Browsing.

Claim Food Rapid	Approach to another elephant, and pick up food within other elephant's reach, or in the other elephant's mouth or trunk, or on its tusks or body. (A)

Claim Location	Rapid approach to another elephant and displacement of another elephant from any location (target must move at least one body length). No physical contact. (A)
Claim Object	Rapid approach to another elephant, and pick up object within other elephant's reach, or in the other elephant's mouth or trunk, or on its tusks or body. (A)
Claim Wallow	Rapid approach and displacement of another elephant from the wallow (target must move at least one body length). No physical contact. (A)
Climb	Place at least two feet on an object, e.g., rock, tree or wall, above ground level. (P) (X)
Climb, Social	Place at least one foot on top of the head or body of another elephant (target is usually laying down). (P) (S)
Consort	Male, usually a male in musth, and an estrous female form a temporary relationship - each member of the pair maintaining close proximity with the other. (R)
Copulation	Successful mating. Penetration maintained for at least 15 seconds. (R)
Covering	Push/pull a calf under the adult's belly. (fM)
Cross Legs	Crosses one hind-leg in front of the other while standing. The "crossing" leg often does not touch the ground. (C)
Crouch	Elephant has its front legs extended forward (straight legs) and its back legs bent (kneeling). (C)
Defecate	Discharges dung: Bolus or loose stool. (C)
Defense, Group	Group (usually a breeding herd) gathers together in a tight cluster—usually with calves in the center—with adults facing outward or toward the perceived threat. (A)

Digging.

Dig	Stab tusks into ground. May also use trunk and foot movements. (F) (X)
Driving	Uses Head, tusks or trunk to push the rear of another elephant, maintaining contact while both elephants move at least one body length. (A) (P)
Ducking-for-cover	A calf moves underneath an adult's belly, or under its chin. (cA) (cB)

Ducking-for-cover.

Dunking	In deep water, climbing on or mounting another elephant so that the other elephant is pushed under the surface. May include tusking. (A) (P)
Eating	Eating hay, pre-cut browse or another elephant's dung. (F)
Eating Minerals (Pica)	Eating mud/dirt/sand/stones/salt. (F)

Erection	Penis extended from sheath and erect. S-shaped. (mR)
Flatulence	Passing gas, often with an audible sound. Behavior correlated with the ingestion of "protein rich" grasses and other foodstuffs. (C)
Flinch	Cringing or pulling away from another elephant's exploratory behavior. (A)
Freeze	Suddenly motionless, head elevated. Sometimes with a forefoot raised and still.(A) (B)

Freeze, listening.

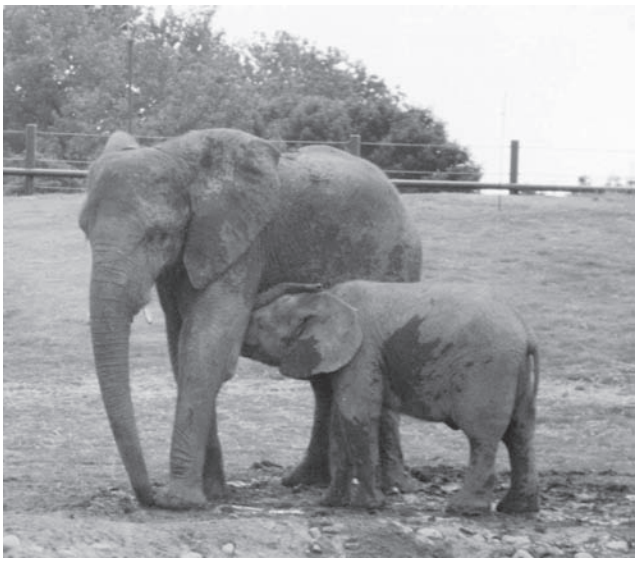
Freeze, Listening	Suddenly motionless, head elevated, ears extended. May rotate head side-to-side slowly (Head Scan). (S) (X)
Grazing	Eating long-stemmed plants, grasses. (F)
Greeting Ceremony, Intense	Reunion of elephants within the same family unit, or familiar family units. Gathering together, spinning, urinating defecating, temporal gland secretions, clicking tusks, rumbling, touching, Ear Flap, Ear Fold, Ear Raise and Ear Spread, trunk entwining, back toward, roar, scream, trumpeting. (S)
Greeting, Male	Trunk contact, smelling, sparring, and rumbling. (mS)
Handler Interaction	A handler is within one body length of an elephant, or the elephant is receiving commands from the handler. (S)
Intervening	Place own body between an aggressor and a target. Typically exhibited by the Matriarch/dominant elephant. (A)
King-of-the-Castle	Elephant climbs onto another elephant, often while the second elephant is laying down or wallowing. (P)

Anita Schanberger, Houston Zoo

King-of-the-castle.

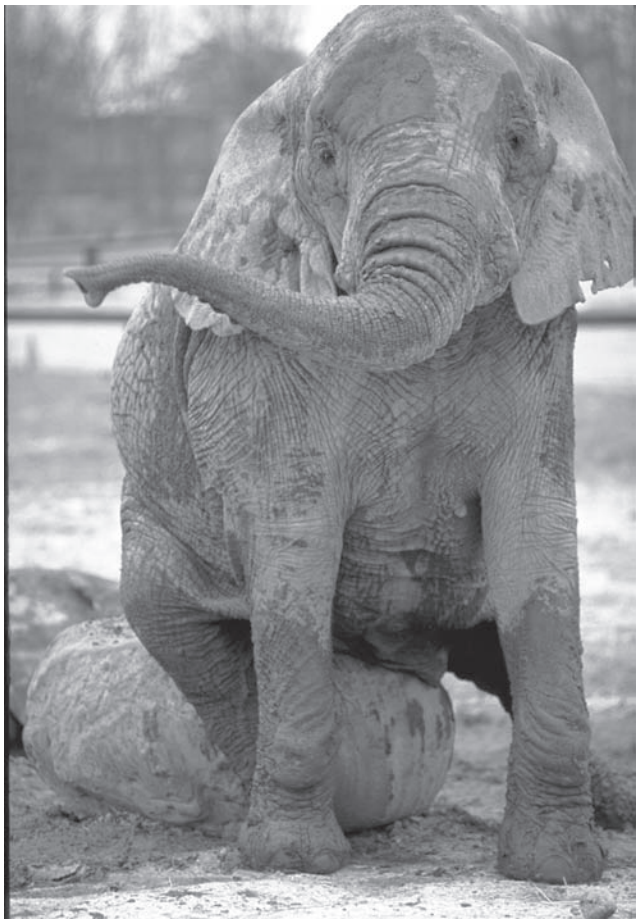
Kneeling	Kneeling on the forelegs in response to the approach or behavior of another elephant. The posture also occurs while grazing on a steep slope. (A) (F) (P)
Lift (companion)	An elephant lifts, and often supports, a prostrate or injured conspecific with its trunk, head, feet, and/or tusks. The fallen elephant may be alive or dead, and a calf or an adult. (S)
Loitering	Standing in an exhibit within two body lengths of the gate to the barn (or transfer yard). Must remain near the gate for at least one minute. (B)
Look Back	Turning head to one side to look behind over its shoulder, then switching sides and looking back over the other shoulder. Occurs while stationary and while walking away from another elephant. (A) (B)

Masturbate	Rub genitals on a tree, rock, etc. (R)
Mount, Mating	Male places his trunk lengthwise on the female's back, rests his head and/or tusks on her rump, and rears up on his hind legs, with his feet on either side of her spine. He sinks down slightly and hooks the tip of his S-curved penis into the female's vulva. Copulation lasts about 45 seconds, with little or no pelvic thrusting. An ejaculatory pause is noticeable. (mR)
Mount, Non-mating	One elephant mounts another from behind (all sex combinations). Possibly a dominant behavior, or a form of masturbation. (A) (P) (R)
Nudge	Gentle head-to-head, head-to-body, or body-to-body contact initiated by one elephant toward another. (S)
Nursing	Mother stands for calf to suckle. (fM)



Nursing.

Nursing, Reject	Adult female does not move a foreleg forward in response to nursing solicitation by a calf. The adult may move her front leg back to block access to a teat when the calf attempts to suckle. (fM)
Nursing, Request	Calf pushes against a foreleg, teat or chest region of an adult female elephant. (cF)
Orienting Response	Turn head, or head and body, to face a stimulus: event/object. (X)
Penis Syndrome, Green	Penis takes on greenish appearance from constant discharge of urine (Urine Dribble) during musth. (mR)
Pillowing	Laying down on object, grass, browse, etc. (C)
Pivot	Elephant rotates its body at least 180 degrees on a central axis. (P)
Push	Head-to-head, head-to-body or body-to-body forceful contact that results in the target elephant moving. Not using tusks. (A) (P)
Ramming	Aggressive, hard contact with head, trunk, or tusks. Usually, more than one contact. (A)
Relinquish Food	Giving up food to another elephant. Not "defending" the food when another elephant approaches. (A)
Relinquish Location	Moving away from a location within 30 seconds of the approach of another elephant. (A)
Relinquish Object	Giving up an object to another elephant. Not "defending" the object when another elephant approaches. (A)
Relinquish Wallow	Giving up a wallow to another elephant. Not "defending" the site when another elephant approaches. (A)
Rub	Rub head or body against a wall, rock, tree or other large object. (C)
Rub, Social	Rub Body or Trunk against another elephant's body or trunk. (P) (S)
Rump Present	Estrous female backs her rump under the chin of a male, then stands still. (fR)



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Rub.

Sharing food.

Rump Present, Non-mating	One elephant pushes its rump under the head/tusks of another elephant. Possibly a submissive behavior. (A)
Scouting	Sitting on haunches or standing on rear feet, extends head and shoulders above water: Usually with both ears flat against the sides of the head. (X)
Sharing Food	Eating from the same food pile, simultaneously. (F) (S)
Sharing Object	More than one elephant simultaneously handling the same object (e.g., rope or tree branch). (P) (S)
Shepherding	Pushing or supporting a calf by touching it gently with the trunk, tusks, foot or tail. (fM)
Sleep/Rest-Laying	Laying on one side, with no movement. "Sleep/Rest" is used because we currently have no reliable means to distinguish sleep from resting, or to distinguish between different types of sleep. (C)
Sleep/Rest-Leaning	No movement, eyes closed, trunk still. Leans against an object, often with the hand (trunk tip) on the ground. (C)
Sleep/Rest-Standing	Standing still, usually with eyes closed. The trunk may be still, and the tip (the hand) may be lying on the ground. (C)
Soliciting	Sits on own rump, throws head back and performs a Trunk Curl. Often used to attract another elephant to play. (P)
Sparring	Head-to-head contact between two elephants. Pushing trunks, tusking, shove, wrestle or Trunk Entwine with another elephant. (A) (P)
Spinning	An elephant rotating its body in circles around a central axis. On land or in the water. (L) (P)
Stretch	Adult elephant supports itself on its "knees", with rear legs extended back and front legs extended forward. (C)
Stretch & Rock (Labor)	Female in labor stretches the front legs forward and kneels on the rear legs, rocking back and forth. (fR)
Submerging	Diving underwater, with only tip of the trunk and, sometimes,

	the shoulders or rump above water. (L) (P)
Sway - Body	Move body side to side repeatedly. Usually with all four feet on the ground. May lift one forefoot at a time. (B)
Swim	Moving in the water without touching the bottom of the pool/pond. (L)
Uprooting	Pushing trees over. May involve head, trunk, tusks and feet. (F)
Urinate	Passes a stream of urine. (C)
Urine Dribble	Penis in sheath. Urine dribbles continuously from penis. Strong odor. In musth males. Flow rate varies. Often rear legs are wet. "Green Penis Syndrome" may appear. (mR)

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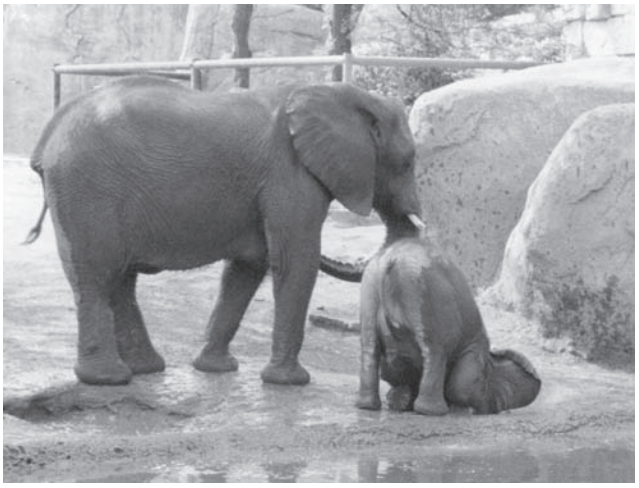
Urine dribble.

Wallowing	Laying down and wriggling in mud, dirt or sand. (C)
Wariness	Heightened alertness, eyes wide open, wary of touch by male, glances at others. Occurs during estrus. (fR)
Water Play	Various behaviors, such a swimming, splashing, skimming, submerging, head lifts. Also, a variety of solitary and social behaviors seen on land. (A) (P) (S)



Wallowing.

2. WHOLE BODY—LOCOMOTION

It is important to distinguish between a "Walk" and a "Run":

Walk (Definition): Moving at a rate of 5–9 km/h with a walking gait, as defined for horses. For quadrupeds, this walk is also referred to as a "lateral sequence" walking gait or an amble. For example, first the rear left foot moves forward. As the rear left foot reaches the position of the front left foot, the front left foot lifts and moves forward. As the front left foot is placed down, the rear right foot is lifted and moves forward. Just as the rear right foot reaches the position of the front right foot, the front right foot is moved forward. As the front right foot is placed on the ground, the rear left foot is lifted again and moves forward (cycle repeated). Head held in "normal" middle position. No trunk swing, no swagger or bounce to the walk. (L)

Walk.

"Run"—Definition Walk at a rapid pace (more than 10km/h–up to 40km/h). Not a true running motion because all four feet are never off the ground at the same time. (L)

Advance Toward	Walks toward another elephant. (A) (S)
Back Away	Backing away from another elephant. (A)
Back Toward	Approach another elephant (or group) rump first. Sometimes extending the tail to touch another elephant. Orientation may be backer's rear to targets head, side or rump. (A)
Back Up	Animal moves backward, rear first. (L)
Casual Walk	Male approaches female(s) "casually", with head low and trunk draped over a tusk. (mR)
Charge, Group	Group (usually a "breeding herd" led by a matriarch) approaches a target quickly but halts about halfway to the target. Often with trumpeting, head and ear movements. (A)
Charge, Mock	"Run" toward another animal or an object (e.g., car, train, human, birds) with ears extended, head and tusks high, tail extended and (sometimes) trunk extended. Charger does not follow through, but stops short of contact with target, and often trumpets. Also occurs as a social behavior. (A) (P)
Charge, Real	Rapidly approach another animal with trunk tucked under head, head up, and Chin Tuck. Attempts to contact target. Often a "silent" charge, without trumpeting. Ears usually close to the head. Often has an Ear Fold. (A)
Chase	A male, usually with an erection, runs after an estrous female. The female usually runs in a wide arc and returns to the family unit. (R)
Crawl	Walking uphill on the "ankles" of the front legs, but with the rear legs fully extended. (F)

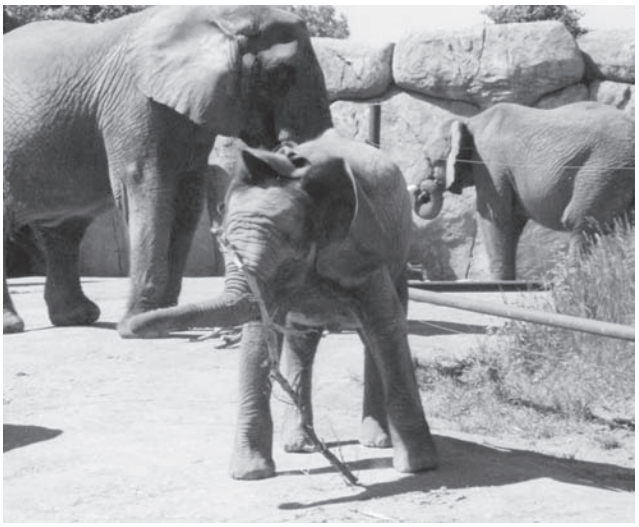
Follow.

Estrous Walk	Rapid walk, avoids male, leaves herd, head high, looks back over shoulder toward pursuing male, makes wide arc in returning to herd. Occurs during Estrus. (fR)
Exaggerated Walk	Exaggerated head movements up and down in rhythm with normal walking speed. Trunk swings side to side more than with normal walk.
Flee	Rapid retreat from an approaching elephant. "Run" rather than walking pace. (A)
Floppy Run	A loose-jointed running. Head is low, with the trunk and ears flapping around. (P)
Follow	Walks along the "path" of another elephant. Both elephants moving and the distance between animals is almost constant. Separation is usually only a few body lengths. (A)
Musth Walk	Walking with head held high, chin tucked. "Self-confident" strut. Occurs during musth. (mR) (Sometimes ears spread?)
Pace	Walks over the same path repeatedly, usually with stereotypical movements. The path that is repeated is often circular, but need not be. (B)
Parallel Walk	Two or more elephants, usually bulls, walk in the same direction at the same speed. They are

	typically separated by about two body lengths. (mS)
Pursuit	One elephant runs after another. The pursuer is attempting to reduce the separation between animals. The elephants may be moving at a fast walking pace. (A)
Retreat	Walking away from the approach of another elephant, usually looking back over its shoulders—alternating shoulders. (A)
Side Step	Walking sideways by crossing over feet ("half-pass").
Sidle	Approach another elephant by moving sideways. (S)
Stalk	Follow another elephant, usually displacing it without reducing the distance between animals. Sustained displacement. Following the target elephant at a constant distance without contact. (A)
Submissive Approach	Walk toward another elephant with head lowered. (A)
Turn Away	Turning away from an approaching elephant. May lower head. Often followed by "Retreat". (A)
Turn Toward	Turning toward another elephant, and approaching while head nodding with the ears half spread. (fA)
Wading	Walk in water with water surface below shoulders. (L) (P)
Withdraw	Move away, calmly, from a stationary elephant. (L) (S)

3. EAR

Ear Extension	Ears fully/partly extended, no other posture change, casual behavior. (C)
Ear Flap	Flapping ears once or rhythmically, usually slowly. Threat display, for cooling or to remove insect/dead matter. (A) (C)



Ear flap, rapid.

Ear Flap, Rapid	Repeated, fast waving of both ears. (fA)
Ear-Flap-Slide	Ears spread, slapped firmly against head and neck, then slid down with a "rasping" sound. Occasionally may slide ears up. (S)
Ear Flatten	Ears pressed close to head and neck, usually by a threatened or submissive elephant. Edges of ears may touch above the head.(A)
Ear Fold	Ears extended. Horizontal fold or crease across the middle of each ear/pinna. May be brief or prolonged. (A)
Ear Lift	Ears slightly elevated, no other posture change, casual behavior. (C)
Ear Secretion	Release a mildly acidic aqueous fluid from the ear hole. (S)
Ear Spread	Extends both ears perpendicular to head. Some Ear Spreads are partial, with the ears extended at an angle less than 90 degrees from the head. (A)
Ear Wave	Usually, involves only one ear at a time. Ear forcefully extended perpendicular to the head. Inner and upper portion is thrown forward vigorously,

	while outer and lower portions follow. Only in musth males. (mR)

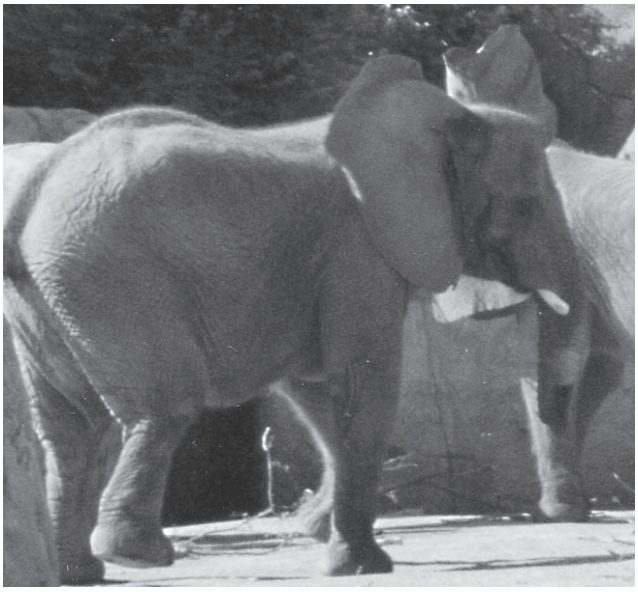
4. FOOT

Crush [Foot]	Step on a small animal (e.g., bird) or object (e.g., pumpkin) with a forefoot. With an object, the foot may be pressed down slowly until the object breaks. (A)
Kick	Kicking at another elephant with front foot or rear foot. Kick may be to front with the front foot, to the side or to the back, with the back foot. (A)
Kick Dust	Kick dust forward with a foreleg. Often directed towards an "opponent", after moving forward. (A)
Kick Food	Kicking or scraping grass, plants, mud, dirt or other material with feet to break it up for eating. (F)
Pawing	Kicking or scraping dust or dirt backward/behind the elephant. May occur as an aggressive behavior, or during digging. (A)
Step on Trunk	An elephant, usually a young calf, "gingerly" steps on the tip of its trunk (hand). The contact is systematic and cautious, rather than accidental and clumsy. The calf appears to be examining its own trunk. (cX)
Stomp	Forefoot stamped on ground during a mock charge, with no object nearby: Possible seismic communication. (A) (S)
Swing [Foot]	Standing still. Lift front foot 10-30 cm and swing it front to back. Usually repeated several times. (B)
Swing [Foot], Stationary	Standing still, holding one forefoot 10-30 cm above the ground. Holds position for more than 10 seconds. (B)
Touch [Foot]	Touching or rubbing any object with a foot (usually a forefoot). (X)
Trampling	Stepping on growing browse or underbrush, breaking it up. (F)

Touch [foot].

5. HEAD

Bite	Bites another elephant's body or tail. (A)
Bow Neck	While charging, an elephant lowers its head and tilts the head upward so that tusks remain horizontal. (A)
Butt [Head]	Strikes or pushes another elephant with the head and/or a curled trunk, but not with tusks. (A) (P)
Chin Tuck	Head raised, chin tucked under head (looks like an attack posture before a headstand). (A)
Dip [Head]	Head is lowered so that the top of the head is well below the level of the shoulders. A submissive posture. (A)
Drive	Use head to push the rear of another elephant. Continuous contact while the target moves at least one body length. (A)
Eye Foam	White foaming liquid forms on medial edge of both eyes. Appears after the elephant is excited for a while. Also appears in cold, windy weather. (C)
Head-shake (and Step)	The head is rotated up to 90 degrees and lifted to one side, then swung back forcefully to the other side—while rotating the head in the opposite direction. The side-to-side head



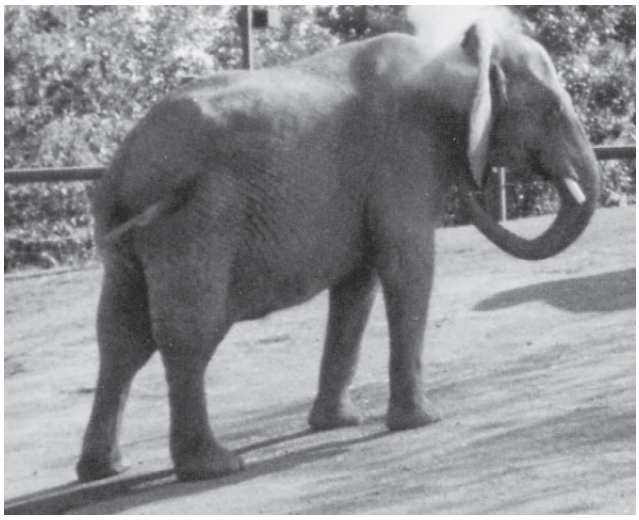
Head shake.

	rotation may be almost 180 degrees. Often, the head "dips" during the rapid rotation [see Head Dip] and ears slap (audibly) against the neck/ shoulders. May take a step sideways or forward in the direction of the Head-shake, because of the elephant's momentum. Often followed by a "Turn Away". (Ca) (Cg) (ADa) (ADg) (ASa) (ASg)
Headstand	Use forehead and/or top of base of trunk to press down on another animal. Tusking may, or may not, occur. Usually kneel on forelegs, or front leg extension. (A)
Marking	Rubbing temporal gland or side of head on objects, trees, or the ground. (A) (S)
Mouth - Chew	Moving its jaws in a chewing motion with non-food material in the mouth. Apparently, no ingestion of the material. (X)
Mouth Drinking	Take water directly into the mouth. Typically kneeling at water container's edge or standing in water. Common for calves. (cF)
Mouth-Exhale steam	The elephant emits a cloud of mist from its mouth while rumbling/vocalizing. The air temperature may be 65–70° F (18–21° C).
Nod [Head]	A quick "up and down" movement of the head. May be repetitive. (A)
Object Carry	Carry object with trunk, tusk, or on body (often hay or browse). Usually with trunk low. (X)
Object Toss-&-Retrieve	Throw object (usually browse or a stick), then retrieve the thrown object, often repeatedly. (P)
Olfactory cues	Chemical cues provided by volatile chemicals released from the temporal glands and in urine may provide cues in reproductive and agonistic situations, may advertise the general physiological state of an elephant, or may serve in kin recognition (Langbauer 2000: Rasmussen and Krishnamurthy, 2000). Since olfactory cues remain after the elephant that produced them has left a location, they are different from acoustic, haptic (touch) and visual cues in an important way. It is possible that secretions from the ear, from between the toes, and from dung also provide olfactory cues.
Oscillation [Head]	A combined Head Toss and Trunk Curl. Swing the head in a vigorous Figure-8 motion. May lift one foreleg, or both forelegs alternatively.
Scan [Head]	Slowly sweeping head horizontally from one side to the other, usually with ears extended. Usually while Freeze -Listening. (X)
Stand Tall	Faces another elephant, raises head above shoulder with tusks approximately horizontal. (A)
Temporal Gland Secretion	A watery, copious flow from temporal gland when an elephant is excited. (A) (S)
Temporal Gland Musth Secretion	Dark, viscous, smelly secretion from the temporal glands. (mR)

Temporal Gland Musth Swelling	Temporal glands conspicuously swollen during musth. (mR)
Toss [Head]	Raises and lowers head and trunk repeatedly, and throws trunk upward. Moves head in a Figure-8 pattern. Usually sitting on haunches. Often with a Trunk Curl. (Primarily by bulls in musth.) (C) (R)
Up [Head] - Water	In water. Head raised, trunk hangs straight down. Ears raised and pressed to head so that the upper edges of the ears touch one another. Usually orients toward another elephant in the water. (A)
Wag [Head]	Slight side-to-side head waggle, usually by a bull.

6. TAIL

Tail Raising	Tail held approximately horizontal (straight out) or curled to the side horizontally. (A) (C) (S)
Tail-Slap Self	Hit own body with tail. Probably to remove insect or other irritant. (C)
Tail Swat	Extending tail to touch or swing toward another elephant. Sometimes the tail is slapped against the other elephant. (A) (S)
Tail Swing	Repetitively swinging tail, and sometimes rump, from side to side.



Tail swing.

7. TRUNK

Bounce [Trunk]	Bounce or drag the "hand" of the trunk on the ground, usually with an audible "thud". (mA) (mR)
Bury	Cover dead animal (elephant or other) with foliage (hay, leaves, grass, browse). (S)
Bury Calf	Cover a live elephant calf with hay or browse. (fC) (fM)
Caress	Male lays his trunk along a female's back/neck; rests his tusks/chin on her rump. Also a male-male behavior. (mR)
Clean Object	Shake object in trunk or beat object against leg. Object is usually a foodstuff. (F)
Collect	Curling trunk around and gathering food. (F)

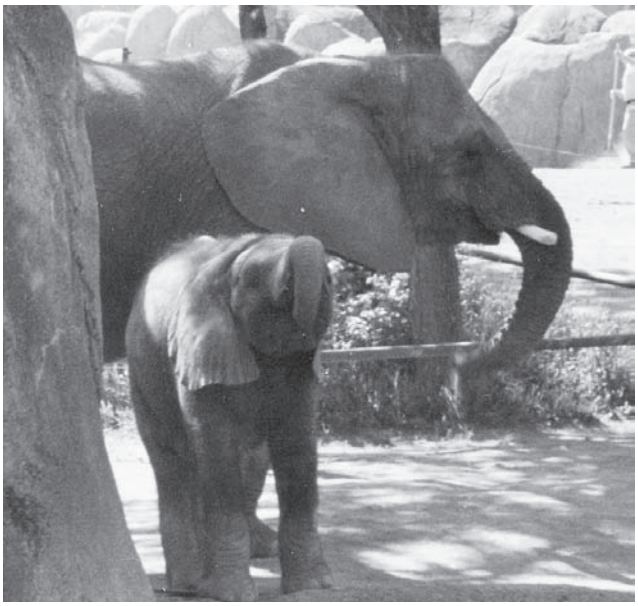
Collect.

Corral	Adult pulls or pushes a calf underneath its belly. (fM)
Curl [Trunk]	Throws trunk above head in a snakelike or writhing movement, then allows it to land on tusk(s) or forehead. Trunk often hangs on tusks. (A) (P)
Distal Frontal Attitude-Approach	While approaching another elephant, an elephant raises its trunk above its head and curls the tip toward the other elephant. Similar to a Periscope Sniff, except for context. (A) (X)

Anita Schanberger, Houston Zoo

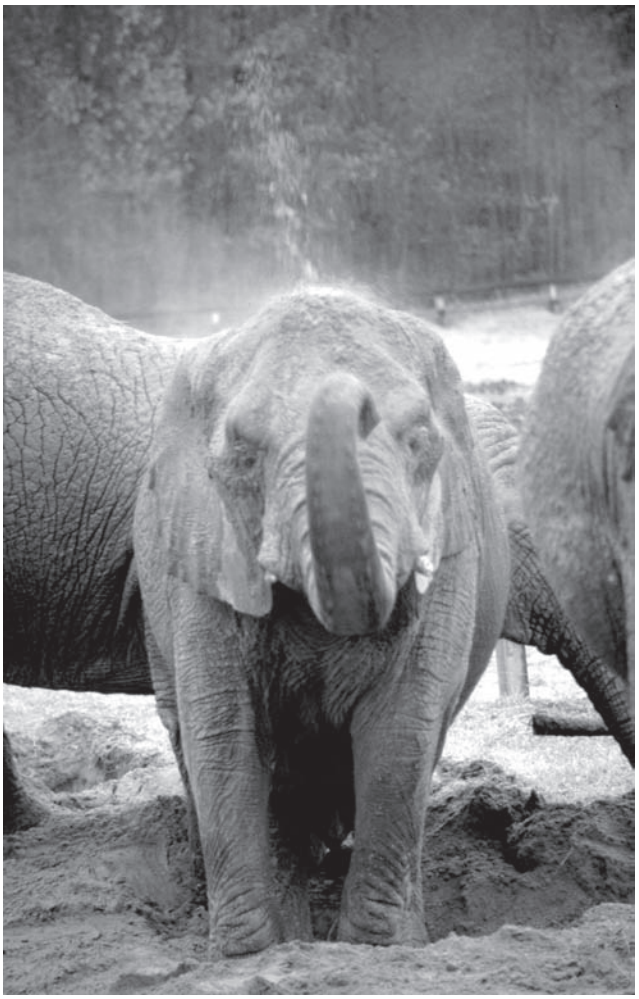
Distal frontal attitude-approach.

Distal Frontal Attitude-Contact	Placing the trunk on top of another elephant's head, with the two elephants facing one another. (A) (P) (R)
Drink-Cleaning Water	Moving the tip of the trunk back and forth on the water surface before drinking. (F)
Drink, Trunk	Draw water into trunk and then spray it into the mouth. Typical of adults and juveniles. (F)



Drink, trunk.

Drink-Urine, Trunk	Drink the urine of another elephant, either from a puddle or directly from the urine stream. (cF)



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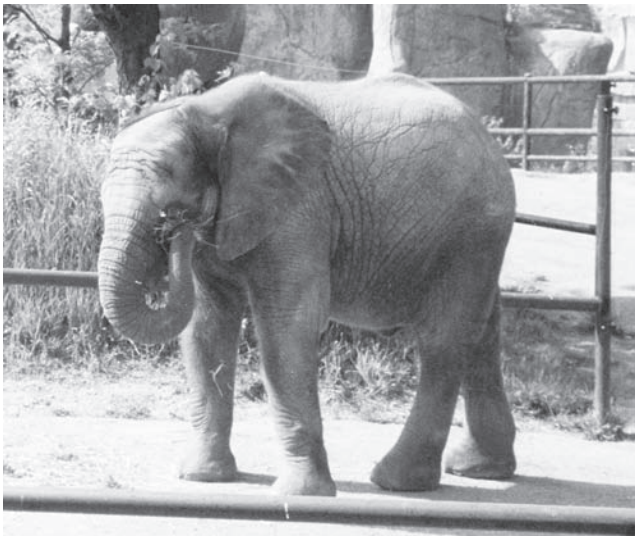
Dusting.

Dusting	Throwing browse, dirt, dung, hay, mud, or sand on self. (C)
Entwining	Two elephants wrap their trunks around each other's trunks. Also a social greeting. (P) (S)
Extension, Horizontal [Trunk]	Trunk extended straight out, tip flared. Sniff toward another elephant. Trunk tip close to target elephant. Trunk posture may be maintained for several seconds. A mildly aggressive movement. (A) (S)
Feeding , Exaggerated/ Displacement	Elephant picks up vegetation, as if foraging, but may not ingest it. Some aggressive behavior directed at bushes, vegetation, an object or the ground, usually during

	agonistic interaction with a dominant animal.(Aa) (A)
Flehmen	After sniffing dung, ground, object or urine, places tip of the trunk into own mouth. Passes air over the opening to the Vomeronasal Organ (VMO). Also occurs after social exploratory behavior to mouth, genitals, anus and temporal gland. (A) (R) (S) (X)
Flick [Trunk]	Flicks out trunk toward another elephant (or other animal) without contact. Trunk movement is to the front or the side. Also called a "forward trunk swish". (A)
Grasp Tail	Grab tail of another elephant with trunk. Two adults or mother and calf. (A) (fM)
Grasp Trunk	Grab the trunk of a calf with trunk. (A)
Grooming, Displacement	In agonistic context, exaggerated throwing of dust, grass, etc. on self. (A)
Hook Legs	A calf hooks or grabs its mother's leg (usually a rear leg) to signal the mother to stop. (cM)
Mooch	In non-dominant, or quiet, exchange, a non-dominant adult or a calf takes food from another elephant's food pile, body or mouth. The dominant animal (possessor) does not appear to react aggressively or defensively. (F)
Musth Wrinkle	A notch or crease that appears on the dorsal surface of the distal third of the trunk of males in Musth. (mR)
Object Display	Carry an object (e.g., hay or a stick) above the head with the trunk in a vertical or S-position. Trunk position similar to a Periscope Sniff. (P) (S)
Offering Food	Pushing food toward another elephant. (F) (S)
Picking	Using trunk tip only to pick up food. The last 30cm of the trunk is often called the "hand". (F)
Raking out	Removing feces from another elephant's rectum, then eating them. (F)
Reaching High	Trunk extended upward and forward at an opponent. Often done by a pursuer at the end of a Pursuit. (A)
Rest Hand	Elephant standing, laying the distal 30cm of the trunk on the ground. (C)
Rolling	Rubbing some material against the underside of the trunk. Makes a "ball" to put into mouth. (F)
Rub Self/Eye/Ear Hole	Use trunk hand (last 30 cm) to rub or scratch own skin, eye or ear hole. (C)

Rub self/eye/ear hole.

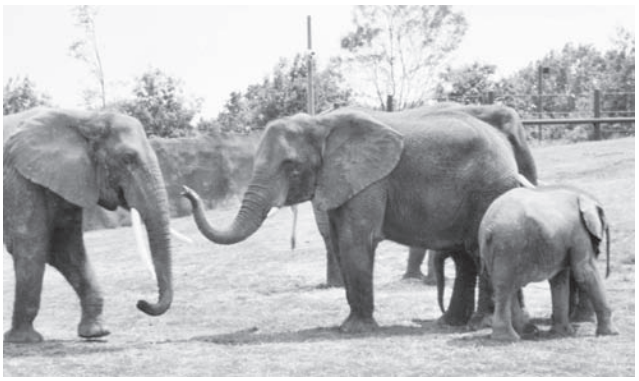
Scratching, Tool	Rub or scratch body with stick, branch, or hay held in trunk. (C)
Showering	Using the trunk to spray or throw water on self. (C)
Skimming	Sweeping the trunk across the surface of the water, with a sideways movement of the head, creating a wave and splashing water. (P)
Slap	Strikes another elephant (or other animal) with trunk. (A)
Slap Self	Flick trunk in and out and slaps own skin. (C)



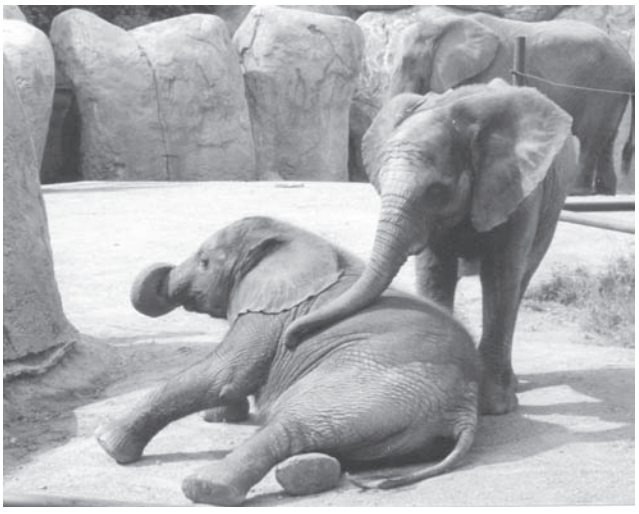
Scratching, tool.

Showering.

Sniff, Horizontal	Trunk extended straight out, tip flared. Sniff toward another elephant or sniff air. (A) (S) (X)
Sniff, J	Trunk extended down in "J" shape. Often curled over at tip. Sniff toward another elephant or sniff air. (X)
Sniff Object	Extend trunk toward object, trunk tip near the object. (X)
Sniff, Periscope	Trunk extended in "S" shape above head, or the trunk extended vertically, with only the tip/hand bent horizontally. Tip higher than elephant's head. Sniff toward another elephant or object, or sniff air. (X)
Splash	Striking the surface of water with the trunk, usually making an audible "smack" sound. (P)
Stroke	Moving the "hand" of the trunk back and forth on the body of another elephant (e.g., a sleeping elephant). (S) (X)



Sniff, J.



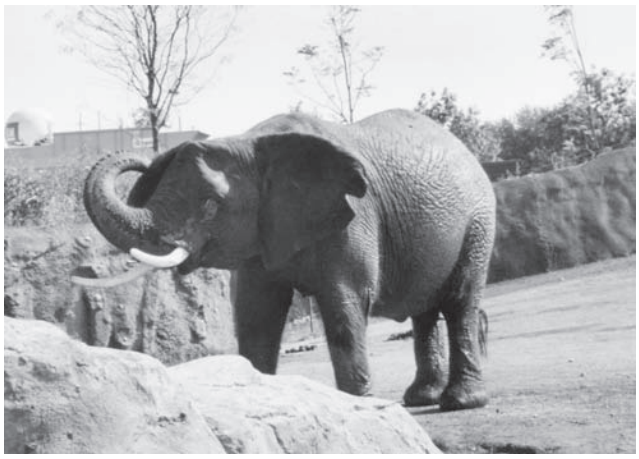
Stroke.

Suck (Own Trunk)	Place trunk in own mouth for several seconds or more. Not eating or drinking. Does not seem to be part of a "Flehmen". (C) (P)
Sway [Trunk]	Repetitively swinging trunk from side to side. (B)

Swing [Trunk]	Repetitively swinging trunk out/forward and back. (B) (C)
Switching	Slap branch or hay against skin. (C)
Test (Another Elephant)	Uses trunk to sniff and/or touch another elephant's anus, ear orifice, genitals, mouth, temporal gland or torso. (A) (F) (R) (S) (X)

Test another elephant.

Test Dung/Object/Urine	Sniffs and/or touches the dung or urine of another elephant with the trunk, or sniffs and/or touches the ground, water or an inanimate object. (A) (F) (R) (X)
Throw Debris	Throwing dirt clods, rocks, or branches toward an opponent during an agonistic encounter. The material is thrown "undertrunk", with the trunk tip starting low and ending high. (A)
Toe/Trunk collecting:	Using toe of foot and trunk together to remove food implanted in the ground. (F)
Tool Creation	Making a tool (e.g., a switch) used to manipulate the environment. (A) (F) (R) (X)
Tool Use	Uses an object (branch, rock, etc.) to manipulate the environment or for grooming. (A) (F) (R) (X)
Toss-and-Fetch	Elephant throws an object (e.g., a stick, a rope) repeatedly, each time retrieving it. Usually the object is thrown backwards, over the elephant's head. Occasionally, the object lands on top of the elephant's head or back, and may be left there for a number of seconds. (P),
Touch Self	Placing the trunk on one's own head, against one's own forehead/brow, ear or eye. Also touching one's own mouth, tusk, or the site of an injury. (A) (C)



Touch self.

Touch Temporal Gland	Rubs trunk on, or touches, one's own temporal gland. Often seen in musth males, or adult male or female elephants in—or just before—an agonistic encounter. (A) (C)
Trunk over Body	Placing the trunk on top of another elephant's body, usually from the side or from behind (unlike Distal Frontal Attitude). Resembles "Caress", which is a male-to-female courting behavior (A) (P) (R)
Trunk Wrestle	Two elephants wrap their trunks around each other's trunks, then pull and/or push one another. (A) (P)
Tug-of-War	Two or more elephants pulling at the same object with their trunk tips (hands). (P)
Twitch	Swings the trunk around erratically, with trunk tip usually remaining below the shoulder. A trunk "wriggle". (C)

8. TUSK

Click Tusks	Two elephants strike their tusks together—not very forcefully. Part of an "Intense Greeting Ceremony" or "Sparring". (A) (S)
Hoarding	Holding food between trunk and a tusk, then eating food. May eat other food while holding hay between the trunk and tusk. The material may be held between the trunk and the tusk to relieve irritation [Shoshani, personal communication]. (C) (F)
Stripping Browse	Stripping bark, branch, or leaf from tree or bush. Involves tusks and trunk. Log or branch may be placed on or against a support, like a rock or wall. (F)
Tusking Object	Striking the ground, dirt, a potential foodstuff, mud, or an object with the tusks. (F)
Tusking, Social	Pushes or strikes another elephant (or other animal) with tusks. Usually strikes the target elephant's rump. May be a forward strike of a "sideswipe" (A)

9. VOCALIZATIONS

Elephant sounds take a wide variety of forms, from flatulence to the vocalizations that have been analyzed in some detail by Judith Berg (1983), and by Katy Payne and her associates (e.g., Poole, Payne, Langbauer, and Moss, 1988). Before 1980, elephant sounds were divided into trumpets, screams, rumbles, growls, bellows, moans and roars. Since the use of sound spectrographs, over 30 African elephant vocalizations and about 10 Asian elephant vocalizations have been distinguished quantitatively. Even when vocalizations are acoustically similar, they may differ in function according to the social context. It is unknown the extent to which there are regional or population differences in "dialect" (Langbauer 2000). The following list of vocalizations and sounds contains some that have been analyzed in detail (e.g., Estrous Rumble), but the descriptions of many other calls—and their functions—are uncertain. Some vocalizations without objective descriptions (indicated by *) are listed in the hope that they will receive further attention by elephant trainers, elephant handlers, and elephant researchers. The data are listed separately for African and Asian elephants, since African elephants seem to have been studied much more thoroughly than Asian elephants.

African elephant (at least 30 vocalizations; many have an infrasonic component).

Alarm (Infrasonic, "Silent")*	No objective evidence that such a call exists.
Attack Rumble	Rare call made by female elephants in a group when they assemble in a pyramidal "attack" formation with the largest females in the front-center. (fAg)
Bark*	No description.
Bawl/Suckle Protest	Calf's high-frequency call, louder than a rumble. (cF) (cfA)
Bellow	A loud, fear or pain-related call. Made by male, female and calf. (A) (cP)
Blow	An air blast from the trunk. Air expelled audibly and/or visually (dust or grass movement) through the trunk. (C) (S)
Calf Response*	No description.
Coalition Rumble	Call by a group of females. May be a low-intensity "Attack Rumble". (fS)
Contact Answer	Abrupt low-frequency call that starts as a loud call, then becomes softer. Often occurs right after a "Freeze, Listening". (cS) (fS)
Contact Call	Call allowing contact with distant elephants (elephants usually not visible to one another). Low-pitched rumble is soft unmodulated call with fundamental frequency of about 15 Hz. Call made by juvenile and adult females. Often accompanied by steady ear flapping. (cS) (fS)
Cry, Gruff*	No description.
Discussion Rumble*	Female call. No description.
Distress Call (SOS)	A high-frequency distress call usually made by calves encountering difficulty (e.g., unable to climb over a barrier). Usually a short call, 0.5s, with a fundamental frequency of about

	650 Hz. Call duration about 0.25s–2.0s. Also referred to as a "squeal", a "scream" or a "roar". Described as a "loud, hoarse, squeaky-door cry". (cA) (cS)
Estrous/Mating Rumble	Pre-copulatory, copulatory or post-copulatory call made by a female in estrus. Loud, low frequency, long pulsating rumbles made repeatedly for up to 30 minutes. A low-frequency modulated call, with the fundamental frequency rising from 18Hz to 35 Hz, then declining back to 18 Hz. (fR)
Female Chorus	Female group response to musth rumble (?) or mating activity by a member of the family unit or group. Low-frequency, modulated call with fundamental frequency rising from 15Hz to 24 Hz and then falling back to 15 Hz. (cfRg)
Female-Female Dominance Rumble*	No description.
Genital Testing Call	Call by female when another elephant does a "Trunk -Test Genitals toward the female. (fR)
Greeting Rumble	Vocalizations associated with intense greeting rituals. Seen with family units (females and calves), not with adult males. A modulated, low-frequency call with a fundamental frequency rising from 18Hz to 25 Hz. Call may be repeated for up 20 minutes. (Sg)
Groan*	No description. (mA)
Grunt*	Calf call. No description. Apparently, refers to a wide variety of sounds. (cB) (cP) (cS)
Honk*	No description.
Humming	A soft vocalization made by a mother to her calf. No other description (mM) [Moss 1988, p. 162]
"Let's Go" Rumble	Female elephant (usually the Matriarch/Dominant elephant) signals herd to move. Low-frequency, unmodulated call. Fundamental frequency about 15 Hz. Often simultaneous with, or followed by, an "Ear Flap Slide". (fS)
Lost Call	A low frequency call made by calves. A calf may start with a low intensity call, then repeat the call at progressively higher intensities. (Sometimes called a "Scream"). (cS)
Male-Male Dominance Rumble*	No description. (mA)
Mating Pandemonium	Loud vocalizations by excited females (and possibly juveniles of both sexes) in a group after a member of the group has mated. Described as various sounds, including, Scream, Trumpet, and "rumbles". (cRg) (fRg)
Moan*	No description. (mA)
Musth Rumble	Musth-male specific call. Deep throated, guttural and "bubbly" vocalization. Loud, low (15 Hz) fundamental frequency. Pulsating call lasting 5–10 s. Often occurs with Ear Wave. (mA) (mR)
Purring	Long, soft rumble.
Reassurance Rumble*	No description (fAg) (cAg)
Scream	Loud call heard when a submissive animal is threatened or attacked. Also produced by an excited elephant, or elephants. (fAg) (cA)
Scream, Newborn	A "non-specific" call made by calves during the first few days of life. Described as a "hoarse growl". (P) (S)
Snort	A high-frequency fear or surprise-related call made by calves and females. (cfA)
Social Rumble*	No description. (fSg) (cSg)
Suckle Cry	Sound made by calf just before, or during, suckling. High frequency, unmodulated sound: Fundamental frequency about 500 Hz. (cF)
Suckle Distress Scream	Sound made by calves when

	suckling is interrupted. A high frequency call: Fundamental frequency rises from 600Hz to 750 Hz. (cF)
Trumpet	Loud, high frequency, pulsating sound. Fundamental frequency about 600-700 Hz. Also called "play trumpet" or "social trumpet". (A) (P) (S)
Trunk Bounce Vocalization	A "thud" sound heard when the trunk is bounced on the ground. May be a combination of two sounds: The (hollow) trunk striking the ground and a sudden exhaling of air. (mA)

Asian elephant (9 vocalizations)

Boom (Trunk Bounce)	A snort with the tip of the trunk bounced on the ground. In Asian elephants, occurs as part of a "Trunk Bounce". (mA)
Chirp	Multiple short squeaks. (A)
Growl	Rolling growl. (S)
Motorcycle	Answer to "Roar". Loud growl with changing pulse rate.
Roar	Pulsating sound. Loud growl. (S)
Rumble	A resonant growl. (S) (R) (A)
Snort - Loud*	No description. (S) (R) (A)
Snort - Soft*	No description (S)
Trumpet	Pulsating sound. (S)

Reproduction

As of the writing of this manual, neither the Asian nor the African elephant populations are self-sustaining in North America. Due to the few elephants that are contributing to the current birth rate, the North American population faces a crisis. Acquiring replacement elephants from range countries to supplement the North American population can be difficult. Therefore it is necessary to increase breeding efficiency within the current population.

If elephant populations are to be maintained in North America, it is essential that reproductive rates are improved, and an aggressive breeding program including all elephant facilities is developed. Given the relatively long generation interval of elephants and the current aging population, the birth rate needs to be increased 7 to 8 percent annually. However, with success brings the challenge of providing holding space for an estimated 30 additional males of both species, or novel ways of preventing the birth of excess male calves (Wiese 2000).

The challenges facing elephant managers are daunting, consisting of both logistical and physiological problems. Major areas of concern are:

- too few breeding bulls available;
- transporting elephants for breeding is expensive and can be stressful for inexperienced elephants;
- elephants of both sexes often exhibit a lack of sexual interest;
- females are aging and experiencing problems such as uterine fibroids and uterine cysts that may interfere with conception;
- many adult bulls are questionable potential breeders; and
- a significant number of adult females are not cycling.

The success or failure of breeding programs will depend, in part, on using available technology to assess reproductive activity. The first priority is to increase the fecundity of captive Asian and African elephants using the

Oregon Park Zoo, Deborah Olson

Given elephants' long generation interval and the current aging population, the birth rate needs to be increased 7 to 8 percent annually.

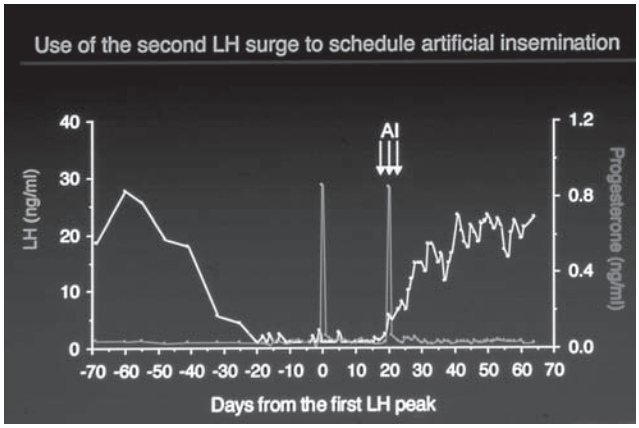
most efficient means possible. To meet this goal it is absolutely critical to be able to assess the reproductive status of individual elephants and develop a database inclusive from puberty to senescence. This information is important as a means of evaluating developmental parameters of individuals in the population, to assess if demographic changes are occurring, and to guard against unexpected pregnancies in very young animals.

Reproductive Monitoring of Female Elephants

Since the 1990s, a considerable amount of information has become available about the basic reproductive biology of elephants, especially females (Brown 2000). Because behavioral signs of estrus are absent without the presence of a breeding male, continuous hormone monitoring is the only way to conclusively determine the level of reproductive activity. This can easily be accomplished by measuring the concentration of progestins in urine or blood samples collected from an ear or leg vein on a weekly basis. If done properly, collecting blood samples poses no health risks to the elephant and can be incorporated into the routine management program. There are numerous examples of elephants bled regularly (daily and weekly) for years without adverse effects. The reproductive monitoring of all females throughout their lifespan is strongly encouraged because many adult female elephants do not cycle normally or may suddenly cease cycling temporarily or permanently. The banking of blood and its products does more than provide a source for reproductive hormonal assessments. Samples can be used prospectively as well as retrospectively to monitor the general health of the captive population, including conducting nutritional analyses and assessing disease status. The routine collection of blood samples should not be considered a luxury, rather it needs to be an integral part of the total management system, as important as proper nutrition and veterinary care.

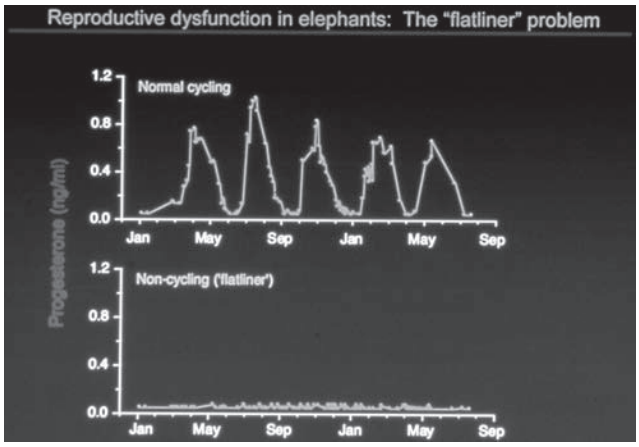
Whenever possible, endocrine analyses should begin as soon as the very young elephant will tolerate blood collection. In the case of very young or untrained elephants, urine can be collected. Based on the limited information to date, captive female elephants attain puberty several years earlier than those in the wild. In a study of five African and two Asian captive elephants, the first pubertal luteal phase increase in progestagens was observed between 7 to 8 years of age (Brown and Savage, unpubl.), although studbook records indicate that females can mature even earlier. Recently, multiple captive 5-year-old Asian elephants have given birth; therefore, conception was achieved at 3 years of age, much earlier than the typical sexual maturity of a wild female at 11 to 13 years of age. Monthly blood sampling may be adequate for initial evaluations, increasing to weekly as the female reaches an age of 4 or 5 years.

In general terms, the estrous cycle of the Asian and African elephant has been characterized. Measurements of steroid and protein hormones indicate an ovarian cycle length of 15 to 16 weeks, comprised of an 8 to 11 week luteal phase and a shorter interluteal (follicular) period of 4 to 6 weeks. This cyclicity can be characterized by measuring serum or plasma progestagens in weekly samples



National Zoo, Janine Brown

The interluteal period is characterized by two discrete luteinizing hormone (LH) peaks about three weeks apart. The second LH surge causes ovulation.



National Zoo, Janine Brown

Top graph: Elephant ovarian cycle length of 15 to 16 weeks, composed of an 8 to 11 week luteal phase and a shorter interluteal (follicular) period of 4 to 6 weeks. Bottom graph: It is now recognized that many female of reproductive age are not cycling, the "flatliner" problem.

using standard immunoassays and modified commercially available progesterone radioimmunoassay (RIA) kits (e.g., Brown et al. 1991; Olsen et al. 1994; Brown and Lehnhardt 1995; Kapustin et al. 1996; Carden et al. 1998). Although cycle length is variable among cows, it often is consistent within an individual. At the National Zoological Park, for example, three Asian elephants cycle consistently at 13, 16, and 17-week intervals. Reproductive activity in captive elephants is not seasonal and estrous cycle synchrony among elephants has been observed in some institutions, but is probably not common. After calving, lactational anestrous lasts 11 months or more; however, females can resume reproductive cyclicity within 2 to 3 months.

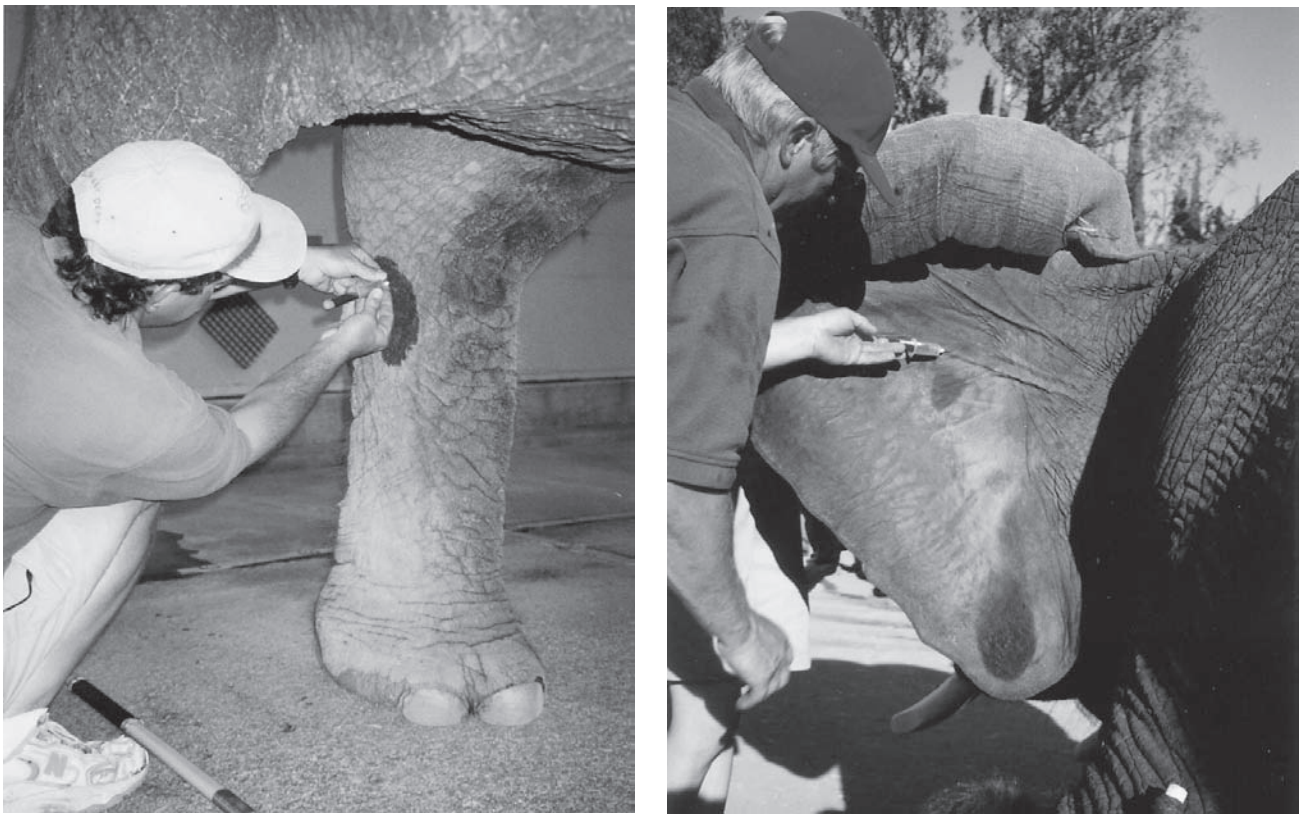
The elephant is unique in that the interluteal period is characterized by two discrete luteinizing hormone (LH) peaks (African: Kapustin et al. 1996; Asian: Brown et al. 1999). The first surge is observed between 12 days

The AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Each male and female elephant of reproductive age (8 to 35 years) must have hormone (progesterone and testosterone) values assessed through weekly (or bi-weekly) collection of blood samples. Exceptions are elephants with known reproductive problems or those with documented medical/behavioral conditions that preclude them from breeding."

(Kapustin et al. 1996) and 21 days (Brown et al. 1999) after progestagens decline to baseline, with the second surge occurring three weeks later (19 to 22 days). The surges are quantitatively and qualitatively similar, yet only the second induces ovulation. The terms anovulatory LH (anLH) surge and ovulatory LH (ovLH) surge are used to define these events. Detection of the surges requires the collection of daily blood samples because concentrations generally are elevated above baseline for only one day.

It is obvious that the ovLH surge induces ovulation and corpus luteum (CL) formation; however, the function of the anLH surge is less clear. It is possible that the "false estrus," occasionally observed three weeks before "true estrus," (or conception) may be associated with the anLH surge. Studies are needed to determine if other physiological changes, such as temporal gland drainage or urinary pheromone excretion, accompany the anLH surge. If so, they may serve as an early advertisement of impending fertility to ensure bulls are available when ovulation occurs. Although the functional significance of the first anLH surge is under investigation, from a practical perspective it can be used to schedule breeding (by artificial insemination or natural mating) to coincide with the ovLH surge.

It is now recognized that many reproductive age female elephants are not cycling. Termed "flatliners," these animals' serum or urinary progestagens remain at baseline, indicating a lack of ovarian activity. Results of a survey sent to institutions maintaining elephants in 1999, indicate that about 15 percent of Asian and 28 percent of African elephant females, most of reproductive age (average age, 24 ± 4.1 years), are not cycling. In general the causes of acyclicity are not known, nor have any reliable treatments been identified. Some elephants exhibit temporary "flat lining," with intermittent but not permanent periods of ovarian inactivity. In one known case, a long-term flatliner resumed cycling, was bred, conceived, and successfully gave birth. Observed acyclicity may involve all elephants at a facility or more commonly, only one of a pair or group of elephants. As yet, there do not appear to be any obvious



Six Flags Marine World

A handler collects from a leg vein (left) and from an ear vein (right).

Blood and Urine Sample Collection Protocols for Monitoring Reproductive Cyclicity in Elephants

Gonadal function (i.e., ovarian and testicular activity) can be assessed in elephants using either blood serum/plasma or urinary steroid analyses. Testing for other hormones, like LH or prolactin, can only be done using blood serum/plasma.

Serum Collection Protocol

1. Blood samples should be collected once a week for a minimum of one year to establish if females are cycling. Weekly to monthly samples should be collected indefinitely from bulls to assess testicular activity. Note: the Elephant Taxon Advisory Group recommends that elephants be reproductively monitored continually so blood should be collected indefinitely for analysis (or banked for future analysis).

2. Collect blood into a 7- or 10-ml red top vacutainer or serum separator tube. Allow blood to clot for one to two hours at room temperature, or for two to four hours at refrigerator temperature. Avoid exposing blood to ambient temperatures for longer than three hours (blood cells can metabolize progesterone and affect results). Plasma (collected in either EDTA or heparinized tubes) can also be analyzed, although serum is preferred.

3. Centrifuge blood (~1000 x g for 10–15 min) and decant serum into a polypropylene vial with a tight-fitting cap that pushes or screws on and is flush with the tube (i.e., cap does not hang over the side of the tube). Recommended tube: round bottom (12 x 75 mm) with a frosted writing space and push caps from the Sarstedt company. Information on the tube should include: animal name or number, date (mo/day/year), and facility name or abbreviation. Provide a minimum 1 ml of serum for each sample. Do not overfill vials; allow room for expansion during freezing. Store frozen (–20°C or colder).

4. Ship samples in a styrofoam container with dry ice (preferred) or cold packs (okay during winter months). Use an overnight express courier. Avoid shipping samples after Wednesdays.

5. Include in the shipment a written request as to what hormone analyses are required.

Urine Collection Protocol

1. Urine samples should be collected once weekly for progestogen analysis for a minimum of one year to establish if females are cycling. Weekly to monthly samples should be collected indefinitely from bulls to assess testicular activity. Note: the Elephant Taxon Advisory Group recommends that elephants be reproductively monitored continually so urine should be collected indefinitely for analysis (or banked for future analysis).

2. Urine samples can be collected "free-catch" (i.e., mid-stream) using a cup or other container, or aspirated off the ground using a syringe or similar device. For urine collected off the ground, moderate contamination with water generally is not a problem because samples are indexed to creatinine concentration. It is recommended that concrete floors be as dry as possible to prevent over-dilution. If animals are separated at any time, urine can be collected from cups placed in the enclosure drain. Dirt contamination is not problem, but it would be helpful if all samples were centrifuged (~1000 x g for 15 min) to remove dirt and other cellular contaminants before putting in tubes for frozen storage.

3. Place urine into a polypropylene vial with a tight-fitting cap that pushes or screws on and is flush with the tube (i.e., cap does not hang over the side of the tube). Recommended tube: round bottom (12 x 75 mm) with a frosted writing space and push caps from the Sarstedt company. Information on the tube should include: animal name or number, date (mo/day/year), and facility name or abbreviation. Provide a minimum of 4.5 ml of urine for each sample. Do not overfill vials; allow room for expansion during freezing. Store frozen (–20°C or colder).

4. Ship samples in a styrofoam container with dry ice (preferred) or cold packs (okay during winter months). Use an overnight express courier. Avoid shipping samples after Wednesdays.

5. Include in the shipment a written request as to what hormone analyses are required.

Blood serum and urine samples can be sent to

Dr. Janine Brown
Endocrine Research Laboratory
Conservation and Research Center
1500 Remount Road
Front Royal, Virginia 22630
540-635-6586
jbrown@crc.si.edu

Dr. Dennis Schmitt
Southwest Missouri State University
901 South National Ave
Springfield, Missouri 65804
417-836-5091
dls234f@smsu.edu

Veterinary Technicians
Indianapolis Zoo
1200 W. Washington St
Indianapolis, IN 46222
317-630-5163

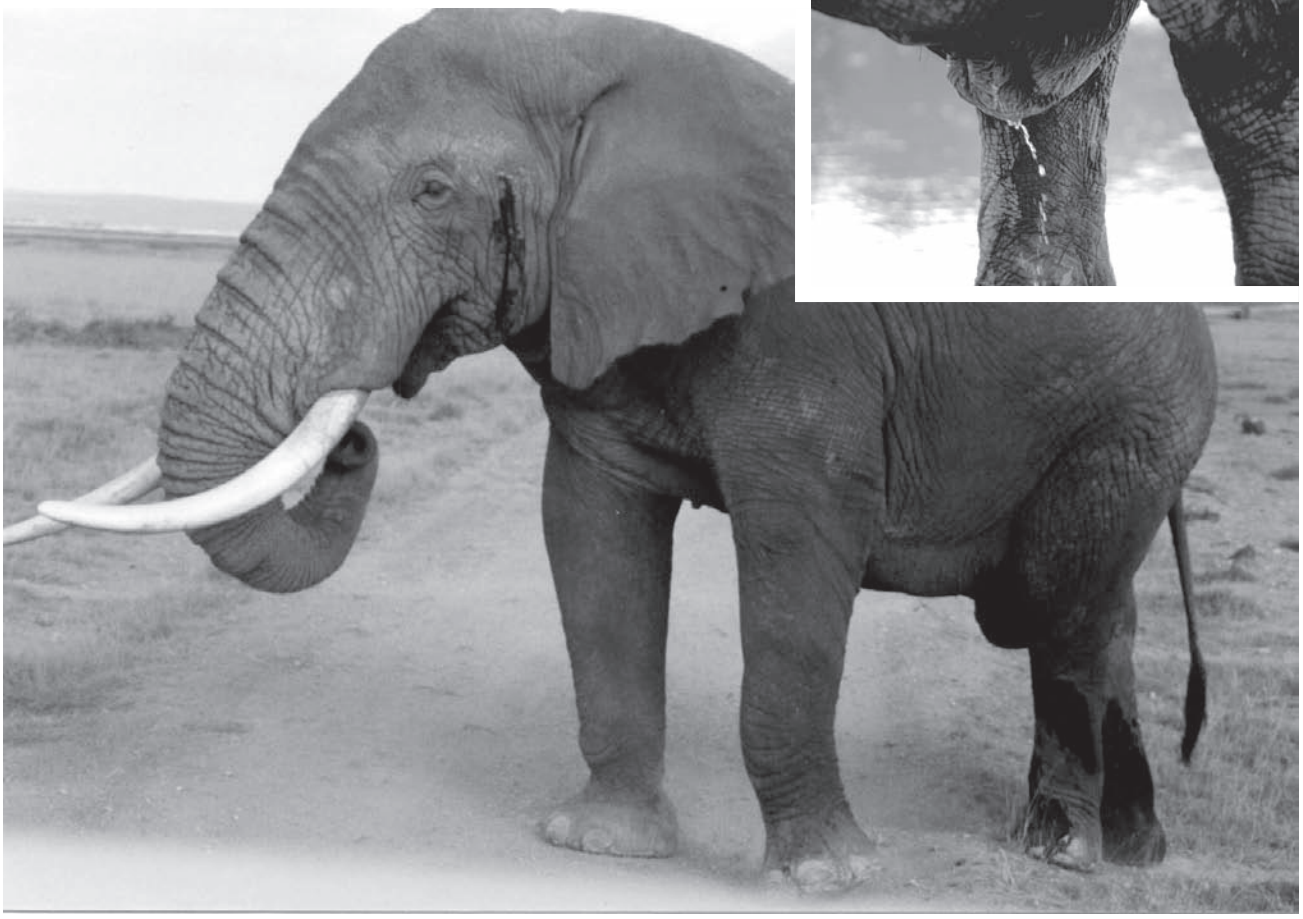
husbandry or management practices associated with ovarian inactivity in elephants, although the possibility that social factors play a role in this disorder needs to be explored. Clearly more work is needed to investigate ovarian dysfunction in captive elephants and to identify effective treatments. In addition, because it is now known that ovarian acyclicity is not always a permanent condition, it is important to hormonally evaluate females throughout their lifespan to identify causative factors.

Endocrine Function in Male Elephants

Less is known about the reproductive endocrinology of bull elephants, aside from limited studies investigating musth. In both species, musth is a period of heightened aggressive and sexual behavior, characterized by increased temporal gland drainage, urine dribbling, and androgen secretion for periods of a few weeks to several months. The factors determining when a bull exhibits musth are related to age, body condition, nutrition, and perhaps social status (Jainudeen et al. 1972; Cooper et al. 1990; Lincoln and Ratnasooriya 1996). Musth can begin as early as 10 to 15 years of age in captivity but is seldom observed before 25 years of age in the wild. Concentrations of testosterone increase dramatically during musth, averaging 10 to 20 ng/ml in pre- and post-musth and sometimes exceeding 50 ng/ml in peak musth (Niemuller and Liptrap 1991).

Janine Brown

Cyclicity is determined by measuring serum or urinary progestins every week.



Male musth is characterized by temporal gland secretion (above) and urine dribbling.

Unlike rut, musth is not seasonal, although a mature bull may exhibit musth annually at the same time each year. Musth also is not a prerequisite for breeding. In fact, the over-aggressiveness often accompanying musth can reduce breeding interest, at least in captive bulls. Musth is affected by nutritional status given that a common method of suppressing musth in male working elephants in Asia is the reduction of caloric intake. Alternative therapies that decrease androgen secretion or activity are currently being investigated and their long-term effects on fertility and behavior determined.

In other mammals, testosterone is essential for maintaining spermatogenesis, promoting normal function of the epididymis and accessory sex glands, and stimulating sexual interest (Knobil and Neill 1998). Evaluating androgen status is an important part of the reproductive health assessment of individual bull elephants. However, the variability within and between animals makes it unwise to assign specific cut-off values to characterize the normalcy of androgen production. Just as the collection of one poor quality ejaculate does not mean a bull is infertile, so should multiple androgen analyses be conducted before concluding that testicular function is compromised. Given that blood samples may be difficult to collect consistently from bulls, especially during musth, routine, weekly urine sample collections are recommended for all bulls, with blood collection done when safe to do so. If consistently low testosterone is detected, a problem with steroidogenic function should be suspected. Whether fertility problems in bulls are associated with low testosterone production or other factors needs to be investigated. Endocrine monitoring, in conjunction with other reproductive assessments involving ultrasound examinations and semen collection, should be initiated and continued to determine the causes and develop treatments.

Steroid Metabolite Hormone Monitoring

Routine blood collection may not be suitable for all elephants or institutions. In those cases, monitoring gonadal status can be done through the analysis of fecal, salivary, or urinary steroid metabolites (Brown 2000). These approaches offer advantages in safety and ease of sample collection, and in general, data are comparable to circulating hormone profiles. However, there are some disadvantages that should be considered. Urine, collected by mid-stream catch or off enclosure floors, can be difficult to obtain depending upon access to the elephant and the enclosure. Urine also requires an additional analysis of creatinine to account for variation in fluid intake. Fecal samples are easier to collect, but analyses are expensive and hampered by a more complicated sample preparation process, the lack of a suitable index (like creatinine) to standardize results, and a comparatively long and often variable excretion lag time. Lag times are important and must be considered when correlating specific events or behaviors with hormone activity. Collection of an appropriate sample is also more critical for feces because steroid concentrations are not evenly distributed (Wasser et al. 1996).

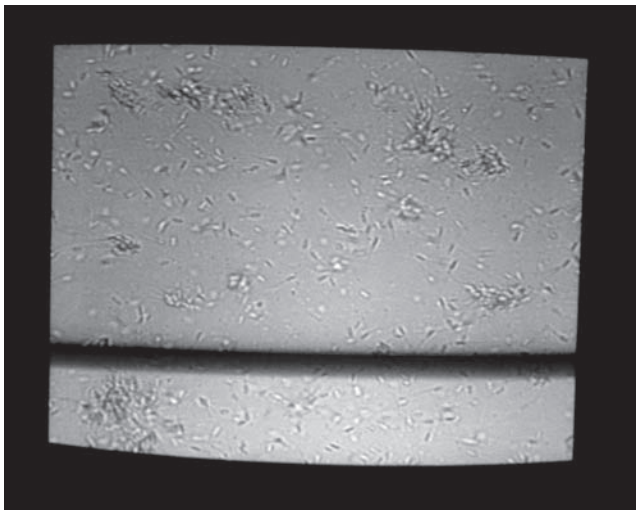
Transrectal Ultrasonography

Recent technological advances have made ultrasonography an effective tool for assessing the reproductive fitness of nonsedated male and female elephants. Through transrectal ultrasonography the entire urogenital tract of both male and female elephants can be scanned facilitating:

- the identification of reproductively healthy animals;
- the identification of the potential causes of reproductive dysfunction;
- the characterization of the testes and accessory sex organs
- the identification of pathological lesions that influence reproduction such as uterine tumors, and endometrial and ovarian cysts;
- the identification of changes in reproductive tract morphology throughout the estrous cycle including changes in mucous consistency, and follicular growth and development; and
- the determination of pregnancy.

Reproductive tract ultrasound examinations should be conducted annually or biannually to track longitudinal changes in morphology. A thorough assessment is also recommended before breeding is scheduled. Presently there are only a few specialists in the world trained in ultrasonography and elephant reproductive physiology that can perform these assessments, although efforts are in place to train more individuals.

The ultrasound procedure itself is relatively simple, and with some training most elephants readily stand and/or lay down for the examination. The elephant first must be trained to stand still or lay down for a period of time. Restraints can be used to further reduce the movement of the elephant. Feces are then removed manually from the rectum to the depth where the examination will take place. Further irrigation of the rectum with lukewarm water



Jeff Peterson, Indianapolis Zoo

Image of elephant sperm.

Albuquerque Biological Park

Urine collection can offer an alternative to blood collection.

enhances the removal of feces that could interfere with the ultrasound transducers.

It is recommended that the elephant be desensitized to the increased activity that will be associated with the assessment, such as the visiting ultrasound technologists, the equipment, and the procedure itself prior to scheduling the examination.

Natural Breeding

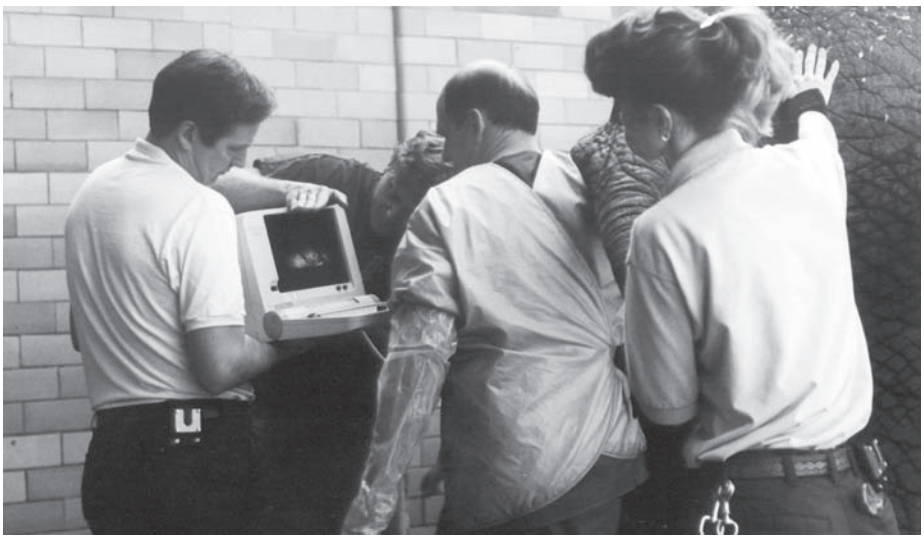
In captivity, breeding problems are often encountered, such as females refusing to stand for mating or bulls having no sexual interest. No known therapies exist to alleviate these problems. However, because a cow is more likely to stand for mating when in estrus, and it is when she is most fertile, it is important to precisely time breeding opportunities around this event. This can be done by identifying the anLH surge and scheduling breeding to coincide with the ovLH surge and estrus. In addition, it has been proposed that captive male elephants may not be given enough opportunities to breed; therefore, initial ejaculations may contain large volumes of dead sperm. Managers of male elephants not used regularly for breeding are encouraged to collect semen from the bull prior to using him for breeding.

If the number of pregnancies are to be increased, then more cows need to be exposed to bulls. At a few elephant breeding facilities, efforts have been made to expand the number of elephants bred to include female elephants from outside their programs. The female is then sent back to her home facility for the birth. For this type of program to be successful:

- The cow must be cycling normally based on hormonal analysis with a healthy reproductive tract determined ultrasonographically. It is paramount that resources are not wasted on elephants of unknown reproductive status.
- The management of the cow should be compatible with the handling protocol of the breeding institution.
- The cow can be moved with a companion elephant to minimize the interruption of the estrous cycle.

It is recommended that female elephants stay through two estrus periods (approximately eight months) at the breeding facility. This will allow time to determine the pregnancy status from the first breeding and if not successful, to conduct a second breeding attempt. Continuing to follow the progestagen cycle allows the cow to be introduced to the bull at the correct time and to confirm pregnancy. This type of accelerated breeding program may provide the opportunity to impregnate more individuals, although sometimes the female elephant will be required to stay at the breeding facility one to two years in order for her to acclimate to the new enclosure, handlers, and other elephants before conception occurs.

In a few cases, a female elephant's estrous cycle has been monitored on a daily basis and when near ovulation, she was brought into the breeding facility for a very short stay of one to two weeks. This accelerated



Seneca Park Zoo, Amy Cutting

Ultrasonography is an effective tool in assessing the reproductive fitness of male and female elephants.

The AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Each male and female elephant of reproductive age (8 to 35 years) must have an initial reproductive assessment and follow-up assessments on a regular basis by transrectal ultrasound to verify reproductive status and assess overall reproductive health. Exceptions are elephants with known reproductive problems or those with documented medical/behavioral conditions that preclude them from breeding."

program can greatly reduce the cost of the breeding, the time required of the staff and facility, and the need to introduce the cow to an unknown group of female elephants. This regimen can also increase the number of successful pregnancies overall. Cows who travel regularly are excellent candidates for this type of accelerated breeding program as the travel or the introduction to new animals or enclosures does not interrupt their estrous cycle.

Assisted Reproduction

Assisted reproduction is especially valuable for overcoming the logistical problems facing elephant managers. Artificial insemination (AI) is not meant to replace natural breeding but to enhance it. AI is a viable alternative to natural breeding in cases where the female's chances of being bred naturally are limited. AI should increase the size of the captive reproductive population—both males and females—ensure reproduction between behaviorally incompatible pairs, eliminate the need to transport, and reduce the need of disrupting established female social groups. It may also provide the opportunity for additional pregnancies to be generated in the captive population by using female elephants with little chance of being bred by a bull due to behavioral or physical considerations, and using male elephants that will not or cannot breed naturally. AI can also be a tool in the future for introducing new genetics into the population without having to remove elephants from their range countries through the use of semen collected from wild bulls. As of the writing of this manual, only primaparous Asian elephants and nulliparous African elephants have conceived through AI.

For more than two decades, attempts to impregnate elephants by AI were unsuccessful. Then, within a short period of time, success was achieved in both the Asian and African elephant. This dramatic turnaround is due mainly to three recent advances: 1) an improved ability to predict the time of ovulation; 2) a semen collection protocol for nonsedated male elephants; and 3) insemination techniques that place semen closer to the site of fertilization.

Correctly timing the AI is essential for conception. To enhance success, it is recommended that each individual elephant's estrous cycle be well defined prior to any AI attempts. This can require a year of multiple cycles of progestagens and LH to determine each cow's individual hormone pattern. Identifying the pattern will provide a foundation to predict when each cow will ovulate. The number of days between the LH surges, the average concentration of the LH surge, and the relation of the LH surges to daily progestagen values should be documented for each individual animal. After a number of progestagen and LH cycles have been determined, a pattern should

Six Flags Marine World

Artificial insemination is a viable option to natural breeding in cases where the chance of natural breeding is limited.

emerge for each animal. Predicting possible ovulations over a 12-month period will allow notification of all parties involved well in advance of potential AI dates. The timing of the actual procedure is then refined as the predicted day of ovulation approaches.

Several bulls of both species of elephants allow semen collections through rectal massage and have become fairly reliable donors. The collection can be performed with the male restrained in an elephant restraint device. The bull's accessory sexual organs are massaged through the floor of the rectum. A veterinary OB glove with the "hand" tied off in a knot is placed over the penis as a condom. This procedure requires the staff to be trained to stimulate the bull properly and to reduce the amount of urine contamination in the ejaculate. Other methods of semen collection are electro-ejaculation, using both standing sedation and complete anesthesia, and the use of an artificial vagina.

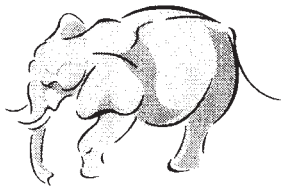
Protocols have been established for the extension of fresh semen. This allows for the storage of semen on a short-term basis prior to insemination, with acceptable loss to its viability and motility. Investigation is currently ongoing into the long-term storage of semen—cryopreservation. Cryopreservation of semen will be necessary for research into sperm cell sexing, to provide increased flexibility for use of AI in the captive population, and to allow the storage and shipment of frozen semen between countries, exchanging genetic material between populations of both captive and wild elephants.

Artificial inseminations in cows which have not given birth is complicated by the presence of an intact hymen. The nonsurgical AI procedure involves the insertion of a balloon catheter into the reproductive tract and, through that, an endoscope. With the aid of an endoscope, a semen catheter is threaded through the hymen to the vagina for semen deposition. The procedure can take as little as 10 minutes or as long as an hour. Extensive training is necessary as the elephant must be comfortable and relaxed with the procedure and the physical manipulation. She also must be calm with a large number of people present and tables of equipment on both sides and behind her. Surgical AI involves the use of a local anesthetic below the anal fold where a small incision is made. The incision allows a sterile, disposable speculum to be placed into the urogenital canal. Semen is deposited via the speculum with a sterile AI pipette directed through the hymen into the vagina. Artificial insemination—both surgical and nonsurgical—in cows which have previously given birth is similar, except that the hymen is not present and semen may potentially be deposited in the cervix or uterus.

Elephant Reproduction Exam Data

Below and in the following pages are exam and ultrasound report forms created by April Tirabassi, Assistant Director of Finance and Administration at the University of Rochester (NY) Medical Center Division of Laboratory Animal Medicine and Vivarium. Originals can be downloaded from http://senecaparkzoo.org/vet/elephant/elephat.php.

FAX to Dr. Jeff Wyatt (716)-336-2517



General Exam Data

Date of Exam _____
Purpose of Exam _____Animal Name _____Institution _____
Studbook Number _____ Street _____
Species *African or Asian* City-State-Zip _____
DOB ____ Age_____ Captive Born *Yes or No*
Gender *Male or Female* Weight (kg) _____
Body Condition ____ Height (m) _____
Contact *Free - Protected - Other* Most Recent Date of US Exam _____
Living Group Information

SB#														
Sex														
Age														

Living Group Comments _____
_____
_____
_____
Health and Reproductive History of Individual & Herd _____
_____
_____
_____

Contact Vet (Name & Phone #) _____
Contact Vet (e-mail) _____
Institution Primary Contact (Name & Phone #) _____
Institution Primary Contact (e-mail) _____

Female Exam and Endocrine Status

Date _____ Animal Name _____ SB# _____

Endocrine Information
Endocrine status *Known or Unknown* Date of Most Recent Endocrine Testing _____
Cycling Regularly *Yes or No* If Abnormal Cycling *Flatliner or Irregular or Other*
Current State of Cycle *Luteal or Interluteal or Unknown*

External Exam
Vestibular Vulva Examined *Yes or No* V/V Comments _____
Mammary Glands Examined *Yes or No* MG Comments _____

Ultrasound Examination
Ultrasonographer _____ US Machine Make & Model _____
Urogenital Canal Examined *Yes or No* mHz _____
UG Canal Comments _____
Urethra Examined *Yes or No* mHz _____
Urethra Comments _____
Bladder Examined *Yes or No* mHz _____
Bladder Comments _____
Vagina Examined *Yes or No* mHz _____ Max H X W ____cm X ____cm
Vaginal Mucus & Other Comments _____
_____
Cervix Examined *Yes or No* mHz _____ Max H X W ____cm X ____cm
Cervical Pathology *Yes or No* Comments _____
Other Comments –Cervix (including presence of mucus) _____
_____
Uterine Body Examined *Yes or No* mHz _ Max H X W ____cm X ____cm
L Uterine Horn Examined *Yes or No orUnlocated* R Uterine Horn *Yes or No or Unlocated*
L Ut Horn Max H X W ____cm X ____cm R Ut Horn Max H X W ____cm X ____cm
Uterine Pathology *Yes or No* Comments _____
Uterus -Other Comments (including presence of mucus) _____
_____
L Ovary Examined *Yes or No or Unlocated* R Ovary Examined *Yes or No or Unlocated*
L Ovary Max H X W ____cm X ____cm R Ovary Max H X W ____cm X ____cm
Ovarian Pathology *Yes or No* Comments _____
_____
Ovaries –Other Comments _____

Probe Extender Comments _____

Breeding Status: *Satisfactory* or *Questionable* or *Unsatisfactory Potential Breeder*

Male Exam & Semen Collection

Date ____ Animal Name _____ SB# _____
Engorged Penis Circumference Under Glans ___cm Base of Penis (under anus) ___cm
# of Contractions before Ejaculate _____
Total # of Contractions during Collection _____ Total Collection Time _____
Urinated During Collection *Yes or No* Ejaculate Volume _____ml
Sperm Count (X 10^6/ml) _____ Sperm Motility (%) _____
Percent Live _____ Motility Status (0-5) _____
Morphology _____
pH _____
Semen Collector & Method _____
Semen Comments _____
_____

ULTRASOUND EXAM *PRE-Collection* or *POST-Collection*

Ultrasonographer _____ US Machine Make & Model _____
Urethra Examined *Yes or No* mHz _____
Comments _____
Bladder Examined *Yes or No* mHz _____
Comments _____
Prostates Examined *Yes or No* mHz _____
Max L Prostate H X W ____cm X ____cm Max R Prostate H X W ___cm X ___cm
Prostate Comments _____
Seminal Vesicles Examined *Yes or No* mHz _____
Max L SemVes H X W ___cm X ___cm Max R SemVes H X W___cm X___cm
Max L Sem Ves Ventral Epith Thickness___cm Max R Sem Ves Ventral Epith ___cm
Seminal Vesicles Comments _____
_____

Ampullae Examined *Yes or No*
Max L Ampulla H X W ____cm X ____cm Max R Amp H X W ___cm X ___cm
Ampullae Comments _____

L Teste Examined *Yes or No or UnLocated* R Teste Examined *Yes or No or Unlocated*
L Teste H X W ____cm X ____cm L Teste H X W ____cm X ___cm
mHz _____Testes Comments _____

US Probe Holder Comments _____

Breeding Status: *Satisfactory* or *Questionable* or *Unsatisfactory Potential Breeder*

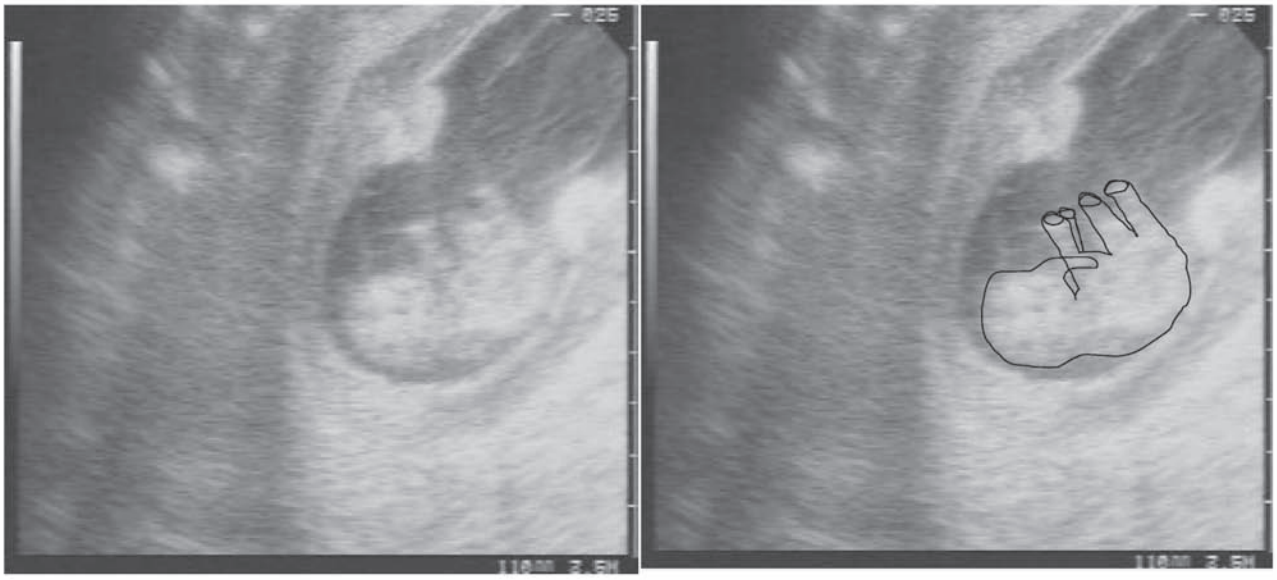
Pregnancy and Parturition

Pregnancy can be diagnosed on the basis of serial weekly serum samples assayed for elevated progestagens or urine beyond the normal luteal phase length. This necessitates that approximately 12 to 16 consecutive weekly samples be assayed for a presumptive pregnancy diagnosis. After a positive diagnosis, progestagens fluctuate at or above luteal phase values throughout the pregnancy. By contrast, pregnancy can be confirmed on the basis of a single blood sample by analyzing prolactin which increases markedly after approximately 20 weeks of gestation (African: McNeilly et al. 1983; Hodges et al. 1987; Asian: Brown and Lehnhardt 1995). This test can be used to diagnose pregnancy if longitudinal progestagen monitoring is not possible. Recently, ultrasound has been used as a tool to diagnose pregnancy.

Ultrasonograhic pregnancy diagnosis can be performed beginning about week eight post-breeding in elephants. However, the fetus is not visible until 9 to 10 weeks post-breeding. Ultrasonographic pregnancy diagnosis can be performed transrectally with the cow standing during early pregnancy (8 to 16 weeks gestation) but often is facilitated by performing the examination in lateral recumbancy as the pregnancy progresses. Recently, transabdominal ultrasonographic monitoring of pregnancy has been possible. Visualization transabdominally is performed during the last half of pregnancy when the conceptus has increased in size enough to provide visualization of the uterine wall, placental membranes, and portions of the fetus in the field through a lateral body wall. The ultrasonongraphic transabdominal "window" is within a larger area delineated by the last rib, the ventral abdominal wall, and the rear leg. Often intestinal loops obscure the uterus and its contents from visualization.

Pregnancy in the elephant lasts approximately 659 days with a range of 612 to 699 days. While pregnant, a female elephant's physical condition and weight should be monitored. If she is in good condition at the time of conception, she should maintain her normal diet. It is strongly cautioned that the female elephant should not be overweight before breeding or gain excessive weight during pregnancy. Elephants in human care are fed high quality diets, are free from stresses such as parasite load and the need to walk great distances to find food and water. Therefore captive elephants are more susceptible to being overweight prior to parturition. Being overweight can result in calves of large birth weight and problems during labor and birth.

It is also important that the pregnant female elephant is in excellent physical condition at the time of parturition. To this end, a daily exercise regimen should be



Dennis Schmitt

Ultrasonic pregnancy diagnosis can be performed at about 8 weeks of age. Ultrasound can then be used to track fetal development. The above ultrasound is of an elephant fetus at 16 weeks of age.

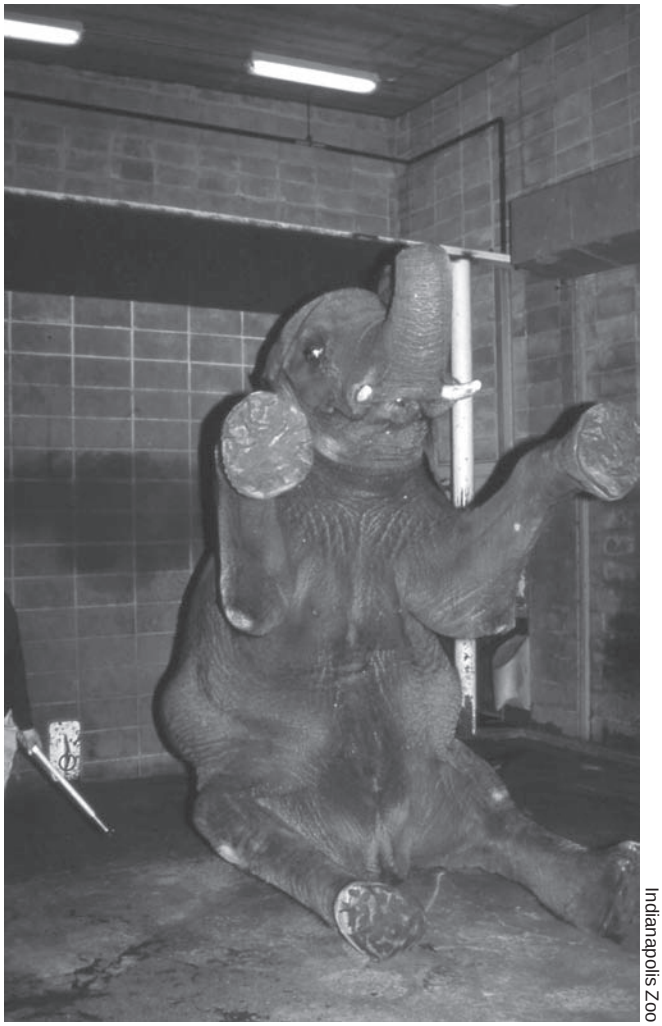
Deborah Olson, Indianapolis Zoo

A veterinarian uses ultrasound to determine parturition.

instituted, including long walks and behaviors that help to stretch and strengthen the muscles of the legs and abdomen and increase stamina. Anecdotal reports indicate that an extremely low percentage of female elephants in an active environment—giving rides, demonstrations, or walked daily—have long labors or experience dystocias. On the other hand, females allowed to gain an excessive amount of weight with inadequate exercise appear to have long labors often resulting in stillbirths and in the death of the calf and/or mother.

Recently a test has been developed that accurately predicts the sex of the fetal Asian elephant calf using maternal serum to measure testosterone from the developing fetus before birth (Duer et al. 2002). Samples from weeks 30 to 60 gestation are used to evaluate fetal sex. A male fetus develops and secretes testosterone, and the increases in testosterone can be measured in the mother's serum. This allows the reliable prediction of fetal sex in Asian elephants. Fetal sexing in African elephants is currently being investigated. However, not enough data are currently available to predict the reliability of the assay in this species.

Considering the amount of time and energy invested in an elephant pregnancy, the ability to predict parturition is critical. Fortunately, this can be done (for the most part) on the basis of a drop in progestin that occurs before birth, (Brown and Lehnhardt 1995; Carden et al. 1998; Doyle et al. 1999) providing a "warning" that parturition is imminent. This ensures staff are adequately prepared, and it is useful as a guide to more rapidly determine when a cow is in distress. It is recommended to monitor serum progesterone weekly until the 20th month of gestation. Monitoring then increases to twice weekly during the last month of gestation, to daily, then twice daily as the due date approaches. The pre-partum decline in progestagen is generally rapid, occurring over a period of days. Secretion is variable, however, making the selection of a lower cut-off value difficult. Also, cut-off values will depend upon which progestagen assay is being used. Typically the



Indianapolis Zoo

It is important to keep pregnant elephants in good physical condition. A daily exercise program—including walking, stretches, and ground sit—should be instituted.

progestagen levels will indicate a 50 percent decrease within 24 hours, and subsequent twice daily assays demonstrate a continuing progestagen decrease. The birth should occur within 1 to 13 days, with an average of 3, of the drop in progestagens to baseline.

Although data are still limited, monitoring the changes of the reproductive tract through transrectal ultrasound shows great promise of further refining the time of birth or potential problems. Ultrasonographic monitoring for dilation of the cervix and passage of the placental membranes can provide reassurance that parturition is progressing normally. Entrance of the fetus into the birth canal usually signals the beginning of active labor and can be monitored via ultrasound. As the calf progresses into the birth canal, the palpation of the fetus transrectally can occur for the remainder of parturition.

If progestagen concentrations fall to nonluteal levels (i.e., baseline), problems should be suspected if birth does not occur within a few days. The birth process involves the dilation of the cervix by the placental membranes and presentation of the fetus into the birth canal. Little outward signs of labor are seen until the feet are well into the birth canal, and often few signs of labor are seen until the feet enter the vaginal vault. The entrance of the feet into the vaginal vault stimulates abdominal contractions and delivery of the calf. Elephant calves have relatively short umbilical cords, which probably break as the feet are seen to protrude under the anus (fetal bulge). Rapid delivery of the calf from the time fetal feet are observed or palpated externally is critical to a viable birth. Prior to the feet appearing in the bulge, the calf may regress into the birth canal, and as long as the umbilical cord is not broken, the calf should be viable. It is not unusual for one foot to be slightly advanced over the other early in the birth process. If only one leg can be palpated as the calf advances, repulsion and repositioning of the calf may be possible through direct manipulation or normal activity of the dam, as long as the calf is able to regress into the uterus. Evaluation via transrectal ultrasonography can be used to establish normal progression of parturition and to evaluate correct presentation of the calf.

If the calf is presented correctly and fetal progression through the birth canal does not appear to be normal, assistance may be necessary. Because of the sensitivity of elephants to oxytocin, its use should be carefully considered. Rectal massage of the area over the vagina may initiate uterine and abdominal contractions that result in active labor. Therefore use of manual stimulation should be tried before instituting oxytocin to induce labor. If the calf is positioned correctly and the cervix is dilated, then oxytocin may be needed to initiate labor. Serum calcium levels could be determined before the use of oxytocin, although in most cases decreased calcium levels are seen in prolonged active labor. The initial bolus of oxytocin is to stimulate uterine contractions that result in normal active labor. An intramuscular injection of 40 to 60 I.U. of oxytocin (30 to 40 IU IV) will often result in active labor in 5 to 10 minutes. If signs of active labor cease in 10 to 15 minutes, then oxytocin may be repeated at a slightly higher dose (50 to 80 I.U. IM) 30 to 45 minutes after the initial injection. The use of oxytocin at doses over 120 I.U. should be carefully considered and additional advice sought (Dennis Schmitt, pers. comm.).

Assisted delivery of a calf may be accomplished through a vestibulotomy incision. However, due to the poor blood supply and contamination of the incision site through which the fetus is delivered, complete healing of the incision is slow.

When assisted delivery of the calf is not possible, there have been reports of successful outcomes from leaving the fetus in utero. Although not considered a reasonable option in other mammals, it is an option that is viable in elephants. There are recent successful outcomes for the dam from allowing the dead fetus to be naturally expelled at a later date. In one case, the dam successfully conceived again.

As of this writing, all attempted C-sections in elephants in North America have resulted in the death of both mother and calf. Of the cases where the female elephant survived post surgery, severe peritonitis necessitated euthanasia of a 19-year-old primiparous mother 11 days post-surgery (Oosterhuis 1990), and septic peritonitis and renal failure resulted in the death of a 36-year-old primiparous cow 19 days post-C-section, despite intensive post-operative care (Burnet Park Zoo, pers. comm.). Consequently, at this point in time, C-sections are not recommended.

Most of the current population of adult female African and Asian elephants are unfamiliar with birth and have no experience with calves. Past incidents demonstrate that many of these female elephants may be frightened of their newborn calves and immediately attempt to harm or kill them. Therefore control of the events of the female elephant's parturition is important regardless of the elephant management style used.

Although it is unrealistic to expect a female elephant to be unquestionably responsive to the handler during the final stages of parturition and the subsequent surprise of a newborn calf, she should be at a level of training that she becomes handleable and cooperative shortly after the birth. Both the physical conditioning and the female's responsiveness require a significant investment of staff time (on a daily basis) during the pregnancy. This area cannot be neglected. The safety of the female, calf, and handlers is based on the training prior to the birth.

The elephant manager should be in charge of all aspects of the birthing process so it is carried out without needless discussion. The role of each person involved should be described in detail, written down, and approved well in advance of the event. Only people with whom the elephants are familiar should be present during the birthing process, unless the elephant is used to a lot of people and activity, and these plans have been made in advance.

When the first signs of labor appear, it is recommended that the elephant handlers put the elephant on at least two (and preferably four) leg tethers. Typical signs of labor are stretching, leaning into walls, swaying, restlessness, crossing her legs, obvious contractions, going down on the knees, going into a stretch position, mucous discharge, vocalizations, pulling on teats, hitting her stomach with

Deborah Olson, Indianapolis Zoo

When the first signs of labor appear, it is recommended that the female be placed on at least two leg tethers.

her legs and/or trunk. Sawdust, bran, or other safe absorbent material should be spread around the elephant to soak up the birth fluids as it is important that the floor be kept dry to prevent both humans and the elephant from slipping. If possible, the rest of the female elephant herd should be moved into an adjacent stall to avoid interfering with the handlers, but they should be are able to observe the birth and newborn calf. It is important for the other female elephants to witness the birth as this may be an invaluable learning experience. Tethering is recommended if the herd becomes agitated.

It is recommended that the elephant handlers remove the calf just out of trunk reach of the tethered female immediately after birth. The calf should be pulled a short distance from the mother so the mother can smell and touch the calf but not grab or step on it. The female should be allowed to calm down as she watches her infant being attended to. This period of separation gives the female time to recover from the birth, gives the handlers time to clean and inspect the calf, the veterinarian time to perform the neonatal exam, and the calf time to become steady on its feet.

Veterinary staff should not enter the holding area to do an initial examination of the calf and treat the umbilicus until it is determined to be safe. The umbilicus in the elephant breaks at the body wall and retracts inside the umbilical sheath. The sheath covering the umbilicus can be seen outside the body wall (the sheath is often mistaken for the umbilical cord). To properly disinfect the umbilicus, it is suggested to use a dilute iodine or chlorhexidine solution and infuse the umbilical sheath via a syringe. The opening to the sheath can be seen by examining the remaining portion outside the body wall. The area of the umbilicus often swells following birth and should be closely examined to ensure a hernia is not present. Blood samples, body weight, and body measurements (height to the top of the back, length with trunk and tail relaxed, and heart girth) should be taken as soon as the calf is considered stabilized; the calf will rapidly gain strength and attempt to get to its feet at which time the calf will be difficult to restrain.

The calf should be allowed to attempt to stand on its own (range from five minutes to two hours) although handlers may need to support the calf to stand if it is weak. A harness made of soft rope can be used to assist the calf to its feet, stand, and walk. It is recommended that the calf is not rushed back to the mother and that all conditions are controlled; the calf is mobile and eager to nurse; and the elephant manager is confident the female is calm, interested, and is responsive to all of the handler's commands before the introduction is attempted.

An elephant handler should control the mother while

Rosamond Gifford Zoo at Burnet Park

It is recommended that the newborn elephant be moved just out of the mother's trunk reach until it is steady on its feet and ready to nurse.

the calf—accompanied by two handlers—is allowed to approach her. The harness, with a lead rope attached (giving staff a handle with which to pull the calf out of danger if necessary) is recommended during the introduction process of the calf to its mother. Handlers need to be alert for aggressive behaviors from the mother, particularly when the calf vocalizes or falls down. At times, it can be difficult to tell if the mother is acting aggressively toward the calf or if she is just protective, curious, nervous, or eager. The mother elephant should not be allowed to demonstrate any aggressive behaviors toward the calf. If she is reluctant to accept her calf, the female elephant should be behaviorally conditioned over time and with each introduction attempt to accept the calf and allow it to nurse. To date, even though the length of time varied from hours to almost three weeks, all female elephants managed in this manner have accepted and successfully raised their calves.

The calf should be allowed to find the teat on its own. The amount of handler intervention should depend on the calf's behavior. Range for initial suckling attempts is one to six hours and successful nursing from the mother has varied from 1 to 10 days. Ideally, successful nursing should occur within the first 12 hours to ensure the calf receives the necessary colostrum. Colostrum is high in calories, but more importantly, contains immunoglobulins which aid in the prevention of disease in the first few months of life while the calf's own immune system is developing. Considering the strength and vitality of the calf, if the calf does not nurse for the first 12 hours the calf may need to be supplemented with either the dam's colostrum, or plasma orally, as a replacement for colostrum. Whole blood from the mother elephant should be collected beginning at least eight weeks prior to the birth for the separation and storage of plasma. The last plasma samples collected prior to birth should be the first plasma samples used and it is recommended that it be given orally. These immunoglobulins can only be absorbed in the first couple of days after birth, emphasizing the importance of the calf suckling from its mother versus being supplemented with another source of milk.

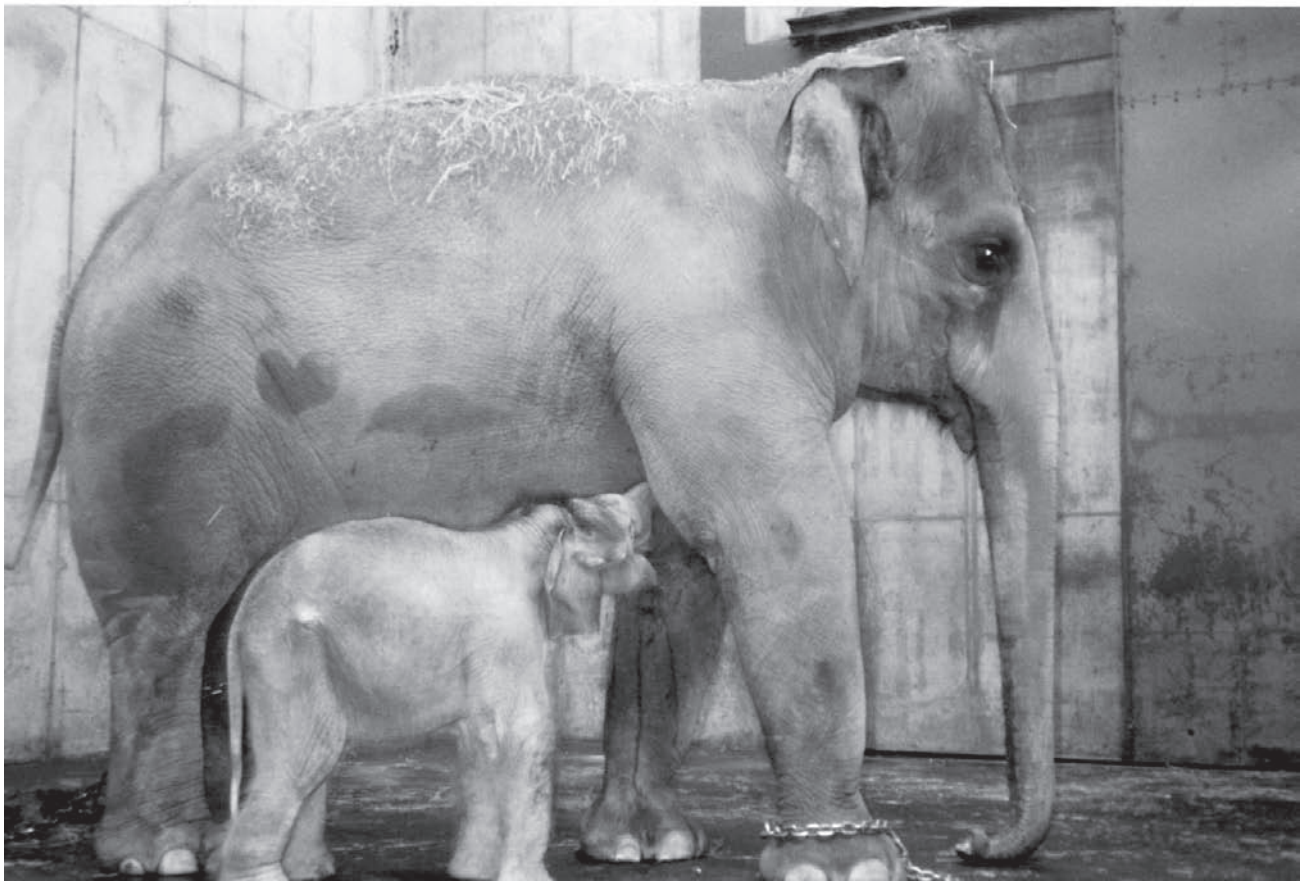
If possible, the entire birth and the bonding sequence should be documented by a person designated to record all pertinent data, first occurrence of specific behaviors, benchmarks and to chart stools. This is extremely important when it comes time to evaluate the process and

Indianapolis Zoo

A harness made of soft rope can be used to assist the calf to its feet, stand, and walk.

Medical Protocol for Weak Calves

1. *Assess immediate needs.* Evaluate respiration, heart rate, and mucous membrane perfusion. Perform resuscitation procedures or begin oxygen therapy before proceeding with further steps if needed.
2. *If temperature is less than 36° C (97.5° F)*, apply heat lamps and/or heating blankets (36.4° C to 37.2° C is normal)
3. *Draw EDTA and Clot blood tubes for:*
   a. Whole blood glucose. If less than 40 mg/dl infuse, 5 percent to 10 percent glucose solution, 10 to 20 ml/kg IV bolus. Recheck blood glucose.
   b. CBC (STAT).
   c. Chemistry panel (STAT) including electrolytes, P, Creatinine, T.P., Globulins, Ca, CPK.
   d. Zinc sulfate turbidity or glutaraldehyde precipitation test (qualitative IgG test).
   e. SAVE extra serum and freeze.
   f. Serum electrophoresis.
4. *Consider blood culture* if calf is weak and/or placentitis is present.
5. *Administer elephant colostrum* if available, 2 to 10 liters orally. Give by stomach tube if necessary (may need to complete further assessments or treatments if tubing is necessary as this is stressful). Colostrum should be given when the calf is less than 12 hours old if possible and no more than 24 hours old. Bovine colostrum can be substituted if necessary.
6. *Weigh.*
7. *Assess fluid balance.* Insert IV catheter if fluid therapy or plasma therapy is indicated. If calf has not received colostrum, plasma is preferred fluid. If calf has received colostrum, use LRS and/or plasma.
8. *Perform thorough physical examination.* Assess maturity. Rule out congenital defects.



Rosamond Gifford Zoo at Burnet Park

The calf should be allowed to find the teat on its own.

Deborah Olson, Indianapolis Zoo

In case of a very tall dam, a stool is sometimes necessary to help the calf nurse.

compile data. The afterbirth should pass about four to five hours post delivery (range of 1 to 12 hours), be collected, examined, and weighed to determine if the mother passed the entire placenta.

The mother and calf should be monitored closely. Monitoring should continue for at least 24 to 48 hours and up to a number of weeks if the female is inexperienced, or if the female demonstrates or has a history of aggression toward calves.

Suggested Birth Supplies and Equipment

Equipment:

Two 5-ton hoists, assortment of slings and belly bands, hand winch and come-along, block and tackle to lift 3,500 pounds, power source, bolt cutters, extension cords, portable lights, portable scale, tape measure, nylon rope, sawdust, towels and blankets, oxygen tank to give oxygen orally or up the trunk if the calf is hypoxic or if respiratory problems are evident.

Medical supplies:

Iodine, suture, OB glove, lubricant, suction unit, stethoscope, thermometer, hot water pad, towels and blankets to remove mucus from the trunk and mouth, and dry and stimulate the calf, serum banked in advance and milk replacer in the event of maternal rejection.

Emergency drugs and dosages:

Dopram—calculate dose for 250-pound calf and have ready and labeled in a syringe. Give under the tongue or IV to stimulate respiration.

Epinephrine—calculate dose for 250-pound calf and have ready and labeled in a syringe. Give intra-cardiac, intra-tracheal, or IV if there is no heart beat.

Oxytocin—Dose is three times the bovine dose given IM or IV to stimulate milk let down after calf is born.

Calculate dosages for the following:

Lasix, Lidocaine, Atropine, Calcium gluconate, Na Bicarbonate
Tetanus antitoxin—3cc given IM
Tetanus toxoid—1cc given IM
Antibiotics if indicated

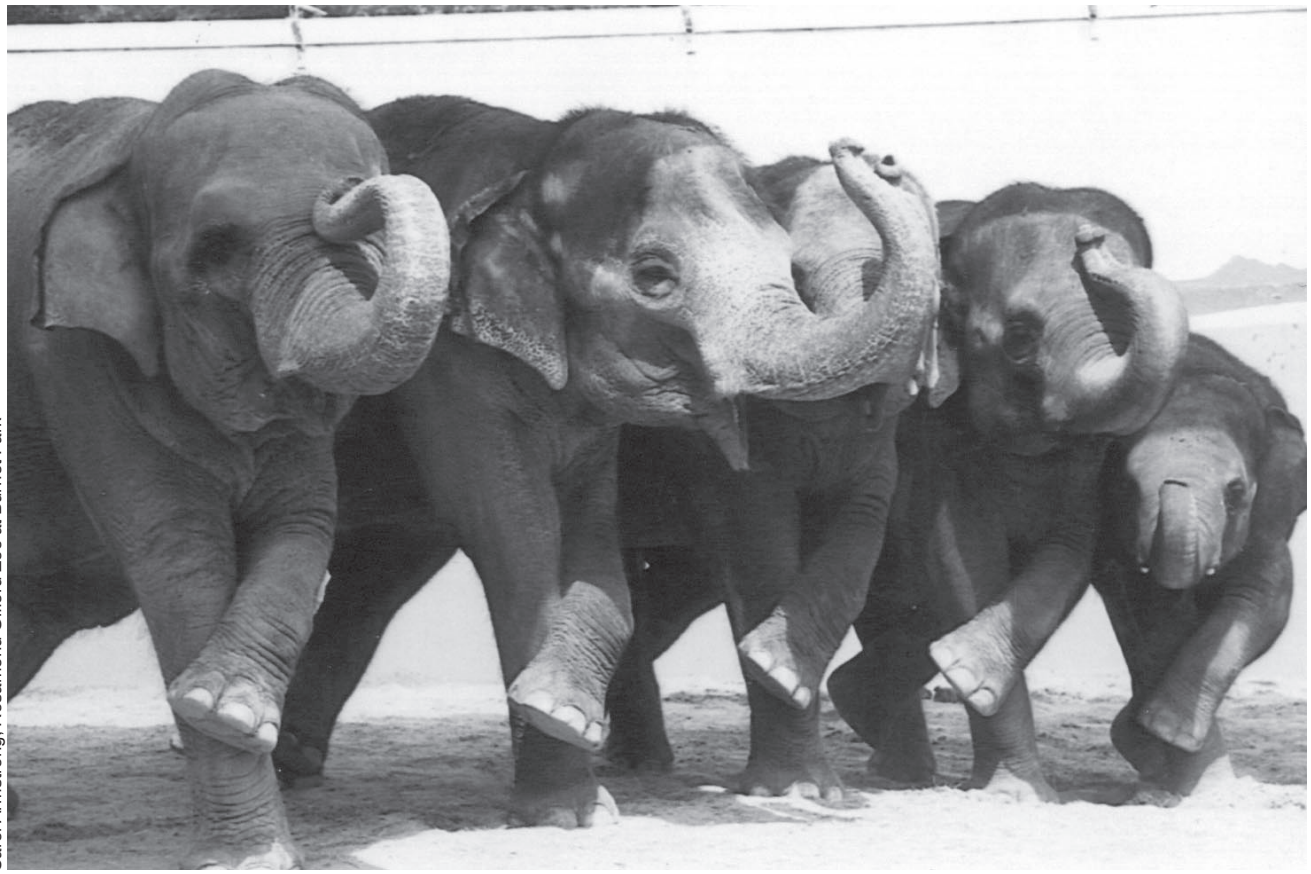
Calf Training and Weaning

The female elephant and her calf should be kept separate from the rest of the herd until she and the calf have bonded and she demonstrates appropriate maternal care. The mother should be watchful of the calf, touching it frequently, and following the calf or restraining it with her trunk. She should allow the calf to touch all parts of her body and walk underneath her. Once bonded, the cow and calf can be introduced to the rest of the herd. It is recommended that they be introduced to one elephant at a time. It is also recommended that each new elephant introduced to the pair be tethered until their response to the calf is known to be positive. When introducing calves to adult elephants, extreme caution must be used, as any aggressive move by an adult could prove fatal and not all female elephants will tolerate calves.

Due to the rapid growth and high potential of mortality, birth to weaning is a critical stage in an elephant's life. Milk consumption is extremely difficult to assess, therefore daily weights of the calf for the first couple of months are important to determine if the calf is receiving its nutritional requirements. In addition, the mother may need an increased amount of food when lactating, depending on the individual elephant. After an expected initial weight loss in the first week, calves should gain approximately 2 pounds per day.

For the calf, nutrition is for growth as well as for body maintenance. Sudden losses in weight can indicate a problem with hydration, which is usually a symptom of a disease process. Too rapid weight gain can be detrimental, causing musculoskeletal abnormalities, obesity, and puberty in a very young elephant. In elephants, as in many animals, sexual maturity is dependent upon weight rather than age (Dennis Schmitt, pers. comm.).

During this time stools should be monitored closely. Stools are first-line signals of good or poor health, and will indicate if the baby is consuming excessive sand or dirt,



Carol Armstrong, Rosamond Gifford Zoo at Burnet Park

It is important that calves grow up to be well-mannered, responsive, healthy, and safe adult elephants.

Table 1. Calf Growth

	FW Asian mother female	CH Asian CH hand	OA African hand male	SD Asian hand male	PI African mother female	RG Asian mother female	RG Asian mother male	RG Asian mother female	IN African mother female	IN African mother* male	RG mother Asian female
Birth	117.5 kg				93 kg	144 kg	125 kg	133 kg	91.1 kg	114.31 kg	130 kg
Day 2	124 kg				93 kg	144 kg	124 kg	130 kg	94.3 kg	110.68 kg	130 kg
Day 3					95 kg	143 kg	125 kg	128 kg	97 kg		131 kg
Day 4					93 kg	143 kg	125 kg	129 kg	98 kg	104.33 kg	133 kg
Day 5					96 kg	144 kg	127 kg	128 kg		103.87 kg	130 kg
Day 6					96 kg	143 kg	127 kg	129 kg		100.7 kg	131 kg
Day 7		120 kg	88.9 kg	122.7 kg	97 kg	144 kg	127 kg	128 kg		104.33 kg	134 kg
Day 8	125.7 kg				98 kg	146 kg	128 kg	130 kg		106.14 kg	135 kg
Day 9					100 kg	148 kg	129 kg	132 kg	98.9 kg		136 kg
Day 10					100 kg	151 kg	132 kg	132 kg	98 kg	104.33 kg	138 kg
Day 11					102 kg	152 kg	133 kg	135 kg		101.6 kg	142 kg
Day 12						155 kg	133 kg	135 kg	100.20 kg	103.42 kg	145 kg
Day 13	128.4 kg				105 kg	155 kg	135 kg	137 kg	100.7 kg	104.33 kg	149 kg
Day 14		125 kg	91 kg	127.3 kg	106 kg		136 kg	138 kg	101.6 kg	104.33 kg	150 kg
Day 15					106 kg	160 kg	137 kg	139 kg	104.30 kg	104.38 kg	151 kg
Day 16					106 kg	164 kg		137 kg	105.20 kg	101.60 kg	150 kg
Day 17					109 kg	165 kg	138 kg	143 kg	107 kg	102.51 kg	153 kg
Day 18					110 kg	165 kg	140 kg	144 kg		102.51 kg	155 kg
Day 19					112 kg	168 kg	140 kg	144 kg	108 kg	102.51 kg	155 kg
Day 20	146.5 kg					169 kg	141 kg	145 kg		106.69 kg	157 kg
Day 21		132 kg	95 kg		113 kg	169 kg		149 kg		107.05 kg	158 kg
Day 22					115 kg	171 kg	144 kg	150 kg	109.80 kg	108.41 kg	158 kg
Day 23						172 kg	145 kg			110.22 kg	160 kg
Day 24					116 kg	175 kg	147 kg		109.8 kg		161 kg
Day 25						174 kg	148 kg			111.81 kg	163 kg
Day 26					117 kg	175 kg	149 kg		110.70 kg	112.49 kg	163 kg
Day 27	156.5 kg					178 kg				112.94 kg	166 kg
Day 28		139 kg	98 kg	141.4 kg	118 kg				112.50 kg	114.31 kg	166 kg
Day 29						180 kg					170 kg
Day 30										117.03 kg	169 kg
Day 31					120 kg	186 kg			113.4 kg	118.00 kg	171 kg

table continued next page

* mother did not fully accept calf until day 20. Until that day, mother was restrained so calf could nurse. Calf was also supplemented with calf replacement formula.

Male at Rosamond Gifford Zoo at Burnet Park was hand raised for 1st five days—day 5 started to nurse from mother

FW - Fort Worth Zoo; CH - Chester Zoo; OA - Oakland Zoo; SD - San Diego Wild Animal Park; PI - Pittsburgh Zoo; RG - Rosamond Gifford Zoo at Burnet Park; IN - Indianapolis Zoo

parasites, and when the calf begins to consume plant matter. The calf should be active, interested in the activities around it, and attentive to its mother. Weather extremes should also be monitored as calves are more sensitive to cold and heat than adults.

It is important that calves grow up to be well-mannered, responsive, healthy, and safe adult elephants. No matter what aspect of the training and management continuum the facility uses with its adult elephants, it is important that the behavioral components, which are the current standards of acceptable elephant care and management, are met with the calf. Therefore, initial training should begin shortly after birth. An elephant calf is very inquisitive and impressionable, ready and willing to learn a pattern of interaction with humans. Elephant calves enjoy interacting with humans and every elephant calf and human interaction should be considered a training opportunity with consistent signals given to the calf. Every interaction allows the handler to mold and encourage behavior that is desired and extinguish behavior that is not desired. Behaviors the calf does naturally are easily shaped at this time to become behaviors in its adult life. This establishes a good foundation of appropriate behavior for the elephant, regardless of how the elephant will be managed in the future.

Not only are elephant calves capable of learning at an early age, but it is best for their welfare. It is important that the calf learn basic behaviors to facilitate husbandry and medical care. With the threat that the elephant herpes virus presents to calves, training at a young age may save its life. For this reason alone, it is important to teach a calf to approach, lead, and stand still on command by 6 months of

Table 1. Calf Growth (continued)

	FW Asian mother female	CH Asian CH hand	OA African hand male	SD Asian hand male	PI African mother female	RG Asian mother female	RG Asian mother male	RG Asian mother female	IN African mother female	IN African mother* male	RG mother Asian female
Month 2	170.1 kg	158 kg	119 kg						130 kg	149 kg	
Month 3	230.9 kg	174 kg	136 kg		172 kg				160 kg	191 kg	
Month 4	271.3 kg	192 kg	140 kg					195 kg	180 kg	218 kg	
Month 5		208 kg	158 kg					220 kg	210 kg	257 kg	
Month 6	332.9 kg	260 kg	183 kg		204 kg			238 kg	219 kg	283 kg	
Month 7		244 kg	208 kg						244 kg	306 kg	343kg
Month 8			233 kg			449 kg			258 kg	335 kg	
Month 9	413.7 kg	276 kg	246 kg			460 kg			279 kg	361 kg	
Month 10	434.7 kg	288 kg	264 kg						306 kg	384 kg	
Month 11	461.8 kg	291 kg	294 kg						333 kg	419 kg	
Month 12			died						363 kg	453 kg	
Month 13	521.6 kg					607 kg			390 kg	483 kg	
Month 14	546.1 kg								421 kg	527 kg	
Month 15	576.1 kg								457 kg	561 kg	
Month 16	601.5 kg	378 kg							483 kg	586 kg	
Month 17	641.4 kg	354 kg							502 kg	625 kg	673kg
Month 18								550 kg	520 kg	646 kg	
Month 19									543 kg	669 kg	
Month 20						756 kg			572 kg	704 kg	
Month 21	688.1 kg								596 kg	739 kg	
Month 22									626 kg	751 kg	
Month 23	752.5 kg								651 kg	822 kg	
Month 24									695 kg	841 kg	
Year 3	1,111 kg					1,357 kg		1,022 kg	962 kg	1,089 kg	
Year 4						1,491 kg		1,227 kg			
Year 5						1,695 kg					

* mother did not fully accept calf until day 20. Until that day, mother was restrained so calf could nurse. Calf was also supplemented with calf replacement formula.

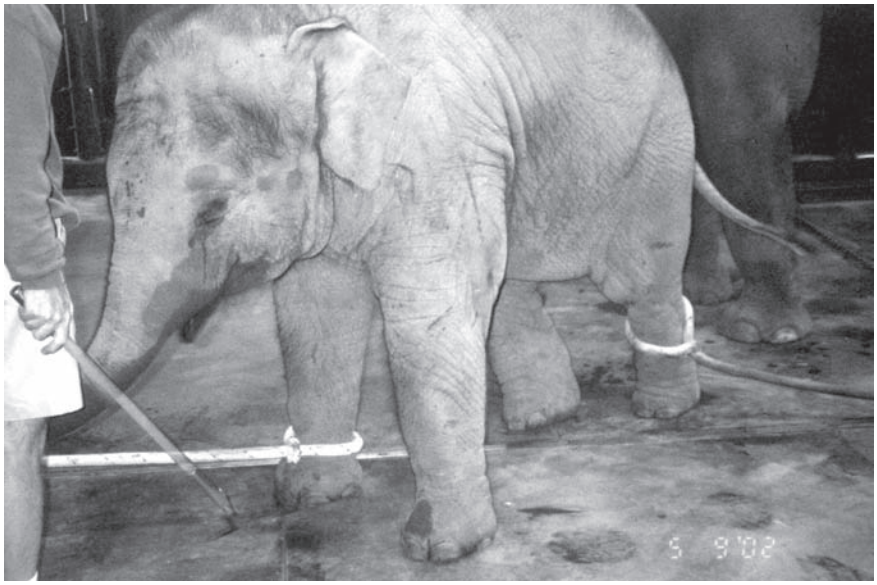
Male at Rosamond Gifford Zoo at Burnet Park was hand raised for first five days. On day five, started to nurse from his mother

FW - Fort Worth Zoo; CH - Chester Zoo; OA - Oakland Zoo; SD - San Diego Wild Animal Park; PI - Pittsburgh Zoo; RG - Rosamond Gifford Zoo at Burnet Park; IN - Indianapolis Zoo

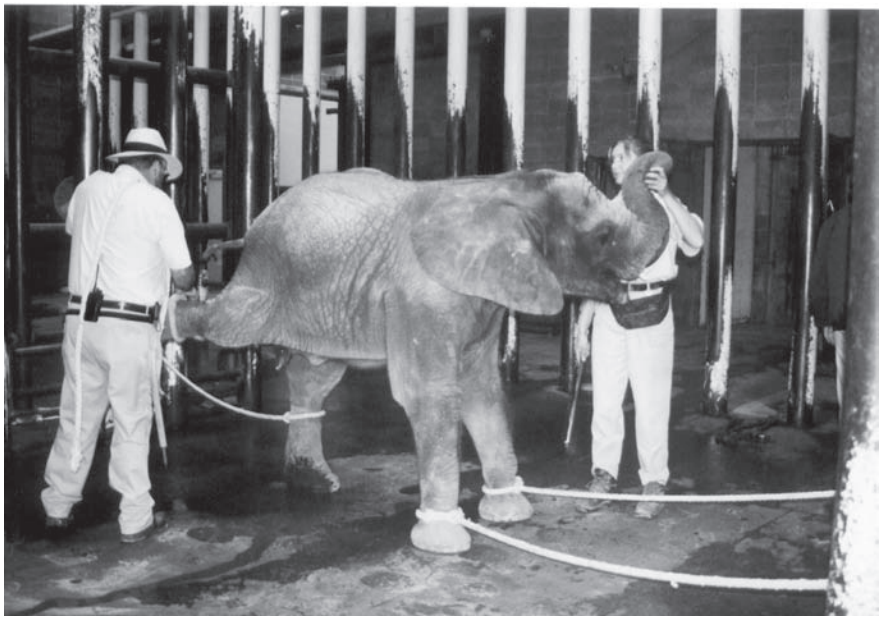
age. The calf should also be taught to tolerate medical examinations, blood collection, foot care, treatment of injuries, trunk wash for tuberculosis, and daily mouth examinations for early signs of the elephant herpes virus. It is also important for a calf to be conditioned to accept some limited separation from its mother in the event of a medical treatment or serious husbandry procedure. If the calf is not conditioned early to separation, and there was an immediate need to do so, the calf could jeopardize its own health and welfare by becoming unmanageable in an attempt to get back to its mother or the other elephants**.** The alternative to training is tranquilization or immobilization, which for most procedures is unacceptable.

All of the training of the calf should be carried out under the supervision and guidance of the elephant manager. With facilities that have no experience training calves, it is highly recommended to bring in a consultant with experience. Training of the calf is a gradual process. Behaviors taught initially should be selected based on the calf's welfare and husbandry needs. As the calf matures and its attention span increases, so do the number and types of behaviors it is ready to learn. Each training session should be planned in advance, and every handler should understand their role in the event. The training sessions should be kept short, end on a positive note, and be fun for the calf.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "The minimum age offspring must remain with their mothers is three years. Some flexibility is necessary in cases of maternal rejection and when infants cannot be reestablished in their social group."



Rosamond Gifford Zoo at Burnet Park



Indianapolis Zoo

To enhance husbandry and medical procedures, elephant calves should be conditioned to be tethered for short periods while they are still young.

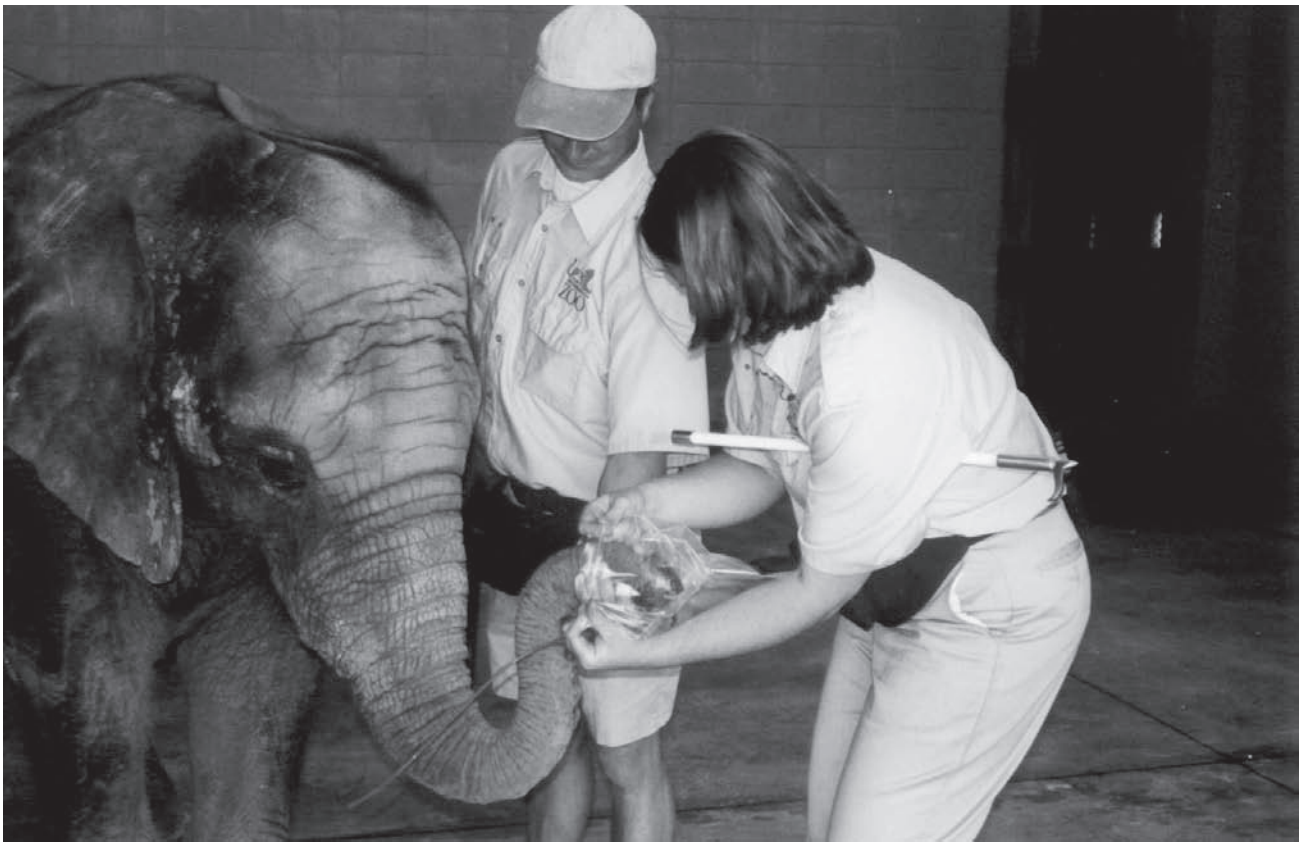
Because human contact is necessary, the calf should be taught to respect the personal space of the handlers and understand the command "no." All handlers must understand that though cute, the calf is quite capable of injuring a human. The calf at birth will weigh approximately 200 pounds or more and be able to knock the handler to the ground. Within months, the calf can weigh more than 500 pounds. Physical play with the calf should never be permitted. The calf can inadvertently learn bad behaviors through inappropriate physical play, which will have to be extinguished as the calf gets bigger, causing unnecessary confusion and training.

To enhance husbandry and medical procedures, elephant calves should be conditioned to be tethered for short periods while they are still young. Most elephant restraint chutes are not designed to restrain young calves without major modifications or additional physical restraints such as chains, straps, or ropes. Initial tethers should be made of soft wide rope to reduce abrasions, although some superficial chafing may occur. It is recommended that calves first be allowed to get used to the feeling of a rope on their legs by initially dragging a short section, then slowly graduating to having a handler maintain hold on the end, and finally tying the rope to a stationary object. Through a slow process of desensitization and reinforcement, the calf can be tethered with little to no agitation.

The individual design of the facility and goals of the elephant management program will dictate the best separation and weaning method to be used for the elephants in any given facility. The following industry recognized experts, representing different facilities, may be contacted for further details on separation and weaning of infant elephants:

David Blasko, Animal Director, Six Flags Marine World, Vallejo, California
Chuck Doyle, Curator, Rosamond Gifford Zoo, Syracuse, New York
Jeff Glazier, Senior Keeper, Dickerson Park Zoo, Springfield, Missouri
Charlie Gray, Elephant Superintendent, African Lion Safari, Cambridge, Canada
David Hagan, Curator, Indianapolis Zoo, Indianapolis, Indiana
Roger Heneous, retired Senior Keeper, Oregon Zoo, Portland, Oregon
Gary Jacobson, Elephant Trainer, Center for Elephant Conservation, Polk City, Florida
Gary and Kari Johnson, Elephant Trainers, Have Trunk will Travel, Perris, California
Dr. Dennis Schmitt, DVM, Ph D, Reproductive Resources, Springfield, Missouri

Indianapolis Zoo



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A young female is trained to accept the TB trunk wash.

Weaning

Weaning is a necessary part of the elephant calf's natural maturation process, even if the calf is to remain with its mother long term. Ideally, four things should be in place before a calf is ready to wean:

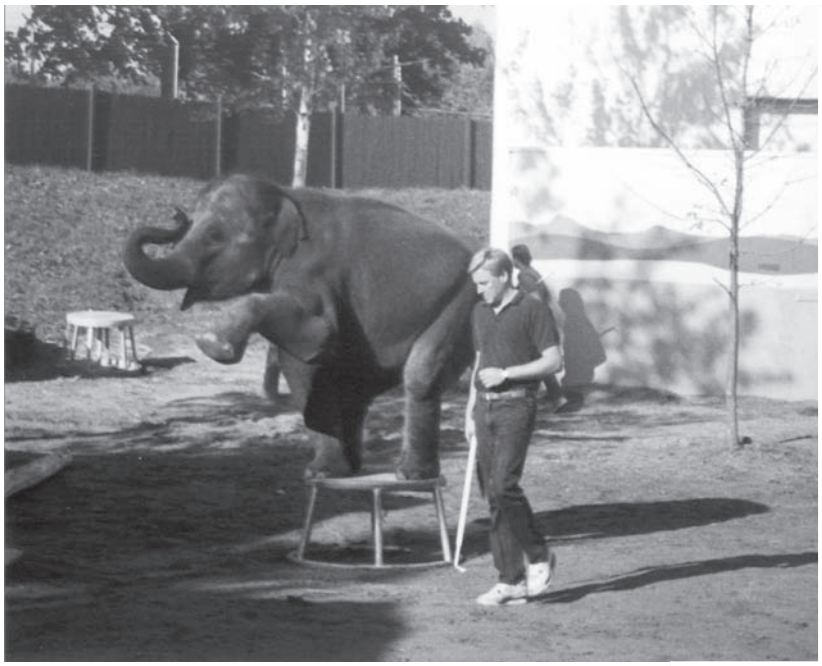
1. The calf should be nutritionally independent from its mother. The calf should derive its nutritional needs from solid food, nursing only occasionally and primarily for comfort.

2. The calf should be sufficiently socialized with other elephants. Weaning should not occur in total isolation. It is a good idea to make sure the calf has been introduced to at least one other elephant that can serve as an "auntie."

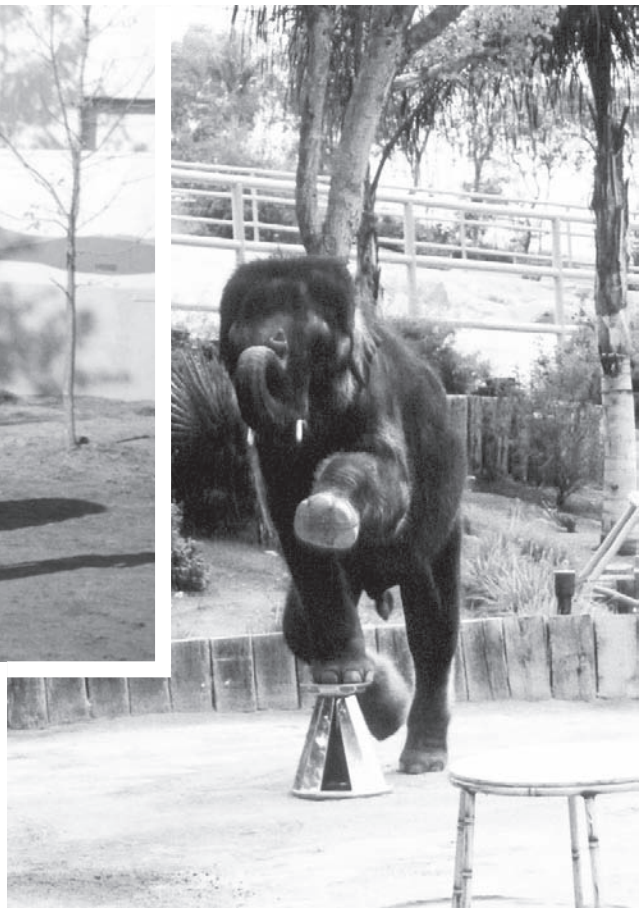
3. The elephant calf should be emotionally independent. Initially, a young elephant is the shadow of its mother—tagging along very close to her side, too insecure to stray far. But as the calf becomes older, its curiosity gradually overcomes its fear, and its dependency on its mother diminishes. The calf is ready to wean when it spends a good deal of time away from its mother's side. Some calves are naturally more adventuresome than others, so this will happen at different rates.

4. The calf should be accustomed to the area it will be weaned.

It has been observed that the natural weaning process by the mother has been both gradual and abrupt. Both of these methods have been used successfully by elephant facilities in North America.



Rosamond Gifford Zoo at Burnet Park



Have Trunk Will Travel

Calves are eager to learn. Above: A young elephant performs tub work as part of a public demonstration. Right: A young bull works on a spindle.

Weaning in the elephant is marked by the change in digestive function from a simple monogastric to a more complex hindgut fermenter, capable of digesting plant material. This involves both modifications to the internal anatomy and alterations in the microbial flora within the intestines. This intestinal flora is obtained when the calves consume fresh feces of the adults. Calves are introduced to solid food by sampling food dropped by the mother within the first few months of life and are consuming grain and plant material by 6 months of age. This begins to end the dependence on nursing from the mother for nutrition and, under normal conditions, begins the cessation of the nursing process.

Separation and weaning of young domestic animals is a common practice in order to keep the dam in good health and reproductive condition, to increase her nutrition, and improve the growth of the young. Most young initially object to the weaning process (even when it is done naturally by the mother) but quickly lose their attachment and need for their mother. Elephant calves are no exception. Weaning is a necessary and acceptable process in captive elephant management.

Weaning is a gradual process and not a single event. Although the dependency on nursing should be extinguished over time, the calf's nursing behavior and social dependency on its mother may not decrease as expected. Unnatural bonding between mother and calf can occur in a captive setting if the calf is not socially integrated with other elephants, or the limits to the enclosure encourage constant contact between mother and calf. This reduces the natural activity of the young wandering from its mother and becoming more independent with age. Maturing calves that are socially integrated with multiple females usually spend less time with their mother and more time with peers or females assuming the role of "aunties." Each elephant calf is different though, and whether the mother weans the calf herself or human caretakers do it, separation and weaning of young elephants may be necessary even if it is planned to keep the calf with the mother for its entire life.

The elephant management staff, with input from the veterinary care staff, will assess the best age to wean a particular calf based on the health of the calf, its personality, and the mother's behavior toward it. An indication that a calf may be ready for weaning is when the calf has a fecal consistency of an adult. At this time calves do not rely on nursing for their nutritional needs but more on solid foods, and can safely be weaned. The mother may also indicate the best time to wean a calf by an increasing lack of tolerance toward it. Captive elephant calves have been successfully weaned at 6 months of age, but that is thought to be the extreme. Most elephant breeders believe weaning is best to occur between 2 and 3 years of age.

It is important to understand that weaning is the separation of the calf from the mother to reduce and ultimately stop nursing behavior and abnormal social dependency. Weaning does not mean a complete separation from all elephants. It is important to provide both the calf and the mother with companion elephants during separation periods.

The weaning process needs to be properly planned by the elephant management staff and the veterinary care staff before any part of the process is started. Decisions must be made as to whether the mother and a companion will be removed from the calf and the rest of the herd or whether the calf and a companion will be removed. Separation and weaning of a calf can be done in many different ways, but it is labor intensive, requires continuous evaluation of the process, and demands good facility design and competent staff. For elephant calves that have been conditioned to some separation while they were still very young, lengthening the period of time the calf is away from its mother until the youngster is completely independent from its mother is a straightforward process.

Supplemental Feeding and Hand-raising of Calves

The increasing reproductive success of elephants in human care may result in a number of female elephants that will initially reject their calves due to a lack of calf-rearing experience. Although many very young elephants have been imported into North America and subsequently bottle fed for a period of time, very few elephants of either species have been successfully hand-raised from birth. In the last few years, six calves were reported to have been successfully reintroduced to their mother after a period of up to 20 days postpartum. This is a significant and encouraging finding as it demonstrates that a mother elephant can be trained to accept her calf.

Therefore, every attempt to reintroduce the calf to its mother *must* be made, and hand-raising should only be a last resort, for example, after an event such as the death of the mother. Consequently, it is of paramount importance to precondition the female elephant and plan for a persistent reintroduction of the potentially rejected calf. At the same time, preparations for any elephant birth must include plans for the possible need to supplement the calf's diet or hand-raise the calf, in the event of the death or illness of the mother, or a weak or disabled calf.

Preconditioning of the mother should include training to desensitize her to gentle mammary gland and nipple manipulation simulating the calf's initial attempts to nurse and milking. However, care must be taken when handling the mammary glands prior to parturition. Excessive

Dickerson Park Zoo, Melissa Carden

Preconditioning of the mother should include training to desensitize her to gentle mammary gland and nipple manipulation.

handling may reduce the amount of colostrum available to the calf if milk is expressed, and may increase the possibility of both mastitis and mammary gland edema.

Planning for supplementation or hand-raising should include the following:

- The acquisition of supplies at least several months in advance of the anticipated birthdate in case the calf is premature or the estimated parturition date is incorrect. Some supplies—like the elephant milk replacer—have to be special ordered and may take weeks for the company to ship. A nutritionist should be consulted regarding the appropriate milk replacer and feeding regimen.
- A plan for 24-hour care of the calf needs to be developed prior to the birth. In each of the cases where calves were successfully reintroduced to the dam, the staff worked around the clock to encourage and facilitate the maternal relationship. Every effort should be made to establish a stable group of people responsible for the calf's care. This group should be large enough to allow for ease of scheduling over a long period of time but small enough for consistency in care.
- In addition to standard medical records, an infant care sheet should be produced well before parturition. For the purposes of tabulation, the sheets should be designed to record a 24-hour period. Basic information should include intake (formula, solids, water) and output (defecation, urination). The calf's vital signs, behavior, physical development, and activity should also be observed and recorded.
- The elephant management committee should develop a plan for the reintroduction of the calf to the dam. The plan should consider the management program, facility, use of outside consultation and assistance, the temperament of the dam, and the impact on the staff.

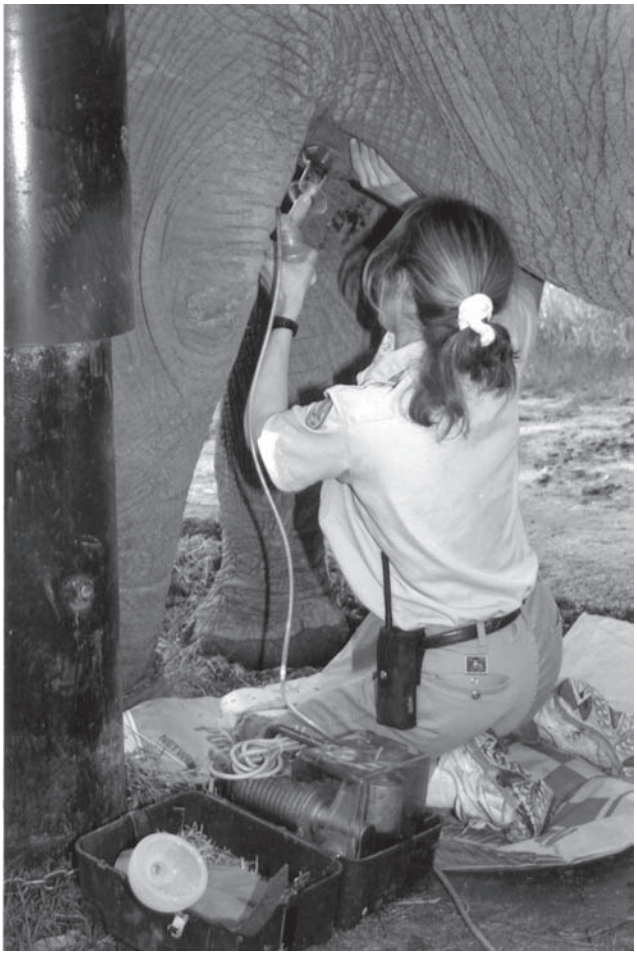
It is strongly recommended that all means possible be employed to allow the calf to nurse frequently from its mother including physical and chemical restraint. Under these conditions it may not be possible to provide the calf enough opportunities to nurse to maintain its strength. Consequently during the reintroduction process, which may take days or weeks, supplemental feedings may be necessary.

Supplemented and hand-raised calves very quickly become imprinted on their human handlers. As with many animals, elephants that are hand-raised prefer human companionship to that of other elephants, therefore, steps must be taken to prevent this imprinting. Interaction with people should be minimized and most of the handler's time should be spent fostering the relationship between mother and calf. It is critical that the calf gets every opportunity to socialize with its mother and even other elephants. The calf should be maintained in close proximity to its mother so the calf can hear, smell, touch and see her at all times.

In reported cases, a wide range of time (2 to 19 hours) passed before individual calves received their first bottle–

Supplies For Hand-raising

- Bovine bottles and nipples
- Milk replacer
- Cloth tape measure
- Human breast pump
- Microwave
- Refrigerator
- Cooking thermometer
- Containers and utensils
- Walk-on scale
- Documentation capabilities
- Camera
- Record sheets
- Notebooks
- File folder box
- Nursery in elephant barn
- Shavings
- Straw
- Blankets
- Towels



Oakland Zoo

Handler uses an electric human breast pump.

Oakland Zoo

Most often, a bovine nurser is used with the nipple opening slightly enlarged to allow a steady drip of formula when the nurser is tipped.

feeding; the longer time period was due to handlers trying to get the calf to nurse from its mother. Most often a bovine calf nurser was used with the nipple openings slightly enlarged to allow a steady drip when tipped. A rubber band was sometimes placed between the nipple and the bottle rim to allow air to escape. In other facilities, an IV line was attached to a fluid bag with the end of the IV line attached to a handler's fingers so the calf could be more easily led to the mother's teat.

If possible, it is preferred that the majority of the calf's diet is its own mother's milk during the period that it is being hand-raised (especially for the first couple of days), so the calf will receive the much needed colostrum. Milking methods are varied and can include:

- by hand (similar in technique to that used to milk goats; squeeze the teat at the top with the thumb and fore finger then squeeze with the other three fingers in succession);
- manual human breast pump; and
- electric human breast pump.

Human lactation consultants can assist in facilitating the loan of breast pump equipment, as well as providing instruction on its use. Oxytocin can be used to aid in milk let down and production. Oxytocin has also been administered after the calf began to nurse and it appeared that the milk let down was poor.

The amount of milk collected in the first 24 hours can vary widely, from 300 to 3,880 ml. Frequent milking and the use of oxytocin can dramatically increase the amount of milk collected. In one case where the mother was milked every three hours and oxytocin was given each time, the average amount collected per milking was 1,080 ml during the first week. Milking has also been used to collect samples from a nursing mother over the course of lactation for the development and modification of elephant formula.

In the event that the mother cannot care for the calf due to illness or death, then hand-raising becomes a necessity. For at least the first three months, it is recommended to feed the calf on demand, or at least every two or three hours, then gradually shift to an every–three–hour feeding schedule. The handlers should begin by offering the bottle, but the calf will soon develop recognizable behaviors indicating a desire to nurse. After three months, the nighttime feedings can be gradually eliminated and by nine months, the calf can be offered as few as four feedings per day.

Milk Replacer and Supplements

An elephant milk replacer formulated by analyzing the milk of lactating females was used in a number of cases. In at least two cases, additional milk samples were analyzed over time and changes were made to the formula composition accordingly. Several human infant formulas have also been used to bottle feed calves. In North America, Grober Company (www.grober.com), located in Cambridge, Ontario, produces the most commonly used elephant milk replacer. Grober produces a replacer for both African and Asian elephants. The Asian formula has 1,215 K–cal digestible energy per liter. The African formula has 750 K–cal digestible energy per liter. Enfamil is the most commonly used human infant formula and has 666 K–cal per liter (note not in digestible energy).

In most reported cases, some kind of dietary supplementation was provided. Bovine colostrum, Colostrix (a colostrum replacer), and lactobacillus were given to protect the gastrointestinal tract. Desiccated coconut and butterfat were added to increase the fat in the diet. Vitamin and mineral supplements were commonly used (mentioned specifically were vitamin E, vitamin B, and calcium). In many cases, rice water (cook rice and pour the water off) and glutinous rice broth were used when mixing the formula to help alleviate diarrhea. Rice cereal, milled whole barley or oatmeal, desiccated coconut, and other ground solid foods were added to the bottles of older calves to facilitate the transition to solid foods.

The amount of milk provided to the calf should be based on its weight and condition. The calf should be weighed daily and on average the calf should gain between 0.5 kilograms (1.1 pounds) and 1.4 kilograms (3 pounds) per day, averaging 0.9 kilograms (2 pounds), although it is normal for a calf to experience slight weight loss for the first several days to a week of life. Calves weighing 100 kilograms (220 pounds) should receive between 6,000 and 8,000 K–cal per day and calves weighing 200 kilograms (440 pounds) should receive between 16,000 and 20,000 K–cal per day.

Although hand-raised calves experiment with solid foods at an early age, they appear to develop normal feeding habits much more slowly than mother-raised calves. Mother-raised calves use their trunks to smell and to take food from the mouth of their mothers learning what is desirable to eat. As stated in the previous chapter, mother-raised calves also consume the feces of their parent, establishing the appropriate stomach flora. For the health of the hand-raised calf, handlers must take every opportunity to encourage the calf to consume solid foods as soon as possible. As with mother-raised calves, weaning and subsequent hunger may increase the calf's appetite for solid foods.

Table 1. Daily feeding rates for different hand–rasing formulas

Formula	Calf weight: 100 kg (amount fed in liters)/day	Calf weight: 200 kg (amount fed in liters)/day
Grober Asian	5–6.6	13.2–16.5
Grober African	8–10.7	21.3–26.7
Enfamil	9–12	24–30

Alhough it can be very difficult to control the movement of very young calves, it is especially important that hand-raised calves are taught from the beginning to be respectful of humans. As with mother-raised calves, young calves need to learn basic manners and to be taught simple behaviors from leading to standing still to allowing blood collection as soon as possible. Due to the amount of time spent together, the human-calf bond can become overemphasized, therefore it is extremely important that hand-raised calves should not be allowed to interact with handlers in any way that would be unacceptable for an adult elephant. Calf butting and charging play behavior directed at the handlers should be immediately eliminated. Having toys available—plastic garbage cans, boat buoys, and hanging objects—allows the calf to exhibit normal play behavior without handler involvement.

Regular exercise is important for normal and healthy calf development. Calves in the wild walk miles each day. Even in a captive situation, a mother-raised calf would spend time walking as it followed its mother. A hand-raised calf should be walked regularly and a routine established. Exercise should also come in the form of play.

Physical development of hand-raised calves should follow very closely that of mother-raised calves. Written, photographic, and other forms of documentation of body measurements, vital signs, eruption of molars and tusks, learning stages of the calf and detailed behavioral and medical records are essential in monitoring the health and development of the calf. Again, daily records that allow for the 24-hour tabulation of input/output will translate easily into weekly and monthly summaries that make it easier to monitor trends.

The medical issues involved in the process of hand-rearing elephants are multiple, and the methods for dealing with these issues can be varied. There is little published information available on the subject.

Some conditions appear to be specific to, or occur more frequently in, hand-reared neonates. Diarrhea is defined as an increase in liquidity or frequency of stool production. Loose stool in a variety of colors may be "normal" for formula-fed infants. Severely odorous stool may be abnormal. The frequency of stool production that is normal for one particular calf is helpful in determining the extent of diarrhea when it occurs.

In cases of mild diarrhea without any additional clinical signs: dilute formula 25 percent to 50 percent for one to three days; discontinue formula and substitute water-electrolyte solution such as Pedialyte™, rice water, or rice milk; alternate each formula feed with a feed of electrolyte

Table 2. Range of Reported Amounts Bottle Fed

Week	Liters/day	Liters/hour	Ml/kg/day
1	5.0–10.7	.208–.446	55.6–87.2
2	8.75–11.6	.364–.483	70.0–91.0
3	11.0–13.2	.458–.550	75.9–128.5
4	11.8–12.0	.490–.500	85.0–98.0
month			
1	5.0–13.2	.208–.550	55.6–128.5
2	12.0–18.0	.500–.750	75.9–128.5
3	10.9–20.0	.456–.833	62.9–119.1
4	12.1–24.0	.504–1.00	63.0–130.7
5	14.5–29.0	.606–1.21	70.0–134.0
6	13.7–31.0	.573–1.29	52.9–138.2
7	10.9–24.6	.456–1.02	44.9–118.3
8	12.7–25.8	.531–1.08	56.2–110.8
9	15.0–28.5	.625–1.19	36.8–107.2
10	10.6–28.3	.441–1.18	36.8–107.2
11	12.7–30.6	.531–1.26	43.8–104.1

solution; or change to a different formula. In cases of diarrhea accompanied by other clinical signs such as lethargy, weakness, reduced appetite, colic, or dehydration, diagnostic evaluation as well as treatment is necessary. Diagnostics include: CBC, chemistry panel (note that blood collection is stressful for elephant calves, so the necessity for this action should be based on history and severity of clinical signs); fecal culture for *Salmonella*, +/– other potential pathogens such as *E. Coli*, *Pseudomonas*, *Clostridium perfringens*, and *Campylobacter*; fecal cytology smear; fecal flotation for parasites, +/– exam for giardia; TPR, and body weight SID to BID; +/– Herpes virus serology test; and a PCR +/– blood culture. Treatment options include diet changes as above, with emphasis on oral electrolyte fluids; IV fluid therapy; antibiotic therapy; Kaopectate orally; anthelmintic when appropriate.

Metabolic bone disease, or Rickets, has occurred in young growing elephants fed a diet with (what appeared to be) an imbalanced calcium-to-phosphorus ratio. Unfortunately there may not be enough information on the calcium-phosphorus content of normal maternal elephant milk to know what the recommended amount should be. Access to sunlight may also be important in the prevention of this disease as a source of vitamin D necessary for calcium absorption from the gut. Chronic intestinal malabsorption was suspected as a causative factor in one case of metabolic bone disease in a hand-reared calf at the San Diego Wild Animal Park (Oosterhuis, personal communication 1996). Diagnostic evaluation may include evaluating serum calcium and phosphorus levels, radiology, and formula (repeat) analysis. Treatment would involve correcting the dietary imbalance, possibly injection(s) of vitamin D, access to sunlight, and care with regard to body weight and type of exercise (or any activity that could lead to pathologic fracture). It is recommended that the calf be exposed to 30 to 60 minutes of sunlight per day depending on the weather. It is also recommended that x-rays of the distal limbs be taken to evaluate bone density at approximately 6 and 8 months of age.

Skin dryness has been noted in hand-raised calves. The cause is unknown. The dryness can cause a marked pruritis resulting in the calf rubbing itself raw on doors, walls, and

Physical development and behavior of hand-raised calves should follow very closely that of mother-raised calves.

Suggested Medical Supplies and Tests

- Elephant plasma: 4 to 8 liters minimum for IV use, plus an additional 4 to 8 liters for possible oral use. Can begin collecting six months prior to calving date and store at –20° C (–4° F); it can be stored for 12 months if a –70° C (–94° F) freezer is available. Donor elephant should be healthy, on-site, a whole blood PCR test for herpesvirus should be negative, and the EEHV ELISA serologic status known.
- Elephant colostrum: 2 to 10 liters, if available. Bovine colostrum can be substituted in emergencies, same volume.
- Stethoscope
- Large animal thermometer
- Flashlight, penlight, ophthalmoscope
- Intravenous (IV) catheters: 18-gauge, 20-gauge intracaths, 1" to 3" in length. Other catheterization supplies including heparinized saline, bandage tape, surgical adhesive, suture kit, 2 percent lidocaine
- IV fluid solutions: Lactated ringers solution preferred, also NaCl, KCL, 50 percent dextrose
- Large animal fluid administration sets, standard administration sets, IV fluid bag pump, possibly IVAC unit
- Antibiotics: ceftiofur (Naxcel®), penicillin G, amikacin/gentamycin, ampicillin, amoxicillin, trimethoprim sulfas. Do not use fluoroquinolones.
- Therapeutics for shock: Dexamethasone NaP, dopram, epinephrine, atropine
- Surgical kit: surgical instrument packs, suture material, (2–0–0, absorbable, slowly absorbable, and nonabsorbable)
- Radiology: portable unit OK for distal extremities, 300 MA or greater for thorax, abdomen, pelvis. On-site preferred, or plan for potential transport to other facility
- Bandaging and casting material
- Antiseptics: Betadyne, Nolvasan, hydrogen peroxide, tincture of iodine
- Vitamin injections: B, C, E and Bo–Se® (vitamin-E-selenium)
- Banamine injectable
- Stanolozol (Winstrol®), prednisone
- Blood collection kit: vacutainer system and standard syringes, serum (clot) tubes and EDTA tubes, access to STAT lab, on–site preferred
- Blood culture bottles
- Calf formula and bottles
- Heat sources: heating blanket, heat lamps, floor heaters
- Tetanus toxoid, tetanus antitoxin
- Oxygen administration system: portable to elephant location. Anesthesia machine or oxygen demand valve with tank
- Anesthetics: Isoflurane vaporizer system, ketamine, xylazine, reversal agent for xylazine
- Endotracheal tubes up to size 18 with stylets, mask to fit over trunk
- Anesthesia monitoring equipment—pulse oximeter, EKG, Doppler unit
- Medical records

so on. Treat with a mixture of lanolin and mineral oil (1 pound lanolin added to 1 gallon mineral oil). Apply to the entire calf's skin one to three times weekly after gently bathing the calf with warm water. It may be advisable to test the calf for allergy to the mixture by applying a small amount to the skin the first time it is used.

An infant that has been rejected may have received traumatic wounds from the dam or other elephants. The wounds can be external (such as abrasions, lacerations, bruising, puncture wounds) or internal (such as fractures, trauma to internal organs). Diagnostic evaluations include physical examination (repeat frequently), aerobic and anaerobic culture, sensitivity of any infected wounds, and radiographs. An x-ray generator of 300 MA or greater will be necessary for all but the distal extremities. Sedation or anesthesia may be required to radiograph a calf that is not depressed or weak. Treatment may include minor or major surgery, wound care +/– bandaging every 12 to 24 hours, antibiotic therapy, and analgesics depending upon the location and extent of the trauma.

Failure of Passive Transfer (FPT) of Immunoglobulins

There have been no recent definitive studies of the immune development of the elephant neonate. Some guidelines, such as volume of plasma to administer in cases of FPT, have been extrapolated from equine recommendations. Some guidelines to consider are as follows:

- Elephant neonates consume 2 to 10 liters of colostrum, with nursing beginning as early as 30 minutes after birth (Fowler 1986). Therefore it is recommended to give this volume, and assume that the window of time for absorption is from birth to 6 to 12 hours of age, possibly up to 24 hours of age, as in the foal. Colostrum can be stored frozen for a period of up to one year at –20° C.
- Elephants have long been thought to have no placental transfer of immunoglobulins, only passive transfer through colostrum after birth. Recent findings suggest that further work is needed in this area .
- More information is needed on testing the immune status of neonatal elephants. Tests that should be performed are: total protein and globulins, serum electrophoresis, and a qualitative immunoglobulin test such as zinc turbidity test. A threshold of 400 mg/dl of IgG is an adequate level for foals, but this may not be adequate for elephants. Note that the two African elephant calves born at Oakland Zoo that had not nursed prior to blood draw had IgG levels of greater than 400 mg/dl as determined by the glutaraldehyde precipitation test (a qualitative IgG test). It has been suggested that a neonate should be considered hypogammaglobulinemic if serum concentrations are less than 25 percent of the adult average for the species. Electrophoresis does not require species-specific reagents and can measure gammaglobulins (Fowler and Miller 1999). Total protein and globulins may not be a reliable indicator of passive transfer in foals and calves. Generally, a serum globulin level of less than 4.5 g/dl suggests FPT, and 4.5 to 5.0 suggests partial FPT, but these values are only guidelines, and again the Oakland calves had values greater than 4.5 even though no nursing had taken place. Quantification of IgG requires radial immuno diffusion (RID), which requires species-specific antiserum. This would have to be developed by a research laboratory. Finally, although not definitive, these tests should be performed not only to assess the calf, but also to gather information for future calves.
- Elephant plasma should be collected up to 6 to 12 months prior to expected calving date. The sterile plasma can be stored at –20° C (–4° F) for 6 months, and at –70° C (–94° F) for 12 months. If the plasma is to be given IV, it should be taken into account that if the donor elephant is the dam there is a potential for isoantibodies; donor should be healthy and herpesvirus negative by whole blood PCR tests. The elephant should be tested at each plasma collection. It is preferable to collect from elephants on-site, as resistance to local infectious agents is more likely.
- The volume of elephant plasma to administer IV to the calf is not known, but it is likely that amounts similar to that required for the foal are necessary. Foals are given 40 to 80 ml/kg IV over a 2 to 4 day period. For a 100-kilogram (220 pounds) elephant calf, this would total 4 to 8 liters. This amount is too large a bolus for one administration, especially in a calf with normal hydration status. Ten to twenty ml/kg is a reasonable amount to give as one IV bolus over 30 to 60 minutes. The volumes of plasma administered to neonatal calves reported in the *Elephant Hand Raising Notebook* have been lower than recommended amounts, 1.5 liters or less. Elephant plasma can also be given orally during the first 24 hours after birth (first 6 to 12 hours preferred), but the antibody content is lower than colostrum, therefore a larger volume must be given to approach a similar level of absorbed immunoglobulin. Colostrum or plasma may have a local protective effect on the gut even if GI absorption is absent.

Medical Management

Elephant medicine is challenging. Diagnosis and treatment options are limited not only by the size of the elephant, but also by the limitations of our knowledge. Elephants may succumb to disorders unique to their species or to conditions that are readily resolved in other species. Table 1 shows the normal physiological values for elephants.

Every elephant facility must have employed (or under contract) a veterinarian with experience in large mammal medicine and some knowledge of elephant medical management to direct the routine health care, monitoring, and treatment of the elephants. This individual or designate must be available at all times. In the case of medical emergencies, this individual must be able to manage the elephant's treatment or identify and contact the appropriate veterinarians for assistance.

The facility veterinarian must give each elephant a thorough annual physical examination including screening for tuberculosis and parasites, and complete blood count and serum chemistries to assess general health. In addition, the veterinarian should inspect each elephant visually on a regular basis. It is strongly recommended that these regular visits also be used as training and desensitization opportunities for the elephant. Elephants can associate veterinarians with negative or uncomfortable procedures. This causes the elephant to either act aggressively toward or be fearful of the veterinarian and their equipment. Regular visits of the veterinarian accompanied by opportunities for reinforcement will make the elephant more accessible to the veterinarian and improve the veterinarian's ability to monitor and treat.

Blood Collection

There are three primary blood collection sites in elephants. The auricular veins are used most commonly and can be accessed with the elephant standing, although

Indianapolis Zoo

There are three primary blood collection sites in elephants. Ear veins (shown) are most commonly used. The saphenous vein—located on the lower medial aspect of the hind limb—is also a good site. The third site is the cephalic vein, located on the proximal medial forelimb.

Table 1. Normal physiological values for elephants

Parameter	Value		Reference
Height (m)	*Elephas maximus maximus*	2.0–3.5	
	Elephas maximus indicus	2.0–3.5	
	Elephas maximus sumatranus	2.0–3.2	
	Loxodonta africana africana	3.0–4.0	
	Loxodonta africana cyclotis	2.0–3.0	Shoshani 1992 a
Weight (kg)	*Elephas maximus maximus*	2,000–5,000	
	Elephas maximus indicus	2,000–5,000	
	Elephas maximus sumatranus	2,000–4,000	
	Loxodonta africana africana	4,000–7,000	
	Loxodonta africana cyclotis	2,000–4,500	Shoshani 1992 a
Life Span	*Elephas maximus* spp	50 – 70 years	Kingdon 1979
	Loxodonta africana spp	65 – 70 years	Wallach and Boever 1983
Heart Rate (beats/minute)	Standing: 25–30 Lateral recumbency: 72–98		Kock et al. 1993
Respiratory Rate (breaths/minute)	4 to 6		Kock et al. 1993
Rectal Temperature	36°–37° C (97.5–99.0° F)		Kock et al. 1993
	The elephant can adjust its temperature by a few degrees to cope with environmental conditions.		Shoshani 1992 a
Mean Arterial Blood Pressure (mm Hg)	120		Kock et al. 1993
Dental Formula	I 1/0 C 0/0 PM 3/3 M 3/3	26 Total	Kock, et al., 1993
Number of chromosomes	56		Hungerford et al. 1966 Sakthikumar et al. 1990 Suwattana et al. 2000
Systolic blood pressure standing (mm Hg)	178.6 +/– 2.94 (*n* = 7 Asian and 8 African elephants)		Honeyman et al. 1992
Diastolic blood pressure standing (mm Hg)	118.7 +/– 3.10 (*n* = 7 Asian and 8 African elephants)		Honeyman et al. 1992
Note that blood pressure increases when elephants are in lateral recumbency			
Arterial PO_2 standing (mm Hg)	96.2 +/– 1.55 (*n* = 7 Asian and 8 African elephants)		Honeyman et al. 1992

they are more prominent in lateral recumbency. The ears play a major role in thermoregulation, particularly in the African elephant (Sikes 1971; Buss 1971). As a consequence, auricular veins may dilate in warm ambient temperatures and constrict in cold weather. Placing elephants in lateral recumbency and applying moist (warm compresses) or dry heat (using a hair dryer) promotes vasodilation and facilitates venipuncture in cold weather. Elephants can also be bled from the cephalic vein, located

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "A veterinarian with experience in large mammal medicine must be on call at all times to deal with routine elephant health evaluation and treatment and medical emergencies."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Each elephant must be given a thorough annual physical examination."

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "A veterinarian or trained veterinary technician must perform fecal examinations to look for parasites and other problems at least twice a year. Results should be recorded. "

on the proximal medial forelimb, and the saphenous vein, located on the lower medial aspect of the hindlimb. Winged infusion sets (butterfly catheters) are useful for blood collection. However, the saphenous vein is deeper than it appears and requires a hypodermic needle or a vacutainer needle inserted to a depth of one inch at a 90-degree angle.

The blood volume of the elephant is about 3.5 percent of the body weight. (Shoshani 1982). Elephants have the largest red blood cells (RBCs) of any mammal. Elephant RBCs have a mean diameter of 8.8 to 10.6 microns (Young and Lombard 1967; Nirmalan et al. 1967; Silva and Kurwitz 1993). The sedimentation rate is the fastest of any mammalian species examined (Young and Lombard 1967; Silva and Kurwitz 1993; Debbie and Clausen 1975). Both Asian and African elephant red blood cells demonstrate Rolleaux formation. Reticulocytes are rarely observed.

The total number of red cells is relatively low compared to other mammals. The total erythrocyte count and hematocrit may decrease in pregnant elephants, and the sedimentation rate may increase (Nirmalin et al. 1967). Total erythrocyte values for young free-ranging African elephants (1 to 5 years) are higher than for adults, but mean corpuscular hemoglobin and mean corpuscular volume are lower (Sikes 1971). Seasonal differences in total red blood cell counts have been observed in free-ranging African elephants (Sikes 1971).

The nuclei of elephant white blood cells (granulocytes) are poorly segmented (Silva and Kuruwita 1993). Basophils are infrequently seen. Two types of monocytes are seen: one with a bilobed or trilobed nucleus and the other with a nonsegmented nucleus. Although some researchers have classified the bilobed and trilobed cells as lymphocytes, the presence of peroxidase-positive cytoplasmic granules supports classification of these cells as monocytes (Silva and Kuruwita 1993). It is not uncommon for the monocyte to be reported as the most numerous leukocyte in normal elephant blood.

Although the total white blood cell count has been reported to be higher in the Asian elephant, the ranges for both species overlap. Increased total white blood cell counts have been reported in free-ranging young Asian and African elephants (Nirmalin et al. 1967; White and Browns 1978). Increased neutrophils, decreased lymphocytes, and decreased eosinophils may be seen in pregnant captive Asian elephants (Nirmalin et al. 1967). Seasonal differences may occur in white blood cell counts in free-ranging African elephants (White and Brown 1978).

Hank Hammet

Fecal sample showing internal parasite infestation.

Parasites

A variety of intestinal parasites occur in elephants. The veterinarian should routinely monitor each elephant for parasites at least twice annually (and more frequently if parasites are an ongoing health problem). Each positive incident must be recorded in the elephant's medical file and treatment noted.

Parasites that have been reported include strongyles, coccidia, flagellates and protozoa (Mikota et al. 1994). Most cases are asymptomatic and can be treated with anthelmintics available for horses. External parasites reported include lice (*Haematomyzus elephantis*), ticks, and mites. External parasites may be treated topically or by the administration of ivermectin orally (Karesh and Robinson 1985). Blood parasites can occur in elephants but have not been been reported in elephants in North America.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, " Institutions must adhere to USDA APHIS requirements for testing and treatment of tuberculosis."

A Trunk Wash Technique for the Diagnosis of Tuberculosis

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Identification of a *M. tuberculosis* infected animal has significant management implications to both the animal and the collection. Management of the infected animal may require isolation of the exposed herd, potential removal of the animal from exhibit or shows, and if elected, treatment of the animals and exposed herd which can be very expensive. In the worst case, a positive diagnosis may lead to euthanasia of the infected animals. For these reasons, the screening test selected needs to be definitive and have as few false positives as possible. A positive culture of *M. tuberculosis* is, therefore, the only diagnostic test result used as a basis for making decisions.

The trunk wash as a method of collecting a culture sample from elephants was selected by the National Tuberculosis Working Group for Zoo and Wildlife Species because it is a practical method of obtaining a culture sample from a large proportion of the elephant population. The procedure requires no sedation or undue stress to the animal. Additionally, the procedure requires no specialized or expensive equipment.

An important consideration of this procedure is that it can potentially be very dangerous to the handlers. This is particularly true when attempted on an uncooperative elephant because any attempts to manually restrain the trunk in an uncooperative elephant can lead to injury. The time spent training the elephant to accept this method will greatly increase the efficiency and safety of the procedure. In some cases, with potentially dangerous or unpredictable animals, an increased level of handler safety can be obtained by having the animal lie in sternal or lateral recumbency prior to sample collection. This technique does not guarantee safety or successful sample collection, as it still requires cooperation of the animal and does not compensate for inadequate training. In the case of elephants managed from behind a barrier, the animal's trunk can be handled though a set of bars. This method still requires that the animal is fully cooperative and, therefore, usually requires extensive training prior to the collection.

A second safety issue is the potential for zoonotic infection. Recently there has been documentation of a zoonotic transmission of tuberculosis between humans and elephants. During the collection of the trunk wash sample, there is exposure to aerosolized mucus from the elephant's respiratory tract. The authors, therefore, suggest that the collectors and handlers wear protective gear during the collection process. Minimal precautions would include a well-fitted respirator or face mask capable of filtering 0.3 micron particles, disposable gloves, and working in a well-ventilated, sunlit area.

Mycobacterial culture as the primary method of detecting infected animals has several limitations that are best illustrated by examination of the underlying biological assumptions. The first assumption is that most infected elephants have respiratory infections. Although the literature suggests that most infected elephants have respiratory infection, there have been no comprehensive necropsy studies to confirm these observations. The second assumption is that most infected animals shed mycobacterial organisms into the respiratory tract. There is little data that determines if and when an infected animal will begin shedding organisms. It is unknown what proportion of elephants can carry latent or "walled off" infections that would be missed with culturing techniques. A third assumption is that animals that are shedding will pass mycobacteria organisms at least once in the three-day testing period. Currently it is unknown if shedding animals pass organisms periodically or continuously. Finally, the samples collected from the distal trunk are often contaminated with normal bacterial flora and foreign material. It is assumed that these contaminants do not routinely overgrow or mask the growth of pathogenic mycobacteria, although no studies have tested this assumption. The interpretations of the culture results should, therefore, be limited. A positive culture is strong evidence that the animal is shedding mycobacteria and is infected; negative culture results provide little information as to whether the elephant is infected or not.

Culturing the distal trunks of all the animals in a population will detect only animals shedding tuberculosis through the trunk, and not detect all animals that are infected. However, with time and repeated cultures of all animals in the population, it may be possible to detect and treat most of the elephants shedding infectious organisms. If these animals are then treated properly and shedding of organisms stops, the spread of tuberculosis from elephant to elephant should decrease.

Materials and Methods

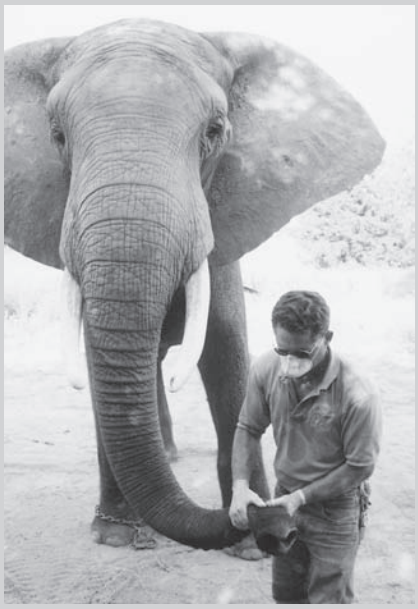
The trunk wash technique requires that the elephant allow the handlers to restrain and manipulate the tip of trunk. This is difficult in an untrained elephant in that most elephants resent this manipulation, and the trunk is many times stronger than the combined force of several handlers. It is therefore important that the animals be trained to present the trunk, and to allow gentle manual restraint, and manipulation of the trunk tip during the collection of the sample. The training period varies with the individual elephant, the prior behavioral conditioning of the animal, and the skill of

the handlers. In our experience, most animals can be adequately trained for the procedure in two to four weeks.

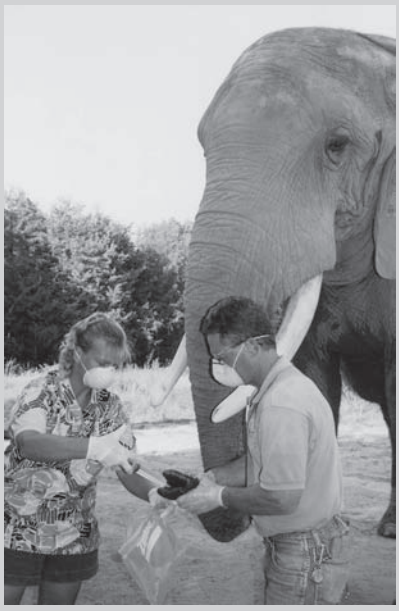
The materials needed for a trunk wash include: Sterile 0.9 percent saline solution, sterile 60 ml syringe, 1 gallon plastic zip lock type bags (heavy duty), and sterile 50 ml screw-top, plastic jar or centrifuge tube. As long as attention is given to collecting a clean sample from the distal nasal passages, the materials and techniques for the sample collection can be modified. For example, some clinicians prefer to use a 14-gauge red rubber feeding tube inserted into the trunk tip instead of simply flushing the sterile saline into the trunk tip. Another common variation is to use a sterile plastic container to catch the trunk wash fluid instead of a plastic bag.

Procedure

Routine screening of an elephant should consist of a series of three trunk wash samples collected on separate days within a one-week period. Trunk washings should be collected in the morning and prior to water being



(a)



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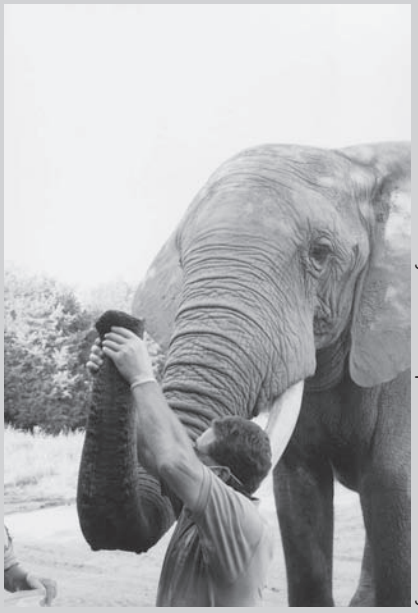
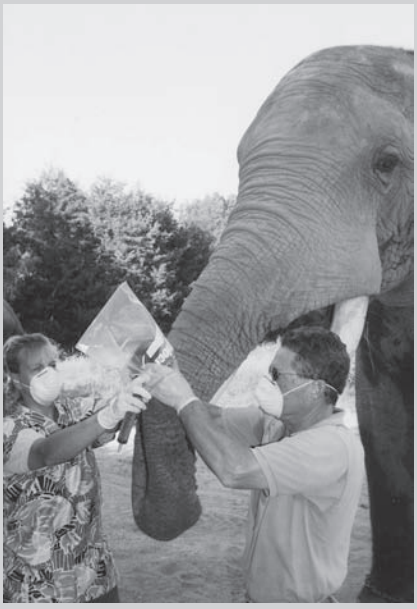


(c)

Photos by Riddle's Elephant and Wildlife Sanctuary



(d)

(e)

(f)

Trunk wash procedure. (a) Trunk is presented. (b) Handlers infuse the trunk with saline. (c) Elephant holds trunk up, allowing saline maximum contact and depth. (d) Handlers place clean bag over end of trunk. (e) Elephant exhales saline and sample into bag. (f) Sample is sealed and prepared for shipment.

offered to the animal. These recommendations are made in an attempt to obtain a representative sample of the nasal flora from the previous night, and to avoid the dilution effect caused by elephants drinking water with their trunks.

The elephant's trunk is manually restrained by the handlers so that the tip is held up. The 60 ml syringe filled with sterile saline is then inserted into one of the nostrils and the saline quickly flushed into the trunk. The handler then lifts the trunk tip as high as possible to help the fluid flow as far into the trunk as possible. The 1 gallon plastic bag is then slipped over the trunk tip and the tip of the trunk is lowered to allow the fluid to drain. If possible, the elephant is allowed to exhale into the bag during this collection phase of the procedure. A good sample should retrieve a significant portion of the saline that was placed into the trunk (about 40 ml). The sample should contain visible mucus from the inside of the trunk and often contains dirt and food particles that are normally found inside the trunk. The collection of moderate amounts of foreign material does not invalidate the sample. If, however, the collector feels the contamination is excessive, a second flush may be attempted.

Once the sample is collected in the plastic bag, it is carefully transferred into a labeled container. The sample must be immediately frozen and sent frozen directly to a laboratory for processing and mycobacterial culture. Often the recommended three daily cultures samples are collected and frozen until all samples are collected and the batch of samples can be sent to the laboratory together.

Infectious Diseases

Tuberculosis

Tuberculosis (TB) in elephants has been infrequently described in the literature and, until recently, did not appear to be prevalent. Between 1996 and 2002, 28 cases of tuberculosis were diagnosed in captive elephants in North America. Although both African and Asian elephants are susceptible, most cases have occurred in Asian elephants. TB is generally caused by *Mycobacterium tuberculosis,* the same organism that causes human TB; however, cases of TB due to *Mycobacterium bovis* (the bovine strain) have also been reported in both elephant species. To date, there are no reports of TB in free-ranging Asian or African elephants in range countries.

Establishing an ante-mortem diagnosis of TB in elephants can be difficult. Elephants with TB often do not show any signs. When present, signs may include weight loss, loss of appetite, or exercise intolerance. Respiratory signs may be absent (Saunders 1983; Garrod 1875) or may be characterized by a harsh cough (Pinto et al. 1973) or labored breathing (Seneviratna et al. 1966). Thoracic radiography is not feasible in adult elephants. The intradermal skin test (tuberculin test), commonly used as a screening test in humans and cattle, is not reliable in elephants and is not recommended.

Several serological assays (ELISA, lymphocyte transformation, gamma-interferon) are currently under investigation. Preliminary evaluation suggests the ELISA test may be a useful tool, but further research is needed (Larsen et al. 2000). Until these, or other tests are validated, isolation of mycobacteria is the only definitive method to diagnose TB. Although it is possible to obtain tracheal washes from elephants, the procedure requires anesthesia (Wallach and Boever 1983). An alternative method has been developed to obtain trunk wash samples from unsedated elephants (see "A Trunk Wash Technique for the Diagnosis of Tuberculosis," p. 162). Nocardia and a variety of nontuberculous mycobacteria are frequently isolated from elephant trunk wash samples. *Mycobacterium avium* is a common isolate. None of these organisms have been associated with clinical disease in elephants.

An intense search for lesions of TB is strongly encouraged in all elephant necropsies even though TB is not suspected. Carefully examine the tonsillar regions and submandibular lymph nodes for tuberculous appearing lesions. Collect any nodes that appear caseous or granulomatous for culture (freeze or ultrafreeze) and fixation (in buffered 10 percent formalin). In addition, search thoracic organs carefully for early stages of TB as follows. After removal of the lungs and trachea, locate the bronchial nodes at the junction of the bronchi from the trachea. Use clean or sterile instruments to section the nodes. Freeze half of the lymph node and submit for TB culture (*even if no lesions are evident*). Carefully palpate the lobes of both lungs from the apices to the caudal borders to detect any firm B-B shot- to nodular-size lesions. Take sections of any suspicious lesions. Open the trachea and look for nodules or plaques and process as above. Regional thoracic and tracheal lymph nodes should also be examined. Split the trunk from the tip to its insertion and take samples of any plaques, nodules, or suspicious areas. Look for extrathoracic TB lesions, particularly if there is evidence of advanced pulmonary TB.

Ideally, elephants should be bled for serology (ELISA) and trunk wash(es) collected just prior to euthanasia. Elephants that die naturally should have a post mortem trunk wash performed and serum should be harvested from post mortem blood for serological assays. Consult the "Guidelines for the Control of Tuberculosis in Elephants" found at www.aphis.gov/ac/lephTBGuidelines2003.html.

Be advised that elephant TB is potentially transmissable by *Mycobacterium tuberculosis* which is contagious to humans. Of 22 handlers screened following the TB deaths of two elephants in 1996, 11 had positive intradermal responses and one had culture positive, active tuberculosis. DNA fingerprint comparison showed that the human isolate matched that of the infected elephants (Michalak et al. 1998). Therefore, be prepared with proper protective apparel and contain any suspicious organs or lesions as soon as possible.

Elephant Endotheliotropic Herpes Virus (EEHV)

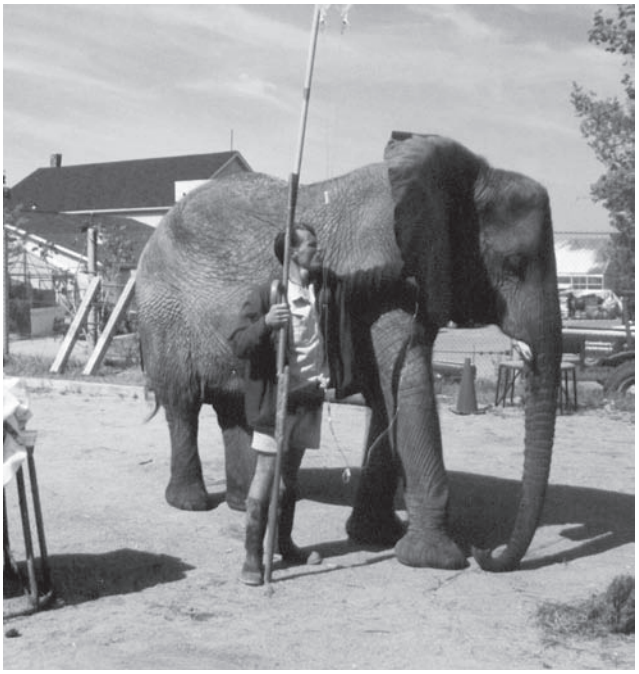
The cause of a highly fatal disease of elephants in North American and European zoos has been identified as a new

type of herpesvirus. As of 2002, 26 cases have been documented in North America, Europe, and Asian (Montali et al. 2001). Elephant Endotheliotropic Herpes Virus or EEHV affects mainly young elephants and usually has a fatal outcome within a week of onset of the clinical signs. Clinical signs are variable and include anorexia, colic, lethargy, edematous swellings of the head and thoracic limbs, oral ulceration and cyanosis of the tongue. The virus affects the endothelial cells of small blood vessels in the heart, liver, tongue and gastrointestinal tract. Vascular damage leads to hemorrhage and organ failure, which is usually fatal. Necropsy findings include extensive cardiac and serosal hemorrhages and edema, hydropericardium, cyanosis of the tongue and oral and intestinal ulcers. Histological features are microhemorrhages and inflammation in the heart, liver and tongue accompanied by intranuclear inclusion bodies in the capillary endothelium.

To date, attempts at virus isolation have been unsuccessful, but infection can be confirmed by a polymerase chain reaction (PCR) technique (Richman and Montali 1998). Serological tests are still being developed. Initial studies suggest that antibody titers develop in previously exposed animals (L. Richman, pers. comm.). Some of the epidemiological aspects of the disease are not yet clear and are still under study. Although African elephants are known to carry the virus that is fatal for Asian elephants, there have been a number of cases in Asian elephants in which no direct contact occurred with African elephants. Herpesviruses have been associated with cutaneous papillomas in captive African elephants (Jacobsen et al. 1986) and with lung nodules in wild African elephants (McCully et al. 1971). Herpesvirus sequences identical to that found in Asian elephants with endothelial disease have been found in healthy African elephants with external herpes lesions. This finding suggests that fatal disease in Asian elephants may be caused by a herpesvirus that is latent and nonpathogenic in African elephants. Similarly, symptomatic disease in African elephants may be caused by an Asian herpesvisrus that is latent and nonpathogenic in that species (Richman et al. 1999).

To date, three of seven elephants treated with the antiviral drug, famciclovir, have recovered and a treatment regimen has been described (Schmitt et. al 2000). Asian elephants that are less than 10 years old and have been moved to another facility and/or have had contact with African elephants are at increased risk for contracting EEHV. Animals traveling between facilities with a history of EEHV cases may be at a greater risk. Therefore, all elephants should be tested for previous exposure to the elephant herpes virus with the serologic ELISA test for EEHV. All young elephants should be physically examined daily for anorexia, lethargy, body swellings, and blue discoloration (cyanosis) of the tongue, and be trained for blood sampling and potential oral and rectal treatment with famciclovir. Recently, recommendations for EEHV testing prior to transport have been developed (see Transportation, p. 222).

Much more research is needed on this disease. All facilities with elephants presenting with clinical signs of the herpes virus should immediately contact: R. J. Montali, National Zoo, Washington DC; W: 202-673-4869 and Laura Richman, Richman@MedImmune.com.



Deborah Olson, Indianapolis Zoo

A handler giving fluid therapy to an elephant with salmonella.

Salmonella

Salmonellosis can cause severe illness or death in elephants. It has been reported in recently caught wild elephants as well as long-term captive animals. Salmonellosis should be in the differential diagnosis of any disorder presenting with diarrhea or vague clinical signs. Typical clinical signs include anorexia, lethargy, constipation, diarrhea, or scant watery feces containing blood and mucus. Abdominal pain may be evidenced by a hunched posture, repeated crossing of the hind limbs, or by the insertion of the trunk in the mouth in association with intestinal spasms. Presenting signs may also be nonspecific (lethargy, weakness, intermittent anorexia, and ventral edema).

In a retrospective study, there were 25 events in which *Salmonella* was cultured. Elephants were symptomatic in all but two cases with loose stool, diarrhea, and anorexia—the most common presenting signs. Blood in feces was observed in only 3 events. Sixteen of the 25 events received medical treatment consisting of antibiotics (ampicillin or chloramphenicol in most cases), fluids, analgesics or antipyretics, steroids, and vitamins. Ten events were successfully treated. Seven elephants died, including one animal that died acutely prior to diagnosis (Mikota et al. 1994).

Salmonella typhimurium was isolated from the liver and spleen of a 6-year-old African elephant with severe anemia, neutrophilia with a regenerative left shift, and normal serum chemistries on laboratory examination. (Raphael and Clubb 1985). Histopathological findings typically include extensive hemorrhages on the mucosal

surface of the intestinal tract and necrotic ulceration of the intestinal tract. Lesions may also be seen in the liver and spleen. Recent PCR technology has been used to detect Salmonella in feces. Serial samples from a herd of African elephants revealed that asyptomatic elephants may intermittently shed salmonella organisms (M. Miller, pers. comm.). Therefore interpretation of positive results should be done with caution.

Encephalomyocarditis virus

First isolated in 1940, encephalomyocarditis viruses (EMCV) have a worldwide distribution. Between 1974 and 1977, three zoos in Florida experienced EMCV outbreaks. The virus was isolated from five elephants (four African and one Asian) and was suspected as the cause of death in seven other elephants (Gaskin et al. 1980; Simpson et al. 1977). Although the exact manner of transmission of EMCV remains controversial, rats and mice are thought to be the natural reservoirs (Tesh and Wallace 1978). In the outbreak that occurred at Audubon Park Zoo between 1985 and 1987, EMCV was isolated from mice, rats, squirrels, as well as a rabbit and an opossum trapped or found dead on zoo grounds.

Although initial outbreaks of EMCV seemed confined to the southeast United States, postmortem findings in an African elephant in New South Wales were consistent with EMCV (Seaman 1987). Also, between December 1993 and November 1994, 64 free-ranging elephants (the majority of which were bulls) died of EMCV in Kruger National Park. Histopathological findings on eight carcasses revealed findings compatible with heart failure; EMCV virus was isolated from the heart tissue of three elephants (Grobler et al. 1995). Subsequent to this outbreak, a killed vaccine was developed using virus isolated from Kruger elephants. Results of trials conducted with 18 elephant calves showed that vaccinated elephants developed significant titers 7 to 10 days post vaccination compared to unvaccinated controls. In addition, all vaccinated elephants survived a challenge with live virus (n = 4), whereas, three of four unvaccinated elephants developed clinical disease. Two of these elephants died of EMCV, but all four demonstrated myocardial lesions at necropsy suggesting subclinical disease in one animal. Challenge studies indicate that the incubation period of EMCV is 9 to 10 days following oral infection (Raath and Bengis 1995).

Death from EMCV is often acute or peracute. Clinical signs, if present, may include anorexia, lethargy, and mild dyspnea and may precede death by 24 hours or less. Pale streaks or hemorrhages in the myocardium, pulmonary edema and froth in the airways may be seen postmortem (Gaskin 1988). Fragmentation and separation of muscle fibers due to lymphocytic infiltration may be seen on histopathological examination. Treatment of EMCV is supportive.

Tetanus

Although infrequently reported, elephants are susceptible to tetanus. In one case (Burke 1975) a 5-year-old Asian elephant presented with stiffness, head-pressing, enophthalmus, adipsia, and dysphagia. An open wound filled with caseous material was found above the sole of the right forefoot, and an acute lameness had been noted two weeks prior. Treatment with antitoxin, fluids, and antibiotics was unsuccessful. In contrast, recovery was complete in an 8-year-old Asian elephant with an infection thought to be of alimentary origin (Goss 1942). She presented with a tightly closed jaw, prolapsed nictitating membranes, hypersensitivity to sound and erection of the tail when touched. A total of 360,000 units of tetanus anti-toxin was given over a five-day period and tetanic spasms were controlled with rectally administered chloral hydrate. The elephant was maintained in a sling and force-fed a bran mash by stomach tube for 29 days at which time she regained jaw tone and could feed herself. Prophylactic vaccination of elephants against tetanus is probably warranted; however, anecdotal evidence suggests that titers diminish quickly, and it may not be possible to achieve protective titers without consequences related to frequent vaccination with large volumes (Dan Laughlin, DVM, pers.comm.).

Poxvirus

Infection with poxvirus has been reported in Asian and African elephants in European zoos (Gehring et al. 1972; Kuntze 1999), but there are no known published reports of pox in elephants in North America or in free-ranging elephants. Early clinical signs may include loss of appetite, dysphagia, muscle stiffness, or lameness. Vesicular lesions that may become filled with clear, blood-tinged, or purulent fluid develop on the tongue, lips, trunk tip, eyelids, and skin surrounding the anus and vulva. In some cases the entire body may be covered and the lesions may rupture. Over a period of days to weeks, crusts form which may become scars. Sepsis and death may result, particularly as a sequela to infection of the corium of the nails.

The elephant poxvirus was initially described as a cowpox-like virus (Baxby and Ghaboosi 1977; Baxby et al. 1979). Subsequently the DNA profiles of eight elephant isolates have been compared to other orthopoxviruses (Pilaski et al. 1986). Diagnosis can be confirmed by viral culture or by observation of Bollinger bodies in samples examined by electron microscopy. Treatment is supportive and may include fluids, antibiotics, and vitamins. Elephant poxvirus has zoonotic potential.

Other infectious diseases

Elephants may demonstrate antibodies against a number of infectious diseases but may not show evidence of clinical disease. Antibodies to leptospirosis have been detected in both Asian and African elephants (Karesh et al. 1997; Bhatt and Manickam 1998). Antibodies to bluetongue virus have been detected in free-ranging African elephants (Karesh et al. 1997; Mushi et al. 1990). Free-ranging African elephants commonly have antibody to the African horsesickness virus and have been implicated in the epidemiology of the disease (Karesh et al. 1997; Erasmus et al. 1978; Meiswinkel and Braack 1994). Both Asian and African elephants appear susceptible to foot-and-mouth disease (Howell et al. 1973; Bhatt and Manickam 1997; Pyakural et al. 1976; Rahman et al. 1988).

Musculoskeletal Disorders

Musculoskeletal events commonly seen in captive elephants include fractures, trauma, movement disorders, swelling and limb abnormalities, ventral edema, and foot problems, often progressing to osteoarthritis. The most common source of trauma is the result of stepping on objects such as stones, nails, or wires. Conditions of the skin include lacerations, abrasions, and contusions and hyperkeratosis at the junction of the skin and the sole. The types of hoof problems affecting other ungulates may also be seen in elephants and include penetrating injuries, sole cracks, cracks in the nail or cuticle, overgrowth, abscesses, nonspecific lesions, wounds, and infection.

Deborah Olson

An Asian elephant in Sumatra has musculoskeletal disorder.

Treatment of cracks in the toenail is complicated by the tremendous weight of the animal. In one case, chronic toenail cracks of 10 years' duration were successfully resolved by trimming (Schanberger et al. 1990). Successful treatment and surgical removal of infected phalanges from a 40-year-old elephant has also been described (Gage et al. 1997). A variety of organisms (*E.coli, Enterobacter, Klebsiella, Proteus, Pseudomonas, Staphylococcus* and *Streptococcus*) have been isolated in foot infections and multiple isolates are common. Some elephants have been euthanized as a result of chronic pododermatitis. Most of these animals received aggressive medical treatment over a period of months or years but with poor response and progressive deterioration. The role of mycoplasmas and rheumatoid arthritis as an underlying etiology of the arthritic problems noted in captive elephants remains unclear. The occurrence of mycoplasma in elephants was first reported in the early 1980s (Clark et al. 1980; Clark et al. 1981; Clark 1991). Two mycoplasma strains isolated from elephants represent a new species, *Mycoplasma elephantis* (Kirchhoff et al. 1996).

Elephants with foot problems may lie down for long periods of time and develop decubital ulcers or sores on pressure-sensitive areas. Padding and topical agents have been minimally successful in resolving these lesions. Use of direct-contact, low-level infrared therapy, used to enhance healing of similar lesions in humans and horses, may be beneficial for elephants as well (Gage et al. 1997). Diagnostic radiographs of elephant feet can be readily obtained using a portable equine radiographic unit (Gage 1999). (See Husbandry, page 37.)

Cardiovascular Disorders

Arterial Disease

Arterial disease has been the subject of several field studies conducted in the 1960s and 1970s. Sikes examined the aortas and arteries from 40 elephants from three distinct habitats in Kenya and Uganda and observed calcium deposition to be more prevalent in grassland than scrubland animals and absent in elephants from montane habitat (Sikes 1968). Animals with severe calcium deposition were lethargic, had decreased mobility, and were, in some cases, emaciated. Sikes implicates several environmental factors, including human population pressures resulting in a lack of arboreal food items (possibly causing mineral deficiency), restricted movement (preventing access to salt licks), and transition away from montane habitat (leading to possible hypervitaminosis D, known to be associated with calcium deposition in other species) as contributory to the development of arterial disease in wild African elephants.

Examination of the hearts and aortas of 415 elephants culled in Uganda and Kenya between 1966 and 1967 revealed gross lesions in 298 aortas (72 percent) and 29 coronary arteries (27 percent) (McCullagh and Lewis 1967).

In contrast to observations in humans, atherosclerotic lesions in elephants were most severe in the aortas and least severe in the coronary arteries. The distribution of lesions in the aorta, however, was similar to humans with lesions in the abdominal aorta more severe than in the thoracic aorta. In elephants over 40 years of age, atherosclerotic plaques covered 8 percent of the total surface area of the thoracic aorta and 50 percent of the total surface of the abdominal aorta. The severity of atherosclerotic lesions does not appear to be corrleated with blood levels of cholesterol, phospholipid, triglyceride, or free fatty acids (McCullagh 1972). In another study (Dillman and Carr 1970), aortic lesions were seen in 36 percent of 207 aortas examined histologically. Serum electrolytes measured in these and 49 other elephants showed no differences in cholesterol between normal elephants and those with aortic lesions. McCullagh (1972) suggested that lesions observed in elephants are more compatible with a "mechanical concept" theory in which hemodynamic stresses such as turbulence and repeated stretching of the arterial wall result in endothelial damage, eventually leading to fibrosis and thickening of the intima.

Arterial disease has been reported in 19 captive elephants (Lindsay et al. 1956; Finlayson 1965). Diagnoses were not identified in all cases but included patent ductus arteriosus in two elephants, EMCV in one elephant, congestive heart failure in one elephant, and cardiogenic shock associated with *E.coli* septicemia in one elephant. Arteriosclerosis or atherosclerosis were noted postmortem in 6 elephants but were implicated as the cause of death in only one case (Mikota et al. 1994).

Diseases of Unknown Etiology

Floppy Trunk Syndrome

Floppy trunk syndrome has been reported only in free-ranging African elephants. The first cases occurred in 1989 in the Fothergill Island area of the Matusadona National Park (Kock et al. 1994). To date, all confirmed cases have occurred in this one area in Zimbabwe. Floppy trunk syndrome presents as a subtle loss of prehension followed by atrophy of the trunk and ascending paralysis which progresses over a period of months. Neuromuscular deficits are confined to the trunk, and although the elephants are initially able to compensate for difficulties in feeding, prehension eventually becomes more difficult and wasting ensues.

As of March 1998, 35 to 40 cases have been identified, 17 biopsies and five postmortems have been performed, and two to three elephants have completely recovered. All cases have been in bulls. Biopsies show neuropathy of the peripheral nerves supplying the trunk with axon, myelin loss, and muscle atrophy (Kock 1996). Plant, soil, and water surveys have been conducted but an underlying etiology has not been identified. Trauma and infectious agents are considered unlikely, and current studies point toward a selenium deficiency combined with plant toxicosis. In 1993, a similar syndrome was observed in Kruger National Park (KNP), and to date 8 cases have been diagnosed, all in adult bulls. Interestingly, nerve lesions have been observed in the limbs as well as the trunks of KNP elephants, and a sublethal neurotoxin (a pollutant rather than a plant toxin) is suspected (Kriek 1998).

Ventral Edema

Ventral edema, generally noticed as swelling in the submandibular or ventral abdominal areas, has been associated with various pathological disorders. There are several reports of ventral edema associated with liver flukes (Caple et al. 1978; Windsor and Scott 1976; Evans 1910), as well as with bots and tapeworms (Singh 1924). Edema may result from renal failure (Morris et al. 1987; Jensen 1986). Submandibular edema was observed in a case of tuberculosis (Pinto et al. 1973) and abdominal ventral edema was seen in a juvenile animal with idiopathic, chronic diarrhea and malabsorption (Heard et al. 1988). Hypoproteinemia was confirmed in some of these cases and appears to be the underlying mechanism. Elephant physicians in Ceylon consider ventral edema to be a cardinal sign of incurable lung disease in elephants (Pinto 1973).

There have been numerous anecdotal reports of a transient ventral edema occurring in captive North American elephants. The etiology is unknown (Schmidt 1986). In a retrospective study there were 84 ventral edema events affecting 61 animals; 17 animals had more than one event, and events occurred at 35 zoos. There was no predilection for species or sex. No cases were reported in neonates or infants and only 12 cases occurred in elephants 1 to 10 years of age. In some cases, concurrent urogenital signs or pathology were noted. Except for one case of salmonellosis in which ventral edema was related to multi-systemic changes, all cases were of unknown cause. Thirty cases were treated. Prescribed treatments included diet change, antibiotics, diuretics, and steroids. Hot packs, analgesics, or steroids were prescribed in a few cases. Ten of the diet changes involved a reduction in grain or a change from grain to pellets; with 5 cases responding favorably. The majority of cases (64 percent) resolved without treatment and only 7 percent persisted longer than three months (Mikota et al. 1994). Anecdotally, exercise has been suggested to aid in the reduction of ventral edema.

Riddle's Elephant Sanctuary, Jay King

An elephant with paralyzed lower trunk drinks water directly from a hose.

Anesthesia and Chemical Restraint

Captive management of elephants requires handling for a wide variety of husbandry and medical procedures. Many procedures—including physical examination, sample collection, and minor medical treatments—can be performed using behavioral training or physical restraint. However, procedures requiring greater analgesia and/or immobilization may necessitate chemical restraint or

Deborah Olson, Indianapolis Zoo

An elephant with ventral edema following the birth of a calf.

general anesthesia. The following information is a summary of techniques that have been used in captivity and in the field. It should be noted that a significant variation may occur between individual elephants and the procedures performed. Therefore, the information provided should be used only as a guide.

In situations that require chemical restraint, several factors should be considered when determining the appropriate drug regimen.

- Temperament of the animal—Calm or easily handled animals usually require lower doses of drugs compared to excited or stressed animals.

- Facilities/equipment—Combining restraint devices with sedatives or anesthetics may lower the amount of drug required for adequate restraint. Padding, non-slip substrate and equipment to assist moving a recumbent animal should be available when performing general anesthesia on elephants. Equipment for monitoring vital signs and providing emergency treatment (including a method for delivering oxygen) should be assembled prior to the procedure.

- Existing medical conditions—Whenever feasible, preprocedural bloodwork should be performed to determine if any compromise of physiologic function is present that may affect response to drugs (i.e., anemia, hypoproteinemia, impaired renal or hepatic function).

- Procedure to be performed—Procedures that are expected to require higher degrees of analgesia and/or complete immobilization may necessitate addition of drugs for pain relief or general anesthesia compared to a procedure requiring only restraint.

- Experience of the personnel—Clinical experience with the particular drug regimen and procedure may determine method of choice. Consultation with veterinarians experienced in elephant sedation/anesthesia is strongly recommended.

Other general principles of chemical restraint should be followed to increase the safety of the procedure for both animals and personnel.

- Review procedure and precautions with personnel involved in the procedure (including possible drug-related hazards).

- Prepare antagonists to the restraint drugs prior to initiation of the procedure (if applicable).

- Carefully monitoring of the patient to identify and rectify any problems that develop. Equipment to monitor heart and respiratory rates, oxygen saturation and blood gases, end tidal CO_2, and blood pressure are useful in detecting complications related to anesthesia. Physiologic parameters for sedated and anesthetized elephants have been published in the literature.

- Adequate equipment and personnel is required for positioning the animal for the procedure to be performed. Padding (mattresses, inner tubes, bedding, etc.) should be placed under the recumbent animal to minimize pressure effects on limbs. Immobilized elephants should be in lateral recumbency to prevent

respiratory compromise associated with increased pressure on the diaphragm when in sternal recumbency.

Etorphine

Etorphine (M-99) has been the drug of choice for immobilizing both captive and free-ranging elephants. Most doses in the literature are expressed as total dose since accurate weights are generally not available. Based on field studies, it appears that there are greater risks associated with underdosing than overdosing. Therefore, it is advisable to administer doses at the high end of the range in situations in which the temperment or environment of the animal necessitates rapid induction. However, higher doses may result in greater respiratory depression. Lower doses may be used in calm elephants under controlled conditions or when the animal will not be stressed by the procedure. Low doses may result in sedation although the animal remains standing.

Etorphine alone has been used to immobilize both Asian and African elephants. It appears that Asian elephants require higher dosages than African elephants. Commonly published dosages are 1 mg/450 kg (0.0022 mg/kg) for Asian elephants and 1 mg/600 kg (0.0017 mg/kg) for African elephants. It should be noted that trained Asian elephants may require lower dosages for similar effects compared to wild or untrained animals. Table 2 lists dose ranges for etorphine based on published reports. Administration of hyaluronidase (Wydase®) 2,000–4,500 IU total dose with intramuscular etorphine results in more rapid induction with reduction in stress and exertion. Incremental amounts of etorphine can be administered by continuous drip or repeated injections to extend anesthesia.

Other drugs have been used in conjunction with etorphine for preanesthetic sedation to provide muscle relaxation or extend anesthesia. These include acetylpromazine-etorphine (Immobilon®), acepromazine, azaperone, xylazine, ketamine, xylazine-ketamine, halothane, and isoflurane. The decision to use these combinations will depend on the planned procedure. Drugs used in combination with etorphine may affect the expected recovery time and effect after administration of the narcotic antagonist.

Antagonism of the effects of etorphine can be accomplished with administration of diprenorphine (2–4x etorphine dose), naltrexone (100x etorphine dose), or nalmefene (10x etorphine dose). Without administration of antagonists, African elephants have been observed to stand two to three hours after a single dose of etorphine.

Table 2. Dose ranges for etorphine anesthesia

Animal Category (references)	Sedation (total dose mg)	Immobilization (total dose mg)	Immobilization (mg/kg)
African—adult male (5, 6, 12, 17, 20, 22, 26, 27)	4	6–9 (up to 20)*	0.0015–0.003
African—adult female (5, 6, 12, 17, 20, 22, 26, 27)	4	6 (up to 15)*	0.0015–0.003
African—juvenile (1–5 yr) (5, 6, 9, 10, 17, 20, 22 24)		1–4	0.002#
Asian—adult male (2, 8, 9, 15, 16, 18)		5–13.5 (up to 20)*	0.002–0.004
Asian—adult female (2, 7, 8, 19)	1.75	5–8	0.002–0.004

*Higher doses used in free-ranging elephants
Dosage after xylazine-ketamine premed.
Numbered references are at end of this chapter

Carfentanil

Inconsistent availability of etorphine in the U.S. may necessitate other drug choices. Carfentanil has been used to immobilize African and Asian elephants. Dosages are similar to etorphine (see Table 3), although induction is more rapid with carfentanil. Due to the higher relative potency of carfentanil, standing sedation with this drug has not been reported in elephants. Although data is limited in Asian elephants, dosages of carfentanil are similar to those for etorphine.

Antagonism of carfentanil in African elephants was achieved with either diprenorphine (2–4x carfentanil dose) or nalmefene (26x carfentanil dose). In a study of 16 animals, one animal was observed to renarcotize after administration of nalmefene (Jacobson, Kollias, Heard, Caligiuri, 1988). As reported in other species, renarcotization is more likely when using carfentanil. This may be due to the longer duration of effect of this drug compared to etorphine. Therefore, elephants immobilized with carfentanil should be closely observed for signs of renarcotization.

Table 3. Dose ranges for carfentanil anesthesia

Animal Category	Total dose used (mg)	Dosage (mg/kg)
African—adult male (6, 14, 17)	9–12	0.002
African—adult female (6, 14, 17)	3–8	0.0013–0.0024
African—juvenile (1–5 yr) (6, 17, 24)	1–5	0.0013–0.0024
Asian—adult (6, 11, 17)	5–12	0.002–0.004

Alpha 2 Agonists

Xylazine (Rompun®) is frequently used alone or with other drugs for sedation. Addition of other drugs such as ketamine or butorphanol result in more consistent levels of sedation. When used in conjunction with etorphine, xylazine improves muscle relaxation and may have a synergistic effect with narcotics.

Table 4. Dose ranges for sedation/anesthesia

Drug (References)	African—adult	African—juvenile	African—calf (<2 yr)	Asian—adult
Xylazine (5, 6, 11, 17-19, 21, 22, 26)	600–1000 mg IM	200–600 mg IM		33–72 ug/kg IV (0.08–0.1 mg/kg) 150–750 mg IM (0.04–0.08 mg/kg)
Xylazine–ketamine (mg/kg) (1, 6, 9, 10, 13, 17, 19)		0.1+/–0.04 mg/kg xyl + 0.6+/–0.13 mg/kg ket IM (sedation) 0.2 mg/kg xyl + 1–1.5 mg/kg ket IM (immobiliz)	0.13+/– 0.03 mg/kg xyl + 1.14+/– 0.21 mg/kg ket IM (immobiliz)	
Xylazine-butorphanol (mg/kg) (9, 19, 21)	0.043–0.16 mg/kg xyl IM 0.007–0.036 mg/kg butor IV, IM			
Azaperone (17, 19, 21, 23)	120–760 mg IM (0.06–0.15 mg/kg)	120 mg IM	30–120 mg IM	0.017–0.046 mg/kg IM
Acepromazine (6, 17, 22)	30 mg IM (0.004–0.005 mg/kg)	10–20 mg IM	5–10 mg IM	10–30 mg IM (0.004–0.005 mg/kg)
Butorphanol (6, 19, 21)	25–55 mg IM (0.01+/–0.003 mg/kg)			
Butorphanol-detomidine (17, pers. comm.)	50–90 mg each IM (0.013–0.02 mg/kg)			

Typical dosages for xylazine used alone are 0.08 mg/kg admininistered intramuscularly (range for Asian elephants 0.04–0.125 mg/kg IM; range for African elephants 0.11–0.55 mg/kg). For best results, the animal should be calm and left undisturbed until maximum effects are observed. Higher doses (up to 0.15 mg/kg) may be required to achieve the same level of sedation in an excited elephant. These high doses may cause animals to become recumbent.

Detomidine (Domosedan®) has been used but has not been fully evaluated. Standing sedation in adult African elephants has been accomplished with equal dosages of detomidine-butorphanol (0.013–0.02 mg/kg IM) (M. Miller, pers. comm.).

Because alpha 2 agonists have depressant effects on heart rate, respiratory rate, and blood pressure, careful monitoring is critical when using these agents. The effects of alpha 2 agonists may be reversed with yohimbine (Antagonil®), atipamezole (Antisedan®), and tolazoline.

Other Drugs (Refer to Table 4)

Acepromazine has been used to reduce anxiety in elephants for procedures such as loading and transport. However, caution should be exercised since this drug does not provide any analgesia, and the animal may override the sedative effect.

Azaperone (Stresnil®) is not currently available in the U.S. but can be imported from Canada after obtaining an investigational new animal drug substance (INAD) permit from the FDA-CVM. This drug has been used alone or in combination with other drugs to achieve sedation in

Houston Zoo, Anita Schanberger

A veterinary staff immobilizes an elephant.

Comprehensive Elephant Health Monitoring Program

Routine health monitoring should be performed on all elephants on an annual basis. Elephants should be trained to permit sampling and examination. The following protocol advises that specific baseline laboratory tests be performed for the purpose of evaluating current health status. Additional tests are recommended to increase baseline information on other diseases to determine their significance to elephant health. The final decision for specific procedures should be made by the elephant care and veterinary staffs based on individual circumstances.

Minimum Database:

1. Signalment—age, sex, origin, studbook#, local ID #; picture of individual (as viewed from the front and sides) should be included in the permanent record.

2. Anamnesis—summary of information regarding health screens, medical problems, diagnostic test results, and treatment over the previous year .

3. Complete physical exam by a veterinarian familiar with elephant health problems. This should include a review of all systems.

4. Body weight—actual or estimated using body measurements; information should be recorded at least semi-annually.

5. Blood collection
   a. Complete blood count (CBC), serum chemistry panel, fibrinogen, serum protein electrophoresis
   b. Serologic (ELISA) +/– PCR test for elephant herpesvirus—contact Drs. Laura Richman or Richard Montali (2).
   c. Bank minimum of 10–20 ml serum—All banked samples should be labeled with species, studbook #, age, sex, and date collected.

6. Serum progesterone assays in females—Serial samples should be collected weekly on an ongoing basis to evaluate estrus cycles. Collect 4 cc serum weekly, freeze, and ship overnight on dry ice. Assays can be performed at the National Zoo, Indianapolis Zoo, or by Dr. Dennis Schmitt.

7. Fecal analyses
   a. Parasite screen—Fecal samples should be collected at least semiannually; direct, flotation, and sedimentation should be performed on every sample to detect intestinal parasitism.
   b. Enteric pathogen screen—Aerobic culture of feces for enteric pathogens should include special media for the detection of *Salmonella spp*. Since Salmonella organisms may be shed intermittently, at least 3–5 fecal cultures should be performed (may be done on consecutive days) on an annual basis.

8. TB screen—Refer to the current USDA Guidelines for the Control of Tuberculosis in Elephants. Protocol can be accessed on the USDA Web site: www.aphis.usda.gov/ac/ElephTBGuidelines2003.html. At this time, annual trunk wash cultures are the only required test; however, collection of other samples for research is strongly encouraged.
   a. Samples for cultures must be collected under the direct visual supervision of a licensed veterinarian.
   b. Three trunk wash samples should be collected on separate days, ideally within a seven-day period. Trunk swabs are no longer acceptable.
   c. All samples should be frozen immediately after collection and shipped frozen.
   d. Ship by overnight express to NVSL (or other laboratory facility offering comparable procedures). Request mycobacterial culture with speciation (use VS Form 10-4 submission form).

9. Vaccinations
   a. Tetanus toxoid—Annual vaccination with a commercial equine product is recommended. Follow label instructions for product use (usually 1ml administered IM). Data are insufficient at this time to determine adequate protective vaccine doses and titers.
   b. Rabies vaccine—Vaccination with a commercial killed rabies product approved for horses should be considered if the elephant resides in or will be traveling to an endemic area. Follow label instructions for product use (usually 2ml administered IM). Vaccination with Imrab 3® has induced detectable titers to rabies virus in African elephants (M. Miller, pers. comm.). Annual vaccination is recommended. Data are insufficient at this time to determine adequate protective vaccine doses and titers.
   c. Other vaccination regimens will depend on regional requirements and exposure risks (consider vaccination for equine encephalitis viruses, Clostridial diseases, Leptospirosis). Insufficient information is available at this time to provide a recommendation for West Nile virus vaccination of elephants.

Additional Preventive Health Recommendations:

1. Serological screening for EMC (encephalomyeleitis virus), leptospirosis (multiple serovars), Mycoplasmosis, Equine Infectious Anemia, and Brucellosis. Although these tests are not species-specific and have not been validated for elephants, they may detect cross-reactive antibodies in exposed animals. The presence of antibodies does not necessarily denote infection/disease. Encephalomyelitis virus may cause clinical disease and death in elephants. Antibodies to leptospirosis have been detected in both Asian and African elephants.

2. Serum vitamin E levels—Submit heparinized plasma to Dr. Ellen Dierenfeld.

3. Reproductive tract examination—Whenever feasible, a complete reproductive examination should be conducted which includes transrectal ultrasound, semen collection and analysis, cytology and microbial cultures of the lower urogenital tract (to be screened for bacteria, chlamydia, protozoa, and herpesvirus). Herpesvirus has been identified in biopsies of vaginal lymphoid patches in an African elephant. A high prevelance of uterine leiomyomas has been observed in captive Asian elephants and could be detected via transrectal ultrasound. Since both of these conditions have potentially significant effects on reproduction, a careful evaluation is warranted if the animal is being considered for breeding. All elephants (male and female) over the age of five years should have both ultrasound and hormonal assessments performed.

4. Urinalysis—Fluid and sediment evaluation should be performed on clean voided sample; +/– microbial culture.

5. Foot radiographs—Baseline radiographs should be taken of all feet. It may be appropriate to annually monitor selected elephants (i.e., those that have a history of chronic feet problems).

6. Ancillary diagnostic tests for tuberculosis—ELISA or other recommended tests should be performed for data collection; see Guidelines for the Control of Tuberculosis in Elephants for current recommendations.

situations similar to those in which xylazine is used. Information on obtaining this drug and dosages are in Schmitt et al. (1996).

Butorphanol has been used in combination with azaperone, xylazine, and detomidine. This drug provides both analgesic and sedative effects. Effects may be partially reversed with naltrexone.

Ketamine combined with xylazine can be used as a primary immobilizing agent in juvenile elephants. Immobilization in adult elephants is difficult with this drug regimen due to the high volumes required (ex. up to 24 mls IM).

Inhalant anesthesia (halothane, isoflurane) can be used to maintain anesthesia in immobilized elephants. It is the anesthetic of choice for long and/or painful procedures after immobilization with another agent. However, it should be discontinued for some period (usually 15–20 minutes) before reversing narcotics since it may result in difficult and unpredictable recoveries.

For additional information, please refer to the following references: Fowler 1995; Mikota, Sargent, and Ranglack 1994; Kock, Morkel, and Kock 1993.

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Diagnostic Resources

Herpesvirus
Dr. Laura Richman
MedImmune
E-mail: Richman@MedImmune.com

Dr. Richard Montali
Dept. of Pathology
Smithsonian National Zoological Park
3001 Connecticut Ave.
Washington, D.C. 20008-2598
(202) 673-4869

Tuberculosis
Guidelines for the Control of Tuberculosis in Elephants. Available on the Internet: www.aphis.usda.gov/ac/ElephTBGuidelines2003.html
For regulatory questions, contact: Dr. Denise Sofranko
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1629 Blue Spruce Dr.
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ELISA (NCSU), Dr. Scott Larsen
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Leptospirosis
Cornell University, College of Veterinary Medicine
Diagnostic Lab
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Serum Vitamin E
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Elephant Necropsy Protocol (*Elephas maximus* and *Loxodonta africana*)

It is hoped that no person or facility faces the immense task of performing an elephant necropsy, but this unfortunate event should be viewed as an important learning opportunity. Following is an abbreviated necropsy protocol. The Necropsy Protocol is a cooperative effort of the Elephant Species Survival Plan (SSP) Propagation Group of the American Zoo and Aquarium Association (AZA) and the Elephant Research Foundation (ERF). Its purpose is to provide a format for the systematic collection of information and samples that will add to our knowledge of elephants. All North American facilities holding elephants should have a *complete* current copy on file. For the most recent edition go to www.aazv.org/elephant.htm. Although it may not be feasible to collect all the information and samples requested, it is encouraged that as much as possible is collected. With the increased availability of digital cameras, it is strongly recommended that photographs of both normal and pathologic structures be recorded for future reference.

Equipment Checklist

1. Standard large animal necropsy instruments. Multiple scalpel handles, duplicates, or triplicates of other instruments. Extra box of scalpel blades, knife sharpener, and a continual supply of sharp knives.
2. Retractors of various sizes and shapes. Self-retaining retractors with one or two movable arms mounted on a slide bar are most useful.
3. Sterile instruments for culture collection.
4. 10% neutral buffered formalin.
5. 4% buffered glutaraldehyde.
6. Containers for sample collection.
7. Culture swabs, sterile urine cups, glass slides.
8. Serum tubes for blood and urine collection.
9. Aluminum foil and plastic bags for freezing tissues.
10. Labels and waterproof marking pens.
11. Scale for obtaining organ weights.
12. Tape measure (metric), at least 2 meters long.
13. Chain saw, axe, or reciprocating saw to cut through the cranium. Hammers, chisels, and handsaws.
14. Hoist/crane.
15. Carts on rollers to move heavy parts.
16. Coveralls, boots, gloves, caps, masks, protective eye and head gear.
17. Accessible water supply with hose.
18. Camera and film, extra batteries.
19. First aid kit.
20. Surgical masks approved for TB exposure (example: 3M model N95).

Logistics and Necropsy Tips

Heavy equipment may be necessary to move a dead elephant. For an onsite necropsy, chains and a tow truck may be sufficient to reposition the animal or to move it a short distance. If the animal must be transported to a remote site, a truck with a hoist will be needed. It may be easier to manipulate the animal onto a flatbed trailer. Vehicles must be able to handle these approximate weights: female Asian: 2,300 to 3,700 kg; male Asian: 3,700 to 4,500 kg; female African: 2,300 to 4,000 kg; male African: 4,100 to 5,000 kg. Trucks can generally be rented or may be available from a telephone company. If a flatbed carrier is used, the animal will need to be strapped to the bed and covered with a tarp (a baseball diamond infield tarp works well). If transportation will be delayed, the carcass can be covered with ice.

If death is imminent or euthanasia is planned, completion of the measurement checklist antemortem will save time at necropsy. Otherwise, measurements should be done as soon after death as possible.

Assigning specific tasks to team members will help the necropsy to proceed in an orderly manner. For example, a team may be assigned to each of these areas: head, forelegs, hindlegs and abdominal region. One person should oversee the collection, labeling, and processing of research materials and any communication concerning research requests. It may be helpful to designate a media spokesperson.

Dissection of the head is best completed after separating it from the body. A good portion of the cranium must be damaged to remove the brain intact; a chain saw, large axe, and chisels are needed to penetrate the thick cranium. A battery operated reciprocating saw with a replaceable metal cutting blade may be safer and easier to handle. A posterior approach to brain removal can be made by three connecting deep cuts with a chain saw in the margins of the flattened triangle formed at the base of the elephant skull. Then remove the bony plate in chunks with a curved crow-bar. Use of a chain saw on bone can be hazardous and cause shrapnel-like fragments to be launched. Protective head and face gear should be worn by the chain saw operator and personnel in the immediate area.

In case an elephant may be unknowingly tuberculous, dissection of the thoracic cavity is best performed last and preferably by at least two people with face masks (HEPA-filter preferred) and other protection against *Mycobacteria*. All other personnel should be dismissed from the area before the thoracic cavity is entered. After the initial incision at the ventral midline is made, one person holds the retractor and the other cuts the tensed skin. Once the sternum is exposed, the ribs are separated at the cartilaginous attachment and adjustable retractors are applied to hold the cavity open. The heart, lungs, and associated structures may be removed "en bloc" with the diaphragm. Visceral and parietal pleura are normally adhered; there is little pleural space. Alternatively, after the abdominal viscera are removed, the diaphragm can be cut from its costosternal attachments and the lungs palpated—from a caudal approach—for tuberculosis nodules, as the lobes are being separated from the closely adhered visceral and parietal pleura. The heart, lungs, and associated structures may then be removed "en bloc."

ELEPHANT NECROPSY PROTOCOL GROSS EXAMINATION WORKSHEET

Institution/Owner_____

Address_____

Species_____ISIS#_____Studbook#_____Name_____

Birth date/Age_____Sex_____Weight (Kg)_____Actual ¨ Estimate ¨

Death date_____Death location_____

Necropsy date_____Necropsy location_____Post mortem interval_____

Captive Born ¨ Wild Caught ¨

History (clinical signs, circumstances of death, clinical lab work, diet & housing)
_____

GROSS EXAMINATION

(If no abnormalities are noted, mark as normal or not examined (NE); use additional sheets if needed)

General Exam (physical and nutritional condition, skin, body orifices, superficial lymph nodes):
Musculoskeletal System (bones, marrow, joints, muscles):
Body Cavities (fat stores, pleura, thymus, lymph nodes):
Spleen:
Respiratory System (trunk passages, pharynx, larynx, trachea, bronchi, lungs, regional lymph nodes; submit lung lesions for TB culture; bronchial lymph nodes should be cultured for TB even if normal in appearance):
Cardiovascular System (heart, pericardial sac, great vessels, myocardium, valves, chambers):
Digestive System (mouth, teeth, tongue, esophagus, stomach, small intestine, cecum, large intestine, rectum, liver, pancreas, mesenteric lymph nodes):
Urinary System (kidneys, ureters, bladder, urethra):
Reproductive System (testes/ovaries, uterus & cervix, penis/vagina, urogenital canal, prostate, seminal vesicles, bulbo-urethral gland, mammary gland, placenta):
Endocrine System (thyroids, parathyroids, adrenals, pituitary):
Central Nervous System (brain, meninges, spinal cord):
Sensory Organs (eyes, ears):

Additional Comments or Observations:

Summarize Preliminary Diagnoses:

TISSUE CHECK LIST

Freeze 3–5 cm blocks of tissue from lesions and major organs (e.g., lung, liver, kidney, spleen) in small plastic bags. Freezing at –70 degrees Celsius in an ultra-low freezer is preferred. If this is unavailable, freezing at conventional temperatures is acceptable (use a freezer *wihout* an automatic defrost cycle if possible).

Any lesions noted in the lungs should be submitted for mycobacterial culture. Bronchial lymph nodes should be cultured for TB even if normal in appearance. Preserve as many of the tissues listed below as possible in 10% buffered formalin at a ratio of approximately 1 part tissue to 10 parts solution. Tissues should be no thicker than 0.5 to 1.0 cm. Fix diced (1x1 mm) pieces of kidney, liver, spleen, and lung in a suitable EM fixative if possible—glutaraldehyde base; e.g., Trump-McDowell fixative. NOTE: There is generally no need to fix and label each tissue separately. Take 2 sets of fixed tissue. Bank one set. Send tissues required for diagnosis to primary pathologist and request a duplicate set of slides for the pathologist, Dr. Richard J. Montali who should be contacted for further instructions. Also, freeze post mortem serum (from heart), urine and any abnormal fluid accumulations. Consult Elephant Research and Tissue Request Protocol for samples requested for specific projects.

Adrenal	Kidney	Penis	Thymus
Blood *	Large intestine	Pituitary	Tongue
Bone with marrow	Liver	Prostate	Trachea
Bulbo-urethral gland	Lung	Salivary gland	Trunk cross section
Brain	Lymph node	Seminal vesicles	Uterus/cervix
Cecum	Mammary gland	Skin	Ureter
Diaphragm	Muscle	Small intestine	Urinary bladder
Esophagus	Nerve (sciatic)	Spinal cord	Vaginal/urogenital canal
Eye	Ovary/testis	Spleen	
Heart/aorta	Pancreas	Stomach	
Hemal node	Parathyroid	Temporal gland	

* Collect post mortem blood, separate serum and freeze for retrospective studies.

SEARCH LIST

The following are anatomical features that need to be confirmed or refuted, or for which few data exist. They are not arranged in order of importance, but rather as one studies the elephant by regions from the tip of the trunk to the tip of the tail. Please be aware of these anatomical questions and attempt to obtain the needed additional data as you proceed in your dissection.

1. Record the number of toenails.
2. Weigh skin after dissection from limbs and carcass.
3. Search for sesamoids especially under tendons. There may be one at the proximal end of the humerus, but check other sites as well.
4. Obtain total skeletal weight. Remove as much soft tissue as possible.
5. Note any pathological conditions in the joints. Slight erosions on articular surfaces can be viewed best in fresh tissues and should be examined soon after death. Grooves and fractures on articular surfaces cannot be mistaken and should be sought. Look also for "joint mice," calcium deposits, and any other abnormal signs.
6. Measure the volume of the nasal passages by instilling water soon after death or by measuring the diameter of the passages at intervals (record total length of trunk and diameter of passages at intervals of 10 cm).
7. Look for the intercommunicating canal between the two nasal passages of the trunk and the associated fibrous arches by sectioning the trunk every 10–20 cm. These structures were described as being located 13 cm from the tip of the trunk in a young female Asian elephant. Other searches in adult Asian females have revealed neither the arches nor the canals (Shoshani et al. 1982).
8. Harvest the lenses from the eyes and weigh them (or keep intact eyes frozen).
9. Search for the trachea-esophageal muscle. This muscle is small and may be overlooked or cut during dissection so we suggest that a section about 20 cm posterior and 50 cm or more anterior to the bifurcation be removed and examined carefully outside the carcass. This muscle was found in only three of twelve elephants examined (Shoshani et al. 1982).
10. Examine the dividing arrangement of the arteries from the aortic arch. There are two possibilities three branches or two branches. In the three-branch arrangement the sequence is right subclavian, a trunk common to the two carotids and the left subclavian. In the two-branch arrangement, the right subclavian and the common carotids merge into one vessel and the left subclavian remains separate.

International Species Information System Tables

The following tables were provided by the International Species Information System, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124 U.S.A.; www.isis.org. All values are given in standard international units. © I.S.I.S. - March 2002

Physiological reference ranges calculated for *ELEPHAS MAXIMUS* ASIATIC ELEPHANT: males only, ages: < 8 Days. Sample results submitted by 2 member institutions.

		Reference Ranges for Physiological Data Values					
Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	17.96	2.687	14.50	20.80	7	3
RED BLOOD CELL COUNT	*10^12/L	4.04	0.27	3.85	4.63	7	3
HEMOGLOBIN	g/L	162	10	155	184	7	3
HEMATOCRIT	L/L	0.469	0.032	0.442	0.536	7	3
MCV	fL	116.1	2.3	114.2	121.0	7	3
MCH	pg/cell	40.1	0.6	39.2	40.8	7	3
MCHC	g/L	345	7	336	355	7	3
PLATELET COUNT	*10^12/L	0.1990	0.0920	0.1210	0.3420	6	2
SEGMENTED NEUTROPHILS	*10^9/L	10.96	3.083	7.400	15.20	7	3
LYMPHOCYTES	*10^9/L	3.131	2.711	0.906	8.630	7	3
MONOCYTES	*10^9/L	1.763	1.866	0.081	5.261	6	3
EOSINOPHILS	*10^9/L	0.151	0.000	0.151	0.151	1	1
BASOPHILS	*10^9/L	0.041	0.000	0.041	0.041	1	1
NEUTROPHILIC BANDS	*10^9/L	2.745	2.451	0.170	6.920	6	3
CALCIUM	mMol/L	2.45	0.25	2.10	2.85	6	3
PHOSPHORUS	mMol/L	2.52	0.26	2.16	2.87	6	3
SODIUM	mMol/L	139	14	129	165	6	3
POTASSIUM	mMol/L	5.1	1.3	3.7	7.2	6	3
CHLORIDE	mMol/L	95	16	82	126	6	3
CARBON DIOXIDE	mMol/L	23.5	9.2	17.0	30.0	2	2
OSMOLARITY	Osmol/L	.2540	.0000	.2540	.2540	1	1
BLOOD UREA NITROGEN	mMol/L	3.570	1.428	2.499	6.426	6	3
CREATININE	µMol/L	256	53	168	327	6	3
TOTAL BILIRUBIN	µMol/L	14	7	5	26	6	3
DIRECT BILIRUBIN	µMol/L	0	0	0	0	1	1
INDIRECT BILIRUBIN	µMol/L	26	0	26	26	1	1
GLUCOSE	mMol/L	6.050	2.165	3.275	8.658	6	3
CHOLESTEROL	mMol/L	1.088	.5439	.6993	1.476	2	2
TRIGLYCERIDE	mMol/L	.3616	.0000	.3616	.3616	1	1
CREATINE PHOSPHOKINASE	U/L	358	463	30	685	2	2
LACTATE DEHYDROGENASE	U/L	743	728	228	1257	2	2
ALKALINE PHOSPHATASE	U/L	190	32	164	252	6	3
ALANINE AMINOTRANSFERASE	U/L	8	10	2	15	2	2
ASPARTATE AMINOTRANSFERASE	U/L	101	84	26	262	6	3
GAMMA GLUTAMYLTRANSFERASE	U/L	0	0	0	0	1	1
AMYLASE	U/L	926.1	.0000	926.1	926.1	1	1
TOTAL PROTEIN (COLORIMETRY)	g/L	73	7	62	81	5	3
GLOBULIN (COLORIMETRY)	g/L	39	1	38	40	5	3
ALBUMIN (COLORIMETRY)	g/L	34	7	24	42	5	3

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, females only, ages: < 8 Days. Sample results submitted by 5 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	16.09	3.867	6.900	22.20	17	6
RED BLOOD CELL COUNT	*10^12/L	3.76	0.40	3.17	4.60	17	6
HEMOGLOBIN	g/L	161	17	138	201	17	6
HEMATOCRIT	L/L	0.465	0.053	0.376	0.580	17	6
MCV	fL	123.4	4.6	113.4	128.5	17	6
MCH	pg/cell	42.7	1.2	40.7	44.5	17	6
MCHC	g/L	346	12	330	376	17	6
PLATELET COUNT	*10^12/L	.2190	.1040	.1330	.3340	3	2
NUCLEATED RED BLOOD CELLS	/100 WBC	2	1	1	2	4	3
SEGMENTED NEUTROPHILS	*10^9/L	7.561	3.096	2.080	12.90	17	6
LYMPHOCYTES	*10^9/L	4.733	4.146	1.240	15.10	17	6
MONOCYTES	*10^9/L	2.264	2.238	0.138	7.644	16	5
EOSINOPHILS	*10^9/L	0.833	0.955	0.121	3.078	10	2
NEUTROPHILIC BANDS	*10^9/L	0.989	1.078	0.171	2.810	7	2
CALCIUM	mMol/L	2.68	0.23	2.25	2.98	10	5
PHOSPHORUS	mMol/L	2.03	0.36	1.55	2.68	10	5
SODIUM	mMol/L	131	2	128	134	10	5
POTASSIUM	mMol/L	4.5	0.8	3.5	6.3	10	5
CHLORIDE	mMol/L	87	2	82	89	8	4
BICARBONATE	mMol/L	23.0	0.0	23.0	23.0	1	1
CARBON DIOXIDE	mMol/L	18.0	9.9	11.0	25.0	2	2
OSMOLARITY	Osmol/L	.2660	.0040	.2620	.2710	4	2
IRON	µMol/L	8.592	.0000	8.592	8.592	1	1
MAGNESIUM	mMol/L	0.823	0.000	0.823	0.823	1	1
BLOOD UREA NITROGEN	mMol/L	2.856	1.071	1.785	4.998	10	5
CREATININE	µMol/L	203	53	133	256	10	5
URIC ACID	mMol/L	0.042	0.012	0.030	0.054	4	1
TOTAL BILIRUBIN	µMol/L	19	9	7	36	10	5
DIRECT BILIRUBIN	µMol/L	3	0	3	3	1	1
INDIRECT BILIRUBIN	µMol/L	10	0	10	10	1	1
GLUCOSE	mMol/L	4.607	1.776	1.665	7.326	10	5
CHOLESTEROL	mMol/L	1.295	.2331	.9842	1.528	4	3
TRIGLYCERIDE	mMol/L	.8136	.1695	.6215	.9605	3	2
CREATINE PHOSPHOKINASE	U/L	294	211	58	587	7	3
LACTATE DEHYDROGENASE	U/L	2458	679	2078	3765	6	2
ALKALINE PHOSPHATASE	U/L	263	99	196	527	10	5
ALANINE AMINOTRANSFERASE	U/L	5	1	3	6	4	3
ASPARTATE AMINOTRANSFERASE	U/L	29	11	9	43	10	5
GAMMA GLUTAMYLTRANSFERASE	U/L	4	2	2	6	3	3
TOTAL PROTEIN (COLORIMETRY)	g/L	72	7	65	83	11	6
GLOBULIN (COLORIMETRY)	g/L	37	6	31	50	10	5
ALBUMIN (COLORIMETRY)	g/L	36	4	32	45	10	5
FIBRINOGEN	g/L	4.000	.0000	4.000	4.000	1	1
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	19	1	18	20	2	2
ALBUMIN (ELECTROPHORESIS)	g/L	41	4	38	43	2	2
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	5.000	0.000	5.000	5.000	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.005	0.000	0.005	0.005	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.005	0.002	0.003	0.006	2	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, both sexes combined. Ages: < 8 days. Sample results submitted by 6 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	17.06	3.023	12.10	22.20	23	9
RED BLOOD CELL COUNT	*10^12/L	3.84	0.39	3.17	4.63	24	9
HEMOGLOBIN	g/L	161	15	138	201	24	9
HEMATOCRIT	L/L	0.466	0.047	0.376	0.580	24	9
MCV	fL	121.3	5.3	113.4	128.5	24	9
MCH	pg/cell	41.9	1.6	39.2	44.5	24	9
MCHC	g/L	346	11	330	376	24	9
PLATELET COUNT	*10^12/L	.2050	.0900	.1210	.3420	9	4
NUCLEATED RED BLOOD CELLS	/100 WBC	2	1	1	2	4	3
SEGMENTED NEUTROPHILS	*10^9/L	8.771	3.312	2.080	15.20	23	9
LYMPHOCYTES	*10^9/L	4.382	3.840	0.906	15.10	23	9
MONOCYTES	*10^9/L	2.222	2.116	0.081	7.644	21	8
EOSINOPHILS	*10^9/L	0.710	0.956	0.121	3.078	10	3
BASOPHILS	*10^9/L	0.041	0.000	0.041	0.041	1	1
NEUTROPHILIC BANDS	*10^9/L	1.927	2.010	0.170	6.920	12	5
CALCIUM	mMol/L	2.60	0.25	2.10	2.98	16	8
PHOSPHORUS	mMol/L	2.23	0.39	1.55	2.87	16	8
SODIUM	mMol/L	132	3	128	141	15	7
POTASSIUM	mMol/L	4.7	1.0	3.5	7.2	16	8
CHLORIDE	mMol/L	88	3	82	93	13	6
BICARBONATE	mMol/L	23.0	0.0	23.0	23.0	1	1
CARBON DIOXIDE	mMol/L	20.8	8.4	11.0	30.0	4	4
OSMOLARITY	Osmol/L	.2640	.0060	.2540	.2710	5	3
IRON	µMol/L	8.592	.0000	8.592	8.592	1	1
MAGNESIUM	mMol/L	0.823	0.000	0.823	0.823	1	1
BLOOD UREA NITROGEN	mMol/L	3.213	1.071	1.785	6.426	16	8
CREATININE	µMol/L	221	53	133	327	16	8
URIC ACID	mMol/L	0.042	0.012	0.030	0.054	4	1
TOTAL BILIRUBIN	µMol/L	17	9	5	36	16	8
DIRECT BILIRUBIN	µMol/L	2	2	0	3	2	2
INDIRECT BILIRUBIN	µMol/L	19	10	10	26	2	2
GLUCOSE	mMol/L	5.106	1.998	1.665	8.658	16	8
CHOLESTEROL	mMol/L	1.217	.3108	.6993	1.528	6	5
TRIGLYCERIDE	mMol/L	.7006	.2712	.3616	.9605	4	3
CREATINE PHOSPHOKINASE	U/L	308	247	30	685	9	5
LACTATE DEHYDROGENASE	U/L	2029	1018	228	3765	8	4
ALKALINE PHOSPHATASE	U/L	216	40	164	307	15	8
ALANINE AMINOTRANSFERASE	U/L	6	5	2	15	6	5
ASPARTATE AMINOTRANSFERASE	U/L	56	61	9	262	16	8
GAMMA GLUTAMYLTRANSFERASE	U/L	3	3	0	6	4	4
AMYLASE	U/L	926.1	.0000	926.1	926.1	1	1
TOTAL PROTEIN (COLORIMETRY)	g/L	72	7	62	83	16	9
GLOBULIN (COLORIMETRY)	g/L	37	5	31	50	15	8
ALBUMIN (COLORIMETRY)	g/L	35	5	24	45	15	8
FIBRINOGEN	g/L	4.000	.0000	4.000	4.000	1	1
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	19	1	18	20	2	2
ALBUMIN (ELECTROPHORESIS)	g/L	41	4	38	43	2	2
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	5.000	0.000	5.000	5.000	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.005	0.000	0.005	0.005	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.005	0.002	0.003	0.006	2	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS* ASIATIC ELEPHANT, males only, ages: 8 Days–9 Years. Sample results submitted by 6 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	16.64	4.465	10.20	28.80	38	7
RED BLOOD CELL COUNT	*10^12/L	3.03	0.23	2.55	3.62	37	6
HEMOGLOBIN	g/L	125	17	89	171	40	9
HEMATOCRIT	L/L	0.350	0.035	0.270	0.460	37	8
MCV	fL	115.5	8.8	98.4	147.4	35	6
MCH	pg/cell	40.7	5.2	30.7	62.6	37	6
MCHC	g/L	358	44	270	503	37	8
PLATELET COUNT	*10^12/L	.4320	.1950	.2740	.6830	4	2
SEGMENTED NEUTROPHILS	*10^9/L	4.348	2.397	1.310	11.20	32	7
LYMPHOCYTES	*10^9/L	5.978	3.820	0.921	14.70	32	7
MONOCYTES	*10^9/L	4.303	3.056	0.550	9.504	26	7
EOSINOPHILS	*10^9/L	0.747	1.072	0.050	3.818	25	6
BASOPHILS	*10^9/L	0.176	0.141	0.017	0.284	3	2
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	1	1
NEUTROPHILIC BANDS	*10^9/L	2.272	2.153	0.383	5.080	4	3
CALCIUM	mMol/L	2.58	0.15	2.25	2.93	28	7
PHOSPHORUS	mMol/L	2.13	0.26	1.78	2.55	14	7
SODIUM	mMol/L	129	2	126	134	21	7
POTASSIUM	mMol/L	4.5	0.6	3.4	6.1	24	8
CHLORIDE	mMol/L	89	2	83	93	14	7
CARBON DIOXIDE	mMol/L	24.4	3.7	19.0	29.0	7	6
OSMOLARITY	Osmol/L	.2650	.0040	.2610	.2680	3	2
IRON	µMol/L	12.53	.0000	12.53	12.53	1	1
BLOOD UREA NITROGEN	mMol/L	5.355	1.428	1.785	7.140	29	7
CREATININE	µMol/L	124	35	62	248	30	8
URIC ACID	mMol/L	0.006	0.000	0.006	0.006	2	2
TOTAL BILIRUBIN	µMol/L	5	3	0	12	16	7
DIRECT BILIRUBIN	µMol/L	2	2	0	2	2	2
INDIRECT BILIRUBIN	µMol/L	3	2	2	3	2	2
GLUCOSE	mMol/L	5.661	1.277	3.663	9.213	30	8
CHOLESTEROL	mMol/L	1.114	.3367	.5180	1.865	13	7
TRIGLYCERIDE	mMol/L	.6215	.2938	.2034	1.458	21	5
CREATINE PHOSPHOKINASE	U/L	353	254	60	788	9	6
LACTATE DEHYDROGENASE	U/L	659	298	344	1377	11	6
ALKALINE PHOSPHATASE	U/L	263	145	75	684	29	7
ALANINE AMINOTRANSFERASE	U/L	9	5	1	22	24	7
ASPARTATE AMINOTRANSFERASE	U/L	29	12	10	66	30	8
GAMMA GLUTAMYLTRANSFERASE	U/L	5	4	0	10	5	3
AMYLASE	U/L	714.8	397.0	111.0	1139	8	5
LIPASE	U/L	4.170	3.892	1.390	6.950	2	2
TOTAL PROTEIN (COLORIMETRY)	g/L	72	7	63	92	25	7
GLOBULIN (COLORIMETRY)	g/L	44	16	24	80	11	7
ALBUMIN (COLORIMETRY)	g/L	32	3	29	39	11	7
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	20	0	20	20	1	1
TESTOSTERONE	nMol/L	1.978	0.000	1.978	1.978	1	1
Body Temperature:	°C	36.3	0.6	36.0	37.0	3	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS* ASIATIC ELEPHANT, females only, ages: 8 days–9 years. Sample results submitted by 15 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	19.48	6.280	7.840	47.10	288	18
RED BLOOD CELL COUNT	*10^12/L	3.24	0.71	1.71	5.86	199	18
HEMOGLOBIN	g/L	125	25	68	196	189	19
HEMATOCRIT	L/L	0.361	0.065	0.211	0.569	304	19
MCV	fL	113.7	18.1	61.9	139.0	197	18
MCH	pg/cell	40.7	6.0	18.9	49.8	185	17
MCHC	g/L	347	30	199	542	187	18
PLATELET COUNT	*10^12/L	.4650	.2060	.1260	1.346	105	7
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	46	9
RETICULOCYTES	%	1.1	1.9	0.0	3.3	3	3
SEGMENTED NEUTROPHILS	*10^9/L	6.061	4.076	1.140	23.90	260	17
LYMPHOCYTES	*10^9/L	7.409	4.145	0.891	21.20	264	17
MONOCYTES	*10^9/L	3.777	2.989	0.034	9.976	221	16
EOSINOPHILS	*10^9/L	0.429	0.488	0.079	3.768	150	14
BASOPHILS	*10^9/L	0.224	0.128	0.050	0.485	19	5
NEUTROPHILIC BANDS	*10^9/L	2.629	2.612	0.109	10.30	73	10
ERYTHROCYTE SEDIMENTATION RATE		102	15	81	125	7	1
CALCIUM	mMol/L	2.65	0.15	2.38	3.15	195	16
PHOSPHORUS	mMol/L	2.16	0.45	1.23	2.91	93	14
SODIUM	mMol/L	131	3	121	143	112	15
POTASSIUM	mMol/L	4.8	0.5	3.5	6.6	113	16
CHLORIDE	mMol/L	88	4	77	102	112	13
BICARBONATE	mMol/L	24.3	3.1	18.0	27.0	7	3
CARBON DIOXIDE	mMol/L	25.0	4.2	16.0	35.0	27	7
OSMOLARITY	Osmol/L	.2660	.0070	.2450	.2810	52	3
IRON	µMol/L	12.35	3.580	3.043	15.39	13	4
MAGNESIUM	mMol/L	0.864	0.148	0.617	1.152	13	6
BLOOD UREA NITROGEN	mMol/L	4.284	1.428	1.428	7.497	216	17
CREATININE	µMol/L	115	27	71	186	211	16
URIC ACID	mMol/L	0.012	0.012	0.000	0.030	5	1
TOTAL BILIRUBIN	µMol/L	5	5	0	26	103	15
DIRECT BILIRUBIN	µMol/L	0	0	0	2	19	7
INDIRECT BILIRUBIN	µMol/L	2	2	0	7	17	7
GLUCOSE	mMol/L	5.828	1.388	2.387	12.38	215	17
CHOLESTEROL	mMol/L	1.684	.9324	.7511	4.895	59	11
TRIGLYCERIDE	mMol/L	.8249	.8362	.1356	4.882	129	6
CREATINE PHOSPHOKINASE	U/L	222	183	31	873	62	11
LACTATE DEHYDROGENASE	U/L	1729	987	322	3665	55	9
ALKALINE PHOSPHATASE	U/L	232	103	70	821	197	17
ALANINE AMINOTRANSFERASE	U/L	8	6	0	25	84	12
ASPARTATE AMINOTRANSFERASE	U/L	21	8	6	58	197	17
GAMMA GLUTAMYLTRANSFERASE	U/L	8	4	2	14	27	10
AMYLASE	U/L	363.9	318.4	.0000	1097	20	7
LIPASE	U/L	4.448	4.726	.0000	11.12	4	4
TOTAL PROTEIN (COLORIMETRY)	g/L	75	8	53	99	214	16
GLOBULIN (COLORIMETRY)	g/L	42	9	23	67	115	14
ALBUMIN (COLORIMETRY)	g/L	33	5	18	43	115	14
FIBRINOGEN	g/L	3.990	2.240	1.000	10.00	23	9
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	11	0	11	11	1	1
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.013	0.000	0.013	0.013	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.006	0.000	0.006	0.006	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
CORTISOL	nMol/L	55	0	55	55	1	1
PROGESTERONE	nMol/L	.0044	.0033	.0010	.0083	9	1
TOTAL THYROXINE	nMol/L	129	0	129	129	1	1
TOCOPHEROL, ALPHA	nMol/L	2.320	2.320	.0000	2.320	4	3

[a] Number of samples used to calculate the reference range.

[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, both sexes combined, ages 8 days–9 years. Sample results submitted by 17 member institutions.

		Reference Ranges for Physiological Data Values					
Test	**Units**	**Mean**	**St. Dev.**	**Minimum Value**	**Maximum Value**	**Sample Size[a]**	**Animals[b]**
WHITE BLOOD CELL COUNT	*10^9/L	19.15	6.158	7.840	47.10	326	25
RED BLOOD CELL COUNT	*10^12/L	3.22	0.73	1.71	7.75	237	24
HEMOGLOBIN	g/L	125	24	68	196	229	28
HEMATOCRIT	L/L	0.360	0.062	0.211	0.569	341	27
MCV	fL	113.7	17.8	36.1	147.4	233	24
MCH	pg/cell	40.7	5.8	18.9	62.6	222	23
MCHC	g/L	349	33	199	542	224	26
PLATELET COUNT	*10^12/L	.4630	.2050	.1260	1.346	109	9
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	46	9
RETICULOCYTES	%	1.1	1.9	0.0	3.3	3	3
SEGMENTED NEUTROPHILS	*10^9/L	5.873	3.961	1.140	23.90	292	24
LYMPHOCYTES	*10^9/L	7.254	4.129	0.891	21.20	296	24
MONOCYTES	*10^9/L	3.832	2.994	0.034	9.976	247	23
EOSINOPHILS	*10^9/L	0.474	0.612	0.050	3.818	175	20
BASOPHILS	*10^9/L	0.217	0.128	0.017	0.485	22	7
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	1	1
NEUTROPHILIC BANDS	*10^9/L	2.610	2.579	0.109	10.30	77	13
ERYTHROCYTE SEDIMENTATION RATE		102	15	81	125	7	1
CALCIUM	mMol/L	2.63	0.15	2.18	3.15	224	23
PHOSPHORUS	mMol/L	2.16	0.42	1.23	2.91	107	21
SODIUM	mMol/L	130	3	121	143	134	22
POTASSIUM	mMol/L	4.7	0.6	3.4	6.6	137	24
CHLORIDE	mMol/L	88	3	81	99	124	20
BICARBONATE	mMol/L	24.3	3.1	18.0	27.0	7	3
CARBON DIOXIDE	mMol/L	24.9	4.0	16.0	35.0	34	13
OSMOLARITY	Osmol/L	.2660	.0070	.2450	.2810	55	5
IRON	µMol/L	13.07	2.148	7.160	15.39	13	5
MAGNESIUM	mMol/L	0.864	0.148	0.617	1.152	13	6
BLOOD UREA NITROGEN	mMol/L	4.284	1.428	1.428	7.497	245	24
CREATININE	µMol/L	115	27	62	186	240	23
URIC ACID	mMol/L	0.012	0.012	0.000	0.030	7	3
TOTAL BILIRUBIN	µMol/L	5	5	0	26	119	22
DIRECT BILIRUBIN	µMol/L	0	0	0	2	21	9
INDIRECT BILIRUBIN	µMol/L	2	2	0	7	19	9
GLUCOSE	mMol/L	5.828	1.388	2.387	12.38	245	25
CHOLESTEROL	mMol/L	1.580	.8806	.5180	4.895	72	18
TRIGLYCERIDE	mMol/L	.7684	.7119	.1356	4.486	149	11
CREATINE PHOSPHOKINASE	U/L	238	196	31	873	71	17
LACTATE DEHYDROGENASE	U/L	1550	993	322	3665	66	15
ALKALINE PHOSPHATASE	U/L	236	109	70	821	226	24
ALANINE AMINOTRANSFERASE	U/L	8	5	0	25	108	19
ASPARTATE AMINOTRANSFERASE	U/L	22	10	6	75	228	25
GAMMA GLUTAMYLTRANSFERASE	U/L	7	4	0	14	32	13
AMYLASE	U/L	464.2	371.9	.0000	1139	28	12
LIPASE	U/L	4.170	4.170	.0000	11.12	6	6
TOTAL PROTEIN (COLORIMETRY)	g/L	74	8	53	99	239	23
GLOBULIN (COLORIMETRY)	g/L	43	10	23	80	126	21
ALBUMIN (COLORIMETRY)	g/L	33	5	18	43	126	21
FIBRINOGEN	g/L	3.990	2.240	1.000	10.00	23	9
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	15	7	11	20	2	2
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.013	0.000	0.013	0.013	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.006	0.000	0.006	0.006	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
CORTISOL	nMol/L	55	0	55	55	1	1
TESTOSTERONE	nMol/L	1.978	0.000	1.978	1.978	1	1
PROGESTERONE	nMol/L	.0044	.0033	.0010	.0083	9	1
TOTAL THYROXINE	nMol/L	129	0	129	129	1	1
TOCOPHEROL, ALPHA	nMol/L	2.320	2.320	.0000	2.320	4	3
Body Temperature:	°C	36.3	0.6	36.0	37.0	3	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, males only, ages: 9 years–30 years. Sample results submitted by 9 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	17.24	5.204	6.600	33.30	61	11
RED BLOOD CELL COUNT	*10^12/L	3.06	0.43	2.37	4.00	37	9
HEMOGLOBIN	g/L	168	117	99	591	43	11
HEMATOCRIT	L/L	0.388	0.047	0.295	0.480	64	12
MCV	fL	122.4	7.9	102.5	149.6	36	9
MCH	pg/cell	45.3	11.4	37.3	109.8	37	9
MCHC	g/L	429	275	300	1430	42	11
PLATELET COUNT	*10^12/L	.4490	.0980	.2740	.5410	6	3
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	1	2	2
RETICULOCYTES	%	0.0	0.0	0.0	0.0	1	1
SEGMENTED NEUTROPHILS	*10^9/L	6.040	3.522	0.495	17.60	55	9
LYMPHOCYTES	*10^9/L	5.368	3.091	0.639	18.50	55	9
MONOCYTES	*10^9/L	4.339	3.038	0.132	9.583	43	9
EOSINOPHILS	*10^9/L	0.405	0.333	0.066	1.413	27	7
BASOPHILS	*10^9/L	0.167	0.057	0.127	0.207	2	2
NEUTROPHILIC BANDS	*10^9/L	0.926	1.338	0.135	4.520	10	5
CALCIUM	mMol/L	2.68	0.20	2.28	3.13	43	9
PHOSPHORUS	mMol/L	1.55	0.23	1.00	2.03	36	8
SODIUM	mMol/L	130	5	118	141	33	8
POTASSIUM	mMol/L	5.1	1.0	3.7	7.7	36	9
CHLORIDE	mMol/L	90	4	84	100	36	8
BICARBONATE	mMol/L	21.0	1.4	20.0	22.0	2	2
CARBON DIOXIDE	mMol/L	24.3	4.3	15.0	33.0	21	3
OSMOLARITY	Osmol/L	.2690	.0040	.2640	.2730	4	1
IRON	µMol/L	10.20	2.327	8.234	12.71	3	3
MAGNESIUM	mMol/L	0.917	0.119	0.699	1.082	11	3
BLOOD UREA NITROGEN	mMol/L	4.284	1.428	1.785	7.497	57	9
CREATININE	µMol/L	159	35	97	318	55	9
URIC ACID	mMol/L	0.012	0.000	0.006	0.012	7	3
TOTAL BILIRUBIN	µMol/L	5	3	2	14	35	8
DIRECT BILIRUBIN	µMol/L	3	7	0	19	7	6
INDIRECT BILIRUBIN	µMol/L	2	2	0	3	6	5
GLUCOSE	mMol/L	4.551	1.055	2.498	7.215	57	10
CHOLESTEROL	mMol/L	1.088	.2590	.6734	1.554	22	7
TRIGLYCERIDE	mMol/L	.2938	.0791	.1808	.5198	19	5
CREATINE PHOSPHOKINASE	U/L	242	152	35	688	30	7
LACTATE DEHYDROGENASE	U/L	789	582	283	2388	22	6
ALKALINE PHOSPHATASE	U/L	167	86	33	440	45	9
ALANINE AMINOTRANSFERASE	U/L	11	8	0	33	34	7
ASPARTATE AMINOTRANSFERASE	U/L	30	15	12	89	56	9
GAMMA GLUTAMYLTRANSFERASE	U/L	15	12	2	40	28	8
AMYLASE	U/L	572.4	415.1	190.4	1219	6	3
LIPASE	U/L	9.452	7.506	3.058	18.90	5	1
TOTAL PROTEIN (COLORIMETRY)	g/L	79	8	62	96	55	9
GLOBULIN (COLORIMETRY)	g/L	44	8	30	59	42	8
ALBUMIN (COLORIMETRY)	g/L	36	4	28	45	44	8
FIBRINOGEN	g/L	3.000	1.000	2.000	4.000	5	4
TESTOSTERONE	nMol/L	139.1	0.00	139.1	139.1	1	1
TOTAL THYROXINE	nMol/L	163	0	163	163	1	1
TOCOPHEROL, ALPHA	nMol/L	.0000	.0000	.0000	.0000	2	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, females only, ages: 9 years–30 years. Sample results submitted by 16 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	14.66	4.294	7.090	27.50	261	23
RED BLOOD CELL COUNT	*10^12/L	2.99	0.63	1.45	5.40	245	20
HEMOGLOBIN	g/L	127	18	94	184	250	21
HEMATOCRIT	L/L	0.362	0.050	0.269	0.559	259	22
MCV	fL	123.0	14.3	75.9	206.9	242	20
MCH	pg/cell	42.9	5.9	23.2	58.6	235	19
MCHC	g/L	350	23	269	411	243	21
PLATELET COUNT	*10^12/L	.3800	.2870	.1020	1.394	119	10
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	5	4
RETICULOCYTES	%	0.0	0.0	0.0	0.0	2	2
SEGMENTED NEUTROPHILS	*10^9/L	4.665	2.443	0.730	14.80	198	20
LYMPHOCYTES	*10^9/L	6.069	3.185	1.260	17.40	199	20
MONOCYTES	*10^9/L	2.635	2.527	0.082	8.968	160	19
EOSINOPHILS	*10^9/L	1.378	1.626	0.071	6.448	150	17
BASOPHILS	*10^9/L	0.206	0.138	0.072	0.482	26	7
NEUTROPHILIC BANDS	*10^9/L	0.980	1.107	0.102	5.810	62	9
ERYTHROCYTE SEDIMENTATION RATE		112	8	102	135	17	1
CALCIUM	mMol/L	2.68	0.15	2.10	3.18	109	19
PHOSPHORUS	mMol/L	1.62	0.26	0.84	2.33	74	17
SODIUM	mMol/L	131	4	120	142	104	16
POTASSIUM	mMol/L	4.7	0.6	3.5	7.6	107	18
CHLORIDE	mMol/L	89	4	79	101	102	16
BICARBONATE	mMol/L	27.4	3.7	22.0	32.3	10	6
CARBON DIOXIDE	mMol/L	25.0	3.5	17.0	34.2	59	10
OSMOLARITY	Osmol/L	.2630	.0070	.2530	.2740	26	2
IRON	µMol/L	9.666	2.506	5.907	14.32	20	6
MAGNESIUM	mMol/L	0.922	0.123	0.699	1.082	12	5
BLOOD UREA NITROGEN	mMol/L	4.998	1.071	2.499	8.211	105	17
CREATININE	µMol/L	133	27	62	194	108	20
URIC ACID	mMol/L	0.012	0.006	0.000	0.018	18	5
TOTAL BILIRUBIN	µMol/L	3	2	0	12	102	16
DIRECT BILIRUBIN	µMol/L	2	2	0	3	24	7
INDIRECT BILIRUBIN	µMol/L	2	2	0	7	24	7
GLUCOSE	mMol/L	4.773	1.055	2.775	8.381	106	18
CHOLESTEROL	mMol/L	1.114	.1813	.7252	1.580	60	13
TRIGLYCERIDE	mMol/L	.5650	.2712	.3051	1.582	27	7
CREATINE PHOSPHOKINASE	U/L	218	313	17	1775	31	15
LACTATE DEHYDROGENASE	U/L	384	233	124	1230	51	11
ALKALINE PHOSPHATASE	U/L	98	42	44	275	103	16
ALANINE AMINOTRANSFERASE	U/L	4	5	0	30	62	9
ASPARTATE AMINOTRANSFERASE	U/L	19	9	3	49	104	18
GAMMA GLUTAMYLTRANSFERASE	U/L	5	2	1	9	23	11
AMYLASE	U/L	798.8	482.5	120.3	1507	14	8
LIPASE	U/L	6.950	10.01	.0000	28.36	8	4
TOTAL PROTEIN (COLORIMETRY)	g/L	84	6	70	101	103	17
GLOBULIN (COLORIMETRY)	g/L	52	7	36	68	104	17
ALBUMIN (COLORIMETRY)	g/L	32	7	18	44	104	17
FIBRINOGEN	g/L	3.050	1.280	.0000	5.000	27	9
CORTISOL	nMol/L	50	0	50	50	1	1
PROGESTERONE	nMol/L	.0074	.0050	.0006	.0175	83	1
TOTAL THYROXINE	nMol/L	137	23	120	152	2	1
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1
TOCOPHEROL, ALPHA	nMol/L	4.640	.0000	4.640	4.640	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, both sexes combined, ages: 9 years–30 years. Sample results submitted by 19 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	15.15	4.585	6.600	33.30	322	34
RED BLOOD CELL COUNT	*10^12/L	3.00	0.61	1.45	5.40	282	29
HEMOGLOBIN	g/L	129	20	94	220	291	32
HEMATOCRIT	L/L	0.367	0.051	0.269	0.559	323	34
MCV	fL	122.9	13.7	75.9	206.9	278	29
MCH	pg/cell	43.0	5.6	23.2	58.6	273	28
MCHC	g/L	351	25	269	503	283	32
PLATELET COUNT	*10^12/L	.3830	.2810	.1020	1.394	125	13
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	7	6
RETICULOCYTES	%	0.0	0.0	0.0	0.0	3	3
SEGMENTED NEUTROPHILS	*10^9/L	4.964	2.765	0.495	17.60	253	29
LYMPHOCYTES	*10^9/L	5.917	3.172	0.639	18.50	254	29
MONOCYTES	*10^9/L	2.996	2.726	0.082	9.583	203	28
EOSINOPHILS	*10^9/L	1.229	1.542	0.066	6.448	177	24
BASOPHILS	*10^9/L	0.204	0.133	0.072	0.482	28	9
NEUTROPHILIC BANDS	*10^9/L	0.973	1.132	0.102	5.810	72	14
ERYTHROCYTE SEDIMENTATION RATE			112	8	102	135	17
1							
CALCIUM	mMol/L	2.68	0.18	1.95	3.18	153	28
PHOSPHORUS	mMol/L	1.58	0.26	0.84	2.33	110	25
SODIUM	mMol/L	130	4	118	142	137	24
POTASSIUM	mMol/L	4.9	0.9	3.5	10.4	144	27
CHLORIDE	mMol/L	89	4	79	101	138	24
BICARBONATE	mMol/L	26.4	4.2	20.0	32.3	12	8
CARBON DIOXIDE	mMol/L	24.9	3.6	17.0	34.2	79	13
OSMOLARITY	Osmol/L	.2640	.0060	.2530	.2740	30	3
IRON	µMol/L	9.666	2.327	5.907	14.32	23	9
MAGNESIUM	mMol/L	0.922	0.119	0.699	1.082	23	8
BLOOD UREA NITROGEN	mMol/L	4.641	1.428	1.785	8.211	164	26
CREATININE	µMol/L	141	27	62	318	163	29
URIC ACID	mMol/L	0.012	0.006	0.000	0.018	25	8
TOTAL BILIRUBIN	µMol/L	3	2	0	12	135	24
DIRECT BILIRUBIN	µMol/L	2	2	0	5	30	12
INDIRECT BILIRUBIN	µMol/L	2	2	0	7	30	12
GLUCOSE	mMol/L	4.718	1.055	2.498	8.381	163	28
CHOLESTEROL	mMol/L	1.114	.2072	.6734	1.580	82	20
TRIGLYCERIDE	mMol/L	.4520	.2486	.1808	1.582	46	12
CREATINE PHOSPHOKINASE	U/L	230	246	17	1775	61	22
LACTATE DEHYDROGENASE	U/L	533	474	124	2542	74	17
ALKALINE PHOSPHATASE	U/L	121	69	33	440	149	25
ALANINE AMINOTRANSFERASE	U/L	7	7	0	33	96	16
ASPARTATE AMINOTRANSFERASE	U/L	22	12	4	89	160	28
GAMMA GLUTAMYLTRANSFERASE	U/L	10	10	1	40	51	19
AMYLASE	U/L	730.8	464.7	120.3	1507	20	11
LIPASE	U/L	7.784	8.896	.0000	28.36	13	5
TOTAL PROTEIN (COLORIMETRY)	g/L	82	7	67	101	158	26
GLOBULIN (COLORIMETRY)	g/L	50	8	31	68	146	25
ALBUMIN (COLORIMETRY)	g/L	33	7	18	45	148	25
FIBRINOGEN	g/L	3.040	1.220	.0000	5.000	32	13
CORTISOL	nMol/L	50	0	50	50	1	1
TESTOSTERONE	nMol/L	139.1	0.00	139.1	139.1	1	1
PROGESTERONE	nMol/L	.0074	.0050	.0006	.0175	83	1
TOTAL THYROXINE	nMol/L	144	22	120	163	3	2
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1
TOCOPHEROL, ALPHA	nMol/L	2.320	2.320	.0000	4.640	3	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, males only, ages: > 30 years. Sample results submitted by 12 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	13.22	3.591	6.500	26.90	98	14
RED BLOOD CELL COUNT	*10^12/L	3.09	0.53	1.88	4.81	69	12
HEMOGLOBIN	g/L	136	23	95	183	72	13
HEMATOCRIT	L/L	0.380	0.077	0.233	0.610	97	14
MCV	fL	127.6	13.5	58.2	142.3	67	11
MCH	pg/cell	44.2	4.6	20.0	51.6	69	12
MCHC	g/L	347	28	281	469	69	12
PLATELET COUNT	*10^12/L	.4870	.1870	.1270	.9300	36	5
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	3	2
SEGMENTED NEUTROPHILS	*10^9/L	4.626	2.572	0.805	12.10	93	13
LYMPHOCYTES	*10^9/L	5.135	3.247	0.778	13.90	93	13
MONOCYTES	*10^9/L	2.909	2.598	0.088	9.436	76	12
EOSINOPHILS	*10^9/L	0.550	0.706	0.065	4.945	65	12
BASOPHILS	*10^9/L	0.236	0.138	0.136	0.508	6	3
NEUTROPHILIC BANDS	*10^9/L	0.651	1.036	0.099	4.330	30	8
CALCIUM	mMol/L	2.55	0.18	2.15	3.03	79	12
PHOSPHORUS	mMol/L	1.62	0.29	0.97	2.36	57	10
SODIUM	mMol/L	131	5	118	145	67	12
POTASSIUM	mMol/L	4.5	0.5	3.2	6.1	68	12
CHLORIDE	mMol/L	89	4	78	100	59	12
BICARBONATE	mMol/L	23.0	3.6	19.0	26.0	3	3
CARBON DIOXIDE	mMol/L	26.7	3.2	20.0	31.0	10	3
OSMOLARITY	Osmol/L	.2680	.0160	.2450	.2830	7	1
IRON	µMol/L	8.950	3.580	6.444	11.46	2	2
MAGNESIUM	mMol/L	0.926	0.000	0.926	0.926	1	1
BLOOD UREA NITROGEN	mMol/L	5.355	1.428	2.499	13.57	78	12
CREATININE	µMol/L	177	35	97	283	78	11
URIC ACID	mMol/L	0.012	0.012	0.000	0.030	27	5
TOTAL BILIRUBIN	µMol/L	3	2	0	10	62	12
DIRECT BILIRUBIN	µMol/L	3	2	0	5	9	5
INDIRECT BILIRUBIN	µMol/L	2	2	0	3	8	4
GLUCOSE	mMol/L	5.106	.9435	2.720	8.325	80	13
CHOLESTEROL	mMol/L	1.191	.2072	.8029	1.684	54	11
TRIGLYCERIDE	mMol/L	.3616	.3277	.0565	2.192	51	8
CREATINE PHOSPHOKINASE	U/L	157	67	31	320	37	8
LACTATE DEHYDROGENASE	U/L	532	359	234	1780	34	5
ALKALINE PHOSPHATASE	U/L	111	39	69	230	78	12
ALANINE AMINOTRANSFERASE	U/L	10	9	0	34	59	9
ASPARTATE AMINOTRANSFERASE	U/L	25	17	7	87	66	13
GAMMA GLUTAMYLTRANSFERASE	U/L	9	7	0	32	24	8
AMYLASE	U/L	273.1	151.7	173.9	771.5	23	5
LIPASE	U/L	.0000	.0000	.0000	.0000	1	1
TOTAL PROTEIN (COLORIMETRY)	g/L	80	7	61	97	80	13
GLOBULIN (COLORIMETRY)	g/L	47	7	29	64	41	10
ALBUMIN (COLORIMETRY)	g/L	34	4	22	45	41	10
FIBRINOGEN	g/L	3.980	1.480	2.000	6.000	6	4
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	19	0	19	19	1	1
ALBUMIN (ELECTROPHORESIS)	g/L	40	0	40	40	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
TOTAL THYROXINE	nMol/L	93	0	93	93	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, females only, ages: > 30 years. Sample results submitted by 51 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	13.42	3.577	5.800	30.00	1589	114
RED BLOOD CELL COUNT	*10^12/L	3.04	0.51	1.64	5.63	1366	109
HEMOGLOBIN	g/L	132	20	71	249	1416	113
HEMATOCRIT	L/L	0.371	0.056	0.203	0.680	1683	118
MCV	fL	123.1	12.9	47.1	213.2	1355	108
MCH	pg/cell	43.6	4.6	16.6	73.2	1329	109
MCHC	g/L	355	35	169	686	1391	112
PLATELET COUNT	*10^12/L	.4410	.1680	.0940	1.029	348	50
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	3	61	31
RETICULOCYTES	%	0.1	0.1	0.0	0.5	13	9
SEGMENTED NEUTROPHILS	*10^9/L	4.389	2.306	0.291	17.40	1309	104
LYMPHOCYTES	*10^9/L	4.800	2.905	0.196	16.70	1317	104
MONOCYTES	*10^9/L	3.827	2.900	0.000	9.983	1155	102
EOSINOPHILS	*10^9/L	0.519	0.719	0.000	5.270	1011	95
BASOPHILS	*10^9/L	0.166	0.110	0.000	0.832	109	37
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	4	2
NEUTROPHILIC BANDS	*10^9/L	0.965	1.796	0.000	11.40	225	65
ERYTHROCYTE SEDIMENTATION RATE		107	21	53	130	10	4
CALCIUM	mMol/L	2.65	0.23	0.00	3.65	1013	109
PHOSPHORUS	mMol/L	1.52	0.29	0.61	3.59	694	106
SODIUM	mMol/L	130	6	99	181	764	108
POTASSIUM	mMol/L	4.6	0.5	3.0	6.9	764	110
CHLORIDE	mMol/L	90	4	77	103	654	107
BICARBONATE	mMol/L	28.3	11.0	20.0	82.0	75	27
CARBON DIOXIDE	mMol/L	24.8	4.1	15.0	40.8	230	53
OSMOLARITY	Osmol/L	.2540	.0460	.0000	.2810	35	15
IRON	µMol/L	11.81	4.833	.0000	28.28	76	20
MAGNESIUM	mMol/L	0.872	0.193	0.000	1.251	98	30
BLOOD UREA NITROGEN	mMol/L	4.641	1.428	1.428	10.71	1053	111
CREATININE	µMol/L	141	27	71	265	1013	111
URIC ACID	mMol/L	0.012	0.012	0.000	0.065	230	43
TOTAL BILIRUBIN	µMol/L	3	2	0	17	692	109
DIRECT BILIRUBIN	µMol/L	2	2	0	7	225	56
INDIRECT BILIRUBIN	µMol/L	2	2	0	9	222	56
GLUCOSE	mMol/L	4.995	1.055	1.832	10.38	1056	112
CHOLESTEROL	mMol/L	1.166	.3885	.0000	4.792	569	95
TRIGLYCERIDE	mMol/L	.7006	.4294	.1130	3.119	589	66
CREATINE PHOSPHOKINASE	U/L	225	176	31	1260	484	90
LACTATE DEHYDROGENASE	U/L	469	342	79	2704	405	63
ALKALINE PHOSPHATASE	U/L	119	41	0	246	1002	108
ALANINE AMINOTRANSFERASE	U/L	7	9	0	112	690	94
ASPARTATE AMINOTRANSFERASE	U/L	21	10	4	91	1012	109
GAMMA GLUTAMYLTRANSFERASE	U/L	7	4	0	32	342	74
AMYLASE	U/L	602.5	457.3	.0000	1825	211	53
LIPASE	U/L	4.170	4.170	.0000	28.08	83	30
TOTAL PROTEIN (COLORIMETRY)	g/L	83	8	52	133	1036	104
GLOBULIN (COLORIMETRY)	g/L	51	9	28	95	610	99
ALBUMIN (COLORIMETRY)	g/L	32	5	19	51	617	100
FIBRINOGEN	g/L	3.740	1.860	.0000	9.090	232	53
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	33	34	0	90	8	2
ALBUMIN (ELECTROPHORESIS)	g/L	42	10	35	49	2	1
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.001	0.007	0.010	5	4
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.002	0.007	0.011	5	4
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.014	0.000	0.014	0.014	1	1
CORTISOL	nMol/L	55	28	14	149	34	3
PROGESTERONE	nMol/L	.8815	2.067	.0006	14.25	487	13
TOTAL TRIIODOTHYRONINE	nMol/L	1.712	0.270	1.384	2.141	12	2
FREE TRIIODOTHYRONINE	nMol/L	35	15	12	57	11	2
TRIIODOTHYRONINE UPTAKE	%	28	2	26	29	2	2
TOTAL THYROXINE	nMol/L	150	21	114	191	18	8
TOCOPHEROL, ALPHA	nMol/L	44.08	32.48	.0000	97.44	8	3
Body Temperature:	°C	36.1	0.0	36.1	36.1	1	1

[a] Number of samples used to calculate the reference range.

[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, both sexes combined, ages: > 30 years. Sample results submitted by 52 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	13.43	3.588	5.800	30.00	1700	133
RED BLOOD CELL COUNT	*10^12/L	3.04	0.51	1.64	5.63	1443	124
HEMOGLOBIN	g/L	132	20	70	249	1501	131
HEMATOCRIT	L/L	0.372	0.058	0.203	0.680	1793	137
MCV	fL	123.4	12.9	47.1	213.2	1430	122
MCH	pg/cell	43.6	4.6	16.6	73.2	1406	124
MCHC	g/L	354	36	169	686	1473	129
PLATELET COUNT	*10^12/L	.4450	.1700	.0940	1.029	385	55
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	3	64	33
RETICULOCYTES	%	0.1	0.1	0.0	0.5	13	9
SEGMENTED NEUTROPHILS	*10^9/L	4.405	2.324	0.291	17.40	1402	115
LYMPHOCYTES	*10^9/L	4.822	2.929	0.196	16.70	1410	115
MONOCYTES	*10^9/L	3.770	2.890	0.000	9.983	1231	112
EOSINOPHILS	*10^9/L	0.520	0.718	0.000	5.270	1076	105
BASOPHILS	*10^9/L	0.169	0.112	0.000	0.832	115	39
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	4	2
NEUTROPHILIC BANDS	*10^9/L	0.928	1.726	0.000	11.40	255	71
ERYTHROCYTE SEDIMENTATION RATE		102	26	53	130	11	5
CALCIUM	mMol/L	2.65	0.23	0.00	3.70	1102	122
PHOSPHORUS	mMol/L	1.52	0.29	0.61	3.59	759	118
SODIUM	mMol/L	130	6	99	181	840	121
POTASSIUM	mMol/L	4.6	0.5	3.2	6.8	838	123
CHLORIDE	mMol/L	90	4	77	103	722	121
BICARBONATE	mMol/L	28.1	10.8	19.0	82.0	78	30
CARBON DIOXIDE	mMol/L	24.9	4.1	15.0	40.8	240	55
OSMOLARITY	Osmol/L	.2570	.0430	.0000	.2830	42	16
IRON	µMol/L	11.64	4.833	.0000	28.28	78	22
MAGNESIUM	mMol/L	0.868	0.197	0.000	1.251	100	32
BLOOD UREA NITROGEN	mMol/L	4.641	1.428	1.428	10.71	1142	127
CREATININE	µMol/L	141	35	71	274	1101	125
URIC ACID	mMol/L	0.012	0.012	0.000	0.065	261	52
TOTAL BILIRUBIN	µMol/L	3	2	0	14	764	124
DIRECT BILIRUBIN	µMol/L	2	2	0	7	242	64
INDIRECT BILIRUBIN	µMol/L	2	2	0	10	236	63
GLUCOSE	mMol/L	4.995	1.055	1.832	10.38	1147	128
CHOLESTEROL	mMol/L	1.166	.3626	.0000	4.792	632	110
TRIGLYCERIDE	mMol/L	.6780	.4520	.1130	3.718	642	75
CREATINE PHOSPHOKINASE	U/L	219	171	31	1260	523	98
LACTATE DEHYDROGENASE	U/L	471	341	79	2704	447	71
ALKALINE PHOSPHATASE	U/L	118	42	0	246	1089	123
ALANINE AMINOTRANSFERASE	U/L	7	9	0	112	759	106
ASPARTATE AMINOTRANSFERASE	U/L	21	11	4	91	1088	126
GAMMA GLUTAMYLTRANSFERASE	U/L	7	4	0	32	374	84
AMYLASE	U/L	574.8	452.0	.0000	1825	235	58
LIPASE	U/L	4.170	4.170	.0000	28.08	84	31
TOTAL PROTEIN (COLORIMETRY)	g/L	83	8	52	133	1127	120
GLOBULIN (COLORIMETRY)	g/L	51	9	28	95	660	111
ALBUMIN (COLORIMETRY)	g/L	32	5	19	51	667	112
FIBRINOGEN	g/L	3.750	1.870	.0000	9.090	244	60
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	31	32	0	90	9	3
ALBUMIN (ELECTROPHORESIS)	g/L	41	7	35	49	3	2
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.001	0.007	0.010	6	5
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.002	0.007	0.011	6	5
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.014	0.000	0.014	0.014	1	1
CORTISOL	nMol/L	55	28	14	149	34	3
PROGESTERONE	nMol/L	.8815	2.067	.0006	14.25	487	13
TOTAL TRIIODOTHYRONINE	nMol/L	1.712	0.270	1.384	2.141	12	2
FREE TRIIODOTHYRONINE	nMol/L	35	15	12	57	11	2
TRIIODOTHYRONINE UPTAKE	%	28	2	26	29	2	2
TOTAL THYROXINE	nMol/L	147	23	93	191	19	9
TOCOPHEROL, ALPHA	nMol/L	44.08	32.48	.0000	97.44	8	3
Body Temperature:	°C	36.1	0.0	36.1	36.1	1	1

[a] Number of samples used to calculate the reference range.

[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, males only, all ages combined. Sample results submitted by 18 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	15.22	4.669	6.500	33.30	204	28
RED BLOOD CELL COUNT	*10^12/L	3.11	0.48	1.88	4.81	150	23
HEMOGLOBIN	g/L	135	24	89	281	159	28
HEMATOCRIT	L/L	0.380	0.064	0.233	0.610	205	29
MCV	fL	122.8	12.0	58.2	149.6	145	22
MCH	pg/cell	43.4	7.2	20.0	109.8	150	23
MCHC	g/L	351	34	270	503	152	26
PLATELET COUNT	*10^12/L	.4450	.1910	.1210	.9300	52	10
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	2	5	4
RETICULOCYTES	%	0.0	0.0	0.0	0.0	1	1
SEGMENTED NEUTROPHILS	*10^9/L	5.231	3.144	0.495	17.60	187	25
LYMPHOCYTES	*10^9/L	5.273	3.306	0.639	18.50	187	25
MONOCYTES	*10^9/L	3.511	2.871	0.081	9.583	151	24
EOSINOPHILS	*10^9/L	0.555	0.740	0.050	4.945	118	20
BASOPHILS	*10^9/L	0.193	0.126	0.017	0.508	12	8
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	1	1
NEUTROPHILIC BANDS	*10^9/L	1.087	1.560	0.099	6.920	50	16
CALCIUM	mMol/L	2.58	0.20	2.10	3.28	157	24
PHOSPHORUS	mMol/L	1.71	0.36	0.97	2.87	113	22
SODIUM	mMol/L	131	4	118	145	127	24
POTASSIUM	mMol/L	4.7	0.8	3.2	7.7	134	26
CHLORIDE	mMol/L	89	4	78	100	114	24
BICARBONATE	mMol/L	22.2	2.9	19.0	26.0	5	5
CARBON DIOXIDE	mMol/L	24.9	4.2	15.0	33.0	40	11
OSMOLARITY	Osmol/L	.2670	.0110	.2450	.2830	15	4
IRON	µMol/L	10.20	2.506	6.444	12.71	6	5
MAGNESIUM	mMol/L	0.917	0.111	0.699	1.082	12	4
BLOOD UREA NITROGEN	mMol/L	4.998	1.785	1.785	16.78	172	25
CREATININE	µMol/L	159	44	53	327	170	25
URIC ACID	mMol/L	0.012	0.012	0.000	0.030	36	8
TOTAL BILIRUBIN	µMol/L	5	3	0	14	118	24
DIRECT BILIRUBIN	µMol/L	2	2	0	5	17	11
INDIRECT BILIRUBIN	µMol/L	2	2	0	3	16	10
GLUCOSE	mMol/L	5.051	1.166	2.498	9.213	173	27
CHOLESTEROL	mMol/L	1.166	.2590	.6734	1.865	90	22
TRIGLYCERIDE	mMol/L	.4068	.3051	.0565	2.192	92	14
CREATINE PHOSPHOKINASE	U/L	217	158	30	788	78	20
LACTATE DEHYDROGENASE	U/L	640	449	228	2388	69	15
ALKALINE PHOSPHATASE	U/L	156	92	33	592	158	24
ALANINE AMINOTRANSFERASE	U/L	10	8	0	34	119	19
ASPARTATE AMINOTRANSFERASE	U/L	29	17	5	113	158	27
GAMMA GLUTAMYLTRANSFERASE	U/L	11	10	0	40	58	16
AMYLASE	U/L	461.2	378.9	111.0	1630	39	13
LIPASE	U/L	6.950	6.950	.0000	18.90	8	4
TOTAL PROTEIN (COLORIMETRY)	g/L	79	8	61	97	164	25
GLOBULIN (COLORIMETRY)	g/L	45	9	29	80	98	22
ALBUMIN (COLORIMETRY)	g/L	35	4	22	45	100	22
FIBRINOGEN	g/L	3.530	1.330	2.000	6.000	11	8
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	20	1	19	20	2	2
ALBUMIN (ELECTROPHORESIS)	g/L	40	0	40	40	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
TESTOSTERONE	nMol/L	70.58	96.99	1.98	139.1	2	2
TOTAL THYROXINE	nMol/L	128	49	93	163	2	2
TOCOPHEROL, ALPHA	nMol/L	.0000	.0000	.0000	.0000	2	1
Body Temperature:	°C	36.3	0.6	36.0	37.0	3	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *ELEPHAS MAXIMUS,* ASIATIC ELEPHANT, females only, all ages combined. Sample results submitted by 52 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	14.35	4.474	5.400	34.40	2151	141
RED BLOOD CELL COUNT	*10^12/L	3.06	0.56	1.64	6.06	1825	133
HEMOGLOBIN	g/L	131	21	70	227	1869	140
HEMATOCRIT	L/L	0.369	0.057	0.203	0.616	2261	145
MCV	fL	122.0	13.9	47.1	213.2	1809	132
MCH	pg/cell	43.2	5.0	16.6	73.2	1766	132
MCHC	g/L	354	33	169	686	1835	138
PLATELET COUNT	*10^12/L	.4310	.2070	.0920	1.394	576	59
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	3	115	44
RETICULOCYTES	%	0.2	0.8	0.0	3.3	18	14
SEGMENTED NEUTROPHILS	*10^9/L	4.684	2.742	0.291	23.90	1780	131
LYMPHOCYTES	*10^9/L	5.292	3.256	0.196	20.60	1793	131
MONOCYTES	*10^9/L	3.680	2.894	0.000	9.983	1549	127
EOSINOPHILS	*10^9/L	0.609	0.904	0.000	6.448	1319	117
BASOPHILS	*10^9/L	0.179	0.118	0.000	0.832	153	46
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	4	2
NEUTROPHILIC BANDS	*10^9/L	1.304	1.999	0.000	11.40	365	81
ERYTHROCYTE SEDIMENTATION RATE		110	11	81	135	33	4
CALCIUM	mMol/L	2.65	0.23	0.00	4.48	1331	136
PHOSPHORUS	mMol/L	1.58	0.39	0.61	3.59	869	129
SODIUM	mMol/L	130	5	99	181	992	130
POTASSIUM	mMol/L	4.6	0.6	3.0	7.6	997	135
CHLORIDE	mMol/L	89	4	77	103	875	127
BICARBONATE	mMol/L	26.7	6.3	18.0	65.0	91	34
CARBON DIOXIDE	mMol/L	24.8	4.0	15.0	40.8	317	64
OSMOLARITY	Osmol/L	.2620	.0270	.0000	.3250	118	19
IRON	µMol/L	11.28	4.475	.0000	28.28	111	29
MAGNESIUM	mMol/L	0.942	0.765	0.000	9.174	125	39
BLOOD UREA NITROGEN	mMol/L	4.641	1.428	1.428	10.71	1384	136
CREATININE	µMol/L	141	27	71	274	1340	137
URIC ACID	mMol/L	0.012	0.018	0.000	0.202	261	50
TOTAL BILIRUBIN	µMol/L	3	3	0	21	905	132
DIRECT BILIRUBIN	µMol/L	2	2	0	22	270	66
INDIRECT BILIRUBIN	µMol/L	2	2	0	10	264	66
GLUCOSE	mMol/L	5.106	1.166	1.832	12.38	1384	138
CHOLESTEROL	mMol/L	1.191	.4662	.0000	4.895	691	113
TRIGLYCERIDE	mMol/L	.7006	.4746	.1130	3.718	745	75
CREATINE PHOSPHOKINASE	U/L	223	175	23	1260	581	109
LACTATE DEHYDROGENASE	U/L	651	716	79	4769	522	78
ALKALINE PHOSPHATASE	U/L	133	58	0	450	1312	134
ALANINE AMINOTRANSFERASE	U/L	7	9	0	112	845	113
ASPARTATE AMINOTRANSFERASE	U/L	21	10	5	91	1315	135
GAMMA GLUTAMYLTRANSFERASE	U/L	7	4	0	32	395	91
AMYLASE	U/L	594.4	455.1	.0000	1825	245	66
LIPASE	U/L	4.448	4.726	.0000	28.36	95	38
TOTAL PROTEIN (COLORIMETRY)	g/L	82	8	52	121	1361	128
GLOBULIN (COLORIMETRY)	g/L	50	9	25	86	836	121
ALBUMIN (COLORIMETRY)	g/L	32	5	18	51	843	122
FIBRINOGEN	g/L	3.670	1.820	.0000	9.090	281	65
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	28	30	0	90	11	5
ALBUMIN (ELECTROPHORESIS)	g/L	41	6	35	49	4	3
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	1.673	2.881	0.007	5.000	3	3
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.001	0.006	0.010	7	6
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.002	0.005	0.011	7	6
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.006	0.003	0.014	3	3
CORTISOL	nMol/L	55	28	14	149	36	5
PROGESTERONE	nMol/L	.7425	1.922	.0006	14.25	579	14
TOTAL TRIIODOTHYRONINE	nMol/L	1.712	0.270	1.384	2.141	12	2
FREE TRIIODOTHYRONINE	nMol/L	35	15	12	57	11	2
TRIIODOTHYRONINE UPTAKE	%	28	2	26	29	2	2
TOTAL THYROXINE	nMol/L	147	21	114	191	21	9
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	3	3
TOCOPHEROL, ALPHA	nMol/L	32.48	34.80	.0000	97.44	11	5
Body Temperature:	°C	36.1	0.0	36.1	36.1	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for, *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, both sexes combined, all ages combined. Sample results submitted by 52 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	14.44	4.515	5.400	35.20	2369	173
RED BLOOD CELL COUNT	*10^12/L	3.07	0.56	1.64	6.06	1983	159
HEMOGLOBIN	g/L	131	21	68	249	2042	172
HEMATOCRIT	L/L	0.370	0.058	0.203	0.616	2479	177
MCV	fL	122.1	13.8	47.1	213.2	1962	157
MCH	pg/cell	43.1	5.0	16.6	73.2	1924	158
MCHC	g/L	353	34	169	686	2001	168
PLATELET COUNT	*10^12/L	.4320	.2050	.0920	1.394	629	69
NUCLEATED RED BLOOD CELLS	/100 WBC	1	1	0	3	120	47
RETICULOCYTES	%	0.2	0.8	0.0	3.3	19	14
SEGMENTED NEUTROPHILS	*10^9/L	4.737	2.786	0.291	23.90	1968	153
LYMPHOCYTES	*10^9/L	5.296	3.270	0.196	20.60	1981	153
MONOCYTES	*10^9/L	3.665	2.892	0.000	9.983	1700	148
EOSINOPHILS	*10^9/L	0.604	0.892	0.000	6.448	1437	135
BASOPHILS	*10^9/L	0.180	0.118	0.000	0.832	165	53
AZUROPHILS	*10^9/L	0.000	0.000	0.000	0.000	5	3
NEUTROPHILIC BANDS	*10^9/L	1.276	1.950	0.000	11.40	416	95
ERYTHROCYTE SEDIMENTATION RATE		110	11	81	135	33	4
CALCIUM	mMol/L	2.65	0.23	0.00	4.48	1498	160
PHOSPHORUS	mMol/L	1.62	0.39	0.74	3.59	989	152
SODIUM	mMol/L	130	5	99	181	1129	154
POTASSIUM	mMol/L	4.6	0.6	3.0	7.7	1139	160
CHLORIDE	mMol/L	89	4	77	103	998	152
BICARBONATE	mMol/L	26.5	6.2	18.0	65.0	96	38
CARBON DIOXIDE	mMol/L	24.9	4.0	15.0	40.8	357	74
OSMOLARITY	Osmol/L	.2630	.0250	.0000	.3250	133	23
IRON	µMol/L	11.28	4.475	.0000	28.28	117	33
MAGNESIUM	mMol/L	0.934	0.728	0.000	9.174	138	43
BLOOD UREA NITROGEN	mMol/L	4.641	1.428	1.428	13.57	1567	163
CREATININE	µMol/L	141	35	62	292	1521	164
URIC ACID	mMol/L	0.012	0.018	0.000	0.202	301	62
TOTAL BILIRUBIN	µMol/L	3	3	0	21	1034	158
DIRECT BILIRUBIN	µMol/L	2	2	0	22	296	80
INDIRECT BILIRUBIN	µMol/L	2	2	0	10	286	78
GLUCOSE	mMol/L	5.106	1.166	1.832	12.38	1568	166
CHOLESTEROL	mMol/L	1.191	.4403	.0000	4.895	791	139
TRIGLYCERIDE	mMol/L	.6667	.4633	.1130	3.718	838	90
CREATINE PHOSPHOKINASE	U/L	224	182	23	1714	662	127
LACTATE DEHYDROGENASE	U/L	645	686	46	4769	600	96
ALKALINE PHOSPHATASE	U/L	134	61	0	450	1478	160
ALANINE AMINOTRANSFERASE	U/L	8	9	0	112	974	135
ASPARTATE AMINOTRANSFERASE	U/L	22	11	4	97	1491	164
GAMMA GLUTAMYLTRANSFERASE	U/L	7	5	0	33	459	108
AMYLASE	U/L	576.1	447.1	.0000	1825	284	78
LIPASE	U/L	4.726	5.004	.0000	28.36	103	42
TOTAL PROTEIN (COLORIMETRY)	g/L	81	8	52	121	1531	155
GLOBULIN (COLORIMETRY)	g/L	49	9	25	86	938	144
ALBUMIN (COLORIMETRY)	g/L	33	5	19	51	947	145
FIBRINOGEN	g/L	3.670	1.820	.0000	9.090	298	76
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	27	27	0	90	13	7
ALBUMIN (ELECTROPHORESIS)	g/L	41	5	35	49	5	4
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	1.673	2.881	0.007	5.000	3	3
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.001	0.006	0.010	8	7
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.002	0.005	0.011	8	7
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.006	0.003	0.014	3	3
CORTISOL	nMol/L	55	28	14	149	36	5
TESTOSTERONE	nMol/L	70.58	96.99	1.98	139.1	2	2
PROGESTERONE	nMol/L	.7425	1.922	.0006	14.25	579	14
TOTAL TRIIODOTHYRONINE	nMol/L	1.712	0.270	1.384	2.141	12	2
FREE TRIIODOTHYRONINE	nMol/L	35	15	12	57	11	2
TRIIODOTHYRONINE UPTAKE	%	28	2	26	29	2	2
TOTAL THYROXINE	nMol/L	146	23	93	191	23	11
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	3	3
TOCOPHEROL, ALPHA	nMol/L	27.84	32.48	.0000	97.44	13	5
Body Temperature:	°C	36.3	0.5	36.0	37.0	4	3

[a] Number of samples used to calculate the reference range.

[b] Number of different individuals contributing to the reference values.

Average weights calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, females only. Weights submitted by ISIS member institutions.

		Reference Ranges for Physiological Data Values					
Age Grouping	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
0–1 days	Kg	118.8	20.7	68.18	133.2	9	7
6–8 days	Kg	136.4	6.8	130.5	148.0	5	3
0.9–1.1 months	Kg	156.3	18.8	118.2	173.9	9	5
5.4–6.6 months	Kg	311.0	79.2	160.0	468.0	9	4
0.9–1.1 years	Kg	339.1	116.4	236.4	514.4	12	3
1.8–2.2 years	Kg	843.7	254.4	424.5	1364	8	3
4.5–5.5 years	Kg	1242	280	763.6	1491	6	3
9.5–10.5 years	Kg	2214	203	1690	2836	83	10
14.5–15.5 years	Kg	2994	588	1734	4091	31	13
19.0–21.0 years	Kg	3300	557	1990	4814	118	20

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Average weights calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, males only. Weights submitted by ISIS member institutions.

Age Grouping	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
0.9–1.1 months	Kg	153.3	2.8	149.5	156.8	7	1
1.8–2.2 months	Kg	197.4	6.7	187.3	206.8	10	1
2.7–3.3 months	Kg	237.0	7.0	227.7	248.2	13	1
5.4–6.6 months	Kg	340.3	14.0	322.7	363.2	7	1
4.5–5.5 years	Kg	1904	142	1645	2073	16	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Average weights calculated for *ELEPHAS MAXIMUS*, ASIATIC ELEPHANT, both sexes combined. Weights submitted by ISIS member institutions.

		Reference Ranges for Physiological Data Values					
Age Grouping	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
0–1 days	Kg	122.3	22.6	68.18	171.0	13	10
6–8 days	Kg	137.4	20.3	117.3	181.4	8	4
0.9–1.1 months	Kg	155.0	13.9	118.2	173.9	16	6
1.8–2.2 months	Kg	192.7	12.8	158.0	206.8	13	4
2.7–3.3 months	Kg	232.0	11.5	207.7	248.2	17	3
5.4–6.6 months	Kg	325.2	23.3	277.3	363.2	14	3
0.9–1.1 years	Kg	402.3	125.9	236.4	560.5	19	5
1.8–2.2 years	Kg	840.9	238.1	424.5	1364	9	4
4.5–5.5 years	Kg	1769	287	1123	2073	21	5
9.5–10.5 years	Kg	2192	235	1600	2836	90	12
14.5–15.5 years	Kg	3217	836	1734	5018	35	14
19.0–21.0 years	Kg	3322	580	1990	4814	120	21

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, males only, ages: 8 days–9 years. Sample results submitted by 1 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	16.80	1.671	15.50	19.00	4	1
RED BLOOD CELL COUNT	*10^12/L	3.43	0.31	3.03	3.73	4	1
HEMOGLOBIN	g/L	139	11	126	149	4	1
HEMATOCRIT	L/L	0.409	0.036	0.367	0.445	4	1
MCV	fL	119.3	1.5	117.4	121.1	4	1
MCH	pg/cell	40.6	1.0	39.4	41.6	4	1
MCHC	g/L	340	7	330	345	4	1
SEGMENTED NEUTROPHILS	*10^9/L	6.348	1.686	4.650	7.980	4	1
LYMPHOCYTES	*10^9/L	9.098	2.392	5.580	10.70	4	1
MONOCYTES	*10^9/L	1.094	0.615	0.380	1.860	4	1
EOSINOPHILS	*10^9/L	0.270	0.170	0.155	0.465	3	1
NEUTROPHILIC BANDS	*10^9/L	0.164	0.012	0.155	0.172	2	1
CALCIUM	mMol/L	3.08	0.18	2.88	3.23	3	1
PHOSPHORUS	mMol/L	2.03	0.36	1.68	2.39	3	1
SODIUM	mMol/L	127	1	127	128	3	1
POTASSIUM	mMol/L	5.4	0.6	4.9	6.0	3	1
CHLORIDE	mMol/L	85	1	84	86	3	1
BLOOD UREA NITROGEN	mMol/L	2.499	1.428	1.071	3.570	3	1
CREATININE	µMol/L	141	18	124	159	3	1
URIC ACID	mMol/L	0.000	0.000	0.000	0.000	1	1
TOTAL BILIRUBIN	µMol/L	9	3	7	14	3	1
GLUCOSE	mMol/L	2.997	.6660	2.276	3.441	3	1
CHOLESTEROL	mMol/L	1.917	.3626	1.502	2.176	3	1
TRIGLYCERIDE	mMol/L	.5311	.0000	.5311	.5311	1	1
CREATINE PHOSPHOKINASE	U/L	305	77	250	359	2	1
LACTATE DEHYDROGENASE	U/L	357	37	332	399	3	1
ALKALINE PHOSPHATASE	U/L	232	26	214	261	3	1
ALANINE AMINOTRANSFERASE	U/L	6	2	4	7	3	1
ASPARTATE AMINOTRANSFERASE	U/L	25	7	17	31	3	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, females only, ages: 8 days–9 years. Sample results submitted by 5 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	12.48	4.370	5.900	21.00	12	6
RED BLOOD CELL COUNT	*10^12/L	3.02	0.45	1.68	5.00	74	6
HEMOGLOBIN	g/L	130	16	78	167	74	6
HEMATOCRIT	L/L	0.379	0.042	0.280	0.478	80	7
MCV	fL	125.2	7.2	84.0	137.7	73	6
MCH	pg/cell	43.4	3.6	28.0	49.3	74	6
MCHC	g/L	346	18	310	387	73	6
PLATELET COUNT	*10^12/L	.5900	.0000	.5900	.5900	1	1
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	0	2	2
SEGMENTED NEUTROPHILS	*10^9/L	4.244	3.078	1.900	11.30	9	5
LYMPHOCYTES	*10^9/L	5.861	2.196	2.480	9.030	9	5
MONOCYTES	*10^9/L	1.686	1.024	0.191	3.416	8	4
EOSINOPHILS	*10^9/L	0.727	0.730	0.095	1.627	4	3
CALCIUM	mMol/L	2.60	0.25	2.03	2.93	14	4
PHOSPHORUS	mMol/L	1.84	0.26	1.23	2.33	14	4
SODIUM	mMol/L	129	5	116	135	13	4
POTASSIUM	mMol/L	5.4	0.8	4.8	7.3	13	4
CHLORIDE	mMol/L	86	3	83	89	3	3
CARBON DIOXIDE	mMol/L	22.0	4.2	19.0	25.0	2	2
OSMOLARITY	Osmol/L	.2710	.0010	.2700	.2720	2	2
BLOOD UREA NITROGEN	mMol/L	3.927	1.428	1.071	6.783	15	4
CREATININE	µMol/L	115	35	62	159	12	4
URIC ACID	mMol/L	0.018	0.000	0.018	0.018	2	2
TOTAL BILIRUBIN	µMol/L	3	2	0	5	12	4
DIRECT BILIRUBIN	µMol/L	0	0	0	0	4	3
INDIRECT BILIRUBIN	µMol/L	3	2	2	3	4	3
GLUCOSE	mMol/L	4.440	1.388	1.665	7.992	15	4
CHOLESTEROL	mMol/L	2.020	.4662	1.243	2.797	14	4
TRIGLYCERIDE	mMol/L	.6667	.1582	.5537	.7797	2	2
CREATINE PHOSPHOKINASE	U/L	1	0	1	1	2	1
LACTATE DEHYDROGENASE	U/L	875	35	850	900	2	2
ALKALINE PHOSPHATASE	U/L	311	85	175	441	14	4
ALANINE AMINOTRANSFERASE	U/L	12	11	1	39	11	4
ASPARTATE AMINOTRANSFERASE	U/L	26	9	10	36	12	4
LIPASE	U/L	2.780	.0000	2.780	2.780	1	1
TOTAL PROTEIN (COLORIMETRY)	g/L	74	6	65	90	14	4
GLOBULIN (COLORIMETRY)	g/L	42	11	27	76	14	4
ALBUMIN (COLORIMETRY)	g/L	33	6	24	42	14	4
TOTAL TRIIODOTHYRONINE	nMol/L	3.219	0.000	3.219	3.219	1	1
TOTAL THYROXINE	nMol/L	89	0	89	89	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for: *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, both sexes combined, ages: 8 days–9 years. Sample results submitted by 6 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	13.56	4.277	5.900	21.00	16	7
RED BLOOD CELL COUNT	*10^12/L	3.04	0.45	1.68	5.00	78	7
HEMOGLOBIN	g/L	131	16	78	167	78	7
HEMATOCRIT	L/L	0.381	0.042	0.280	0.478	84	8
MCV	fL	124.9	7.2	84.0	137.7	77	7
MCH	pg/cell	43.3	3.6	28.0	49.3	78	7
MCHC	g/L	346	18	310	387	77	7
PLATELET COUNT	*10^12/L	.5900	.0000	.5900	.5900	1	1
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	0	2	2
SEGMENTED NEUTROPHILS	*10^9/L	4.892	2.837	1.900	11.30	13	6
LYMPHOCYTES	*10^9/L	6.857	2.658	2.480	10.70	13	6
MONOCYTES	*10^9/L	1.489	0.925	0.191	3.416	12	5
EOSINOPHILS	*10^9/L	0.531	0.580	0.095	1.627	7	4
NEUTROPHILIC BANDS	*10^9/L	0.164	0.012	0.155	0.172	2	1
CALCIUM	mMol/L	2.70	0.30	2.03	3.23	17	5
PHOSPHORUS	mMol/L	1.87	0.29	1.23	2.39	17	5
SODIUM	mMol/L	129	5	116	135	16	5
POTASSIUM	mMol/L	5.4	0.7	4.8	7.3	16	5
CHLORIDE	mMol/L	86	2	83	89	6	4
CARBON DIOXIDE	mMol/L	22.0	4.2	19.0	25.0	2	2
OSMOLARITY	Osmol/L	.2710	.0010	.2700	.2720	2	2
BLOOD UREA NITROGEN	mMol/L	3.570	1.428	1.071	6.783	18	5
CREATININE	µMol/L	115	35	62	159	15	5
URIC ACID	mMol/L	0.012	0.012	0.000	0.018	3	3
TOTAL BILIRUBIN	µMol/L	3	3	0	14	15	5
DIRECT BILIRUBIN	µMol/L	0	0	0	0	4	3
INDIRECT BILIRUBIN	µMol/L	3	2	2	3	4	3
GLUCOSE	mMol/L	4.218	1.388	1.665	7.992	18	5
CHOLESTEROL	mMol/L	1.994	.4403	1.243	2.797	17	5
TRIGLYCERIDE	mMol/L	.6215	.1356	.5311	.7797	3	3
CREATINE PHOSPHOKINASE	U/L	153	181	1	359	4	2
LACTATE DEHYDROGENASE	U/L	564	286	332	900	5	3
ALKALINE PHOSPHATASE	U/L	297	83	175	441	17	5
ALANINE AMINOTRANSFERASE	U/L	11	10	1	39	14	5
ASPARTATE AMINOTRANSFERASE	U/L	26	8	10	36	15	5
LIPASE	U/L	2.780	.0000	2.780	2.780	1	1
TOTAL PROTEIN (COLORIMETRY)	g/L	74	6	65	90	14	4
GLOBULIN (COLORIMETRY)	g/L	42	11	27	76	14	4
ALBUMIN (COLORIMETRY)	g/L	33	6	24	42	14	4
TOTAL TRIIODOTHYRONINE	nMol/L	3.219	0.000	3.219	3.219	1	1
TOTAL THYROXINE	nMol/L	89	0	89	89	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for, *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, males only, ages: 9 years–30 years. Sample results submitted by 5 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	12.20	2.386	7.300	19.30	85	6
RED BLOOD CELL COUNT	*10^12/L	3.10	0.49	2.61	6.60	86	6
HEMOGLOBIN	g/L	127	12	103	159	83	6
HEMATOCRIT	L/L	0.382	0.041	0.290	0.526	85	6
MCV	fL	124.8	7.5	100.0	141.3	84	6
MCH	pg/cell	41.6	1.9	35.9	46.3	82	6
MCHC	g/L	335	18	283	415	82	6
PLATELET COUNT	*10^12/L	.6000	.2660	.3900	1.300	26	3
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	0	3	2
SEGMENTED NEUTROPHILS	*10^9/L	4.460	1.635	1.260	10.80	84	6
LYMPHOCYTES	*10^9/L	5.477	2.022	0.456	9.460	85	6
MONOCYTES	*10^9/L	1.257	1.432	0.000	6.384	75	6
EOSINOPHILS	*10^9/L	0.275	0.220	0.000	1.269	65	6
BASOPHILS	*10^9/L	0.157	0.130	0.000	0.525	19	2
NEUTROPHILIC BANDS	*10^9/L	1.434	0.926	0.101	3.910	53	4
CALCIUM	mMol/L	2.70	0.15	2.35	3.23	72	6
PHOSPHORUS	mMol/L	1.74	0.26	1.23	2.65	73	6
SODIUM	mMol/L	127	4	116	138	71	6
POTASSIUM	mMol/L	4.7	0.4	4.1	6.3	72	6
CHLORIDE	mMol/L	86	3	78	95	72	6
CARBON DIOXIDE	mMol/L	26.1	4.0	19.0	32.0	17	4
OSMOLARITY	Osmol/L	.2550	.0050	.2460	.2630	14	3
IRON	µMol/L	8.055	.0000	8.055	8.055	1	1
MAGNESIUM	mMol/L	0.457	0.226	0.304	0.905	6	3
BLOOD UREA NITROGEN	mMol/L	3.213	1.071	1.428	5.355	74	6
CREATININE	µMol/L	177	27	71	248	71	6
URIC ACID	mMol/L	0.018	0.012	0.000	0.048	47	3
TOTAL BILIRUBIN	µMol/L	3	3	0	17	71	6
DIRECT BILIRUBIN	µMol/L	2	2	0	5	12	2
INDIRECT BILIRUBIN	µMol/L	3	5	0	15	12	2
GLUCOSE	mMol/L	3.996	.7215	2.553	5.606	71	6
CHOLESTEROL	mMol/L	2.098	.5180	.9842	3.341	70	6
TRIGLYCERIDE	mMol/L	.4633	.1921	.1921	1.141	60	5
CREATINE PHOSPHOKINASE	U/L	199	73	90	388	21	5
LACTATE DEHYDROGENASE	U/L	634	438	291	1874	58	4
ALKALINE PHOSPHATASE	U/L	181	53	76	340	71	6
ALANINE AMINOTRANSFERASE	U/L	7	8	0	26	18	5
ASPARTATE AMINOTRANSFERASE	U/L	18	8	7	43	73	6
GAMMA GLUTAMYLTRANSFERASE	U/L	11	6	0	23	19	4
AMYLASE	U/L	329.5	364.6	83.99	1380	12	4
LIPASE	U/L	1.112	.5560	.2780	1.668	5	2
TOTAL PROTEIN (COLORIMETRY)	g/L	79	6	66	96	31	6
GLOBULIN (COLORIMETRY)	g/L	43	5	32	54	30	6
ALBUMIN (COLORIMETRY)	g/L	36	6	28	55	30	6
FIBRINOGEN	g/L	1.950	1.110	1.000	4.000	11	2
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	14	3	12	17	2	2
ALBUMIN (ELECTROPHORESIS)	g/L	45	6	41	49	2	2
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.011	0.000	0.011	0.011	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.000	0.009	0.009	1	1
CORTISOL	nMol/L	99	97	14	246	8	1
TESTOSTERONE	nMol/L	22.76	31.11	0.763	44.76	2	2

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, females only, ages: 9 years–30 years. Sample results submitted by 13 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.56	1.763	6.100	18.50	485	19
RED BLOOD CELL COUNT	*10^12/L	3.02	0.29	2.25	4.20	474	19
HEMOGLOBIN	g/L	134	12	93	183	475	19
HEMATOCRIT	L/L	0.387	0.036	0.300	0.516	501	21
MCV	fL	128.8	6.7	83.3	170.2	472	19
MCH	pg/cell	44.5	2.1	26.7	55.1	467	19
MCHC	g/L	345	13	276	383	472	19
PLATELET COUNT	*10^12/L	.3920	.2370	.1300	1.324	67	11
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	1	8	3
RETICULOCYTES	%	0.0	0.0	0.0	0.0	7	3
SEGMENTED NEUTROPHILS	*10^9/L	2.596	1.430	0.011	8.490	322	16
LYMPHOCYTES	*10^9/L	5.267	2.251	0.032	12.00	329	18
MONOCYTES	*10^9/L	1.741	1.863	0.002	8.281	286	17
EOSINOPHILS	*10^9/L	0.290	0.240	0.000	1.926	238	16
BASOPHILS	*10^9/L	0.134	0.073	0.000	0.368	53	5
NEUTROPHILIC BANDS	*10^9/L	1.180	0.864	0.009	7.840	202	9
CALCIUM	mMol/L	2.73	0.10	2.33	3.28	449	20
PHOSPHORUS	mMol/L	1.62	0.19	1.10	2.33	449	20
SODIUM	mMol/L	129	2	122	137	435	18
POTASSIUM	mMol/L	4.7	0.4	3.7	6.1	436	18
CHLORIDE	mMol/L	88	2	75	95	441	18
BICARBONATE	mMol/L	1081	0.0	1081	1081	1	1
CARBON DIOXIDE	mMol/L	27.3	2.8	20.0	32.0	70	9
OSMOLARITY	Osmol/L	.2570	.0020	.2530	.2620	25	1
MAGNESIUM	mMol/L	0.510	0.350	0.267	1.728	36	7
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	1.428	7.497	445	20
CREATININE	µMol/L	124	18	0	186	442	20
URIC ACID	mMol/L	0.012	0.018	0.000	0.065	117	9
TOTAL BILIRUBIN	µMol/L	3	2	0	17	374	20
DIRECT BILIRUBIN	µMol/L	2	2	0	3	7	5
INDIRECT BILIRUBIN	µMol/L	2	2	2	3	7	5
GLUCOSE	mMol/L	4.662	.5550	3.053	6.716	447	20
CHOLESTEROL	mMol/L	1.528	.4144	.0000	2.720	445	20
TRIGLYCERIDE	mMol/L	.9266	.3729	.2147	2.023	425	12
CREATINE PHOSPHOKINASE	U/L	178	57	92	313	44	9
LACTATE DEHYDROGENASE	U/L	1167	516	305	4140	399	13
ALKALINE PHOSPHATASE	U/L	112	46	65	290	438	19
ALANINE AMINOTRANSFERASE	U/L	5	7	0	32	101	18
ASPARTATE AMINOTRANSFERASE	U/L	25	8	10	57	437	18
GAMMA GLUTAMYLTRANSFERASE	U/L	12	6	3	37	98	15
AMYLASE	U/L	504.5	206.3	228.3	956.5	78	7
LIPASE	U/L	2.502	3.058	.0000	10.84	31	3
TOTAL PROTEIN (COLORIMETRY)	g/L	76	6	58	105	119	17
GLOBULIN (COLORIMETRY)	g/L	43	6	35	61	117	17
ALBUMIN (COLORIMETRY)	g/L	34	5	22	44	120	18
FIBRINOGEN	g/L	2.920	1.850	.0100	6.000	8	5
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	19	5	15	24	3	2
ALBUMIN (ELECTROPHORESIS)	g/L	38	1	37	39	3	2
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.003	0.004	0.009	3	2
PROGESTERONE	nMol/L	.0088	.0100	.0016	.0385	130	4

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, both sexes combined, ages 9 years–30 years. Sample results submitted by 15 member institutions.

Test	Units	Reference Ranges for Physiological Data Values: Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.82	1.985	6.100	19.30	572	25
RED BLOOD CELL COUNT	*10^12/L	3.03	0.30	2.01	4.43	561	25
HEMOGLOBIN	g/L	133	13	89	185	560	25
HEMATOCRIT	L/L	0.386	0.036	0.290	0.516	585	27
MCV	fL	128.1	7.2	83.3	170.2	556	25
MCH	pg/cell	44.0	2.4	26.7	55.1	552	25
MCHC	g/L	344	14	276	415	554	25
PLATELET COUNT	*10^12/L	.4500	.2620	.1300	1.324	93	14
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	0	10	4
RETICULOCYTES	%	0.0	0.0	0.0	0.0	7	3
SEGMENTED NEUTROPHILS	*10^9/L	3.011	1.716	0.011	11.80	408	22
LYMPHOCYTES	*10^9/L	5.296	2.212	0.032	12.00	416	24
MONOCYTES	*10^9/L	1.643	1.790	0.000	8.281	363	23
EOSINOPHILS	*10^9/L	0.294	0.269	0.000	2.573	304	22
BASOPHILS	*10^9/L	0.140	0.091	0.000	0.525	73	7
NEUTROPHILIC BANDS	*10^9/L	1.225	0.883	0.009	7.840	257	14
CALCIUM	mMol/L	2.73	0.13	2.33	3.28	521	26
PHOSPHORUS	mMol/L	1.62	0.23	1.10	2.33	521	26
SODIUM	mMol/L	129	3	121	138	508	24
POTASSIUM	mMol/L	4.7	0.4	3.7	6.3	509	24
CHLORIDE	mMol/L	88	3	75	99	514	24
BICARBONATE	mMol/L	1081	0.0	1081	1081	1	1
CARBON DIOXIDE	mMol/L	27.0	3.2	19.0	32.0	88	13
OSMOLARITY	Osmol/L	.2560	.0040	.2460	.2630	39	4
IRON	µMol/L	8.055	.0000	8.055	8.055	1	1
MAGNESIUM	mMol/L	0.502	0.333	0.267	1.728	42	10
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	1.428	7.497	519	26
CREATININE	µMol/L	133	27	0	212	513	26
URIC ACID	mMol/L	0.012	0.012	0.000	0.065	164	12
TOTAL BILIRUBIN	µMol/L	3	3	0	17	445	26
DIRECT BILIRUBIN	µMol/L	2	2	0	5	19	7
INDIRECT BILIRUBIN	µMol/L	3	3	0	15	19	7
GLUCOSE	mMol/L	4.551	.6660	2.886	7.160	520	26
CHOLESTEROL	mMol/L	1.606	.4662	.0000	2.901	516	26
TRIGLYCERIDE	mMol/L	.8701	.3842	.1921	2.023	485	17
CREATINE PHOSPHOKINASE	U/L	185	63	90	388	65	14
LACTATE DEHYDROGENASE	U/L	1100	537	291	4140	457	17
ALKALINE PHOSPHATASE	U/L	122	55	65	385	511	25
ALANINE AMINOTRANSFERASE	U/L	6	7	0	32	119	23
ASPARTATE AMINOTRANSFERASE	U/L	24	8	7	57	511	24
GAMMA GLUTAMYLTRANSFERASE	U/L	11	5	0	27	115	19
AMYLASE	U/L	476.6	241.1	68.82	1380	91	12
LIPASE	U/L	1.668	1.946	.0000	8.896	34	4
TOTAL PROTEIN (COLORIMETRY)	g/L	77	6	54	105	151	23
GLOBULIN (COLORIMETRY)	g/L	43	6	32	61	148	23
ALBUMIN (COLORIMETRY)	g/L	34	5	20	55	151	24
FIBRINOGEN	g/L	2.250	1.560	.0100	6.000	20	7
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	17	4	12	24	5	4
ALBUMIN (ELECTROPHORESIS)	g/L	41	5	37	49	5	4
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.011	0.000	0.011	0.011	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.003	0.004	0.009	4	3
CORTISOL	nMol/L	99	97	14	246	8	1
TESTOSTERONE	nMol/L	22.76	31.11	0.763	44.76	2	2
PROGESTERONE	nMol/L	.0088	.0100	.0016	.0385	130	4

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, males only, ages: > 30 years. Sample results submitted by 16 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.71	2.649	4.300	18.80	126	15
RED BLOOD CELL COUNT	*10^12/L	3.08	0.48	2.05	4.80	115	18
HEMOGLOBIN	g/L	128	15	96	178	116	18
HEMATOCRIT	L/L	0.381	0.047	0.257	0.522	204	19
MCV	fL	121.6	9.9	93.8	141.6	114	18
MCH	pg/cell	42.2	3.7	35.7	51.4	113	18
MCHC	g/L	346	21	258	457	114	18
PLATELET COUNT	*10^12/L	.2780	.0810	.1770	.6100	29	5
NUCLEATED RED BLOOD CELLS	/100 WBC	4	8	0	17	5	4
SEGMENTED NEUTROPHILS	*10^9/L	3.977	1.830	1.320	9.460	115	15
LYMPHOCYTES	*10^9/L	4.579	2.792	0.845	11.60	117	15
MONOCYTES	*10^9/L	2.285	1.751	0.000	8.058	95	15
EOSINOPHILS	*10^9/L	0.202	0.151	0.065	0.847	73	11
BASOPHILS	*10^9/L	0.123	0.080	0.000	0.324	14	5
NEUTROPHILIC BANDS	*10^9/L	0.726	0.879	0.070	2.910	19	8
ERYTHROCYTE SEDIMENTATION RATE		44	12	17	70	15	1
CALCIUM	mMol/L	2.75	0.33	2.38	4.45	102	18
PHOSPHORUS	mMol/L	1.52	0.32	0.90	2.49	66	18
SODIUM	mMol/L	127	7	107	159	89	15
POTASSIUM	mMol/L	4.8	0.8	3.0	9.5	89	15
CHLORIDE	mMol/L	85	5	71	97	89	15
BICARBONATE	mMol/L	21.9	4.7	13.0	28.0	7	1
CARBON DIOXIDE	mMol/L	26.0	3.1	17.0	33.4	33	8
OSMOLARITY	Osmol/L	.2570	.0060	.2430	.2680	30	3
IRON	µMol/L	12.17	7.876	.5370	23.27	6	5
MAGNESIUM	mMol/L	3.978	6.562	0.864	15.72	5	4
BLOOD UREA NITROGEN	mMol/L	3.927	2.499	.7140	15.71	103	19
CREATININE	µMol/L	150	62	71	389	102	19
URIC ACID	mMol/L	0.024	0.018	0.000	0.060	17	9
TOTAL BILIRUBIN	µMol/L	3	2	0	9	89	17
DIRECT BILIRUBIN	µMol/L	2	2	0	3	25	7
INDIRECT BILIRUBIN	µMol/L	2	2	0	5	24	7
GLUCOSE	mMol/L	4.773	.9435	.0000	7.548	100	18
CHOLESTEROL	mMol/L	2.098	1.295	.0000	6.061	68	17
TRIGLYCERIDE	mMol/L	.5424	.2486	.1921	1.096	34	12
CREATINE PHOSPHOKINASE	U/L	375	303	13	1884	45	13
LACTATE DEHYDROGENASE	U/L	843	527	246	2778	33	13
ALKALINE PHOSPHATASE	U/L	171	73	60	411	99	17
ALANINE AMINOTRANSFERASE	U/L	7	7	0	26	38	11
ASPARTATE AMINOTRANSFERASE	U/L	21	9	10	80	97	15
GAMMA GLUTAMYLTRANSFERASE	U/L	13	6	5	29	37	10
AMYLASE	U/L	277.1	206.8	68.64	609.8	9	5
TOTAL PROTEIN (COLORIMETRY)	g/L	76	9	62	96	88	17
GLOBULIN (COLORIMETRY)	g/L	44	7	31	59	81	16
ALBUMIN (COLORIMETRY)	g/L	31	6	17	44	82	17
FIBRINOGEN	g/L	2.160	.8100	.0000	4.500	39	8
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	14	0	14	14	1	1
ALBUMIN (ELECTROPHORESIS)	g/L	40	0	40	40	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.000	0.009	0.009	1	1
TESTOSTERONE	nMol/L	8.002	7.072	2.082	29.15	15	1
PROGESTERONE	nMol/L	1.113	.0000	1.113	1.113	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, females only, ages: > 30 years. Sample results submitted by 43 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.21	2.774	4.000	24.20	1311	78
RED BLOOD CELL COUNT	*10^12/L	3.19	0.48	1.83	5.49	1088	76
HEMOGLOBIN	g/L	138	17	77	261	1137	76
HEMATOCRIT	L/L	0.395	0.048	0.266	0.560	1653	83
MCV	fL	124.9	9.6	91.1	191.3	1067	75
MCH	pg/cell	43.6	3.9	31.4	81.6	1065	73
MCHC	g/L	349	23	239	579	1112	76
PLATELET COUNT	*10^12/L	.3500	.1810	.0250	1.380	223	31
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	1	177	26
RETICULOCYTES	%	0.0	0.0	0.0	0.0	5	3
SEGMENTED NEUTROPHILS	*10^9/L	3.266	1.439	0.000	11.90	1082	71
LYMPHOCYTES	*10^9/L	4.719	2.406	0.022	17.40	1111	71
MONOCYTES	*10^9/L	1.837	1.751	0.000	9.480	1024	68
EOSINOPHILS	*10^9/L	0.220	0.238	0.000	2.288	705	60
BASOPHILS	*10^9/L	0.135	0.125	0.000	0.888	129	33
NEUTROPHILIC BANDS	*10^9/L	0.657	0.702	0.000	6.530	362	52
ERYTHROCYTE SEDIMENTATION RATE		66	18	22	106	52	2
CALCIUM	mMol/L	2.75	0.15	2.03	3.70	1160	78
PHOSPHORUS	mMol/L	1.55	0.29	0.90	2.58	935	78
SODIUM	mMol/L	129	4	112	182	1015	77
POTASSIUM	mMol/L	4.8	0.5	3.6	8.0	1024	76
CHLORIDE	mMol/L	88	4	71	129	988	74
BICARBONATE	mMol/L	26.2	3.3	21.0	36.0	58	13
CARBON DIOXIDE	mMol/L	25.6	4.1	10.0	61.4	311	39
OSMOLARITY	Osmol/L	.2580	.0060	.2430	.2720	122	9
IRON	µMol/L	13.96	7.339	1.432	31.15	54	22
MAGNESIUM	mMol/L	0.913	0.193	0.399	1.440	87	27
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	.0000	7.497	1155	77
CREATININE	µMol/L	124	27	35	398	1154	78
URIC ACID	mMol/L	0.012	0.024	0.000	0.303	304	39
TOTAL BILIRUBIN	µMol/L	3	2	0	17	937	76
DIRECT BILIRUBIN	µMol/L	2	2	0	5	140	39
INDIRECT BILIRUBIN	µMol/L	3	2	0	15	139	39
GLUCOSE	mMol/L	4.773	.8325	2.109	9.935	1169	77
CHOLESTEROL	mMol/L	1.761	.3885	.0000	4.274	982	74
TRIGLYCERIDE	mMol/L	.6328	.2712	.0000	1.910	775	55
CREATINE PHOSPHOKINASE	U/L	242	159	69	1263	292	62
LACTATE DEHYDROGENASE	U/L	960	577	157	4306	686	54
ALKALINE PHOSPHATASE	U/L	121	52	32	364	1135	75
ALANINE AMINOTRANSFERASE	U/L	6	5	0	26	531	66
ASPARTATE AMINOTRANSFERASE	U/L	23	10	5	93	1142	77
GAMMA GLUTAMYLTRANSFERASE	U/L	12	5	0	29	405	53
AMYLASE	U/L	466.2	291.4	.0000	1465	269	41
LIPASE	U/L	3.058	3.614	.0000	20.29	60	15
TOTAL PROTEIN (COLORIMETRY)	g/L	78	6	60	98	775	74
GLOBULIN (COLORIMETRY)	g/L	46	10	24	82	656	74
ALBUMIN (COLORIMETRY)	g/L	33	6	17	52	662	74
FIBRINOGEN	g/L	2.270	1.100	.0000	5.080	124	26
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	17	5	7	25	10	8
ALBUMIN (ELECTROPHORESIS)	g/L	41	3	36	45	10	8
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.006	0.002	0.002	0.008	7	6
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.010	0.003	0.008	0.016	7	6
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.004	0.006	0.017	6	5
TESTOSTERONE	nMol/L	6.246	0.000	6.246	6.246	1	1
PROGESTERONE	nMol/L	4.570	6.707	0.002	31.96	372	12
TOTAL THYROXINE	nMol/L	115	12	106	123	2	2
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1
TOCOPHEROL, GAMMA	nMol/L	.0000	.0000	.0000	.0000	1	1
Body Temperature:	°C	39.0	0.0	39.0	39.0	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, both sexes combined, ages: > 30 years. Sample results submitted by 46 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.25	2.765	4.000	24.20	1439	93
RED BLOOD CELL COUNT	*10^12/L	3.18	0.48	1.83	5.40	1204	93
HEMOGLOBIN	g/L	137	18	77	261	1257	93
HEMATOCRIT	L/L	0.394	0.048	0.260	0.560	1860	101
MCV	fL	124.6	9.7	91.1	191.3	1182	92
MCH	pg/cell	43.4	3.9	31.4	81.6	1180	90
MCHC	g/L	349	23	239	579	1229	93
PLATELET COUNT	*10^12/L	.3440	.1780	.0250	1.380	253	36
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	3	184	30
RETICULOCYTES	%	0.0	0.0	0.0	0.0	5	3
SEGMENTED NEUTROPHILS	*10^9/L	3.335	1.495	0.000	11.90	1196	84
LYMPHOCYTES	*10^9/L	4.706	2.445	0.022	17.40	1227	84
MONOCYTES	*10^9/L	1.875	1.755	0.000	9.480	1119	81
EOSINOPHILS	*10^9/L	0.216	0.219	0.000	2.091	777	69
BASOPHILS	*10^9/L	0.133	0.121	0.000	0.888	142	37
NEUTROPHILIC BANDS	*10^9/L	0.658	0.710	0.000	6.530	380	60
ERYTHROCYTE SEDIMENTATION RATE		62	19	22	106	66	2
CALCIUM	mMol/L	2.75	0.18	2.03	4.20	1263	95
PHOSPHORUS	mMol/L	1.55	0.29	0.90	2.58	1003	95
SODIUM	mMol/L	129	4	107	182	1105	90
POTASSIUM	mMol/L	4.8	0.6	3.0	9.7	1119	90
CHLORIDE	mMol/L	87	4	67	129	1080	88
BICARBONATE	mMol/L	25.9	3.4	20.0	36.0	64	14
CARBON DIOXIDE	mMol/L	25.6	4.0	10.0	61.4	345	46
OSMOLARITY	Osmol/L	.2580	.0060	.2430	.2720	152	11
IRON	µMol/L	14.14	7.160	1.432	31.15	59	26
MAGNESIUM	mMol/L	0.893	0.222	0.337	1.440	95	34
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	.0000	7.854	1258	96
CREATININE	µMol/L	124	35	35	398	1258	96
URIC ACID	mMol/L	0.012	0.024	0.000	0.303	321	47
TOTAL BILIRUBIN	µMol/L	3	2	0	17	1030	93
DIRECT BILIRUBIN	µMol/L	2	2	0	5	167	46
INDIRECT BILIRUBIN	µMol/L	2	2	0	15	164	46
GLUCOSE	mMol/L	4.718	.8325	.0000	7.548	1266	94
CHOLESTEROL	mMol/L	1.787	.4921	.0000	6.061	1052	90
TRIGLYCERIDE	mMol/L	.6328	.2712	.0000	1.910	809	64
CREATINE PHOSPHOKINASE	U/L	260	189	25	1884	338	74
LACTATE DEHYDROGENASE	U/L	954	575	157	4306	720	67
ALKALINE PHOSPHATASE	U/L	125	55	32	411	1235	90
ALANINE AMINOTRANSFERASE	U/L	6	5	0	26	571	77
ASPARTATE AMINOTRANSFERASE	U/L	23	10	5	93	1241	92
GAMMA GLUTAMYLTRANSFERASE	U/L	12	5	0	29	444	63
AMYLASE	U/L	460.1	290.6	.0000	1465	278	45
LIPASE	U/L	3.058	3.614	.0000	20.29	60	15
TOTAL PROTEIN (COLORIMETRY)	g/L	77	6	58	98	865	90
GLOBULIN (COLORIMETRY)	g/L	46	10	24	82	739	89
ALBUMIN (COLORIMETRY)	g/L	33	6	17	52	746	90
FIBRINOGEN	g/L	2.250	1.040	.0000	5.080	165	33
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	17	4	7	25	11	8
ALBUMIN (ELECTROPHORESIS)	g/L	41	3	36	45	11	8
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.006	0.002	0.002	0.008	7	6
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.010	0.003	0.008	0.016	7	6
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.004	0.006	0.017	7	5
TESTOSTERONE	nMol/L	7.891	6.846	2.082	29.15	16	2
PROGESTERONE	nMol/L	4.560	6.697	0.002	31.96	373	13
TOTAL THYROXINE	nMol/L	115	12	106	123	2	2
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1
TOCOPHEROL, GAMMA	nMol/L	.0000	.0000	.0000	.0000	1	1
Body Temperature:	°C	39.0	0.0	39.0	39.0	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, males only, all ages combined. Sample results submitted by 17 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	11.45	2.692	5.600	19.30	214	21
RED BLOOD CELL COUNT	*10^12/L	3.09	0.44	2.05	5.16	205	24
HEMOGLOBIN	g/L	128	14	89	185	205	24
HEMATOCRIT	L/L	0.382	0.045	0.279	0.526	292	25
MCV	fL	122.9	9.0	93.8	141.6	201	24
MCH	pg/cell	41.9	3.0	35.7	51.4	200	24
MCHC	g/L	341	21	258	457	200	24
PLATELET COUNT	*10^12/L	.4390	.2570	.1770	1.300	56	9
NUCLEATED RED BLOOD CELLS	/100 WBC	2	6	0	17	8	6
SEGMENTED NEUTROPHILS	*10^9/L	4.235	1.780	1.260	10.80	202	21
LYMPHOCYTES	*10^9/L	5.055	2.581	0.456	11.60	205	21
MONOCYTES	*10^9/L	1.821	1.682	0.000	8.058	173	21
EOSINOPHILS	*10^9/L	0.238	0.189	0.000	1.269	140	17
BASOPHILS	*10^9/L	0.143	0.111	0.000	0.525	33	7
NEUTROPHILIC BANDS	*10^9/L	1.218	0.964	0.070	3.910	74	12
ERYTHROCYTE SEDIMENTATION RATE		44	12	17	70	15	1
CALCIUM	mMol/L	2.73	0.28	2.18	4.45	179	24
PHOSPHORUS	mMol/L	1.65	0.32	0.84	2.65	143	24
SODIUM	mMol/L	127	6	107	159	164	21
POTASSIUM	mMol/L	4.8	0.9	3.0	11.6	165	21
CHLORIDE	mMol/L	86	4	73	99	164	21
BICARBONATE	mMol/L	21.9	4.7	13.0	28.0	7	1
CARBON DIOXIDE	mMol/L	26.0	3.4	17.0	33.4	50	12
OSMOLARITY	Osmol/L	.2560	.0050	.2430	.2680	44	6
IRON	µMol/L	11.64	7.339	.5370	23.27	7	6
MAGNESIUM	mMol/L	2.057	4.542	0.304	15.72	11	7
BLOOD UREA NITROGEN	mMol/L	3.570	1.785	.7140	15.71	180	25
CREATININE	µMol/L	159	62	71	513	177	25
URIC ACID	mMol/L	0.018	0.012	0.000	0.060	65	12
TOTAL BILIRUBIN	µMol/L	3	3	0	17	165	24
DIRECT BILIRUBIN	µMol/L	2	2	0	5	38	9
INDIRECT BILIRUBIN	µMol/L	3	3	0	15	36	9
GLUCOSE	mMol/L	4.385	.9435	.0000	7.160	175	23
CHOLESTEROL	mMol/L	1.968	.7252	.0000	5.076	138	23
TRIGLYCERIDE	mMol/L	.4972	.2147	.1921	1.141	95	17
CREATINE PHOSPHOKINASE	U/L	319	262	13	1884	68	18
LACTATE DEHYDROGENASE	U/L	698	476	246	2778	94	17
ALKALINE PHOSPHATASE	U/L	176	65	60	411	173	23
ALANINE AMINOTRANSFERASE	U/L	7	7	0	26	59	16
ASPARTATE AMINOTRANSFERASE	U/L	20	9	7	80	173	21
GAMMA GLUTAMYLTRANSFERASE	U/L	12	6	0	29	57	14
AMYLASE	U/L	307.1	301.6	68.64	1380	21	9
LIPASE	U/L	1.112	.5560	.2780	1.668	5	2
TOTAL PROTEIN (COLORIMETRY)	g/L	77	8	62	96	119	23
GLOBULIN (COLORIMETRY)	g/L	44	7	31	59	111	22
ALBUMIN (COLORIMETRY)	g/L	33	6	17	55	112	23
FIBRINOGEN	g/L	2.070	.9100	.0000	4.500	51	10
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	14	2	12	17	3	3
ALBUMIN (ELECTROPHORESIS)	g/L	43	5	40	49	3	3
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.000	0.008	0.008	1	1
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.011	0.000	0.011	0.011	1	1
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.000	0.009	0.009	2	2
CORTISOL	nMol/L	99	97	14	246	8	1
TESTOSTERONE	nMol/L	9.737	11.33	0.763	44.76	17	3
PROGESTERONE	nMol/L	1.113	.0000	1.113	1.113	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, females only, all ages combined. Sample results submitted by 46 member institutions.

Reference Ranges for Physiological Data Values

Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.34	2.606	4.230	24.20	1817	98
RED BLOOD CELL COUNT	*10^12/L	3.14	0.43	1.88	5.10	1632	94
HEMOGLOBIN	g/L	136	16	70	261	1687	94
HEMATOCRIT	L/L	0.393	0.046	0.266	0.560	2235	103
MCV	fL	125.9	8.8	83.3	190.0	1613	93
MCH	pg/cell	43.8	3.3	26.7	66.8	1602	91
MCHC	g/L	348	21	184	579	1659	94
PLATELET COUNT	*10^12/L	.3610	.1960	.0250	1.380	291	40
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	1	187	29
RETICULOCYTES	%	0.0	0.0	0.0	0.0	12	6
SEGMENTED NEUTROPHILS	*10^9/L	3.132	1.516	0.000	11.90	1422	87
LYMPHOCYTES	*10^9/L	4.848	2.383	0.022	17.40	1458	89
MONOCYTES	*10^9/L	1.817	1.776	0.000	9.480	1327	85
EOSINOPHILS	*10^9/L	0.250	0.289	0.000	2.898	953	75
BASOPHILS	*10^9/L	0.136	0.114	0.000	0.888	184	37
NEUTROPHILIC BANDS	*10^9/L	0.839	0.803	0.000	7.840	571	62
ERYTHROCYTE SEDIMENTATION RATE		66	18	22	106	52	2
CALCIUM	mMol/L	2.75	0.15	2.03	3.83	1624	96
PHOSPHORUS	mMol/L	1.55	0.26	0.87	2.58	1399	96
SODIUM	mMol/L	129	4	111	182	1469	93
POTASSIUM	mMol/L	4.7	0.5	3.6	7.6	1481	92
CHLORIDE	mMol/L	88	3	71	129	1432	90
BICARBONATE	mMol/L	26.2	3.3	21.0	36.0	58	13
CARBON DIOXIDE	mMol/L	25.9	3.9	10.0	61.4	384	46
OSMOLARITY	Osmol/L	.2580	.0060	.2430	.2720	149	12
IRON	µMol/L	13.96	7.339	1.432	31.15	54	22
MAGNESIUM	mMol/L	0.782	0.313	0.267	1.728	127	37
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	.0000	6.783	1618	95
CREATININE	µMol/L	124	27	0	398	1620	96
URIC ACID	mMol/L	0.012	0.024	0.000	0.303	424	47
TOTAL BILIRUBIN	µMol/L	3	2	0	17	1323	94
DIRECT BILIRUBIN	µMol/L	2	2	0	5	151	45
INDIRECT BILIRUBIN	µMol/L	3	2	0	15	150	45
GLUCOSE	mMol/L	4.718	.7770	2.276	8.880	1631	95
CHOLESTEROL	mMol/L	1.684	.4144	.0000	4.274	1443	92
TRIGLYCERIDE	mMol/L	.7345	.3390	.0000	2.023	1203	66
CREATINE PHOSPHOKINASE	U/L	235	153	25	1263	338	70
LACTATE DEHYDROGENASE	U/L	1036	563	157	4306	1087	65
ALKALINE PHOSPHATASE	U/L	120	53	32	385	1586	92
ALANINE AMINOTRANSFERASE	U/L	6	6	0	32	647	84
ASPARTATE AMINOTRANSFERASE	U/L	23	10	5	93	1594	93
GAMMA GLUTAMYLTRANSFERASE	U/L	12	5	0	34	502	67
AMYLASE	U/L	465.3	261.0	.0000	1365	345	49
LIPASE	U/L	2.780	3.614	.0000	20.29	92	19
TOTAL PROTEIN (COLORIMETRY)	g/L	77	6	54	105	902	90
GLOBULIN (COLORIMETRY)	g/L	46	9	24	82	781	90
ALBUMIN (COLORIMETRY)	g/L	33	6	18	52	790	91
FIBRINOGEN	g/L	2.280	1.120	.0000	5.080	131	30
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	17	4	7	25	13	10
ALBUMIN (ELECTROPHORESIS)	g/L	41	3	36	45	13	10
ALPHA GLOBULIN (ELECTROPHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.006	0.002	0.002	0.008	7	6
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.010	0.003	0.008	0.016	7	6
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.009	0.004	0.004	0.017	9	7
TESTOSTERONE	nMol/L	6.246	0.000	6.246	6.246	1	1
PROGESTERONE	nMol/L	3.387	6.106	0.002	31.96	502	16
TOTAL TRIIODOTHYRONINE	nMol/L	3.219	0.000	3.219	3.219	1	1
TOTAL THYROXINE	nMol/L	106	17	89	123	3	3
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1
TOCOPHEROL, GAMMA	nMol/L	.0000	.0000	.0000	.0000	1	1
Body Temperature:	℃	39.0	0.0	39.0	39.0	1	1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Average weights calculated for, *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, females only. Weights submitted by ISIS member institutions.

		Reference Ranges for Physiological Data Values					
Age Grouping	**Units**	**Mean**	**St. Dev.**	**Minimum Value**	**Maximum Value**	**Sample Size[a]**	**Animals[b]**
1.8–2.2 years	Kg	379.2	70.2	264.5	456.8	10	3
2.7–3.3 years	Kg	545.5	119.3	382.7	690.0	12	3
4.5–5.5 years	Kg	1001	163	569.7	1186	17	5
9.5–10.5 years	Kg	2225	337	1718	2955	14	10
14.5–15.5 years	Kg	2790	484	1882	3886	46	17
19.0–21.0 years	Kg	3519	275	2455	4014	48	16

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Average weights calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, males only. Weights submitted by ISIS member institutions.

		Reference Ranges for Physiological Data Values					
Age Grouping	**Units**	**Mean**	**St. Dev.**	**Minimum Value**	**Maximum Value**	**Sample Size[a]**	**Animals[b]**
9.5–10.5 years	Kg	2903	151	2670	3015		5 1

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Average weights calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, both sexes combined. Weights submitted by ISIS member institutions.

		Reference Ranges for Physiological Data Values					
Age Grouping	**Units**	**Mean**	**St. Dev.**	**Minimum Value**	**Maximum Value**	**Sample Size[a]**	**Animals[b]**
1.8–2.2 years	Kg	379.2	70.2	264.5	456.8	10	3
2.7–3.3 years	Kg	545.5	119.3	382.7	690.0	12	3
4.5–5.5 years	Kg	1001	163	569.7	1186	17	5
9.5–10.5 years	Kg	2403	426	1718	3015	19	11
14.5–15.5 years	Kg	2790	484	1882	3886	46	17
19.0–21.0 years	Kg	3491	370	2269	4136	52	20

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Physiological reference ranges calculated for *LOXODONTA AFRICANA*, AFRICAN ELEPHANT, both sexes combined, all ages combined. Sample results submitted by 49 member institutions.

Test	Units	Reference Ranges for Physiological Data Values: Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
WHITE BLOOD CELL COUNT	*10^9/L	10.45	2.641	4.200	24.20	2036	118
RED BLOOD CELL COUNT	*10^12/L	3.13	0.44	1.83	5.20	1842	116
HEMOGLOBIN	g/L	136	16	70	261	1896	116
HEMATOCRIT	L/L	0.392	0.046	0.266	0.560	2530	126
MCV	fL	125.7	9.1	83.3	191.3	1817	115
MCH	pg/cell	43.6	3.5	26.7	81.6	1809	113
MCHC	g/L	347	21	184	579	1862	116
PLATELET COUNT	*10^12/L	.3730	.2080	.0250	1.380	347	48
NUCLEATED RED BLOOD CELLS	/100 WBC	0	0	0	3	197	35
RETICULOCYTES	%	0.0	0.0	0.0	0.0	12	6
SEGMENTED NEUTROPHILS	*10^9/L	3.268	1.592	0.000	11.90	1626	105
LYMPHOCYTES	*10^9/L	4.869	2.410	0.022	17.40	1665	107
MONOCYTES	*10^9/L	1.815	1.764	0.000	9.480	1502	103
EOSINOPHILS	*10^9/L	0.248	0.278	0.000	2.898	1095	89
BASOPHILS	*10^9/L	0.137	0.113	0.000	0.888	217	43
NEUTROPHILIC BANDS	*10^9/L	0.882	0.831	0.000	7.840	645	74
ERYTHROCYTE SEDIMENTATION RATE		62	19	22	106	66	2
CALCIUM	mMol/L	2.75	0.15	2.03	3.93	1804	119
PHOSPHORUS	mMol/L	1.58	0.26	0.84	2.65	1544	119
SODIUM	mMol/L	129	4	107	182	1634	112
POTASSIUM	mMol/L	4.8	0.5	3.0	8.9	1650	112
CHLORIDE	mMol/L	87	4	67	129	1600	110
BICARBONATE	mMol/L	25.7	3.7	13.0	36.0	65	14
CARBON DIOXIDE	mMol/L	25.9	3.9	10.0	61.4	435	57
OSMOLARITY	Osmol/L	.2580	.0060	.2430	.2720	193	17
IRON	µMol/L	13.96	7.160	1.432	31.15	60	27
MAGNESIUM	mMol/L	0.773	0.317	0.267	1.728	137	43
BLOOD UREA NITROGEN	mMol/L	3.570	1.071	.0000	7.854	1798	119
CREATININE	µMol/L	124	35	0	972	1802	120
URIC ACID	mMol/L	0.012	0.024	0.000	0.303	491	58
TOTAL BILIRUBIN	µMol/L	3	2	0	17	1490	117
DIRECT BILIRUBIN	µMol/L	2	2	0	5	190	54
INDIRECT BILIRUBIN	µMol/L	3	2	0	15	187	54
GLUCOSE	mMol/L	4.662	.7770	.0000	7.271	1802	117
CHOLESTEROL	mMol/L	1.735	.4921	.0000	6.061	1587	114
TRIGLYCERIDE	mMol/L	.7232	.3390	.0000	2.023	1298	80
CREATINE PHOSPHOKINASE	U/L	249	178	25	1884	406	87
LACTATE DEHYDROGENASE	U/L	1009	564	157	4306	1182	82
ALKALINE PHOSPHATASE	U/L	126	59	32	441	1765	113
ALANINE AMINOTRANSFERASE	U/L	6	6	0	32	708	100
ASPARTATE AMINOTRANSFERASE	U/L	23	10	5	90	1768	114
GAMMA GLUTAMYLTRANSFERASE	U/L	12	5	0	34	560	81
AMYLASE	U/L	456.2	265.7	.0000	1380	366	57
LIPASE	U/L	2.780	3.336	.0000	20.29	97	21
TOTAL PROTEIN (COLORIMETRY)	g/L	77	6	54	105	1030	112
GLOBULIN (COLORIMETRY)	g/L	46	9	24	82	901	111

continued next page

Physiological reference ranges calculated for *LOXODONTA AFRICANA,* AFRICAN ELEPHANT, both sexes combined, all ages combined. Sample results submitted by 49 member institutions.

		Reference Ranges for Physiological Data Values						
Test		**Units**	**Mean**	**St. Dev.**	**Minimum Value**	**Maximum Value**	**Sample Size[a]**	**Animals[b]**
ALBUMIN (COLORIMETRY)	g/L	33	6	17	55	911	113	
FIBRINOGEN	g/L	2.230	1.070	.0000	5.080	184	38	
GAMMA GLOBULIN (ELECTRO-PHORESIS)	g/L	17	4	7	25	16	12	
ALBUMIN (ELECTRO-PHORESIS)	g/L	41	3	36	49	16	12	
ALPHA GLOBULIN (ELECTRO-PHORESIS)	g/L	0.007	0.000	0.007	0.007	1	1	
ALPHA-1 GLOBULIN (ELECTRO-PHORESIS)	g/L	0.007	0.002	0.002	0.008	8	7	
ALPHA-2 GLOBULIN (ELECTRO-PHORESIS)	g/L	0.010	0.003	0.008	0.016	8	7	
BETA GLOBULIN (ELECTRO-PHORESIS)	g/L	0.009	0.003	0.004	0.017	11	8	
CORTISOL	nMol/L	99	97	14	246	8	1	
TESTOSTERONE	nMol/L	9.546	11.02	0.763	44.76	18	4	
PROGESTERONE	nMol/L	3.384	6.102	0.002	31.96	503	17	
TOTAL TRIIODO-THYRONINE	nMol/L	3.219	0.000	3.219	3.219	1	1	
TOTAL THYROXINE	nMol/L	106	17	89	123	3	3	
TOCOPHEROL	nMol/L	.0000	.0000	.0000	.0000	1	1	
TOCOPHEROL, GAMMA	nMol/L	.0000	.0000	.0000	.0000	1	1	
Body Temperature:	°C	39.0	0.0	39.0	39.0	1	1	

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Nutrition

Although elephants have been in human care for centuries, and numerous publications document the natural history and feeding behaviors of elephants, surprisingly little is known concerning actual nutrient requirements or nutritional physiology. Anatomically, elephant digestive tracts are similar to those of horses, with an enlarged colon that allows microbial fermentation of fibrous diets. Captive digestion trials as well as field work have revealed that elephants have fermentation processes similar to other herbivorous species, although elephants exhibit a slower rate of end product production.

A rapid gut transit time has been recorded in elephants, ranging from 21 to 54.5 hours in captive Asian and 21.4 to 46 hours in captive African elephants fed forage-based diets (Benedict 1936; Laws et al. 1975; Rees 1982). This difference in rates may indicate species-specific differences in tissue metabolism of volatile fatty acids. Low apparent diet digestibility overall and high fiber profiles of many of the plant species eaten by elephants dictate the large amounts of vegetation needed by the elephant to meet nutritional requirements.

Elephants in general display low diet digestibilities compared with other herbivores fed similar diets. Dry matter digestibility ranges from 22 to 39 percent in captive African elephants fed grass hays to up to 62 percent when fed alfalfa hay. Asian elephants display a generally higher diet digestibility, 36–53% when fed grass hay and 60% when fed alfalfa. Field studies using lignin ratio as an internal marker suggested average dry matter digestibility of 30 to 45 percent for free-ranging African elephants, and up to 70 to 80 percent for Asian elephants fed fresh palm leaves. While fresh, forage-based diets appear to be more digestible than dry, hay-based diets, overall digestibility (Dierenfeld 1994) probably does not exceed 50 percent for African elephants and 70 percent for Asian elephants. Highly digestible diets are clearly not necessary for adult maintenance and may not be physiologically optimal.

Few controlled experiments have been conducted with elephants to determine their nutritional requirements. Field observations on food intake and analyses of plant material eaten provide some guidance to nutrient concentrations, but minimal or optimal intakes cannot be determined from such data. In the absence of research data with elephants, minimum requirements have been estimated based largely on extrapolation from published nutrient requirements of horses (Table 1), which are considered the most suitable nutritional model for elephants. Until further information is obtained, the National Research Council (NRC 1989) recommendations for diet formulation should be considered the basis of ration formulation for elephants at differing physiological stages.

Jill Sampson

Elephants are described as generalized feeders, selecting from more than 400 different plant species.

Asian Elephant Condition Score (by Liz Hile)

Score	Description
1 (Poor/Emaciated)	Skin tight over ribs, spinous process sharp, muscling either side of spine absent, angular pelvis, skin tight over pelvis
2 (Thin)	Ribs and spinous process easily visible, slight muscling either side of spine, pelvis visible
3 (Good)	Ribs covered, spinous process visible with good muscling either side, pelvis outline rounded
4 (Fat)	Ribs well covered, slight spinous process, pelvis barely visible and covered by soft fat
5 (Obese)	Ribs and pelvis buried, back broad and flat

As shown in Table 1, nutrient requirements are determined in part by the elephant's age and condition. For example, young growing elephants and lactating cows require diets containing more crude protein (CP; 10 percent 15 percent, dry matter basis) and should be fed higher quality diets than mature elephants (8 percent CP). Note: the need for increased nutrition during pregnancy may not be indicated in our elephants in North America. Overfeeding should be avoided. Additionally, the young and reproducing elephants may require somewhat higher levels of fat-soluble vitamins (A, D, and E), calcium, phosphorus, and perhaps potassium. Essentially nothing is known of nutrient requirements for minerals and water-soluble vitamins or differences in requirements based on physiological stage.

Obesity is a problem in captive zoo elephants, linked to the consumption of diets which are overly digestible combined with a lack of physical activity. A recent publication (Taylor and Poole 1998) suggested a high incidence of obesity in captive elephants in western zoos, which may contribute to poor reproductive output. Obesity may also be a contributing factor to a poor reproductive performance on the part of both the male and female. Additionally, obesity is believed by many to be a contributing factor to long labors, dystocias, stillbirths, and ultimately the death of the calf and dam. Conversely animals in good physical condition, not carrying excess weight and exercised frequently are reported to have very short labors and easy deliveries.

Table 1. Proposed minimum nutrient concentrations (DM basis) in elephant diets based largely on extrapolation from nutrient requirements of horses (NRC 1989).

Nutrient	Maintenance, breeding, early pregnancy	Late pregnancy	Lactation	Growth of juveniles
Crude protein, %	8–10[a]	12	12–14[b]	12–14[c]
Lysine, %	0.3	0.4	0.4–0.5	0.5–0.6
Calcium, %	0.3	0.5	0.5	0.5–0.7
Phosphorus, %	0.2	0.3	0.3	0.3–0.4
Magnesium, %	0.1	0.1	0.1	0.1
Potassium, %	0.4	0.4	0.5	0.4
Sodium, %	0.1	0.1	0.1	0.1
Sulfur, %	0.15	0.15	0.15	0.15
Iron, ppm	50	50	50	50
Copper, ppm	10	10	10	10
Manganese, ppm	40	40	40	40
Zinc, ppm	40	40	40	40
Cobalt, ppm	0.1	0.1	0.1	0.1
Iodine, ppm	0.6	0.6	0.6	0.6
Selenium, ppm	0.2	0.2	0.2	0.2
Vitamin A, IU/kg	3,000	3,000	3,000	3,000
Vitamin D, IU/kg	800	800	800	800
Vitamin E, IU/kg	100	100	100	100
Thiamin, ppm	3	3	3	3
Riboflavin, ppm	3	3	3	3

[a]Adult maintenance, 8 percent CP; breeding bull, pregnant cow (first two-thirds of pregnancy), 10% CP
[b]First yr of lactation, 14 percent CP; second year of lactation, 12 percent CP.
[C]weanling, 14 percent CP; 3-year-old, 13 percent CP; 4-year-old to 12-year-old, 12 percent CP.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "High quality and nutritionally correct food must be provided in sufficient quantities to maintain animal health and appropriate weight. Hay and grain should be formulated to provide a complete diet as recommended by the Elephant SSP Nutrition Advisor."

Adequacy of energy intake can best be determined by monitoring the elephant and adjusting feed intake accordingly. Regular weighing and recording of body mass are valuable tools. But if scales are not available, body measurements such as heart girth can provide useful estimates of body weight (Hile et al. 1997; see p. 215). Standardized body condition indexes should be implemented into elephant captive management programs as a tool for evaluating body condition and the elephant's response to dietary husbandry.

Adult captive elephants consume anywhere from 1.2 to 1.9 percent of their body mass in dry matter on a daily basis (Hackenberger 1987; Roehrs et al. 1989). That translates into about 52 kilograms of food for a 3,500-kilogram elephant (or 115 pounds for a 7,700-pound elephant). Thus, expected intake for adults can be calculated based on body weight, ranging somewhere between 100 and 200 pounds of food per day, with individual elephant variations depending on activity levels; the more active, the higher the intake. Growing elephants eat more, 2 to 2.6 percent of body weight in dry matter daily. In general, hay comprises the bulk of a captive elephant's food, with browse, produce, and supplements making up the remainder.

Surveys show that most facilities use a grass hay, primarily timothy hay (orchard, sudan, bermuda, and other grasses are fed as well depending on geographic location) as the basis of the elephant's diet. A number of facilities feed some quantity of alfalfa hay, usually as a supplement or a treat item. Hay is fed (and consumed) by the elephant at approximately 40 to 88 percent of its diet. Those elephants at the lower consumption range are offered more browse. The nutrient analysis of a bale of grass hay fed to an elephant averages 7 percent crude protein (CP; range 5.5 to 12 percent), 68 percent neutral detergent fiber (NDF; range 47 to 72 percent), and 41 percent acid detergent fiber (ADF; range 40 to 47 percent).

Although hays should be the foundation of the feeding program, they may not supply adequate energy, protein, minerals, and vitamins in all situations. The steps for evaluating diet quality in feeding elephants are:

- Use grass hay or a mixture and legume hays, of known composition, as the base for elephant diets. The hay should be of good quality, not dusty or moldy, and must be toxin free.
- Analyze hays for dry matter, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, calcium, and phosphorus in a laboratory with demonstrated expertise. A regular hay analysis and record-keeping program should be initiated, with sampling protocols as recommended by the analytical laboratory. Contacting local university agricultural extension services with local guidelines for quality evaluation already established and available may be the

Table 2. Formulas for ADF16, ADF25, and Herbivore Supplement (percentage by weight).[a] Ulrey et al. (1997).

Ingredient	ADF16	ADF25	Herbivore Supplement
Alfalfa meal, dehydrated (17% CP)	31.9	59.7	20.0
Wheat middlings	29.8	31.6	36.3
Corn grain	19.0	—	—
Soybean meal, dehulled, solvent extr. (48% CP)	11.0	—	30.0
Cane molasses	5.0	5.0	5.0
Soybean oil	1.0	1.0	2.0
Mono-dicalcium phosphate (16% Ca, 21% P)	1.0	—	2.0
Sodium tripolyphosphate (31% Na, 25% P)	—	1.5	—
Calcium carbonate (38% Ca)	—	—	0.8
Salt	0.6	0.5	2.0
Trace mineral premix[b]	0.1	0.1	0.3
Vitamin premix[c]	0.4	0.4	1.2
Choline Cl premix (60% choline)	0.1	0.1	0.3
Mold inhibitor (50% propionic acid on verxite)[d]	0.1	0.1	0.1
	100.0	100.0	100.0

[a]These designations do not refer to particular commercial feeds, and manufactured products that have been given these names may or may not have the same formulas and specifications.
[b]Contains per kg: 50 g Fe, 10 g Cu, 45 g Mn, 90 g Zn, 0.1 g Co, 0.8 g I, and 0.2 g Se
[c]Contains per kg: 1 g riboflavin, 5 g pantothenic acid, 10 g niacin, 5 mg vitamin B_{12}, 1,250,000 IU vitamin A, 300,000 IU vitamin D_3, and 75,000 IU vitamin E
[d]MonoProp®, Anitox Corp., Buford, GA

Nutrient analysis of Fort Worth Zoo elephant diet compared to Fort Worth Zoo target range on a dry matter basis. Fort Worth Zoo diet on an as fed basis is 10 percent elephant supplement (pelleted feed), 85 percent grass hay (coastal Bermuda), 5 percent produce (apples, carrots, potatoes, bagels). By weight this is approximately 11 pounds of elephant supplement, 90 pounds of coastal Bermuda hay, 5 pounds of produce.

Nutrient	Level in the diet	Fort Worth Zoo target range Maintenance*
Crude Protein, %	10	10–12
Neutral detergent fiber, %	69	65
Vitamin A, IU/g	3.2	2.0
Vitamin E, mg/kg	130	130
Vitamin D3, IU/g	0.48	0.30
Thiamin, mg/kg	7.2	3.0
Riboflavin, mg/kg	2.4	2.0
Calcium, %	0.40	0.24
Phosphorus, %	0.16	0.17
Magnesium, %	0.17	0.09
Potassium, %	1.4	0.30
Sodium, %	0.17	0.10
Iron, mg/kg	99	40
Zinc, mg/kg	51	40
Copper, mg/kg	13	10
Manganese, mg/kg	91	40
Selenium, mg/kg	0.15	0.10
Iodine, mg/kg	0.24	0.1–0.6

*Target range based on nutrient requirements for horses with some adaptation for possible differences in needs for elephants past on free-ranging data and levels supporting health in captivity.

most efficient means of implementing a hay sampling program.

3. Using analyzed and published nutrient concentrations (available in agricultural databases, dietary software programs, or see, for example, AZA Nutrition Advisory (www.nagonline.net) Group Fact Sheet #1, Hay Quality Evaluation) determine the need for supplemental sources of energy, protein, minerals, and vitamins. This comparison is based on the nutrient composition of your available forage, by comparison with nutrient recommendations listed in Table 1.
4. When hay mixtures are not adequate to meet digestible energy, protein, mineral, and vitamin needs, consider adding a formulated pellet, which can be obtained through various zoological feed suppliers.
5. Provide clean water and grass hay in appropriate amounts or ad libitum, and add legume hay and properly formulated grain or herbivore supplements in amounts proportional to estimated need. Note that grass hay to be fed ad libitum should have 30 percent or more ADF to avoid problems with colic.
6. Make all dietary changes gradually (over one to two weeks) to avoid digestive upsets. Observe elephants regularly and conscientiously and record diet consumption daily
7. All elephants should be weighed on a regular basis, at least annually, to monitor their weight gain or loss.

Elephants need adequate fiber to maintain normal digestive function. Too little fiber can lead to rapid changes in microbial populations in the large intestine, which can cause excessive gas production and colic (abdominal pain). Hays provide fiber and therefore are the foundation of most elephant feeding programs. To increase the amount of fiber and add additional nutrients, most facilities feed some amount of browse on a regular basis.

Most facilities offer a pelleted diet made for zoo herbivores which contains between 16 to 17 percent protein and less than 17 percent ADF. Some facilities offer a more specialized "elephant supplement" containing between 24 to 25 percent protein and some facilities feed other types of products such as a horse/cattle feed at 10 percent protein or calf chow at 14 percent protein. The type of supplemental product offered to the elephant should be chosen based upon the nutrient analysis of the hay and the desire to formulate a complete diet.

Feed should be offered on a clean concrete pad or in livestock troughs, bins, or buckets. Sand impaction has been documented repeatedly in elephants, therefore

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "Fresh browse and produce should be used as dietary supplements and enrichment for animals."

Aside from enrichment opportunities, fresh and/or frozen browse may be essential to dietary health. Browse may contribute required nutrients that have not yet been quantified and may also be of benefit to dilute a captive diet that is too digestible. The following list of North American browse species that have been successfully fed to elephants was compiled by the American Zoo Horticulturists. Care must be taken to ensure the browse has not been sprayed with a pesticide or herbicide.

Abies balsamea	Balsam Fir
Acacia albida	Winterthorn
Acacia cyclopsis	Cyclops Acacia
Acacia longifolia	Sydney Golden Wattle
Acacia saligna	Blue Leaf Wattle
Acacia seiberiana 'Woodii'	Paperbark Thorn
Acer negundo	Box Elder
Acer platanoides	Norway Maple
Acer saccharinum	Silver Maple
Acer saccharum	Sugar Maple
Acer sp. (all but *A. rubra*, Red Maple)	Maple
Acmena smithii	Monkey Apple
Alnus glutinosa	Black Alder
Alnus rubra	Red Alder
Amelanchier canadensis	Serviceberry
Amelanchier sp.	Serviceberry
Arundo donax	Giant Reed Grass
Bambusa olhamii	Giant Timber Bamboo
Bambusa ventricosa	Buddha's Belly Bamboo
Betula nigra	River Birch
Betula sp.	Birch
Brachiara mutica	Para Grass
Catalpa speciosa	Northern Catalpa
Celtis laevigata	Sugarberry
Celtis sp.	Hackberry
Cercis canadensis	Eastern Redbud
Cornus sericea	Red-twig Dogwood
Cotoneaster sp.	Cotoneaster
Cucurbita pepo	Pumpkin
Cyathea medullaris	Black Tree Fern
Dendrocalamus giganteus	Giant Bamboo
Fagus grandifolia	American Beech
Ficus benjamina	Weeping Fig
Ficus elastica	Rubber Tree
Ficus lyrata	Fiddle Leaf Fig
Ficus macrophylla	Fig
Ficus nekbudu	Zulu Fig
Ficus nitida	Indian Laurel Fig
Ficus pumila	Creeping Fig
Ficus retusa	Indian Laurel Fig
Ficus rubignosa	Rusty Leaf Fig
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Gleditsia triacanthos inermis	Thornless Honeylocust
Grewia occidentalis	Lavender Star Flower
Hedychium flavescens	Yellow Ginger
Hedychium gardneranum	Kahili Ginger
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Tulip Tree
Lonicera sp.	Honeysuckle
Malus sp.	Crabapple
Meryta sinclairii	Puka
Miscanthus sp.	Maiden Grass
Morus alba	White Mulberry
Morus rubra	Red Mulberry
Morus sp.	Mulberry
Musa sp.	Banana
Musa x *paradisiaca*	Banana
Phoenix canariensis	Phoenix Palm
Phoenix dactylifera	Date Palm
Phyllostachys aurea	Gold Stem Bamboo
Phyllostachys aureosulcata	Yellow-groove Bamboo
Phyllostachys sp.	Bamboo
Pinus palustris	Longleaf Pine
Platanus occidentalis	Sycamore
Populus deltoides	Eastern Cottonwood
Populus sp.	Cottonwood
Populus tremuloides	Quaking Aspen
Populus yunnanensis	Chinese Poplar
Pterocarpus indicus	Burmese Rosewood
Pueraria lobata	Kudzu
Pyrus calleryana	Callery Pear (e.g. Bradford Pear)
Pyrus sp.	Pear
Quercus laurifolia	Laurel Oak
Quercus sp.	Oak
Quercus virginiana	Live Oak
Saccharum officinarum	Sugar Cane
Salix alba	White Willow
Salix discolor	Pussy Willow
Salix nigra	Black Willow
Salix sp.	Willow
Syagrus romanizoffianum	Queen Palm
Terminalia catappa	Indian Almond
Ulmus alata	Winged Elm
Ulmus americana	American Elm
Ulmus parvifolia	Chinese Elm
Ulmus pumila	Siberian Elm
Ulmus rubra	Red Elm
Viburnum sp.	Viburnum
Zea mays	Field Corn

feeding pellets directly on the natural substrate is not recommended (see Husbandry, p. 37). Some institutions feed bran on a regular basis to reduce problems associated with the elephants consuming sand.

Individual feeding stations are recommended and handlers should observe the amount of grain each individual elephant consumes. Trainer observations and feeding practices should reduce competition for food and allow the monitoring of each individual elephant's intake and eagerness to consume the diet offered.

Most facilities offer various produce including fruits, vegetables, and leafy vegetables to their elephants. Bread is also fed on a regular basis. In terms of total intake, produce ranges from 3 to 21 percent of the diet, averaging 10 percent. Manufactured primate biscuits, horse apple treats, and other manufactured animal grains or treat items may

be fed in low quantities as reinforcement.

Supplements are provided at many facilities. These supplements consist of a variety of trace mineral supplements, general vitamin and/or mineral supplements, biotin supplements, and vitamin E—either Emcelle (Stuart Products, Inc., 2541 Stonegate Dr. N., Bedford, TX 76021), TPGS (distributed by Mazuri, P.O. Box 66812, St. Louis, MO 63166), or in one case, additional d,l, a-tocopherol acetate (Rovimix, Hoffmann LaRoche, Inc., Nutley, NJ 07110).

Circulating retinol, as a measure of vitamin A, is normally low in both free-ranging and zoo elephants (< .1 ug/ml; Dierenfeld et al. 1998). Normal concentrations found in other herbivores (0.2 to 0.8 ug/ml) should not be considered physiologically comparable to the elephant.

Research on vitamin E nutrition of elephants has been emphasized in recent years following the initial report of a young Asian elephant's death linked with apparent vitamin E deficiency (Dierenfeld and Dolensek 1988), with a recommendation for dietary supplementation of this nutrient. Subsequently, vitamin E deficiency was implicated in at least two other elephant deaths. In response to that early report, the Wildlife Conservation Society (WCS) ran plasma analysis of vitamin E resulting in a database totaling almost 1,000 samples.

A water-soluble form of vitamin E, TPGS, added as a component in elephant diets, showed effectiveness in raising circulating plasma concentrations (Papas et al. 1990; Sadler et al. 1994), as did the use of micellized d-alpha-tocopherol as a vitamin E supplement for captive elephants (Wallace et al. 1992). Recent publications have shown that circulating levels of this nutrient appear normally to be low in both captive and free-ranging elephants (Dierenfeld et al. 1998; Shreshtha et al. 1998). Thus, excessive supplementation in attempt to achieve circulating plasma concentrations similar to livestock species may not be warranted.

Both lipoprotein profiles in the blood (the carriers for vitamin E), and normal circulating concentrations of this nutrient (<1.0 ug/ml) suggest that the horse is not the optimal physiological model for understanding vitamin E

Table 3. Nutrient specifications for ADF16, ADF25, and Herbivore Supplement (concentration).[a] Ulrey et al. (1997).

Nutrient	ADF16	ADF25	Herbivore Supplement
Crude protein, min. %	17	15	23
Lysine, min. %	0.8	0.7	1.2
Acid detergent fiber, min. %	13	21	10
Acid detergent fiber, max.	17	26	14
Crude fat, min. %	3	3	3
Linoleic acid, min. %	1	1	1.5
Ash, max %	8	11	12
Calcium, min. %	0.65	0.85	1.20
Calcium, max. %	1.00	1.20	1.50
Phosphorus, min. %	0.65	0.75	0.90
Magnesium, min. %	0.20	0.25	0.25
Sodium, min. %	0.25	0.50	0.80
Potassium, min. %	1.20	1.50	1.50
Sulfur, min. %	0.20	0.20	0.25
Iron, min. ppm	150	200	300
Copper, min. ppm	20	20	35
Copper, max. ppm	30	30	50
Manganese, min. ppm	90	90	150
Zinc, min. ppm		120	120
Cobalt, min. ppm	0.3	0.3	0.4
Iodine, min. ppm	0.8	0.8	2.0
Selenium, min. ppm	0.3	0.4	0.8
Thiamin, min. ppm	5	5	7
Riboflavin, min. ppm	9	9	15
Pantothenic acid, min. ppm	30	30	75
Niacin, min. ppm	50	50	180
Biotin, min. ppm	250	250	800
Vitamin B_{12}, min. ppm	20	20	60
Choline, min. ppm	1,500	1,500	1,500
b-Carotene, min. ppm	30	50	20
Vitamin A, min. IU/kg	5,000	5,000	15,000
Vitamin D_3, min. IU/kg	1,200	1,200	3,600
Vitamin E, min. IU/kg	300	300	900

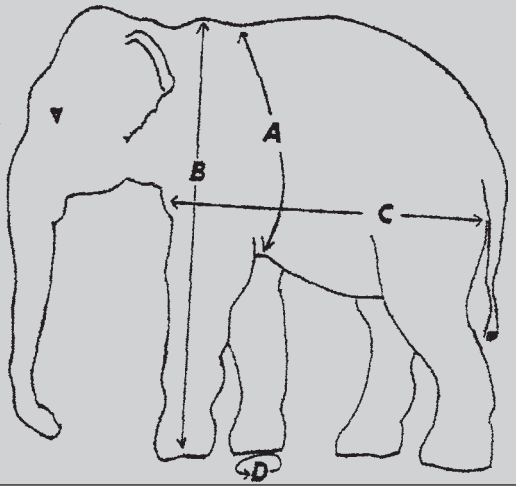
[a]These designations do not refer to particular commercial feeds, and manufactured products that have been given these names may or may not have the same formulas and specifications.
[b]Min. = minimum; max. = maximum; ppm = parts per million = mg/kg; ppb = parts per billion = mg/kg

In a study by Hile et al. (1997), it was concluded the body weight of an Asian elephant could be predicted from body measurements. In a study measuring heart girth, height at the withers, length from point of shoulder to pin bone, and pad circumference, the heart girth was concluded to be the best measurement parameter. For those institutions unable to weigh their elephants on a regular basis, using the heart girth measurement is minimally a good predictor of weight gain or loss in the Asian elephant.

Asian Elephant Conversion Chart (Heart Girth: Weight) HG=Heart Girth

HG in cm	kg	lb	Hg in cm	kg	lb
190	84	184.8	380	3504	7708.8
195	174	382.8	385	3594	7906.8
200	264	580.8	390	3684	8104.8
205	354	778.8	395	3774	8302.8
210	444	976,8	400	3864	8500.8
215	534	1174.8	405	3954	8698.8
220	624	1372.8	410	4044	8896.8
225	714	1570.8	415	4134	9094.8
230	804	1768.8	420	4224	9292.8
235	894	1966.8	425	4314	9490.8
240	984	2164.8	430	4404	9688.8
245	1074	2362.8	435	4494	9886.8
250	1164	2560.8	440	4584	10084.8
255	1254	2758.8	445	4674	10282.8
260	1344	2956.8	450	4764	10480.8
265	1434	3154.8	455	4854	10678.8
270	1524	3352.8	460	4944	10876.8
275	1614	3550.8	465	5034	11074.8
280	1704	3748.8	470	5124	11272.8
285	1794	3946.8	475	5214	11470.8
290	1884	4144.8	480	5304	11668.8
295	1974	4342.8	485	5394	11866.8
300	2064	4540.8	490	5484	12064.8
305	2154	4738.8	495	5574	12262.8
310	2244	4936.8	500	5664	12460.8
315	2334	5134.8	505	5754	12658.8
320	2424	5332.8	510	5844	12856.8
325	2514	5530.8	515	5934	13054.8
330	2604	5728.8	520	6024	13252.8
335	2694	5926.8	525	6114	13450.8
340	2784	6124.8	530	6204	13648.8
345	2874	6322.8	535	6294	13846.8
350	2964	6520.8	540	6384	14044.8
355	3054	6718.8	545	6474	14242.8
360	3144	6916.8	550	6564	14440.8
365	3234	7114.8	555	6744	14836.8
370	3324	7312.8	565	6834	15034.8
375	3414	7510.8	570	6924	15232.8

Location of body measurements
A. Heart girth
B. Height at withers
C. Length from point of shoulder to pin bone
D. Pad circumference



Diet of Free-Ranging Elephants

The natural diet of elephants has been extensively documented and references to elephant nutrition should be consulted for details. Insight into diet selection, nutrient composition of native feedstuffs, and feeding behavior of free-ranging elephants can provide a foundation for husbandry practices in captivity, while contributing to the conservation of the elephant and its natural habitat.

Elephants have been described as "generalized feeders" in the wild, selecting from more than 400 different species of plants. A few botanical taxa have been found to be preferentially consumed by elephants, but choices vary widely and are likely influenced by region, season, and ecosystem. For example, Viljoen (1989) reported that desert-dwelling elephants of Namibia had a preference for woody plant species, irrespective of abundance or plant size. In contrast, Chiaki (1996) observed savannah elephants from Tsavo National Park in Kenya choosing grasses, shrubs, and herbs as the main part of their diet. Using spoor analysis, Tchamba and Seme (1993) found the diet of forest elephants in Cameroon to consist mainly of grasses and fruits. By use of observation, Sukumar (1989) found that just 25 species of plants, ranging from grasses, bamboo, trees such as *Acacia* spp., shrubs and fruit, constituted 85 percent of the diet of elephants in southern India.

The influence of season on the extent of grazing was observed in Uganda where grass consumption ranged from 28.6 percent of the total diet in the dry months to between 57.2 percent and 97 percent in the wet months (Eltringham 1982; Buss 1990). Similarly, for Asian elephants the proportion of time spent grazing ranged from 10 percent to 94 percent, while browsing time ranged between 6 percent and 90 percent in southern India, with variation depending on habitat, time of day, and season (Sukumar 1989). During the wet season, elephants tend to be preferential grazers, using sedges and grasses at a time when the protein content of these species is high. However, more browsing occurs in the dry season when the protein content of grass decreases to less than 2.5 percent and tannins and toxins accumulate (Barnes 1982; Kaufman 1998).

Reported crude protein levels in diets consumed by elephants ranged from 2 percent of dry matter (DM), found in palm leaves from India (Nair and Ananthasubramaniam 1979), to 26 percent DM, found in shrubs from Kenya (Chiaki 1996). Seasonal effects on dietary crude protein levels, examined in Uganda, indicate variation from 5.2 percent DM in the dry season to 12.4 percent DM in the wet (McCullagh 1969). Brown and White (1979) reported a low urea concentration in elephant plasma, which correlated with low dietary protein, during the dry season.

Field studies have shown many browses to contain a high crude fat content, more than 5 percent DM (Dierenfeld 1994). A diet low in browse, such as the diet of elephants from Murchison Falls National Park, Uganda, which was reported to contain 1.2 to 1.8 percent of DM as lipid (McCullagh 1969) may be deficient in certain essential fatty acids (Field 1971; McCullagh 1969, 1973; Dierenfeld 1994). Fatty acid profiles from elephant diets show the concentration of saturated palmitic acid to be approximately 1.5 times greater than for the unsaturated oleic, linoleic, and linolenic acids (McCullagh 1969). At the same time, the mean plasma cholesterol levels in the elephant has been found to be low, which is attributed to the overall small amount of total lipid in the elephants diet (McCullagh 1969).

Lignin concentration in plants examined in Uganda was found to range between 3.1 to 38.4 percent DM in the early dry season and 2.6 to 27.8 percent in the late dry season whereas cellulose concentrations showed no seasonal differences, with a range between 21.9 to 71.8 percent DM (Chiaki 1996). McCullagh (1969), reporting lignin and cellulose values together (equivalent to acid detergent fiber or ADF), showed a variation between 32 percent DM in the wet season and 41 percent DM in the dry season.

Mineral analysis of elephant diets resulted in significant variations recorded both between seasons and among plant species. Calcium, which has received more attention than other minerals, has been found to range from 0.13 percent DM in the wet season to 0.38 percent DM in the dry season and from 0.36 to 1.44 percent DM in grass-herb vegetation to 0.53 to 8.92 percent DM in shrubs (McCullagh 1969; Sikes 1971; Chiaki 1996). Bark, with a calcium concentration of up to 5.7 percent, has been suggested to serve as a supplementary dietary source of this nutrient (Sukumar 1989). McCullagh (1969), however, believes elephants are unlikely to be deficient in calcium on a diet comprising green vegetation, and should be able to meet calcium requirements without consumption of bark.

nutrition of the elephant. Furthermore, species differences in circulating levels, and perhaps metabolism, of this nutrient are becoming apparent between Asian and African elephants. Nonetheless, overall vitamin E nutritional status of elephants in North American zoological facilities has been raised significantly over the past decade through emphasis on dietary supplementation.

Biotin supplementation has been reported as beneficial in preventing foot problems in elephants but has not been studied in detail. A single investigation of the kinetics of plasma biotin in supplemented elephants demonstrated that the vitamin was cleared very rapidly from the system, questioning the usefulness of large doses of biotin (Ullrey et al. 1988).

Mineral nutrition in elephants has not been extensively studied. The few data that do exist on mineral composition of native forages suggest that dietary mineral concentrations determined as adequate for horses would be roughly suitable for elephants at varying physiological stages. Calcium requirements of 8 to 9 grams per day have been

determined for proper tusk growth in male elephants, and McCullagh (1969) and Sukumar (1989) calculated that a lactating cow would require up to 60 grams of calcium daily to meet the growth needs of her calf. Rickets was observed in a hand-reared Asian elephant (Ensley et al. 1994). However, there have been no other published reports of calcium, phosphorus, or vitamin D being problematic in other elephants fed typical zoo diets.

Zinc deficiency was suspected in one Asian elephant with chronic foot problems. The animal appeared to show an immune deficiency and other symptoms of zinc deficiency—for example, skin problems. The elephant's diet was evaluated and found to be low in zinc. Subsequently, the animal was treated with dietary zinc supplementation and the foot problems subsided. Although hair and serum samples were analyzed for zinc, no correlation could be drawn. Authors stressed the importance of meeting probable requirements for dietary zinc in elephants (Schmidt 1989), based again on equine recommendations.

Reported Health Problems Linked to Diet

Tooth or tusk problems. Loss of molars is a natural occurrence in elephants since normally the plates flake and molars are replaced. However, permanent loss of molars, especially the sixth molars can be particularly devastating in an animal consuming a highly fibrous diet. Decreased mastication will not allow for proper particle size needed for digestion. Thus, the elephant will not be able to extract the nutrition it needs (Reichard et al. 1982), and a more highly digestible geriatric diet may be indicated in these situations.

Colic. There have been unpublished reports of colic symptoms in elephants. The symptoms present similar to that of the horse—laying down and standing back up, stretching, kicking at the belly, inappetance. Most often the symptoms appear to be alleviated by decreasing the fermentable carbohydrates in the diet (produce items and bread) and increasing the fiber. Since the grass hay that most institutions use is fibrous, offering grass hay alone will provide good fiber. At times, wheat bran is added to the diet to decrease the incidence of colic or treat bouts of colic. Wheat bran is known to contain 17 percent CP, 51percent NDF, and 15 percent ADF. Compared with the average timothy hay used: 7 percent CP, 68 percent NDF, and 41 percent ADF the hay is more fibrous than the bran. Colic symptoms have been noted in at least one elephant consuming large quantities of enclosure soil/clay. The animal was treated with enemas and a fiber powder and supervised to decrease clay ingestion. Ingestion of earth is a common occurrence in free-ranging elephants and may be helpful to them in supplying minerals in the diet (Warren et al. 1996). With a nutritionally complete diet supplied in captivity, there should be no nutritional reason for the elephants to consume soil, clay, or sand.

Protein and Energy. Sixty-three severely malnourished young elephants were examined in 1984 (Ullrey et al. 1985). The diet evaluated was deficient in protein and digestible energy with hay at 4% CP and pelleted feed at 10% CP. A diet change was put into effect, which substantially improved the health and status of these animals. The hay source was changed as was the pellet portion of the diet resulting in hay with a 10–13% CP level and a nutritionally complete pelleted product at 17% CP.

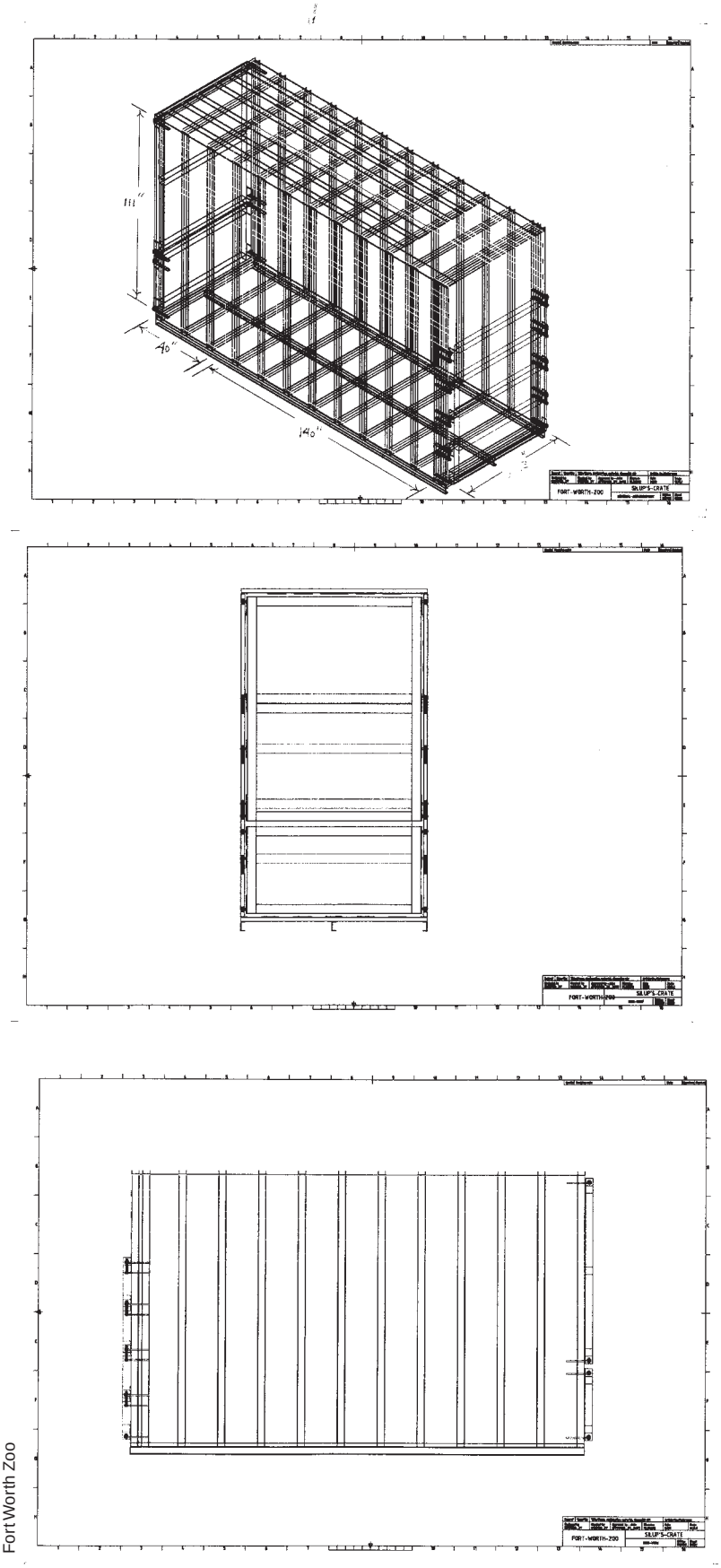
Transporting

When trained and habituated to transport, elephants are easily relocated and travel with no ill effects (Toscano et al. 2001). Working elephants, such as those in circuses, may change location daily or multiple times in a week for a portion of the year. These elephants are walked into and transported in specially designed trailers or rail cars. The movement of these elephants is well coordinated in regards to equipment, weather, and itinerary. The elephants are healthy and suited to travel, are accompanied by their handlers and are under the direction of veterinarians, and the regulations of the United States Department of Agriculture.

Conversely, some elephants are rarely moved to a new location. An elephant in a zoological facility is often moved only to improve breeding opportunities or to establish a new social group. In this case, the movement of the elephant to another facility permanently, or for an extended period of time, requires planning. Prior to the shipment, elephant managers and veterinarians at both the shipping facility and the receiving facility should establish clear lines of communication. The receiving facility should be advised of the elephant's behavior profile, medical history, breeding history, nutrition, and management program. Knowledgeable elephant handlers from the receiving facility should travel to the shipping facility and observe the elephant to be received. In addition, the elephant handlers of the shipping facility should conduct a site inspection of the receiving facility and review that facility's ability to meet the needs of the elephant. All site and elephant inspections should be done well in advance of the move, and all questions should be resolved prior to

Have Trunk Will Travel

When trained and habituated to transport, elephants are easily relocated and travel with no ill effects. This specially designed trailer includes a ventilation system, complete insulation, and sliding screen doors for comfort. The walls and floors are designed for easy cleaning. On-board water tanks hold 100 gallons of fresh water.



Fort Worth Zoo

Three views of a transport crate design.

any firm commitment to the transfer.

It is strongly recommended that the physical transport of the elephant be arranged with an individual experienced in and properly equipped for transporting elephants. Contacting other facilities that have had experience moving elephants for references is suggested. Once the elephant transporter has been chosen, the elephant managers from both facilities, facility veterinarians, and the transporter should develop a written plan to move the elephant. The plan should detail the channels of communication, lines of authority, the point of the move where the responsibility for the elephant changes, and describe responses to any situation where the elephant's safety might be jeopardized. It is also strongly recommended that elephant holding facilities along the route be contacted prior to the move to arrange for their assistance in the case of an emergency.

If the elephant is transported in a trailer, it is important that the trailer be reinforced for elephants. Trailers need to be specially designed to contain an elephant safely and securely, with proper ventilation, heating/cooling as the weather dictates, and a means to provide food and water. Trailers should be constructed so that the elephant can comfortably stand, the floor should be reinforced to support the weight of the elephant, and drainage holes should be provided so urine does not puddle where the elephant stands.

The elephant may be trained to walk into the trailer at the handler's side, or the elephant may be slowly encouraged into the trailer by taking up slack in the leg restraints with a winch. Both of these methods are acceptable and the decision as to which method to use depends on the facility's elephant management training program, elephant staff ability and experience, and the behavior and demeanor of the elephant. Once in the trailer, the elephant must be placed on tethers to limit its movement during the transport, which helps prevent injury and ensures the elephant's security.

An elephant can also be trained to enter a specially designed crate and then the crate is placed on a trailer. Crates are usually constructed of metal or hardwood with steel reinforcements. Crate dimensions should be determined by the elephant's size, but in general the crate should be 0.3 meter (1 foot) longer, taller,

Rosamond Gifford Zoo, Linda Costello

Rosamond Gifford Zoo, Michele Delperuto

Two views of a crate used to transport an elephant overseas.

and wider than the elephant and allow for normal head movement above, while restricting excessive body movement**.** Crates with bars situated at the head allow the handler access to the elephant to provide feed and water, although the bars must be placed close enough together to prevent the elephant from extending the majority of its trunk beyond the containment of the crate.

Elephants that are shipped by airline fall under guidelines set by the International Air Transport Association (IATA) and the most recent standards set by IATA must be reviewed by the shipping facility and met. Containers that conform to the principle of written guidelines, but look slightly different, will still meet IATA standards.

Training the elephant to enter a trailer or crate prior to shipping is strongly recommended. Acclimation to the crate or the trailer may require two to six weeks, although many institutions, depending on the tractability of the animal, have trained an elephant in seven days or less.

If the elephant does not completely acclimate to entering the trailer or the crate, partial immobilization or sedation may be needed. The usual pre-immobilization procedures—fasting, detainment in an adequate holding area, etc.—should be observed for any procedure requiring the use of chemical immobilization/tranquilization agents. If chemical immobilization is used, it is recommended the elephant be held at the loading location for up to 24 hours for observation or accompanied by a veterinarian during transport in the event of a drug-induced health problem or renarcotization. Complications brought on by sedation can be handled more easily and effectively in-house than en-route. It is suggested that the veterinarian involved in the loading, the accompanying veterinarian, and the receiving facility's veterinarian all agree when the elephant is safe to travel.

The use of tranquilization agents must be fully investigated if the transport of the elephant is by air. Most, if not all, commonly used tranquilizing agents have the effect of lowering the elephant's blood pressure, which also occurs naturally at high altitudes. The combination of altitude and drugs is potentially fatal in old, chronically sick, or severely stressed elephants (IATA Live Animal Regulations; https://www.iataonline.com). If sedatives are used, the name of the drug and the time and route of administration must be clearly marked on the container. A copy of the record must be attached to the crate. A veterinarian familiar with elephants and the administration of tranquilization agents must accompany the flight.

Regardless of the mode of transport, every effort should be made to make the travel time as short as possible. For the mental and physical well-being of the elephant, a primary elephant handler should accompany the elephant during the transport to the receiving facility. In all situa-

Recommendations for EEHV Testing and Transport of Elephants

September 2002

Background: A serologic test for EEHV has been recently developed for Asian elephants to determine antibody titers. Reagents for testing African elephants will be available in the future. Previously, the only diagnostic test available was PCR to detect the presence of virus in whole blood (positive for a short period of time during active infection). The ability to detect antibodies will permit assessment of exposure status in asymptomatic elephants. Based on extrapolation from other related herpesviruses, it is assumed that animals that have been infected and shown clinical signs will become carriers and mount a life-long antibody response. Elephants that do not have antibodies to EEHV are presumed to be "naïve" or not previously exposed. It is unclear at this time how to interpret low levels of antibody.

Recommendations: It is critical that a program for current and ongoing assessment of exposure to EEHV be developed for the North American captive elephant population. Serologic testing on a routine basis will create a database that can be used to develop more informed epidemiological guidelines for movement and other management purposes.

Current assumptions:

1. Elephants with high EEHV titers have been previously exposed/infected and may have protective immunity or resistance to developing potentially fatal clinical disease.
2. Elephants with high EEHV titers and a clinical history of disease are presumed to be carriers of EEHV and may periodically shed virus (with or without clinical signs).
3. Elephants with no EEHV titers are probably immunologically naïve. Other risk factors including age (fatal cases have occurred mostly in younger animals under 10 years of age), health status, and previous exposure to other elephants, may alter the susceptibility of these individuals to EEHV infection and the development of clinical disease. However, these elephants should be considered "susceptible" to infection.
4. Elephants with intermediate EEHV titers may have previous exposure and/or be potential carriers. These animals may require serial sampling to determine their EEHV status.
5. Currently, results of individually tested animals may provide preliminary guidelines for risk assessment on a case by case basis; however, sufficient data is not available to make broad-based management recommendations on risk of EEHV infection at this time; immediate action should be taken to screen the current population and develop a long-term monitoring program to provide information for future management guidelines.
6. There are several different strains of EEHV circulating around the world and it is not yet known if exposure to one strain will confer protection against other strains of EEHV.

General recommendations for elephant transports and introductions based on EEHV titers.

1. The institutions receiving and sending elephants should submit samples to determine EEHV titers in their herds.

2. If EEHV titers are available, the risk factors should be assessed using the following general assessment. Other risk factors such as age, exposure to other elephants, health status, and herd histories should be taken into consideration.

EEHV titer in:

	Animal/herd to be transported:	
Receiving herd	**+ titer**	**– titer**
+ titer	Low risk	Risk to incoming animal (naïve animal going into herd that may have carriers)
– titer	Risk to receiving herd of exposure to potential carrier (incoming animal)	Low risk

3. If EEHV titers are not available, the other risk factors mentioned above (statement 2) should be considered.

Goals:

1. Development of an EEHV serologic database using historical, current and on-going serum samples from captive North American elephant population to assess the usefulness of this diagnostic test and the interpretation of individual results.
2. Improved management recommendations based on potential risk of exposure to EEHV using the database.
3. Increased epidemiological information of EEHV in the captive elephant population.

Elephant Crate Design and Construction

- The crate must protect humans from the elephant being transported.
- Due to the immense weight of the elephant, forklift spacers must be part of the crate design.
- The crate must be strong enough to restrain the elephant and made of strong materials, metal and/or nonchemically impregnated wood, welded or bolted together depending on the weight of the elephant.
- The size of the crate must restrict the movement of the elephant but be large enough so the elephant can stand naturally.
- The inside of the crate must be smooth with no sharp projections on which the elephant can injure itself.
- The floor must be solid, support the weight of the elephant, drain or absorb liquid waste, and have a non-slip surface.
- There must be a roof over the elephant's head that restricts the upward movement of the trunk.
- It is recommended that a series of metal bars be secured either horizontally or vertically at both the entry and exit of the crate allowing for the care of the elephant. The entry and exit must be clearly marked as such.
- The container must be adequately ventilated with the opportunity for cross ventilation at the top of the crate, as well as at the lower half of the crate. Elephants breathe only through their trunk and when relaxed, the elephant's trunk is rested on the ground. The ventilation openings must prevent any part of the elephant protruding resulting in injury to the elephant or humans.

Guidelines modified from IATA standards to include specifications for ground transport. Before shipping by air, consult the current IATA specifications and/or airline.

tions, the elephant's behavior and condition should be regularly monitored. It is possible for an elephant unaccustomed to being transported to damage the trailer or crate and injure itself in the process. Elephants should be provided with fresh hay periodically during the transport and if the trip lasts more than 16 hours, they should be provided with an opportunity to drink water. In addition, enough hay and grain from the shipping facility to allow for a controlled transition of the elephant's diet (about two weeks) should accompany the shipment.

The primary elephant handler should stay at the receiving facility for a period of time after the transport to make sure the transition period is progressing normally and this period is as safe as possible for the elephant and the new handlers. The decision as to when this primary handler should return to their facility should be based on the behavior and demeanor of the elephant, and the ability of the elephant handlers at the receiving facility.

Recommended Elephant Preshipment Guidelines

Routine health monitoring should be performed on all elephants on an annual basis (see "Guidelines for Comprehensive Elephant Health Monitoring Program," p. 172). Animals should be trained to permit sampling and examination. Whenever possible, preshipment testing should be performed within 30 to 90 days of the anticipated shipping date (note: mycobacterial cultures require 60 days for final results). The following protocol advises that specific baseline laboratory tests be performed for the purpose of evaluating current health status. Additional tests are recommended to increase baseline information to determine their significance to elephant health. The final decision for specific procedures should be made in partnership between the shipping and receiving institutions. Any abnormal findings should be communicated to the receiving institution in a timely manner.

Minimum Database

1. Signalment—age, sex, origin, studbook#, local ID#, pictures of the elephant as viewed from the front and sides.

2. Anamnesis—summary of information regarding previous health screens, medical problems, diagnostic test results, and treatment. A hard copy and disk of the complete medical record should be sent to the receiving institution prior to shipment.

Specific areas to be included:

a. foot/skin conditions
b. dental/tusk conditions
c. history of colic, diarrhea, GI parasitism (including fecal parasite screens and Salmonella cultures)
d. serologic status, if known (EMC, elephant herpesvirus, Leptospirosis)
e. vitamin E status, if known
f. TB culture (dates and results)
g. reproductive history
b. musth history
c. sedation/immobilization data

3. Complete physical exam by a veterinarian familiar with elephant health problems. This should include a review of all systems.

4. Body weight—actual or estimated using body measurements.

5. Blood collection

a. Complete blood count (CBC), serum chemistry panel.

Buffalo Zoo

If the elephant is transported in a trailer, it is important that the trailer be suitably reinforced.

b. Bank minimum of 10 to 20 ml serum—all banked samples should be labeled with species, studbook#, age, sex, and date collected.
c. Serologic (ELISA) test for elephant herpesvirus.

6. Fecal analyses
   a. Parasite screen—Fecal samples should be collected every seven days for a total of three weeks; direct, flotation, and sedimentation should be performed on every sample to detect intestinal parasitism.
   b. Enteric pathogen screen—Aerobic culture of feces for enteric pathogens should include special media for the detection of *Salmonella spp*. Since Salmonella organisms may be shed intermittently, at least three to five fecal cultures should be performed (may be done on consecutive days).
   c. Contact receiving institution with any abnormal results and treatments.

7. TB culture—At this time, annual trunk wash cultures are the only required test; however, collection of other samples for research is strongly encouraged.
   a. Samples for cultures must be collected under the direct supervision of a licensed veterinarian.
   b. Three trunk samples should be collected on separate days within a one-week period.
   c. All samples should be frozen immediately after collection and shipped frozen.
   d. Ship by overnight express to NVSL or other laboratory facility that offers comparable procedures. Request mycobacterial culture with speciation.

Buffalo Zoo

The elephant may be trained to walk into the trailer, or the elephant may be slowly guided into the trailer using restraints and a winch.

8. Vaccinations
   a. Tetanus toxoid—Current vaccination (within 12 months) is recommended using a commercial equine product. Data are insufficient at this time to determine adequate protective vaccine doses and titers.
   b. Rabies vaccine—Vaccination with a commercial killed rabies product approved for horses should be considered if the animal resides or will be traveling to an endemic area. Data are insufficient at this time to determine adequate protective vaccine doses and titers.

9. PCR test for elephant herpesvirus.

10. Reproductive tract examination—A complete reproductive examination should be conducted to include transrectal ultrasound, semen collection and analysis, cytology and microbial cultures of the lower urogenital tract (to be screened for bacteria, chlamydia, protozoa, and herpesvirus). Herpesvirus has been identified in biopsies of vaginal lymphoid patches in an African elephant. A high prevelance of uterine leiomyomas has been observed in captive Asian elephants and could be detected via transrectal ultrasound. Since both of these conditions have potentially significant effects on reproduction, a careful evaluation is warranted if the animal is being considered for breeding

11. Other vaccination regimens will depend on regional requirements and exposure risks (consider vaccination for equine encephalitis viruses, Clostridial diseases, Leptospirosis).

Quarantine Guidelines for Elephants

December 2002

Due to the size, strength, and social nature of elephants, it may be logistically difficult to maintain isolation from other elephants during arrival and quarantine. Most zoological institutions will not have facilities available to safely house and manage a newly arriving elephant. However, every attempt should be made to maintain some degree of physical separation from the resident elephants. Current quarantine practices recommend a minimum 30- to 90-day quarantine period for most species found in zoos and aquaria. Social concerns, physical facility design, and availability of trained elephant staff may dictate a modified quarantine protocol. The final decision for specific quarantine protocols at each institution should be made by the veterinary staff in consultation with the elephant management staff. For additional information, refer to the AZA Quarantine Guidelines and the AAZV Preventive Medicine Recommendations.

The following guidelines provide recommendations for minimum standards for elephant quarantine.

- ❑ Whenever possible, the newly arrived elephant should be maintained with physical separation from all other resident elephants. This should include provisions to prevent contact with feed, bedding, or feces/urine between animals. One option to allow social interaction is to provide a "companion" and treat both animals as "quarantined."
- ❑ Initial visual assessment of the elephant, along with review of the medical records, to determine health status should be used to develop an individual quarantine plan.
  - Ideally, the recommended length of quarantine is a minimum of 30 days. However, this may be changed in light of social concerns or detection of abnormal health status.
  - Risk of disease transmission between animals should be balanced with the concern for well-being (physical, psychological, and social) of the elephant.
- ❑ Quarantine procedures should be planned as soon as the elephant can be safely managed and appears to be settling in the facility.
  - Thorough physical examination including a review of all systems.
  - Blood collection for CBC, serum chemistry panel, fibrinogen, serum protein electrophoresis, and serum bank.
  - Fecal collection for parasite screening should be done weekly for the first three weeks.
  - Fecal cultures for Salmonella should be conducted at least weekly for the first three weeks.
  - Any procedures that were not completed prior to transport or may have come due; such as vaccination, serologic screening, or TB testing.
- ❑ Release from quarantine should be the decision of the veterinary staff (after completion and review of results from any quarantine procedures), in conjunction with the assessment of the elephant management staff.

Environmental Enrichment

Enrichment is defined as a process for improving or enhancing the captive elephant environment within the context of the elephant's behavioral biology and natural history.

Enrichment must be an integral component of every elephant management program. It is a dynamic process in which changes to structures and husbandry practices are made with the goal of increasing behavioral opportunities. Elephant enrichment is fertile ground for the imagination as it is an ongoing and creative process. The following should serve to offer basic information, ideas, and resources from which each facility can launch its own enrichment program.

An appropriate social and physical environment can encourage the development of a wider repertoire of elephant appropriate behaviors, enhance social skills, allow the elephant to feel a sense of control over its environment, and contribute to an elephant's ability to cope with stress and novel situations.

Enrichment strategies should stem from knowledge of the natural history of elephants. Some of the key characteristics of elephant biology that are important in the design of facilities and enrichment programs are:

- Elephants are highly social animals. Matriarchal groups are composed of females of all ages and males up to the age of puberty. Males lead a more solitary life, but they still form loose associations and have many varied and dynamic social relationships with other males and with

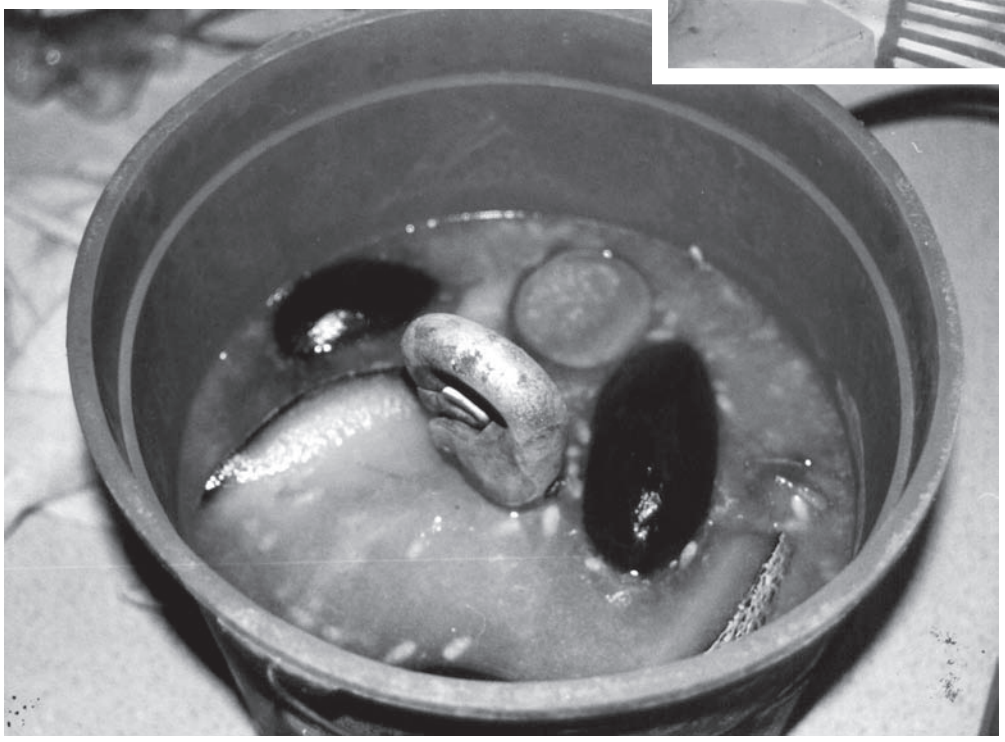
Buffalo Zoo

Grazing outside of the exhibit is an effective form of enrichment.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Management and Care adopted March 21, 2001, states, "All holding institutions must have a written environmental enrichment plan for their elephants and show evidence of implementation."

matriarchal groups. Communication takes place by visual, tactile, vocal, and olfactory means.

- Elephants roam over large home ranges determined by the dispersion of vital resources such as water, mates, shade/resting areas, rubbing trees, and food. The availability and location of these resources change regularly with the seasons and less predictably from year to year over the life span of an elephant. Elephants demonstrate great intelligence and groups of elephants acquire historical knowledge in order to efficiently exploit these resources.
- Elephants spend large amounts of time foraging (e.g., 12 to 14 hours/day; McKay 1973) for a wide variety of foods (e.g., 89; McKay 1973) using a variety of techniques. Some foraging behaviors may include grasping the stems of grasses, uprooting and knocking off the soil to grasping and pulling off the twigs of shrubs, raising up on hind legs to reach the branches of tress, and pushing over trees.
- Other potentially important environmentally modulated behaviors observed in wild elephants include



Albuquerque Biological Park

Above: A mounted xylophone for the musically inclined elephant. Left: A range of treats frozen into an ice block is enrichment.

Sedgwick County Zoo

Scattered basketballs in the elephant exhibit provide enrichment.

mud/dust bathing, climbing up steep slopes, and swimming.

In order to develop priorities for elephant enrichment, knowledge of elephant natural behavior is combined with knowledge of what elephants actually do in captive situations. For instance, many enrichment techniques rely on the fact that elephants are curious about new things and will explore and interact with them in order to learn about them. Needless to say, these techniques will not work if repeated on a routine and predictable basis.

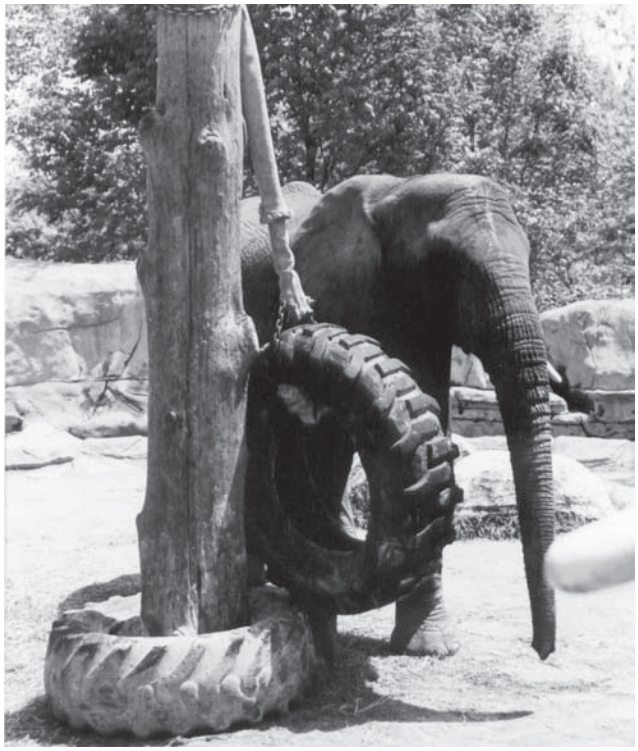
Unfortunately, little published information specific to environmental enrichment for elephants exists. In general, environmental enrichment techniques for elephants should:

1. Allow opportunities for appropriate social interaction. Few captive herds replicate the complexity of herds of wild elephants in terms of age structure, sex ratio, and history of past interactions. In particular, herds lacking young by reproduction are missing an important source of interaction and associated activity. Increasing social complexity through the careful consideration of appropriate social group size and composition, breeding and maintaining a male elephant(s) is considered to be an important aspect of enrichment.

*2. Provide conditions in which the elephant's exploration is rewarded with new and useful information, allowing it to make choices about its activities and some control of its environment***.** Increasing the complexity of the environment within an enclosure in a species appropriate way may result in increased opportunities for activity. Adding substrates such as dirt, leaf litter, mulch, vegetation, and trees, and concealing food and smells may elicit foraging and investigatory behavior. Barriers and landscaping can provide privacy, reduce territorial behavior, provide escape routes, and improve social interactions. Structures provide shade and temperature gradients for choice of microclimate, and promote activities such as scratching and climbing. They can also provide visual barriers from conspecifics and the public. The elephant is therefore provided with choices. If it is too warm, the elephant can seek shade or bathe; if it is hungry, it can seek food; if it is frightened, it can move to a place it feels more secure.

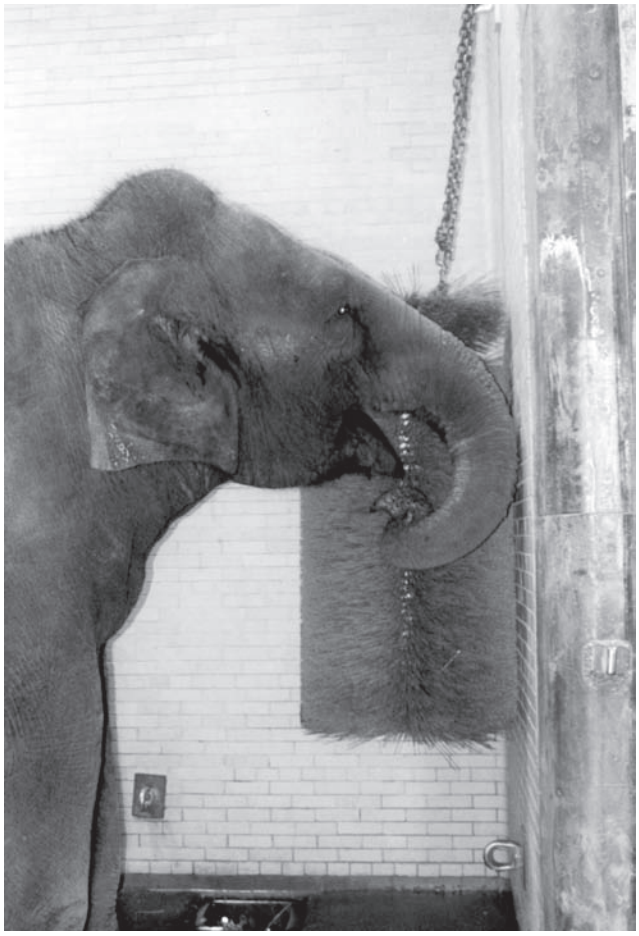
*3. Present cognitive challenges, such as learning what a trainer is requesting, or solving a task***.** Cognitive challenges, by definition, put captive elephants in a position in which they can learn to control some aspect of their environment. Husbandry training can be defined as a type of learning and viewed as a component of environmental enrichment (see Training, p. 21).

Hediger (1950, 1969) believed strongly that simple training exercises (i.e., performing behaviors for entertainment and education) were a form of "occupational therapy" for animals, reducing boredom in captivity. His use of the term "training" referred mainly to nonhusbandry related behaviors; he perceived this type of behavior as "disciplined play." Today, both types of training (nonhusbandry and husbandry training) can be viewed as forms of enrichment. Training certainly appears to engage the animals on a cognitive level, allows positive interaction with handlers, and facilitates routine husbandry activities (Shepherdson 1998). As with other



Grant's Farm, Jenny Joyce

Rosamond Gifford Zoo at Burnet Park, Linda Costello



Buffalo Zoo

Six Flags Marine World

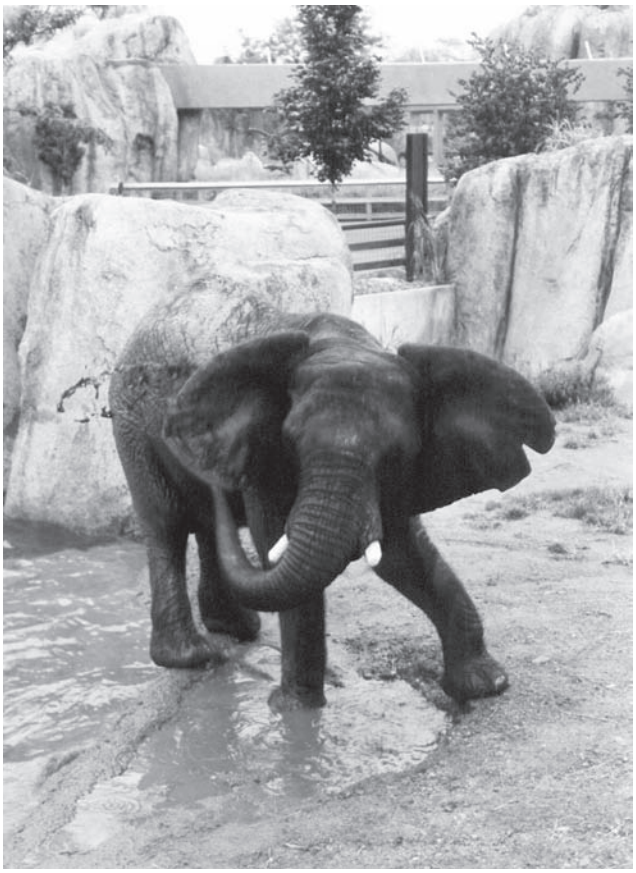
A variety of enrichment opportunities are available to elephant managers. Top left: Tires suspended from a support. Top right: Elephant plays with a ball. Bottom right: Treats placed in a high basket encourage foraging behaviors. Bottom left: Car wash brush suspended by chain.

components of enrichment, training programs should involve planning, assessment, and re-evaluation and not be viewed as the only form of enrichment offered.

4. Provide opportunities for elephants to seek shelter, forage, exercise, etc. in a species-appropriate way. Hughes and Duncan (1988) presented evidence that animals may need to perform some appetitive behaviors (such as nest building or foraging) even when the performance of those behaviors is not necessary in order to achieve a desired goal (such as a nest or food). Although it is clear that many behaviors are stimulus driven, in which case there may or may not be any motivation to perform a behavior in the absence of a specific stimulus, Hughes and Duncan pointed out that there are some behaviors that do seem to be internally driven. Preventing performance of these behaviors could result in frustration and may lead to stress. The "need" for exercise may be one of these behaviors. Some institutions are currently addressing exercise requirements by walking the elephants for a specified amount of time on a daily basis and providing energetic tasks for the elephants to perform such as pulling weighted sleds. Techniques for exercising an elephant handled from behind a barrier appear to be more limited at this point in time and is an area that needs more attention. But some limited exercise may be provided by setting up situations that encourage spontaneous activity such as large piles of soil placed in exhibits and foraging tasks that require movement.

Captive elephants spend less time foraging for their diet than do elephants in the wild. A priority for enrichment should be to increase the time and activity related to foraging without increasing caloric consumption or cause a nutritionally balanced diet to be imbalanced. Enrichment should not be viewed as the provision of "treats" but the method by which the elephant's regular diet is presented in a species-appropriate way. The goal with food-related enrichment is to lengthen the consumption time and provide more of a challenge to securing the food item. In so doing, many elephant-appropriate behaviors are stimulated. Suggested food-related enrichment include:

- Novel food items that are not a part of the regular diet. The different flavors are often unexpected and add variety. Even providing foods that the elephant does not like adds stimulation. Novel food items, when provided, should replace a part of the normal diet.
- Providing fresh cut browse. Large branches with fresh leaves, fruits, and/or flowers will stimulate foraging and add fiber to the diet.
- Forage material cut in small pieces and spread throughout the holding area. This increases the time the elephant spends foraging.
- Devices that provide a challenge to retrieve food (puzzle boxes, treat logs). These devices increase the time the elephant spends foraging and causes them to use their cognitive abilities.



Deborah Olson, Indianapolis Zoo

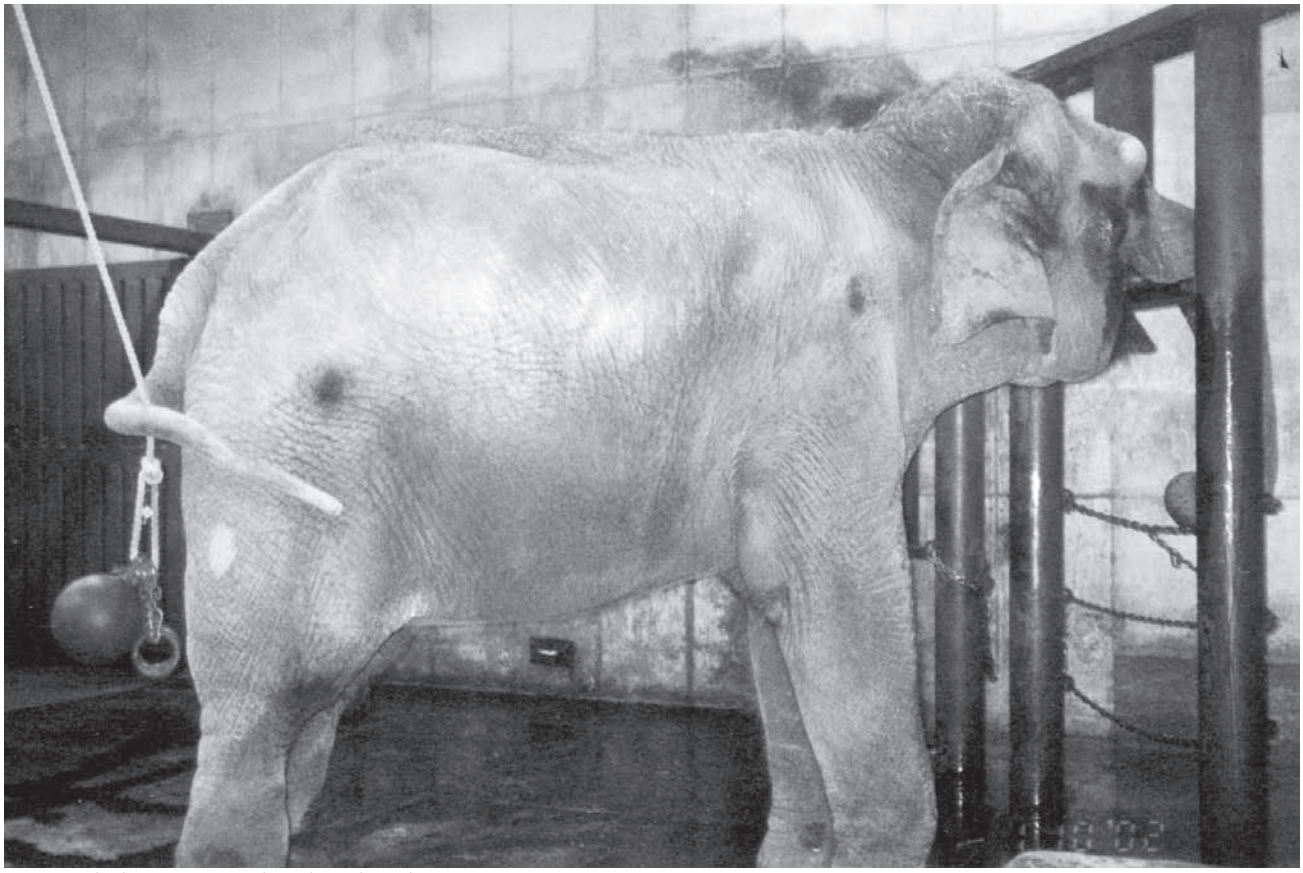
Creating the appropriate environment is the basis for all enrichment.

Enrichment Basics

Handlers should be required to provide environmental enrichment opportunities to their elephants on a regular basis. This practice should be a normal part of the handler's duties, and time should be allotted for them to do so. An enrichment program should consist of the following components.

1. An enrichment plan should be developed for elephants based on their natural history, individual history, and exhibit constraints. Enrichment initiatives and the goal of the enrichment (i.e., what behavior is being encouraged or discouraged, minutes of exercise per elephant per week, percentage of time elephants interact) must be identified, clearly defined, quantifiable, and established prior to beginning an enrichment program. The enrichment should:

- increase the elephant's activity level;
- allow elephants to make choices about how they interact with their environment;
- stimulate the elephant's mental capacity;



Rosamond Gifford Zoo at Burnet Park

Suspended toy manipulated with tail.

- produce species-appropriate behavior and decrease undesirable behaviors such as stereotypies, aggressiveness, coprophagy, etc.;
- improve the overall well-being of the elephant by allowing it to use its intelligence and physical abilities; and
- improve the educational experience for the public as the public observes species typical behaviors, such as foraging, social bonding, problem solving, etc.

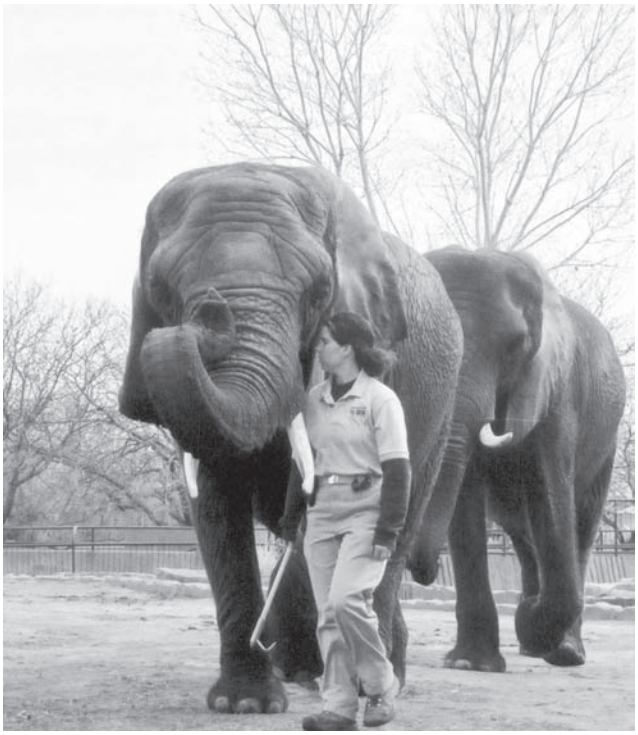
2. A list of approved enrichment activities should be maintained. For the elephant's health and safety, each activity should be approved by the facility management and veterinarian prior to being presented to the elephant for the first time.

3. Scheduling enrichment activities in advance is the best way to ensure that enrichment becomes a part of the everyday routine and that items are rotated through the exhibit. This makes it possible to plan the acquisition of items needed or prepare the exhibit or holding yard in advance. Producing a well-conceived rotating schedule in advance and keeping good records will increase the novelty and effectiveness of the enrichment.

4. As with any aspect of elephant husbandry, priority should be placed on the health and safety of the elephants, their handlers, and the public. It is crucial to observe the elephants when first giving them a new enrichment item to ascertain its safety and effectiveness.

5. An evaluation sheet should be used to document all enrichment practices. Having a record can be helpful when determining if the enrichment encouraged the goal behavior or in deciding how it may be altered to be more effective. This may also assist with efforts to foster communication between institutions regarding elephant enrichment. Observations, the amount of time decided in advance, should be made when the elephant first receives the novel enrichment. Notes should be taken of the elephant's reaction, positive or negative, and how long the activity occupies its time or encourages a desired behavior. Observations may be required throughout the day to document the amount of time the elephant is interested.

6. It is also important to re-evaluate the enrichment after the elephants have been exposed to it for a while to determine if it is still effective, since elephants tend to habituate to items quickly. Evaluation of the enrichment determines if the activity is actually successful in "enriching" the elephant's lives. The evaluation should be an ongoing process. As the elephants habituate to items or activities, it is important to know when to remove an object or how often to offer it. If at any time the elephant is no longer interested in that particular enrichment activity, the



Sedgwick County Zoo

Walking is a great form of exercise and enrichment.

activity can be removed from the schedule for a period of time and reintroduced at a later date. A calendar is an excellent means to record the enrichment given, its effectiveness, and to allow for scheduling in advance to make sure items are rotated through the exhibit to maintain the elephants' interest.

Enrichment Options

The following are enrichment ideas gathered from zoos all over North America. This list is not complete as the possibilities are endless with a little imagination and initiative. Because of the elephant's size and strength, it can be difficult to find enrichment items that will not be immediately destroyed. Although the items are not always "natural," they may still stimulate the same behaviors seen in the wild.

Food-Related Enrichment

The premise behind food-related enrichment is to encourage foraging behavior and stimulate exercise. The elephants must search for or devise ways to retrieve items, simulating food-gathering in the wild.

- Hide small food items around the exhibit for the animals to find.
- Place food items inside cardboard boxes.
- Drill holes in the sides of Jungle Balls® or Boomer Balls® and fill with food.
- Hang 55-gallon drums with holes in the sides as a feeder device.
- Freeze fruits and vegetables inside large volumes of water to create ice blocks. Use a 55-gallon drum cut in half or a garbage can for a container. A chain can be attached for the purpose of hanging.
- Dab peanut butter around the exhibit to initiate exploring.
- Bury carrots, peanuts, or other food items in the sand around the exhibit.
- Cement PVC pipes (trunk size) in a wall with both ends open. Place food items, such as whole apples, inside the pipes so the elephants have to "vacuum" them out.
- Create log feeders.

Creating an Enrichment Program

1. Handlers should decide which behaviors are desireable and make a list of behavioral goals.
2. Make a list of all current, approved enrichment practices.
3. Identify new enrichment ideas by making a list of any enrichment practices, novel ideas, or items currently being used by others. These practices must be approved by management prior to implementation.
4. Logistics

Discuss the ideas with management to evaluate any safety issue concerning the elephants, staff, or public.

Discuss ideas with the graphics/public relations departments for suggestions to make the enrichment devices more aesthetically pleasing and for public education opportunities.

Discuss ideas with the maintenance department for ideas on construction of the device.

List all items needed to make the enrichment.

5. Using an enrichment schedule, plan a week or month of enrichment activities in advance. This will make it easier for the elephant staff and assure that the activity will take place by making it part of the daily routine.
6. Use an enrichment evaluation sheet for each time an activity is presented to the elephant to document whether it encouraged the goal behavior.
7. Create an enrichment notebook that includes all the schedule sheets and evaluations for each individual elephant or the group. The notebook will provide a quick reference as to the activities used and their successfulness.
8. An enrichment sign should be provided outside of the elephant enclosure describing the enrichment practice to the public. This will explain why there may be an unnatural item in the area or help them to find the enrichment activity.

Fort Worth Zoo Enrichment Request

Name / Contact: Date:

Department:

Species:

Enrichment is for : Exhibit Off Exhibit

Description of enrichment: (include all necessary materials, safety concerns, etc):

Goals of enrichment (justification, explanation of stereotypies):

Does item need to be: Purchased Constructed

Estimated cost: $0–20 21–50 $51–100 Over $100

Staff time investment for: Installation Construction

Staff time available for documentation:
None Checksheet Behavior observations

Attach drawings if applicable or sketch on back side of this sheet

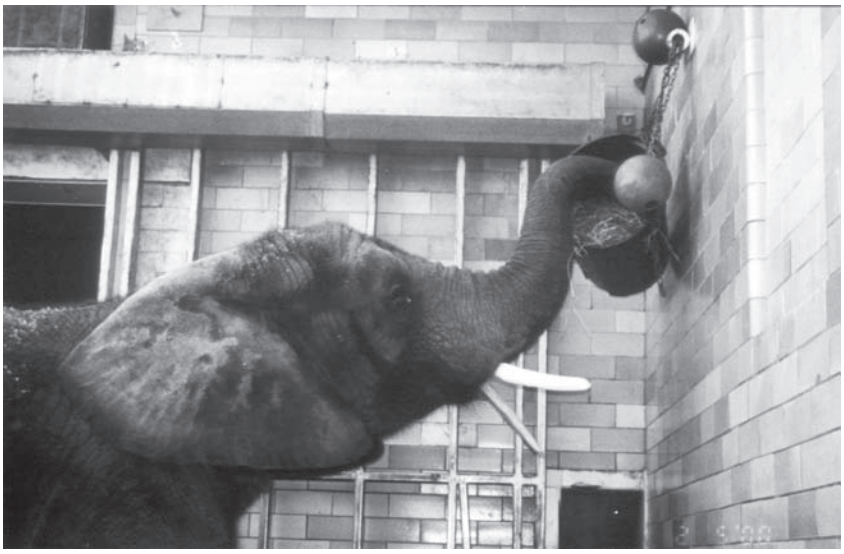
OFFICE USE ONLY COMMENTS

Engineering cost estimate attached:

Approval (attach comments as needed) Date

Conservation Biologist
Curator
Veterinarian / Nutritionist
(if applicable)
Director of
Conservation & Science

APPROVED NOT APPROVED Date



Gail Tabone, Seneca Park Zoo

Treats buried in a suspended bucket of hay make the elephant work a little harder for its reward.

Scents

The purpose of using scents is to stimulate olfactory senses. Spraying or sprinkling different scents around the elephant's enclosure also encourages them to move around the whole space. This is particularly effective in large exhibits where the animals tend to stay in one favorite spot. Many scents have been tried with elephants, and the following have elicited the most response.

- allspice
- cinnamon
- nutmeg
- cloves
- coriander
- chili powder
- paprika
- anise
- vanilla
- urine and feces from other animals (free from parasites)
- doe/buck scent and other hunting lures
- fresh herbs

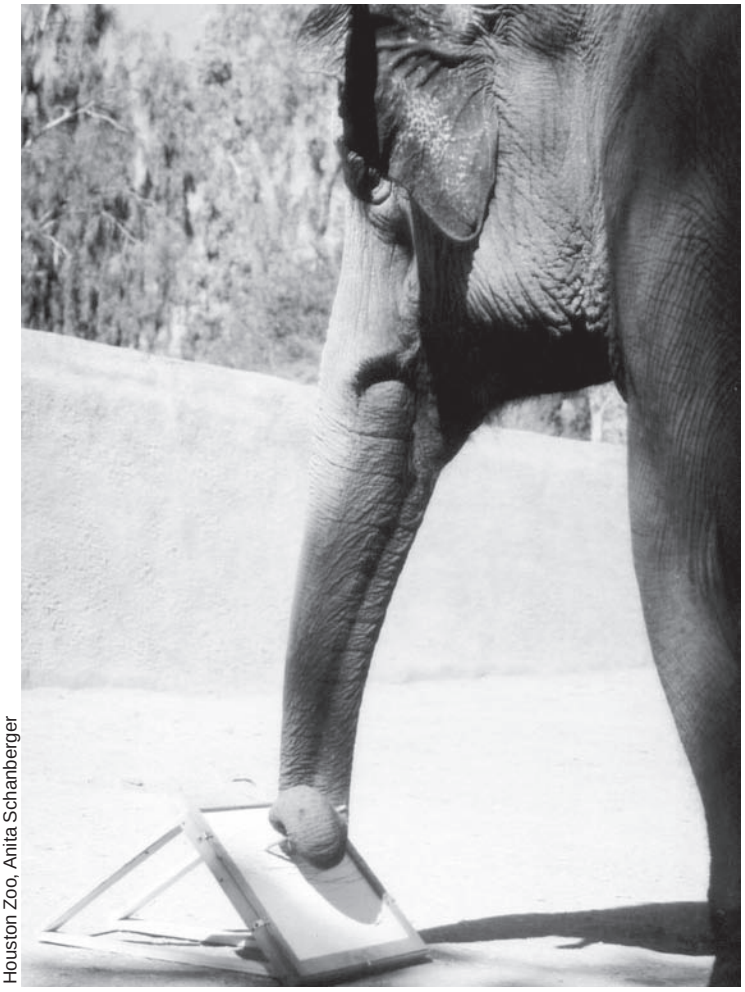
Natural Items

Items such as fresh browse, fresh logs, peat moss, earth, root balls, and sand can also be provided to evoke natural investigative behaviors. The browse is eaten, the bark is stripped off the logs and consumed, and the other substances provide digging and dust bathing opportunities. These are all behaviors elephants perform in the wild.

Toys or Manipulative Items

Providing objects for the elephants to play with or otherwise manipulate is important to develop motor skills and stimulate the mind.

- String tires on a chain.
- Hang 55-gallon drums.
- Hang a fire hose between two trees or poles, to be used for rubbing
- Place large Boomer Balls® or Jungle Balls®, bowling balls, or empty beer kegs in exhibit.
- Large cardboard carpet rolls and 3-foot-long rawhide bones can also be placed in the elephant's exhibit.



Houston Zoo, Anita Schanberger

Elephants appear to enjoy painting, and humans appreciate the final product.

Disney's Animal Kingdom—Enrichment Assessment

Handlers are asked to assess direct evidence (they observe the elephant's response to some enrichment) and/or indirect evidence (handlers are unable to directly observe elephant's response, but look for evidence that the elephant had interacted with the enrichment provided). Both direct and indirect evidence are scored on a five-point Likert scale. Although this assessment tool has yet to be validated, it is felt that it represents an important first step in systematically assessing the impact of enrichment.

Rating Scales for Enrichment
Direct Evidence (handler observed and measuring how much elephant is interacting with enrichment)
1= elephant runs/flees from enrichment
2= elephant appears to ignore enrichment
3= elephant orients to/looks at, but does not physically contact enrichment
4= elephant makes brief contact, (sniffs/licks enrichment)
5= elephant makes substantial or repeated contact with enrichment

Indirect Evidence (handler is unable to observe)
1= no evidence of interaction
3= moderate evidence of interaction
5= significant evidence of interaction

Evaluation of enrichment simply involves asking the question: Did the enrichment plan achieve its desired goal? The handlers' assessment of the enrichment can be examined for trends. The data can provide information on the elephant's response to an enrichment item over time and thus suggests the frequency of delivery for optimal effectiveness.

Rating measuring if enrichment achieved any of the intended goals
1= no reaction, did not achieve any goal behaviors
2= elephant reacted, but behaviors were unrelated to planned goal. Describe behaviors
3= some reaction, achieved some of the goal behaviors
4= moderate reaction, achieved moderate amount of goal behaviors
5= strong reaction, encouraged many goal behaviors

- Create a rolling pipe toy out of 8' long PVC pipe capped at both ends and filled with gravel or a fiddle chain from odd bits of iron strung to a sturdy chain and shackle to a fence.
- Make snowmen in the exhibit.

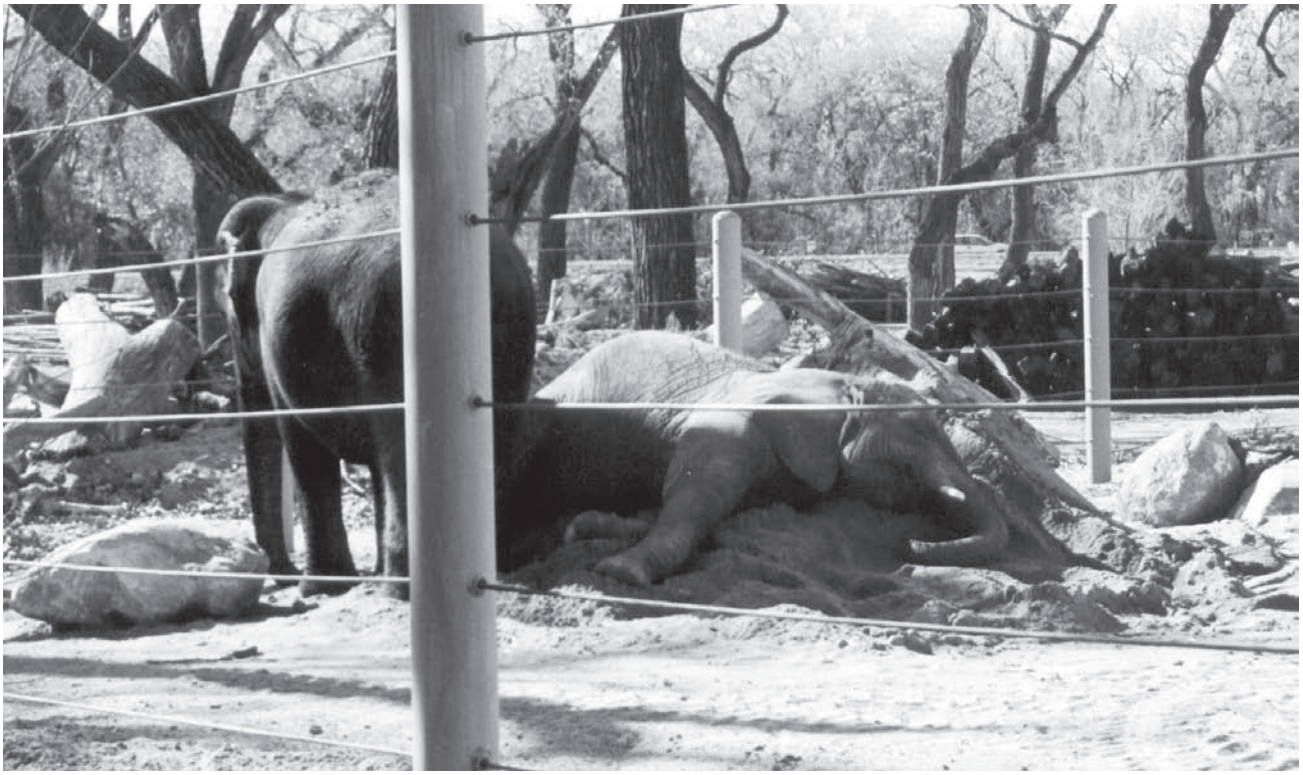
Husbandry
- Change the daily routine;
- leave elephants in the exhibit overnight instead of night holding;
- provide access to both night housing and exhibit; and
- provide food several times during the day.

Physical changes to the exhibit
- Rearrange exhibit or night holding "furniture;"
- add plants, shrubs, trees; and
- add deadfalls

Auditory
- Use recorded vocalizations of animals of a different species;
- use recorded vocalizations from elephants at a different institution; and
- use recorded sounds from the natural habitat.

Social Structure
- Add new individuals;
- make any change to the social group; and
- create a mixed species exhibit.

Training
- Shift elephants on and off exhibit;
- train new husbandry behaviors;
- desensitize elephants to novel situations;
- train elephants to demonstrate natural behaviors on cue; and
- modify existing natural behaviors



Albuquerque Biological Park

A suitable physical environment can encourage elephant-appropriate behavior.

Buffalo Zoo

A water hose provides a cognitive challenge to the elephant as it manipulates the spray of water.

Enrichment Web sites

www.enrichment.org
www.zooregon.org/cards/Enrichment/enrich.htm
www.enrich.org/aazk
www.enrichmentonline.org
www.folsom.ca.us/zoo/games/html
www.tamu.edu/ethology/Concepts/DT_AS.htm
www.animalenrichment.org
www.animaltraining.org
www.animalwelfare.com/Lab_animals/biblio/enrich.htm
www.well.com/user/abs/dbs/eesb
www.humbolt1.com/aak/n7.htm
www.wwwebspace.co.uk/
www.lazoo.org/elephants/b-e.html
www.wolfpark.org/Links_enrichment.html
www.birminghamzoo.com/sorty/past/dec/001216.html

Evaluation of Enrichment Practice

Species: Elephant's name:

Date of enrichment: Is this the first time this activity was presented?

Description of Enrichment Practice:

Observation on initial reaction to enrichment (after 15 minute observation):

1. Did all of the elephants in the enclosure react to the enrichment? Yes No

2. Was there any negative response to the enrichment? Yes No

Explain:

3. How long did the elephants react to the enrichment?

Describe the actions of the elephants upon presentation of the enrichment activity:

Were the elephants still using the enrichment after

1 hour	Yes	No
2 hours	Yes	No
3 hours	Yes	No
4 hours	Yes	No

Observations of the enrichment activity made throughout the day:

Recommendation for future use:

Completed by:

Date:

Fort Worth Zoo
Keeper Checksheet - Elephants

Item:
Date: Weather: __ On exhibit __ Off exhibit

Time	Animal	Locomotion	Eating	Foraging	Affiliation	Aggression	Sway/Rock	Stereotypy	Inactive	Out of View	Other	Contact/Manipulation	Indirect Evidence of Use	Initials	Comments
	Groucho														
	Rasha														
	Kimbo														
	Babe														
	Blue														
	Angel														
	Groucho														
	Rasha														
	Kimbo														
	Babe														
	Blue														
	Angel														
	Groucho														
	Rasha														
	Kimbo														
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	Babe														
	Blue														
	Angel														
	Groucho														
	Rasha														
	Kimbo														
	Babe														
	Blue														
	Angel														
Total AM	**Groucho**														
Total PM	**Groucho**														
Total AM	**Rasha**														
Total PM	**Rasha**														
Total AM	**Kimbo**														
Total PM	**Kimbo**														
Total AM	**Babe**														
Total PM	**Babe**														
Total AM	**Blue**														
Total PM	**Blue**														
Total AM	**Angel**														
Total PM	**Angel**														

See next page for instructions on how to use this sheet.

FWZ 6/98

Directions for Using the Fort Worth Zoo's Handler Check Sheet for Elephants

When taking observations, handlers should make every effort to avoid being detected by the elephants and potentially affecting their behavior.

During an observation period, the handler should scan the group (or individual) and indicate which behavior each elephant is exhibiting AT THAT INSTANT.

When observing elephants:

a. One behavior should be checked on the left side of the bold line for each elephant in the exhibit.

b. When enrichment is present, the handlers should indicate if any contact or evidence of contact with enrichment item occurs during or seems to have occurred since the last observation period.

* For example, if the elephant is given bamboo feeders and during the observation period, he/she is holding onto the feeder while traveling across the exhibit, the handler would check "locomotion" to the left of the bold line and "contact manipulation" on the right side of the bold line.

* If the enrichment item appears to have been moved or manipulated in some way since the last observation but the elephants are not in contact with the item at the time of the observation, a check mark should be made in the "indirect evidence of use" column.

c. If enrichment is not present, only the behaviors on the left side of the data sheet should be used.

d. If the behavior is not listed on the data sheet, handlers should check the other box and describe the behavior in the comments column on the right side of the data sheet.

Education

Every day someone sees or perhaps even touches an elephant and gains a greater understanding of the animal he or she has known only from picture books and video. Every day young and old alike marvel at an elephants' strength and agility, its intelligence and personality, and its ability to make you gasp and laugh. Every day the people who exhibit elephants in facilities of all types plant important seeds of conservation in fertile minds, creating concern where before there was apathy and raising consciousness about the world's largest land animal. Every day the work to save elephant habitat helps in conserving many other kinds of wildlife. The popular appeal of elephants is so great that attention and efforts garnered to save this flagship species benefits many endangered animals.

As with many species threatened with extinction, captive management programs are becoming increasingly important to the survival of elephants. The opportunities for people to learn about and appreciate elephants is perhaps the most important reason for elephants to be maintained in captivity—as ambassadors of their species. It is the general public who will decide the eventual fate of elephants in the wild, and conservation of their habitat and our environment as a whole. It is important that people are exposed to elephants in a variety of situations—from the zoo, to the circus, to private facilities, to the wild. Ultimately, the more people know about elephants as individuals the more likely they are to care about what happens to them *as a species*. Successful conservation programs are realized through the education of the decision-makers of tomorrow. As people become more and more removed from the natural world, every person who can be reached is a potential conservationist, and there are no such things as surplus conservationists.

Caring for the world's largest land mammal provides a wonderful opportunity to encourage humans to explore the world of the Asian and African elephant. Through

Six Flags Marine World

Giving people an opportunity to learn about and appreciate elephants is perhaps the most important reason for elephants to be maintained in human care.

Deborah Olson, Indianapolis Zoo

Making use of other media outlets is key to an education program.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Every institution should institute a program to educate zoo visitors about elephant and elephant conservation issues."

organized educational classes and impromptu elephant-human interactions, people investigate elephant evolution and anatomy; learn how elephants are cared for; understand the interesting behaviors demonstrated by elephants; investigate the threats facing elephants today and are empowered to seek and participate in solutions. Elephants can be a tool to study concepts in Life Science, Social Studies, Language, Mathematics, Fine Art, Geography, and Physical Education.

Unlike schools, elephant facilities offer life-long learning opportunities. Our "students" can range in age from 1 to 100. Although everyone who works with an elephant, regardless of the capacity, can be an educator, education departments provide an organized structure for learning. Formal education departments can develop programs that meet National Science Education Standards appropriate for the age and learning abilities of the student. In addition, education departments have staff trained specifically to educate, understand the audience's cognitive skills and needs, and are knowledgeable about the means of shaping positive visitor experiences. Formal education classes should be developed with curricula appropriate for the elephant facility, formal classroom, home-schooling, and the public education system. Education departments should work closely with the elephant manager, trainers and veterinary staff in order to develop a positive and well-informed message.

With advances in modern exhibitry, the presentation of the educational message has improved dramatically. Larger enclosures allow for larger groups of elephants, more activity, and therefore increased species appropriate behaviors. New exhibitry and educational techniques allow opportunities for stationary and interactive graphics. Graphics can be displayed alongside the elephant enclosures and/or in dedicated buildings devoted to imparting the educational message of the facility. Graphics and interactive devices can demonstrate how the elephant's trunk works, illustrate the anatomy of the elephant's foot, display the tools used in captive management, and even demonstrate current scientific investigations such as the

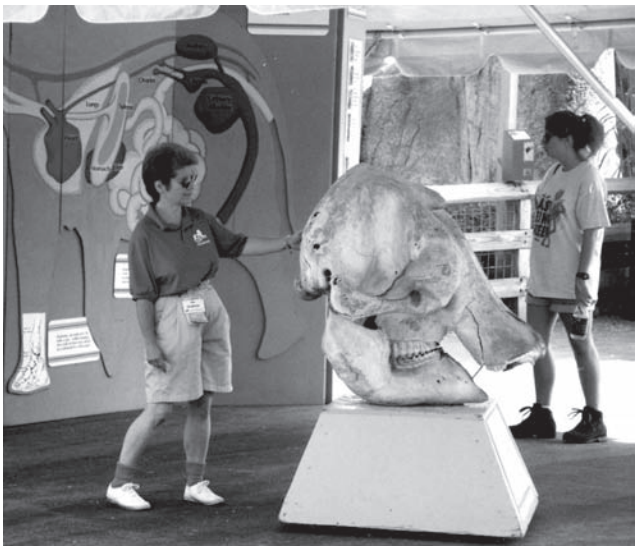
Buffalo Zoo

An elephant enthusiast is born. Here, a young visitor gets his hands wet learning how to care for an elephant.

Six Flags Marine World

Six Flags Marine World

Deborah Olson, Indianapolis Zoo



Deborah Olson, Indianapolis Zoo

Graphics strategies: Top left and top right: Graphics can be displayed alongside the elephant enclosure. Bottom left: An excellent outreach strategy is to station volunteers with educational materials at the enclosure. Bottom right: Dedicated buildings offer even more options.

ultrasound of a fetus and the real-time infrasonic vocalizations of the herd.

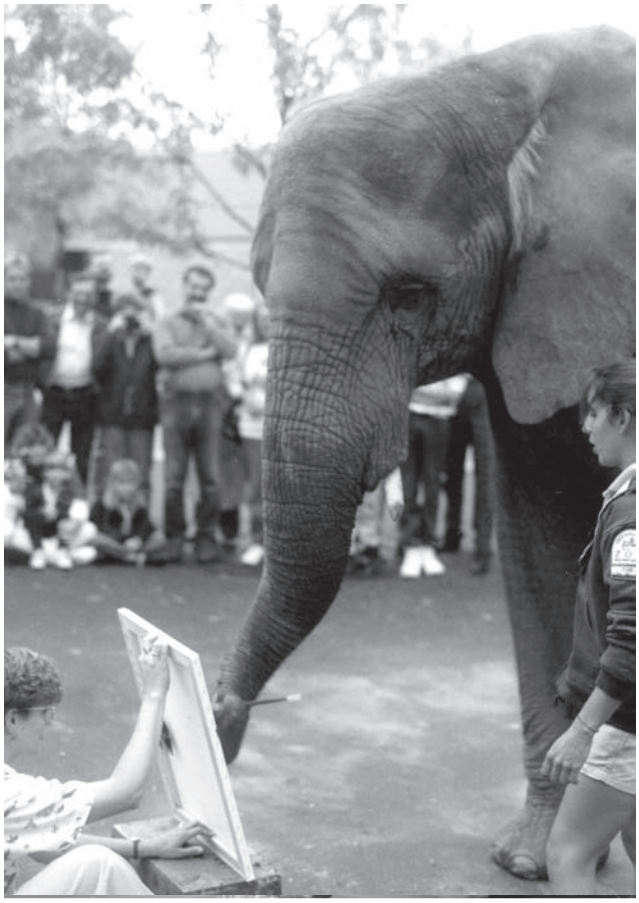
At some facilities, permanent graphics are not possible or effective. In that case, hand-outs, audio message systems, or guided tours can be extremely successful. In addition, an excellent educational opportunity can be realized by stationing volunteers and/or staff well-versed in the natural history of elephants at the elephant enclosure. Studies demonstrate that the public enjoys the opportunity to interact with the facility's staff, and education occurs from discussions transpiring while viewing the elephants.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Every institution should have up-to-date educational graphics and/or information about elephants on display to the public."

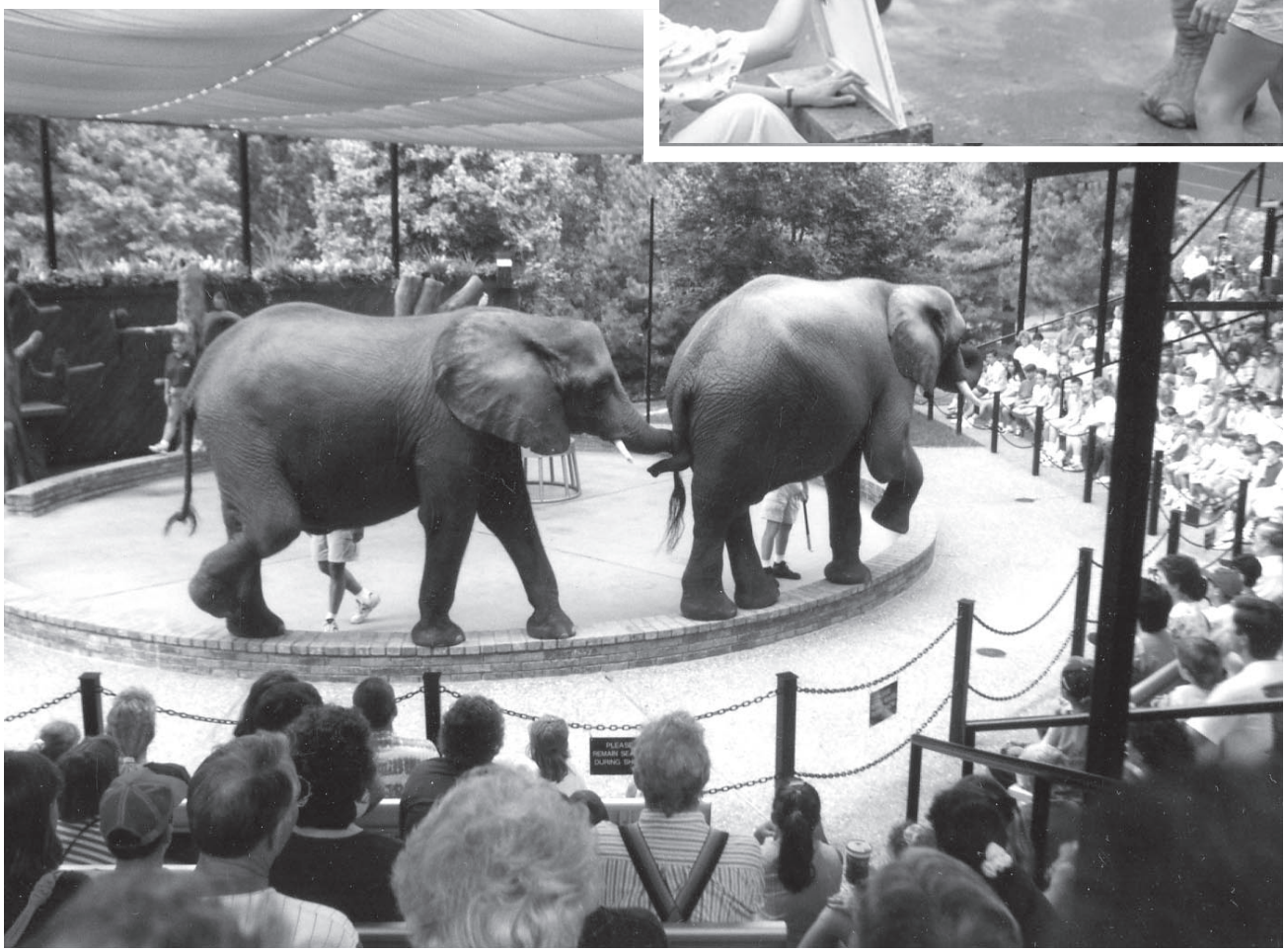
There are many gaps in our knowledge about elephants that must be filled if we are to save them for future generations. Many of these questions can only be answered through scientific inquiry using captive elephants. The research that provided the insight we now have into elephant reproduction, memory, visual acuity, nutritional requirements, pathology of disease and its treatment would have been impossible to conduct in the wild. The science that underlies these incredible accomplishments is truly astounding. It is strongly recommended that not only should this research be put to good use in the conservation of elephants, it should also be used to educate the public about elephant issues and the role of science in resolving these issues.

Topics recommended for graphics, interactives, written materials, curriculums, and discussion are (but not limited to)

- natural history
- captive elephant management
- husbandry requirements
- behavior enrichment
- conservation issues



Deborah Olson, Indianapolis Zoo



Grant's Farm, Deborah Olson

Elephant demonstrations feature the biggest, most impressive learning tools . . . the elephants themselves. Top: Crowds gather for a painting demonstration. Below: Audiences enjoy learning about elephants' intelligence and dexterity.

Six Flags Marine World

Often, the best form of education is entertainment.

- current scientific investigation
- reproduction
- sources of additional information
- ways individuals can become involved

Often times the best form of education is through entertainment. Elephant demonstrations feature the biggest and most impressive learning tools—the elephants. Thrilling an adult or child with the intelligence and physical abilities of an elephant through entertaining performances have been shown to be an effective educational strategy. The opportunity to experience the great size of an elephant, the texture of its skin, and its very own elephant odor contributes to a greater understanding and respect for elephants and their habitat. Demonstrations should have a strong educational content with respect to elephant behavior, management, habitat destruction, and population decline. These demonstrations should also attempt to meet some of the daily physical and mental exercise requirements of the elephants. Performances derived from natural behaviors that have been modified—for example, tub and ground sits, walking on balance beams, long mounts, and so on—are acceptable forms of education, mental stimulation, and exercise for the elephant.

Some elephant facilities view elephant rides as an important management and education tool. The regular exercise received by giving rides to visitors is an excellent way to provide elephants with physical and intellectual activity. The elephant is mentally stimulated by the sights, sounds, smells, and the people they meet. The elephant handler uses the ride to promote the bond between the elephant and handler. The two must work together,

Sedgwick County Zoo

Studies demonstrate that the public enjoys the opportunity to interact with elephant staff. This is a primary education tool, and elephant managers should create as many staff-public interactions as possible.

Elephant Ride Guidelines

1. Good dispositions and calm personalities are requirements for any elephant chosen to give rides.
2. Each ride elephant must receive extensive training to become familiar and comfortable around bright lights, loud noises, vehicles, fireworks, other animals, music and other activities that might cause excitement.
3. Two qualified elephant handlers should be present at all times while the rides are operating.
4. All handlers must be trained in safe handling of riders, dealing courteously with patrons, and contacting proper authorities in case of an emergency.
5. The ride platform and saddles must be cleaned and inspected for safety daily before giving rides. Worn or damaged parts must be replaced prior to the first ride.
6. The elephant must be visually inspected and all debris brushed or hosed off before saddling.
7. The elephant's feet must be inspected for any foreign objects prior to the first ride.
8. The elephant handler must physically and visually check the saddle for proper placement and necessary adjustments before giving any rides.
9. For loading of riders, the elephant is to stand erect, touching the platform with its right shoulder and hip.
10. The handler must make a visual inspection of the riders and confirm that the elephant is properly loaded before leaving the platform.
11. The handler must make frequent visual and verbal contact with the riders to ensure that the riders are sitting appropriately in the saddle and to answer questions.
12. The elephant must not be positioned next to the loading platform if a loader is not in place to assist the guests on and off the elephant. This will prevent the guests from mounting or dismounting without assistance.
13. During any exchange of handlers, the new handler must physically check the saddle for proper placement and make necessary adjustments.
14. The elephant must be provided water as necessary and hosed periodically for cooling in warm weather .
15. The ride area should be kept clean of debris and manure.
16. At the end of the ride period, the elephant must be unsaddled, visually inspected, and the bottom of its feet checked before returning the elephant to its holding.
17. At the end of the ride period, the saddle and all tack must be inspected, and any worn or damaged equipment must be noted for replacement. The supervisor must also be informed of the needed repairs.

communicating by voice and body language to be an effective team. Most importantly, elephant rides provide the public with a unique first-hand experience. Sitting on the back of an elephant provides a perspective of the elephant that cannot be gained through any other medium. Additionally, this experience allows a unique educational opportunity for the guest to chat one-on-one with the handler.

Elephant handlers should always remember that their actions and facial expressions will be closely scrutinized by the public. It is important that the concern and love handlers have for their charges and the profession is easily recognized by the public. Handlers should make themselves accessible to the public, be presentable in appearance, speak knowledgeably, anticipate the public's concerns, and be available to address these concerns. The public wants to believe that elephant facilities are "doing the right" things, and it is extremely important that handlers help the public interpret what they observe. Experienced handlers can assist new handlers in their interaction with the public by helping prepare standard answers for all common questions. In addition, recording all new questions or concerns presented by the public and reviewing these regularly, will asssist all handlers become better informed and better able to educate.

Handling complaints is an often overlooked educational opportunity. The public is more sensitive than ever to animal welfare issues, and very willing to speak up when concerned. Visitors have probably read the variety of viewpoints offered by animal rights and environmental organizations. Without adequate explanation, the public may misinterpret the training methods, elephants in captivity, group size, and individual elephant actions, among other things. Concerns and complaints by the public must be handled immediately, honestly, sincerely and with sensitivity. Time and effort must always be taken to explain elephant management philosophy and to attempt to create an understanding about elephants in human care.

Additional information regarding the care and management of captive elephants, conservation issues, education and research programs, etc. can be found in a variety of sources:

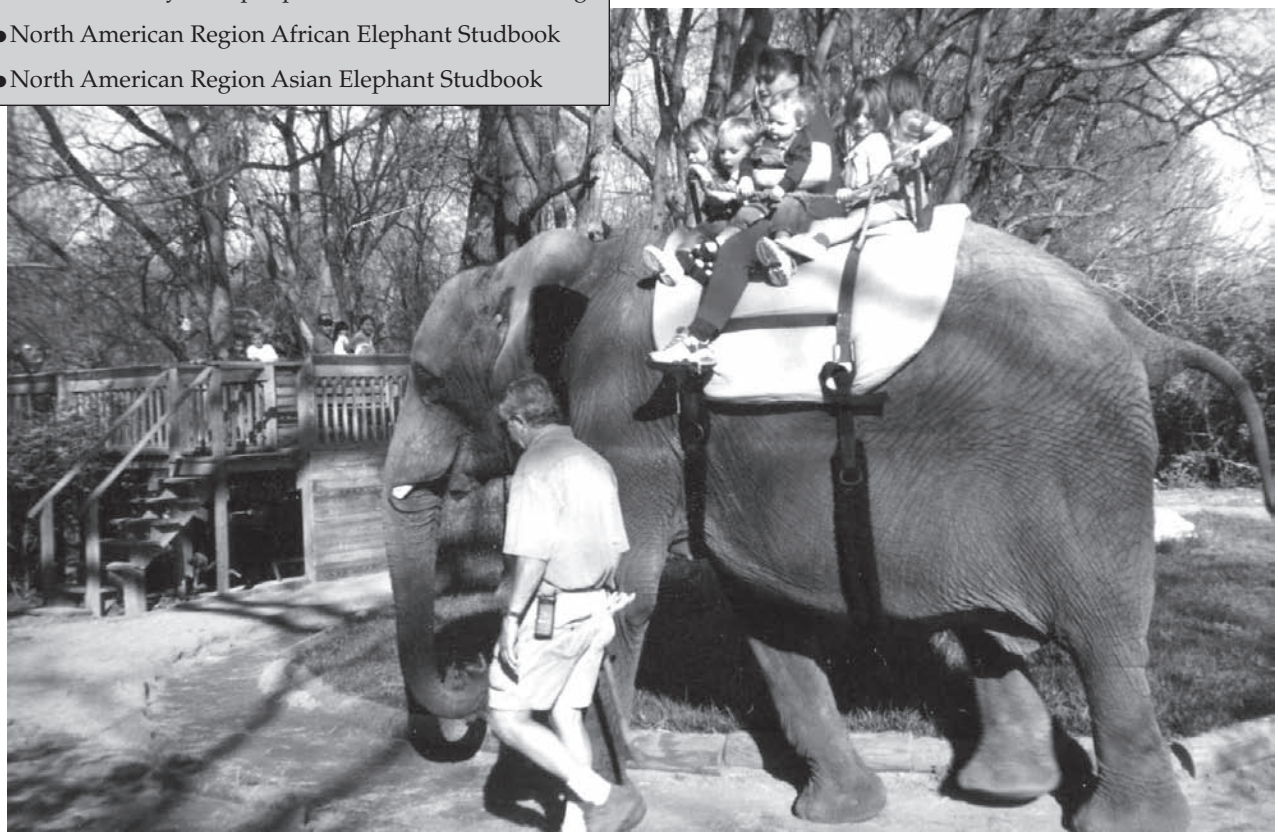
- Elephant Managers Association (EMA) hosts an Annual Conference and publishes yearly, six newsletters and three issues of the *Journal of the Elephant Managers Association*; www.elephant-managers.com
- ELEPHANTS: CONSERVATION TODAY AND TOMORROW. A Teaching and Curriculum Guide for Kindergarten to Grade 12—prepared by the Elephant Manager's Association, www.elephant-managers.com
- International Elephant Foundation, www.elephantconservation.org
- Elephant Care International, www.elephantcare.org
- Riddles Elephant and Wildlife Sanctuary, www.elephantsanctuary.org
- European Elephant Keeper and Manager Association, www.eekma.org
- Elephant Managers and Owners Association, www.emoa.org
- African Elephant Specialist Group, www.iucn.org/afesg
- Save the Elephants, www.savetheelephants.org
- U.S. Department of Agriculture's Animal Welfare Act
- American Zoo and Aquarium Association Elephant Taxon Advisory Group/Species Survival Plan, aza.org
- North American Region African Elephant Studbook
- North American Region Asian Elephant Studbook

Elephant demonstrations feature the biggest and most impressive learning tools—the elephants. There are three basic types of demonstrations.

- Stationing an elephant handler, educator, or volunteer outside of the elephant exhibit to present a prepared talk followed by questions from the audience.
- Demonstration by the handlers of basic training and husbandry behaviors. A handler or an additional person narrates a script and/or interacts with the audience.
- Advanced demonstrations exhibit natural behaviors that have been modified to resemble "tricks." These tricks are eye-catching and entertaining to the audience, and when paired with an effective script, can be very educational.

Some basic components of effective demonstrations:

- skilled handlers
- capable speakers
- researched and well-prepared material
- script tailored to the audience demographics
- professional presentation
- an opportunity for the audience to ask questions
- an opportunity for the audience to interact with an elephant.



Chuck Pankow

Some elephant facilities view elephant rides as an important management and education tool.

The Elephant Managers Association (EMA) has developed an extensive K-12 curriculum. Educators should contact Chuck Doyle, EMA, 1 Conservation Place, Syracuse, NY 13204 for more information. The next 5 pages show an outline of the lesson plans.

Kindergarten through Fourth Grade Lesson Plan

Subject	Rationale	Objective	Lesson	Activity
Language Arts Life Science	The beginning of the lesson is meant to introduce the topic of elephants to the students. This portion will help them become familiar with them.	Students will be able to recognize and use vocabulary words associated with elephants.	Present and define vocabulary terms.	Vocabulary Word Search Puzzle (A-1) Decoding Activity (A-2) Elephant Poem (A-3)
Life Science Mathematics	This portion of the lesson is to help students become more knowledgeable about elephant physical features.	Students will be able to identify basic elephant physical characteristics.	Discuss features of elephant such as tusks and trunk.	How many elephants can you find in the picture? (A-4)
Life Science Geography	This section of the lesson will broaden students' knowledge of elephant physical characteristics between the different elephant species.	Students will be able to determine the difference between African and Asian Elephants.	Discuss the different physical characteristics between the two species. Also discuss their habitats.	Listing the differences between the two species. (A-5)
Life Science Mathematics	This portion of the lesson will help students relate elephants to other living and non-living organisms.	Students will be able to compare elephants with other organisms.	Describe the size of elephants and compare their size to other organisms.	Name objects larger and smaller than elephants (A-6)
Life Science Social Studies Language Arts	The final portion of this lesson will help students obtain a broader knowledge of elephants including information about their social behavior.	Students will be able to understand elephant social behaviors including information about their life cycle.	Discuss the elephant social behavior including topics such as matriarch, infrasound, rumble, cow, calf, and bull.	Writing exercise about elephants in the wild and have students share their stories (A-7) Elephant Maze (A-8)
Assessment	To determine the effectiveness of the lessons and to evaluate student learning.	Students will be able to complete with 80% accuracy the multiple choice elephant quiz based on the above lesson.		Elephant Quiz (A-9)

Fifth through Eighth Grade Lesson Plan

Subject	Rationale	Objective	Lesson	Activity
Life Science Language Arts	This lesson is to provide students with background information and terms about elephants.	Students will be able to identify and explain vocabulary terms pertaining to elephants.	Present and define vocabulary terms.	What Will We Be Studying Activity (B-1) Vocabulary Word Search Puzzle (B-2)
Life Science Fine Art	This lesson is to enable students to become more aware of elephant physical features.	Students will be able to recognize elephant physical features.	Discuss the different physical features of elephants including their trunk, tusks, ears, etc.	Create an elephant with recycled products (B-3)
Life Science Physical Ed.	This lesson is designed to help students learn cooperation skills necessary to live in a group—much like elephants.	Students will learn cooperation skills through elephant relay activity.	Give students the opportunity to make their elephant relay sheet and develop a plan for their race—Relate their need for cooperation to that of elephants social system.	Elephant Relay (B-4)
Mathematics	This will help students develop an understanding of the enormity of elephants as well as help them develop mathematical skills.	Students will learn how to mathematically convert pounds to tons.	Provide students with background information on making conversions.	Tons of Elephants (B-5)

Fifth through Eighth Grade Lesson Plan (Con't)

Subject	Rationale	Objective	Lesson	Activity
Life Science Fine Art Geography	The purpose of this activity is to create an awareness and understanding of the habitats in which elephants live.	Students will be able to describe various elephant habitats.	Discuss the difference between tropical forests, desserts, savannas, and tropical beaches.	Creating an Eco-Box (B-6)
Life Science Social Issues	The purpose of this study is to create interest and awareness in the many conservation issues surrounding elephants, and to encourage students to become proactive in conservation issues.	Students will be able to recognize various conservation issues that involve elephants.	Provide students with background information on the importance of zoos, the importance of elephants in the wild, and the significant impact that poaching has on elephants.	Role-play activity (B-7)
Life Science Social Studies	This lesson will provide information on how elephants are managed in captivity.	Students will obtain an understanding of zoos and circuses, including husbandry and training.	Continue the discussion of elephants in captivity focusing on training and enrichment.	The Training Game (B-8)
Assessment	To determine the effectiveness of the lessons and to evaluate student learning.	Students will be able to answer Jeopardy questions with a minimum score of 4000 points.		Elephant Jeopardy (B-9)

Ninth through Twelfth Grade Lesson Plan

Subject	Rationale	Objective	Lesson	Activity
Life Science Language Arts	The purpose of this lesson is to develop student awareness of basic elephant terminology.	Students will be able to recognize and define words associated with elephants.	Present and define vocabulary terms.	Vocabulary Word Search Puzzle (C-1)
Life Science	This lesson will allow students to become more aware of the impact that elephants have on the environment that surrounds them.	Students will be able to recognize the relationship between elephants and the organisms that surround them.	Discuss the relationship between elephants and their environment. Provide information about the feeding habits of elephants and the organisms that surround them.	Creating a Food Web (C-2)
Life Science Fine Art Geography	This lesson will present physical features and social patterns of elephants.	Students will be able to recognize physical features of elephants and demonstrate the social behaviors of elephants.	Provide students with information about the physical characteristics of elephants and with this knowledge relate features of their anatomy to their social behavior.	Masks & Plays (C-3)
Life Science Geography	This lesson will enable students to use an evolutionary time line and provide them with evidence of how elephants have changed over time.	Students will be able to classify elephants according to an evolutionary time table.	Provide students with information about the evolution and classification of elephants.	Elephant Evolution (C-4)

Ninth through Twelfth Grade Lesson Plan (Con't)

Subject	Rationale	Objective	Lesson	Activity
Life Science Social Studies Language Arts	This lesson will provide students with an understanding of the many conservation issues affecting elephants.	Students will be able to use written and verbal skills to relate elephant conservation issues.	Provide students with the costs and benefits of keeping elephants in zoos and the positive and negative affects of culling.	Creative Writing—Poetry and Essays (C-5) Culling Debate (C-6)
Life Science Social Studies Language Arts Geography	The lesson will encapsulate information students have learned about elephants, and foster their understanding by having them develop a presentation about elephants.	Students will be able to create a power point presentation providing information about elephant anatomy, management, evolution, and conservation.	Connect all of the information about elephants previously discussed in the lessons, so that students can present information about elephants.	Power Point Presentation (C-7)
Life Science Social Studies	This lesson will provide information on how elephants are managed in captivity.	Students will obtain an understanding of zoos and circuses, including husbandry and training.	Continue the discussion on elephants in captivity focusing on training and enrichment.	The Training Game (B-8)
Assessment	To determine the effectiveness of the lessons and evaluate student learning.	Students will complete with 80% accuracy the multiple choice and short answer elephant quiz.		Quiz (C-8)

Research Initiatives

Humans have learned more about elephants and their needs in the last 20 years than in the last 200 years. Despite that rapid progress, there is still much to learn about their behavior and physiology. Part of the challenge has been the elephants themselves: their large size, the expertise required to manage them, the specialized facilities to house them, and their unique physiology. There are also limited resources, including a lack of sufficient numbers of elephants, lack of adequately trained staff and investigators, and lack of funding for conducting comprehensive studies. In general, there has not been a systematic or coordinated program of research for elephants. Establishing organized scientific studies on elephants is crucial to the future creation and maintenance of self-sustaining captive populations. In addition, with the serious depletion of natural populations, the survival of elephants in the wild may depend on the knowledge gained through coordinated research efforts.

To initiate a methodical and organized program of research, regional and global communication must be improved. Communicating and coordinating efforts will allow a greater contribution to overall efforts to conserve both wild and captive populations of elephants and decrease redundant research. Some means of improving communication are to:

- conduct a formal survey of research activities: present and historical, national and international, *in situ* and *ex situ*;
- compile an easy-to-access, up-to-date database of all elephant-related research and publications; and
- compile a "professional" directory dividing research by discipline to establish global *in situ* and *ex situ* connections.

The following is an overview of current research, program initiatives, and speculation on future needs.

Male Elephant Fertility

For successful self-sustaining breeding programs, it is important to understand what proportion of the male elephant population is fertile, at what age males mature,

Deborah Olson

The International Elephant Foundation hosts an annual elephant research symposium to increase communication and coordinate an organized program of research.

International Elephant Foundation, Deborah Olson

Organized discussions of elephant issues are crucial to the future of elephants in the wild and in captivity.

and specifics of the male's reproductive potential. Males have been observed breeding as young as 5 years of age in captivity, but it is not known at what age they actually reach puberty (when fertile sperm are produced) or if there is an age difference at puberty between species. Reproductive senescence is not uncommon in species with long lifespans. However, little is known about normal reproductive senescence in the elephant or if age-related pathologies and changes in semen quality occur in older bulls.

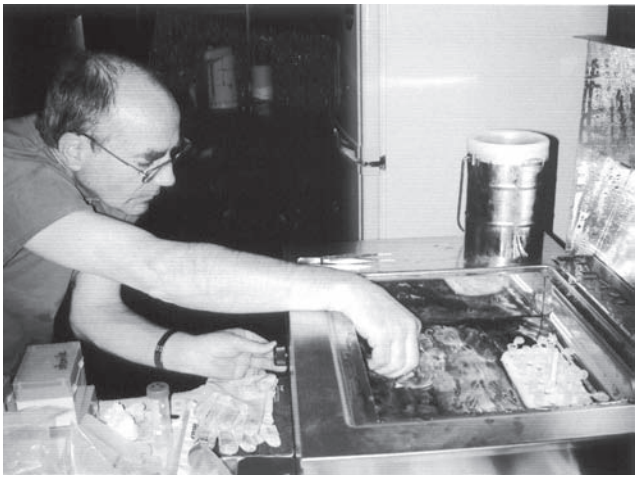
Future Research and Program Initiatives:

- All male elephants of both species, even those believed to be prepubertal, should be reproductively assessed

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states "Every institution should contribute in some way to elephant research activities. Involvement in one or more of the following disciplines is strongly recommended: behavior, cognition, reproduction, communication, enrichment, health (disease/pathology, nutrition), and education."

Deborah Olson

Male reproductive biology is an important research area.



Janine Brown

Techniques are being developed for cryopreservation of semen. This will allow for long-term storage and greater breeding opportunities.

annually using transrectal ultrasonography. Visualizing the accessory glands and testes will help to monitor the health, maturity, and fertility status of each male throughout its lifespan. Assessing immature bulls will provide important data on the maturation process and may have the potential to predict their reproductive soundness as adults.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "Every institution should contribute in some way to *in situ* conservation of elephants and their habitats."

- A database should be developed detailing the results of these procedures to provide data on the developmental process, as well as the incidences of reproductive anomalies, fertility, infertility, etc.

Semen Collection, Evaluation, and Preservation

For captive male elephants, manual manipulation and stimulation present the safest and most effective technique for semen collection, although results vary among individuals and from collection to collection. For that reason, semen should be collected on a regular basis, at least quarterly, and assessed for sperm concentration, motility, and morphology in order to identify fertile males for natural and assisted breeding efforts. Semen collected from captive and wild bulls should be analyzed and screened for pathogens in a standardized fashion.

Deborah Olson, Kansas City Zoo

Semen collection and preservation remain areas of active research.

Deborah Olson

Musth occurs annually or biannually in most adult bulls and, although not absolutely necessary for breeding, it is regarded as an important reproductive strategy. More research needs to be conducted to understand this condition.

Future Research and Program Initiatives

- Optimize methods for semen collection that result in the consistent production of sperm that reflect the true fertility status of individual bulls.
- Develop a standard protocol for semen analysis, processing for short-term storage and shipping.
- Examine treatment methods to stimulate motility in high concentration ejaculates that contain live but nonmotile sperm.
- Investigate the causes of poor semen quality in sexually mature bulls.
- Standardize and draft procedural protocols for pathogen assessment of semen.
- Develop techniques for cryopreservation of semen for long-term storage, and establish a genome resource bank for captive and wild bulls.
- Develop a database of the results of these procedures to establish semen parameter norms.
- Investigate sperm cell sexing technology.

For member institutions of the American Zoo and Aquarium Association (AZA), the AZA Standards for Elephant Care and Management adopted March 21, 2001, states, "AZA members are strongly encouraged to provide financial, personnel, logistical, and other support for priority research and conservation initiatives in the AZA Elephant TAG/SSP Action Plan."

Musth and Endocrine Assessment

Even though the phenomenon of musth has been recognized for centuries to occur in the Asian elephant, and more recently in the African elephant (Poole 1981), little is understood about the phenomenon in either species. Musth occurs annually or biannually in most adult bulls and, although not absolutely necessary for breeding, it is regarded as an important reproductive strategy. Males in musth experience a temporary rise in dominance rank and are more successful at courting and mating estrous females.

More investigation is needed to understand the role of

musth in the behavior and reproductive potential of the male elephant. It is not known if musth impairs or enhances fertility, or if it has any effect at all. Because bulls breed and are fertile before the onset of the first musth, it does not appear to be a precursor to fertility. In addition, some captive male elephants exhibit musth behavior not only annually but every time a female in their presence ovulates.

From a management standpoint, musth bulls create serious problems because of associated increases in aggressive and unpredictable behavior. Captive elephants in musth have severely injured and even killed handlers, and free-ranging musth bulls often threaten human life and property. It would be beneficial if musth could be controlled, particularly in nonbreeding bulls. Although castration offers a permanent solution to fertility, it is still unknown what effect it has on musth. Furthermore, permanent sterility may not be preferable as some of these bulls may be needed for future breeding.

Research is needed to understand the role of testicular androgens in male elephant behavior and reproduction. Testosterone concentrations typically increase in most bulls around the time of puberty, while musth may start two or more years later. Because musth appears to be related to elevated circulating testosterone concentrations, any therapy that temporarily suppresses pituitary luteinizing hormone (LH) release and subsequent testosterone secretion might attenuate or even alleviate behavior problems until the musth cycle ends. Several analogs of gonadotropin-releasing hormone (GnRH) have been shown to suppress LH and testosterone secretion in domestic and laboratory animals and humans. Because of their antigonadotrophic activity, it is possible these compounds might similarly inhibit endocrine function during periods of musth in the bull elephant. Use of antiandrogens (e.g., cyproterone acetate or flutamide), with or without concomitant GnRH analog suppression, could also be a means of suppressing musth symptoms and eliminating behavioral aggression problems.

Eric Sampson

It is imperative to identify what percentage of the female elephant population is reproductively viable. Ultrasound is a vital tool for reproductive assessment.

Future Research and Program Initiatives

- Serum and urine should be collected monthly from all male elephants more than 5 years of age for endocrine profiles.
- Develop a continuous, long-term project monitoring endocrine function of all captive male elephants throughout their lifespan and create a centralized reproductive database.
  - Analyze testosterone to assess testicular activity.
  - Analyze other hormones (pituitary, adrenal, thyroid, etc.) to provide an endocrine database.
  - Record behaviors throughout the year and correlate with endocrine changes to determine if there are predictors of impending musth periods.
- Conduct research to understand and then control musth.

Female Reproductive Biology

Reproductive Assessment

It is imperative to identify what percentage of the female elephant population is reproductively viable, at what age a female typically reaches puberty, and the average age of reproductive senescence. Female elephants should be reproductively assessed annually using transrectal ultrasonography. Some reproductive pathologies (e.g., uterine cysts, leiomyomas) do not appear to disrupt normal reproductive cyclicity, while others apparently do (e.g., ovarian cysts). However, regardless of cyclicity status, these or other physical anomalies could prevent conception and need to be studied in more detail. To that end, continuous, weekly, long-term monitoring of ovarian cyclicity using progesterone analyses to assess reproductive status pre-puberty through senescence is absolutely necessary.

Future Research and Program Initiatives

- Develop a database on the results of transrectal ultrasonography and hormone evaluations to provide data on the age at puberty, incidences of reproductive tract anomalies, and prevalence of ovarian acyclicity, etc.
- Standardize serum and urinary progesterone assays, and establish and distribute pooled standards.
- Develop a centralized database of endocrine results.

- Investigate urinary estrogen levels and assay procedures to assess follicular activity.

Evaluation of Noncycling Female Elephants

The number of "flatliners," or acyclic females, both African and Asian, in North America appears to be significant. Observed acyclicity may involve all elephants at a facility or, more commonly, only one of a pair or group of elephants. In general the causes of acyclicity are not known nor have any reliable treatments been identified. As yet, there do not appear to be any obvious husbandry or management practices associated with ovarian inactivity in elephants. This is becoming a critical issue because prime-breeding age animals are being lost from the reproductive population. Therefore, it is imperative that the cause of "flatlining" is investigated and treatments developed to reinitiate normal cyclicity.

In addition, there is a critical need to obtain normative physiological data. In particular, pituitary LH responses to GnRH and reproductive tract ultrasound must be obtained to identify any pathologies associated with acyclicity and to aid in proper interpretation of treatment results.

Future Research and Program Initiatives

- Identify acyclic female elephants by endocrine and ultrasound analyses.
- Develop a comparative database (ovarian, pituitary, adrenal, thyroid, uterine activity) for cycling and noncycling females.
- Assemble a diagnostic action plan pairing transrectal ultrasound with GnRH, hCG, or alternative drug therapies.
- Develop a database of behavioral, physiological, social, and environmental changes to aid in identifying the cause of acyclicity.

Artificial Insemination

To enhance genetic variability, managers of captive and wild-ranging populations will become increasingly reliant upon assisted reproductive techniques.

Future Research and Program Initiatives

- Continue to refine and simplify artificial insemination procedures.
- Train more personnel in the use of transrectal ultrasonography for reproductive tract assessments and in the artificial insemination technique.
- Develop hormonal methods of manipulating and synchronizing the female elephant estrous cycle to increase breeding efficiency. This strategy could improve *in situ* conservation efforts by making artificial insemination a more practical breeding tool.

Natural Breeding and Parturition

Natural breeding is the preferred method of reproduction and every natural breeding opportunity possible should be attempted. While an extensive database now exists on hormonal patterns during the estrous cycle, data on endocrine changes during pregnancy are limited and based on only a few elephants. Using endocrine assessments to diagnose pregnancy and predict parturition could greatly facilitate the captive management of this species.

Future Research and Program Initiatives

- Develop a comparative database of endocrine profiles during pregnancy in African and Asian elephants.
- Investigate if elephants produce an early pregnancy factor that can be used diagnostically.
- Develop rapid, noninstrument based techniques to predict parturition.
- Develop protocols for introducing male and female elephants for breeding.
- Standardize protocols for managing the pregnant cow.
- Standardize protocols for managing the cow during parturition and introduction to her calf.

Clinical Medicine and Pathology

Several diseases continue to be problematic for captive elephants. These include tuberculosis, elephant herpesvirus, pododermatitis, arthritis, salmonellosis, other gastrointestinal problems, and ventral edema. Although a limited number of pharmacokinetic studies have been conducted in elephants, further research is needed in this area.

Future Research and Program Initiatives

- Compile clinical data annually.
- Compile elephant mortality data annually.
- Investigate problems affecting geriatric elephants.
- Further characterize the herpes virus identified in elephants to develop improved diagnostic and treatment protocols.
- Continue tuberculosis research to develop improved diagnostic and treatment protocols.
- Expand diagnostic imaging of the elephant by further refining X-ray and ultrasound techniques.
- Initiate pharmacokinetic studies of drugs commonly used to treat elephants. Antibiotics and nonsteroidal anti-inflammatory agents in particular should be investigated.
- Investigate immune transfer and development in the elephant neonate.
- Conduct a survey to identify the prevalence of paralyzed or partially paralyzed trunks to determine the underlying etiology.
- Investigate the differences between African and Asian elephants in regard to foot disease and tissue structure, and the correlation between skeletal conformation and foot disease.
- Investigate the early signs of foot disease, indications for both topical and systemic drugs, and determine drug dosages.
- Investigate an EMC vaccine for captive elephants.

Charles Hyatt

Behavior studies help managers better understand elephants and provide enrichment ideas. Top left: An elephant learns to use a computer joystick. Top right: An elephant solves a problem. Bottom left: A mirror is used in a classic self-awareness experiment.

Postmortem Protocol

Little is known about the physiology of the elephant, and every opportunity should be made to perform an extensive and complete necropsy on each elephant that dies. Problems exist due to the elephants' great size and the commitment of time and resources to do a complete necropsy. It is essential that the postmortem protocol is readily available, tissue requests are prioritized and experienced individuals are available to contact should problems arise.

Future Research and Program Initiatives

- Simplify the postmortem protocol.
- Reevaluate present tissue requests and set priorities.
- Develop and assemble a team approach to necropsies.

Behavior Studies

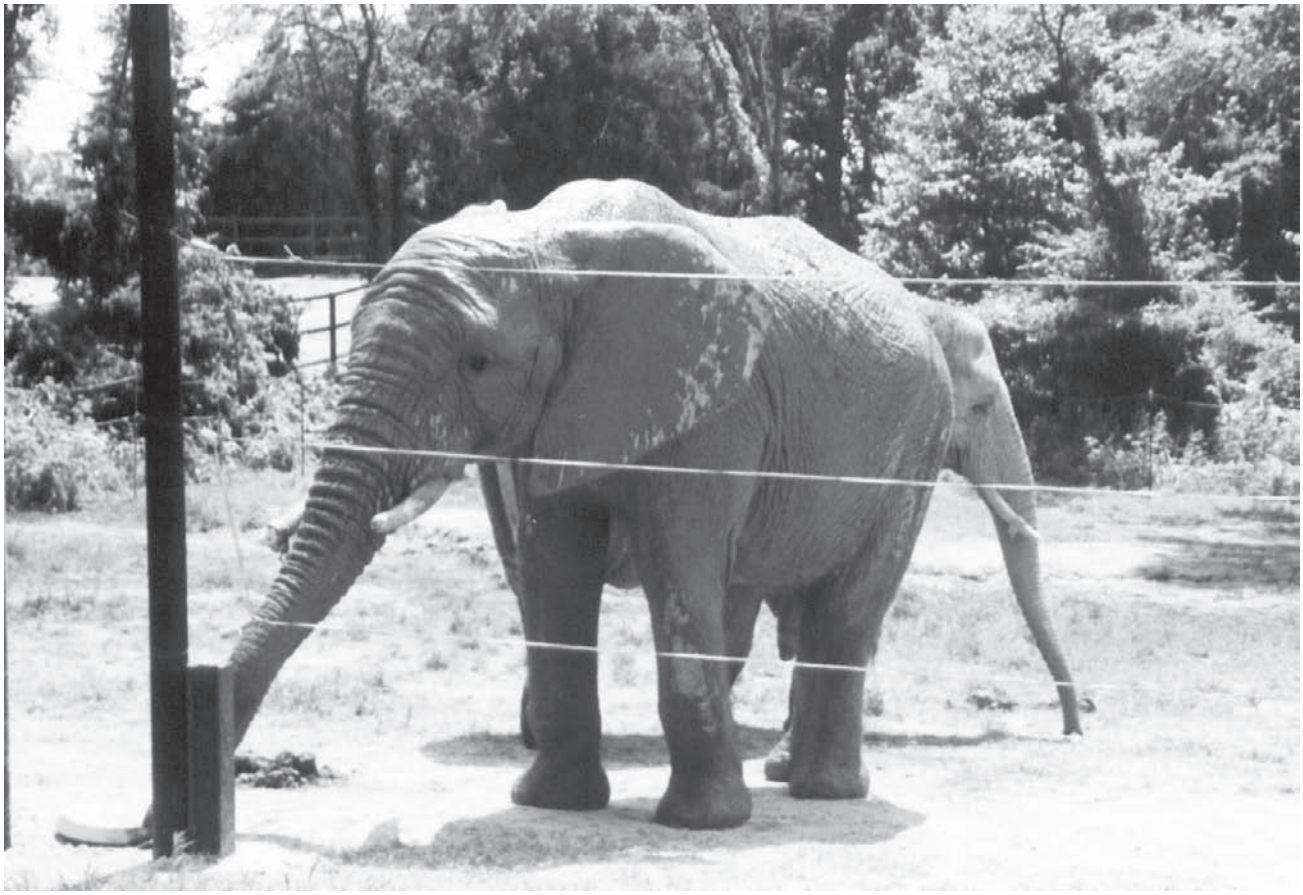
Maintenance of a self-sustaining captive population requires a clear understanding of the behavior of elephants in both wild and captive populations. The lack of documentation and the reliance on anecdotal information can cause misinterpretation of significant behavior. Methods of measurement, data collection, and reliable ethograms need to be developed, standardized, and distributed to improve our understanding of captive elephant husbandry including social factors, behavior, health, lifespan, reproduction, stress and distressers, etc.

Future Research and Program Initiatives

- Continue to add to the standardized and comprehensive ethogram for assessing elephant behavior.
- Develop studies in areas of group and social dynamics, conflict resolution, etc.
- Study the impact of social factors and interactions on behavior and reproduction including identifying how to detect true estrus, understanding sexual disinterest, and determining the role of mate choice.
- Evaluate the relationship of stress and distressers to social and environmental conditions, behavior, and reproduction. Whenever possible, these investigations should be combined with an assessment of adrenal activity (preferably via urinary cortisol analysis) as an index of stress.
- Study of maternal behavior and calf development.
- Perform long-term research on the role of learning and experience in maternal behavior, including the role of "allomothers" and introducing the calf to the herd.
- Investigate infrasonic communication in elephants.
- Investigate strategies to increase the amount of exercise provided each elephant.

Chemical Communication

Elephants are among the most cognitive mammals and have evolved a highly complex society. The smooth functioning of this society is significantly dependent upon chemical communication between conspecifics. Elephants of both species are equipped with an extensive dual olfactory system to facilitate the sensory aspects of chemical communication. The brain is anatomically set up to process and integrate this input. Behavioral and chemical aspects of this sensory input have been well



Deborah Olson, Riddle's Elephant and Wildlife Sanctuary

Jay King, Riddle's Elephant and Wildlife Sanctuary

Jay King, Riddle's Elephant and Wildlife Sanctuary

Opposite page—Top: A male elephant investigates female elephant urine (presented on a paving stone). Researchers are trying to identify what chemical signals females emit during estrus. Bottom: Handlers collect temporal gland secretions, which may also play a role in chemical communication. This page—Above: A researcher uses a device to sample volatile substances, including urine and breath.

studied but studies linking hormonal aspects of chemical signal messages are seriously lacking. Five demonstrated aspects of elephant social organization that are affected by chemical communication and need further study include female-to-female relationships, male-to-female interactions, offspring- to-mother interactions, female-to-male interactions, and male-to-male relationships. For the last two categories pheromones have been identified, (Z)-7-dodecenyl acetate and frontalin, respectively.

Future Research and Program Initiatives

- More precisely quantify *musth* chemical signals to allow assessment of inter-male effects, including immediate behavioral and longer term hormonal changes. Male-male chemical signals may influence both musth duration and intensity.
- Assess the influence of female chemical signals on musth onset, duration, and intensity.
- Determine if particular chemical signals at critical times in the estrous cycle of both sender and receiver females can influence the length of the estrous cycle.
- Examine all flatliners for pheromone production.
- Determine if chemical signals are used to stabilize female-female relationships.
- Investigate maternal-offspring recognition via chemical signals.
- Investigate the role of chemical signals in the recognition of relatedness.
- Conduct supportive anatomical/cytological studies using modern technology to characterize the temporal gland, palatal pits, tongue, ear gland, and Harderian gland of elephants.

Behavior Enrichment

Enrichment should ideally generate activity that resembles that of healthy wild conspecifics. Current management practices include some type of behavior enrichment but it is poorly understood which activities have an impact, what type of impact they have, how much time they occupy, and for how long the activity is successful.

Future Research and Program Initiatives

- Develop a list of effective behavioral, environmental, psychological, physical, and social enrichment activities and responses.
- Develop a standardized evaluation of enrichment activities and means to measure the efficacy of enrichment devices or activities that is scientifically validated. Whenever possible, these evaluations should include an analysis of adrenal activity (preferably via urinary cortisol analysis) to assess physiological responses.

Nutrition

A wide variety of diets are currently fed in captivity to both species of elephants. Hay and processed feeds consumed by elephants vary greatly in nutritional components, quality, and quantity. Many of the health problems identified in captive elephants may be linked to diet and nutritional imbalances. Diet is thought to affect foot health, colic, ventral edema, and obesity. Obesity and poor body condition create problems during pregnancy and parturition. And although diet is known to affect reproductive efficiency, the relationship between dietary imbalances or nutritional deficiencies and specific reproductive problems (e.g., ovarian acyclicity, poor sperm production) has not been studied in elephants.

Future Research and Program Initiatives

- Determine vitamin and mineral requirements of elephants by assessing the captive population's nutritional status and setting physiological normal ranges through plasma sampling.
- Research and verify common feeding practices.
- Determine the composition of browse and its role in a complete diet.

- Develop optimal diets for captive Asian elephants at various life stages.
- Develop optimal diets for captive African elephants at various life stages.
- Encourage the analysis of the diets and nutritional status of both species of elephants in the wild.
- Study the relationship between nutritional status and reproductive problems.
- Establish how nutrition and/or exercise impacts reproductive activity (cyclicity, pregnancy, parturition).
- Create a central database for compiling nutritional information.
- Develop a national genome bank for biomaterials and other tissues for nutritional analysis.
- Collect information on milk composition, specifically more detailed vitamin, fatty acid, and mineral analyses for developing supplemental formulas.

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