ASSOCIATION OF ZOOS & AQUARIUMS

LION
(Panthera leo)
CARE MANUAL

CREATED BY THE
AZA LION SPECIES SURVIVAL PLAN®
IN ASSOCIATION WITH THE
AZA FELID TAXON ADVISORY GROUP

Lion (*Panthera leo*) Care Manual

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Disclaimer: This manual presents a compilation of knowledge provided by recognized animal experts based on the current science, practice, and technology of animal management. The manual assembles basic requirements, best practices, and animal care recommendations to maximize capacity for excellence in animal care and welfare. The manual should be considered a work in progress, since practices continue to evolve through advances in scientific knowledge. The use of information within this manual should be in accordance with all local, state, and federal laws and regulations concerning the care of animals. While some government laws and regulations may be referenced in this manual, these are not all-inclusive nor is this manual intended to serve as an evaluation tool for those agencies. The recommendations included are not meant to be exclusive management approaches, diets, medical treatments, or procedures, and may require adaptation to meet the specific needs of individual animals and particular circumstances in each institution. Commercial entities and media identified are not necessarily endorsed by AZA. The statements presented throughout the body of the manual do not represent AZA standards of care unless specifically identified as such in clearly marked sidebar boxes.

Acknowledgements

Lions are an iconic species, both loved and feared. While they do not have the striking color patterns of a jaguar or the cultural significance of a tiger, the striking mane and complex social structure makes them unique among all the wild cats. Nearly half of all AZA-accredited institutions house lions, a testament to their charisma and popularity. For many years lions were easy to breed and we believed they would always be in zoos. Over those same years we saw tens of thousands of them in Africa and believed they would rule the wild forever. In the thirty years since the AZA Lion SSP was established we have been proven wrong on every level.

Every day keepers, animal managers, wildlife managers, and scientists work tirelessly to ensure that lions remain the highlight of a zoo experience or a wildlife safari. Mike Fouraker, Tarren Wagener, and Bob Wiese managed this SSP many years before I did and much of the information in this document comes from their hard work, as well as the advisors and active members of the SSP, and they deserve recognition for their many years of voluntary service to the AZA Lion SSP.

The AZA Felid TAG is made up of an incredible group of individuals whom I am grateful to call mentors, colleagues, and friends. I owe special thanks to Norah Fletchall and Danny Morris for inviting me into this group and providing me opportunities and support over the last seven years.

This document has been a long time coming, for a variety of reasons. It represents the best information available today from the best zoos and most experienced animal managers in AZA and around the world. It is a living document and should be continually updated with both the published and anecdotal information available at the time. The intent of this document is to serve as a resource for the keepers, managers, and curators that care for this species today or hope to in the future, so that we can provide the best possible care for every lion and ensure that future generations hear a lion's roar both at their zoo and in the wild.

Hollie Colahan
Coordinator, AZA Lion SSP
January 2012

For Elson (1995-2011), the one who started it all for me
Photo courtesy of D. Bredahl

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Introduction

J. Kiseda

Preamble

AZA accreditation standards, relevant to the topics discussed in this manual, are highlighted in boxes such as this throughout the document (Appendix A).

AZA accreditation standards are continuously being raised or added. Staff from AZA-accredited institutions are required to know and comply with all AZA accreditation standards, including those most recently listed on the AZA website (http://www.aza.org) which might not be included in this manual.

Taxonomic Classification

Table 1. Taxonomic classification for lions

Classification	Taxonomy
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Suborder	Feliformia
Family	Felidae

Genus, Species, and Status

Dubach et al. (2005) recognize two subspecies, the Asian Lion (*P. leo persica*) and the African Lion (*P. leo leo*). In their review in Mammalian Species, Hass et al. (2005) listed seven extant subspecies, although none of these have been subjected to molecular analysis. Haas et al.'s classification is listed in Table 2 below. The AZA Lion SSP manages all African lions as *P. l. leo*, following Dubach et al.'s classification.

Table 2. Genus, species, and status information for lions

Genus	Species	Common Name	USFWS Status	IUCN Status	AZA Status
Panthera	*leo*	Lion	Not listed	Endangered (P. l. persica)	SSP

IUCN data current as of 2008 indicates that African lion populations have declined as much as 30% over the last two decades (www.IUCN.org). Lions have disappeared from over 80% of their historic range, and current numbers indicate there may be less than 30,000 wild lions left in Africa. They remain in 26 countries in Africa but only 7 of these (Botswana, Ethiopia, Kenya, South Africa, Tanzania, Zambia and Zimbabwe) boast populations over 1000 (www.panthera.org).

For many years, African lions were not a priority for conservation but in the last 2 decades, they have come under threat from a variety of factors, including habitat loss, human conflict, and disease from domestic animals. Retaliatory killing in east Africa and distemper and bovine tuberculosis outbreaks in southern Africa threaten the last large populations of lions on the planet.

The AZA Lion SSP began as a program for Asiatic lions 1981 and the focus on African lions did not begin until the early 1990s after genetic testing revealed that animals thought to be *P. l. persica* were in fact African-Asiatic hybrids (O'Brien, et al., 1987). Efforts continued to develop an Asiatic program but a source of founders was never established. Currently the European Breeding Program (EEP), the European counterpart to the SSP, manages Asiatic lions. In 1993 the AZA Lion SSP expanded to include African lions and animals of known ancestry began to be imported from southern Africa. A moratorium on the breeding of "generic" (unknown pedigree) lions also began at this time (Fouraker, Wagener, & Wiese, 1998).

Table 3. Lion subspecies (S. Haas, et al., 2005)*

Subspecies	Common Name	Range
P. l. azandicus		Mozambique, Zambia, Democratic Republic of Congo
P. l. bleyenberghi		Namibia, Angola, Zambia
P. l. krugeri	Transvaal Lion	Botswana, South Africa, Zimbabwe, Mozambique
P. l. leo	Barbary Lion	Extinct, formerly North Africa
P. l. melanochaitus		Botswana, South Africa, Zimbabwe, Mozambique
P. l. nubicus		Kenya, Somalia, Ethiopia, Tanzania, Sudan, Democratic Republic of Congo, Central African Republic
P. l. persica	Asiatic Lion	Gir Forest of India
P. l. senegalensis		Equatorial central and west Africa

*Haas et al. is not based on genetic analysis, which indicates only two subspecies.

General Information

The information contained within this Animal Care Manual (ACM) provides a compilation of animal care and management knowledge that has been gained from recognized species experts, including AZA Taxon Advisory Groups (TAGs), Species Survival Plan® Programs (SSPs), Studbook Programs, biologists, veterinarians, nutritionists, reproduction physiologists, behaviorists and researchers. They are based on the most current science, practices, and technologies used in animal care and management and are valuable resources that enhance animal welfare by providing information about the basic requirements needed and best practices known for caring for *ex situ* lion populations. This ACM is considered a living document that is updated as new information becomes available and at a minimum of every 5 years.

Information presented is intended solely for the education and training of zoo and aquarium personnel at AZA-accredited institutions. Recommendations included in the ACM are not exclusive management approaches, diets, medical treatments, or procedures, and may require adaptation to meet the specific needs of individual animals and particular circumstances in each institution. Statements presented throughout the body of the manuals do not represent specific AZA accreditation standards of care unless specifically identified as such in clearly marked sidebar boxes. AZA-accredited institutions which care for lion must comply with all relevant local, state, and federal wildlife laws and regulations; AZA accreditation standards that are more stringent than these laws and regulations must be met (AZA Accreditation Standard 1.1.1).

AZA Accreditation Standard

(1.1.1) The institution must comply with all relevant local, state, and federal wildlife laws and regulations. It is understood that, in some cases, AZA accreditation standards are more stringent than existing laws and regulations. In these cases the AZA standard must be met.

The ultimate goal of this ACM is to facilitate excellent lion management and care, which will ensure superior lion welfare at AZA-accredited institutions. Ultimately, success in our lion management and care will allow AZA-accredited institutions to contribute to lion conservation, and ensure that lion are in our future for generations to come.

Evolution

The first lions appeared about 600,000 years ago in Europe. They ranged from Europe to eastern Asia. These cave lions (*Panthera leo spelaea*) were probably the largest cats to ever live, and were 25% larger than modern lions. The North American lion (*Panthera atrox*) was similar to the cave lion and ranged throughout North America until about 11,500 years ago. Fossil evidence suggests it may have been a social animal that lived in prides like its modern counterpart. Together, these lions may have been the widest ranging cat in the world (Sunquist & Sunquist, 2002).

Description

Lions are the second largest felid. There is some physical variation between subspecies and geographic regions, including coat color, size, and mane characteristics. Lions of southern Africa are generally larger than those of eastern portion of the range. Coat color is generally tawny with lighter under parts. The male's mane varies from tawny to black and may darken with age. Asian lions have a fold of skin running along the belly (Haas, 2005). Cubs are born with dark rosettes that may appear as stripes when close together. Faded spots may remain on the belly of some females (Sunquist & Sunquist, 2002).

Spots may remain into adulthood with some females
K.Cox

Albinism and melanism are rare but white lions have been found in the Transvaal region of South Africa. The AZA Lion SSP discourages the breeding or acquisition of this color phase as all individuals currently found in zoos are severely inbred (AZA, 2011).

Table 4. Physical characteristics (S. Haas et al., 2005)

Characteristic	Males	Females
Body length	1.7-2.5 m (66-98 in)	1.4-1.75 m (55-96 in)
Height	0.9-1.05 m (34-41 in)	1.07 m (42 in) average
Weight	150-225 kg (330-496 lb)	120-182 kg (264-401 lb)

The most distinctive feature of the lion is the male's mane, making lions one of the most sexually dimorphic members of the order Carnivora. Males begin to grow a mane at about 11 months of age but the appearance will vary greatly between individuals, in fact it can be used to distinguish individuals in the wild at some distance.

Immature male
M. Durham

Adult male
M. Wagoner

In general it will grow thicker, longer and darker with age. In addition to providing an impressive and intimidating appearance, the mane also provides some protection during aggressive interactions with other animals (Sunquist & Sunquist, 2002). Manes are an indicator of physical condition, communicating this to both males and females but it also may limit mobility and restrict thermoregulation. In general, the hotter and more arid the climate, the smaller the mane, which is a reflection of both food availability and temperature. Not surprisingly, zoo lions have larger manes than their wild counterparts (Patterson et al., 2006).

Distribution

Asian lions once ranged throughout India but by the early 1900s its range had been reduced to the Gir Forest in India. Lions are now extinct from North Africa but still range from south of the Sahara to the Cape, except for Congo forest. They range from the desert to mountainous regions over 13,000 feet (Haas et al., 2005).

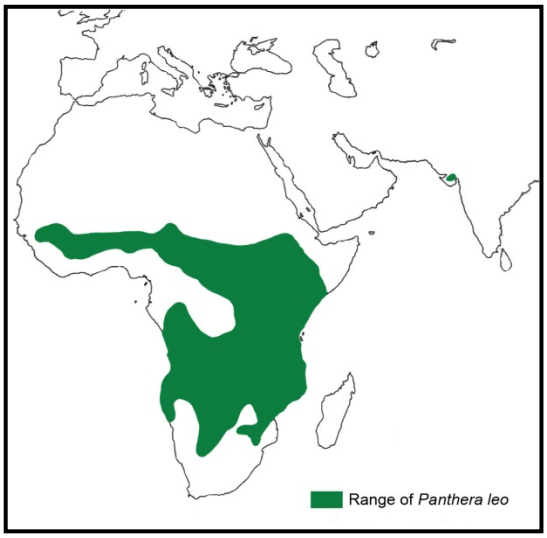


Figure 1. Distribution of Panthera leo (Sunquist and Sunquist, 2002)

Ecology and Behavior

The lion's habitats include grasslands, dry forest, scrub, woodlands and desert. Lions are primarily terrestrial but do occasionally climb trees to rest or escape other animals. Cubs are good climbers and will play in trees. Lions have also been known to dig to get to aardvark or warthogs in burrows. They do not use water as frequently as some other cats but are adept swimmers (Sunquist & Sunquist, 2002).

Lions will drink water every day if it is available but can go several days without it if needed. Lions that live in arid habitats get needed moisture from their food and rest during the hottest part of the day to regulate body temperature and water loss by evaporation. Overall activity patterns are determined by habitat type. They are primarily nocturnal but will hunt during the day if there is sufficient cover and Serengeti lions follow a more crepuscular activity pattern. Regardless of patterns, lions are well known as the least active felid, averaging about 19 hours of rest each day. East African lions spend 1-3 hours each night traveling and hunting and about an hour feeding. Most only travel 1.6-8 km (1-5 mi) each night but distance traveled and time spent hunting increases in areas with less abundant prey, with Kalahari and Etosha lions spending closer to 7 hours hunting and traveling up to 12.8 km (8 mi) each night (Sunquist & Sunquist, 2002).

A female lion stalks prey in the Kalahari, Botswana
H. Colahan

Lions are stalk and ambush predators so the availability of cover is critical to success. They will also scavenge carcasses occasionally from leopards, hyenas and cheetahs. Lions have been recorded as feeding on “almost every imaginable land mammal” and a few aquatic animals too (Sunquist & Sunquist, 2002). Ungulates are the primary prey but they have been known to eat ostrich eggs, crocodiles, chimpanzees, other lions, and on the Skeleton Coast of Namibia they hunt seals. Lions frequently take prey much larger than themselves such as giraffe, hippos, and most commonly, buffalo. Lions are highly adaptable predators, which enables them to take advantage of whatever food source is most available in the habitat and the season (Sunquist & Sunquist, 2002).

The hunting methods and killing techniques vary with group size and the size of the prey but usually involve a throat bite or suffocation by covering the nose. Unlike many other felids, lions do not usually move their kill, but rather eat it quickly where it falls (Sunquist & Sunquist, 2002). Schaller reported a pride of lions reducing an entire zebra to bones in 30 minutes. One lion may consume over 31.7 kg (70 lb) of meat in just a few hours (Schaller, 1972). Females do most of the hunting but are displaced by males for feeding.

The social system of lions can be fluid depending on prey availability and other pressures on the pride. The typical pride structure for African lions is a group of related females and their offspring plus 1–7 males who are unrelated to the females but frequently related to each other. Sub-adult males leave the pride on their own or are forced out and form coalitions with siblings and sometimes unrelated males of the same age while they wait for an opportunity to take over a pride of their own when they are sexually mature. Females may stay in their natal pride their entire lives, as once they are old enough to breed, new males will have taken over the pride (Sunquist & Sunquist, 2002).

Home range and territory size also varies with prey abundance but males will patrol and defend a territory from other males. Females will also defend resources such as water holes and den sites from other females if needed. Both males and females will also mark boundaries by scraping with their hind feet and spraying urine, although males do this much more frequently than females. Roaring may be another way for lions to advertise that a territory is occupied, although it is also thought to facilitate group contact. Lions most frequently roar at dawn, dusk and midnight, coinciding with when they are most active. Lions also growl, hiss, meow, grunt and puff, which is a friendly social sound that sounds like a “stifled sneeze” (Sunquist & Sunquist, 2002).

A female lion contact calling to the rest of the pride at dusk, Botswana
H. Colahan

Chapter 1. Ambient Environment

K. O'Connell

1.1 Temperature and Humidity

Animal collections within AZA-accredited institutions must be protected from weather detrimental to their health (AZA Accreditation Standard 1.5.7). Animals not normally exposed to cold weather/water temperatures should be provided heated enclosures/pool water. Likewise, protection from excessive cold weather/water temperatures should be provided to those animals normally living in warmer climates/water temperatures.

AZA Accreditation Standard

(1.5.7) The animal collection must be protected from weather detrimental to their health.

Lions can be tolerant of fluctuating temperature extremes, at least during daylight hours. Regardless, lions kept outside should always have access to shade, especially during warmer months of the year. When kept indoors for any length of time, lions should also be protected from temperatures above 30 °C (85 °F). If lions are acclimatized, and provided shelter from the wind, they can tolerate temperatures as low as -1.1 °C (30 °F) without difficulty, although they should be provided access to an indoor enclosure or supplemental heat if temperatures fall below 10 °C (50 °F). The relative humidity of indoor exhibits should range between 30–50%.

The heat index, humidity and wind chill can affect tolerance of temperature variations by animals, as can the degree to which individual animals are acclimatized; so animal managers should use good judgment in deciding to place lions outdoors in cold climates. Providing sections of varying shelter, supplemental heat, and sunlight exposure in an exhibit can create temperature zones that permit the animals to select the most comfortable location during cold weather. Similarly, cold rocks, perches, and fans can be provided within the exhibit to increase the animals' comfort and public visibility during very warm weather (Law, 2003).

With sufficient shelter and access to heated areas, lions enjoy the snow
R. Macy

AZA institutions with exhibits which rely on climate control must have critical life-support systems for the animal collection and emergency backup systems available, while all mechanical equipment should be included in a documented preventative maintenance program. Special equipment should be maintained under a maintenance agreement or records should indicate that staff members are trained to conduct specified maintenance (AZA Accreditation Standard 10.2.1).

AZA Accreditation Standard

(10.2.1) Critical life-support systems for the animal collection, including but not limited to plumbing, heating, cooling, aeration, and filtration, must be equipped with a warning mechanism, and emergency backup systems must be available. All mechanical equipment should be under a preventative maintenance program as evidenced through a record-keeping system. Special equipment should be maintained under a maintenance agreement, or a training record should show that staff members are trained for specified maintenance of special equipment.

1.2 Light

Careful consideration should be given to the spectral, intensity, and duration of light needs for all animals in the care of AZA-accredited zoos and aquariums. Because of their large size and activity patterns, lions should be maintained in outdoor enclosures under conditions of natural light. Regardless of the temperature and level of acclimation, however, all outdoor enclosures should provide shaded areas for use during hot weather. In the wild, lions are mostly nocturnal and/or crepuscular and less active during daylight hours. Indoor lighting should mimic natural lighting cycles.

Skylights provide the best daytime lighting for indoor facilities but fluorescent lighting is an efficient light source providing broad-spectrum illumination. Fluorescent lighting is acceptable, and is commonly used as an artificial light source indoors, but full spectrum UV bulbs are recommended for animals that spend

longer periods of time indoors. When building new facilities or making improvements, indoor areas should be inspected after dark to ensure that the lighting is sufficient without natural sunlight.

1.3 Water and Air Quality

AZA-accredited institutions must have a regular program of monitoring water quality for collections of aquatic animals and a written record must document long-term water quality results and chemical additions (AZA Accreditation Standard 1.5.9). Monitoring selected water quality parameters provides confirmation of the correct operation of filtration and disinfection of the water supply available for the collection. Additionally, high quality water enhances animal health programs instituted for aquatic collections.

AZA Accreditation Standard

(1.5.9) The institution must have a regular program of monitoring water quality for collections of fish, pinnipeds, cetaceans, and other aquatic animals. A written record must be maintained to document long-term water quality results and chemical additions.

The recommended standardized rate of exchange for non-re-circulated air for a pet shop is 1.0 cubic foot of fresh air/minute/square foot of floor space to keep odors and humidity at a level satisfactory to the public (American Society of Heating, 1981). A range of 5–15 air changes per hour is sufficient for indoor areas, and will vary based on the size of the enclosure and the number of animals. The higher end of this range should control odors effectively but the lower rates may be needed in the winter to conserve heat (Aquilina, 2007). Glass barriers and separate ventilation systems between exhibit and visitor areas will also help reduce complaints from odor.

Fresh water should be available at all times and should be checked daily by keepers to make sure water is clean and that automatic drinkers, if used, are working properly. Water can quickly become stagnant in warmer temperatures and freeze in colder environments so alternative sources may need to be used during some times of the year. Chapter 2 provides more information on types of drinkers for lions.

1.4 Sound and Vibration

Consideration should be given to controlling sounds and vibrations that can be heard by animals in the care of AZA-accredited zoos and aquariums. Consideration should be given to controlling sounds and vibrations that can be heard by animals. Lions have excellent hearing, and staff should pay special attention to the pride when there is unusual or excessive noise around the enclosure, as this may cause stress or aggression.

1.5 Cleaning and Sanitation

Lions do scent mark their territories, but typical spot-cleaning of outdoor enclosures on natural substrate will not adversely affect this behavior. In general, outdoor natural substrates are preferred; dirt and grass substrates in outdoor enclosures should be spot-cleaned daily. Hard surface enclosures, both inside and out, should be cleaned daily, and cleaned with detergent and disinfectant on a regularly scheduled basis.

Natural dirt substrates can become contaminated over time with microorganisms and parasites, thereby exposing the cats to potentially dangerous concentrations of pathogens. Provisions should be made so that the contaminated substrate can be removed periodically and replaced with clean materials. Housing animals that have been properly quarantined and treated helps to reduce the potential contamination load on the substrate, especially the parasitic load.

Lions should not be given access to wet concrete floors on a regular basis for footpad health. Properly sloped floors and the addition of fans will help decrease drying time after cleaning. Logs, play objects such as Boomer Balls®, as well as food containers, should also be cleaned daily and disinfected on a regular schedule.

Footbaths containing appropriate disinfectants such as quaternary ammonia should be used prior to entering all felid enclosures and service or quarantine areas, and their use strictly adhered to by all personnel. Footbaths should be changed out daily, or more frequently if noticeably soiled.

Phenolic compounds should not be used due to adverse reactions in felids. After any chemical application, surfaces should be rinsed with a high-pressure water stream. Steam cleaning of hard surface areas is recommended annually, where practical.

1.6 Pest Management

An active and aggressive pest control program should be established. Rodent control can be accomplished using snap traps, live traps, etc. All chemicals should be approved by the institutional veterinarian prior to use. Applications should be performed by a licensed pest control technician accompanied by staff members to assure the safety of the animals and staff.

An obvious need for pest control exists in any animal holding facility. Wild animals are a source of diseases for large felids. Rodents, birds, domestic cats or dogs, or other pests with access to the lion or its enclosure may serve as sources of contamination for microorganisms or parasites.

The ectoparasites of mammals such as fleas, ticks and mites, can be transmitted to lions; additionally, internal parasites from feral animals can be acquired by lions and cause infection. Feral animals also serve as potential sources of pathogens such as feline viral diseases, rabies, yersiniosis, leptospirosis, salmonellosis, toxoplasmosis, feline infectious peritonitis, and others.

Well-maintained perimeter fencing provides an initial deterrent to the larger feral animals. However, climbing animals, such as feral cats, can easily defeat such barriers; therefore, areas around lion enclosures should be monitored regularly for feral animal activity. Live trapping provides a method of removing some feral animals, and is acceptable to the public and humane animal interest groups. Trapping does not provide a total eradication of pests; therefore, the design of the lion enclosures should be such that it reduces exposure to feral animals.

Rodents: Rodent pests should be handled through a well-planned, supervised, continuous pest control program. Safe rodenticides are available for use around lions when they are applied according to their directions. Care should be taken in choosing compounds that are effective, yet not highly toxic, especially when considering secondary toxicities from the ingestion of treated rodents. A number of anticoagulant rodenticides are available that are effective and have little or no secondary toxicity potential (e.g., warfarin, diphacinone, cholecalciferol, brodifacoum). These are the backbone of most vermin control programs. When rodent populations become unmanageable or resistant to anticoagulants, other more toxic compounds, such as zinc phosphide may be needed, requiring extra care in their application. It should be emphasized that at no time should lions have primary access to any rodenticide. In addition, the program should be designed to minimize secondary exposure (i.e., consuming rodents that have fed on poisonous baits).

Insects: Good sanitation aids in reducing insect populations, but all zoological situations experience insect pests, particularly cockroaches. Insecticide applications can be made around lion enclosures with chemicals that are safe when applied in a proper manner. There are many chemicals available, both primary insecticides (e.g., diazinon, piperonyl butoxide, natural and synthetic pyrethrins, carbamates, chlorpyrifos), and newer growth regulator compounds (e.g., Gencon) that have low toxicity potential when used correctly. Lion enclosures should be treated by removing the lions, applying chemicals that have been deemed safe to use in primary enclosures, and then cleaning the enclosure to avoid exposure to returning lions. The residual chemicals in cracks and crevices should be minimal if contacted by lions.

All personnel involved with lion husbandry should participate in the planning stage of the pest control program, and be aware of the location, proper application, and safe handling of the compounds being used. Safety of the lions is a priority in any program. Inadvertent use or misuse of insecticides (and herbicides and miscellaneous toxic compounds not intended for use around animals) can lead to accidental exposure to lions and possibly fatal results.

Chapter 2. Habitat Design and Containment

A. F. Eagleson

2.1 Space and Complexity

Careful consideration should be given to exhibit design so that all areas meet the physical, social, behavioral, and psychological needs of the species. Animals should be displayed, whenever possible, in exhibits replicating their wild habitat and in numbers sufficient to meet their social and behavioral needs (AZA Accreditation Standard 1.5.2).

AZA Accreditation Standard

(1.5.2) Animals should be displayed, whenever possible, in exhibits replicating their wild habitat and in numbers sufficient to meet their social and behavioral needs. Display of single specimens should be avoided unless biologically correct for the species involved.

The best lion exhibits safely replicate the features of the lion's natural habitat. This will encourage natural behaviors, which will result in healthier animals and provide an educational and inspirational experience for zoo guests. Lions are territorial animals that patrol and protect a well-defined area from intrusion by other conspecifics. In the wild, territorial borders are typically marked with scent, and this behavior is also seen in zoos. Lions are largely terrestrial, and do best when maintained outdoors, at least during warmer weather, in large spacious enclosures designed to encourage species-appropriate behaviors such as resting, walking, hunting, stalking, grooming, playing, breeding, etc. (Schaller, 1972).

Enclosures should be planted with grasses and bushes for visual privacy from guests and conspecifics, trees for shade, and include various substrates, surfaces to mark, deadfall for scratching, and other aspects in their enclosure that will change their pathways and create complex behavioral opportunities. This varied topography will help create multi-leveled pathways that may reduce development of stereotypic behaviors such as pacing.

All enclosures should allow each animal the ability to retreat from conspecifics through the use of visual barriers, such as rock outcroppings, hills, and foliage, without limiting an animal's access to food, water, heat, or shade. Sufficient numbers of holding spaces should be available to separate cats individually when the need arises, and these should be interconnected to allow maximum flexibility. Similarly, it should be possible to house incompatible groups of lions separately at least on a short-term basis. Situations where this may be necessary include during parturition, for introductions, at sexual maturity of cubs, for contraceptive purposes, etc. Institutions that plan to breed lions should ensure they have adequate space to house cubs for 2 years. In most cases, cubs can be maintained with the group but social issues or hand-rearing may require managing separate groups during this time.

Large rocks can provide shelter as well as resting areas
B. Van Ellen

Both exhibit and holding spaces should be designed with a means of egress to avoid animals being trapped in corners. Holding cages and exhibits with at least two doors will help prevent trapping and/or one animal excluding another from access. Hallways often work fine but they do provide another small area where animals may become trapped or simply choose not to leave. Designs with the most flexibility and the shortest travel routes are generally most successful.

All enclosures should have shift facilities to permit safe cleaning, enclosure repair, or other separations. The off-exhibit enclosures are essential to proper management and health care of the animals, and include additional working, holding, and quarantine areas. All animals should be able to be easily transferred from one indoor enclosure to the next. Each indoor transfer area should have transfer/guillotine doors operated from the keeper area. If animals are going to be locked in for a prolonged period of time, such as overnight, larger holding areas are highly recommended.

Space

Outdoor Enclosures: The outdoor space needs will vary depending on the size and demographics of the pride. According to the 2010 AZA Lion SSP Space Survey, the majority of exhibits are over 929 sq m

(10,000 sq ft), which should be considered the minimum size for new exhibits. Exhibits for institutions that plan to breed and/or hold more than three animals should be larger, and ideally have the ability to divide that outdoor space into two exhibits to manage future social issues. Alternatively, an outdoor off-exhibit holding yard also provides space for managing multiple groups of animals.

Indoor Holding/Shift Areas: Indoor space is dependent on group size, but also on climate and management plans. In warmer climates where animals can go outside most days, less indoor space is needed. However, it should still provide enough space for animals to be separated and kept inside for short periods of time when weather, construction, or health issues require indoor confinement. If animals are to be locked in overnight, they will be spending the majority of their time indoors, so the space should reflect this.

Ideally, indoor holding stalls should be at least 3.6m L x 3.6m W x 2.4m H (12ft L x 12ft W x 8ft H). There should be a minimum of four stalls to accommodate the most common group size of 1.2 animals (46.5–55.7 m^2 [500–600 ft^2]) but institutions that plan to breed and/or house larger groups should have more stalls, ideally one more stall than the number of animals to allow shifting, although a shift hallway can alleviate this issue.

Indoor Enclosures: In regions with colder climates and/or those institutions that have indoor exhibits, where animals may spend most of the time during inclement weather, indoor space should provide natural light and fresh air via operable windows or skylights. Again, the size of the enclosure will vary with group size and demographics but 185.8 sq m (2000 sq ft) should be the minimum for a group of 1.2 lions, with more space for larger groups. If animals are given access to the holding stalls mentioned above, this could be included in the total indoor square footage listed above.

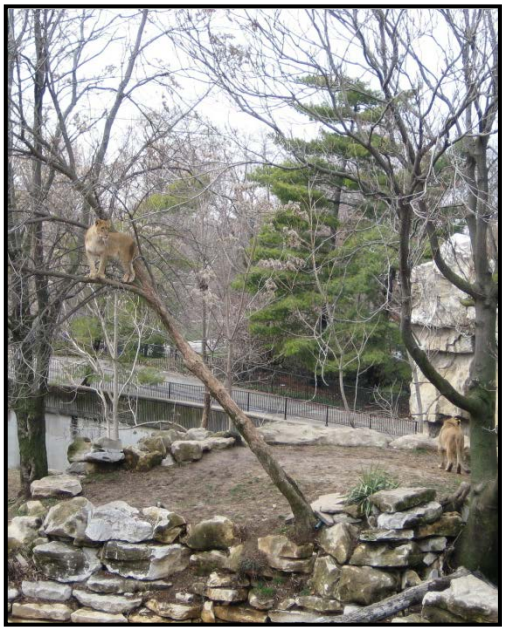
The same careful consideration regarding exhibit size and complexity and its relationship to the animal's overall well-being must be given to the design and size all enclosures, including those used in exhibits, holding areas, hospital, and quarantine/isolation (AZA Accreditation Standard 10.3.3).

AZA Accreditation Standard

(10.3.3) All animal enclosures (exhibits, holding areas, hospital, and quarantine/isolation) must be of a size and complexity sufficient to provide for the animal's physical, social, and psychological well-being; and exhibit enclosures must include provisions for the behavioral enrichment of the animals.

Complexity

Outdoor Enclosures: Large outdoor enclosures with additional outdoor holding options are ideal in cases of incompatibility or if offspring are expected from multiple numbers of females. Elevated resting areas such as boulders or pallets will be well utilized, and will enhance visibility for the public. Plant toxicity should be ascertained prior to planting an enclosure with landscaping materials.



Many lions are adept at tree climbing
R. Macy

This may include allowing the lions to have access to an outdoor enclosure overnight. Outdoor enclosures are typically larger than indoor ones yet cats that are shifted inside at night spend most of their time in the smaller area. More space and choices about where to spend their time may help prevent social and behavioral problems. According to the 2010 AZA Lion SSP Husbandry Survey, half of the institutions responding allow lions to have access to outdoor enclosures overnight. Reasons for locking animals in at night include escape concerns, weather concerns, lack of staff on grounds at night, and security of the entire facility and/or park. Each institution should determine if they have the appropriate safety and security measures in place when determining if lions will be left outside overnight.

All outdoor exhibits should have a large entryway suitable for bringing in heavy equipment for landscaping, adding/exchanging furniture, etc. All areas of the exhibit should be visible to staff from outside the enclosure to ensure

proper monitoring of animals. Permanent lighting is also useful for monitoring animals at night if needed. Areas that are difficult to access visually can be monitored via remote cameras.

Indoor Holding/Shifting Areas: These areas should also include arboreal resting platforms (one per animal) as mentioned above. The addition of a smaller room without benches (or benches that are easily removed) is a useful space for weighing animals, training, darting, and for animals that require a confined space due to injury or other treatment. A smaller, outdoor enclosure (either on or off-exhibit) is useful in the management of cubs, geriatrics, and other animals that may not be able to utilize a large exhibit due to physical limitations.

T. Webb

Indoor Enclosures: If housed indoors during part of the year, access should be given to the outside during warm parts of the day. Animals that spend longer periods of time indoors will need additional and more complex space. Indoor space should be designed to maximize the welfare of the animals, enhance their behavioral repertoire, and accommodate individual differences in the cats, incompatibility issues, offspring, and introductions.

While lions are not as arboreal as some felids, a vertical height of 3–3.6 m (10–12 ft) will allow the placement of resting platforms and better use of the limited space. Multiple resting spaces at various elevations should be included with at least one resting location per individual. All lions should have access to an elevated platform in their sleeping quarters.

Off Exhibit Holding/Shifting Areas: All enclosures should have shift facilities to permit safe cleaning, enclosure repair, or other separations. The off-exhibit enclosures are essential to proper management and health care of the animals, and may include additional working, holding, and quarantine areas. All animals should be able to be easily transferred from one indoor enclosure to the next. Each indoor transfer area should have transfer/guillotine doors operated from the keeper safety area.

A smaller, outdoor enclosure (either on or off-exhibit) is useful in the management of cubs, geriatrics, and other animals that may not be able to utilize a large exhibit due to physical limitations.

E. Ray

Birthing Dens: Isolated areas that have low-light capabilities and reduced human foot-traffic activity should be available for institutional breeding programs. Keeper viewing areas/slots, closed circuit television monitors, and/or one-way glass are strongly suggested to aid in the management and observation of the animals. See Chapter 7.4 for additional information.

Restraint and Transfer: It is recommended that squeeze/restraint chutes be incorporated into the design of the facility, in order to provide an alternative method of handling for procedures normally necessitating anesthesia. A properly designed restraint cage allows simple close examination, collection of biological samples (e.g., blood, urine, or culture), or drug injection (e.g., antibiotics, vaccinations, anthelmintics, anesthetic drugs). The use of such a cage is less stressful compared to the remote delivery methods such as darts or pole syringes, especially when large volumes are required (see Chapter 6.6 for more

Transfer chute with squeeze & scale. M. Wagoner

information). Animals should be acclimated to these devices prior to when they are needed for actual procedures. One way this can be accomplished is by placing the squeeze in a location that the animals have to pass through regularly for shifting.

Scales: An accurate scale should be included in the off-exhibit area to allow routine body weights in order to monitor the health and nutritional status of the animal. Scales may be built in to a holding cage or restraint, or a load bar or platform scale provides portability for use in multiple areas.

Furnishings

Logs and stumps for scent marking and sharpening claws are also recommended for night holding enclosures. All enclosures should have varied topography to add complexity to the animals' environment. Hills, trees, shrubs, branches, rocks and stumps are good pieces of enclosure furniture for lions, and can be used for shade as well as for territorial marking. Large wooden objects should also be available for scratching. If possible, these objects should be moveable in order to change pathways daily, weekly or at least periodically, as a way to provide environmental variability.

While most enclosure furniture is large and not easily moved, large branches can be placed in the exhibit and later moved regularly to initiate exploration. An active enrichment program will aid in the welfare of lions, and can supplement efforts to move or change the environment periodically. Enrichment items can be hidden in the exhibit to further stimulate interest, exploration, marking, and feeding behaviors. See Chapter 8.2 for more information about enrichment. Exhibits should be designed to provide complete access to machinery to allow large items of exhibit furniture to be moved, or to allow the additional (or removal) of substrates and other exhibit

Resting and Sleeping: Under normal circumstances, lions do not require bedding materials, but should be provided with one sleeping ledge or wood platform per animal. Bedding may be added as enrichment and older animals may benefit from softer sleeping surfaces. Each lion should have its own resting/nest box or enclosure for sleeping, or enclosure servicing. Elevated platforms will be used by lions, and should be offered whenever possible. Platforms should be made of materials that are easily cleaned, fast drying, and easily replaced when damaged or worn.

Visual and Auditory Barriers: Ideally, exhibits should be viewable by the public on no more than two sides so that animals may be able to hide from each other and the public. There should be visual barriers for the animal to feel hidden from the public. Care should be taken to note behavioral changes and minimize all conditions causing the animals to display signs of stress. Loud or repetitive noises, unusual activity, and unknown personnel in off-exhibit or night house areas may act as potential triggers for aggression (Law, 2003). While stability of routine is important, lions will also benefit from exposure to unusual stimuli in a short duration in a controlled environment. Medical procedures, severe weather, construction, etc. will inevitable intrude, so previous exposure may help develop better-adapted lions that are not as easily stressed.

Doors

Shift and night cages should be designed to prevent accidental contact that would allow a lion to reach into the cage of an adjacent, incompatible cat, resulting in injury. Shift doors should be designed to prevent tail injury during transfer procedures. Optional "howdy" doors between individual holding units are beneficial during introductions.

Doors may move horizontally (sliders) or vertically (guillotines) and design is often driven by the space available. Sliders may become obstructed by debris in the track, although this can be mitigated by a door that hangs from a track rather than setting on one. Heavy guillotine doors are difficult for staff to operate

and also pose a risk of animal injury if they fall or are dropped. Doors operated by cable and pulley systems should be inspected regularly for wear, as a door with a broken cable may move freely. Pins that go through the door and frame provide an additional safety backup while staff are in the enclosure.

Doors may be electric, hydraulic, or manually operated. Well-designed manual doors are the most cost effective choice and do not require as much specialized maintenance. Electric and manual doors should have a manual or battery backup for use in power outages. Regardless of design, door controls should be in a location that allows the keeper to have good visibility of the door and the animals passing through it.

Floors

Surfaces within indoor animal areas should provide good traction, especially when wet, but not be so abrasive as to cause footpad trauma during normal movement or pacing. Concrete floors are recommended for easy cleaning and disinfecting. If the surface is too hard, trauma to bony prominences in normal resting or sleeping positions can result. Rubberized flooring, although soft, may be damaged by the animals, resulting in potential gastrointestinal foreign bodies. It can also be difficult to clean properly.

Natural substrates such as grass and dirt are recommended for outdoor enclosures. Substrates such as sand, wood chips, and mulch can also be utilized. The use of hard, artificial substrates (e.g., cement) should be minimized in outdoor enclosures, as these have been associated with footpad injuries and early symptoms of arthritis (Law, 2003).

Food and Water Delivery

Watering devices that are built into the exhibit/enclosure are appropriate for lions. This may include simple cement bowls or commercially available waterers such as those made by Nelson or Lix-it. While all of these have been used successfully with lions, there is risk of the waterer being damaged by a determined lion, which could also cause injury.

Small and large pools can also be used as water sources but unless their cleanliness can be assured, an additional smaller, easy to clean water source is needed. Whatever the device, it should be designed to be easily emptied and cleaned. Many felids will urinate and defecate in water bowls, so frequent cleaning will be necessary.

Food chutes may be utilized to deliver meat to lions safely. Well-designed chutes enable keepers to deliver meat quickly and safely and may require a cover when not in use to keep lions from reaching out or visitors from dropping items into them. If the chute is too large, it may block visibility so location should be carefully considered.

Food chute, animal side.
M Wagoner

Food chute, keeper side.
M. Wagoner

2.2 Safety and Containment

Animals housed in free-ranging environments should be carefully selected, monitored and treated humanely so that the safety of these animals and persons viewing them is ensured (AZA Accreditation Standard 11.3.3).

AZA Accreditation Standard

(11.3.3) Special attention must be given to free-ranging animals so that no undue threat is posed to the animal collection, free-ranging animals, or the visiting public. Animals maintained where they will be in contact with the visiting public must be carefully selected, monitored, and treated humanely at all times.

Staff Training and Safety

Lions can easily cause injury or death to other animals and humans. Even young animals are capable of injuring animal caretakers, and staff should not enter cages of juvenile or adult individuals no matter how tame they were as cubs.

All staff working with lions should receive thorough training from managers and coworkers. It is important that lion keepers understand the natural history as well as the individual background of the cats with which they work. Operation of doors and other exhibit features should be thoroughly covered, as well as all safety guidelines and emergency procedures. A good lion keeper will be safety conscious, attentive to protocols, and be able to make good decisions in an emergency.

Ensuring that doors, gates, and barriers are secure is critical, as is checking of locks to ensure animals cannot escape. Checks of the exhibit perimeter for cage integrity or damage from fallen debris or storms should occur at least daily to prevent the potential for escape. Performing an accurate count of animals should occur before entering any lion enclosure. A system of keeper labels on entrances and shift doors can help ensure that staff does not enter animal enclosures while animals are present, although such systems should not replace checking the location of the animals before entering and the status of locks before shifting animals. Staff should still double check animal and staff locations before shifting animals, and never depend solely on signs or lock-out tags or other mechanical safety measures. It is also important when feeding or interacting with lions for keepers to be cognizant of their surroundings, to avoid falling or leaning against caging, or placing fingers or other extremities into the enclosure.

Establishing a culture of safety consciousness in the area and throughout the institution is critical to maintaining a safe environment for staff, guests, and animals. Safety concerns should be taken seriously at all levels of the organization and violations of safety protocols should be considered serious disciplinary issues. Double-checking locks and maintaining open communication is critical. Staff should recognize in themselves and well as in their coworkers when personal issues such as illness, fatigue, or stress may cause a distraction and remove themselves from potentially dangerous parts of the routine.

Simple safety guidelines for working with lions:

1. Count the cats
2. Assume nothing
3. Trust no one

These guidelines emphasize the importance of double checking and confirming before proceeding. Keepers should never assume that an area is as they left it, even if they are certain that no one else has entered the area. Finally, keepers should always check that status of locks and doors and location of cats themselves, and never rely on verbal confirmation from another person. Each person that enters the area or opens a shift door is responsible for their personal safety and the consequences of their actions.

Some institutions have instituted a two-person rule in large cat areas, requiring that a second person be present for shifting, feeding, and other potentially dangerous activities. This procedure provides a backup to check locks and hopefully catch a mistake before it becomes a problem. In the event of an injury or escape, this second person is also available to call for help. There are potential drawbacks to this procedure as well, the most obvious being the burden on a small staff. A second person can also be a distraction if both people are engaged in conversation and do not have their full focus on the task at hand. In an effort to be more efficient, two keepers in a large building may split up to complete their work, thereby negating the benefit of having the second person present. This can also create another potential hazard if the two keepers do not communicate carefully about their locations when cats are being moved around. However, if there are clear procedures for communication and shifting procedures, multiple keepers can work in the building safely. Examples include designating only person to shift on a given day

or assigning certain areas to individuals and not allowing any other individuals shift those animals. A procedure for verbal confirmation of shifting plans and confirming the location of all staff and volunteers before shifting is also good practice. Individual institutions should evaluate their staff and facility and consider all of these factors when deciding whether to implement this procedure.

All large cat keepers should carry a radio at all times and ideally the holding facility will also be equipped with a phone. The decision to allow staff to carry cell phones with them should be considered carefully. Cell phones can provide a keeper with another critical means of communication if the radio fails. However, the phone can also be a distraction, particularly if the keeper is receiving text messages or calls while working. Even if they are ignored, it still causes a distraction that can dangerously interrupt a train of thought during shifting, feeding, or training. Turning off all ring and vibration notifications is a potential solution to this problem.

Many institutions also provide pepper spray (marketed as a bear deterrent) for large cat keepers, which has been proven to be effective in deterring large cats. Pepper spray should only be used in an emergency situation when a keeper finds him/herself in the same space and close proximity to a large cat. It may provide the keeper a few moments to escape the immediate area and will have no long-term effect on the cat. Staff should be carefully trained in how to use the spray and informed of the potential risks to other people and animals if it is accidentally discharged.

If non-animal staff (i.e., maintenance, horticulture, volunteers, etc.) are working in lion areas, staff should provide close supervision and clear instructions about safety procedures. This includes careful tracking of the number of people entering and leaving the area and strict instructions as to where they are allowed to go and what they are allowed to do. Non-zoo staff (contractors, guests, etc.) should be escorted at all times and provided careful instruction before entering the area. Depending upon the facility design, lines may be painted on the floor to indicate safe distance from cages.

Acceptable forms of Human/Lion Interaction

Successful husbandry and reproduction depends on stable, long-term relationships between large cats and their keepers. Most animals quickly adapt to daily routines, shifting readily as well as accepting training to allow routine and non-routine veterinary tasks. They also quickly recognize familiar keepers by their voice, movement, and other behaviors. Operant conditioning and protected contact training, particularly if done by the consistent individuals, will greatly assist veterinary examinations and procedures (see Chapter 8 for more information on training).

Feeding a lion using a meat stick
H. Colahan

Feeding diet and treats through bars, wire, or other containment surfaces also allows for animal/staff reinforcement even as it provides an opportunity for medication. Caution should be used when hand-feeding large cats to ensure that the keeper is not bitten. One option is the use of a meat stick to deliver food, which allows the keeper to keep a safe distance from the mesh and the animal's mouth. Meat sticks may be custom-made or store bought items may be used. Staff should carefully inspect the item to make sure it does not have splinters or sharp points that may injure the animal. Another option is a food chute built into the front of the holding area, which allows meat to be dropped in and delivered safely to the animal (see Chapter 2.1 for more information). Items such as back scratchers and brushes may be used with some cats to provide tactile stimulation safely. Lions are very strong and quick, so keepers that scratch or touch a cat directly through the mesh are at risk of being bitten, scratched, or having their fingers smashed. Institutional protocols should address policies for the feeding and tactile contact with lions.

Free contact with adult lions is very dangerous, and is not recommended under any circumstances.

Animal exhibits and holding areas in all AZA-accredited institutions must be secured to prevent unintentional animal egress (AZA Accreditation Standard 11.3.1). Exhibit design must be considered carefully to ensure that all areas are secure and particular attention must be given to shift doors, gates, keeper access doors, locking mechanisms and exhibit barrier dimensions and construction.

AZA Accreditation Standard

(11.3.1) All animal exhibits and holding areas must be secured to prevent unintentional animal egress.

Containment

Exhibits and off-exhibit holding areas should be designed to provide the highest level of security for this species. Great care should be taken in placement of landscaping and exhibit furniture to avoid the possibility of use by cats to reach areas in which public, animals, or staff may be injured. Consideration should include prevention of a stepping stone effect by animals jumping from one landscaping element to another in order to reach a location otherwise out of reach. No matter what containment material is used, the composition of the material and the external coatings applied must be non-toxic, non-irritating, and non-traumatic.

Moats: Dry or water moat enclosures that are 7.6 m (25 ft) wide have successfully contained lions. Lions do not swim as frequently as some cats but are capable and even the most reluctant will enter the water if sufficiently motivated. Dry moats should be monitored for erosion, debris dropped from outside the exhibit and vegetation should be maintained to allow daily visual inspection of the containment barriers. Lions are adept climbers and young animals in particular will use trees and rock barriers to get a better vantage point.

Sharp drop offs and water moats can also pose a hazard to young cubs and during introductions and should have a transfer system or ramp to get animals out if needed. Hotwire may be used to deter access but should not be depended on for primary containment.

Dry moat barrier that does not create a fall risk for animals
T. Webb

Chain link fence barrier with 90 degree turnback
M. Jeffries

Walls/Fences: The jumping ability of lions should not be underestimated, and vertical jump walls (dry moats or exterior walls) in enclosures lacking a top should be tall enough to prevent jumping or climbing out. Current practice for new exhibits in AZA institutions has been a minimum 4.5 m (15 ft) height with a turnback/overhang. However, the type of barrier must be considered when determining necessary height. Themed rock walls may be easier for animals to climb if not designed with sufficient negative relief, and chain link fences may be easily climbed by agile animals. Hotwire is not an adequate form of primary containment and should not be used to compensate for inadequate primary barriers, although it is sometimes used as a supplemental deterrent to climbing.

Zoos with outdoor enclosures using wire fence perimeters should consider the nature of the

soils. Wild lions have been observed digging up aardvarks and zoo lions will dig up sprinklers or other objects if properly motivated. If soft soils are present, chain link fencing that makes contact with a natural substrate should be to a depth of 91.4 cm (36 in.) along that perimeter or with a 91.4 cm (36 in.) apron at the bottom extending into the exhibit as a dig barrier, in order to prevent digging or bending of the fencing at the bottom from pushing. It can also be attached to a concrete footing. Fencing on hard surfaces with horizontally supported fencing or metal panels are adequate without burial.

Fence or mesh material should be no less than 8-gauge composition for hard mesh or chain link and 1/8" or 3/16" being the most common size for flexible woven mesh. Good results have been achieved with 5x5, 5x10, 7.6x7.6, and 10x10 cm (2x2, 2x4, 3x3, and 4x4-inch) welded mesh and custom woven meshes. However, a mesh measuring no more than 7.6x7.6 cm (3x3 in.) is recommended in keeper work areas to prevent injury from a cat reaching out. Lightweight mesh is not appropriate for lions. Also, when using a flexible mesh, the potential increases for damage to teeth, or the mesh itself, because lions often bite or pull it, and may get claws caught in it.

Secondary Containment: Exhibits and service areas should also have a secondary door system to maximize safety through keeper error. Cameras or convex mirrors can be used in areas where keeper cannot see down a hallway without entering the enclosure. Small, secure windows in exterior doors can also provide a safe way to view an area without entering.

Exhibits in which the visiting public may have contact with animals must have a guardrail/barrier that separates the two (AZA Accreditation Standard 11.3.6).

AZA Accreditation Standard

(11.3.6) Guardrails/barriers must be constructed in all areas where the visiting public could have contact with other than handleable animals.

Guest Barriers: Secondary guardrails should be utilized wherever the potential exists for guests contact with primary containment fencing or mesh materials. Designers should consult state or local regulations and guidelines for public barriers to exhibit contact. The public should be protected from unauthorized contact with lions. Public viewing points composed of tempered glass are commonly used in conjunction with interpretive graphics, and these do not require the use of secondary guardrails. Moated exhibits do not necessarily require guardrails, but they do tend to discourage the public from climbing onto or placing children on the containment wall. A height of no less than 1.2 m (4 ft) on the public side is recommended, and the vertical surface should lack footholds that would allow guests, particularly children to climb. Fences with decorative vertical poles or thin horizontal top rails will discourage guests from sitting children on them. Ensuring that children can view the exhibit while standing on the ground will help reduce the temptation to climb walls and fences.

Doors: Animal access to the exhibit should be by remotely operated shift doors; sliding or guillotine types are preferred with a secure and easily checked locking mechanism reinforced with padlocks. Signage on the door or near the exhibit that alerts keepers as to whether there are animals in the exhibit, if it is being serviced, etc., can be used as an additional safety mechanism, although it does not replace visually confirming the location of animals before entering or opening doors. Door handles and controls should also be clearly labeled or color-coded as to which door they operate and the open and closed positions. All doors to lion exhibits should have secondary containment to serve as a safety measure against escape. See Chapter 2.1 for more information on door design and safety mechanisms.

AZA Accreditation Standard

(11.2.3) All emergency procedures must be written and provided to staff and, where appropriate, to volunteers. Appropriate emergency procedures must be readily available for reference in the event of an actual emergency. These procedures should deal with four basic types of emergencies: fire, weather/environment; injury to staff or a visitor; animal escape.

Emergency Protocols and Procedures

All emergency safety procedures must be clearly written, provided to appropriate staff and volunteers, and readily available for reference in the event of an actual emergency (AZA Accreditation Standard 11.2.3).

AZA Accreditation Standard

(11.2.4) The institution must have a communication system that can be quickly accessed in case of an emergency.

Staff training for emergencies must be undertaken and records of such training maintained. Security personnel must be trained to handle all emergencies in full accordance with the policies and

procedures of the institution and in some cases, may be in charge of the respective emergency (AZA Accreditation Standard 11.6.2).

Emergency drills should be conducted at least once annually for each basic type of emergency to ensure all staff is aware of emergency procedures and to identify potential problematic areas that may require adjustment. These drills should be recorded and evaluated to ensure that procedures are being followed, that staff training is effective and that what is learned is used to correct and/or improve the emergency procedures. Records of these drills should be maintained and improvements in the procedures duly noted whenever such are identified. AZA-accredited institutions must have a communication system that can be quickly accessed in case of an emergency (AZA Accreditation Standard 11.2.4).

AZA Accreditation Standard

(11.6.2) Security personnel, whether staff of the institution, or a provided and/or contracted service, must be trained to handle all emergencies in full accordance with the policies and procedures of the institution. In some cases, it is recognized that Security personnel may be in charge of the respective emergency (i.e., shooting teams).

AZA-accredited institutions must also ensure that written protocols define how and when local police or other emergency agencies are contacted and specify response times to emergencies (AZA Accreditation Standard 11.2.5)

AZA Accreditation Standard

(11.2.5) A written protocol should be developed involving local police or other emergency agencies and include response times to emergencies.

AZA-accredited institutions which care for potentially dangerous animals must have appropriate safety procedures in place to prevent attacks and injuries by these animals (AZA Accreditation Standard 11.5.3).

Animal attack emergency response procedures must be defined and personnel must be trained for these protocols (AZA Accreditation Standard 11.5.3).

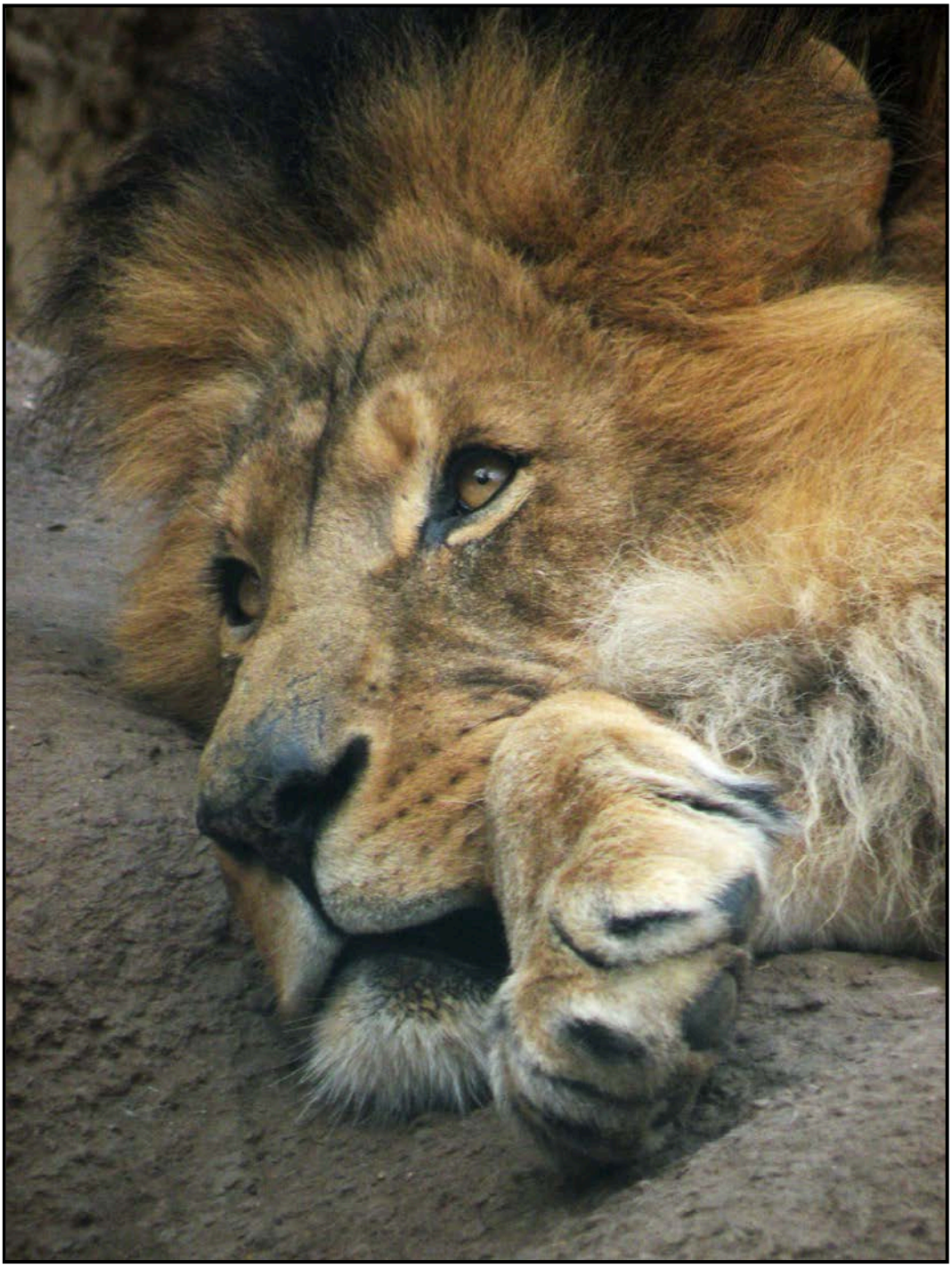
Animal attack emergency drills should be conducted at least once annually to ensure that the institution's staff know their duties and responsibilities and know how to handle emergencies properly when they occur. All drills need to be recorded and evaluated to ensure that procedures are being followed, that staff training is effective, and that what is learned is used to correct and/or improve the emergency procedures. Records of these drills must be maintained and improvements in the procedures duly noted whenever such are identified (AZA Accreditation Standard 11.5.3).

AZA Accreditation Standard

(11.5.3) Institutions maintaining potentially dangerous animals (sharks, whales, tigers, bears, etc.) must have appropriate safety procedures in place to prevent attacks and injuries by these animals. Appropriate response procedures must also be in place to deal with an attack resulting in an injury. These procedures must be practiced routinely per the emergency drill requirements contained in these standards. Whenever injuries result from these incidents, a written account outlining the cause of the incident, how the injury was handled, and a description of any resulting changes to either the safety procedures or the physical facility must be prepared and maintained for five years from the date of the incident.

If an animal attack occurs and injuries result from the incident, a written account outlining the cause of the incident, how the injury was handled, and a description of any resulting changes to either the safety procedures or the physical facility must be prepared and maintained for five years from the date of the incident (AZA Accreditation Standard 11.5.3).

Chapter 3. Transport



D. Bredahl

3.1 Preparations

Animal transportation must be conducted in a manner that adheres to all laws, is safe, and minimizes risk to the animal(s), employees, and general public (AZA Accreditation Standard 1.5.11). Safe animal transport requires the use of appropriate conveyance and equipment that is in good working order.

AZA Accreditation Standard

(1.5.11) Animal transportation must be conducted in a manner that is safe, well-planned and coordinated, and minimizes risk to the animal(s), employees, and general public. All applicable local, state, and federal laws must be adhered to.

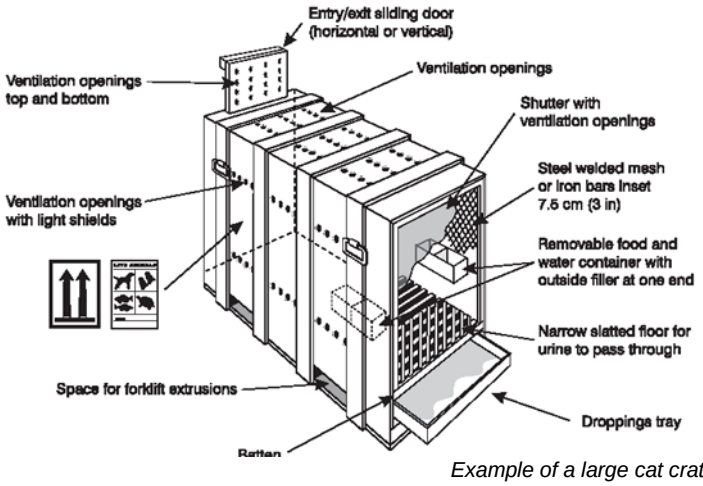
Documentation: Health certificates, transaction paperwork, air-bills, and all other relevant documents should be shipped along with animals and attached to the crate. A document outlining details of the sending institution's husbandry procedures, diet, and behavior notes is an important component of this paperwork. The Animal Data Transfer Sheet (ADT), a form printed by the American Association of Zoo Keepers, is a convenient method. A copy of this form can be found in Appendix G.

The International Air Transport Association (IATA) publishes animal transportation guidelines annually, which are available for a fee. Airlines in the United States utilize these guidelines to determine the suitability of any animal crate for use in transport.

Pre-shipment Preparations: Training a lion to enter a shipment crate in advance of actual transport is highly recommended, and can be accomplished using standard training techniques (see Chapter 8 for additional information on training). Crate training helps to eliminate the need for general anesthesia and its accompanying psychological and physiological stress. For information on pre-shipment medical evaluations that are recommended, see Chapter 6.3.

Transport Container: Care must be taken that transport crates have no spaces that allow lions to reach out with their claws. Padlocks are necessary on every door, and the keys included with the shipment paperwork that is attached to the crate.

Crates for large felids should be heavy, durable containers made of hardwood, metal, welded mesh, and/or iron bars. The frame should be made from metal bolted or screwed together and must include a spacer bar 2.5 cm (1 in.) deep along the side for air circulation. The interior must be metal lined.



Example of a large cat crate
IATA

Ventilation openings should be placed at heights that will provide ventilation at all levels, particularly when the animal is lying down. Exterior mesh ventilation openings, with a minimum diameter of 2.5 cm (1 in.), should be open on all sides, entry door, and roof. The crate design should include an access area for use by a pole syringe. Many functional lion crates have the ability to be opened from either end. One end, typically the one closest to the lion's head, can be equipped with narrow spaced bars of a 2.5 cm (1 in.) space between them to visualize and feed the animal if necessary. This can then be covered for transport by a wooden door with appropriate ventilation holes. This end can also be equipped with a tray to hold water that can be accessed from outside. The most common doors for transport containers are those that slide vertically in a track (guillotine type) and are secured with screws into the crate and then padlocked as an additional measure. Additionally, handles should be positioned around the crate in case manual unloading is necessary. Spacer bars on the bottom will aid in unloading with machinery.

The height of the container should allow the animal to stand erect with its head extended; the length of the container should permit the animal to lie in the prone position. There should be at least 10 cm (4 in.)

of clearance around the animal when standing in a normal position. It is not essential that the lion be able to turn around.

3.2 Protocols

Due to their large size and aggressive nature, lions should be shipped individually regardless of age.

Provision of Food and Water: Food intake should be reduced 2–3 days prior to shipment. A light feeding may be given prior to shipment. Lions do not normally require feeding during transport, or the 24 hours following the time of dispatch. If animals are fed during transport, they should be fed in small quantities to ensure consumption or in a container that can be safely removed so that food does not spoil if uneaten.

If feeding or watering is warranted due to delay, lions may be fed 0.45 kg (1 lb) of meat per 9.9 kg (22 lb) of body weight. Water containers should be positioned at the front of the crate and fixed off the floor to prevent soiling. Safe outside access should be provided for filling in case of a delay. Ideally, some of the lion's diet should be shipped with the cat in a cooler (if a different brand from the receiving institution) to ease any transition to a new diet.

Provision of Bedding or Substrate: Straw, woodwool, or other absorbent material should be included in the container for comfort and absorption of excreta, but care should be taken if international shipments are involved to ensure that plant material is acceptable to receiving countries. Shredded paper or cat litter products are another alternative.

Mechanism(s) for Separating Animal from Urine and Feces: The floor should either be constructed in a narrow slatted form over a liquid proof tray in such a manner that all feces fall onto the tray, or it should be leak-proof and covered by sufficient absorbent material to prevent any excreta from escaping.

Appropriate Temperature Range: General temperatures by airlines for live animals (7.2–29.4 °C, [45–85 °F]) are adequate for lions. Animals being transported in unheated vehicles should not be exposed to temperatures below 4.4 °C (40 °F) unless protected from the wind, and previously acclimated to such temperatures. Environmental temperature is an important consideration in the loading process and during actual transport. Animals may experience sudden dangerous increases in body temperature, especially if anesthesia or sedation has been utilized.

The Animal Welfare Act specifies that a temperature range of 7.2–23.9 °C (45–75 °F) is normally acceptable for transport. A temperature range between 23.9–29.5 °C (75–85 °F) is only acceptable for a time period less than 4 hours. Animals being moved between the animal holding areas in cargo terminals and planes on the ramp may be subjected to temperatures exceeding 29.5 °C (85 °F) or below 7.2 °C (45 °F) for no more than 45 minutes.

Light Levels and Noise: Lions should be kept in darkened containers to minimize stimulus from their surroundings. Ventilation openings should be covered with burlap or shade cloth to provide the animal with privacy, but with consideration for airflow circulation. Crate doors should be secure to prevent rattling. Lions tend to become aggressive under stress from outside noises and activity. When shipping via air, animals may be placed in temperature controlled, quiet rooms at the airport, if available. During transport, containers should be located away from people, loud equipment, and other sources of potential stressors.

Staff Access to Animal: Due to the aggressive nature of lions, animals should not be released from their transport containers in transit under any circumstances. Under normal circumstances, lions may be shipped by air without specialized staff accompanying the animal(s). If transported by truck, animals should be visually checked by the driver when making routine stops.

Maximum Duration of Transport: Lions can be transported in their shipping crate for multiple days if food and water are offered daily but transports should be carefully planned to ensure that the fastest route is taken, with the fewest number of stops and transfers. It can be helpful to contact zoos along the route, prior to transport, in case assistance is needed along the way.

Due to the decreasing size of many commercial airplanes, air transportation of adult large felids is becoming increasing difficult unless transport only involves very large cities; increasingly specialized truck or van transportation is often the only means of transferring large felids.

Release: Lions should be released as quickly and safely as possible upon reaching the transport destination. Unloading may be made easier with the use of equipment such as a skidsteer, provided the crate is properly secured and will not topple over or fall off. Before releasing the animal into an enclosure, the crate should be secured to the cage by means of chain, canvas strapping, etc. This is to prevent the crate from being pushed away from the cage as the animal is released, creating a potential escape gap. After the door to the release cage is closed and secured, the crate can be removed. Despite being confined to the crate for some time, animals may be reluctant to come out into a strange environment at first. A quiet calm atmosphere with minimal number of staff will help.

Chapter 4. Social Environment

Jim Schultz

4.1 Group Structure and Size

Adult males housed together
D. Parsons

The basis of a pride in the wild is a group of related females and their young and 1–7 adult males, who are usually related to each other but not to the females. In managed settings, lions may be kept in large groups, usually multiple females with a single adult male or a pair of related males. Larger groups may be maintained, but such groups are best established if the cats are siblings, a young age when introduced, or hand-reared together.

Multiple males may also be maintained, especially while the animals are young or sub-adults. Coalitions of related males raised together may last into adulthood and make an impressive exhibit grouping. This grouping also provides social housing for surplus males when there is not an available group of females to house them with.

Careful behavioral monitoring is essential; sufficient space to maintain ostracized individuals, as outlined in Chapter 2.1, is also important.

Forced Emigration of Adolescents

In the wild, prides of related females may persist for generations, generally being closed to strange females. Daughters of the pride typically remain, but males depart as they approach maturity. In managed care settings, adult lions tolerate their offspring for up to 2 years of age. Males will often tolerate their offspring and cubs are frequently introduced back to the sire with their dam at a young age. Separation of cubs should be done gradually by letting the cubs sleep in separate but nearby enclosures at night, while remaining with the female during the day. When transferred, cubs will then adapt to total separation easier.

Cohorts

Lion males, especially siblings or juveniles of the same age, often form cohorts. These cohorts can be maintained throughout the animals' lives, depending on the individual temperaments of the animals, environmental factors (space, stress levels, etc.), and the makeup of the social group. Females are highly social, and develop preferred groupings, often between close relatives such as mother/daughter or siblings.

4.2 Influence of Others and Conspecifics

Animals cared for by AZA-accredited institutions are often found residing with conspecifics, but may also be found residing with animals of other species. Lions can generally be housed near other lions or large felids, although the resultant stress of nearby animals of other (or the same) species of cats can affect pair formation and reproduction in other species of felids (Brown & Wielebnowski, 1998) (Wielebnowski, 2003). Likely due to being apex predators, lions are not as susceptible to being stressed by proximity to other felid or carnivore species in general. However, some individuals may be more affected than others and these situations should be monitored and adjusted as needed. Care should be taken that space is not present at the bottom of enclosures that would allow a tail or foot to enter the enclosure of an adjacent, incompatible animal.

4.3 Introductions and Reintroductions

Managed care for and reproduction of animals housed in AZA-accredited institutions are dynamic processes. Animals born in or moved between and within institutions require introduction and sometimes reintroductions to other animals. It is important that all introductions are conducted in a manner that is safe for all animals and humans involved.

Successful introductions are the key to a self-sustaining managed population. Large cat introductions are noisy, sometimes bloody affairs that require a confident, well-prepared staff. Because of the potential for serious or fatal injuries, all introductions should be well planned and intensely monitored. Staff that do not have previous experience introducing large cats will benefit from viewing video of introductions. The AZA Lion SSP Management Group is also available to provide advice and answer questions about introductions.

In general terms, younger animals are easier to introduce than older ones and opposite sex introductions are easier than same sex. Lions with significant age differences have been successfully introduced several times. However, the backgrounds of the individual cats should also be considered. If the cats came from another institution, that staff should be contacted to get information about previous social and introduction experience. Finally, although introductions should be well planned, it is also important to let the animals, rather than an arbitrary schedule, dictate the progress and timelines.

If the area is large enough, it is recommended that introductions take place in off-exhibit areas. It is critical that staff know the behavior of their individual animals. Once the pair has been introduced (off-exhibit), the process of introducing the pair to the exhibit can begin. Depending on the space and facility constraints, some institutions may opt to begin introductions in the exhibit rather than in holding.

In general it is best to feed the lions before the introduction, which may facilitate a calmer demeanor. Alternatively, withholding food may better facilitate separations if that becomes necessary. Food, bones, or highly valued enrichment should not be present during introductions, as this will lead to fighting. Any enclosure features that could be obstacles or escape hazards should also be removed because cats that are being introduced may show athletic abilities not previously seen and/or may injure themselves when fleeing from another animal. Water moats and pools can be a serious drowning hazard, even for cats that normally avoid going in the water. One introduction resulted in one female chasing another into a deep water moat and then pursuing her and attacking in the water. Fortunately the cats were distracted but it took quite some time for the exhausted attacked female to come out of the water.

The decision to attempt to separate fighting lions during an introduction should be made by the appointed staff member in charge and criteria should be determined in advance. Some level of grappling and slapping may be expected. If fighting is intense and sustained, if an animal is put into a life-threatening position (such as on the back or grabbed by the throat), or if serious injury appears imminent, attempts should be made to separate. After successful intervention, the introduction team should meet and discuss potential next steps. It may be necessary to start over with tactile access, or it may be determined that the cats are incompatible.

Introduction of Unrelated Adult or Juvenile Lions

Basic guidelines for introducing pairs or groups of lions (or reintroducing pairs/groups that have been separated for a long period of time) include the following:

1. Maintaining a stable feeding and cleaning routine. Staff working with cats should remain on a familiar schedule to make sure that the animals are comfortable in their surroundings.
2. Animals should be housed in adjacent caging of adequate size for each animal. Ideally, solid walls between the cages should have a shift door or window that can be converted to a mesh opening to allow visual and olfactory access (a “howdy” door).
3. If possible, other animals not part of the introduction should be removed from the area.
4. The area should have minimum outside disturbance and, if possible, have remote video camera capabilities installed.
5. Sufficient time should be allowed for each new animal to adjust to its new surroundings before beginning the introduction process. This period can take a month or more depending upon the

individuals involved. It is beneficial to allow time for the animals to become comfortable with the husbandry routine and be shifting reliably and responding to the keeper staff.

6. Once animals are at ease with their surroundings, limited visual introductions can begin. Behavioral cues such as postures, vocalizations, etc. should be monitored. The number and length of exposures can be increased over several days. Initial reaction may be aggressive, with roaring and lunging but this should calm down over time.
7. Tactile introduction through a common wall is important. Such walls should be constructed of wire or similar materials with only small openings (1.27 cm [1/2 in.] or less) to prevent injury to either cat. Shift doors between adjacent enclosures may be modified to facilitate this stage. At this point, potential pairs may show antagonistic or aggressive behavior such as growling, hissing, or spitting. This may be shown initially and pass within a short period, but introductions should not progress until these behaviors pass. Another behavior is one of disregard for one another characterized by cats spending little time in close proximity. A third set of behaviors finds the female is in estrus, as demonstrated by cheek rubbing, rolling, crying, and lordosis. In some cases, females who previously have shown no signs of heat when isolated may act differently when put in close proximity to a male. Cats may be introduced if either of the last two behaviors is evident. Once the aggressive behaviors have passed, staff should be ready to proceed fairly quickly, as a prolonged “howdy” situation can create frustration for the cats and cause aggression to escalate again.
8. When the animals appear to be at ease with each other at the tactile access point, as demonstrated by lying side by side or one animal presenting itself in a vulnerable position while the other animal reacts non-aggressively, they are ready for limited physical introductions. All cats should be fully aware of each other’s presence before they are physically put together. All parts of the enclosure should be clearly visible to both animals. Ample escape routes should exist for both cats so that neither can be trapped or cornered by the other. This full access should only be done with staff members present to separate the animals if necessary. Fighting cats can be separated with water, CO_2 fire extinguishers, or any object that makes a loud noise.
9. Periods of supervised access can be increased in duration as long as the cats continue to appear comfortable with each other. Careful attention should be paid to the cats’ behavior during this time and pace of the introduction should be based on their behavior, not arbitrary timelines. During this period, changes in the cat’s environment and any outside interference, such as machinery, public visitation/viewing, etc. should be kept to a minimum. Later the pair can be allowed short periods of unsupervised access.
10. The use of remote monitoring equipment at this stage will give valuable insight to the pair's behavior when alone, with some felids reacting differently when keepers are not present. Similarly, hand-raised felids may react differently toward a potential mate in the keeper’s presence than when left alone. Care should be given not to distract a cat during an introduction. Calling to a lion or interacting with a cat during an introduction might provide a brief moment of vulnerability, subjecting the cat to potential injury.

Male to Female Introductions In general, these are the easiest introductions and usually go smoothly when following the above steps. If there are multiple females, they may be introduced to the male individually or as a group. If there is concern that the male may have an advantage due to size or age, introducing multiple females at the same time may help. If there are multiple males, keeping the females together will also balance the scales. However, bonded female coalitions (usually sisters) can be aggressive and will “gang up” on a male. Staff should consider the ages and backgrounds of the animals, as well assessing the behavior seen during the howdy process.

Female to Female Introductions These can be very difficult, as bonded females are more averse to allowing new females into the pride. Introducing single females to each other is the best scenario and introducing a single female to a group of females is very difficult. Young animals (less than 2 years old) are the best candidates for this type of introduction. If there is to be a male in the group as well, both groups should be introduced to him separately first. Ideally he may then be the mediator between the two

groups, but it is also possible the possessiveness over his attention may lead to more fighting. As stated above, information gained during the howdy period will guide the progress of the introduction.

Male to Male Introductions Males that grow up together or are introduced at a young age (less than 1 year old) can form tight bonds that last a lifetime. In the wild, adult males would be competitors and these types of introductions are rarely successful.

Introduction of Mother-Reared Cubs to the Pride

In the wild, females will separate themselves from the pride to give birth, but the cubs are soon introduced back to the pride and all pride members, including the males, become part of the cubs' social group. Replicating this process with lions in zoos is not only natural and socially beneficial, but will also ease space constraints and provide an enhanced experience for exhibit for zoo guests. No introductions are without risk, and temperaments of individual animals must be taken into account. The AZA Lion SSP recommends that institutions evaluate this risk and strongly encourages the introduction of cubs back to the full pride. The SSP Management Group is available to answer questions and provide advice and should be consulted in cases where an animal's background or temperament is cause for concern.

Reintroduction of Dam and Cubs to the Pride The reintroduction process will benefit from an early start, although cubs have been introduced at as old as 8 months of age. Introductions after 6 months of age have been more problematic than those that are done earlier and the only reported injuries were to cubs older than 6 months. The following is a fairly aggressive protocol and adjustments can (and should) be made according to individual animal temperaments and facility constraints.

Between 2–4 weeks after birth, the pride can have visual access to the cubs. If the group is particularly compatible and the mother is comfortable, the pride can even have visual access from the time of the birth. There should be a sufficient barrier (solid material or an empty cage or hallway) to ensure that members of the pride cannot injure a curious cub.

After about a week of positive visual access a "howdy" can be set up. Ideally this will be a low mesh window or door so it is easy for the cubs approach the pride. This should still be small enough mesh to prevent injury. If there is no aggression, introductions can proceed. Signs of aggression from the pride are unusual and should be cause for concern.

By the time the cubs are 3–4 weeks old the female may become restless and this is the ideal time to start full introductions. If she is separating comfortably from the cubs, she can be allowed to be with the pride during this time (without the cubs). If possible, allow her to have visual access to the cubs during this time and once she appears to want to go back with them or becomes agitated, return her to their stall. Once the cubs are cleared by the veterinarian, they can also start going out on exhibit with her during this time period (without the pride).

Cubs can be introduced back to the pride as early as 3 weeks but 7–8 weeks is more common. Again, this will depend on the temperament of the female and the rest of the pride. These introductions should follow the same preparations and procedures as other introductions described above.

Begin with the pride member that has the best relationship with the mother and the best temperament for the cubs (this may even be the male). The rest of the pride can be introduced one by one, with the pace determined by both the adults and cubs. This may be accomplished in a single day or occur over several days. Adults should be monitored for appropriate and calm behavior and the cubs may tire before everyone is introduced.

Adult male corrects a cub, a normal behavior and not cause for concern
G. Jones

Some of the pride, particularly the male, may be cautious or even avoid the cubs at first. This is not unusual and they will likely calm down after a few introductions and some time has passed. Other adults may also correct the cubs, which is appropriate behavior as well. The behavior of the dam will be a good indicator of whether the contact is acceptable or not, and she may chase, snarl, and swat at them if she feels they are being too rough. Aggressive actions such as shaking a cub or pursuing them like a prey item are cause for concern and staff should intervene immediately.

Reintroduction of Assisted-Reared Cubs

There are a wide variety of scenarios for introductions, depending on the individual animals and the circumstances of the cubs being pulled. More information on assisted rearing can be found in Chapter 7.

Ideally cubs would be reintroduced back to their dam, but if she is not a good option due to the rejection or her health (or even death) then another animal should be chosen. Exposure to adult lions is a critical component to a cub's social development so all options (even males) should be considered. This is especially important for singletons.

Introduction Back to Dam If cubs are pulled for medical reasons (as opposed to maternal abuse or neglect), they should be introduced back to the dam as soon as they are healthy enough. If the cubs have to be removed from the dam's holding area, supplying her with bedding that the cubs have used may help maintain the bond. Successful introductions of cubs born via C-section have been done as early as 1 day and hand reared cubs have been successfully introduced back to the dam as old as 6 months.

First allow the dam to see and smell the cubs through the mesh. She should show interest and attempt to smell and lick the cub through the mesh. If her reaction is positive, the cubs can be placed in the den box and the dam shifted back to them. Introductions back to the pride can proceed as described above for mother-raised cubs.

If the dam is indifferent through the mesh and/or does not resume full maternal care, the cubs can still be housed with her and only separated for feedings by the staff. If she is not aggressive toward the cubs, this option is still recommended over nursery rearing.

Introduction to a Lion Other Than the Dam Ideal candidates after the dam are females with previous experience with cubs and a calm disposition. Wild lions frequently care for and nurse cubs that are not their own so this is within the natural behavior for this species. The cubs should have a visual howdy with the female for at least 24 hours to gauge her interest and attitude toward them. Ideally there will be interest and maternal behavior but as above, cubs can be introduced to a female that is indifferent towards them and still benefit socially.

Introduction procedures are as outlined above, and if the adoptive female shows maternal behavior, she should be kept alone with the cubs for a few weeks to ensure proper bonding. Introductions back to the pride can proceed as described above for mother-raised cubs.

If the dam or adoptive mother is indifferent at first, they should be given time alone together to see if a maternal bond develops. If the cubs are not in danger, be patient as things develop. If the female does not behave maternally but tolerates the cubs the procedures for introductions are slightly different.

When introducing back to the pride, the adoptive female should only go back with the pride when the cubs do so. In other words, do not put her back with the pride individually, as this will be important in ensuring that the pride views the cubs as hers, rather than from another pride (which can trigger aggression). Introductions should proceed slower than with mother-reared cubs, spread out over several days with the adoptive mother and cubs still separated from the pride at night for a few weeks to ensure she remains focused on them.

Chapter 5. Nutrition

R. Earl

5.1 Nutritional Requirements

AZA Accreditation Standard

(2.6.2) A formal nutrition program is recommended to meet the behavioral and nutritional needs of all species and specimens within the collection.

A formal nutrition program is recommended to meet the nutritional and behavioral needs of all species (AZA Accreditation Standard 2.6.2). Diets should be developed using the recommendations of nutritionists, the Nutrition Scientific Advisory Group (NAG) feeding guidelines:(http://www.nagonline.net/Feeding%20Guidelines/feeding_guidelines.htm), and veterinarians as well as AZA Taxon Advisory Groups (TAGs), and Species Survival Plan® (SSP) Programs. Diet formulation criteria should address the animal's nutritional needs, feeding ecology, as well as individual and natural histories to ensure that species-specific feeding patterns and behaviors are stimulated.

Feeding Strategy and Foraging Behavior

The lion can be found in Africa and Asia where it is a successful predator except where in conflict with agriculture and human pressure. The lion persists mainly in open woodland, brush, scrub and grassland habitats, with additional populations found in arid, forested or mountainous regions. Lion prides defend home ranges which are size-dependent on prey and water availability and range from approximately 50 km^2 (19 mi^2) to over 700 km^2 (270 mi^2) (although with the majority of activity occurring in a central area) (Haas et al., 2005).

Lions are opportunistic predators, and acquire approximately 40% of their intake from scavenging (Haas, et al., 2005). Lions may hunt individually or as a group, with greater success in tandem. In the Kalahari, lions were successful at 40–50% of hunts, depending on prey (Eloff, 1984). Stalking time was also dependent on prey, for example 7 min (small un-preferred prey) to 30 minutes (large preferred prey) (Hayward & Kerley, 2005). Twelve to 50 kills per year are estimated per lion, depending on prey availability (Eloff, 1984).

Lions spend the majority of time (20–21 hours/day) inactive, approximately 2 hours walking and 1 hour eating, although activities may vary significantly between days. Peak activity (80–100%) occurs at night (Clarke & Berry, 1992; Eloff, 1984; Visser, 2009)

A male lion consumes a waterbuck in Sabi Sands, South Africa
H. Colahan

Lions will hunt and consume a variety of prey but the majority of kills range between 40–250 kg (88–552 lb) with an average weight of 115 kg (254 lb)/kill. If larger prey is available, lions will select for prey weighing 190–550 kg (418–1212 lb) (Hayward & Kerley, 2005). Preferred species include wildebeest (*Connochaetes taurinus*), gemsbok (*Oryx gazella*), buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis*), porcupine (*Hystrix africaeaustralis*) and zebra (*Equus buchelli*) (Hayward & Kerley, 2005). Similar prey preferences were found in Shamwari, where the average mass of prey killed was 132 kg (291 lb) (Rapson & Bernard, 2007) . Lions persisting in arid regions are restricted to smaller prey (average 55 kg [121 lb]; median 25 kg [55 lb]) but small prey is associated with higher cub mortality due to starvation (Eloff, 1984). Care should be taken when extrapolating prey preference to proportional contribution to the diet as availability and mass per prey species are highly variable.

When large prey is captured, lions may spend several hours consuming the kill (Visser, 2009). Kalahari lions were reported to leave on average 1/3 of the carcass (Eloff, 1984), while lions in managed settings consumed 90% of hind limbs offered and 100% of skin (Smith et al., 2006). In 4 hours of video tape on 5 kills by Masai Mara lions, only about 12% of feeding observation included bone and then only when muscle was present (van Valkenburgh, 1996). In addition to vertebrate carcass, traces of soil and grass were common in lion stomachs (Smuts, 1979).

Lions may go several days between kills either consuming and digesting large carcasses or seeking prey (Eloff, 1984). In Namibia, lions were observed to eat every 2.5 days on average (Clarke & Berry, 1992), another population was reported to average one kill every 4 days (range 1–13 days) (Smuts, 1979) and a group of Kalahari lions was reported to go as long as 8 days without a kill (Eloff, 1984). Others report lions eating every 1.5 to 3.5 days, depending on prey availability (Altman et al., 2005). Of 257 stomachs of free-ranging lions, 47.1% were found empty (Smuts, 1979).

Lions require 50 ml water/kg BW/day and acquire 50–100% of this through prey depending upon availability (Clarke & Berry, 1992; Green et al., 1984b).

Digestive System Morphology and Physiology

Lions are obligate carnivores and therefore possess a simple digestive tract comparable to the system of other carnivores (Fig. 2) (Mazak, 1981; Seymour, 1989). Dentition of the lion is reduced, with incisors and canines primarily used to bite and consume soft tissue and premolars and carnassials to slice skin and chew muscle from bone (van Valkenburgh, 1996). Pulling motions of the neck are used approximately 50% of the time and paws approximately 30% of the time when extracting food from the carcass (van Valkenburgh, 1996).

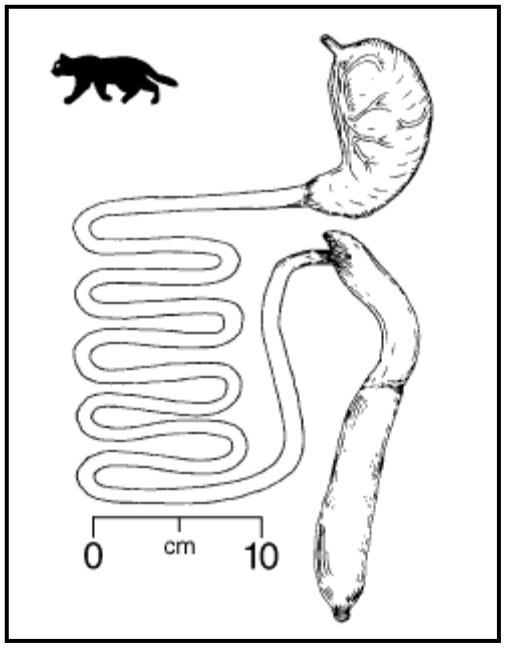


Figure 2 Digestive tract of *Felis domesticus* (Stevens & Hume, 1995). Available online from http://www.cnsweb.org/digestvertebrates/AAAEdStevensINTRODUCTION.html, accessed March 2011.

Figure 3 Digestive tract of adult female lion (115 kg) whole (A) and opened lengthwise (B) from stomach, through small intestine, cecum, large intestine and rectum. Total intestine length was 344 cm, which was significantly shorter than the average length of 3 other lions measured (746 cm) (Smith et al., 2006). The stricture in the lower large intestine shown here was not reported for other lions, tigers, or domestic cats and is expected to be abnormal.

The esophagus of the lion is approximately 70–80 cm (28–31 in.) long (Smith et al., 2006). The stomach can hold a substantial volume (20% of BW or greater) (Eloff, 1984). Measured stomach contents great than 20% BW were found to be common in cubs, but usually below 15% in adult lions (Smuts, 1979).

The small intestine comprises 74% of the total gastrointestinal tract length at 6–7 m (19–23 ft) (Smith, et al., 2006). A small cecum (approximately 10 cm [4 in.] or 1% of tract) is present at the intersection between small and large intestine. The large intestine is just over 1 m (3 ft) in length (13% of tract) (Smith et al., 2006). These values are comparable, proportionally, to reported values in tigers (*Panthera tigris*) and one jaguar (*Panthera onca*) (Mazak, 1981; Seymour, 1989) with both species also possessing small ceca. The intestine of domestic cats (*Felis domesticus*) maintains bacterial colonies comparable to those in herbivorous species (Brosey et al., 2000) which can provide protection against invading bacteria, stimulate gastrointestinal function such as immunity and motility and digest fiber sources to produce volatile fatty acids (Suchodolski, 2011). This is likely for *Panthera leo* as well, however due to the small relative volume of the feline tract, the contribution to digestion is probably negligible (Suchodolski, 2011).

This digestive tract allows for storage of large meals in the stomach and efficient digestion of vertebrate prey (Bennett et al., 2010; Clauss et al., 2010; Smith et al., 2006; Vester et al., 2010) but limited digestion of more complex fiber sources which omnivores and herbivores are able to utilize (Edwards et al., 2001; Wynne, 1989).

Energy Requirements

Equations for basal metabolic rates (BMR) in carnivores are higher than for omnivorous or herbivorous species with predicted daily energy requirements of 50-75 kcal/kg $BW^{0.75}$/day for lions and domestic cats (McNab, 2000, 2008; Munoz-Garcia & Williams, 2005). Examples of 52 managed lion diets provided approximately 130 kcal/kg $BW^{0.75}$, 1.7–2.5 times the expected BMR (Table 5). This is higher than the daily maintenance energy requirement predicted for domestic cats at maintenance (90 kcal ME/kg$BW^{0.75}$) which is only 1.5 time BMR (NRC, 2006). The estimated field metabolic rates (FMR) for carnivores the size of lions are 4–6 times BMR (Nagy et al., 1999), around 2.5 times higher than the energy level provided by diets in zoos. Field metabolic rates calculated for domestic cats are also 2.5 times the expected maintenance requirement (Nagy et al., 1999; NRC, 2006) Lower energy requirements for zoos lions and domestic cats likely reflect reduced activity associated with hunting and territory defense.

Estimates of food and energy intake in adult wild lions averaged 195 kcal/kg $BW^{0.75}$/day, falling between the energy requirements of zoo lions and estimates of FMR for carnivores. High metabolic rates in carnivores are attributable to high cost of capturing and handling food which may be partially ameliorated by the social behavior of lions.

Based on these observations, a maintenance requirement of 115–130 kcal/kg$BW^{0.75}$ for lions in zoos is proposed (approximately 3.5 kg [7.8 lb] per day for adult male lions and 2.7 kg [6 lb] per day for adult female lions) based on diets containing 1.75 kcal/g. Individual feeding rates should be evaluated and readjusted based on regular assessment of body condition score and weights.

Table 5: Estimates of daily energy and prey requirements for lions (*Panthera leo*). Zoo diets (reported as mean and range) are based on values and schedules reported by AZA institutions and may fail to account for whole prey or bones. Calculations based on 1.75 kcal ME/g for zoo raw diets and 1.4 kcal ME/g wild diet based on previous estimates and whole prey values (Bennett, et al., 2010; Green, et al., 1984; Smith, et al., 2006). If bodyweights were not reported, 185 kg (407 lb) was used for adult males, 130 kg (286 lb) for adult females, and 150 kg (330 lb) for unspecified adults.

Lion	BW (kg)	kg/d	kcal/d	kcal/kg $BW^{0.75}$/d	Reference
BMR male[e]	185		2500–3770	50–75	(McNab, 2000, 2008; Munoz-Garcia & Williams, 2005)
BMR female[e]	130		2000–2820	52–73	(McNab, 2000, 2008; Munoz-Garcia & Williams, 2005)
Zoo male (n=23)		3747 (2330–6031)	6558 (4077–10555)	131 (81–210)	
Zoo Female (n=21)		2502 (1750–3772)	4379 (3063–6602)	114 (80–171)	
Zoo unspecified (n=8)		3247 (2273–4286)	5683 (3977–7500)	133 (53–175)	
Male	193	5060 [c]	7084	137	(Green et al., 1984)
Adult		4930[a]	6902	161	(Green et al., 1984)
Adult		5100[a]	7140	167	(Green et al., 1984)
Female		4700[a]	6580	171	(Eloff, 1984)
Female		5000[a]	7000	182	(Schaller, 1976)
Male		7000[a]	9800	195	(Schaller, 1976)
Male		7200[a]	10080	201	(Eloff, 1984)
Female (n=3)	139.5	6090 ±2000[c]	8526	210	(Green et al., 1984)
Female[b]		6700[a]	9380	244	(Rapson & Bernard, 2007)
Male[b]		10050[a]	14070	280	(Rapson & Bernard, 2007)
FMR male[d]	185		15069	300	(Nagy et al., 1999)
FMR female[d]	130		11090	288	(Nagy et al., 1999)
Male cub	91	6530 [c]	9142	310	(Green et al., 1984)

Felis domesticus	BW (kg)	kg/d	kcal/d	kcal/kg $BW^{0.75}$/d	Reference
BMR	4			56–64	(McNab, 2000, 2008; Munoz-Garcia & Williams, 2005)
FMR	4			190–217	(Nagy et al., 1999)
Maintenance	4			90	(NRC, 2006)
Gestation	4			125–140	(NRC, 1986, 2006)
Peak Lactation	4			208	(NRC, 2006)

[a]Diet estimated from observed kills
[b]Female equivalent is the amount estimated per female lion based on observations of multiple lion groups. An adult male lion was estimated to represent 1.5 FEQ
[c]Diet estimated from sodium turnover
[d]Field metabolic rate derived from 7 species of Carnivora
[e]Basal metabolic rates derived from estimates for Carnivores, Carnivora, and Felidae with highest values estimated from 12 species of Felidae including 1 subadult lion.

Reproduction

Gestation and lactation in the domestic cat are periods of increased energy demand. The maternal contribution to reproduction is dependent on the size of the litter, growth rate of the offspring, and relative size of the offspring; therefore comparison between the domestic cat and larger felids may not be appropriate. Energy requirements for the domestic cat are approximately 40% higher during gestation and approximately twice that of maintenance during peak lactation (NRC, 2006), however no difference in metabolic rate was observed in a female puma (*Puma concolor*) during lactation (McNab, 2000). A factorial approach might allow for the most appropriate extrapolation of energy requirements (ME_{lact}) for exotic felids (E. Kienzle, 1998):

ME_{lact} kcal/d = ME_{mat} + [%N*(ME_o + ME_{og})]/$Efficiency_{milk}$

Where $Efficiency_{milk}$ is the conversion factor for maternal ME intake to milk ME output, which has been assumed to be 70% in cats (Kienzle, 1998). %N is the proportion of the offspring's energy derived from nursing (as opposed to solids), ME_o is the maintenance energy requirement for the offspring and ME_{og} is the energy for offspring growth. Using milk output and intake studies (Hendricks & Wamberg, 2000b; Kienzle, 1998) and energy estimated for lion maintenance and growth presented elsewhere in this chapter, the above equation becomes:

ME_{lact} kcal/d = $125*BW_m^{0.75}$ + [%N*($125*\Sigma(BW_o^{0.75})$ + $1.8(ADG_o)$)]/0.7

Where BW_m = maternal bodyweight, kg; BW_o = weight of each offspring, kg; and ADG_o = combined g growth of offspring.

During gestation the female domestic cat gains mass in addition to the mass of the kittens then subsequently loses weight during lactation (NRC, 2006). Optimal weight gain or weight loss during reproduction in large felids has not been studied. Since extreme body condition scores are associated with multiple health risks to the mother and offspring, it is recommended that gestating and lactating lionesses be fed to maintain body condition within the moderate range (BCS 4-6).

Growth

Energy requirements for post-weaning growth in domestic cats are estimated as:

$$ME_g \text{ kcal/d} = ME_m \times 6.7 \times [e^{-0.189p} - 0.66]$$

Where ME_m = maintenance energy requirement and p = proportion of mature bodyweight = bodyweight/mature bodyweight. Example expected values for p are reported in Table 6. This equation can be estimated by the linear equation:

$$ME_g \text{ kcal/d} = ME_m + (1.3*ME_m - 1.15*p)$$

Such that as p approaches 0 (birth), ME_g approaches 2.3*Maintenance and as p approaches 1 (maturity), ME_g approaches $1.13*ME_m$ (i.e. overestimates energy requirements close to maturity by 13%). An alternative equation based on energy requirements derived from nursing kittens for which 1 g gain costs 1.8 kcal (Hendricks & Wamberg, 2000; E. Kienzle, 1998) is:

$$ME_g \text{ kcal/d} = ME_m + 1.8(ADG)$$

These equations were fit to growth and hand-rearing data for three lion cubs using $125*BW^{0.75}$as the maintenance energy requirement, 130 kg (286 lb) as mature bodyweight, and the broken-line model for average daily gain (ADG). The NRC equation overestimated kcal consumed by 50% (interquartile range +32% to +69%). The Hendricks equation underestimated kcal consumed by 6% (interquartile range -18% to +17%) so would appear to be a better estimator of energy requirement for lion growth. However this equation and the growth curves presented below only represent a guideline. Lion cubs should be monitored with regular weights and visual assessment to determine appropriate individual feeding rates.

Weight data were collated from 190.229 parent reared, 74.73 hand reared, 33.32 unknown reared, and 23.25 wild born African lions reported in the literature (Clarke & Berry, 1992; Green et al., 1984; Haas et al., 2005; Schaller, 1976; Smuts et al., 1980; Visser, 2009) and 27.43 parent reared, 8.19 hand reared, and 1.2 unknown reared Asian lions for a total of 779 lions and 14,456 data points. Weights of male lions were always greater than female lions of the same age, but there was no difference between Asian and African lions nor was there a difference between parent-reared lions in human care which were wild born versus zoo-born. Data were compared to growth curves for 158.186 wild lions reported in the literature (Smuts et al., 1980) (Figure 4, Figure 5, Table 6).

Growth is often assumed to be linear in young animals, including domestic cats and as was reported in wild lions (Smuts et al., 1980) and in general this is an adequate assumption. However, when assessing the needs of neonates (for example when hand-rearing) a more accurate model of early growth is critical. Unfortunately continuous growth curves for lion in human care and wild lions fail to estimate reasonable weights during the first year of growth (Smuts et al., 1980). The broken-line model was constrained to derive accurate weight estimates from birth to maturity to provide a practical tool for evaluation of growing lions.

The rate of lion growth differed based on rearing and gender, however changes in the growth rate (breakpoints) were similar for males and females within each rearing group. Parent-reared males and females accelerated growth around 45 and 100 days of age whereas hand-reared males and females began growing at about 72% of the parent-reared rate but accelerated earlier around 30 and 70 days of age so that they equaled or surpassed the parent-reared animals in weight around 85 days of age. All animals decelerated growth around 18 months of age and reached mature weights around 3 years of age. After 365 days of age, the broken-line and continuous growth curve become similar and both could be appropriate (Zullinger et al., 1984). Continuous deceleration of growth is more physiologically accurate; however the broken-line model also describes the data well.

Continuous growth curves for both wild and zoo animals predicted maximum average daily gains around 10 months for female lions and 11 months for male lions (Smuts et al., 1980), however maximum growth rates for wild lions were predicted to be only 60% of the maximum rate for lions in human care. Overall, wild lions grew more slowly and for a longer period of time, although the linear estimate of growth predicted maturity at a similar age to lions in human care (Smuts et al., 1980). The difference between these animals was also observed by Smuts et al. (1980) and attributed to restricted nutrient availability for wild lions. This suggests that the higher growth rates in zoo animals reflect a more optimal plane of nutrition. Conversely, too-rapid growth rates can increase the risk of metabolic disorders, particularly in association with obesity. Rapid “catch-up”’ growth following periods of restriction may exacerbate these risks and could be occurring in hand-reared animals (Forsen et al., 2000; Ozanne, 2001; Ozanne & Hales, 2005). However, due to the small differences between hand-reared and parent-reared lions, the likelihood that nutrition is limiting in wild lion populations, limited data suggesting that metabolic disease is a significant problem in lions in human care, the growth rates reported here for both parent-reared and hand-reared lions in human care are expected to be appropriate. Difference in growth rate of hand-reared animals may result from formula composition initially followed by more rapid weaning to solids.

Figure 4. Growth curves of male lions in human care plotted with models from 158 wild lions (Smuts et al., 1980).

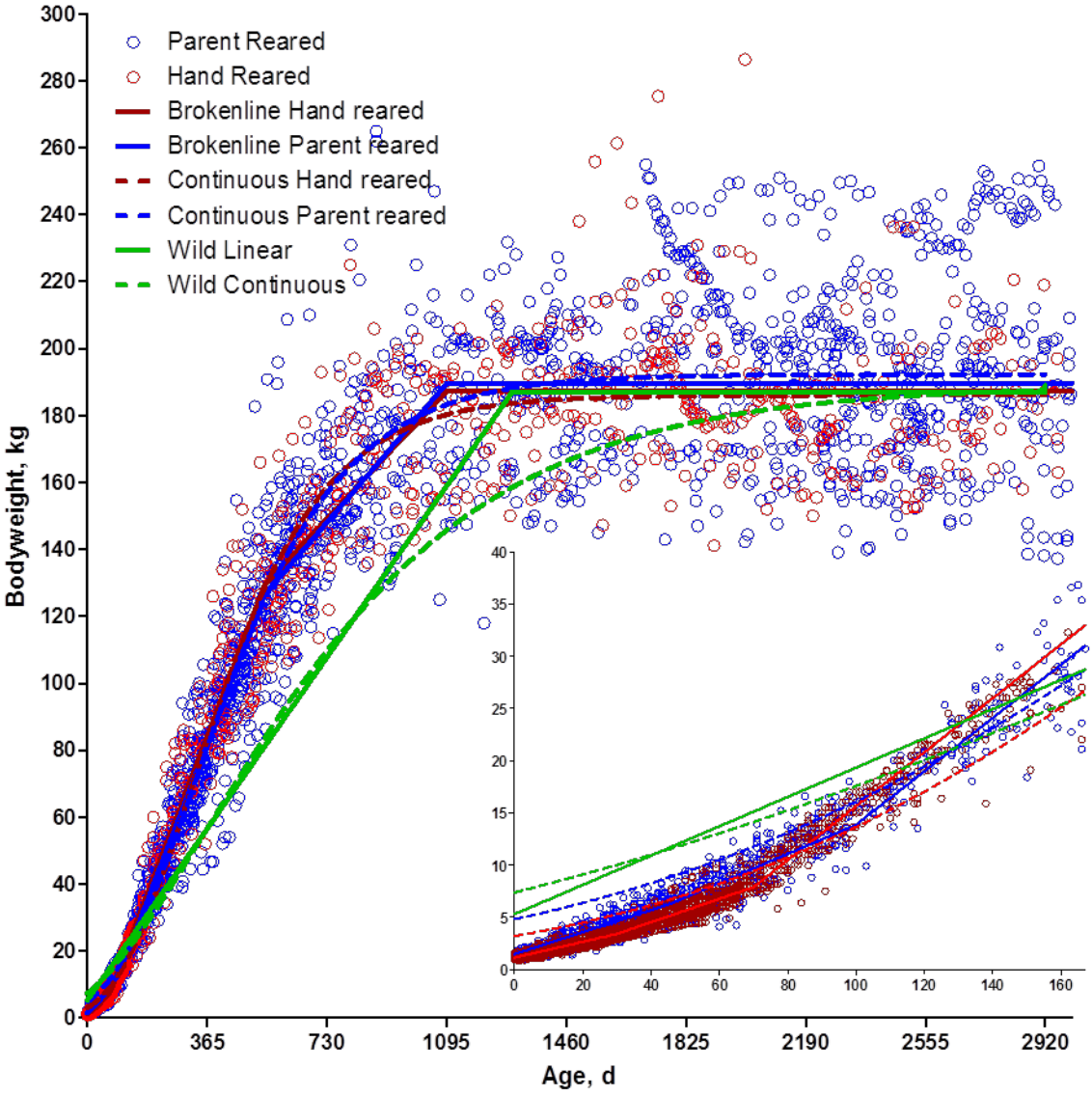


Figure 5. Growth curves of female lions in human care plotted with models from 186 wild lions (Smuts et al., 1980).

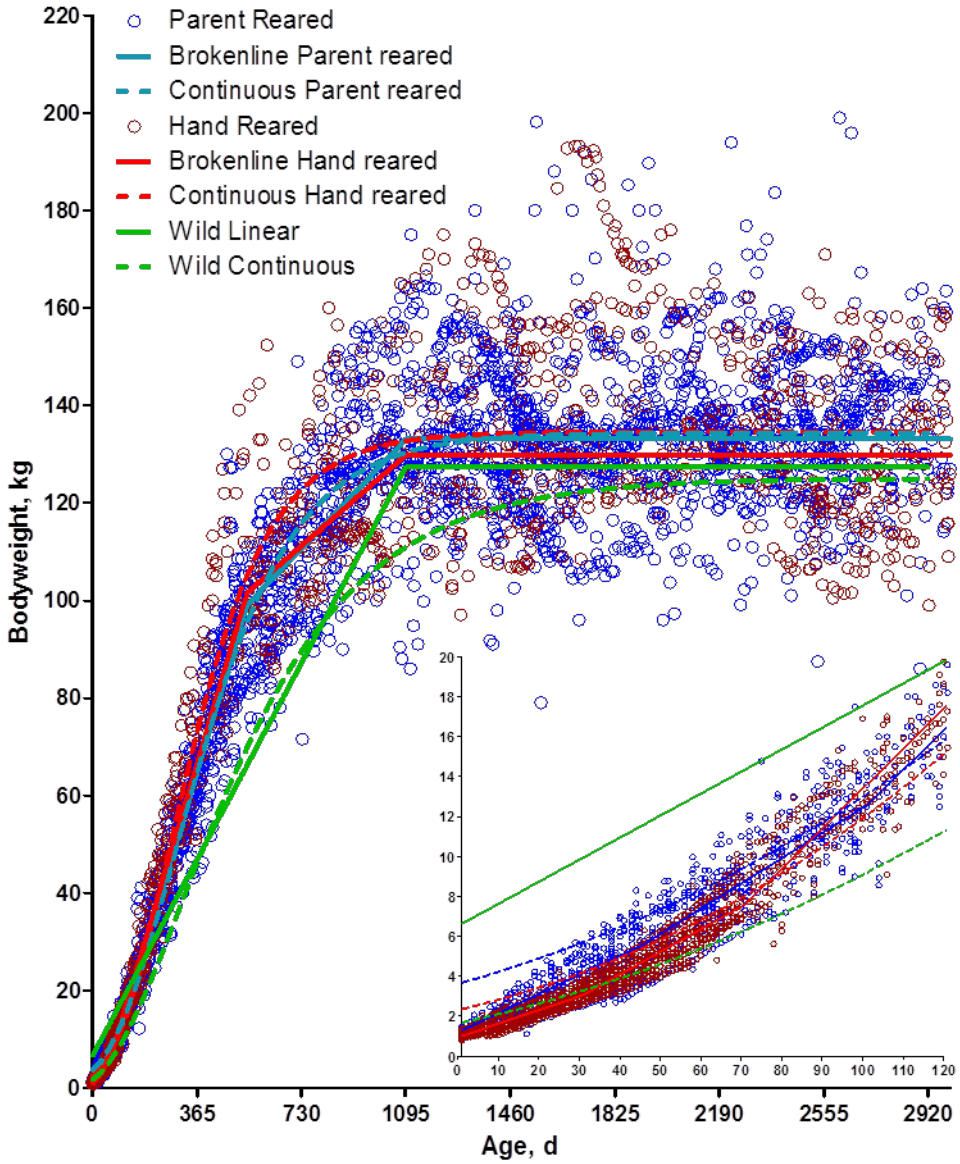


Table 6. Growth Curves for lions in zoos and wild lions reported by Smuts et al. (1980). Observed birth weights were 1.5 ± 0.2 and 1.2 ± 0.2 kg for male parent- and hand-reared lions in zoos and 1.3 ± 0.2 and 1.1 ± 0.2 for female parent- and hand-reared lions in zoos, respectively. Observed mature weights were 192 ± 22 and 187 ± 22 kg for male parent- and hand-reared lions in zoos and 134 ± 17 and 135 ± 18 kg for female parent- and hand-reared lions in zoos, respectively.

Male lions	**In Zoos**				**Wild**	
	Broken line		Continuous[6]			Linear
Rearing	Parent (n=218)	Hand (n=60)	Parent (n=218)	Hand (n=60)	Wild (n=158)	Wild (n=158)
Birthweight[3], kg	1.5	1.3	4.9	3.2	7.5	5.4
Mature weight, kg	190	187	192	186	188	NA
Time to maturity[4], d	1062	1060	1313	1197	2250	1267
Time to 50% maturity, d	417	402	422	400	610	629
Max ADG, g/d	256	258	280	303	159	140
Age of max ADG, d	100–540	70–540	329	317	361	0–1095
	Average daily gain[5], g/d					
0–30	105	76	70–94	57–81	82–95	140
30–45		112	94–107	81–98	95–101	
45–70	139		107–130	98–124	101–110	
70–100		258	130–158	124–158	110–121	
100–365	256		158–280	158–303	121–159	
365–540			278–214	297–211	159–148	
540–730	114	104	214–127	211–113	148–124	
730–1095			127–35	113–25	124–75	
1095–1460	0	0	35–9	25–5	75–41	NA
Female	**In Zoos**				**Wild**	
	Broken line		Continuous[6]			Linear
Rearing	Parent (n=272)	Hand (n=83)	Parent (n=272)	Hand (n=83)	Wild (n=186)	Wild (n=186)
Birthweight[3], kg	1.2	1.0	3.7	2.4	1.7	6.7
Mature weight, kg	133	130	134	135	125	127
Time to maturity[4], d	1052	1044	1188	1024	1729	1071
Time to 50% maturity, d	375	357	378	341	482	517
Max ADG, g/d	197	200	216	256	151	110
Age of max ADG, d	100-540	70-540	293	270	304	0-1095
	Average daily gain, g/d[4]					
0–30	96	69	58–79	49–74	44–64	110
30–45		113	79–90	74–90	64–73	
45–70	127		90–110	90–117	73–88	
70–100		200	110–133	117–151	88–104	
100–365	197		133–216	151–256	104–151	
365–540			207–142	231–135	148–122	
540–730	61	51	142–75	135–59	122–86	
730–1095			75–17	59–10	86–37	
1095–1460	0	0	17–4	10–1	37–14	NA

Energy of feeds

Several equations for estimating the energy content of typical cats feeds are available (Clauss et al., 2010; NRC, 2006) as well as numerous papers determining gross energy and digestible energy (Barbiers et al., 1982; Bennett et al., 2010; Vester et al., 2010). Care should be taken when making, comparing or reporting estimates that the different terms for energy are used appropriately (i.e. gross energy (GE) * digestibility = digestible energy (DE) * metabolic efficiency = metabolizable energy (ME)). A review of literature on raw diets and whole prey as are generally offered to lions in zoos supported the following Atwater equation for estimating ME in carnivores (Clauss et al., 2010):

ME kcal/kg = 39.9*(%CP+%NFE) + 90.0*(%Fat)

Where %CP is the percent crude protein and %NFE is the percent nitrogen free extract (which can be estimated as 100-CP-Fat-Fiber-Ash.

The more specific an estimation equation is to the feed evaluated, the more accurate the estimate, therefore estimates based on a single property (e.g. protein or fiber) should be used with caution. Feed composition varies between products, manufacturers and even lots (Allen et al., 1995) therefore regular quality control of feeds and assessment of managed animals for changes in weight or condition remain critical.

Nutrient Requirements

The nutrient content of food items consumed by lions has not been completely characterized. For the limited number of nutrients studied, the domestic cat remains an appropriate model (Vester et al., 2010). The nutrient levels presented below have been recommended by the National Research Council of the National Academies for the domestic cat (Table 7). As in all species, nutrient requirements vary depending on growth, activity, reproductive status, health status, environment and group dynamics.

Table 7. Target nutrient levels for carnivores on a dry matter basis (NRC, 2006).

Nutrient	Growth	Maintenance	Gestation/Lactation	All
Protein, %	22.5	20.00	21.3-30.0	20.0–30.0
Fat, %	9.00	9.00	15.00	9.0–15.0
Linoleic acid, %	0.55	0.55	0.55	0.55
Vitamin A, IU/g	3.55	3.55	7.50	3.55–7.50
Vitamin D3, IU/g	0.25	0.25	0.25	0.25
Vitamin E, mg/kg	38.00	38.00	38.00	38.00
Vitamin K, mg/kg	1.00	1.00	1.00	1.00
Thiamin, ppm	5.50	5.60	5.50	5.5–5.6
Riboflavin, ppm	4.25	4.25	4.25	4.25
Niacin, ppm	42.50	42.50	42.50	45.50
Vitamin B6, ppm	2.50	2.50	2.50	2.50
Folic acid, ppm	0.75	0.75	0.75	0.75
Biotin, ppm	0.08	0.08	0.08	0.08
Vitamin B12, ppm	0.02	0.02	0.02	0.02
Pantothenic acid, ppm	6.25	6.25	6.25	6.25
Choline, ppm	2550.00	2550.00	2550.00	2550.00
Calcium, %	0.80	0.29[1]	1.08	0.29–1.08[1]
Phosphorus, %	0.72	0.26[1]	0.76	0.26–0.72[1]
Magnesium, %	0.04	0.04	0.06	0.04–0.06
Potassium, %	0.40	0.52	0.52	0.40–0.52
Sodium, %	0.14	0.07	0.13	0.07–0.14
Iron, ppm	80.00	80.00	80.00	80.00
Zinc, ppm	75.00	75.00	60.00	60–75
Copper, ppm	8.40	5.00	8.80	5.0–8.8
Manganese, ppm	4.80	4.80	7.20	4.8–7.2
Iodine, ppm	2.20	2.20	2.20	2.20
Selenium, ppm	0.40	0.40	0.40	0.40

[1]Data do not exist for large maintenance level exotic felids fed 0.3% calcium and phosphorus diets.

As obligate carnivores, lions have unique nutrient requirements compared to omnivores. These differences are consistent with constant consumption of a high protein diet. Strict carnivores require higher levels of most essential amino acids, taurine, preformed vitamin A, niacin, and arachidonic acid (NRC, 1986). Omnivores can meet these requirements with other nutrients or possess enzymes or greater enzyme activity to up-regulate metabolic pathways to meet these requirements.

5.2 Diets

The formulation, preparation, and delivery of all diets must be of a quality and quantity suitable to meet the animal's psychological and behavioral needs (AZA Accreditation Standard 2.6.3). Food should be purchased from reliable, sustainable and well-managed sources. The nutritional analysis of the food should be regularly tested and recorded.

AZA Accreditation Standard

(2.6.3) Animal diets must be of a quality and quantity suitable for each animal's nutritional and psychological needs. Diet formulations and records of analysis of appropriate feed items should be maintained and may be examined by the Visiting Committee. Animal food, especially seafood products, should be purchased from reliable sources that are sustainable and/or well managed.

Food preparation must be performed in accordance with all relevant federal, state, or local regulations (AZA Accreditation Standard 2.6.1). Meat processed on site must be processed following all USDA standards. The appropriate hazard analysis and critical control points (HACCP) food safety protocols for the diet ingredients, diet preparation, and diet administration should be established for the taxa or species specified. Diet preparation staff should remain current on food recalls, updates, and regulations per USDA/FDA. Remove food within a maximum of 24 hours of being offered unless state or federal regulations specify otherwise and dispose of per USDA guidelines.

AZA Accreditation Standard

(2.6.1) Animal food preparations must meet all local, state/provincial, and federal regulations.

Diet Composition

Lions in zoos can be maintained on diets consisting of commercially available meat mixes, whole prey, bones, carcasses, and muscle meat diets balanced with supplements. Some or all of these ingredients fed in combination should meet the target nutrient ranges for domestic cats (Table 7).

Commercially prepared meat mixes should be formulated to meet the nutrient needs specific to cats. As such, these products have the advantage of requiring no additional supplementation. However, soft diets provide little abrasion for good dental health and thus should be fed with whole prey, bones or carcass. Meat mixes have traditionally consisted of predominately horse or beef. More recently, pork products have become available (Watts, 2011). In general, these diets are well digested by lions. Studies comparing digestibility of horse and beef diets fed to large cats (lion, cheetah, tiger, jaguar) and domestic cats show high digestibility of dry matter (75–90%), organic matter (79–96%), crude protein (81–97%), and fat (92–97%) with variability attributable to level and type of fiber, collagen content, ingredients and possibly species (Barbiers, et al., 1982; Morris, et al., 1974; Vester, et al., 2010; Wynne, 1989). Domestic cats fed the same diets had similar or greater nutrient digestibilities further supporting the cat as an appropriate model for exotic carnivores.

Commercial meat mixes contain little fiber (3% max, dry matter basis) with sources typically either cellulose or beet pulp. Cellulose is considered unfermentable and beet pulp moderately fermentable. Fermentable fiber has been suggested to promote intestinal health in domestic cats by supporting intestinal cells and microflora (Barry, et al., 2010). Small exotic felids (leopard cat, caracal) have been maintained on diets including fructooligosaccharides, another fermentable carbohydrate (Edwards et al., 2001)

All products, regardless of meat and fiber source should meet the target nutrient ranges discussed above. Additionally, products should meet the below ingredient standards (Allen et al., 1999).

Ingredient and Product Standards

All meat and meat products shall originate from animals slaughtered in plants subject to the Meat and Poultry Inspection Operations regulations of the USDA Food Safety and Inspection Service (FSIS), or under a system of inspection approved by FSIS. All bones, cartilage, heavy connective tissue, lymph glands, and central nervous system tissue shall be removed. Likewise, meat and meat products that originate from animals or carcasses designated as 3-D or 4-D shall not be used. Other (non-meat) ingredients shall conform to standards as defined by the Association of Feed Control Officials (AAFCO). The product shall be routinely monitored for specific microbial populations. The diet must test negative for the presence of *Salmonella* and *Listeria*, and within specified tolerance limits for total coliforms and *E. coli*.

Bones are recommended for abrasion for dental health and for enrichment, provided abnormal deleterious wear does not occur such as loss of enamel or damage to the teeth (Briggs & Scheels, 2005). Twice weekly feeding may favor more frequent plaque dislodgement and markedly reduced calculus formation and gingivitis (Haberstroh et al., 1983). Bones commonly fed to lions include: horse neck bones, horse tails, oxtails, knuckle bones, and femurs. Ribs bones are less common.

Whole prey is an intact animal with entrails and fur (or feathers) typically chicks, quail, rabbits, rats, and mice. Whole prey is also recommended to ensure proper dental health. The hide/fur, cartilage, gut and gut contents more approximate the natural diet of lions than hard bones and may therefore be more appropriate for abrasion. Whole prey fed to lions includes predominately rabbits but also guinea pigs, and rats.

The diet of wild lions is whole carcass. In zoos, whole carcass may or may not have the hide and viscera removed. Carcass typically refers to larger animals such as goats, sheep, calves, and deer. *Ex situ* supplementation of whole carcasses can promote a wide range of feeding and foraging behaviors. Institutions choosing to feed carcass should be aware potential hazards that may exist including presence of pharmaceutical drugs, pesticides, toxic organic compounds, pathogenic bacteria (Harrison et al., 2006). The origin and history of the carcass should be known and institutions must follow USDA policy #25 (USDA, 1998) specifying feeding the carcass as soon as possible or processing into smaller pieces and freezing, avoiding sick animals, removing lead shot from animals euthanized by gunshot, avoiding animals with signs of central nervous system disease or at risk of transmissible spongiform encephalopathies, including animals with scrapie, chronic wasting disease, and those with Johne's disease. Feeding of roadkill is discouraged. The AZA Nutrition Advisory Group only condones carcass feeding as part of a feeding program that ensures the diet of the animal is nutritionally balanced and free of pathogens. Whole carcass fed to lions includes deer, goats, sheep, whole or quartered, turkeys and chickens. See Chapter 8 for more information on food enrichment.

Muscle meat does not provide a complete diet. Muscle contains too little calcium, vitamins A, D, and E and other micronutrients to support health without additional sources of these nutrients. Muscle meat can be fed in combination with other diet items that meet the target nutrient levels so that additional supplementation is not required. For example, muscle meat is often utilized as a training tool or a medication vector. If muscle meat must be fed at a significant level in the diet or exclusively, the following supplementation is recommended per 2 kg of muscle (Ullrey & Bernard, 1989):
5 g calcium carbonate

10 g dicalcium phosphate

1.5 g (1 tablet) Centrum multi vitamin mineral tablets

Commercially available supplements specifically designed to balance muscle meat, such as Mazuri Carnivore supplement and Nebraska Meat Complete with Taurine, can also be fed.

Enrichment foods consumed by lions should be considered a part of the diet. All dietary enrichment should go through an institutional approval process, including review by nutritionists and veterinarians. All new items should be monitored closely when first provided. Ice should be used with caution considering several cases of tooth damage in domestic and exotic carnivores treated by zoo dentists (Briggs & Scheels, 2005).

Standards for inspecting meat and whole prey items are available in the *USDA Manual of Standard Operating Procedures for Handling Frozen/Thawed Meat and Prey Items Fed to Captive Exotic Animals* (Crissey et al., 2001). Food items from non-domestic stock should be frozen prior to feeding to kill any pathogens that might be present. Meat-based diets should not be allowed to warm to room temperatures or above for extended periods of time, as this may result in the growth of harmful bacterial organisms.

Sample Diets

Those institutions supplying detailed diet information fed diets based on commercially available nutritionally complete meat mixes using beef, horse, or pork (Table 8). Though carcass was not fed in the below diets, from a general survey, AZA institutions do feed carcass.

Table 8. Ingredient composition as a percent of the total diet (as fed) of 24 diets offered at 8 institutions

Ingredient	Average	Range
Meat mix[1]	75%	59–91%
Whole prey[2]	5%	0–12%
Bones[3]	15%	6–32%
Chunk meat[4]	5%	0–14%

[1]Meat mixes: Natural Balance Carnivore 5, Natural Balance Carnivore 10, Natural Balance Pet Foods, Pacoima, CA; Nebraska Premium Feline and Canine diets, Nebraska Premium Beef Feline, Nebraska Premium Beef Feline, 10%, Nebraska Special Beef Feline, Central Nebraska Packing, Inc. North Platte, NE; Toronto Zoo Feline Diet, Milliken Meat Products, Ltd., Markham, Ontario, Canada; Tucker's Zoological Select.
[2]Whole prey: rabbits, guinea pig
[3]Bones: Horse or beef femur or knuckle bones, horse necks, beef ribs, horse tails
[4]Chunk meat: horse muscle meat, beef heart, chicken breast.

Table 9. Nutrient content, energy on an as fed basis, all other nutrients on a dry matter basis, of 20 sample diets compared to target nutrient levels described in Table 7.

Nutrient	Average	Range	Target Range[1]
Energy, kcal/g AS FED	1.77	1.35–2.09	-
Protein, %	55.18	48.53–60.56	20.0–30.0
Fat, %	28.59	19.44–39.50	9.0–15.0
Ash, %	7.22	5.14–9.34	NA[2]
Linoleic acid, %	NA[3]	NA[3]	0.55
Vitamin A, IU/g	11.45	10.31–14.22	3.55–7.50
Vitamin D3, IU/g	NA[3]	NA[3]	0.25
Vitamin E, mg/kg	365.07	276.8–418.4	38
Vitamin K, mg/kg	NA[3]	NA[3]	1
Thiamin, ppm	11.06	9.16–12.28	5.5–5.6
Riboflavin, ppm	14.20	11.11–16.09	4.25
Niacin, ppm	163.44	128.0–282.20	45.5
Vitamin B6, ppm	17.76	12.51–20.39	2.5
Folic acid, ppm	0.86	0.26–1.42	0.75
Biotin, ppm	NA[3]	NA[3]	0.08
Vitamin B12, ppm	0.10	0.07–0.16	0.02
Pantothenic acid, ppm	NA[3]	NA[3]	6.25
Choline, ppm	NA[3]	NA[3]	2550
Calcium, %	1.89	1.45–2.14	0.29–1.08
Phosphorus, %	1.45	0.91–1.59	0.26–0.72
Magnesium, %	0.11	0.10–0.12	0.04–0.06
Potassium, %	0.89	0.40–1.06	0.40–0.52
Sodium, %	0.56	0.40–0.96	0.07–0.14
Iron, ppm	172.92	139.60–197.30	80
Zinc, ppm	116.39	98.3–199.90	60–75
Copper, ppm	13.18	8.61–21.16	5.0–8.8
Manganese, ppm	19.77	10.99–26.19	4.8–7.2
Iodine, ppm	NA[3]	NA[3]	2.2
Selenium, ppm	0.53	0.23–0.67	0.4

[1]Target nutrient range encompassing growth, pregnancy, lactation, and maintenance from table 7.
[2]Nutrient requirement not established.
[3]Missing values in database thus composition could not be calculated.

Feeding Schedules

Food items are either fed daily or rotated throughout the week.

Table 10. Example of a possible feeding schedule for lions

Ingredient	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Meat mix	X	X		X	X	X	
Guinea pig			X				
Rabbit							X
Knucklebone							X
Horse tail			X				
Chunk meat	X	X	X	X	X	X	X

Fasting for 24 hours without access to food is part of the feeding management at some institutions. Per USDA #25 animals should not be fasted more than 2 days per week.

Overall, most diets as reported would meet the known nutrient requires for cats for all physiological stages.

Provision of water
Clean, potable drinking water should be available at all times. Regardless of size, portable water containers should be cleaned and disinfected daily; built-in streams and pools should be cleaned and disinfected at least weekly. In cold climates, installation of means to prevent pipes freezing is an important consideration.

In outdoor exhibits or large indoor enclosures, water features for drinking, bathing, and aesthetics can be added in the form of pools, re-circulating streams, large, built-in water features, or commercial livestock waterers. As lions routinely defecate in pools, auxiliary drinking water sources should be provided. All water features should be drained, cleaned, and sanitized on a regular basis. See Chapter 1 for more information on types of drinkers and water features.

5.3 Nutritional Evaluations

Nutrition-Related Health Issues
Thiamine Deficiency: A case was reported of a young lion with presumed primary thiamine deficiency due to a diet of only beef muscle meat. Clinical signs observed included ataxia, generalized weakness, marked hypermetria and seizure-like episodes. Blood thiamine level in this lion was 11 nmol/L (normal reference range 160-350 nmol/L (Hoover & DiGesualdo, 2005). Signs improved with supplementation of thiamine and changing to a more balanced diet (DiGesualdo et al., 2005).

Hypovitaminosis A: Vitamin A deficiency has been reported in young lions (Hartley et al., 2005; Maratea et al, 2006; McCain et al., 2008; Shamir et al., 2008). Most cases presented with neurological signs, including ataxia, tetraparesis, seizures, head tilt, and opisthotonus. Death can occur within a few months, although affected animals are often euthanized as a result of the neurologic deterioration. The most common finding on pre-mortem or post-mortem examination is occipital bone proliferation with secondary cerebellar herniation through the foramen magnum, similar to a Chiari I-type malformation. A degenerative myelopathy of the cervical cord has been observed as well (Maratea et al., 2006). Vitamin A levels of <20 IU/g wet liver have been reported in all of these cases (normal reference value of 5,400 IU/g wet liver was obtained from a free-living lion) (Shamir et al., 2008). Milder clinical cases may respond to vitamin A supplementation. Sub-occipital craniectomy has been used with success in two reported cases (McCain et al., 2008; Shamir et al., 2008).

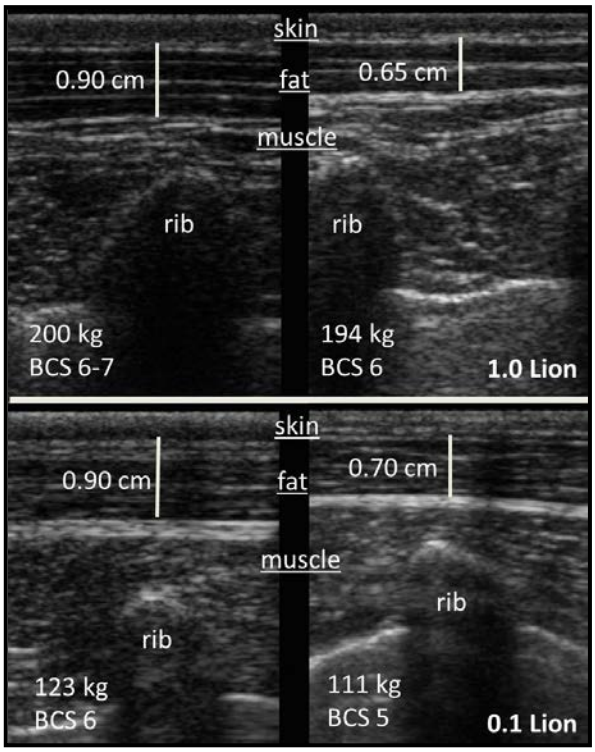


Figure 6 Transcutaneous ultrasound images over ribs of 1.1 lions during annual exams. Standardization of ultrasound location using morphometric measures is critical when comparing across images.

Body Condition Scoring
Obesity is purported to be the most common nutritional disorder in domestic felines (Zoran, 2002). The most practical method for evaluating degree of fatness for animals which cannot be readily palpated is visual body condition scoring. Body condition scoring (BCS) systems provide a spectrum of fatness usually with 1–5 or 1–9 levels (BCS points). Nine point BCS systems are more specific and preferred in domestic cats, dog, horses and other species and have been validated against direct and indirect

objective measures of fatness (German et al., 2006; Henneke et al, 1983; LaFlamme, 1997; Laflamme, 2005; Stevenson & Woods, 2006). One advantage of a 9 point body condition scoring system is that scores of 4 (moderate low) and 6 (moderate high) serve as warning zones where diet or management changes can be made to avoid ever reaching body conditions of increased health risk (low 1–3 and high 7–9 scores). Weights can provide the most specific measure of change in fatness, however body condition scoring is necessary in addition to weight to determine appropriate target ranges and also to track animals when weights alone are not indicative of BCS such as during growth and gestation. Body condition also does not require special equipment or animal training to achieve, although scorer training is needed.

A 9 pt. BCS scale has been developed for the lion based on 125 images collected from the internet and other institutions, 60 photosets collected from 2.4 lions at an AZA-accredited zoo, 26 of which were paired with weights, and 5 paired with palpations and transcutaneous ultrasounds collected over ribs, back, rump and tail while the animals were anesthetized (Fig 6, Fig 8). Although each species has unique conformation supporting the development of specific BCS systems, areas of fat accumulation are similar across many quadrapedal species, in particular: over the hips, the base of the tail, the torso and ribs, the backline, behind and over the shoulder, and the neck.

It is generally recommended that animals in zoos be maintained within the range of moderate body condition scores (4–6 on a 9 point scale). More extreme body conditions are associated with increased health risks, poor reproductive performance and reduced longevity in domestic cats and dogs (Laflamme, 2005). Palpation and transcutaneous ultrasound can provide a more accurate measure of fatness and should be used in conjunction with weights to calibrate visual assessment if possible.

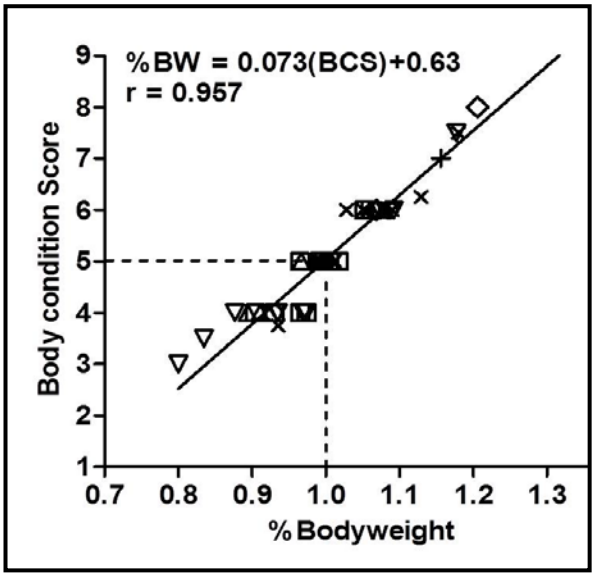


Figure 7. Plot of body condition score versus percent of moderate (BCS5) bodyweight for *Panthera leo* (1.0 open square, 0.1 x-symbol), *Panthera tigris* (1.0 open diamond, 0.1 plus sign), *Panthera tigris jacksonii* (1.0 open inverse triangle, 0.1 open triangle), *Panthera once* (1.0 open circle).

BCS scores showed a strong linear relationship (r=0.939) to weights for lions. This relationship was similar in other large felids so lion data were combined with data from 2.2 tigers (*Panthera tigris*) and 1.0 jaguar (*Panthera onca*) for a total of 50 weight/score pairs with pairs for each individual spanning at least 3 body conditions. Weights were normalized (weight at BCS 5 = 100%) and plotted against body condition scores (Figure 7). Linear regression for combined data clustered by animals gave a value of 7.3% change in bodyweight per unit BCS (95% confidence interval 6.3 to 8.3%, r = 0.957).

More specific body composition techniques exist and can further validate BCS scales in exotic animals, however these techniques are challenging or expensive to apply. Beyond the data reported above, body composition has not been assessed in lions, however it has been estimated from total body water from 14 wild lions in 2 studies (Clarke & Berry, 1992; Green et al., 1984). Average total body water was 64% and did not differ between males and females or immature vs. mature lions (P>0.05). This corresponds to an average fat mass of 13% bodyweight (range 3 to 21%). Studies in domestic cats using the same method, bioimpedance or DEXA, found fat masses of 23%, 28% and 5-55% bodyweight (Ballevre et al., 1994; Elliot, 2006; German et al., 2006). From these studies, an equation was derived to estimate body composition from body condition scores using a 9 pt scale in the cat (German et al., 2006):

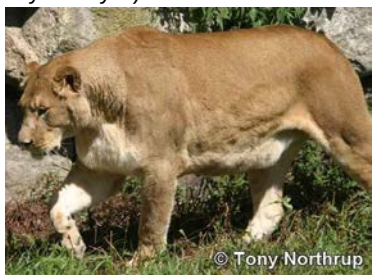
%Fat Mass = 6.652(BCS)-14.07

Based on this equation an increase in 1 body condition score is equivalent to a 6.652% increase in bodyweight, very similar to the 7.3% estimated for large felids. The equation also predicts 0 fat mass at BCS 2 which would seem appropriate the BCS systems for lions presented above. Accordingly, the equation for estimating fat mass from BCS in domestic cats appears to be applicable to lions and other

big cats, estimating 20% body fat corresponding to a BCS 5 out of 9. Extrapolating from this equation, wild lions ranged from 2.5 to 5.25 BCS, with an average BCS of 4 out of 9 (Clarke & Berry, 1992; Green et al., 1984).

Figure 8. Nine-point body condition scoring system for lions (*Panthera leo*)

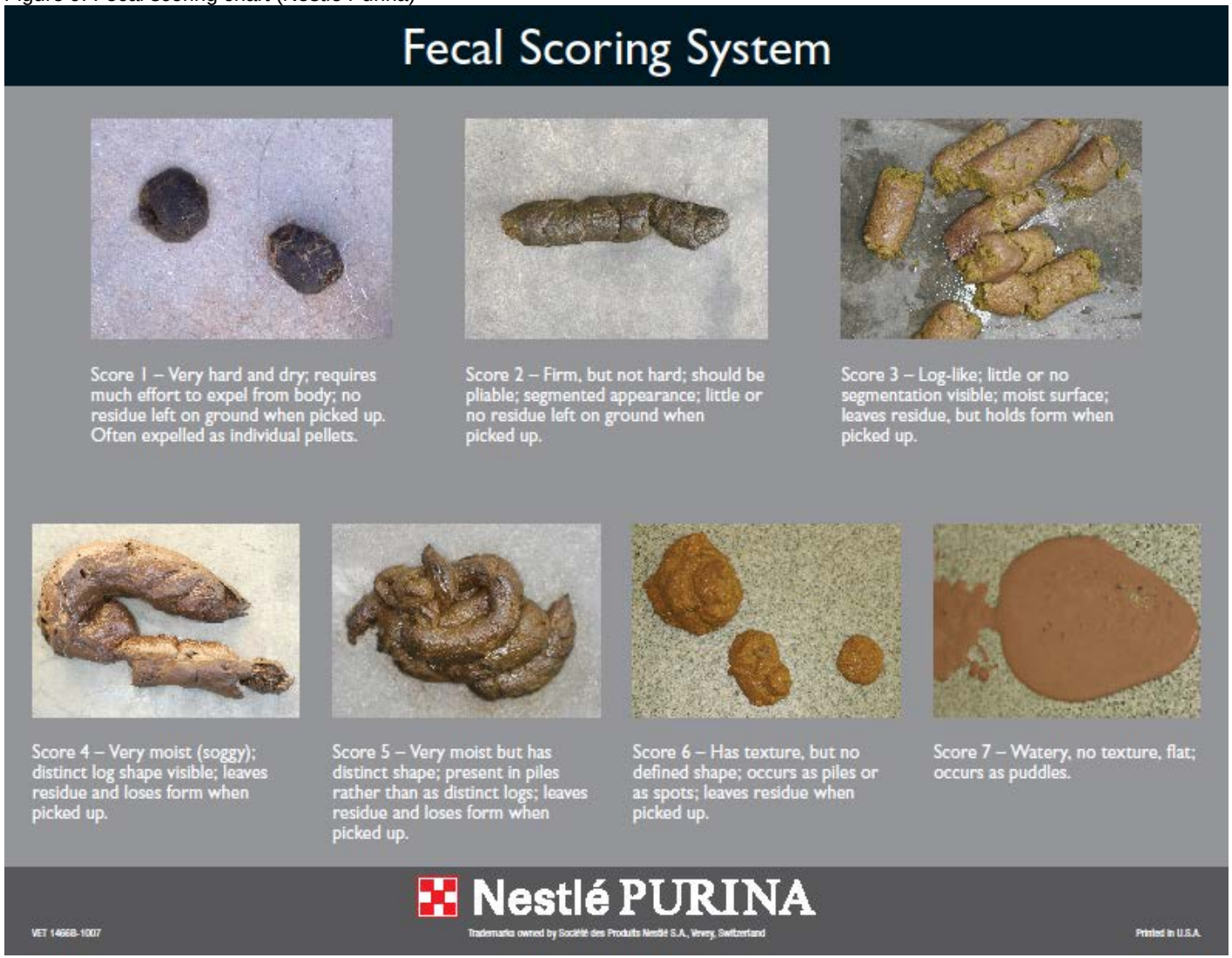
(1) Extreme Low (emaciated, no fat covering, skeleton visible)  	**Forequarters:** Neck thin & deeply shrunken. Shoulder wasted, vertical line of scapula visible. Angles of shoulder blade & arm sharp. Bones & joints clearly visible. **Midsection:** Multiple ribs visible with deep depressions between. Individual vertebrae visible. Waist shrunken & tucked. Sharp angles dividing shoulder, torso & hip. **Hindquarters:** Point of hip & ischium sharp & clearly visible. Bones of leg (femur & knee) clearly visible. Flank sunken. Sacral vertebrae visible. Tail base protruding above hip.
(2–3) Low (minimal fat covering, articulations angular & some bones visible)  	**Forequarters:** Neck thin & shrunken, sinews apparent but flowing into shoulder. Angles & bones of shoulder & arm prominent but with slight covering. Peak of scapula prominent. **Midsection:** Multiple ribs visible; abdominal muscles may be apparent. Vertebrae may be visible. Waist/belly shrunken & tucked. Abdominal skin flap may be apparent but not filled. Clear definition between shoulder, torso & hip. **Hindquarters:** Point of hip prominent but slightly covered. Ischium visible but blunt. Muscle & bones of upper leg angular but softened by slight covering. Sacrum flat or slightly depressed. Tail base becoming visible.
(4) Moderate/Low (slight fat covering, bones barely noticeable, articulations apparent but smooth)  	**Forequarters:** Neck cylindrical but discernible from shoulder. Muscles of shoulder apparent but slightly smooth. Peak of scapula apparent. **Midsection:** Some ribs visible; abdominal muscles apparent. Vertebrae rarely visible. Waist evident. Abdominal skin flap may be apparent with nominal filling. Smooth but noticeable delineation between shoulder, torso & hip. **Hindquarters:** Point of hip visible but covered. Ischium noticeable but rounded. Muscles of upper leg apparent & smoothed by slight fat covering. Sacrum sloped, but beginning to fill & round.

(5) Moderate (slight fat covering, bones not apparent, articulations visible but smooth)  	**Forequarters:** Neck filled in to flow smoothly into shoulder. Muscles of shoulder noticeable but with smooth covering. Peak of scapula noticeable but topline flows smoothly from neck into torso. **Midsection:** Ribs not visible; abdominal muscles noticeable as a transverse line. Vertebrae not visible; back smooth or heart-shaped & muscled. Waist noticeable as a smooth concavity. Abdominal skinflap may be present with nominal filling. Slight delineation between shoulder, torso & hip. **Hindquarters:** Point of hip barely noticeable, well-rounded. Ischium noticeable when walking, barely noticeable (flat/straight) when standing. Upper leg smooth & filled with slight muscle definition. Slope of hip becoming rounder.
(6) Moderate/High (noticeable fat covering, articulations becoming less noticeable)  	**Forequarters:** Neck filled & becoming continuous with shoulder. Muscles of shoulder apparent but covered with fat. Peak of scapula noticeable but topline flows smoothly from neck into torso. **Midsection:** Ribs not visible; abdominal muscles barely noticeable. Back smooth & rounded, becoming flat. Waist less discernable as a shallow depression. Abdominal skin flap filling with fat. Delineation between shoulder & torso but torso flows smoothly into hip. **Hindquarters:** Point of hip & ischium completely rounded. Upper leg smooth & rounded, muscle definition minimal/barely noticeable. Sacrum rounded.
(7–8) High (considerable fat covering, animal becoming rounded & bulging)  	**Forequarters:** Cheeks beginning to fill. Neck continuous between head & shoulder. Muscles of shoulder barely noticeable, covered in fat. Fat accumulating under neck & chest, & behind shoulder & arm. **Midsection:** Abdomen smooth, rounded & well-covered; ribs or muscles not visible. Back rounded & becoming flat. Waist almost filled, barely discernible. Abdominal skin flap apparent & thickened with fat. Shoulder barely differentiated from torso, but torso continuous with hip. **Hindquarters:** Point of hip & ischium covered & rounded. Hip & upper leg filled & convex throughout. Muscles of leg barely noticeable. Sacrum rounded, tail base flush & tail beginning to thicken.
(9) Extreme High (animal bulging & completely covered in a heavy fat layer)  	**Forequarters:** Cheeks filled out. Neck bulging & convex, continuous with head & shoulder. Shoulder rounded & muscles barely discernable. Pendulous fat accumulated beneath neck, chest, arms & abdomen. **Midsection:** Torso rounded & smooth, continuous with shoulder & hip. Back smooth & rounded or flat & table-like. Waist filled & not discernible. Thick, pendulous fat along undercarriage. **Hindquarters:** Hip & upper leg smooth & rounded. Muscles of leg not apparent. Tail noticeably thickened.

Fecal Scoring

A fecal scoring chart for lions has not been developed. In the literature, 1–5 scales are described without a photo record. To minimize this subjective assessment, a scale with photos is highly recommended. The attached chart should be used to provide consistency between evaluators.

Figure 9. Fecal scoring chart (Nestle Purina)



Chapter 6. Veterinary Care

M. Murphy

6.1 Veterinary Services

Veterinary services are a vital component of excellent animal care practices. A full-time staff veterinarian is recommended, however, in cases where this is not practical, a consulting/part-time veterinarian must be under contract to make at least twice monthly inspections of the animal collection and to any emergencies (AZA Accreditation Standard 2.1.1). Veterinary coverage must also be available at all times so that any indications of disease, injury, or stress may be responded to in a timely manner (AZA Accreditation Standard 2.1.2). All AZA-accredited institutions should adopt the guidelines for medical programs developed by the American Association of Zoo Veterinarians (AAZV) www.aazv.org/associations/6442files/zoo_aquarium_vet_med_guidelines.pdf.

AZA Accreditation Standard

(2.1.1) A full-time staff veterinarian is recommended. However, the Commission realizes that in some cases such is not practical. In those cases, a consulting/part-time veterinarian must be under contract to make at least twice monthly inspections of the animal collection and respond as soon as possible to any emergencies. The Commission also recognizes that certain collections, because of their size and/or nature, may require different considerations in veterinary care.

AZA Accreditation Standard

(2.1.2) So that indications of disease, injury, or stress may be dealt with promptly, veterinary coverage must be available to the animal collection 24 hours a day, 7 days a week.

Protocols for the use and security of drugs used for veterinary purposes must be formally written and available to animal care staff (AZA Accreditation Standard 2.2.1). Procedures should include, but are not limited to: a list of persons authorized to administer animal drugs, situations in which they are to be utilized, location of animal drugs and those persons with access to them, and emergency procedures in the event of accidental human exposure.

Animal recordkeeping is an important element of animal care and ensures that information about individual animals and their treatment is always available. A designated staff member should be responsible for maintaining an animal record keeping system and for conveying relevant laws and regulations to the animal care staff (AZA Accreditation Standard 1.4.6). Recordkeeping must be accurate and documented on a daily basis (AZA Accreditation Standard 1.4.7). Complete and up-to-date animal records must be retained in a fireproof container within the institution (AZA Accreditation Standard 1.4.5) as well as be duplicated and stored at a separate location (AZA Accreditation Standard 1.4.4).

AZA Accreditation Standard

(1.4.6) A staff member must be designated as being responsible for the institution's animal record-keeping system. That person must be charged with establishing and maintaining the institution's animal records, as well as with keeping all animal care staff members apprised of relevant laws and regulations regarding the institution's animal collection.

AZA Accreditation Standard

(1.4.5) At least one set of the institution's historical animal records must be stored and protected. Those records should include permits, titles, declaration forms, and other pertinent information.

AZA Accreditation Standard

(1.4.7) Animal records must be kept current, and data must be logged daily.

AZA Accreditation Standard

(1.4.4) Animal records, whether in electronic or paper form, including health records, must be duplicated and stored in a separate location.

Record Keeping

It is imperative that accurate and detailed medical records are kept on all animals. When possible, all entries should record recent history, results of physical exam findings, procedures completed, diagnostic tests run, an assessment of current medical status, and a plan for future management. Ideally, for anesthetic events, the data should be even more detailed, with information that describes the anesthetic drug(s) used, the dose, and route of administrations, as well as the response to the initial dose. All supplemental anesthetic drugs and dosages should be recorded, and medications given, as well as vaccinations should be recorded. All monitoring data (heart rate, respiratory rate, temperature, oxygen saturation, etc.) should be recorded as well as a summary of the anesthetic event describing the depth and character of the anesthetic plane along with potential recommendations for future anesthetic procedures. A computerized medical record system, which can help track problems and can easily be transmitted from one institution to the next, is extremely beneficial. Currently, many institutions use computerized programs for managing medical records (i.e., MedARKS). When the new

Zoological Information Management System (ZIMS) becomes widely available, it is recommended that institutions make full use of this resource.

6.2 Identification Methods

Ensuring that animals are identifiable through various means increases the ability to care for individuals more effectively. Animals must be identifiable and have corresponding ID numbers whenever practical, or a means for accurately maintaining animal records must be identified if individual identifications are not practical (AZA Accreditation Standard 1.4.3).

AZA Accreditation Standard

(1.4.3) Animals must be identifiable, whenever practical, and have corresponding ID numbers. For animals maintained in colonies or other animals not considered readily identifiable, the institution must provide a statement explaining how record keeping is maintained.

Lions are often easily distinguishable by physical characteristics such as size, facial features, and scars. Young animals, particularly siblings can be difficult to distinguish from one another. Temporary markings such as hair dye, shaving, or colored nail polish on claws can be used to assist in identification.

Transponders provide a long-term identification that also assists in tracking animals when they move to different institutions. They can also be used to confirm identification at exams and may even be able to be checked on animals that are awake if facilities allow access for the reader. Transponders can be placed in lion cubs during their first round of vaccinations (see Chapter 6.5).

AZA member institutions must inventory their animal population at least annually and document all acquisitions and dispositions (AZA Accreditation Standard 1.4.1). Transaction forms help document that potential recipients or providers of the animals should adhere to the AZA Code of Professional Ethics, the AZA Acquisition/Disposition Policy (see Appendix B), and all relevant AZA and member policies, procedures and guidelines. In addition, transaction forms must insist on compliance with the applicable laws and regulations of local, state, federal and international authorities. All AZA-accredited institutions must abide by the AZA Acquisition and Disposition policy (Appendix B) and the long-term welfare of animals should be considered in all acquisition and disposition decisions. All species owned by an AZA institution must be listed on the inventory, including those animals on loan to and from the institution (AZA Accreditation Standard 1.4.2).

AZA Accreditation Standard

(1.4.1) An animal inventory must be compiled at least once a year and include data regarding acquisitions and dispositions in the animal collection.

AZA Accreditation Standard

(1.4.2) All species owned by the institution must be listed on the inventory, including those animals on loan to and from the institution. In both cases, notations should be made on the inventory.

6.3 Transfer Examination and Diagnostic Testing Recommendations

The transfer of animals between AZA accredited institutions or certified related facilities due to SSP recommendations occurs often as part of a concerted effort to preserve these species. These transfers should be done as altruistically as possible and the costs associated with specific examination and diagnostic testing for determining the health of these animals should be considered. Table 11 lists veterinary procedures recommended for lions prior to shipment.

Preshipment Exam and Testing

The purpose of performing preshipment and quarantine examinations is to evaluate the health of an animal prior to transfer to another institution, to monitor for the emergence of any stress/shipment related illnesses or injuries, and to protect the health of the receiving institution's collection. Ideally, prior to initiating a preshipment examination, the veterinary staff at both institutions should communicate directly to discuss all pertinent medical history including age, reproductive and vaccination status, deworming history, and exposure to any possible pathogens. This is also the time to clarify preshipment testing requirements. Veterinarians at the receiving institution should also take this opportunity to request and review the medical records prior to the preshipment examination. The Department of Agriculture State Veterinarian should also be contacted for information on tests requirements necessary for the animals to enter the state, statements that need to appear on the health certificate, and how to go about acquiring

permit numbers (www.usda.aphis.org). Traditionally, it is the sending veterinarian's responsibility to check with interstate shipping requirements, although the responsibility can be shared by both institutions. When both veterinary departments have agreed to transfer the animal, the shipment can be scheduled. All animal shipments should be accompanied by a hard copy of the medical record, as well as a health certificate and the USDA acquisition, disposition, or transport form.

Examination should be thorough with all organ systems evaluated. A complete physical examination, with bloodwork for CBC, chemistries, Heartworm Ag, viral titers, serum banking, thoracic and abdominal radiographs, an enteric fecal culture, and 2 negative fecal parasite checks is recommended. Results of preshipment examination and any abnormalities that are noted should be brought to the attention of the receiving institution's veterinarians and resolved prior to shipment. Table 11 lists veterinary procedures recommended for lions prior to shipment.

Table 11. Recommended procedures during pre-shipment testing

Procedure	**Description**
Physical exam	Within 30 days of transfer
Visual exam	Performed at time of Health Certificate signing
Fecal examinations	Within 30 days of transfer
Enteric fecal culture	For Salmonella—common in large felids
CBC, chemistry panel	
Identification	Transponder implanted intra-scapularly
Thoracic and Abdominal radiographs	
Occult heartworm antigen and antibody test	
Serology	For feline leukemia virus (FeLV), Feline Immunodeficiency Virus (FIV), Feline Infectious Peritonitis (FIP), and toxoplasmosis
Complete Medical History	All medical records should be sent prior to shipment.

Samples for FeLV and FIV testing should be sent to Cornell Diagnostic Laboratory, P.O. Box 5786, Ithaca, NY 14822-5786, 607-253-3333 (Ph.), 607-253-3943 (Fax). Samples for FIP testing should be sent to Washington State University, Washington Animal Disease Diagnostic Laboratory, College of Veterinary Medicine, Pullman, WA 99164, 509-335-9696 (Ph.), 509-335-7424 (Fax).

6.4 Quarantine

AZA institutions must have holding facilities or procedures for the quarantine of newly arrived animals and isolation facilities or procedures for the treatment of sick/injured animals (AZA Accreditation Standard 2.7.1). All quarantine, hospital, and isolation areas should be in compliance with AZA standards/guidelines (AZA Accreditation Standard 2.7.3; Appendix C). All quarantine procedures should be supervised by a veterinarian, formally written and available to staff working with quarantined animals (AZA Accreditation Standard 2.7.2). If a specific quarantine facility is not present, then newly acquired animals should be kept separate from the established collection to prohibit physical contact, prevent disease transmission, and avoid aerosol and drainage contamination. If the receiving institution lacks appropriate facilities for quarantine, pre-shipment quarantine at an AZA or American Association for Laboratory Animal Science (AALAS) accredited institution may be applicable. Local, state, or federal regulations that are more stringent than AZA Standards and recommendation have precedence.

AZA Accreditation Standard

(2.7.1) The institution must have holding facilities or procedures for the quarantine of newly arrived animals and isolation facilities or procedures for the treatment of sick/injured animals.

AZA Accreditation Standard

(2.7.3) Quarantine, hospital, and isolation areas should be in compliance with standards or guidelines adopted by the AZA.

AZA Accreditation Standard

(2.7.2) Written, formal procedures for quarantine must be available and familiar to all staff working with quarantined animals.

Upon arrival at the new institution, lions should be quarantined separately from other species of carnivores, particular other felids. Quarantine can be established in a hospital building separate from the exhibit area, or in an area in the habitat that can be isolated (via solid walls, use of disinfectant foot pans, separate keepers, or keepers that use dedicated quarantine boots and coveralls) from the rest of the collection, in order to prohibit physical contact, prevent disease transmission, and avoid aerosol and drainage contamination.

Zoonotic Diseases and Quarantine

AZA institutions must have zoonotic disease prevention procedures and training protocols established to minimize the risk of transferable diseases (AZA Accreditation Standard 11.1.2) with all animals, including those newly acquired in quarantine. Keepers should be designated to care only for quarantined animals if possible. If keepers must care for both quarantined and resident animals of the same class, they should care for the quarantined animals only after caring for the resident animals. Equipment used to feed, care for, and enrich animals in quarantine should be used only with these animals. If this is not possible, then all items must be appropriately disinfected, as designated by the veterinarian supervising quarantine before use with resident animals.

AZA Accreditation Standard

(11.1.2) Training and procedures must be in place regarding zoonotic diseases.

It is recommended that veterinarians at each institution develop their own specific disinfection protocols for animal management equipment and enrichment initiatives provided in quarantine. These protocols should take into consideration the material to be disinfected, and should ensure that disinfectants are thoroughly rinsed off or neutralized before the equipment or enrichment is used again with the lions.

A quarantine period of no less than 30 days, longer if necessary, at the receiving institution is essential. Animals received from outside the North America should be quarantined for 90 days if born in the wild or from institutions lacking strong veterinary protocols. During this time the lion should remain separate from the other lions in the collection. If additional carnivores are introduced into their corresponding quarantine areas, the minimum quarantine period must begin over again. However, the addition of mammals of a different order to those already in quarantine will not require the re-initiation of the quarantine period.

During the quarantine period, specific diagnostic tests should be conducted with each animal if possible or from a representative sample of a larger population (e.g., birds in an aviary or frogs in a terrarium) (see Appendix C). A complete physical, including a dental examination if applicable, should be performed. Animals should be evaluated for ectoparasites and treated accordingly. Blood should be collected, analyzed and the sera banked in either a -70º C (-94º F) freezer or a frost-free -20º C (-4º F) freezer for retrospective evaluation. Fecal samples should be collected and analyzed for gastrointestinal parasites

and the animals should be treated accordingly. Vaccinations should be updated as appropriate, and if the vaccination history is not known, the animal should be treated as immunologically naive and given the appropriate series of vaccinations.

A tuberculin testing and surveillance program must be established for animal care staff as appropriate to protect both the health of both staff and animals (AZA Accreditation Standard 11.1.3). Depending on the disease and history of the animals, testing protocols for animals may vary from an initial quarantine test to yearly repetitions of diagnostic tests as determined by the veterinarian. Animals should be permanently identified by their natural markings or, if necessary, marked when anesthetized or restrained (e.g., tattoo, ear notch, ear tag, etc.). Release from quarantine should be contingent upon normal results from diagnostic testing and two negative fecal tests that are spaced a minimum of two weeks apart. Medical records for each animal should be accurately maintained and easily available during the quarantine period.

AZA Accreditation Standard

(11.1.3) A tuberculin testing and surveillance program must be established for appropriate staff in order to ensure the health of both the employees and the animal collection.

During quarantine, examination of feces for parasites via direct examination and floatation should be performed, and any necessary de-worming treatments administered. A minimum of 3 fecals should be collected, preferably at weekly intervals. A complete examination under anesthesia should be conducted, preferably in the 2nd or 3rd week. As with the preshipment examination, this examination should be thorough and include all organ systems. Bloodwork, radiographs, abdominal ultrasound, and enteric fecal cultures are also recommended to evaluate for changes from preshipment examination and to establish a baseline database at the receiving institution. Vaccinations should be updated as appropriate. Table 12 lists veterinary procedures recommended for lions during the quarantine period.

Table 12. Recommended procedures during quarantine

Procedure	Description
Physical exam	Performed halfway through quarantine
Visual exam	Performed at the end of quarantine
Identification	Verify transponder
Three fecal examinations	Direct, float, and sediment. Two follow-up exams should be performed post-treatment
Enteric fecal culture	For Salmonella—common in large felids
Urinalysis	-
CBC & serum chemistry	Sera should be banked
Thyroid screen	T4 & TSH; for animals over 5 years of age
Occult heartworm antigen & antibody test	-
Serology	For feline leukemia virus (FeLV), Feline Immunodeficiency Virus (FIV), Feline Infectious Peritonitis (FIP), & toxoplasmosis
Thoracic and abdominal radiographs	
Abdominal ultrasound	

Samples for FeLV and FIV testing should be sent to Cornell Diagnostic Laboratory, P.O. Box 5786, Ithaca, NY 14822-5786, 607-253-3333 (Ph.), 607-253-3943 (Fax). Samples for FIP testing should be sent to Washington State University, Washington Animal Disease Diagnostic Laboratory, College of Veterinary Medicine, Pullman, WA 99164, 509-335-9696 (Ph.), 509-335-7424 (Fax).

Isolation in quarantine can have an impact on this social species. If animals were housed together at the previous institution, they may be quarantined together at the receiving institution, but they should be watched closely for signs of aggression. Quarantine space is typically smaller and more sterile than exhibit space so additional attention and enrichment may be required (see Chapter 8 for more behavior management information).

If an animal should die in quarantine, a necropsy should be performed on all it and the subsequent disposal of the body must be done in accordance with any local or federal laws (AZA Accreditation Standard 2.5.1). Necropsies should include a detailed external and internal gross morphological examination and representative tissue samples from the body organs should be submitted for histopathological examination (see Chapter 6.7).

AZA Accreditation Standard

(2.5.1) Deceased animals should be necropsied to determine the cause of death. Disposal after necropsy must be done in accordance with local/federal laws.

6.5 Preventive Medicine

AZA-accredited institutions should have an extensive veterinary program that must emphasize disease prevention (AZA Accreditation Standard 2.4.1). The American Association of Zoo Veterinarians (AAZV) has developed an outline of an effective preventative veterinary medicine program that should be implemented to ensure proactive veterinary care for all animals (www.aazv.org/associations/6442/files/zoo_aquarium_vet_med_guidelines.pdf).

AZA Accreditation Standard

(2.4.1) The veterinary care program must emphasize disease prevention.

General Medical Guidelines

As stated in the Chapter 6.4, AZA institutions must have zoonotic disease prevention procedures and training protocols established to minimize the risk of transferable diseases (AZA Accreditation Standard 11.1.2) with all animals. Keepers should be designated to care for only healthy resident animals, however if they need to care for both quarantined and resident animals of the same class, they should care for the resident animals before caring for the quarantined animals. Care should be taken to ensure that these keepers are "decontaminated" before caring for the healthy resident animals again. Equipment used to feed, care for, and enrich the healthy resident animals should only be used with those animals. When working with lions, caretakers should always be aware of potential zoonotic diseases that can be transmitted from the animals to humans and from humans to animals.

AZA Accreditation Standard

(11.1.2) Training and procedures must be in place regarding zoonotic diseases.

All animal staff working with lions should be educated about the preventative measures necessary to prevent these kinds of diseases. Zoonotic diseases can be spread by fecal-oral transmission, contamination of human mucous membranes or open wounds with lion excretions or secretions (i.e. feces, saliva, blood, pus, etc., and contact with infected/infested tissues. Diseases of concern when working with lions are rabies virus, salmonellosis, demodicosis, glanders, and toxoplasmosis. Care staff can also act as potential fomites and transfer feline specific diseases between domestic cats and lions. Effective measures that help prevent the transmission of these diseases include:

- Washing of hands between and after handling of animals, feces, urine, and other bodily fluids and secretions
- Wearing appropriate personal protective equipment (PPE) such as gloves, goggles and mask when cleaning animal habitats
- Wearing gloves when handling tissues
- Having appropriate foot baths
- Having separate clothing and footwear that is worn only during work

Animals that are taken off zoo/aquarium grounds for any purpose have the potential to be exposed to infectious agents that could spread to the rest of the institution's healthy population. AZA-accredited institutions must have adequate protocols in place to avoid this (AZA Accreditation Standard 1.5.5).

AZA Accreditation Standard

(1.5.5) For animals used in offsite programs and for educational purposes, the institution must have adequate protocols in place to protect the rest of the collection from exposure to infectious agents.

Also stated in Chapter 6.4, a tuberculin testing and surveillance program must be established for animal care staff, as appropriate, to protect the health of both staff and animals (AZA Accreditation Standard 11.1.3). Depending on the disease and history of the animals, testing protocols for animals may vary from an initial quarantine test, to annual repetitions of diagnostic tests as determined by the veterinarian. To prevent specific disease transmission, vaccinations should be updated as appropriate for the species. Lions are reported to be carriers of bovine TB, however, reports of transmission to humans could not be found. Staff should routinely be TB tested following the institutional policy.

AZA Accreditation Standard

(11.1.3) A tuberculin testing and surveillance program must be established for appropriate staff in order to ensure the health of both the employees and the animal collection.

Routine examinations

It is recommended that all lions receive physical examinations on a regular basis. The frequency of the examination may be determined by evaluating a number of factors including age, health, reproductive and

vaccination status, risk of disease exposure, medical history, and management policies at each institution. At a minimum, lions should be examined triennially and more frequently if possible.

Recommended procedures for annual exams are similar to procedures recommended for quarantine exams (Table 12). In addition, a comprehensive oral health assessment and prophylactic dental scaling and polishing should be performed at the time of the exam. Particular attention should be paid to the dental status and if possible a complete dental chart maintained for each individual.

Viral titers should be performed at each routine examination (including FeLV, FIV, and CDV). As noted in section Chapter 6.7 some animals seroconvert years following exposure to FIV and frequent monitoring is recommended. Serum should be banked at every opportunity.

For regular assessment of blood values, behavioral training to allow safe protected contact blood collection (e.g., from the tail vein) is recommended to reduce the need for immobilization. Institutions that have lions trained to enter squeeze cages may choose to anesthetize their lions biannually or triennially and then evaluate, vaccinate, and collect blood in the squeeze cages in alternate years. See Chapter 8 additional information on training.

Vaccinations

Vaccination schedules vary from institution to institution depending upon the available recent literature, an institution's vaccination schedule, an individual veterinarians experience, beliefs, and the evaluated risk vs. benefit of vaccinations. Vaccines may be given annually, although many institutions are now opting for monitoring viral titers through Cornell and then vaccinating when titers fall. More in depth recommendations will be made as more information becomes available.

In general, a combination vaccine against feline respiratory viruses is recommended in addition to rabies vaccine. The decision as to whether to vaccinate lions against canine distemper depends upon the assessed risk at each institution.

Feline rhinotracheitis (FRV), Feline calicivirus (FCV): Lions, like their domestic counterpart, are highly susceptible to several respiratory virus. A killed vaccine product against these viruses as well as for the feline panleukopenia virus (FPLV) should be used. The most commonly used is Felovax (Fort Dodge). One mL given every 2 weeks from 8 weeks to 16 weeks of age and then a booster at 6 and 12 months. Due to the risk of vaccine-induced sarcomas, and more recent literature that suggests that vaccine titers in domestic cats remain high for several years; it is currently recommended to give boosters triennially. Alternately, virus titers can be run more frequently (available through the Cornell diagnostic laboratory). Pregnant females should be boostered during gestation, if possible.

Rabies: Rabies vaccines are recommended for all carnivores. Only a killed vaccine product should be used. The most commonly used is Imrab3 (Merial). Initially at 4–6 months followed by an annual booster. Some institutions are beginning to vaccinate less frequently (either biannually or triennially)

Parasite control: Lions are susceptible to the same endo- and ectoparasites as most felids. All lions in zoos should have routine fecal exams (both direct and float) once or twice a year, more frequently if problems/persistent infections are identified, and have two follow-up exams at weekly intervals 1–2 weeks post-therapy.
Routine monthly treatment for heartworm prevention (Ivermectin) should be performed year around in warm regions, and for at least 6 months in colder climates.

Medical Management of Neonates

For information on the feeding of hand-reared neonates, see the hand-rearing protocols in Chapter 7. Depending on the preventative health protocols in place and the ability to safely separate cubs from dam, young animals may be handled for sexing, weighing, microchip implants, and vaccinations. Table 13 shows a neonate vaccination schedule. During the neonate examination, special attention should be made to potential congenital/developmental abnormalities, such as cleft palate, hernias, etc. as well as for any signs of ulcers in mucocutaneous areas. Bloodwork may be obtained at time of exam for a CBC, chemistry panel, and serum banking. See Chapter 7 for more information on handling and restraint of cubs.

Table 13. Neonate vaccination schedule

Age	Treatment
4 weeks	Antihelminthics (Strongid T)
8 weeks	1 ml FVRCP (Felovax)
	Antihelminthics (Strongid T)
10 weeks	1 ml FVRCP (Felovax)
12 weeks	1 ml FVRCP (Felovax)
	Antihelminthics (Strongid T)
14 weeks	1 ml FVRCP (Felovax)
16 weeks	1 ml FVRCP (Felovax)
	Antihelminthics (Strongid T)
	Rabies (Imrab killed)
6 months	FVRCP (Felovax) booster
1 year	FVRCP (Felovax) booster

Where disease is a concern, neonates may show only subtle clinical signs in the early stages of illness. Close monitoring and quick action may be necessary to deal with illnesses. The following are some of the medical issues that may arise in both hand-reared and parent-raised neonates.

Hypothermia: To treat, cubs should be slowly re-warmed to 3 degrees of normal body temperature to prevent overheating. Causes for hypothermia should be ruled out with a thorough examination and bloodwork. Cubs should not be offered formula until their body temperature is back to normal.

Hypoglycemia: Moribund cubs may be hypoglycemic. 50% dextrose treatment can be given. However these cubs should also be re-warmed and re-hydrated. Cause of hypoglycemia should be explored.

Aspiration pneumonia: Aspiration of fluids or thin particles can occur secondary from bottle-feeding. However, if this occurs, neonates should always be checked for the presence of a cleft palate.
Oral or carpal ulcerations: Ulcerations can be due to feline calicivirus (FCV) and can lead to inappetence, dehydration, or secondary bacterial infections. It may be associated with upper respiratory signs. Having an appropriate vaccination program, limiting access of neonates to other felids, establishing appropriate quarantine protocols, and having an appropriate feral cat trapping program will decrease the potential of the cubs contracting this disease (Harrison et al., 2007).

Diarrhea: Diarrhea can be caused by many factors including viral, bacterial, parasitic, nutritional, or husbandry causes. Establishing a quarantine protocol (foot baths, hand washing, disinfectant protocols, dedicated nursery area, dedicated clothing, footwear, and keepers) for care of neonates will prevent some of these causes.

Nutrition: A balanced nutrition is important for the neonate. Rickets has been documented in hand-reared cubs. See Chapter 5 for more information on appropriate balanced nutritional formulas.

Pregnancy
No significant changes to the female's routine should be made in the 4 weeks prior to anticipated parturition. Pregnant females should receive a FVRCP (Felovax) booster during gestation, if possible.
See Chapter 7 for more information on reproduction.

6.6 Capture, Restraint, and Immobilization

The need for capturing, restraining and/or immobilizing an animal for normal or emergency husbandry procedures may be required. All capture equipment must be in good working order and available to authorized and trained animal care staff at all times (AZA Accreditation Standard 2.3.1).

AZA Accreditation Standard

(2.3.1) Capture equipment must be in good working order and available to authorized, trained personnel at all times.

Manual Restraint
Adult lions are too strong and dangerous for manual restraint, but can be trained for hand injections and blood draws (see Chapter 8 for training information). Squeeze cages of sufficient strength and integrity can be utilized for injecting lions and are an integral part of facility design. If not trained, they should be injected using an aerosol dart injection system, or after entering a crate.

Cubs may be held under manual restraint with appropriated equipment depending on their temperament, behavior, age, and each institution's comfort level. When manual restraint is not possible, anesthetic protocols used in adult lions may be used.

Cubs being manually restrained for exam
T. Webb

Chemical Immobilization

Lions have been anesthetized using different chemical agents (see Table 15). For lengthy procedures, endotracheal intubation with administration of Isoflurane in O_2 is preferred over repeated supplementation with injectable agents. Anesthetic monitoring for lions is as for other carnivores.

Lions can be trained to accept hand injections by keeper or veterinary staff to reduce the need for darting. See Chapter 8.1 for more information on training.

Table 14. Suggested anesthetic protocols for lions

Drug	Dose	Reversal agent	Dose
Ketamine Xylazine	4.5–10mg/kg 1–3mg/kg	Yohimbine	0.125 mg/kg ½ IV & ½ IM
Medetomidine Ketamine	0.020–0.08mg/kg 2–5 mg/kg	Atipemazole	5mg Ati: 1mg Med IM
Telazol	2–8 mg/kg IM	None	None
Telazol Medetomidine	1–1.5 mg/kg 0.015–0.030 mg/kg	Atipamezole	5mg Ati: 1mg Med IM
Ketamine Medetomidine Midazolam	1.5–2.5 mg/kg 0.037–0.057 mg/kg 0.1mg/kg	Atipamezole +/- Flumazenil	5mg Ati: 1mg Med IM 0.03 mg/kg
Ketamine Medetomidine Butorphanol	3–5 mg/kg 0.010-–0.030 mg/kg 0.1–0.4 mg/kg	Atipamezole Naltrexone	5mg Ati: 1mg Med IM 1 mg Nalt: 1mg Torb IM
Butorphanol Medetomidine Midazolam	0.2–0.4 mg/kg 0.045–0.060 mg/kg 0.1–0.2 mg/kg	Naltrexone Atipamezole Flumazenil	1 mg Nalt: 1mg Torb IM 5mg Ati: 1mg Med IM 0.003–0.001 mg/kg
Propofol (maintenance)	0.5–1 mg/kg IV every 5–10 min CRI= 0.02-0.2 mg/kg/min IV		

6.7 Management of Diseases, Disorders, Injuries and/or Isolation

AZA-accredited institutions should have an extensive veterinary program that manages animal diseases, disorders, or injuries and has the ability to isolate these animals in a hospital setting for treatment if necessary. Keepers should be trained for meeting the animal's dietary, husbandry, and enrichment needs, as well as in restraint techniques, and recognizing behavioral indicators animals may display if their health becomes compromised (AZA Accreditation Standard 2.4.2). Protocols should be established for reporting these observations to the veterinary department. Hospital facilities should have x-ray equipment or access to x-ray services (AZA Accreditation Standard 2.3.2), contain appropriate equipment and supplies on hand for treatment of diseases, disorders or injuries, and have staff available that are trained to address health issues, manage short and long term medical treatments and control for zoonotic disease transmission.

AZA Accreditation Standard

(2.4.2) Keepers should be trained to recognize abnormal behavior and clinical symptoms of illness and have knowledge of the diets, husbandry (including enrichment items and strategies), and restraint procedures required for the animals under their care. However, keepers should not evaluate illnesses nor prescribe treatment.

AZA Accreditation Standard

(2.3.2) Hospital facilities should have x-ray equipment or have access to x-ray services.

Signs of illness: Non-domestic felids may hide signs of illness until a disease is advanced. In human care, it is important that animal care staff be astute to subtle changes in behavior or physiological signs that may suggest illness. Keepers who have daily contact with lions are often the best persons for noting these subtle changes. Any change in appetite, urination, defecation, or general behavior should be documented. For example, changes in urine and fecal color, quantity, and consistency should be noted. Dehydration can be assessed by a visual examination that shows a lions with dry mucous membranes and a dry hair coat. Other visual observations that can be obtained from outside the enclosure include evaluation for normal breathing patterns and rate.

Non-Infectious Diseases

Dermatology/foot pad cracks: Footpad lesions are somewhat commonly reported in *ex situ* large felids. The prevalence of foot pad cracks and lesions appears to increase during winter months when cats spend more time indoors, usually in concrete enclosures. Whenever possible it is preferable to add natural substrates or platforms to exhibits to minimize contact with concrete. Treatment methods and successes vary between institutions.

There are some anecdotal reports of improvement in lesions following oral supplementation of the diet with Essential Fatty Acids (EFA's). Also there are anecdotal reports of success by placing trays of diatomaceous earth where the lions will travel through these areas to toughen pads. Similarly, other zoos have had success with applying topical emollients such as bag balm or lanolin-based ointments. At least one report of a wild lion sloughing its paw pads has been reported, but it is not clear if this is related.

Dental: The oral cavity and the integrity of teeth should be evaluated at every opportunity. At some institutions lions have been trained to hold their mouths open for brief veterinary inspection (see Chapter 8 for training information). More in depth exams require examination under anesthesia. As with most mammals, the incidence of dental disease in lions tends to increase with age, although fractured canines can occur at any age. It is preferable to identify and treat dental issues as early on as possible. Advanced dental procedures such as root canals or complicated extractions are best performed with the aid of an experienced veterinary dentist.

Musculoskeletal: There is a case report of young lions developing spinal compression due to congenital occipitoatlantoaxial malformations. Decompressive surgery offers the best prognosis for recovery (Galloway et al., 2001). Fibrocartilaginous embolic myelopathy (FCE) leading to paraplegia of the hind limbs has also been reported in an adult lion (Ricci et al., 2010).

Reproductive: Pyometra has been reported in several lions (McCain, et al. 2009). Clinical signs were similar to those seen in the domestic cat. However, lions did not exhibit noticeable polydypsia and polyuria. Abdominal ultrasound was diagnostic in every case reported. Treatment of choice is ovariohysterectomy along with intra-op and post-op antimicrobial therapy. In domestic cats, pyometra is often associated with cystic endometrial hyperplasia. In lions this can be caused secondarily from melengesterol acetate contraceptive implants as well due to aging (McCain et al., 2009) (Munson et al., 2002). In the 2009 study, both lions with history of contraceptive implants as well as those without developed pyometra.

Infectious Diseases: Viral

Lions are susceptible to the same viral infections that most felids See Chapter 6.5 for recommended vaccine schedules.

Feline Leukemia Virus (FELV) is an oncovirus that has been associated with clinical illness and neoplasia, such as leukemia and lymphoma, in domestic cats. There are several reports that describe FeLV in nondomestic felids. The virus is present in saliva and nasal secretions of cats actively infected with FeLV. Diagnosis is by ELISA (although false positives are not uncommon). Although a vaccine is available for domestic cats, the SSP does not recommend vaccinating lions.

Feline immunodeficiency virus (FIV) is a lentivirus that has been identified and isolated from many species of felid including domestic cats, Pallas' cats, and lions. Transmission is thought to be primarily via bite wounds, but has also been reported to be transmitted by artificial insemination and nursing. Although seroprevalence varies greatly between felid species, unfortunately in lions the prevalence is high in both managed and most free ranging lion populations. One study reported that 57% of African Lions in European zoos were seropositive, while the seroprevalence in US zoos hovered at 12%. Even more concerning, seroprevalence rates in some East and South African wild populations is high with 70% in one East African population and 91% in Kruger, South Africa (Brown et al., 1993). Lions from Etosha, Namibia were negative as were Asian lions from the Gir Forest, India. Diagnosis is by ELISA or IFA as screening tools. If the IFA or ELISA comes back as either positive or equivocal, Western Blot at Cornell University is recommended. Management of a Western-blot seropositive lion is problematic. Currently the development of clinical illness has not been specifically linked to the presence of FIV virus, but anecdotal accounts of behavior changes, illness, retinal lesions, neurologic deficits, and neoplasia associated with FIV infection have been reported. In addition, more recent studies have demonstrated

that FIV+ African lions do develop deficiencies in their lympocyte population (Bull et al., 2003). To make matters worse, it may be difficult to get an accurate assessment of the current FIV status of any individual lion since some animals can take years to convert following initial exposure to the virus. Although a vaccine is available for domestic cats, the SSP does not recommend vaccinating lions. In addition, the SSP recommends maintaining separate FIV positive and negative populations.

Feline Infectious Peritonitis (FIP) is a corona virus that infects both domestic and non-domestic felids. Although the incidence of FIP infection in some non-domestic felids such as cheetahs is high, this is not been commonly reported in lions. Diagnosis is by serology and clinical signs, but serologic tests may cross-react with intestinal corona virus. Although a vaccine is available for domestic cats, the SSP does not recommend vaccinating lions at this time.

Rhintotracheitis: Feline Herpes Virus 1: All felids are susceptible to this highly contagious virus. Clinical signs are upper respiratory with conjunctivitis and inflammation of nasal passages. This virus appears to be more pathogenic in some species (i.e., cheetahs) and in cubs. Diagnosis is by clinical signs and virus isolation. A combination vaccine (Rhinotracheitis, Calici, and Panleukopenia) is available and is recommended for use in lions.

Calicivirus: Like Rhinotracheitis, Calici virus is highly contagious. Clinical signs are predominantly upper respiratory—with sneezing and nasal and ocular discharge—sometimes with oral ulceration. Morbidity is high and mortality varies depending on the strain and degree of pulmonary involvement. Cats may become chronic carriers with continuous or intermittent shedding of the virus. Diagnosis is by presentation and virus isolation. A combination vaccine is available and is recommended in lions.

Panleukopenia: This highly contagious virus is fortunately not common. All felids, including lions, are susceptible. Infected animals typically present with predominantly gastrointestinal signs (anorexia, vomiting, diarrhea, etc) and characteristic clinical pathology findings (panleukopenia). Diagnosis is by clinical signs, clinical pathology, serology, viral isolation and/or IFA. A combination vaccine (Rhinotracheitis, Calici, and Panleukopenia) is available and is recommended for use in lions.

Feline Papillomavirus: This virus causes papilloma-like growths in the oral cavity and the skin in both domestic and non-domestic felids. The oral lesions are generally mild and self-limiting. In Asian lions, papillomavirus lesions have been reported in both the wild and managed populations. The lesions are described as focal hyperplasia and are found on the ventral surface of the tongue. Diagnosis is by clinical presentation and histopathology of lesion. Currently a vaccine is not available. Oral lesions often resolve on their own while skin lesions may require removal.

Rabies: A lethal Lyssa rhabdovirus that can infect all mammals. Clinical signs are neurological. Diagnosis is by histopathology and IFA on brain tissue. A vaccine that is licensed for use in domestic cats is available and is recommended for use in lions. Initially yearly boosters were recommended, but more recently many institutions are moving towards a triannual schedule.

Canine Distemper Virus (CDV): This is a morbillivirus. Initially this virus was thought to be primarily a canid disease. It is thought that a genetic mutation of the virus has increased its virulence in the felid population. Since 1991, outbreaks in both the managed and wild lion populations have been associated with high mortality. In both circumstances, the route of infection was thought to be related to an epidemic in a neighboring canid or procyonid population. Infected lions present with one of two syndromes. The more acute syndrome presents with neurological signs (myoclonus, seizures, etc) while the more chronic form has a more vague initial presentation of lethargy and anorexia that progresses to similar neurological signs over a period of 1-2 weeks (Appel et al., 1984). Diagnosis is by history, clinical signs, serology, histopathology and IFA. A canary-pox vectored vaccine is currently available, and some institutions have used this without reported ill effects in the face of an outbreak. Currently the SSP does not recommend this vaccine for routine use, although each institution may want to weigh the exposure risk.

Infectious Diseases: Bacterial

Lions are susceptible to the same bacterial infections that most felids are and they do not appear to have any particular susceptibility to a specific bacterium. There are reports in the literature describing infections with particular bacteria (i.e., Listeria, Clostridium) but such reports are somewhat uncommon.

Salmonella: Since lions are fed a meat based diet it is not unusual to culture Salmonella from feces. The pathogenecity varies with the strain. Typically if salmonella is cultured from an asymptomatic animal, treatment is not initiated. However, if a pathogenic strain is isolated from a symptomatic animal, treatment is recommended based on sensitivity results. The strain of Salmonella can be identified by sending a sample to NVSL.

Table 15. Commonly used antibiotics

Drug	Dose	Notes
Amoxicillin	10–20 mg/kg PO BID	
Cephalexin	10–20 mg/kg PO BID	
Enrofloxacin	2.5–5 mg/kg PO SID	Use with caution due to propensity of felids to develop non-reversible retinal lesions in association with dose-dependent enrofloxacin administration. Also use with caution in young animals due to rare, but reported lameness problems.
Trimethoprim sulfa	15 mg/kg PO BID or 30 mg/kg PO SID	

Infectious Diseases: Mycobacterial

Infection with *Mycobacteria bovis* has been reported in both managed and wild lion populations. This disease has only rarely been reported in managed populations. In the wild population the prevalence appears to vary with geographic location. In Kruger National Park in South Africa, lions are thought to represent “spill over” hosts that have become incidentally infected after feeding on infected buffalo.

Infectious Diseases: Fungal

Fungal diseases in lions are not particularly common, but there have been reports in the literature of both superficial skin fungal infections such as *Microsporum canis* and systemic infections such as Blastomycoses. Depending upon the differential diagnosis list diagnostic tests may include skin scrapings for cytology, KOH prep, and fungal culture, while some of the systemic fungal infections may best be diagnosed through serology. A number of antifungal medications have been reported used in lions including Itraconazole, ketoconazole, and lufenuron as well as some topical antifungal solutions.

Infectious Diseases: Parasitic

Lions are susceptible to the same endo- and ectoparasites as most felids. All lions in zoos should have routine fecal exams (both direct and float) once or twice a year, and more frequently if problems/persistent infections are idenitified.

Blood parasites have not been commonly noted in lions. At least one anecdotal report of an unspeciated Hepatazoan in a lion in human care was identified, but this infection was not associated with any clearly defined clinical illness. In 1991/1992 a possibly new species of piroplasm was described in wild lions from Kruger National Park, South Africa. Although this piroplasm resembled *Babesia felis*, they were serologically distinct and were subsequently characterized and described as a new species, *B. leo* (Lopez-Rebollar et al., 1999; Penzhorn et al., 2001), The clinical significance of infection with a piroplasm is unclear. Lastly, an unspecified form of Babesia was also identified in lions; once again, the clinical significance is uncertain.

Table 16. Commonly used anthelmentics and dosages

Drug	Dosage
Fenbendazole	10–25 mg/kg PO SID x 3 days
Pyrantel pamoate	5–10 mg/kg PO
Ivermectin	0.2 mg/kg PO or SQ. For heartworm prophylaxis can be used at 0.025 mg/kg PO once a month.
Metronidazole	10–15 mg/kg PO BID

Geriatric Animal Medical Issues

Geriatric management is an increasing issue as managed care continues to improve and animals live longer than ever before. As the life span/expectancy for large mammals living in zoos continues to increase, so do age-related medical conditions. For more information on these types of treatments, consultation with a veterinarian or the AZA Lion SSP Veterinary Advisor is recommended.

Musculoskeletal problems: The development of intervertebral disc disease and spondylosis is an important problem in large nondomestic felids. In large felids, such as lions and tigers, the lumbar region tends to be the primary area affected although almost any area of the spine can be involved. Lions can present with progressive posterior paresis, varying degrees of ataxia, and occasional muscle wasting. Depending upon the animal's history, it is not uncommon to find a large cat acutely down – a condition that requires immediate medical attention.

For the more slowly progressive and chronic conditions, some institutions have been successful managing the lion's condition with anti-inflammatory medications (prednisone) and more recently with non-steroidal anti-inflammatories, such as Meloxicam. There are reports of successful use of Etodolac for managing osteoarthritis in Bengal tigers but the safety of this medication in lions has not yet been documented. Carprofen, although efficacious in controlling pain, was associated with severe renal toxicity in at least one lion and is currently not recommended for use in lions.

For an acute onset of paralysis more aggressive intervention is required. Although surgical correction of disc injury was reported in a tiger, similar successes have not yet been reported in a lion. Due to the physical size of the animal and long-term, intensive post-operative care, and uncertain outcome, that spinal surgery would require, most institutions opt for either an attempt at medical management or humane euthanasia. The combination of medicating with high dose anti-inflammatory medications, sedatives, and prolonged strict cage rest has been somewhat successful in managing severe spondylosis and intervertebral disc disease.

Table 17 lists the drugs and associated dosages have been compiled from information from various zoos. Pharmacokinetic studies have not been done, and safety and efficacy is based upon personal accounts.

Table 17. Commonly used pain medications and dosages

Drug	Dosage
Cosequin (Glucosamine and Chondroitin)	1 scoop PO SID to BID
Meloxicam	Day 1: 0.1–0.2 mg/kg PO once Day 2–4: 0.05–0.1 mg/kg PO sid Day 5 on: 0.025 mg/kg PO eod
Tramadol	1–4 mg/kg PO bid, (total dose for lion 50–100 mg PO bid) for long-term use give 10 mg/kg PO q 72hr
Gabapentin	3–5mg/kg PO sid to bid
Fentanyl (intra-op analgesia)	10 mcg/kg/hr IV

Renal disease: As with most felids, advanced age in lions is often associated with some degree of renal compromise. Although renal disease can present at young ages, typically it is the older animals that first shows typical signs of increased water consumption, increased urination, weight loss and generalized ill thrift. Diagnosis is usually by a combination of physical exam, bloodwork, and urinalysis. Characterization of the type of renal disease can best be accomplished by ultrasonic evaluation +/- renal biopsy. Ultrasound guided renal biopsies can be accomplished with a tru-cut biopsy needle. Depending upon the institutions resources, the progression of renal disease can be monitored by sequential urinalysis +/- chemistry profiles drawn from the lateral tail vein while the lion is in a squeeze cage or through operant conditioning.

Neoplasia: As with most animals, advanced age can be associated with increased incidence of neoplastic conditions. Currently it does not appear that lions are predisposed to developing any particular type of neoplasia. The following is a list of some of the neoplastic conditions that have been reported in lions: lymphoma, reproductive tumors, spindle cell sarcoma, gall bladder adenocarcinoma, and mammary carcinoma.

Sedation

Occasionally the need arises to sedate a lion for either management or medical reasons. Pharmacokinetic data are not available on the following medications. If the need to sedate a lion arises, it is recommended to start at the low end of the recommended dosage and then titrate depending upon the resultant effects. It is important to note that although Haldol has been used in many species with great success, extrapyramidal effects have also been reported in some species. Please report any successes with other sedatives, or any untoward reactions, to the veterinary advisor.

Table 18. Commonly used sedatives and dosages

Drug	Dosage
Diazepam	0.5–2 mg/kg PO SID-TID (can cause fulminant hepatic failure in domestic cats)
Haldol	-
Acepromazine	0.5–1mg/kg PO
Perphinazine -enanthate	0.5–2 mg/kg mg/kg IM (long-acting 5–7 days)

Pain Management

Felids have the propensity to develop severe, and sometimes lethal, side effects to anti-inflammatory medications such as aspirin, phenylbutazone, and some Cox-2 inhibitors. However, several institutions have reported recent success in using some of the newer Cox-2 inhibitors such as Meloxicam and Etodolac in large cats such as lions and tigers. Dosages are listed above in Table 17.

Hospitalization

Hospital facilities should have x-ray equipment or access to x-ray services (AZA Accreditation Standard 2.3.2), contain appropriate equipment and supplies on hand for treatment of diseases,

AZA Accreditation Standard

(2.3.2) Hospital facilities should have x-ray equipment or have access to x-ray services.

disorders or injuries, and have staff available that are trained to address health issues, manage short and long term medical treatments and control for zoonotic disease transmission.

Lions should be maintained with socially accepted members of the pride whenever possible to avoid stress and aberrant behaviors. Some medical procedures may require isolation, and all effort must be taken to minimize this time. Allowing visual access to group mates in adjacent cages can alleviate this issue. If animals are extremely stressed during isolation, it may be necessary to provide drugs to calm them during this time. Acepromazine can be used as needed, and under the direction of a veterinarian (see Sedation section, earlier in this chapter).

AZA-accredited institutions must have a clear process for identifying and addressing animal welfare concerns within the institution (AZA Accreditation Standard 1.5.8) and should have an established Institutional Animal Welfare Committee. This process should identify the protocols needed for animal care staff members to communicate animal welfare questions or concerns to their supervisors, their Institutional Animal Welfare Committee or if necessary, the AZA Animal Welfare Committee. Protocols should be in place to document the training of staff about animal welfare issues, identification of any animal welfare issues, coordination and implementation of appropriate responses to these issues, evaluation (and adjustment of these responses if necessary) of the outcome of these responses, and the dissemination of the knowledge gained from these issues.

AZA Accreditation Standard

(1.5.8) The institution must develop a clear process for identifying and addressing animal welfare concerns within the institution.

Euthanasia

As care givers for the animals residing in our zoos and aquariums, it is vital that we provide the best care possible for them until the time their health deteriorates to a point where euthanasia is the most humane treatment, or the animal dies on its own. Institutions should refer to the AZA Acquisition and Disposition Policy for more information.

Necropsy

AZA-accredited zoos and aquariums provide superior daily care and husbandry routines, high quality diets, and regular veterinary care, to support longevity. In the occurrence of death however, information obtained from necropsies is added to a database of information that assists researchers and veterinarians in zoos and aquariums to enhance the lives of lions both in their care and in the wild. As stated in Chapter 6.4, necropsies should be conducted on deceased animals to determine their cause of death, and the subsequent disposal of the body must be done in accordance with local, state, or federal laws (AZA Accreditation Standard 2.5.1). Necropsies should include a detailed external and internal gross morphological examination and representative tissue samples form the body organs should be submitted for histopathological examination. Many institutions utilize private labs, partner with Universities or have their own in-house pathology department to analyze these samples. The AZA and American Association of Zoo Veterinarians (AAZV) website should be checked for any AZA Lion SSP Program approved active research requests that could be filled from a necropsy.

AZA Accreditation Standard

(2.5.1) Deceased animals should be necropsied to determine the cause of death. Disposal after necropsy must be done in accordance with local/federal laws.

Complete gross and histopathologic examination of all lions that die is suggested. Samples should be archived for future use. Information on tissue collection, sampling, and storage, and on post-mortem examination is provided at: http://aazv.org/displaycommon.cfm?an=1&subarticlenbr=96**.** Note that these documents are only accessible to those with an AAZV login.

Chapter 7. Reproduction

Photo courtesy G. Jones

7.1 Reproductive Physiology and Behavior

It is important to have a comprehensive understanding of the reproductive physiology and behaviors of the animals in our care. This knowledge facilitates all aspects of reproduction, artificial insemination, birthing, rearing, and even contraception efforts that AZA-accredited zoos and aquariums strive to achieve.

Female Reproductive Cycle Traits

Lions exhibit a 17-day estrous cycle. Concentrations of estrogens increase as follicles develop on the ovary and peak near the time the female becomes receptive to the male (estrus or "heat", usually 1 to 5 days). If the male and female repeatedly copulate, the female will ovulate ("induced ovulation"), estrogen concentrations will decrease, and the ovary will begin to secrete progesterone. Spontaneous ovulation has previously been reported in the lion (Schramm et al., 1994). More recently, spontaneous ovulations (increase in fecal progesterone metabolite) have been reported in several female lions, ages 3–9 years (Putman, et al., 2011). All spontaneous ovulators were housed with another female and within auditory and olfactory vicinity of at least one male. Despite these variations, lions are considered to be predominantly induced ovulators.

If the female becomes pregnant after mating, progesterone concentrations remain elevated until the time of parturition. Following an induced or spontaneous ovulation when pregnancy is not achieved, progesterone concentrations will remain elevated for several weeks, typically ~40 days (range 21–58) in lions (Putman et al., 2011). If progesterone continues to remain elevated beyond 50–60 days after copulation, the female may be considered to be pregnant. However, an additional test including radiography is warranted to confirm pregnancy. After parturition, a period of anestrous may be expected while the cubs are nursing though this should not be counted on for management purposes. In the wild, females generally give birth approximately every 2 years but in zoos it is possible that females can sustain a pregnancy at a shorter interval. However, if the cubs do not survive, females will often resume cycling within a few weeks (Packer & Pusey, 1983; Schaller, 1972).

Table 19. Reproductive Data for Lions (Packer & Pusey, 1983; Pfaff, 2010; Sunquist & Sunquist, 2001)

	Estrus	Estrous Cycle	Gestation	Litter size	Birth weight	Age at sexual maturity (females)	Litters per year
Wild	4–16 days	16 days 10–31 days (range)	100–114 days	3 (average)	1150–1785g	33–50 months	0.5
Zoos	2.5–4 days	16 days	110 days 103–119 days (range)	2 (average) 1–7 (range)	900–1360g	18–20 months	1

Male Reproductive Traits

In males, testosterone is produced at a relatively consistent rate. Male reproductive traits especially ejaculate traits can be safely evaluated using electroejaculation. The most unique aspect of reproduction in male cats is that most species produce a very high proportion of sperm with abnormal morphology. In most species, the proportion of sperm with normal morphology is typically ~50% (Howard, 1993). The proportion of morphologically normal sperm appears to vary with inbreeding levels. For example, assessment of two wild populations in East Africa demonstrated a direct correlation between genetic variability and the proportion of morphologically abnormal sperm (Wildt et al., 1987). A highly inbred population in the Ngorongoro crater consistently produced ejaculates containing <50% normal sperm while their more diverse counterparts in the Serengeti plains produced ejaculates containing ~75% normal sperm. On average, lions produce ~50% morphologically normal sperm in their ejaculate.

Seasonality

Lions do not show a seasonality of breeding. They are considered polyestrus, and will come into estrus approximately every 2.5 weeks. Females in the same pride may have synchronized estrous cycles and will often give birth within a short time of each other (Packer & Pusey, 1983; Sunquist & Sunquist, 2001). This has been observed in zoos, which may need to be considered in the management of a pride if space is an issue (Putman et al., 2011). Systematic studies examining the impact of season on male reproduction are yet to be conducted.

Hormone Tracking Methods

Felids excrete the majority of steroids and steroid metabolites in feces, so determining concentrations of estrogen and progestagen metabolites in fecal samples is the primary method used for monitoring endocrine events in felids (Brown, 2006; Brown et al., 1994). Fecal steroid metabolite monitoring enables the assessment of pubertal status and the generation of normative, species-specific data on seasonality, duration of the estrous cycle, and the length of the non-pregnant luteal phase. These techniques also determine the incidence of spontaneous versus induced ovulation (important for developing artificial insemination), predicting parturition, identifying causes of reproductive inactivity, and assessing the levels of physiological stress (Brown, 2006).

While these techniques are excellent for determining what has happened in the past, the time and expense involved in daily assays may preclude this method as a guide for when/if to introduce males and females for the purposes of breeding. However, by correlating behavioral data with physiological data, we will be able to create effective tools (behavioral assays) to assist in our management decisions. Such studies have been done with cheetahs but similar studies have not been done in lions (Wielebnowski et al., 2002).

Numerous studies have been conducted that document estrus cycles in females, and provide useful information in helping to determine behavioral estrus cycles (e.g., (Brown, 2010). Institutions interested in initiating such tests should contact the AZA Lion SSP Reproductive Advisor for the latest information on protocols, methodologies, and costs for such tests.

Although monitoring fecal concentrations of progestagens can be used to diagnose pregnancy in all felids except lynx, variation in hormone concentrations between animals and between samples from the same animal can complicate the interpretation of results (Brown, 2006; Fanson et al., 2010). Reliable results require collection of pre-breeding samples from each female, as well as weekly samples collected for at least 8 weeks after breeding. Therefore, there is interest in the development of a pregnancy test for cats that can provide accurate results with a single sample. Urinary concentrations of relaxin can be used to diagnose pregnancy in domestic cats, but results are only reliable when relaxin concentrations are determined by radioimmunoassay (Dorsser et al., 2006). More recently, Braun et al. (2009) reported that pregnancy can be diagnosed in the critically endangered Iberian lynx using a relaxin assay in both serum and urine during the second half of gestation.

Reproductive Behavior

The onset of estrus in female small felids is indicated (behaviorally) by an increase in a combination of several behaviors including cheek rubbing (both male and female), flehmen (male), male following female, male approaching female, male “watching” female, urine marking (both male and female), male sniffing anogenital region of female, and vocalization (either or both male and female) (Mellen, 1993).

The copulatory sequence in felids is remarkably similar from species to species. Male approaches female, grasps her by the nape, mounts by straddling the female first with the front feet and then with the hind feet. The female responds to the nape bite by adopting a lordosis posture (front quarters lowered, rear quarters elevated, and tail is moved to one side), the female sometimes also treads with her hind feet. At this point, the male occasionally begins stepping with his hind feet, often simultaneously rubbing against the female’s flanks. The rubbing by the male may induce the female to adjust or to exaggerate her lordosis posture. The male then begins pelvic thrusting. Mounts typically last 1–5 minutes before intromission occurs. In most instances, the male maintains a firm grasp on the female’s nape throughout the mount. Intromission is readily apparent and is signaled by a “copulatory cry” given by the female; this vocalization is typically a low, barely audible growl. Five to 10 seconds after the female emits this vocalization, she throws the male off her back, often threatening him, and then she begins to vigorously roll on her back. Rolling on the back typically lasts 5–30 seconds. Both the male and female usually then groom their own anogenital regions. Copulations are short but they may occur many times over the 1-5 days the female is in estrus.

Sequence of interactions leading up to copulation between wild lions in Botswana
H. Colahan

Introductions for Breeding
Male and female lions are typically housed together whether they are breeding or not. However, if introductions are being done for the first time, it may be advantageous to wait until the female shows behavioral signs of being in estrus. See Chapter 4.3 for additional information on introductions. Pairs that fail to breed for an extended period of time after introduction can sometimes benefit from being moved to a new exhibit or even being separated for a time.

Signs of estrus in females may include increased vocalizations and increased aggression towards other lions and keepers. She may then begin to initiate play and solicit the male by walking past him and rolling on the ground. The male will back down from her aggression without retaliating and keep attempting to approach her until she allows it. The male may also show decreased appetite, intolerance of other lions and staff, and will remain in close proximity of the cycling female.

If the female does not become pregnant, loses the litter, or cubs are pulled for handrearing, she will come into estrus again right away. Females that have live, parent-reared cubs may begin to cycle again 5–8 months after giving birth.

Problems Associated with Breeding
Once lions are successfully introduced, they will usually begin to breed. If they breed repeatedly over several months without a pregnancy, this could be cause for further investigation. This may include fecal hormone monitoring, semen collection from the male, and reproductive assessments for the female.

Females that have been contracepted may take considerably longer (1–2 years) to get pregnant, even after they begin to cycle (see Chapter 7.5 for more information on contraception and reversal). Females that do not breed for the first time until they are older or have not bred in several years may also experience difficulty getting pregnant.

Another area of concern is breeding females that are not yet physically mature. Females will begin to cycle as early as 18 months but don't reach physical maturity until 2–3 years old. If they are bred too soon, they can have complications associated with carrying the pregnancy to term and giving birth.

Institutions with questions or concerns about their pair should contact the AZA Lion SSP Reproductive and Contraception Advisors.

7.2 Assisted Reproductive Technology
The practical use of artificial insemination (AI) with animals was developed during the early 1900s to replicate desirable livestock characteristics to more progeny. Over the last decade or so, AZA-accredited zoos and aquariums have begun using AI processes more often with many of the animals residing in their care. AZA Studbooks are designed to help manage animal populations by providing detailed genetic and demographic analyses to promote genetic diversity with breeding pair decisions within and between our institutions. While these decisions are based upon sound biological reasoning, the efforts needed to ensure that transports and introductions are done properly to facilitate breeding between the animals are often quite complex, exhaustive, and expensive, and conception is not guaranteed.

AI has become an increasingly popular technology that is being used to meet the needs identified in the AZA Studbooks without having to re-locate animals. Males are trained to voluntarily produce semen samples and females are being trained for voluntary insemination and pregnancy monitoring procedures

such as blood and urine hormone measurements and ultrasound evaluations. Techniques used to preserve and freeze semen has been achieved with a variety, but not all, taxa and should be investigated further.

Artificial insemination has not been performed in lions but this is an area of future research interest.

7.3 Pregnancy and Parturition

It is extremely important to understand the physiological and behavioral changes that occur throughout an animal's pregnancy.

Confirmation of Pregnancy

There is no single step pregnancy test for lions (see Chapter 7.1 for details on fecal hormone monitoring) but there are other visual and behavioral cues that are effective, although differences between individual cats may be significant. Pregnant females may gain 20–50 pounds, particularly in the last 3–4 weeks of the pregnancy. Milk production and nipple development can be seen within about 2 weeks of parturition. Missed estrus cycles are indicator, although regular estrus is difficult to detect in some cats and cats that are not pregnant may go 8 weeks between cycles in some cases. Lions that are trained for abdominal ultrasound can be checked throughout the pregnancy, although it is sometimes difficult to confirm the presence of cubs.

Diet and Feeding Routine

Daily diet should be increased 500–1000g beginning about 1 month prior to parturition. Fast days should be eliminated and splitting the amount into multiple feedings may improve consumption. This amount can be adjusted based on appetite and body condition. Inappetance a few days pre- and post-parturition is to be expected and daily diet may need to be increased further after birth depending on litter size.

Prior to Parturition

Lions are unique among felids in their social structure and the male's tolerance for young. Since separating the female from the pride for birth is recommended, it is important to begin acclimating her to this as early as possible. If the pride is a compatible group, it is also beneficial to keep her with them for as much as possible and as close to the date of parturition as possible. This can be accomplished by doing regular, short separations prior to pregnancy. See Chapter 8 for training this behavior.

Once short separations are an established part of the routine, begin separating the female in the stall where she will give birth overnight no later than 1 week prior to the first possible due date. If she does not show any signs of labor she can be reunited with the pride during the day. This will reduce her anxiety about being separated and will also make reintroduction to the pride after the birth easier.

No other significant changes to the female's routine should be made in the 4 weeks prior to anticipated parturition. It is strongly suggested that only experienced keepers with whom the female is familiar with should care for the female. Managers may want to consider reducing the frequency of cleaning in the female's enclosure. Den box materials should not be changed unless soiled, and no more than 40-50% of the bedding changed at any given time.

If possible, leave the female with access to the den box during the day and monitor her behavior closely. Signs of labor include increased vocalizations, restlessness, vaginal discharge and licking, lack of appetite and isolating herself from the rest of the pride. She may also become more aggressive towards the pride and/or keepers. First time mothers with single cubs may not show many signs at all however, and should be managed more conservatively. Ideally she will move to the den box on her own and should be closely monitored, ideally by remote camera.

Birth Preparation and Management

Once birth has occurred, access to the female's den and the holding area should be limited, and the female left totally alone for 24 hours. If the female is spending large amounts of time in the nest box and all is quiet, the young are probably being taken care of satisfactorily. Disturbances during the early stages of rearing may cause the female to neglect or become aggressive toward the cubs. A remote camera system will allow monitoring and prevent unnecessary intervention or disturbance. If she can be monitored by camera, the behaviors to watch for include cleaning the cubs, stimulating them to urinate and defecate and nursing.

Problems Associated with Parturition
Common problems associated with parturition that occur in the domestic cat and dogs, may also present in lions (Feldman & Nelson, 2004):

Pre-Partum Vaginal Hemorrhage: Between the second and eighth week of gestation (in a 9 week gestation) bleeding may indicate fetal resorption or abortion. Following the eighth week, this may be a sign of pre-mature birth as the placenta separates from the endometrium. A cesarean section should be considered if bleeding is excessive near the expected due date.

Dystocia*:* Nonproductive contractions for more than 60 minutes or a cub visible in the vestibule without subsequent delivery may be indicative of dystocia. Large or misshapen fetuses can lead to fetal dystocia. Maternal dystocia can result from a narrow pelvis (often a result of metabolic bone disease earlier in life), torsion of the uterus, or cessation of contractions before all cubs are delivered.

Post-Partum Vaginal Hemorrhage: Small amounts of hemorrhage in the first 3 weeks post-partum are not unusual, unless bleeding is excessive, red blood counts or hematocrit values change, or discharge becomes mucupurulent.

Retained Placenta: Retention can be difficult to diagnose in non-domestic cats unless the birth was observed, since placentae are frequently consumed. Females that develop a fever, become anorexic, or stop nursing may have a retained placenta.

Acute Metritis: When acute metritis develops it occurs within 12–96 hours of parturition, secondary to retained fetal tissue or trauma during natural or assisted delivery. Females may become listless, anorexic, and ignore cubs.

Uterine Prolapse: Prolapse of one or both uterine horns may occur during parturition or within 48 h post-partum.

Veterinary Procedures Associated with Parturition
Cesarean Section: The primary indication for a cesarian section is fetal distress. Other causes include small pelvic size, large fetus, obstructive dystocia, and primary or secondary uterine inertia. Decision should be based on clinical signs of dam and length and stage of labor. Surgical approach is the same as in domestic dogs and cats.

Problems after Parturition
Hypothermia and injury from the mother are the most common problems and often associated with first time mothers. If the female is not spending most of her time in the den box, supplemental heat may be needed for the cubs. This may be provided by increasing the ambient temperature of the building or by additional heat sources.

It is not uncommon for first-time mothers to kill and even cannibalize their cubs. Doing this as a first time mother does not necessarily indicate that the same behavior will occur with subsequent litters. It is also not unusual for a single cub to be abandoned or killed. The criteria for when to intervene (if at all) should be discussed prior to the earliest possible birth date.

Management Routine
During the first week, traffic should be limited to regular animal care staff and a quick, dry cleaning of adjacent stalls can be done if needed. Unusual noises or traffic should be minimized but exposure to things that were routine prior to the birth can actually be more reassuring than total silence. The following guidelines are based on general timelines at several institutions. Every lion is different, and animal managers should work closely with keepers and veterinarians to assess their facilities and their animals when making decisions about the cubs.

Females may not eat for the first few days after birth, but fresh water should be available at all times. Food can be offered near the den box but should be left in place that can be easily removed if she does not eat it, which may happen for a few days. Ideally, she should be hand fed at this time to encourage her cooperation in shifting away from the cubs later on. However, some females may be very protective of the cubs, which manifests as aggression toward the keepers. This should be respected and staff should give her time to once again become comfortable with human presence. Once her appetite is back, daily diet may be increased up to 2.5kg/day (in 0.5kg increments) by the time the cubs are weaned.

After the initial postpartum period (4–7 days), a gradual return to normal cleaning and activities in the area can begin. Cubs should be left undisturbed for at least the first week, depending on the behavior of the female. When the opportunity arises, cubs can be weighed and sexed and the den box can be dry cleaned, but this should only occur when the female is voluntarily out of the box. Once she is shifting out of the box regularly (3–4 consecutive days) regular cleaning of the den box stall can resume. The management routine during this time should be guided by the female's personality and attitude. A relaxed, confident mother may be comfortable with shifting out of the den box at 4–5 days, but nervous or first time mothers may take 3 weeks or more. If the cubs and mother are healthy there is no reason to push this timeframe and new and nervous mothers should be managed conservatively. As the cubs get older it is wise to provide adequate room for the female to get away from them if she chooses. An elevated pallet or access to an outside run will allow her to get away if she chooses.

32 day old cubs, restrained for exam
K. O'Connell

As early as 2–3 days, it may be possible for staff with which the female is familiar to begin examining the cubs if the dam is easily separated. It is important that these encounters be kept to a minimum, and only with the people that the female is most familiar. Cubs should initially be handled with rubber gloves that have been soiled with feces from the den. These socialization sessions can be used to sex, weigh and examine the cubs. If they are not easily identifiable as individuals, a small area of fur can be shaved to aid in identification. Regular weights (1–2x/week) will assist with monitoring nursing and overall health, as well as prepare the cubs for their vaccinations. Veterinary exams and the first round of vaccinations begin at 6 weeks of age (see Chapter 6 for details).

At 3–4 weeks less familiar people can be slowly introduced back into the area and by 6 weeks old they should be in a fairly regular routine, and they should be getting exposed to new enrichment, new sounds, different people and adjacent holding cages. This early exposure in a safe familiar environment will help them better cope with unfamiliar and overwhelming stimuli later on.

Depending on the exhibit features and local disease concerns, healthy cubs may go outside after their first set of vaccinations at 6 weeks old. If the exhibit has large drop offs, water features, or other hazards, it may be necessary to wait longer. Outdoor off exhibit holding yards are also ideal for these first outdoor experiences. Shallow water tubs and boxes to climb on can help cubs learn to navigate the features they will encounter outside as well. Cubs that are socialized with caretakers (see below) may be able to be accompanied by staff when introduced to the exhibit that can help them become familiar with the exhibit and assist if they encounter any hazards.

Table 20. Developmental milestones for mother-raised lion cubs

Age	Description
At birth	Fully covered in fur
	Genitalia is easily distinguished
0–6 days	Eyes open
25 days	Teeth erupt
2–3 weeks	Mobility improves, begin wandering farther from dam
30 days	Begin leaving the den box
30–45 days	Start to show interest in meat (starts with smelling and licking)
40 days	Begin drinking water from bowls
45 days	Begin urinating on their own
10 weeks	Den box can be removed
7–11 weeks	Chewing on bones
	Consuming meat (rather than just licking)
3–5 months	Cubs become too large and/or aggressive for free contact
7–8 months	Weaning (although they may nurse up to a year if dam allows)
11 months	Male's mane become noticeable
1 year	Males capable of siring offspring
1.5 years	Females begin cycling
2–3 years	Physically mature

Socialization with Caretakers: Conventional wisdom about rearing felids has been to leave mother and cubs completely alone in order to raise socially and reproductively competent cats. On the other hand, hand-reared cats are perceived to be easier to train and possibly to make better exhibit animals due to their comfort around humans. A management strategy that focuses on both maternal care and socialization with human caretakers can provide the best of both worlds. However, this should only be done after careful consideration is given to the temperament of the mother, the experience of the staff, and clear guidelines have been developed for the entire process. Each facility should make decisions that best suit their goals and meet the needs of their lions.

Once the female is comfortable shifting away from the cubs, she can be given something to do such as bones, enrichment, or time with the other lions to gradually increase that time from a few minutes up to 20 minutes. During this time, familiar staff can sit outside the den box and wait for the cubs to come out and eventually they will begin to interact and even play with the staff. This up close time with the cubs allows the staff to inspect them and monitor growth and developmental milestones. More importantly, it is the beginning of a relationship between keepers and lions that will be built on trust and positive interactions, resulting in lions that are comfortable and cooperative with people.

This interaction should cease before the cubs' play becomes dangerous, which is usually around the time of their last vaccines at 3 months old. After this time, staff can continue the interactions from outside the cage and begin focusing on more structured husbandry training.

Several institutions have employed this strategy with great success. However, it may not work in all cases, as even cats that were relaxed and comfortable around humans may become shy and aggressive after giving birth, particularly the first time. Even cats raised using the above techniques may not tolerate it with their own cubs. Institutions are advised to carefully evaluate the behavior of the dam, as pushing her may result in serious harm to cubs.

7.4 Birthing Facilities

Den Boxes and Birthing Stalls

A large wooden box can easily be constructed in-house for a den box. It should be large enough for her to enter, turn around, and lie down comfortably (approximately 1.2 m H x 2.1 m W x 1.2 m D [4 ft H x 7 ft W x 4 ft D]).The box should be placed in a stall that is out of the way of regular traffic and can be kept dark and quiet. The entrance should be at one end so she can enter and lie down out of view. Adding a lip to the entrance will prevent cubs from rolling out onto a cold floor before they are mobile enough to return.

Den box
K. O'Connell

If space allows, an entire stall may be used by covering the front mesh with plywood or a tarp to provide privacy. Lions have also used larger boxes (2.1 m H x 2.1 m W x 1.5 m D [7 ft H x 7 ft W x 5 ft D]) and if the box is this tall a top is not needed. A box this size is also easier for staff to enter and clean.

Den boxes should be equipped with video cameras that can be monitored remotely from another part of the building. Cameras connected to a network can even be viewed from off site, which may be useful for managers to advise from home if there are concerns. While not as sophisticated as systems built specifically for animal facilities, those designed for home or small business surveillance will serve this purpose. A package of 4 night vision cameras with a DVR and monitor can be purchased for less than $500.

Birth facilities should have shavings, straw or grass hay added for bedding, although some females will remove all of it from the nest box and others will need to be monitored for ingestion. The bedding should be carefully inspected for dust, mold or possible inhalation risks to the cubs. The death of a cub did occur at one facility after aspiration of a tiny hay seed, although this was likely unavoidable and very rare.

As parturition draws near, animal care staff should ensure that the area is "baby-proofed." The birthing area and any holding area associated with it should be free of places where the cubs could get their head, feet, or other body parts caught. This could include large mesh, drains, pools, steps, gutters, drinkers, and tight spaces where furniture attaches to the wall or floor. Cubs should also be restricted from climbing up onto elevated areas until they are capable of navigating them safely. Bedding can also be used to provide a soft landing in areas where cubs could climb and fall.

7.5 Assisted Rearing

Although mothers may successfully give birth, there are times when they are not able to properly care for their offspring, both in the wild and in *ex-situ* populations. Fortunately, animal care staff in AZA-accredited institutions are able to assist with the rearing of these offspring if necessary.

The AZA Lion SSP does not recommend elective hand rearing of cubs. However, if a cub is in danger, ill, injured or being neglected, intervention is needed. If an institution does not wish to hand rear, humane euthanasia is an acceptable form of intervention so that the cub does not suffer unnecessarily. Assisted rearing by human caretakers is also an option after intervention, and institutions considering this option should make preparations well in advance of parturition. Keepers, managers, and veterinarians should discuss the criteria and procedures for intervening well in advance as well. By the time the cubs are born, everyone will be tired and under pressure, so advanced planning will help avoid emotional decision-making and disagreements later on when timing will become critical.

Hand-reared females of most species will rear their own young if they were peer-reared with a sibling, or another young felid, provided they are not otherwise overly imprinted on humans. This can be avoided by rearing with a conspecific or even another suitable animal. In the event of a single birth, every effort should be made not to hand-rear the young alone. The AZA Lion SSP Coordinator can provide information on possible similar age cubs at other institutions for peer rearing of singletons.

If conspecific young are not available, a domestic dog can be introduced. This relationship needs to be monitored closely because over a short period the lion will mature to the point where injury to the dog is a serious concern (A. Blue, personal communication). This companionship will provide valuable play experience necessary for proper socialization and normal developmental skills, factors that are critical in the lion's later success in dealing with conspecifics.

Foster rearing has been successful if a suitable dam is readily available (G. Noble, personal communication, 2006). Ideal candidates are other females in the pride with previous cub experience, and females that have recently lost cubs may even be able to nurse cubs.

Hand-rearing protocols: Ideally, criteria for hand-rearing a lion cub should be well established, and a management plan in place before the female gives birth. This will help to ensure that supplies, equipment, and support are available and on-hand should they be needed. It will also help guide the process during a time when quick decision-making may be necessary. Hand-rearing any animal requires around-the-clock care, and while an exhausting endeavor, it usually works best if only one or two caregivers provide the primary care during the first critical few weeks. Too many caregivers can cause problems with getting young cats to nurse and eliminate reliably, and subtle changes in the cat can often go unnoticed when too many people are involved. If it is necessary that multiple caregivers are involved, one person should set the feeding schedule and provide guidance on how to mix the formula (Hedberg, 2002).

When hand-rearing young felids, staff should pay close attention to three critical areas: volume of consumption per feeding, total daily consumption, and daily weight gain. Other important factors are stool quality, frequency of urination, and general condition (i.e., alertness and responsiveness). A daily chart should be maintained for recording these factors.

Medical Assessment

When neonates are initially removed from the dam, they should first receive a general physical. While conducting initial physical exams, problems such as cleft palate, wounds, herniated umbilical cord, and physical deformities should be reviewed. Because neonates do not have a fully developed immune system, the umbilical cord site may be a major source of infection; this site can be cleaned by applying antiseptic (solution of 50% betadine, 50% water) every 4–6 hours until the cord dries out and falls off. If vital signs are not within acceptable ranges, issues of dehydration, hypothermia, or hyperthermia may have to be addressed first. Dehydration can be determined by pulling up on the skin on the back of the neck. If the skin does not retract immediately, and stays suspended, warm fluids need to be administered by tube into the stomach, or subcutaneously, by a veterinarian. To regulate temperature, young may need to be maintained in a warm or cool environment, as required.

Milk Composition

In the domestic cat nutrient composition of milk is affected by stage of lactation with protein increasing from early to late lactation (Table 21 below). A wide range of fat levels have been reported for domestic cat milk (3–14%) which may be attributed to maternal diet, milk collection method, and/or methods of analysis (Oftedal & Iverson, 1995). The nutrient content of domestic cat milk is comparable to domestic dog milk (Oftedal & Iverson, 1995), therefore formulas appropriate to dogs should also be appropriate for cats. The selection process for a milk replacer should be based on the nutrients and their levels. Depending on the data used to formulate a product, it may or may not be appropriate for the target species, and/or may be applicable to more than one.

Data specific to lions is limited (Table 21), but shows similar trends in protein and slightly lower lactose than the milk of domestic cats. Most poignantly, fat values at the low end of the range reported for domestic cats and reflected in milk replacer formulas may be inappropriate for the lion (Table 21). Though commercial cat and dog replacers have resulted in healthy young lions, lower initial growth in hand reared animals compared to parent reared cohorts (Figure 4, Figure 5, Table 6) could be due in part to the difference in the composition of mother's milk and the milk replacers.

Table 21. Nutrient composition of domestic cat milk, lion milk, and commercial milk replacers

	Stage of lactation	Dry Matter, %	Fat, %	Protein, %	Lactose or Carbohydrate, %
Domestic cat[1]	0–43 days	[2]	3.4–5.3	4.0–7.5	3.4–4.3
Domestic cat[3]	6–8 days	[2]	10.9	11.0	3.4
Domestic cat[4]	0–6 weeks	25.3–28.6	13.1–13.6	6.7–10.0	3.9–4.1
Lion, 40 hours[5]	40 hours	19.2	11.4	6.0	2.65
Lion, 10 days[5]	10 days	16.7	13.7	8.5	[2]
Lion, 45-90 days[6]	45–90 days	26.8	8.7	11.8	3.2
Lion[7]	unknown	36.1	18.9	12.5	2.7
KMR[8]	Liquid	18.0	4.5	7.5	4.7
Milk Matrix 42/25[8]	Reconstituted	17.7	5.2	7.9	3.4
Esbilac[8]	Liquid	15.0	6.0	4.5	2.4
Milk Matrix 33/40[8]	Reconstituted	15.8	6.9	5.5	2.5

[1](Keen, et al., 1982)
[2]Values not reported
[3](Folin et al., 1919)
[4](Jacobsen et al., 2004)
[5](de Waal, et al., 2004)
[6](Oftedal & Iverson, 1995)
[7](Shaul, 1962)
[8]PetAg, Inc. Hampshire, IL. Reconstituted formulas are powders mixed with water following the label instructions (1 part powder to 2 parts water).

Formula Selection

From a recent survey, most institutions used Esbilac to hand rear lions (9 of 13 respondents) compared to KMR (3) and Milk Matrix 33/40 (1). Custom formulas have been suggested but follow up data on amounts fed, stool condition, and growth were not provided (Hedberg, 2002). Formulation based on mother's milk is likely to be closer to optimal. If formulas do not contain taurine, cubs should be supplemented with 250 mg per day to meet the increased requirement for taurine by cats (NRC, 1986). Formulas fed as specified by the manufacturer should not require additional vitamin and mineral supplementation. Many institutions use products to assist with the breakdown of lactose. Considering some commercial products may contain levels of lactose greater than lion milk, use of these products may be warranted.

If colostrum is not available to a lion cub within 16 hours of birth, adult cat serum can be given. Based on recommendations made for tigers, a minimum of 75mL serum/kg should be given as an intraperitoneal injections or a subcutaneous injection twice a day (Hedberg, 2002).

Amount to Feed

Amount of formula fed should be based on body weight. Average daily gain for parent reared lions was approximately 100 g/d during days 0–100 while hand reared lions grew more slowly at approximately 70 g/d. Early growth data is not available for young wild lions. A target energy intake to support this growth can be estimated based on the previous mentioned equation and knowing the energy content of the formula and solids offered. Caloric goals can be estimated as described above: ME_g kcal/d = ME_m + 1.9(ADG) = ($125BW_{kg}^{.75}$) + 1.9(100). Amounts should be based on achieving target gains and body condition.

Considering the estimated energy content of the commercial formulas, this amount may be up to 29% of body weight initially, dropping to 20% at 10 days and 11% at 70 days. In comparison to the data on lion milk, this growth may be achieved with 16% of body weight dropping to 6% of body weight at 70 days. Most hand rearing protocols do not significantly exceed 20%. Thus it is not surprising early growth goals are not met. Frequent adjustment to the amount fed based on body weight facilitates consistent growth. Cubs should be weighed daily, and should be weighed at the same time of day to allow accurate comparison of weight over time. Weighing before or after a feed can significantly affect the weight.

Feeding Schedule

The maximum stomach capacity of a carnivore may be, in general 5–7% of body weight. Consequently, to feed 20% of body weight, a minimum of 5 feeds should be offered. Some institutions start with 7–10 feeds for the first 10 days. Consistent, small meals can help avoid gastrointestinal tract stress. Animals should not be fed as much as they will take; this often leads to overfeeding and diarrhea.

Feeding Apparatus
In general, felids of the genus *Panthera* nurse well from human nursing bottles. Preemie nipples or cross cut normal nipples can also be used. A wide selection of nipple types and openings should be available, as some trial and error may be needed to find the best type to use with each individual cub. Bottles and bowls should be cleaned and sanitized between feedings. After cleaning, bottles can be boiled to avoid contamination from the environment.

Weaning
The weaning process may be instituted as soon as the incisors erupt, which can be around 5 weeks of age (Hedberg, 2002). Solids can be introduced in the form of a nutritionally complete canned cat food or a blended nutritionally complete raw meat diet. By this time, the cubs should be consuming formula from a bowl. The blended canned or raw meat diet can be added to the formula in the bowl. If canned cat food is used, it will need to be mixed with the raw meat diet and gradually decreased and removed over time. The benefit to using a canned diet initially is to delay microbial introduction to the cub's gastrointestinal tract. However, several species have been weaned onto raw diets without apparent ill effects. At this time, once the cub is consistently consuming solids, the amount of formula offered can be slowly decreased. Complete removal of formula can be attempted as early as 7.2 weeks, and as late as 12 weeks. Balanced calcium and phosphorus ratios should be maintained throughout the hand-rearing process. Commercial kitten and puppy milk replacers provide the appropriate ratio. However, during weaning the ratio can become skewed if the cubs are fed baby food, muscle or organ meat. In such instances, calcium supplementation may be required until the lion is weaned onto a nutritionally complete commercial diet.

Growth
Growth curves for parent, hand reared, and wild lions are shown in Figures 4 and 5. Though other authors have suggested 100 g average daily gains increasing to 200 g when solids are introduced (Hedberg, 2002), gains of 200 g were not observed before 70 days of age, when animals are nearly or completely weaned (Table 6).

Food Safety/Sanitation
Formula should be stored refrigerated separate from human consumption food. Formula over 24 hours should be discarded. Bottle and nipples should be cleaned and disinfected between feeds.

Record Keeping
Accurate records are critical to assess progress of the hand rearing process. Date, day, body weight, formula strength, amount consumed, stool condition, urination/defecation (stool quality), medications/treatments, comments on behavior including feeding response should be recorded. Electronic files facilitate quick assessment and summarizing.

Feeding and Eliminating
When feeding young felids, they should be placed on their stomach on a flat surface (e.g., table). Cubs held in an upright or head back position during feeding are more prone to aspiration and death. To promote elimination, the cub should be held in a sternal position, and the region extending from the belly to the anus gently stroked with a warm, moist cloth. Only slight pressure is needed to help guide the fecal material through the digestive tract and out the anal canal. After a week, this procedure can be reduced to two times a day. After the young begin eating solid food, this procedure can be reduced to one time per day. Most young will defecate on their own at 8–10 weeks, if not sooner.

Exercise and Socialization
After the cub starts walking, it is vital that sufficient space and time be provided to allow it to run and climb, and it should be provided with low climbing structures. Enrichment should be provided to promote stalking and pouncing. Although biting and clawing behaviors toward keepers should be discouraged, other natural behaviors should be encouraged. Providing the cub with a variety of safe toys will help keep them developmentally challenged, and may help to minimize the development of undesirable or stereotypic behaviors.

Shaping a cub's behavior through positive reinforcement and identifying the causes of undesirable behavior will help to prevent a cub from biting or displaying problematic behaviors later on. When caregivers provide opportunities for socialization, they help develop the cub's confidence and can reduce more dangerous behaviors. Leash training can begin at an early age, and can help facilitate outings,

exercise, and control while the cubs are young and more easily handled if large contained areas are not available (Hedberg, 2002). It should be stressed that the leash is only a temporary method of restraining a young cub under 6 months of age. See Chapter 7 for more information on socialization of cubs with staff.

Hand reared cubs should be introduced to adult lions whenever possible at the earliest possible age. Several cubs have been reared using a hybrid rearing technique that allows the cubs to be housed with conspecifics and bottle fed by staff. Cubs should be housed in visual access to conspecifics as soon as they are stable and introductions can proceed as described in Chapter 4.

Recommended Equipment

- Isolette/incubator (set at 29 °C [85 °F])
- Sheepskins/synthetic fleece pads
- Heating pad (set on low with a double thickness of bedding place over half the pad enabling neonates to move if they become too warm)
- Bottles/nipples
- Milk replacer
- Supplemental lactase enzyme (Lactaid®)—decreases gastrointestinal upset
- Electrolytes such as Pedialyte can be used in place of water for first few feedings or if diarrhea develops - Scale to measure weights daily
- Body temperature can be monitored daily to determine when the neonates are able to maintain their body temperature

7.6 Contraception

Many animals cared for in AZA-accredited institutions breed so successfully that contraception techniques are implemented to ensure that the population remains at a healthy size. In addition to reversible contraception, reproduction can be prevented by separating the sexes or by permanent sterilization. In general, reversible contraception is preferable because it allows natural social groups to be maintained while managing the genetic health of the population. Permanent sterilization may be considered for individuals that are genetically well-represented or for whom reproduction would pose health risks. The contraceptive methods most suitable for lions are outlined below but zoos are encouraged to contact the SSP before contracepting animals, particularly permanent sterilization. More details on products, application, and ordering information can be found on the AZA Wildlife Contraception Center (WCC) webpage: www.stlzoo.org/contraception and in Asa and Porton (2005).

The progestin-based melengestrol acetate (MGA) implant, previously the most widely used contraceptive in zoos, has been associated with uterine and mammary pathology in felids and suspected in other carnivorous species (Munson, 2006). Other progestins (e.g., Depo-Provera®, Ovaban®) are likely to have the same deleterious effects. For carnivores, the AZA Wildlife Contraception Center now recommends GnRH agonists, e.g., Suprelorin® (deslorelin) implants or Lupron Depot® (leuprolide acetate) as safer alternatives. Although it appears safe and effective, dosages and duration of efficacy have not been systematically evaluated for all species. GnRH agonists can be used in either females or males, and side effects are generally those associated with gonadectomy, especially weight gain, which should be managed through diet. Suprelorin® was developed for domestic dogs and has been used successfully in lions and other felids (Berschinger et al., 2001; Munson et al., 2001).

Gonadotropin releasing hormone (GnRH) agonists [Suprelorin® implants, or Lupron Depot®]: GnRH agonists achieve contraception by reversibly suppressing the reproductive endocrine system, preventing production of pituitary (FSH and LH) and gonadal hormones (estradiol and progesterone in females and testosterone in males). The observed effects are similar to those following either ovariectomy in females or castration in males (which will result in mane loss), but are reversible. GnRH agonists first stimulate the reproductive system, which can result in estrus and ovulation in females or temporary enhancement of testosterone and semen production in males. Then, down-regulation follows the initial stimulation in 3-4 weeks. The stimulatory phase can be prevented in females by daily Ovaban (megestrol acetate) administration for one week before and one week after implant placement (Wright et al., 2001).

GnRH agonists should not be used during pregnancy, since they may cause spontaneous abortion or prevent mammary development necessary for lactation. They may prevent initiation of lactation by inhibiting progesterone secretion, but effects on established lactation are less likely. New data from domestic cats have shown no effect on subsequent reproduction when treatment began before puberty; no research in prepubertal lions has been conducted.

A drawback of these products is that time of reversal cannot be controlled. The depot vehicle (Lupron®) cannot be removed to shorten the duration of efficacy to time reversals. The implant, Suprelorin®, may be placed strategically to allow for removal though this technique has not been fully tested. Contact the WCC for more information and tips on placement to facilitate removal which may hasten reversal. The most widely used implant formulations are designed to be effective either 6 or 12 months, but those are to be considered minimum durations, which can be longer in some individuals. To date two male lions have been treated with a GnRH agonist in an Australian Zoo which suppressed testosterone and resulted in a loss of mane. This may not be ideal for exhibit animals.

Although GnRH agonists can also be an effective contraceptive in males, they are more commonly used in females, because monitoring efficacy by suppression of estrous behavior or cyclic gonadal steroids in feces is usually easier than ensuring continued absence of sperm in males, since most institutions cannot perform regular semen collections. Disappearance of sperm from the ejaculate following down-regulation of testosterone may take an additional 6 weeks, as with vasectomy. Suprelorin® has been tested primarily in domestic dogs, whereas Lupron Depot® has been used primarily in humans, but should be as effective as Suprelorin®, since the GnRH molecule is identical in all mammalian species.

Progestins [Melengestrol acetate (MGA) implants, Depo-Provera® injections, Ovaban® pills] If progestins must be used, they should be administered for no more than 2 years and then discontinued to allow for a pregnancy. Discontinuing progestin contraception and allowing non-pregnant cycles does not substitute for a pregnancy. **Use of progestins for more than a total of 4 years is not recommended**. MGA implants last at least 2 years, and clearance of the hormone from the system occurs rapidly after implant removal. The MGA implants should be removed because they can continue to release progestin well past the minimum effective duration of 2 years, which can continue to delay fertility. Progestins are considered safe to use during lactation.

Vaccines: The porcine zona pellucida (PZP) vaccine has not been tested in lions but may cause permanent sterility in carnivore species after only one or two treatments, **so this method is not recommended.**

Surgical Sterilization

Any surgical procedure in a large nondomestic animal carries some inherent risks in terms of both surgery and post-surgical management. However, ovariohysterctomies have been safely performed in lions on numerous occasions.

Ovariectomy or Ovariohysterectomy (OVH): Removal of ovaries is a safe and effective method to prevent reproduction for animals that are eligible for permanent sterilization. In general, ovariectomy is sufficient in young females, whereas, removal of the uterus as well as ovaries is preferable in older females, due to the increased likelihood of uterine pathology with age.

A traditional OVH via laparatomy has several advantages and a few drawbacks. The procedure itself will remove the source of the gonadal hormones that affect behavior and uterine pathology. Post-operative management of the suture line and enforcing cage rest may become problematic, but have been effectively managed at many institutions.

In an attempt to minimize potential complications of suture line dehiscence and to speed recovery times OVH via laparoscope is a somewhat newer technique that is being performed with increasing frequency. Within the past few years, several zoos have chosen this technique. Specialized equipment and expertise performing this procedure in lions is recommended.

Tubal Ligation: As with OVH, this procedure can be performed via laparotomy or laparoscope. The major difference is that the gonads are not removed and the body is still exposed to hormones that can affect behavior and uterine pathology. Although blocking access of sperm to eggs will prevent fertilization, it will not prevent the potential adverse effects to females that can result from prolonged, cyclic exposure to the

endogenous progesterone associated with the pseudo-pregnancy that follows ovulation induced by copulation. **This method is not recommended for lions.**

Vasectomy: Gonadal hormones are still present so behavior and secondary sexual characteristics will not be affected. The mane will be unaffected and the lion will continue to copulate if receptive females are present. As with tubal ligation above, vasectomy of males will not prevent potential adverse effects to females that can result from prolonged, cyclic exposure to the endogenous progesterone associated with the pseudo-pregnancy that follows ovulation induced by copulation. **This method is not recommended for lions.**

Castration: The permanent removal of the gonads is a very effective method of non-reversible contraception. The removal of these hormones will also affect behavior and secondary sexual characteristics such as the appearance of the mane.

Chapter 8. Behavior Management

K. Cox

8.1 Animal Training

Classical and operant conditioning techniques have been used to train animals for over a century. Classical conditioning is a form of associative learning demonstrated by Ivan Pavlov. Classical conditioning involves the presentation of a neutral stimulus that will be conditioned (CS) along with an unconditioned stimulus that evokes an innate, often reflexive, response (US). If the CS and the US are repeatedly paired, eventually the two stimuli become associated and the animal will begin to produce a conditioned behavioral response to the CS.

Operant conditioning uses the consequences of a behavior to modify the occurrence and form of that behavior. Reinforcement and punishment are the core tools of operant conditioning. Positive reinforcement occurs when a behavior is followed by a favorable stimulus to increase the frequency of that behavior. Negative reinforcement occurs when a behavior is followed by the removal of an aversive stimulus to also increase the frequency of that behavior. Positive punishment occurs when a behavior is followed by an aversive stimulus to decrease the frequency of that behavior. Negative punishment occurs when a behavior is followed by the removal of a favorable stimulus also to decrease the frequency of that behavior.

AZA-accredited institutions are expected to utilize reinforcing conditioning techniques to facilitate husbandry procedures and behavioral research investigations.

Overview

Behavior management is an essential element of animal care and welfare. Two key components of behavior management include animal enrichment and animal training, both of which should be governed by formal, written programs with goals aimed at increasing species-appropriate behavioral opportunities. It is important for both enrichment and training programs to have a system in place for setting, evaluating, and readjusting goals as needed. Using a defined system will allow all members of the animal care staff to be consistent with enrichment practices and training techniques.

The SPIDER framework for training and enrichment programs (Mellen & Sevenich-MacPhee, 2001)

Before starting an enrichment or training program, the natural history and behavior of the animal should be clearly understood. Both the training and enrichment of an animal should begin with specific goals that are consistent with its natural behavior. When setting up a new program, the needs of the species, group, and individual should all be taken into account. It is also important to include input and approval from animal management, veterinarians, and keepers at each step of the planning process.

Once the goals have been set and the plans for reaching them have been made, implementation can begin. During this phase, care should be taken to collect consistent and accurate data, and these data should be periodically evaluated to ensure that the goals are being met. In cases where the pre-set goals are not being met, the program will need to be adjusted. Both enrichment and training programs should be maintained continuously for the best results. If the program is intermittent, the results may not be reliable.

Finally, there should be safety protocols for both animal enrichment and training that are designed to protect the animals and the keepers. During the data collection and evaluation processes, safety concerns may arise which may necessitate the continual amendment of safety protocols. It is important to keep these protocols current through annual review.

Introduction

Why Train? It is important to train lions in order to meet basic husbandry needs, aid in medical procedures and transports, and provide valuable enrichment through mental stimulation. Husbandry

needs can be met with simple and easy to train behaviors such as shifting on and off exhibit and shifting between multiple dens. After these behaviors are established, the most desirable behaviors are those that aid in the veterinary care of the animal. For example, behaviors can be trained that allow for visual inspection of body parts, weighing, hand injections, blood draws, and restraint such as squeeze or crate training. These behaviors help decrease animal stress levels prior to or during a medical procedure. They also help to decrease the number of immobilizations needed and can often give keepers the ability to apply topical medications if needed (Young & Cipreste, 2004). These behaviors will also make animal transports less stressful and possibly occur without anesthesia.

T. Webb

Training also serves as a valuable form of enrichment. It can be used to stimulate lions mentally as well as physically. It also fosters the animal-keeper bond, which can reduce aggression and stress.

How To Train Lions: A good review for anyone just starting a program can be found in Karen Pryor's book *Don't Shoot the Dog.* A great overview is available in much more detail than can be outlined here. There are courses on animal training offered by AZA as well as other groups and the staff at other AZA institutions are also a useful resource. Several consulting groups also help zoos set up new training programs and assist with specific goals or issues.

Before beginning a training program, designated trainers should have a working knowledge of classical and operant conditioning techniques. Training that emphasizes positive reinforcement is usually most effective and is encouraged. Lions can be easily trained using operant conditioning. Training should be goal-oriented, behaviors should be well defined, and an action plan should be in place before training begins. The training plan should consist of a description of the training goal, the verbal and visual cue, the type of bridge (typically a whistle or clicker) and the reinforcer. It should also include a training schedule and the actual steps taken to achieve the behavior. Having a contingency plan for unintended reactions is also helpful. The lack of a plan during a training session can result in the reinforcement of unwanted behaviors (Ramirez, 1999)

Lions are highly food-motivated, which makes operant conditioning an ideal training method. Once the plan has been established and the secondary reinforcer, or bridge, is conditioned, advanced behaviors such as target and station training should come fairly quickly (Mellen & Ellis, 1996; Ramirez, 1999). More complex behaviors such as hand injections or blood draws should be broken down into smaller steps (Broder et al., 2008). With these more complex behaviors, it is especially important to have a training plan. This will assist the trainer in expecting the unexpected and in having a plan to handle unforeseen reactions or regression.

When training animals, especially if the behavior is new, it is important to be as consistent as possible. This may mean that only one trainer will be responsible for training an animal or a behavior. It is equally important not to begin training too many new behaviors at once; the pace will vary with individual animals.

It is important to have the ability to train lions as an isolated individual or in a group setting. Even though lions are social animals and live in prides, they also need to be conditioned to separate as individuals for various management reasons. Once a lion is habituated to separating out for feeding, keepers have the ability to pull a specific lion out for any number of reasons.

The most common reason to isolate a lion from its pride is for feeding. Appetite is an important indicator of a lion's overall health. It is often an indicator of illness, heat cycle, seasonal change, and stress. Allowing a lion to eat separately will give the keeper an opportunity to gauge any of these factors and to get a good visual inspection for any signs of injury.

Examples of other behaviors trained while individuals are separated include ultrasound, blood draw, hand injection, and crate/squeeze restraint training. These behaviors often have to be trained individually because the areas used to train them are often smaller off exhibit areas with special caging adaptations

that only accommodate one lion. Having animals that are not stressed when separated but instead have positive events occur while separated makes animal management easier and less stressful for the animal, thus improving animal welfare.

A good lion training program begins by training a lion as an isolated individual, whether working on basic or complex behaviors. When basic behaviors such as target, up, and down are established, lions can be trained in a group setting. In a group situation, a lion can be trained as an individual, part of a subgroup, or part of the whole group. Deciding how to train a lion in a group setting should depend on your lion- to-keeper ratio. With a 1:1 lion to keeper ratio, new behaviors could be worked on as well as established ones. When the lion to keeper ratio increases (i.e., more lions than keepers), it may be easier to train established behaviors because training new ones requires more focus. Group training sessions are a great way to demonstrate behavioral management for guests or tours. This is a very dynamic way to inspire people to help endangered species and their local zoo.

Where To Train? Ideally, facilities will have public and private training areas (Anderson et al., 2003). Some facilities already have training demonstration areas in place and have received positive feedback from the public. It is a great opportunity to educate the public about behavioral management, and give them a "close encounter" experience that will get them excited about the animals. Just as with other individual differences, every animal may not readily train on exhibit. Because of this, private training areas are also extremely important. This is where most veterinary care will take place and the animals need to be comfortable and conditioned to training there. Off-exhibit training areas are also necessary when training new behaviors, which require the animal and trainer's complete attention. Training animals to enter squeeze cages and step onto scales are important behaviors for proper animal care. Behaviors such as side presentations require a large span mesh for the keepers to access the animal and provide enough room for the animal to easily position itself. Having these tools built into a facility will increase the level of care institutions can provide their animals.

Safety Considerations

Each institution should have a safety protocol specific to training (Young & Cipreste, 2004). The protocol should address safety for the trainer, the animal and the guests. The training area should be closely inspected for gaps in the fence through which a lion could extend a paw. These should be eliminated, if possible. If they cannot be eliminated, the trainer should define a safe distance to stand while training. It may be beneficial to mark the ground with a brightly colored line to distinguish between the safe and unsafe zones, especially in public training areas. In addition, meat sticks can be used to deliver the reward instead of hand feeding. To ensure animal safety, proper shifting and squeezing procedures should be utilized and keepers should have adequate knowledge of equipment usage. Management and veterinarian oversight will further ensure safety. Implementing these safety precautions will further ensure overall safety (See Chapter 2.2 for more information on keeper safety).

When training on exhibit or for an audience, trainers should be aware that they may be distracted which could result in mistakes and injury. A safer method in this case is to have one person focused on training the animal and a second person doing the presentation and answering questions. Depending on facilities, staff, and the temperament of the lions, some facilities may elect to not allow guests to view training.

Behaviors and Priorities: Table 22 lists the behaviors that lions in AZA-accredited zoos have been trained to do. It is important to consider and discuss the needs of the institution when setting training goals. Time and other resources are often limited, so trainers will need to prioritize behaviors. For example, crate training may be a top priority for an animal that is scheduled for transfer, whereas blood collection may be more important for an animal with health issues. The list in Table 22 is intended to provide an overview of what has been done and can be done, but not all institutions will need to train all the behaviors on this list.

There is a tendency for trainers to want to focus on behaviors that may appear to be more high profile or challenging but it is important to remember that simple behaviors that are needed every day are also important. Reliable shifting, monthly weighing, and full body visual inspections are critical to the day-to-day management and should not be overlooked.

Table 22. Training behaviors

Behavior	Description
Shifting	Enter holding, exhibit, or other areas on cue
Emergency recall	Return to holding quickly, ignoring any distractions
Crate	Enter crate and allow door to be closed
Separation	Separate from other members of the pride voluntarily
Line up	Stand parallel to mesh front
Target	Place nose, paw or other body part on target pole, or other object
Body part presentations	Position so that various body parts can be inspected. Each body part is a separate behavior but examples include ears, paws, tail, head, etc.
Stand (on hind legs)	Stand on hind legs with paws on cage front
Injections	Position and allow injection (injection site may vary)
Take oral medications	Accept and swallow food item, liquid or medication, regardless of taste
Abdominal ultrasound	Position for ultrasound probe and allow procedure
Open mouth	Open mouth and allow for visual inspection
Vocalize	Roar, chuff, growl, etc. on cue
Blood collection	Position and allow blood collection from tail vein
Scale	Stand or sit on scale
Sit	Sit
Lie Down	Lie down sternally
Table/Get Up	Get on table, platform or other elevated area on cue
Station (individual or group)	Go to a location and remain there until released
Chute/Squeeze	Enter chute or squeeze cage and allow manipulation
Paws	Place paws on mesh for examination
Recall	Return to trainer on cue
Come Here	Come to trainer on cue
Shake Head	Shake head on cue
Crawl	Move across area while lying down
Ball (touch or sit on)	Go to and touch ball

8.2 Enrichment

Environmental enrichment, also called behavioral enrichment, refers to the practice of providing a variety of stimuli to the animal's environment, or changing the environment itself to increase physical activity, stimulate cognition, and promote natural behaviors. Stimuli, including natural and artificial objects, scents,

and sounds are presented in a safe way for the lions to interact with. Some suggestions include providing food in a variety of ways (i.e., frozen in ice or in a manner that requires an animal to solve simple puzzles to obtain it), using the presence or scent/sounds of other animals of the same or different species, and incorporating an animal training (husbandry or behavioral research) regime in the daily schedule.

AZA Accreditation Standard

(1.6.1) The institution must have a formal written enrichment program that promotes species-appropriate behavioral opportunities.

Enrichment programs for lions should take into account the natural history of the species, individual needs of the animals, and facility constraints. The lion enrichment plan should include the following elements: goal-setting, planning and approval process, implementation, documentation/record-keeping, evaluation, and subsequent program refinement. The lion enrichment program should ensure that all environmental enrichment devices (EEDs) are "lion" safe and are presented on a variable schedule to prevent habituation AZA-accredited institutions must have a formal written enrichment program that promotes species-appropriate behavioral opportunities (AZA Accreditation Standard 1.6.1).

AZA Accreditation Standard

(1.6.2) The institution must have a specific staff member(s) or committee assigned for enrichment program oversight, implementation, training, and interdepartmental coordination of enrichment efforts.

Enrichment programs should be integrated with veterinary care, nutrition, and animal training programs to maximize the effectiveness and quality of animal care provided. AZA-accredited institutions must have specific staff members assigned to oversee, implement, train, and coordinate interdepartmental enrichment programs (AZA Accreditation Standard 1.6.2).

Why enrich? A principle objective of enrichment is to promote animal welfare. Animals in zoos inhabit a much less complex environment than their counterparts in the wild. This can limit their ability to control the external stimulation to which they are exposed (Carlstead, 1996). Possessing an element of control is essential for animals to be able to adapt to their environment and to support their well-being (Sambrook & Buchanan-Smith, 1997). Therefore, one of the more important goals of an enrichment program should be to offer the animals a complex exhibit that gives them choices and a way to control their environment, which, in turn, can enhance welfare. This program should target species-appropriate behaviors that are in the animals' best interest and allow the public to observe their natural behaviors.

D. Bredahl

Why enrich lions?

Lions are opportunistic carnivores that have a strong innate drive to hunt, stalk, chase and kill their prey in the wild, both as individuals and as a group (Estes, 1991). Their active predatory instinct requires the need for food-based enrichment as well as for object enrichment to simulate a kill. Lions also have a well-defined sense of smell that is used in the wild for gathering information about their territory (Schaller, 1972). Sensory enrichment can stimulate lions to investigate their zoo territories in a similar manner. Enrichment should also address the social complexity of lions, and lion enclosures need to be as

multifaceted as possible to mimic a natural environment. They should offer the lions opportunities to choose how and where they will spend their time.

How to enrich lions?

Food-based enrichment

Food is an inherently enriching item for the lion. Lions spend a quarter to a third of their daily activity hunting prey and consuming their kill (Sunquist & Sunquist, 2002). Consequently, feeding a lion its food ration once daily, which can usually be consumed within minutes, may limit the enrichment properties it should have. There are ways to make food and feeding more enriching. For example, a variable feeding schedule could be implemented. There are studies to suggest that animals can benefit from an unreliable feeding schedule if it is paired with a reliable cue (Bassett & Buchanan-Smith, 2007). One study of lions in a managed setting examined the effects of switching the cats from a conventional daily feeding schedule to a gorge and fast diet. Large meals were fed on a random schedule that resulted in increased digestibility and better weight maintenance (Altman, et al., 2005). Another strategy for making food more enriching is to hide, scatter or present it in a manner that requires the lions to "hunt" for their food. Finally, offering a variety of food types may prove physically and mentally enriching. Bones and carcasses give the animals a more naturalistic way to exhibit feeding behaviors, which may reduce stereotypic behavior as well as improve dental health (Bond & Lindburg, 1990).

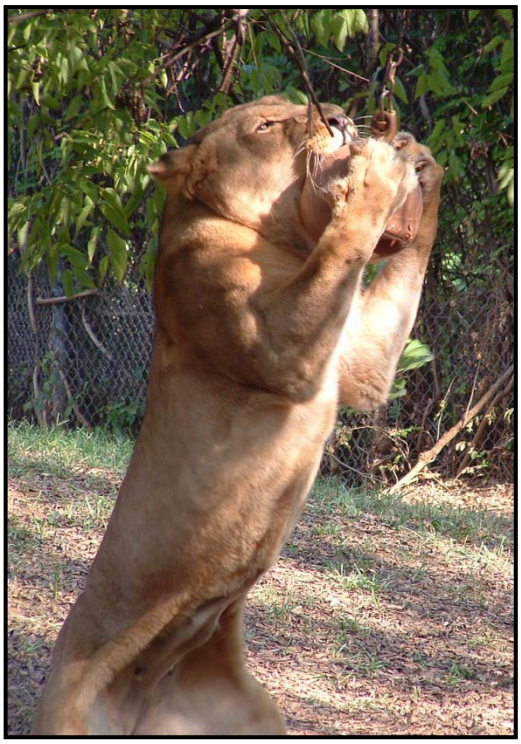
K. Cox

A variety of bones are available from commercial zoo food distributors. Rabbits are a good carcass choice because they are available throughout the year from rabbit breeders. Deer carcasses can be obtained during deer hunting season from a meat processor. It is beneficial to the processor to have the unprocessed parts of the deer disposed of by the zoo and it is equally beneficial to the zoo to have the deer cleaned and prepared for consumption. The typical unclaimed portions of the deer that are readily available are rib cages with rib meat, heads, legs and hides, all of which receive great response from the lions while only slightly increasing dietary consumption. See Chapter 5 for more information on food sources and quality.

Offering food in addition to the diet or feeding multiple times per day can alter the shifting pattern for lions. Lions are very food motivated and will often shift for food, but a satiated lion may not shift until hungry. It is important to determine the needs of the facility as well as the lions when choosing a feeding regime.

Object Enrichment

The instinct to hunt can be indulged with prey-resistance devices and other "toys" that allow them to stalk and kill "prey" (i.e., paper animals, boomer balls). Again, it is important to evaluate the responses these items receive to ensure it is achieving its goal. Simply giving a lion an item to "hunt" does not guarantee it will. Determining which items illicit the desired response, and using these items, is essential. Prey-resistance devices (see photo at left) are very popular with some lions and they are versatile in that they can be rotated frequently with different "prey" (e.g. balls, kegs, burlap bags, bones or animal hides.) Great care should be taken when designing a prey-resistance device to prevent injury. A heavy duty spring should be used and covered with fire hose or PVC pipe (as deemed appropriate for the animal) to prevent the lion from getting caught in the spring. A garage door spring rated to 400 pounds or more is a good choice for prey-resistance devices, allowing the lion to pull on the "prey" without over-stretching the spring. Similar items are available from commercial enrichment distributors.



K. Cox

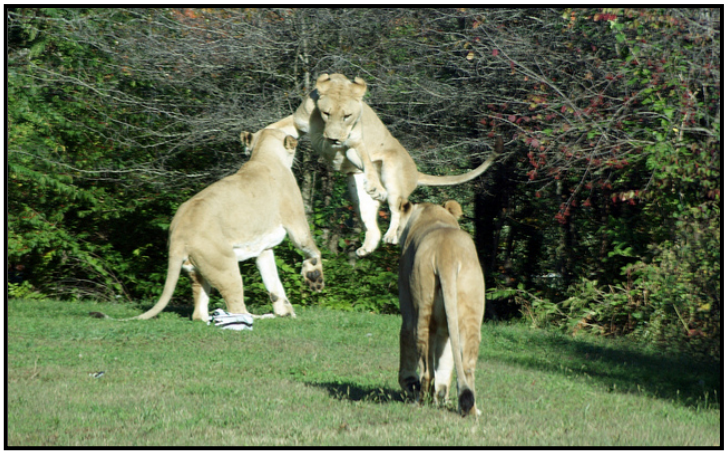
Sensory Enrichment

Felids have a well-defined sense of smell and can be enticed by scent-based enrichment, but different species, and even individuals of the same species, show variation in their response to different scents. Not every new scent is equally enriching to every cat.

A study at Knoxville Zoo was conducted to compare sensory-based enrichment among the different taxa of large felids, which included tigers, lions, snow leopards, and cheetahs. The study specifically looked at comparing reactions of the different species to different colognes, perfumes, spices, and animal-based scents such as urine. The results of this study were used to refine the felid enrichment program so that only the sensory enrichment that is truly enriching is used. With respect to lions, this study found that lions respond particularly well to animal-based scents such as urine, feces, and fur (Wachenfeld, 2008). Ungulates are a good source of animal-based scents due to the low risk of disease transmission. Also, there are commercially prepared urine sprays available that work well.

Social Enrichment

Lions are the only truly social species of cat and they should be housed with conspecifics in exhibits that offer socially enriching opportunities. Interactions with enclosure mates are a continuous source of stimulation for social groups that is unavailable to singly-housed animals (Hosey et al., 2009). Facilities should be designed to offer enrichment opportunities for multiple lions, instead of individual lions, to encourage social behavior while taking care to prevent aggression. Lions are known to feed together in the wild, but when offering food enrichment, enough should be offered in the beginning so that all lions can have access to it in order to determine if the lions will fight over the food. Similarly, object enrichment should first be offered so that all lions in a particular enclosure can participate. This may mean having



Lions playing
E. Ray

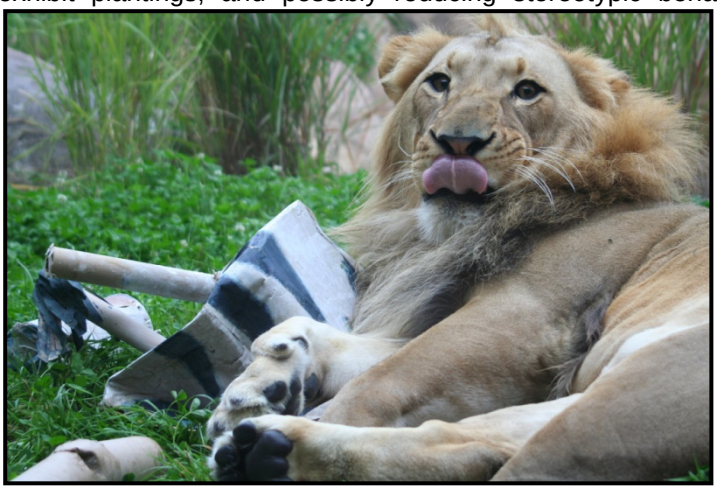
more than one prey-resistance device or having multiple elevated pallets for sleeping. If the lions are particularly social, they may be willing to "share" and less may need to be offered.

Lions have exhibit wide range of behaviors and enrichment goals should be based on encouraging or discouraging these behaviors. They exhibit typical cat behaviors such as predatory and territorial behaviors but in addition, they also have social behaviors that are unique to lions. The following are some of the most common lion behaviors (note that some behaviors are listed in more than one category).

Table 23. Lion behaviors

Activity	**Associated behaviors**
Locomotion	Climb
	Walk
	Run
Feeding	Licking
	Chewing
Hunting	Stalk
	Chase
	Bite
	Drag prey
Territorial	Flehmen
	Scratching
	Rubbing
	Urine spry
	Defecate
	Fight
Inactive	Sleep
	Sit
	Lie down
Social	Vocalizations
	Fight
	Groom
	Head rub
	Licking
	Tail twitch
	Bare teeth
	Play with object
	Play with other lion
	Care for young
Reproductive	Mounting
	Flehmen
	Neck biting
	Lordosis
	Vocalize

Where to enrich? Offering a variety of enclosure furniture such as different perches, substrates, scratching material or water sources can give enclosures and exhibits an element of complexity and give animals control in a habitat that offers limited variation. It also has the added benefit of allowing keepers to determine animal preferences. This knowledge can be used advantageously in such ways as encouraging animals to spend more time in public viewing areas; redirecting scratching behaviors from exhibit plantings; and possibly reducing stereotypic behavior. It has been suggested that adding appropriate complexity to an animal's environment can result in appropriate species-specific behavioral patterns (Maple & Perkins, 1996).



A. F. Eagleson

One final consideration when designing an enrichment program for lions: lions sleep approximately 20 hours per day in the wild and are active mostly between dusk and dawn (Nowak & Paradiso, 1999). Enrichment aimed at increasing lion activity during the day may not be achieving the goal of promoting species-appropriate behavior. It may be more beneficial for the lions to focus enrichment opportunities during the evening hours.

Safety Considerations

Enrichment programs should have a safety protocol that clearly defines the areas of concern when enriching the animal. This protocol should address topics such as ingestion hazards, disease cross-contamination, and animal and facility safety. Animals must be observed when a new element is introduced and adverse reactions should be noted. Again, it is important to have program oversight that involves veterinarian and management input to further ensure enrichment safety. Any problematic enrichment should be included in a data transfer document, such as the AAZK Animal Data Transfer Form, to help future institutions safeguard against injury or illness in their enrichment practices.

Like any animal, lions respond best to enrichment aimed at increasing or providing an outlet for species-appropriate behaviors. Enrichment items should be frequently rotated and exchanged to increase novelty and reduce boredom. A good enrichment program should have a process for identifying types of enrichment, getting appropriate approval from management and veterinarians, providing the enrichment, recording what types have been given and evaluating their effectiveness, and then re-adjusting based on these findings (www.animalenrichment.org).

Table 24 is a listing of enrichment used with lions in AZA zoos. This list is intended to provide ideas to assist staff in planning enrichment but each item on this list should be carefully considered before using. Individuals react differently to enrichment and what was safe and effective for one animal may be hazardous to another animal. The Shape of Enrichment website (www.enrichment.org) keeps an enrichment safety database where institutions can anonymously report problems with enrichment. Institutions are encouraged to consult this information before offering enrichment and to report any problems they experience.

K. O'Connell

Table 24: Examples of enrichment used with lions

Enrichment	Description	Potential Hazards
Play, Manipulation, Locomotion		
Boomer Balls, Kegs, Barrels, Jugs, Buckets, Tires Plastic toys, bowling pins, bowling balls	Items encourage play, object manipulation, and provide opportunities to hide food. Items hung or placed in trees encourage exercise	Items should be monitored for wear and ingestion. Kegs and bowling balls can cause tooth damage. Small objects may be choke hazards. Large items may be cause injury if they are heavy or create an escape hazard
Phone Books	Lions will shred pages, food items may be used to encourage investigation	Monitor for ingestion of paper
Fire Hose Rope Chain Bungees	Items can be used to make hammocks, hang items, or attach furniture	Monitor for ingestion and entrapment
Pneumatic Pop Up Plastic Meerkats	Encourage hunting and stalking behaviors	Monitor for damage
Hanging Items	Encourage climbing, jumping standing	Ensure that animal cannot become entangled
Cardboard, Paper Mache, Piñatas, paper bags	Can be filled with food, encourage stalking, hunting, feeding behaviors	Check carefully for staples, tape, etc. Monitor for ingestion
Non-toxic Paint	In addition to sensory stimulation, can be combined with training to create animal artwork	Monitor for excessive ingestion
Brushes	Encourage rubbing, can be used with scents	Monitor for damage and ingestion
Bedding Materials and Substrates (hay, shavings, wood wool, mulch, burlap, sand)	Provides sensory enrichment and provides resting and digging opportunities	Monitor for ingestion
Pools	Provide opportunities for swimming or fishing	Monitor plastic pools for damage and ingestion, drowning hazards
Bushes, grasses, trees, logs	Provide opportunities for hiding, climbing, scratching, shade	Ensure plants are non-toxic, rotten logs may introduce pests
Lure Course	Encourage exercise, chasing behavior	Monitor for damage, trip hazards
Sensory		
Spices, Perfumes, Extracts Feathers, Wool, Snake Sheds, Fur Deer Urine Soiled bedding from prey species Browse from prey species exhibits Catnip and Other Herbs	Encourages locomotion, rubbing, flehmen, digging	Monitor for stress or frustration responses. Items from other exhibits/species should be clear of contagions
Visual stimulation outside exhibit – lights, disco ball, bubbles, kites Music, TV, Video Animal Sounds	Encourages stalking, locomotion	Monitor for stress or frustration responses
Food		
Live Prey (fish, insects)	Encourages stalking, hunting, feeding responses	Welfare concerns with prey species, risk of injury to lions
Carcass/ Whole Prey (rats, mice, guinea pigs, rabbit, chicken, goat, deer, elk)	Encourages stalking, hunting, feeding responses	Overeating, fur ingestion, may cause digestive upset.
Heart, Tongue, Liver Dog Treats Bones Hides	Provide variety in diet, can also be used at training treats. Items can be frozen to increase feeding time	Bones may cause dental damage or impaction problems in some animals

Enrichment	Description	Potential Hazards
Fish Eggs Cat food Goat's milk Baby Food (meat flavors) Rawhide Pigs Ears Produce Pasta Ice	Encourage feeding behaviors, items can be hidden to encourage searching	Pasta and produce are not digestible and may cause digestive upset. Rawhide and pig's ears are choking and impaction risks

8.3 Staff and Animal Interactions

Animal training and environmental enrichment protocols and techniques should be based on interactions that promote safety for all involved.

See Chapter 2.2 for more information on staff and animal interactions.

8.4 Staff Skills and Training

Staff members should be trained in all areas of animal behavior management. A reference library appropriate to the size and complexity of the institution should be available to all staff and volunteers to provide them with accurate information on the behavioral needs of the animals with which they work. Staff should be provided training on the principles of animal enrichment and training. Depending on the institution, this training may be provided by internal staff, consultants, or by sending staff to appropriate training courses.

Before providing enrichment or training lions, staff should be familiar with the natural history and behavior of lions, the background of their individual lions, the husbandry routine for the area, the institutions training and enrichment program, and the principles of animal enrichment and training. New staff should be carefully supervised to ensure they understand and animals' behavior and the procedures.

See Chapter 2.2 for more information on staff skills and training.

Chapter 10. Research

M. Durham

10.1 Known Methodologies

AZA believes that contemporary management, husbandry, veterinary care and conservation practices should be based in science, and that a commitment to scientific research, both basic and applied, is a trademark of the modern zoological park and aquarium. AZA-accredited institutions have the invaluable opportunity, and are expected, to conduct or facilitate research both in *in situ* and *ex situ* settings to advance scientific knowledge of the animals in our care and enhance the conservation of wild populations. This knowledge might be achieved by participating in AZA Taxon Advisory Group (TAG) or Species Survival Plan® (SSP) Program sponsored research, conducting original research projects, affiliating with local universities, and/or employing staff with scientific credentials (AZA Accreditation Standard 5.3).

AZA Accreditation Standard

(5.3) Institutions should maximize the generation of scientific knowledge gained from the animal collection. This might be achieved by participating in AZA TAG/SSP sponsored research when applicable, conducting original research projects, affiliating with local universities, and/or employing staff with scientific credentials.

Lion Research

Both zoo and wild lion populations may benefit from *ex situ* research. Zoo animals are often used as models to test field equipment and procedures in a more controlled environment. Other research benefits the managed population by improving husbandry and veterinary care, thereby improving welfare. As mentioned several times in this manual, all aspects of lion management should be based on the natural history of wild lions. This requires that lion keepers and managers familiarize themselves with current literature, spend time observing lions and possibly even conduct research of their own to answer questions and solve problems.

The AZA Lion SSP falls under the AZA Felid Taxon Advisory Group (TAG), which has a long history of both *in situ* and *ex situ* research. Many of the issues that affect the AZA Lion SSP also affect other large felid programs such as the Tiger, Jaguar, Snow Leopard, Amur Leopard and Cheetah SSPs. The AZA Lion SSP also works closely with the AZA Contraception Advisory Group and the AZA Population Management Center.

The AZA Felid TAG seeks to collaborate with researchers both in the field and in zoological settings. The IUCN Cat Specialist Group is often included in meetings and projects, as well as the TAG and SSP's EAZA counterparts in Europe. The Lion Research Center, run by Dr. Craig Packer at the University of Minnesota, has published an enormous amount of research on Serengeti lions and human conflict with lions in that region. Both the Cat Specialist Group and the Lion Research Center maintain excellent information on lions as well as an online database of published literature (see Bibliography for more information).

Research investigations, whether observational, behavioral, physiological, or genetically based, should have a clear scientific purpose with the reasonable expectation that they will increase our understanding of the species being investigated and may provide results which benefit the health or welfare of animals in wild populations. Many AZA-accredited institutions incorporate superior positive reinforcement training programs into their routine schedules to facilitate sensory, cognitive, and physiological research investigations and these types of programs are strongly encouraged by the AZA.

Research on lions has included a variety of topics and paradigms. Much of that work is referenced throughout this manual but includes contraception, reproduction, nutrition and feeding, disease issues and veterinary care, and genetics. Some of this work was conducted by individuals or single laboratories but the vast majority is the result of AZA institutions sending information and samples to various advisors and other researchers. This has included behavior data, tissue samples and necropsy results. This cooperation remains the most significant way that institutions holding lions can play a role in research.

AZA-accredited institutions are required to have a clearly written research policy that identifies the types of research being conducted, methods used, staff involved, evaluations of the projects, the animals included, and guidelines for the reporting or publication of any findings (AZA Accreditation Standard 5.2). Institutions must designate a qualified individual to oversee and direct its research program (AZA Accreditation Standard 5.1). If

AZA Accreditation Standard

(5.2) Institutions must have a written policy that outlines the type of research that it conducts, methods, staff involvement, evaluations, animals to be involved, and guidelines for publication of findings.

institutions are not able to conduct in-house research investigations, they are strongly encouraged to provide financial, personnel, logistical, and other support for priority research and conservation initiatives identified by Taxon Advisory Groups (TAGs) or Species Survival Plans® (SSP) Programs.

AZA Accreditation Standard

(5.1) Research activities must be under the direction of a person qualified to make informed decisions regarding research.

Lion Conservation

The AZA Lion SSP strongly encourages institutions to support lion conservation. This can be accomplished a variety of ways, from providing financial support to TAG and SSP-endorsed projects to developing and staffing entire projects. This will depend on the resources and interests of each institution. The most pressing topics for lion conservation at this time are disease issues and human conflict. Existing projects are located throughout the lion's range, particularly in east and southern Africa, with more projects developing in west Africa, where numbers are critically low.

Institutions seeking more information on projects and how to get involved should contact the AZA Lion SSP Coordinator.

10.2 Future Research Needs

This Animal Care Manual is a dynamic document that will need to be updated as new information is acquired. Knowledge gaps have been identified throughout the manual and are included in this section to promote future research investigations. Knowledge gained from areas will maximize AZA-accredited institutions' capacity for excellence in animal care and welfare as well as enhance conservation initiatives for the species.

Chapter 4: Social Environment

4.1 Group Size and Structure: Further investigation of long-term management of multi-male groups.

4.3 Introductions and Reintroductions: Collect more data on introduction process and results.

Chapter 7. Reproduction

7.1 Reproductive Physiology and Behavior: Development of real-time methods for monitoring reproductive cycles.

7.1 Reproductive Physiology and Behavior: Development of a reliable pregnancy test requiring a minimum number of urine or fecal samples.

7.2 Assisted Reproductive Technology: Improving sperm cryopreservation technologies.

7.2 Assisted Reproductive Technology: Development of artificial insemination technologies for improved genetic management.

7.6 Contraception: Assess the short- and long-term impact of contraception on female reproduction.

7.6 Contraception: Assess the effects on females that go several years between pregnancies so that this can be factored into population planning.

Conservation

Identify key partners to advise the AZA Lion SSP Program.

Identify key projects for AZA Lion SSP Program endorsement.

Develop criteria and process for AZA Lion SSP Program endorsement of projects.

Develop a resource for institutions seeking projects to support.

Chapter 11. Additional Resources

Lion cubs in Sabi Sands, South Africa
H. Colahan

11.1 Lion Bibliography by Subject

Husbandry, Welfare and Management

AZA. (2011). White Tigers, Lions & King Cheetahs: Welfare & Conservation Implications Of Intentional Breeding For The Expression Of Rare Recessive Alleles. Association of Zoos & Aquariums.

Bassett, L., & Buchanan-Smith H. (2007). Effects of Predictability on the Welfare of Captive Animals. *Applied Animal Behavior Science, 102*, 223–245.

Clubb, R., & Mason, G. (2003). Captivity Effects on Wide-ranging Carnivores. *Nature, 425*, 473.

Coe, J., & Klein, H. (1986). The African Savanna Exhibit at Woodland Park Zoo. *International Zoo Yearbook, 24/25*, 332–339.

Fouraker, M., Wagener, T., & Wiese, R. (1998). Lion Species Survival Plan Mid-Year Meeting Summary & Master Plan. Fort Worth Zoological Park.

Kleiman, D., Allen, M., Thompson, K., & Lumpkin, S. (Eds.). (1996). Wild Mammals in Captivity: Principles & Techniques. Chicago: University of Chicago Press.

Pfaff, S. (2010). African Lion Studbook. Columbia: Riverbanks Zoo.

Powell, D. (1995). Preliminary Evaluation of Environmental Enrichment Techniques for African Lions (*Panthera leo*). *Animal Welfare, 4*, 361–370.

Sambrook, T., & Buchanan-Smith, H. (1997). Control & Complexity in Novel Object Enrichment. *Animal Welfare, 6*, 207–216.

Shoemaker, A., & Pfaff, S. (1997). Developing a Management Plan for the African Lion (*Panthera leo* sp) in North America. *International Zoo Yearbook, 35*, 120–125

Wachenfeld, C. (2008). Do You Smell That? An Analysis of Scent Preference in Carnivores. *The Shape of Enrichment, 17*(3), 125.

Wielebnowski, N. (2003). Stress & Distress: Evaluating Their Impact for the Well-being of Zoo Animals. *Journal of the American Veterinary Medical Association, 233*(7), 973–977.

Veterinary Care

Aguilar, R., Mikota, S., Smith, L., Munson, L., Freman, L.,& Kolata, R. (1997). Endoscopic Ovariohysterectomy in Two Lions (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 28*(3), 290–297.

Appel, M., Yates, R., Foley, G., Bernstein, J., Santinelli, S., Spelman, L., Miller, L., Harp, L., Anderson, M., Barr, N., Pearce-Kelling, S., & Summers, B. (1984). Canine Distemper Epizootic in Lions, Tigers, Leopards, in North America. *Journal of Veterinary Diagnostic Investigation, 6*(3), 277–288.

Baker, R., Henderson, R., & Silberman, M. (1983). Pyometra in an African Lioness. *Journal of The American Veterinary Medical Association, 183*(11), 1314.

Barr, M., Calle, P., Roelke, M. E., & Scott, F. (1989). Feline Immunodeficiency Virus Infection in Nondomestic Felids. *Journal of Zoo & Wildlife Medicine, 20*(3), 265–272.

Brown, E., Yuhki, N., Packer, C., & O'Brien S. (1993). Prevalence of Exposure to Feline Immunodeficiency Virus in Exotic Felid Species. *Journal of Zoo & Wildlife Medicine, 24*(3), 357–364.

Bull, M., Kennedy-Stopskopf, S., Levinne, J., Loomis, M., Gebhard, D., & Tompkins, W. (2003). Evaluation of T Lymphocytes in Captive African Lions (*Panthera leo*) Infected with Feline Immunodeficiency Virus. *American Journal of Veterinary Research, 64*(10), 1293–1300.

Chesney, R., & Hedberg, G. (2008). Rickets in Lion Cubs at the London Zoo in 1989: Some New Insights. *Pediatric, 123*(5), 948–950.

Clyde, V., Ramsey, E., & Bemis, D. (1997). Fecal Shedding of Salmonella in Exotic Felids, *Journal of Zoo and Wildlife Medicine*, 148–152.

Daoust, P., Haigh, J., & Pharr, J. (1978). Pleuro-pericarditis & Pneumonia Due to *Listeria monocytogenes* in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 9*(2), 38.

De La Fe, C., Rodriguez, J., Ramirez, G., Hervas, J., Gil, J., & Poveda, J. (2006). Sudden Death Associated with *Clostridium sordellii* in Captive Lions (*Panthera leo*). *Veterinary Pathology, 433*, 370–374.

Deem, D., Spelman, L., Yates, R., & Montali, R. (2000). Canine Distemper in Terrestrial Carnivores: A Review. *Journal of Zoo & Wildlife Medicine, 31*(4), 441–451.

DiGesualdo, C., Hoover, J., & Lorenz, M. (2005). Presumed Primary Thiamine Deficiency in a Young African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 36*(3), 512–514.

Dorso, L., Risi, E., Triau, S., Labrut, S., Nguyen, F., Guigand, L., Wyers, M., & Abadie, J. (2008). High-grade Mucoepidemidermoid Carcinoma of the Mandibular Salivary Gland in a Lion (*Panthera leo*). *Veterinary Pathology, 45*(1), 104–108.

Duarte, M., Barros, S., Henriques, M., Fernandes, T., Bernardino, R., Monteiro, M., & Fevereiro, M. (2009). Fatal Infection with Feline Panleukopenia Virus in Two Captive Wild Carnivores (*Panthera tigris* & *Panthera leo*). *Journal of Zoo & Wildlife Medicine, 40*(2), 354–359.

Galloway, D., Coke, R., Rochat, M., Radinski, M., Hoover, J., Carpenter, J., Hubbard, J., & Ketz-Riley, C. (2001). Spinal Compression Due to Atlantal Vertebral Malformation in Two African Lions (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 40*(2), 354–359.

Harrenstein, L., Munson, L., & Seal, U. (1996). Mammary Cancer in Captive Wild Felids & Risk Factors for its Development: A Retrospective Study of the Clinical Behavior of 31 Cases. *Journal of Zoo & Wildlife Medicine, 27*(4), 468–476.

Harrison, T., Sikarskie, J., Kitchell, B., Rosenstein, D., Flaherty, H., Fitzgerald, S., & Kiupel, M. (2007). Treatment of Malignant Lymphoma in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 38*(2), 333–336.

Harrison, T., Sikarskie, J., Kruger, J., Wise, A., Mullaney, M., Kiuoel, M., & Maise, R. (2007). Systemic Calicivirus Epidemic in Captive Exotic Felids. *Journal of Zoo & Wildlife Medicine, 38*(2), 292–299.

Hartley, M., Keberger, R., Haagenson, M. & Sweers, L. (2005). Diagnosis of Suspected Hypovitaminosis A Using Magnetic Resonance Imaging in African Lions (*Panthera leo*). *Journal of the South African Veterinary Association, 76*(3), 132–137.

Herbst, L., Packer, C., & Seal, U. (1985). Immobilization of Free-ranging African lions (*Panthera leo*) with a Combincation of Xylazine Hydochloride & Ketamine Hydrochloride. *Journal of Wildlife Disease, 21*(4), 401–404.

Hettlich, B., Hobson, P., Ducote, J., Fossum, T., & Johnson, J. (2010). Esophageal Hiatal Hernia in Three Exotic Felines – *Lynx lynx, Puma concolor, Panthera leo*. *Journal of Zoo & Wildlife Medicine, 41*(1), 90–94.

Hoover, J., & DiGesualdo, C. (2005). Blood Thiamine Values in Captive Adult African Lions (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 36*(3), 417–421.

Jacquier, M., Aarhaug, P., Amermo, J., Bauer, H., & Enriquez, B. (2006). Reversible Immobilization of Free-ranging African Lions (*Panthera leo*) with Metetomidine-tiletamine-zolazepam & Atipamezole. *Journal of Wildlife Disease, 42*(2), 432–436.

Kennedy-Stopskopf, S. (1999). Emerging Viral Infections in Large Cats. M. Fowler (Ed.). *Zoo & Wild Animal Medicine* (4th ed.). Philadelphia: W.B. Saunders Co.

King, J., Bertram, B., & Hamilton, P. (1977). Tiletamine & Zolazepam for Immobilization of Wild Lions & Leopards. *Journal of American Veterinary Medical Association*,138–147.

Kock, N., Kock, M., Arif, A., & Wahid, M. (1984) Case Report: Skin Sloughing & Foot Pad Loss in a Lion (*Panthera leo*).

Kolata, R. (2002). Laparoscopic Ovariohysterectomy & Hysterectomy on African Lions (*Panthera leo*) Using the Ultracision Harmonic Scalpel. *Journal of Zoo & Wildlife Medicine, 33*(3), 280–282.

Kolmsetter, C., Munson, L., & Ramsay, E. (2000). Degenerative Spinal Disease in Large Felids. *Journal of Zoo & Wildlife Medicine, 31*(1), 15–19.

Larsson, M., Coelho, F., Oliveira, V., Yamaki, F., Pereira, G., Soares, E., Fedullo, J., & Pereira, R. (2008). Electrocardiographic Parameters of Captive Lions (*Panthera leo*) & Tigers (*Panthera tigris*) Immobilized with Ketamine Plus Xylazine. *Journal of Zoo & Wildlife Medicine, 39*(3),314–319.

Lopez-Rebollar, L., Pezhorn, B., Waal, D., & Lewis, B. (1999). A Possible New Piroplasm in Lions From the Republic of South Africa. *Journal of Wildlife Disease, 35*(1), 82–85.

Maratea, K., Hooser, S., & Ramos-Vera, J. (2006). Degenerative Myeolopathy & Vitamin A in a Young Black-maned Lion (*Panthera leo*). *Journal of Veterinary Diagnostic Investigation, 18*(6), 608–611.

McAloose, D., Munson, L., & Naydan, D. (2007). Histologic Features of Mammary Carcinomas in Zoo Felids Treated with Melengestrol Acetate (MGA) Contraceptives. *Veterinary Pathology, 44*, 320–326.

McCain, S., Ramsay, R., Allender, M., Souza, C., & Schumacher J. (2009). Pyometra in Captive Large Felids: A Review of Eleven Cases. *Journal of Zoo & Wildlife Medicine, 40*(1), 147–151.

McCain, S., Souza, M., Ramsay, E., Schumacher, J., Hecht, S., & Thomas, W. (2008). Diagnosis & Surgical Treatment of a Chiari I-like Malformation in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 39*(3), 421–427.

Morris, P., Thoen, C., & Legendre, A. (1996). Pulmonary Tuberculosis in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 27*(3), 392–396.

Munson, L., Gardner, A., Mason, R., Chassy, L. &, Seal U. (2002). Endometrial Hyperplasia & Mineralization in Zoo Felids Treated with Melengesterol-Acetate Contraceptive. *Veterinary Pathology, 39*, 419–427.

Munson, L., Terio, K., Kock, M., Mlengeya, T., Roelke, M.E., Dubovi, E., Summers, B., Sinclair, A., & Packer, C. (2008). Climate Extremes Promote Fatal Co-Infections During Canine Distemper Epidemics in African Lions. *Publice Library of Science, 3*(6), 2545.

Osofsky, S., Hirsch, K., Zuckerman, E., & Hardy, W. (1996). Feline Lentivirus & Feline Oncovirus Status of Free-ranging Lions (*Panthera leo*), Leopards (*Panthera pardus*) & Cheetahs (*Acinonyx jubatus*) in Botswana: A Regional Perspective. *Journal of Zoo & Wildlife Medicine, 27*(4), 453–467.

Owston, M., Ramsay, E., & Rotstein, D. (2008). Neoplasia in Felids at the Knoxville Zoological Gardens 1979-2003. *Journal of Zoo & Wildlife Medicine, 39*(4), 608–613.

Penzhorn, B., Kjemtrup, A., Lopez-Rebollar, L., & Conrad, P. (2001). *Babesia leo* N Sp. From Lions in the Kruger National Park, South Africa & its Relation to Other Small Piroplasms. J*ournal of Parasitology, 87*(3), 681–685.

Poli, A., Abramo, F., Cavicchio, P., Bandecchi, P., Ghelardi, E., & Pistello, M. (1995). Lentivirus Infection in an African Lion: A Clinical, Pathologic, & Virologic Study. *Journal of Wildlife Disease,*70–74.

Ramsay, E. (2008). Use of Analgesics in Exotic Felids. *Zoo & Wildlife Medicine*. In M. E. Fowler, & R. E. Miller (Eds.). *Zoo and wild animal medicine: current therapy*, *6*, 289–293.

Raymond, J., Butler, T., & Jonovitz, E. (1998). Unilateral Cerebral Necrosis Resembling Fline Ischemic Encephalopathy in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine,* 328–330.

Ricci, E., Cavicchio, P., & Cantile C. (2010). Fibrocartilaginous Embolic Myelopathy in a Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 41*(2), 334–337.

Rodini, D., Gutierrez Felippe, E., & Oliveira, C. (2007). Measurement of Thyroid Hormones (thyroxine, T4; Triiodothyroninr, T3) in Captive Nondomestic Felids. *Journal of Zoo & Wildlife Medicine, 38*(1), 125–126.

Roelke, M. E., Brown, M., Troyer, J., Winterbach, H., Winterbach, C., Smith, D., Johnson, R., Pecon-Slattery, J., Roca, A., Alexander, K., Klein, L., Martinelli, P., Krishnsamu, K., & O'Brien, S.J. (2010). Pathological Manifestations of Feline Immunodeficiency Virus (FIV) in Wild African Lions. *Virology, 390*(1), 1–12.

Roelke, M. E., Munson, L., Packer, C., Kock, R., Cleaveland, S., Carpenter, M., O'Brien, S.J., Pospischil, A., HofmannLehmann, R., Lutz, H., Mwamengele, G. L. M., Mgasa, M. N., Machange, G. A., Summers, B. A.,& Appel, M. J. G. (1996). A canine distemper virus epidemic in Serengeti lions (*Panthera leo*). *Nature, 379*(6564), 441–445.

Scaglione, F., Schroder, C., Degiorgi, G., Zeira, O.,& Bollo, E. (2010). Cranial Malformations in Related White Lions (*Panthera leo krugeri). Veterinary Pathology, 47*(6), 1095–1099.

Shamir, M., Horowitz, I., Yahobson, B.,& Ofri, R. (1998). Arnold-Chiari Malformation in a Captive African Lion Cub. *Journal of Wildlife Disease, 34*(3), 661–666.

Shamir, M., Shilo, Y., Fridman, A., Chai, O., Reifen, R., & Miara, L. (2008). Sub-occipital Craniectomy in a Lion (*Panthera leo*) & Hypovitaminosis A. *Journal of Zoo & Wildlife Medicine 39*(3), 455–459.

Storms, T., Clyde, V., Munson, L., & Ramsay, E. (2003). Blastomycosis in Nondomestic Felids. *Journal of Zoo & Wildlife Medicine, 34*(3), 231–238.

Stringfield, C. (1999). Nutraceutical Chondroprotectives & Their Use in Steoarthritis. *Zoo Animals*, 63–68.

Suedemeyer, W. (2002). Conditioning Programs of Transabdominal Ultrasound Gestational Monitoring in an Eastern Black Rhinoceros (*Dicornis bicornis micheaeli*), African Elephant (*Loxodonta*), African Lion (*Panthera leo*) & Bornean Orangutan (*Pongo pygmaeus pygmaeus*), 50.

Sundberg, J., Van Ranst, M., Montali, R., Bush, M., Phillips, L., O'Brien, S.J., Jensen, A., & Burk, R. (1996). Papilloma-associated Focal Oral Hyperplasia in Wild & Captive Asian Lions (*Panthera leo persica*). *Journal of Zoo & Wildlife Medicine, 27*(1), 61–70.

Tucker, A., Ramsay, E., & Donnell, R. (2008). Ologodendroglioma in an African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 39*(4), 650–654.

Wack, R. (2003). Felidae. M. E. Fowler (Ed.). *Zoo & Wild Animal Medicine*, 491–501.Philadelphia: W.B. Saunders Co.

Wenger, S., Buss, P., Joubert, K., Steeamp, J., Shikwambana, P., & Hatt, J. (2010). Evaluation of Butorphanol, Medetomidine, & Midazolam as a reversible Narcotic Mobniation in Free-ranging African Lions (*Panthera leo*). *Veterinary Anaesthesia & Analgesia, 37*,491–500.

Nutrition & Feeding

Allen, M. E.,Oftedal, O. T., Earle, K. E., Seidensticker, J., & Vilarin, L. (1995). Do maintenance energy requirements of felids reflect their feeding strategies? NAG Proceedings.

Allen, M. E., Ullrey, D. E., & Edwards, M. S. (1999). The development of raw meat-based carnivore diets. In: *Proceedings of the American Associaton of Zoo Veterinarians*, 317–319.

Altman, J. D., Gross, K. L., & Lowry, S. R. (2005). Nutritional & behavioral effects of gorge & fast feeding in captive lions. *Journal of Applied Animal Welfare Science, 8*, 47–57.

Barbiers, R. B., Vosburge,L. M. P., Ku, K., & Ullrey, D. E. (1982). Digestive efficiencies & maintenance energy requirements of captive wild felidae: cougar (*Felis concolor*); leopard (*Panthera pardus*); lion (*Panthera leo*); & tiger (*Panthera tigris*). *Journal of Zoo and Wildlife Medicine, 13*, 32–37.

Briggs, M. B., & Scheels, J. (2005). Selection of proper feeds to assist in the dental management of carnivores. In: 6th Conference of the AZA Nutrition Advisory Group on Zoo & Wildlife Nutrition, Omaha, NE, 106–107.

Clarke, B. C., & Berry, H. H. (1992). Water flux in free-living lions (*Panthera leo*) in the Etosha National Park, Namibia. *Journal of Mammology, 73*, 552–558.

Clauss, M., Kleffner, H., & Kienzle E. (2010). Carnivorous mammals: nutrient digestibility & energy evaluation. *Zoo Biology, 29*, 687–704.

Crissey, S., Slifka, K., Shumway, P., & Spencer, S. (2001). Handling Frozen/Thawed Meat & Prey Items Fed to Captive Exotic Animals. In U.S. Department of Agriculture (Ed.). *National Agricultural Library*, 23.

De Waal, H. O., Osthoff, G., Hugo, A. Myburgh, J., & Botes, P. (2004). The composition of African lion (*Panthera leo*) milk collected a few days postpartum. *Mammalian Biology, 69*, 375–383.

DiGesualdo, C., Hoover, J., & Lorenz, M. (2005). Presumed Primary Thiamine Deficiency in a Young African Lion (*Panthera leo*). *Journal of Zoo & Wildlife Medicine, 36*, 512–514.

Eloff, F. C. (1984). Food ecology of the Kalahari lion *Panthera leo vernayi*. Koedoe Supplement, 249–258.

Fellicetti, L., Kearney, C., Woodward, L., & Dierenfeld, E. (2008). Proportion of Soft Tissue in Selected Bone Cuts Fed Primarily as Enrichments to Large Carnivores*. Zoo Biology, 27*, 154–158.

Green, B., Anderson, J., & Whateley, T. (1984). Water & sodium turnover & estimated food consumption in free-living lions (*Panthera leo*) & spotted hyenas (*Crocuta crocuta*). *Journal of Mammalogy, 65*, 593–599.

Hartley, M., Keberger, R., Haagenson,M. & Sweers, L. (2005). Diagnosis of Suspected Hypovitaminosis A Using Magnetic Resonance Imaging in African Lions (*Panthera leo*). *Journal of the South African Veterinary Association, 76*, 132–137.

Hayward, M. W., & Kerley, G. I. H. (2005). Prey preferences of the lion (*Panthera leo*). *Journal of Zoology, 267*, 309–322.

Hedberg, G., & Gage, L. J. (2008). Exotic felids. *Hand-Rearing Wild and Domestic Mammals*, 207–220.

Hoover, J., & DiGesualdo, C. (2005). Blood Thiamine Values in Captive Adult African Lions (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 36*, 417–421.

Maratea, K., Hooser, S., & Ramos-Vera, J. (2006). Degenerative Myeolopathy & Vitamin A in a Young Black-maned Lion (*Panthera leo*). *Journal of Veterinary Diagnostic Investigation, 18*, 608–611.

McCain, S., Souza, M., Ramsay, E., Schumacher, J., Hecht, S., & Thomas, W. (2008). Diagnosis and Surgical Treatment of a Chiari I-like Malformation in an African Lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 39*(3), 421–427.

McNab, B. K. (2000). The standard energetics of mammalian carnivores: Felidae & Hyaenidae*. Canadian Journal of Zoology, 78*, 2227–2239.

Morris, J. G., Fujimoto, J., & Berry, S. C. (1974). The comparative digestibility of a zoo diet fed to 13 species of felid & badger. *International Zoo Yearbook, 14*, 169–171.

Munoz-Garcia, A., & Williams, J. B. (2005). Basal metabolic rate in carnivores is associated with diet after controlling for phylogeny*. Physiological and Biochemical Zoology, 78*, 103–91056.

Nagy, K. A., Girard, I. A., & Brown, T. K. (1999). Energetics of free-ranging mammals, reptiles, & birds. *Annual review of nutrition, 19*, 247–277.

NRC. (1986). Nutrient requirements of cats (Revised ed.). National Academy Press, Washington, D.C.

NRC. (2006). Nutrient requirements of dogs & cats. National Academy Press, Washington, D.C.

Oftedal, O. T., & Iverson, S. J. (1995). Comparative analysis of nonhuman milks. *Handbook of Milk Composition*, 749–788.

Rapson, J. A., & Bernard, R. T. F. (2007). Interpreting the diet of lions (*Panthera leo*); a comparison of various methods of analysis. *South African Journal of Wildlife Research, 37*, 179–187.

Shamir, M., Shilo, Y., Fridman, A., Chai, O., Reifen, R., & Miara, L. (2008). Sub-occipital Craniectomy in a Lion (*Panthera leo*) and Hypovitaminosis A. *Journal of Zoo and Wildlife Medicine, 39*(3), 455–459.

Smith, Y., De Waal, H. O., & Kok, O. B. (2006). Aspects of carcass digestibility by African Lions (*Panthera leo Linnaeus*, 1758) under captive conditions. *Pakistan Journal of Biological Sciences, 9*, 2149–2152.

Smuts, G. L. (1979). Diet of lions & spotted hyaenas assessed from stomach contents. *South African Journal of Wildlife Research, 9*, 19–25.

Smuts, G. L., Robinson, G. A., & Whyte, I. J. (1980). Comparative growth of wild male & female lions (*Panthera leo*). *Journal of Zoology, 190*, 365–373.

Ullrey, D. E., & Bernard, J. B. (1989). Meat diets for performing exotic cats. *Journal of Zoo and Wildlife Medicine, 20*, 20–25.

USDA. (1998). Animal Care Resource Guide: Nutrition for large felids No. Policy #25 Proper Diets for Large Felids.

Van Valkenburgh, B. (1996). Feeding behavior in free-ranging, large African carnivores. *Journal of Mammology, 77*, 240–254.

Visser, H. (2009). Factors influencing lion (*Panthera leo*) home range, movement & diet in Waza National Park, Cameroon.

Watts, J. C. (2011). Potential of alternative protein sources for exotic carnivores: observations & discussion. In *9th Conference of the AZA Nutrition Advisory Group on Zoo & Wildlife Nutrition*, 9. Kansas City, MO.

Wynne, J. E. (1989). Comparative digestibility values in four species of felidae. *Journal of Zoo and Wildlife Medicine, 20*, 53–56.

Zoran, D. L. (2002). The carnivore connection to nutrition in cats. *Journal of the American Veterinary Medical Association, 221*, 1559–1567.

Reproduction & Contraception

Asa, C., Porton, I. (Eds.). (2005). Wildlife Contraception: Issues, Methods, & Application, 256. Johns Hopkins Press.

Bertschinger. H., Asa, C., Calle, J., Long, J., Bauman, K., DeMatteo, L., Jochle, W., Trigg, T., & Human, A. (2001). Control of Reproduction & Sex Related Behaviour in Exotic Wild Carnivores with the GnRH Analogue Deslorelin: Preliminary Observations. *Journal of Reproduction & Fertility Supplement, 57*, 257–283.

Bertschinger, H., Guimaraes, M. B. V., Trigg, T., & Human, A. (2008). The Use of Delsorelin Implants for the Long-term Contraception of Lionesses & Tigers. *Journal of Zoo and Wildlife Research, 35*, 525–530.

Briggs, M., Fithian, C., Starkey, P., Richards, R., Schramm, R. D., & Reeves, J. (1990). Endocrine Profiles in Estrus, Pregnant & Pseudopregnant African Lions (*Panthera leo*) Throughout the Year, 279–281.

Brown, J. (2006). Comparative Endocrinology of Domestic & Nondomestic Felids. *Theriogenology, 66*, 25–36.

Brown, J. L. (2011). Female Reproductive Cycles of Wild Female Felids. *Animal Reproduction Science*, *124*(3–4), 155–162

Brown, J. L., Bush, M., Packer, C., Pusey, A., Monfort, S., O'Brien, S. J., Janssen, D., & Wildt, D. E. (1991). Developmental Changes in Pituitary-gonadal Function in Free-ranging Lions (*Panthera Behavior*) of the Serengeti Plains & Ngorongoro Crater. *Journals of Reproduction & Fertility, 91*, 24–40.

Brown, J. L., Bush, M., Packer, C., Pusey, A., Monfort, S., O'Brien, S. J., Janssen, D., & Wildt D. E.

(1993). Hormonal Characteristics of Free-Ranging Female Lions (*Panthera leo*) of the Serengeti Plains & Ngorongoro Crater. *Journal of Reproduction & Fertility, 97*, 107–114.

Brown, J. L., Wasser, S., Wildt, D. E., & Graham, L. (1994). Comparative Aspects of Steroid Hormone Metabolism & Ovarian in Felids Measured Noninvasively in Feces. *Biological Reproduction, 51*, 776–786.

Brown, J. L., & Wildt, D. E. (1997). Assessing Reproductive Status in Wild Felids by Non-Invasive Faecal Steroid Monitoring. *International Zoo Yearbook, 35*,173–191.

Dorsser, F. H., Swanson, W., Lasano, S., & Steinetz, B. (2006). Development, Validation, & Application of a Urinary Relaxin Radioimmunoassy for the Diagnosis & Monitoring of Pregnancy in Felids. *Biological Reproduction, 74*(6), 1090–1095.

Eaton, R., & York, W. (1971). Reproductive Biology, & Preliminary Observations on Mating Preferences, in a Captive Lion*. Husbandry and Research*, 198–202.

Feldman, E., & Nelson, R. (2004). Feline Reproduction. R. Kersey & D. LeMelledo (Eds.). Canine & Feline Reproduction. St Louis: Saunders, 1016–1045.

Herbert, C., & Trigg, T. (2005). Applications of GnRH in the Control & Management of Fertility in Female Animals*. Animal Reproduction Science, 88*,141–153.

Howard, J. (1993). Semen Collection & Analysis in Carnivores. M. Fowler (Ed.). Zoo & Wild Animal Medicine III. Philadelphia: W.B. Saunders Company, 390–399.

Lehmann, M. B., Funston, P. J., Owen, C. R., & Slotow, R. (2008). Reproductive biology of a pride of lions on Karongwe Game Reserve. *South African Journal of Zoology, 43*(2), 230–236.

Munson, L. (2006). Contraception in Felids. *Theriogenology, 66,* 126–134.

Munson, L., Bauman, K., Asa, C., Jochle, W., & Trigg, T. (2001). Effacy of the GnRG Analogue Deslorelin for Suppression of Oestrus Cycle in Cats. *Journal of Reproduction & Fertility Supplemen, 57*, 269–273.

Munson, L., Brown, J. L., Bush, M., Packer, C., Janssen, D., Reiziss, S., & Wildt, D. E. (1996). Genetic Diversity Affects Testicular Morphology in Free-ranging Lions (*Panthera leo*) of the Serengeti Plains & Ngorongoro Cater. *Journal of Reproduction & Fertility, 108*, 11–15.

Packer, C. (2000). The Ecology of Menopause. J. Robine, T. Kirkwood, & M. Allard (Eds.). Sex & Logevity: Sexuality, Gender, Reproduction, Parenthood. Springer.

Packer, C. (2001). Infanticide is No Fallacy. *American Anthropologist, 102*(4), 829–831.

Packer, C., Herbst, L., Pusey, A., Bygott, J., Hanby, J., Cairns, S., & Borgerhoff-Mulder, M. (1988). Reproductive Success of Lions. T. Clutton-Brock (Ed.). Reproductive Success Studies of Individual Variation in Contrasting Breeding Systems. Chicago, London: University of Chicago Press.

Packer, C., & Pusey, A. E. (1983). Male Takeovers & Female Reproductive Parameters—A Simulation Of Estrous Synchrony In Lions (*Panthera-leo). Animal Behaviour* , 334-340.

Schmidt, A., Nadal, L., Schmidt, M., & Beamer, N. (1979). Serum Concentrations of Oestrodiol & Progesterone Dring the Normal Oestrus Cycle & Early Pregnancy in the Lion (*Panthera leo*). *Journal of Reproduction and Fertility, 5*7, 267–272.

Schramm, R. D., Briggs, M. B., & Reeves, J. (1994). Spontaneous & Induced Ovulation. *Zoo Biology, 13*(4), 301–307.

Seal, U., Barton, R., Mather, L., Gray, C., & Plotka, E. Long-term Control of Reproduction in Female Lions (*Panthera leo*) with Implanted Contraceptive (1975). *Proceedings of the American Association of Zoo Veterinarians Annual Meeting*, *1975*, 66–80.

Wright, P., Verstegen, J., Onclin, K., Jochle, W., Armour, A., Martin, G., & Trigg, T. (2001). Suppression

of the Oestrus Responses of the Butches to the GnRH Analogue Deslorelin by Progestin. *Journal of Reproduction and Fertility Supplement, 57*, 263–268.

Conservation

Barnett, R., Yamaguchi, N., Barnes, I., & Cooper, A. (2006). Lost Populations & Preserving Genetic Diversity. The Lion *Panthera Leo*: Implications For Its Ex Situ Conservation. *Conservation Genetics, 7*(4), 507–514.

Bauer, H., & Van Der Merwe, S. (2004). Inventory of free-ranging lions *Panthera leo* in Africa. *Oryx, 38*(1), 26–31.

Bertram, B. (1975). Weights & Measures of Lions. *East African Wildlife Journal, 13*, 141–143.

Burger, J., & Hemmer, H. (2006). Urgent call for further breeding of the relic zoo population of the critically endangered Barbary lion (*Panthera leo leo* Linnaeus 1758). *European Journal of Wildlife Research, 52*(1), 54–58.

Henschel, P., Azani, D., Burton, C., Malanda, G., Saidu, Y., Sam, M., & Hunter, L. T. B. (2010). Lion StatusUpdates from Five Range Countries in West & Central Africa. *Cat News,* 52.

Kissui, B. (2008). Livestock Predation by Lions, Leopards, Spotted Hyenas, & Their Vulnerability to Retalitory Killing in Maasai Steppe, Tanzania. *Animal Conservation*, 1–11.

Kissui, B., Mosser, A., & Packer, C. (2010). Persistence & Local Extinction of Lion Prides in the Ngorongoro Crater, Tanzania. *Population Ecology, 52*(1), 103–111.

Kushnir, H., Leitner, H., Ikanda, D., & Packer, C. (2010). Human & Ecological Risk Factors for Unprovoked Lion Attacks on Humans in Southeastern Tanzania. *Human Dimensions of Wildlife,15*(5), 315–331.

Loveridge, A., Searle, A., Murindagomo, F., & Macdonald, D. W. (2007). The Impact of Sport-Hunting on the Population Dynamics of an African Lion Population in a Protected Area. *Biological Conservation, 134*, 548–558.

Packer, C. Coping with a Lion Killer. *Natural History, 6*(96), 14–17.

Packer, C., Ikanda, D., Kissui, B., & Kushnir, H. (2005). Lion Attacks on Humans in Tanzania. *Nature, 436*(18), 926–927.

Packer, C., Ikanda, D., Kissui, B., & Kushnir, H. (2006). The Ecology of Man-eating Lions. *Nature & Faune, 21*(2), 10–15.

Packer, C., Kosmala, M., Cooley, H., Brink, H., Pintea, L., Garshelis, D., Purchase, G., Strauss, M., Swanson, A., Balme, G., Hunter, L. T. B., & Nowell, K. (2009). Sport Hunting, Predator Control, & Conservation of Large Carnivores, *Public Library of Science, 4*(6), 5941.

Packer, C., Pusey, A., Rowley, H., Gilbert, D., Martenson, J., & O'Brien, S. J. (1991). Case Study of Population Bottleneck of Lions of Ngorongoro Crater. *Conservation Biology, 5*(2), 219–230.

Ranta, E., & Kaitala, V. (2005). A Leap for Lion Populations. *Science, 307*, 365–366.

Saberwal, V., Gibbs, J., Chellam, R., & Johnsingh, A. (1994). Lion-Human Conflict in the Gir Forest, India. *Conservation Biology, 8*(2), 501–507.

Treves, A., Plumptre, A. J., Hunter, L. T. B., & Ziwa, J. (2009). Identifying a potential lion *Panthera leo* stronghold in Queen Elizabeth National Park, Uganda, & Parc National des Virunga, Democratic Republic of Congo. *Oryx, 43*(1), 60–66.

Trinkel, M., Ferguson, N., Reid, A., Reid, C., Somers, M., Turelli, L., Graf, J., Szykman, M., Cooper, D., Havermann, P., Kastberger, G., Packer, C., & Slotow, R. (2008). Translocating Lions into an Inbred Lion Population in the Hluhluwe-iMfolozi Park, South Africa. *Animal Conservation, 11*, 138–143.

Trinkel, M., Funston, P.J., Hofmeyr, M., Hofmeyr, D., Dell, S., Packer, C., & Slotow, R. (2010). Inbreeding

& Density-dependent Population Growth in a Small, Isolated Lion Population. *Animal Conservation, 13*, 374–382.

Wildt, D. E., Bush, M., Goodrowe, K. L., Packer, C., Pusey, A. E., Brown, J. L., Joslin, P., & O'brien, S. J. (1987). Reproductive & Genetic Consequences Of Founding Isolated Lion Populations. *Nature, 329*(6137), 328–331.

Taxonomy, Natural History, & Behavior

Bauer, H., De Iongh, H. H., & Di Silvestre, I. (2003). Lion (*Panthera leo*) social behavior in the West & Central African savannah belt. *Mammalian Biology, 68*(4), 239–243.

Bygott, J., Bertram, B., & Hanby, J. (1979). Male Lions in Large Coalitions Gain Reproductive Advantages. *Nature, 282*(20/27), 839–841.

Christiansen, P. (2008). Distinguishing skulls of lions (*Panthera leo*) & tigers (*Panthera tigris*). *Mammalian Biology, 73*(6), 451–456.

Christiansen, P. (2008). On the distinctiveness of the Cape lion (*Panthera leo melanochaita* Smith, 1842), & a possible new specimen from the Zoological Museum, Copenhagen. *Mammalian Biology, 73*(1), 58–65.

Coulson, T. (2007). Group Living & Hungry Lions. *Nature, 449*, 996–997.

Driscoll, C. A., Clutton-Brock, J., Kitchener, A. C., & O'Brien, S. J. (2009). The Taming of the Cat. *Scientific American, 300*(6), 68–75

Dubach, J., Patterson, B. D., Briggs, M.B., Venzke, K., Flamand, J., Stander, P., Scheepers, L., & Kays, R. (2005). Molecular Genetic Variation Across the Southern & Eastern Geographic Ranges of the African Lion, *Panthera leo*. *Conservation Genetics, 6*, 15–24.

Estes, R. (1991). The Behavior Guide to African Mammals. Berkley: University of California Press.

Fryxell, J., Mosser, A., Sinclair, A., & Packer, C. (2007). Group Formation Stabilized Predator-Prey Dynamics. *Nature, 449*, 1041–1044.

Gilbert, D., Packer, C., Pusey, A., Stephens, J., & O'Brien, S. J. (1991). Analytical DNA Fingerprinting in Lions. *Journal of Heredity, 82*, 378–386.

Gnoske, T. P., Celesia, G. G., & Peterhans, J. C. K. (2006). Dissociation between mane development & sexual maturity in lions (*Panthera leo*): solution to the Tsavo riddle? *Journal of Zoology, 270*(4), 551–560.

Grinnell, J. (2002). Modes of Cooperation During Territorial Defence by African Lions*. Human Nature, 13*(1), 85–104.

Grinnell, J., & McComb, K. (1996). Maternal Grouping as a Defense Against Infanticide Males: Evidence from Field Playback Experiments in African Lions. *Behavioral Ecology, 7*(1).

Grinnell, J, Packer, C., & Pusey, A. (1995). Cooperation in Male Lions: Kinship, Reciprocity or Game Theory? *Animal Behaviour, 49*, 95–105.

Haas, S., Hayssen, V., & Krausman, P. (2005*).* Panthera leo. *Mammalian Species, 762*, 1–11.

Hanby, J., Bygott, J., & Packer, C. (1995). Ecology, Demography, & Behavior of Lions in Contrasting Habitiats: Ngorongoro Crater & the Serengeti Plains. A. Sinclair, & P. Arcese (Eds.). Serengeti II: Dynamics, Managagement & Conservation of an Ecosystem. Chicago: University of Chicago Press.

Hayward, M. W., & Kerley, G. I. H. (2005). Prey preferences of the lion (*Panthera leo*). *Journal of Zoology, 267*, 309–322.

Heinsohn, R., & Packer, C. (1995). Complex Cooperative Strategies in Group-Territorial African Lions. *Science, 269*, 1260–1262.

Heinsohn, R., Packer, C., & Pusey, A. (1996). Development of Cooperative Territoriality in Juvenile Lions.

Proceedings of the Royal Society of London, 263, 475–479.

Hopcraft, G., Sinclair, A., & Packer, C. (2005). Planning for Success: Serengeti Lions Seek Prey Accessibility Rather Than Abundance. *Journal of Ecology, 74*, 559–566.

Kiffner, C., Meyer, B., Muhlenberg, M., & Waltert, M. (2009). Plenty of prey, few predators: what limits lions *Panthera leo* in Katavi National Park, western Tanzania? *Oryx, 43*(1), 52–59.

Legge, S. (1996). Cooperative Lions Escape the Prisoner's Dilemma. *Tree, 11*(1), 2–3.

McComb, K., Packer, C., & Pusey, A. (1994). Roaring & Numerical Assessment. In: Contests Between Groups Of Female Lions, *Panthera leo*. *Animal Behaviour, 47*(2), 379–387.

McComb, K., Pusey, A., & Packer, C. (1993). Female Lions Can Identify Potentially Infanticidal Males from Their Roars. *Proceedings of the Royal Society of London, 252*, 59–64.

Montellano-Ballesteros, M., & Carbot-Chanona, G. (2009). *Panthera leo atrox* (Mammalia: Carnivora: Felidae) in Chiapas, Mexico*. Southw Naturalist, 54*(2), 217–222.

Mosser, A., & Packer, C. (2009). Group Territoriality & the benefits of Sociality in the African Lion, *Panthera leo*. *Animal Behaviour, 78*, 359–370.

Natoli, E. (1990). Mating Strategies In Cats—A Comparison Of The Role & Importance Of Infanticide In Domestic Cats, *Felis-catus* & Lions, *Panthera-leo*. *Animal Behaviour, 40*, 183–186.

Nowak, R., & Paradiso, J. (1999). Walker's Mammals of the World (6th ed.). Johns Hopkins University Press.

O'Brien, S. J., Joslin, P., III, G. S., Wolfe, R., Schaffer, N., Heath, E., Ott-Joslin, J., Rawal, P., Bhattacharjee K., & Martenson, J. (1987). Evidence for African Origins of Founders of the Asiatic Lion Species Survival Plan. *Zoo Biology, 6*, 99–116.

O'Brien, S. J., Martenson, J., Packer, C., Herbst, L., De Vos, V., Joslin, P., Ott-Joslin, J., Wildt, D. E., & Bush, M. (1987). Biochemical Genetic Variation in Geographic Isolates of African & Asiatic Lions. *National Geographic Research, 3*(1), 114–124.

Packer C. (1986). The Ecology of Sociality in Felids. D. Rubenstein & R. Wrangham (Eds.). Ecological Aspects of Social Evolution Birds & Mammals. Princeton: Princeton University Press.

Packer, C. (1992) Captives in the Wild. National Geographic.

Packer, C., & Clottes, J. (2000). When Lions Ruled France. *Natural History, 11*, 52–57.

Packer, C., Hillborn, R., Mosser, A., Kissui, B., Borner, M., Hopcraft, G., Wilmshurst, J., Mduma, S., & Sinclair, A. (2005). Ecological Change, Group Territoriality, & Population Dynamics in Serengeti Lions. *Science, 307*, 390–393.

Packer, C., & Pusey, A. (1982). Cooperation & Competition Within Coalitions of Male Lions: Kin Selection of Game Theory. *Nature, 296*(5859), 740–742.

Packer , C., Lewis, S., & Pusey, A. (1992). A Comparative Analysis of Non-offspring Nursing. *Animal Behaviour, 43*, 263–281.

Packer, C., & Pusey, A. (1983). Adaptations of female lions to infanticide by incoming males. *The American Naturalist, 121*(5), 716–728.

Packer, C., & Pusey, A. (1984). Infanticide in Carnivores. G. Hausfater & S. Blaffer-Hrdy (Eds.). Infanticide Comparative & Evolutionary Perspectives. New York: Aldine.

Packer, C., & Pusey, A. (1987). Intrasexual Cooperation & the Sex Ratio in African Lions. *The American Naturalist, 13*(4), 636–642.

Packer, C., & Pusey, A. (1993). Dispersal, Kinship, & Inbreeding in African Lions. N. Thornhill (Ed.). The Natural History of Inbreeding & Outbreeding. Chicago: University of Chicago Press.

Packer, C., & Pusey, A. (1997). Divided We Fall: Cooperation Among Lions. *Scientific American,* 32–39.

Packer, C., Pusey, A., & Eberly, L. (2001). Egalitarianism in Female African Lions. *Science, 293*, 690–693.

Packer, C., & Pusey, A. (1995). The Lack Clutch In A Communal Breeder—Lion Litter Size Is A Mixed Evolutionarily Stable Strategy. *American Naturalist, 145*(5), 833–841.

Packer, C., & Ruttan, L. (1988). The Evolution of Cooperative Hunting. *The American Naturalist, 132*(2), 159–198.

Packer, C., Swanson, A., Ikanda, D., & Kushnir, H. (2011). Fear of Darkness, the Full Moon & the Nocturnal Ecology of African Lions. *Public Library of Science, 6*(7), 22285.

Patterson, B. D. (2007). On the nature & significance of variability in lions (*Panthera leo*). *Evolutionary Biology, 34*(1-2), 55–60.

Patterson, B. D., Kays, R. W., Kasiki, S. M., & Sebestyen, V. M. (2006). Developmental effects of climate on the lion's mane (*Panthera leo*). *Journal of Mammalogy, 87*(2), 193–200.

Patterson, J. (1925). The Man-eating Lions of Tsavo. Chicago: Field Museum of Natural History.

Pfefferle, D., West, P.M., Grinnell, J., Packer, C., & Fischer, J. (2007). Do acoustic features of lion, *Panthera leo*, roars reflect sex & male condition? *Journal of the Acoustical Society of America, 121*(6), 3947–3953.

Power, R. J., Compion, R. X. S. (2009). Lion predation on elephants in the Savuti, Chobe National Park, Botswana. *African Zoology, 44*(1), 36–44.

Pusey, A., & Packer, C. (1983) Once & Future Kings*. Natural History, 8*, 54–62.

Pusey, A., & Packer, C. (1987). The Evolution of Sex-Biased Dispersal in Lions. *Behaviour, 101*(4), 275–310.

Pusey, A., & Packer, C. (1994). Infanticide in Lions: Consequences & Counterstrategies. S. Parmigiani, & F. Vom Saal (Eds.). Infanticide & Parental Care. Chur, Switzerland: Harwood Academic Publishers.

Pusey, A., & Packer, C. (1996). Non-offspring Nursing in Social Carnivores: Minimizing the costs. *Behavioral Ecology, 5*(4), 362–374.

Putman, S., Brown, J., Baker, T., & Pukazhenthi, B. (2011). Understanding African Lion Reproductive Biology & Establishing a Genome Research Bank. Front Royal: Smithsonian Conservation Biology Institute.

Schaller, G. (1972). The Serengeti Lion: A Study in Predator-Prey Relations. Chicago: University of Chicago Press.

Scheel, D. (1993). Profitability, Encounter Rates, & Prey Choice of African Lions. *Behavioral Ecology, 4*(1), 90–97.

Scheel, D. (1993). Watching for Lions in the Grass: The Usefulness of Scanning & its Effects During Hunts*. Animal Behaviour, 46*, 695–704.

Scheel, D., & Packer, C. (1991). Group Hunting Behaviour of Lions: A Search for Cooperation. *Animal Behaviour, 41*, 697–709.

Scheel, D., & Packer, C. (1995). Variation in Predation by Lions: Tracking a Moveable Feast. A. Sinclair & P. Arcese (Eds.). Serengeti II: Dynamics, Management & Conservation of an Ecosystem. Chicago: University of Chicago Press.

Sunquist, M., & Sunquist, F. (2002). Wild Cats of the World. Chicago: University of Chicago Press.

Spong, G. (2002). Space use in lions, *Panthera leo*, in the Selous Game Reserve: social & ecological factors. *Behavioral Ecology & Sociobiology, 52*(4), 303–307.

Spong, G., & Creel, S. (2004). Effects of kinship on territorial conflicts among groups of lions, *Panthera leo. Behavioral Ecology & Sociobiology, 55*(4), 325–331.

Spong, G., Stone, J., Creel, S., & Bjorklund, M. (2002). Genetic structure of lions (*Panthera leo*) in the Selous Game Reserve: implications for the evolution of sociality. *Journal of Evolutionary Biology, 15*(6), 945–953.

VanderWaal, K. L., Mosser, A., & Packer, C. (2009). Optimal group size, dispersal decisions & postdispersal relationships in female African lions. *Animal Behaviour, 77*(4), 949–954.

Weissengruber, G. E., Forstenpointner, G., Peters, G., Kubber-Heiss, A., & Fitch, W. T. (2002). Hyoid apparatus & pharynx in the lion (*Panthera leo*), jaguar (*Panthera onca*), tiger (*Panthera tigris*), cheetah (*Acinonyx jubatus*) & domestic cat (*Felis silvestris f. catus*). *Journal of Anatomy, 201*(3), 195–209.

West, P., & Packer, C. (2002). Sexual Selection, Temperature, & the Lions Mane. *Science, 297*, 1339–1343.

West, P. M., Maccormick, H., Hopcraft, G., Whitman, K., Ericson, M., Hordinsky, M., & Packer, C. (2006). Wounding, mortality & mane morphology in African lions, *Panthera leo*. *Animal Behaviour, 71*, 609–619.

Yamaguchi, N., Cooper, A., Werdelin, L., & Macdonald, D.W. (2004). Evolution Of The Mane & Group-Living In The Lion (*Panthera leo*): A Review. *Journal of Zoology, 263*, 329–342.

11.2 Web Resources

Lions and Other Felids	
www.catsg.org	IUCN Cat Specialist Group
www.cbs.umn.edu/lionresearch/	Lion Research Center (Dr. Craig Packer's lab)
www.panthera.org	Panthera
Training and Enrichment	
www.enrichment.org	The Shape of Enrichment
www.animalenrichment.org	Disney's Animal Kingdom sites (includes information on the
www.animaltraining.org	SPIDER model)
www.clickertraining.com/	Karen Pryor Clickertraining
www.aussiedog.com.au/	Enrichment Vendor
www.desertplastics-abq.com/Animals.asp	Enrichment Vendor
AZA	
www.felidtag.org	AZA Felid TAG
www.aza.org	Association of Zoos and Aquariums
www.stlzoo.org/contraception	AZA Contraception Center

References

Allen, M. E., Oftedal, O. T., Earle, K. E., Seidensticker, J., & Vilarin, L. (1995). Do maintenance energy requirements of felids reflect their feeding strategies? *NAG Proceedings*.

Allen, M. E., Ullrey, D. E., & Edwards, M. S. (1999). *The development of raw meat-based carnivore diets.* Paper presented at the Proceedings of the American Association of Zoo Veterinarians.

Altman, J., Gross, K., & Lowry, S. (2005). Nutritional and Behavioural Effects of Gorge and Fast Feeding in Captive Lions. *Journal of Applied Animal Welfare Science, 8*(1), 47–57.

American Society of Heating, R., Air Conditioning Engineers (1981). Outdoor Air Requirements for Ventilation 3.1 Commercial Facilities (Offices, Stores, Shops, Hotels, Sports Facilities, etc.) Vol. ASHRAE Standard 62–11981, 74–85.

Anderson, U., Kelling, A., Pressley-keough, R., Bloomsmith, M., & Maple, T. (2003). Enhancing the Zoo Visitor's Experience by Public Animal Training and Oral Interpretation at an Otter Exhibit. *Environment and Behavior, 35*(6), 826–841.

Appel, M., Yates, R., Foley, G., Bernstein, J., Santinelli, S., Spelman, L., et al.. (1984). Canine Distemper Epizootic in Lions, Tigers, Leopards, in North America. *Journal of Veterinary Diagnostic Investigation, 6*(3), 277–288.

Asa, C., & Porton, I. (Eds.). (2005). *Wildlife Contraception: Issues, Methods and Application*: Johns Hopkins University Press.

AZA (2011). *White Tigers, Lions And King Cheetahs: Welfare And Conservation Implications Of Intentional Breeding For The Expression Of Rare Recessive Alleles*: Association of Zoos and Aquariums.

Ballevre, O., Anantharaman-Barr, G., Gicquello, P., Piguet-Welsh, C., Thielin, A. L., & Fern, E. (1994). Use of the Doubly-Labeled Water Method to Assess Energy Expenditure in Free Living Cats and Dogs. *Journal of Nutrition, 124*(12_Suppl), 2594–2600.

Barbiers, R. B., Vosburge, L. M., Ku, P. K., & Ullrey, D. E. (1982). Digestive efficiencies and maintenance energy requirements of captive wild felidae: cougar (*Felis concolor*); leopard (*Panthera pardus*); lion (*Panthera leo*); and tiger (*Panthera tigris*). *Journal of Zoo and Wildlife Medicine, 13*, 32–37.

Barry, K. A., Wojcicki, B. J., Middelbos, I. S., Vester, B. M., Swanson, K. S., & Fahey, G. C. (2010). Dietary cellulose, fructooligosaccharides and pectin modify fecal protein catabolites and microbial populations in adult cats. *Journal of Animal Science, 88*, 2978–2987.

Bassett, L., & Buchanan-Smith, H. (2007). Effects of Predictability on the Welfare of Captive Animals. *Applied Animal Behavior Science, 102*, 223–245.

Bennett, C. L., Booth-Binczik, S. D., & Steele, S. R. E. (2010). Nutritional composition and digestibility by ocelots (*Leopardus pardalis*) of whole animals and a commercial diet. *Zoo Biology, 29*, 753–759.

Berschinger, H., Asa, C., Calle, J., Long, J., Bauman, K., DeMatteo, K., et al. (2001). Control of reproduction and sex related behaviour in exotic wild carnivores with the GnRH analogue deslorelin: preliminary observations. *Journal of Reproduction and Fertility, Supplement 57*, 275–283.

Bond, J., & Lindburg, D. (1990). Carcass Feeding of Captive Cheetahs (*Acinonyx jubatus*): The Effects of a Naturalistic Feeding Program on Oral Health and Psychological Well-being. *Applied Animal Behavior Science, 26*, 373–382.

Braun, B., Frank, A., Dehnhard, M., Voight, C., Vargas, A., Goritz, F., et al. (2009). Pregnancy Diagnosis in Urine in Iberian Lynx (*Lynx pardinus*). *Theriogenology, 7*(5), 754–761.

Briggs, M. B., & Scheels, J. (2005, October 16–18). Selection of proper feeds to assist in the dental management of carnivores. Paper presented at the 6th Conference of the AZA Nutrition Advisory Group on Zoo and Wildlife Nutrition, Omaha, NE.

Broder, J., McFadden, A., Cosens, L., Rosenstein, D., & Harrison, T. (2008). Use of Positive Reinforcement to Monitor Pregnancy in an Unanesthetized Snow Leopard (*Uncia uncia*) via Transabdominal Ultrasound. *Zoo Biology, 27*(1), 78–85.

Brosey, B. P., Hill, R. C., & Scott, K. C. (2000). Gastrointestinal volatile fatty acid concentrations and pH in cats. *American Journal of Veterinary Research, 61*(4), 359–361.

Brown, E., & Wielebnowski, N. (1998). Influence of Social Environment on Ovarian Activity and Behavior in Captive Cheetahs. *Advances in Ethology,* (33), 54.

Brown, E., Yuhki, N., Packer, C., & O'Brien, S. (1993). Prevalence of Exposure to Feline Immunodeficiency Virus in Exotic Felid Species. *Journal of Zoo and Wildlife Medicine, 24*(3), 357–364.

Brown, J. (2006). Comparative Endocrinology of Domestic and Nondomestic Felids. *Theriogenology* (66), 25–36.

Brown, J. L. (2011). Female Reproductive Cycles of Wild Female Felids. *Animal Reproduction Science,* 124(3–4),155–162.

Brown, J. L., Wasser, S., Wildt, D., & Graham, L. (1994). Comparative Aspects of Steroid Hormone Metabolism and Ovarian in Felids Measured Noninvasively in Feces. *Biological Reproduction, 51*, 776–786.

Bull, M., Kennedy-Stopskopf, S., Levinne, J., Loomis, M., Gebhard, D., & Tompkins, W. (2003). Evaluation of T Lymphocytes in Captive African Lions (*Panthera leo*) Infected with Feline Immunodeficiency Virus. *American Journal of Veterinary Research, 64*(10), 1293–1300.

Carlstead, K. (1996). Effects of Captivity on the Behavior of Wild Mammals. In Kleiman, D., Allen, M., Thompson, K., & Lumpkin, S. (Eds.). *Wild Mammals in Captivity: Principles and Techniques*, 317–333.

Clarke, B. C., & Berry, H. H. (1992). Water flux in free-living lions (*Panthera leo*) in the Etosha National Park, Namibia. *Journal of Mammalogy, 73*(3), 552–558.

Clauss, M., Kleffner, H., & Kienzle, E. (2010). Carnivorous mammals: nutrient digestibility and energy evaluation. *Zoo Biology, 29*, 687–704.

Crissey, S., Sifka, K., Shumway, P., & Spencer, S. (2001). Handling Frozen/Thawed Meat and Prey Items Fed to Captive Exotic Animals. N. A. Library (Ed.). *U.S. Department of Agriculture*, 23.

De Waal, H. O., Osthoff, G., Hugo, A., Myburgh, J., & Botes, P. (2004). The composition of African lion (*Panthera leo*) milk collected a few days postpartum. *Mammalian Biology, 69*, 375–383.

DiGesualdo, C., Hoover, J., & Lorenz, M. (2005). Presumed Primary Thiamine Deficiency in a Young African Lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 36*(3), 512–514.

Dorsser, F. D. H. V., Swanson, W., Lasano, S., & Steinetz, B. (2006). Development, Validation, and Application of a Urinary Relaxin Radioimmunoassy for the Diagnosis and Monitoring of Pregnancy in Felids. *Biological Reproduction, 74*(6), 1090–1095.

Dubach, J., Patterson, B. D., Briggs, M. B., Venzke, K., Flamand, J., Stander, P., et al. (2005). Molecular Genetic Variation Across the Southern and Eastern Geographic Ranges of the African Lion, *Panthera leo*. *Conservation Genetics, 6*, 15–24.

Edwards, M. S., Gaffney, M., & Bray, R. E. (2001). Influence of fiber source on apparent digestibility, rate of passage and fecal consistency in small felids fed a beef-based carnivore diet, 71–80.

Elliot, D. A. (2006). Techniques to assess body composition in dogs and cats. *Waltham Focus, 16*, 16–20.

Eloff, F. C. (1984). Food ecology of the Kalahari lion *Panthera leo vernayi*. *Koedoe, Supplement* , 249–258.

Estes, R. (1991). *The Behavior Guide to African Mammals*. Berkley: University of California Press.

Fanson, K., Wielebnowski, N., Schenk, T., Vashon, H., Squires, J., & Lucas, J. (2010). Patterns of Ovarian and Luteal Activity in Captive and Wild Canada Lynx (*Lynx canadensis*). *General Comparative Endocrinology, 169 (3), 217–224,*

Feldman, E., & Nelson, R. (2004). Feline Reproduction. In Kersey, R., & LeMelledo, D. (Eds.). *Canine and Feline Reproduction*, 1016–1045.

Folin, O., Denis, W., & Minot, A. S. (1919). Lactose, fat and protein in milk of various animals. *The Journal of Bioogical Chemistry, 38*, 349–352.

Forsen, T., Eriksson, J., Tuomilehto, J., Reunanen, A., Osmond, C., & Barker, D. (2000). The fetal and childhood growth of persons who develop type 2 diabetes. *Annals of Internal Medicine, 133*(3), 176–182.

Fouraker, M., Wagener, T., & Wiese, R. (1998). *Lion Species Survival Plan Mid Year Meeting Summary and Master Plan*: Fort Worth Zoological Park.

Galloway, D., Coke, R., Rochat, M., Radinski, M., Hoover, J., Carpenter, J., et al. (2001). Spinal Compression Due to Atlantal Vertebral Malformation in Two African Lions (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 40*(2), 354–359.

German, A. J., Holden, S. L., Moxham, G. L., Holmes, K. L., Hackett, R. M., & Rawlings, J. M. (2006). A simple, reliable tool for owners to assess the body condition of their cat or dog. *Journal of Nutrition, 136*, 2031–2033.

Green, B., Anderson, J., & Whateley, T. (1984). Water and sodium turnover and estimated food consumption in free-living lions (*Panthera leo*) and spotted hyenas (*Crocuta crocuta*). *Journal of Mammalogy, 65*, 593–599.

Haas, S. K., Hayssen, V., & Krausman, P. R. (2005). Panthera Leo. *Mammalian Species, 762*, 1–11.

Haberstroh, L. I., Ullrey, D. E., Sikarskie, J. G., Richter, N. A., Colmery, B. H., & Myers, T. D. (1983). *Diet and oral health in captive Amur tigers (Panthera tigris altaica).* Paper presented at the Proceedings of the 3rd Annual Dr. Scholl Nutrition Conference, Chicago, IL.

Harrison, T., Sikarskie, J., Kitchell, B., Rosenstein, D., Flaherty, H., & Fitzgerald, S., et al. (2007). Treatment of Malignant Lymphoma in an African Lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 38*(2), 333–336.

Harrison, T. M., Harrison, S. H., Rumbeiha, W. K., Sikarskie, J. G., & McClean, M. (2006). Surveillance for selected bacterial and toxicologic contaminants in donated carcass meat fed to carnivores. *Journal of Zoo and Wildlife Medicine, 37*, 102–107.

Hartley, M., Keberger, R., Haagenson, & Sweers, L. (2005). Diagnosis of Suspected Hypovitaminosis A Using Magnetic Resonance Imaging in African Lions (*Panthera leo*). *Journal of the South African Veterinary Association, 76*(3), 132–137.

Hayward, M. W., & Kerley, G. I. H. (2005). Prey preferences of the lion (Panthera leo). *Journal of Zoology, 267*, 309–322.

Hedberg, G., & Gage, L. J. (2008). Exotic felids. *Hand-Rearing Wild and Domestic Mammals*, 207–220.

Hendricks, W. H., & Wamberg, S. (2000). Milk intake of suckling kittens remains relatively constant from one to four weeks of age. *Journal of Nutrition, 130*, 77–82.

Henneke, D. R., Potter, G. D., Kreider, J. L., & Yeates, B. F. (1983). Relationship between condition score, physical measurements and body fat percentage in mares. *Equine Veterinary Journal, 15*(4), 371–372.

Hoover, J., & DiGesualdo, C. (2005). Blood Thiamine Values in Captive Adult African Lions (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 36*(3), 417–421.

Hosey, G., Melfi, V., & Pankhurst, S. (2009). *Zoo Animals: Behavior, Management and Welfare.* Oxford University Press, Oxford.

Howard, J. (1993). Semen Collection and Analysis in Carnivores. In M. Fowler (Ed.). *Zoo and Wild Animal Medicine III*, 390–399.

Jacobsen, K. L., DePeters, E. J., Rogers, Q. R., & Taylor, S. J. (2004). Influences of stage of lactation, teat position and sequential milk sampling on the composition of domestic cat milk (Felis catus). *Journal of Animal Physiology and Animal Nutrition, 88*, 46–58.

Keen, C. L., Lonnerdal, B., Clegg, M. S., Hurley, L. S., Morris, J. G., Rogers, Q. R., et al. (1982). Developmental changes in composition of cats' milk: trace elements, minerals, protein, carbohydrate and fat. *Journal of Nutrition, 112*, 1763–1769.

Kienzle, E. (1998). Factorial calculation of nutrient requirements in lactating queens. *Journal of Nutrition,* 128.

LaFlamme, D. (1997). Development and validation of a body condition score system for dogs. *Canine Practice, 22*(4), 10–15.

Laflamme, D. P. (2005). Nutrition for Aging Cats and Dogs and the Importance of Body Condition. *Veterinary Clinics of North America: Small Animal Practice, 35*(3), 713–742.

Law, C. (Ed.). (2003). *Guidelines for Captive Management of Jaguars*. Fort Worth: Jaguar SSP.

Lopez-Rebollar, L., Pezhorn, B., Waal, D. D., & Lewis, B. (1999). A Possible New Piroplasm in Lions From the Republic of South Africa. *Journal of Wildlife Disease, 35*(1), 82–85.

Maple, T., & Perkins, L. (1996). Enclosure Furnishing and Structural Environmental Enrichment. D. Kleiman, M. Allen, K. Thompson & S. Lumpkin (Eds.). *Wild Mammals in Captivity: Principles and Techniques*, 88–99.

Maratea, K., Hooser, S., & Ramos-Vera, J. (2006). Degenerative Myeolopathy and Vitamin A in a Young Black-maned Lion (*Panthera leo*). *Journal of Veterinary Diagnostic Investigation, 18*(6), 608–611.

Mazak, V. (1981). Panthera tigris. *Mammalian Species, 152*, 1–8.

McCain, S., Ramsay, R., Allender, M., Souza, C., & Schumacher, J. (2009). Pyometra in Captive Large Felids: A Review of Eleven Cases. *Journal of Zoo and Wildlife Medicine, 40*(1), 147–151.

McCain, S., Souza, M., Ramsay, E., Schumacher, J., Hecht, S., & Thomas, W. (2008). Diagnosis and Surgical Treatment of a Chiari I-like Malformation in an African Lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 39*(3), 421–427.

McNab, B. K. (2000). The standard energetics of mammalian carnivores: Felidae and Hyaenidae. *Canadian Journal of Zoology, 78*, 2227–2239.

McNab, B. K. (2008). An analysis of the factors that influence the level and scaling of mammalian BMR. *Comparative Biochemistry and Physiology, 151*, 5–28.

Mellen, J. (1993). A Comparative Analysis of Scent-Marking, Social and Reproductive Behavior in 20 Species of Small Cats (*Felis*). *American Zoology, 33*, 151–166.

Mellen, J., & Ellis, S. (1996). Animal Learning and Husbandry Training. D. Kleiman, M. Allen, K. Thompson & S. Lumpkin (Eds.). *Wild Mammals in Captivity: Principles and Techniques* , 212–222.

Mellen, J., & Sevenich-MacPhee, M. (2001). Philosophy of Environmental Enrichment: Past, Present, and Future. *Zoo Biology, 20*, 211–226.

Morris, J. G., Fujimoto, J., & Berry, S. C. (1974). The comparative digestibility of a zoo diet fed to 13 species of felid and badger. *International Zoo Yearbook, 14*, 169–171.

Munoz-Garcia, A., & Williams, J. B. (2005). Basal metabolic rate in carnivores is associated with diet after controlling for phylogeny. *Physiology and Biochemical Zoology, 78*, 1039–1056.

Munson, L., Bauman, K., Asa, C., Jochle, W., & Trigg, T. (2001). Effacy of the GnRG analogue deslorelin for suppression of oestrus cycle in cats. *Journal of Reproduction and Fertility, Supplement 57*, 269–273.

Munson, L., Gardner, A., Mason, R., Chassy, L., & Seal, U. (2002). Endometrial Hyperplasia and Mineralization in Zoo Felids Treated with Melengesterol-Acetate Contraceptive. *Veterinary Pathology, 39*, 419–427.

Nagy, K. A., Girard, I. A., & Brown, T. K. (1999). Energetics of free-ranging mammals, reptiles, and birds. *Annual Review of Nutrition, 19*(1), 247–277.

Nowak, R., & Paradiso, J. (1999). Walker's Mammals of the World (6th ed.). Johns Hopkins University Press.

NRC (1986). *Nutrient requirements of cats* (Revised ed.). Washington, D.C.: National Academy Press.

NRC (2006). *Nutrient requirements of dogs and cats*. Washington, D.C.: National Academy Press.

O'Brien, S. J., Joslin, P., III, G. S., Wolfe, R., Schaffer, N., Heath, E., et al. (1987). Evidence for African Origins of Founders of the Asiatic Lion Species Survival Plan. *Zoo Biology, 6*, 99–116.

Oftedal, O. T., & Iverson, S. J. (1995). Comparative analysis of nonhuman milks *Handbook of Milk Composition*, 749–788.

Ozanne, S. E. (2001). Metabolic programming in animals. *British Medical Bulletin, 60*, 143–152.

Ozanne, S. E., & Nicholas Hales, C. (2005). Poor fetal growth followed by rapid postnatal catch-up growth leads to premature death. *Mechanisms of Ageing and Development, 126*(8), 852–854.

Packer, C., & Pusey, A. E. (1983). Male Takeovers And Female Reproductive Parameters - A Simulation Of Estrous Synchrony In Lions (*Panthera-leo*). *Animal Behaviour,* 334–340.

Patterson, B. D., Kays, R. W., Kasiki, S. M., & Sebestyen, V. M. (2006). Developmental effects of climate on the lion's mane (*Panthera leo*). *Journal of Mammalogy, 87*(2), 193–200.

Penzhorn, B., Kjemtrup, A., Lopez-Rebollar, L., & Conrad, P. (2001). *Babesia leo* N Sp. From Lions in the Kruger National Park, South Africa and its Relation to Other Small Piroplasms. *Journal of Parasitology, 87*(3), 681–685.

Pfaff, S. (2010). African Lion Studbook. Columbia: Riverbanks Zoo.

Putman, S., Brown, J., Baker, T., & Pukazhenthi, B. (2011). Understanding African Lion Reproductive Biology and Establishing a Genome Research Bank. Smithsonian Conservation Biology Institute.

Ramirez, K. (1999). Animal Training: Successful Management Through Positive Reinforcement. Chicago: Shedd Aquarium Society.

Rapson, J. A., & Bernard, R. T. F. (2007). Interpreting the diet of lions (*Panthera leo*); a comparison of various methods of analysis. *South African Journal of Wildlife Research, 37*, 179–187.

Ricci, E., Cavicchio, P., & Cantile, C. (2010). Fibrocartilaginous Embolic Myelopathy in a Lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine, 41*(2), 334–337.

Sambrook, T., & Buchanan-Smith, H. (1997). Control and Complexity in Novel Object Enrichment. *Animal Welfare, 6*, 207–216.

Schaller, G. (1972). The Serengeti Lion: A Study in Predator-Prey Relations. Chicago: University of Chicago Press.

Schaller, G. B. (1976). The Serengeti Lion: A Study of Predator-Prey Relations: University of Chicago Press.

Schramm, R. D., Briggs, M. B., & Reeves, J. (1994). Spontaneous And Induced Ovulation In The Lion (*Panthera-leo*). *Zoo Biology, 13*(4), 301–307.

Seymour, K. L. (1989). Panthera onca. *Mammalian Species, 340*, 1–9.

Shamir, M., Shilo, Y., Fridman, A., Chai, O., Reifen, R., & Miara, L. (2008). Sub-occipital Craniectomy in a Lion (*Panthera leo*) and Hypovitaminosis A. *Journal of Zoo and Wildlife Medicine, 39*(3), 455–459.

Shaul, B. (1962). The composition of the milk of wild animals. *International Zoo Yearbook*, *4,* 333–342.

Smith, Y., De Waal, H. O., & Kok, O. B. (2006). Aspects of carcass digestibility by African Lions (*Panthera leo Linnaeus*, 1758) under captive conditions. *Pakistan Journal of Biological Sciences, 9*, 2149–2152.

Smuts, G. L. (1979). Diet of lions and spotted hyaenas assessed from stomach contents. *South African Journal of Wildlife Research, 9*, 19–25.

Smuts, G. L., Robinson, G. A., & Whyte, I. J. (1980). Comparative growth of wild male and female lions (Panthera leo). *Journal of Zoology, 190*, 365–373.

Stevens, C. E., & Hume, I. D. (1995). Comparative physiology of the vertebrate digestive system Retrieved March 13, 2011, from www.cnsweb.ord/digestvertebrates/AAAEdStevensINTRODUCTION.html

Stevenson, R. D., & Woods, W. A. (2006). Condition indices for conservation: new uses for evolving tools. *Integrative and Comparative Biology, 46*(6), 1169–1190.

Suchodolski, J. S. (2011). Microbes and gastrointestinal health of cats and dogs. *Journal of Animal Science, 89*, 1500–1530.

Sunquist, M., & Sunquist, F. (2002). *Wild Cats of the World*. Chicago: University of Chicago Press.

Ullrey, D. E., & Bernard, J. B. (1989). Meat diets for performing exotic cats. *Journal of Zoo and Wildlife Medicine, 20*, 20–25.

USDA (1998). Animal Care Resource Guide: Nutrition for large felids.

Van Valkenburgh, B. (1996). Feeding behavior in free-ranging, large African carnivores. *Journal of Mammology, 77*, 240–254.

Vester, B. M., Burke, S. L., Liu, K. J., Dikeman, C. L., Simmons, L. G., & Swanson, K. S. (2010). Influence of feeding raw or extruded feline diets on nutrient digestibility and nitrogen metabolism of African wildcats (*Felis lybica*). *Zoo Biology, 29*, 676–686.

Visser, H. (2009). Factors influencing lion (*Panthera leo*) home range, movement and diet in Waza National Park, Cameroon.

Wachenfeld, C. (2008). Do You Smell That? An Analysis of Scent Preference in Carnivores. *The Shape of Enrichment, 17*(3).

Watts, J. C. (2011, October 23-26). Potential of alternative protein sources for exotic carnivores: observations and discussion. Paper presented at the 9th Conference of the AZA Nutrition Advisory Group on Zoo and Wildlife Nutrition, Kansas City, MO.

Wielebnowski, N. (2003). Stress and Distress: Evaluating Their Impact for the Well-being of Zoo Animals. *Journal of American Veterinary Medical Association, 233*(7), 973–977.

Wielebnowski, N., Ziegler, K., Wildt, D. E., Lukas, J., & Brown, J. L. (2002). Impact of Social Management on Reproductive, Adrenal, and Behavioural Activity in the Cheetah (*Acinonyx jubatus*). *Animal Conservation, 5*, 291–301.

Wildt, D. E., Bush, M., Goodrowe, K. L., Packer, C., Pusey, A. E., Brown, J. L., et al. (1987). Reproductive And Genetic Consequences Of Founding Isolated Lion Populations. *Nature, 329*(6137), 328–331.

Wright, P., Verstegen, J., Onclin, K., Jochle, W., Armour, A., Martin, G., et al. (2001). Suppression of the oestrus responses of bitches to the GnRH analogue deslorelin by progestin. *Journal of Reproduction and Fertility, Supplement 57*, 263–268.

Wynne, J. E. (1989). Comparative digestibility values in four species of felidae. *Journal of Zoo and Wildlife Medicine, 20*, 53–56.

Young, R., & Cipreste, C. (2004). Applying Animal Learning Theory: Training Captive Animals to Comply with Veterinary and Husbandry Procedures. *Animal Welfare, 13*(2), 255–262.

Zoran, D. L. (2002). The carnivore connection to nutrition in cats. *Journal of the American Veterinary Medical Association, 221*(11), 1559–1567.

Zullinger, E. M., Ricklefs, R. E., Redford, K. H., & Mace, G. M. (1984). Fitting sigmoidal equations to mammalian growth-curves. *Journal of Mammalogy,* 607–636.

Appendix A: Accreditation Standards by Chapter

The following specific standards of care relevant to lions (*Panthera leo*) are taken from the AZA Accreditation Standards and Related Policies (AZA, 2011) and are referenced fully within the chapters of this animal care manual:

General Information

(1.1.1) The institution must comply with all relevant local, state, and federal wildlife laws and regulations. It is understood that, in some cases, AZA accreditation standards are more stringent than existing laws and regulations. In these cases the AZA standard must be met.

Chapter 1

(1.5.7) The animal collection must be protected from weather detrimental to their health.

(10.2.1) Critical life-support systems for the animal collection, including but not limited to plumbing, heating, cooling, aeration, and filtration, must be equipped with a warning mechanism, and emergency backup systems must be available. All mechanical equipment should be under a preventative maintenance program as evidenced through a record-keeping system. Special equipment should be maintained under a maintenance agreement, or a training record should show that staff members are trained for specified maintenance of special equipment.

(1.5.9) The institution must have a regular program of monitoring water quality for collections of fish, pinnipeds, cetaceans, and other aquatic animals. A written record must be maintained to document long-term water quality results and chemical additions.

Chapter 2

(1.5.2) Animals should be displayed, whenever possible, in exhibits replicating their wild habitat and in numbers sufficient to meet their social and behavioral needs. Display of single specimens should be avoided unless biologically correct for the species involved.

(10.3.3) All animal enclosures (exhibits, holding areas, hospital, and quarantine/isolation) must be of a size and complexity sufficient to provide for the animal's physical, social, and psychological well-being; and exhibit enclosures must include provisions for the behavioral enrichment of the animals.

(11.3.3) Special attention must be given to free-ranging animals so that no undue threat is posed to the animal collection, free-ranging animals, or the visiting public. Animals maintained where they will be in contact with the visiting public must be carefully selected, monitored, and treated humanely at all times.

(11.3.1) All animal exhibits and holding areas must be secured to prevent unintentional animal egress.

(11.3.6) Guardrails/barriers must be constructed in all areas where the visiting public could have contact with other than handleable animals.

(11.2.3) All emergency procedures must be written and provided to staff and, where appropriate, to volunteers. Appropriate emergency procedures must be readily available for reference in the event of an actual emergency. These procedures should deal with four basic types of emergencies: fire, weather/environment; injury to staff or a visitor; animal escape.

(11.6.2) Security personnel, whether staff of the institution, or a provided and/or contracted service, must be trained to handle all emergencies in full accordance with the policies and procedures of the institution. In some cases, it is recognized that Security personnel may be in charge of the respective emergency (i.e., shooting teams).

(11.2.4) The institution must have a communication system that can be quickly accessed in case of an emergency.

(11.2.5) A written protocol should be developed involving local police or other emergency agencies and include response times to emergencies.

(11.5.3) Institutions maintaining potentially dangerous animals (sharks, whales, tigers, bears, etc.) must have appropriate safety procedures in place to prevent attacks and injuries by these animals. Appropriate response procedures must also be in place to deal with an attack resulting in an injury. These procedures must be practiced routinely per the emergency drill requirements contained in these standards. Whenever injuries result from these incidents, a written account outlining the cause of the incident, how the injury was handled, and a description of any resulting changes to either the

safety procedures or the physical facility must be prepared and maintained for five years from the date of the incident.

Chapter 3

(1.5.11) Animal transportation must be conducted in a manner that is safe, well-planned and coordinated, and minimizes risk to the animal(s), employees, and general public. All applicable local, state, and federal laws must be adhered to.

Chapter 5

(2.6.2) A formal nutrition program is recommended to meet the behavioral and nutritional needs of all species and specimens within the collection.

(2.6.3) Animal diets must be of a quality and quantity suitable for each animal's nutritional and psychological needs. Diet formulations and records of analysis of appropriate feed items should be maintained and may be examined by the Visiting Committee. Animal food, especially seafood products, should be purchased from reliable sources that are sustainable and/or well managed.

(2.6.1) Animal food preparations must meet all local, state/provincial, and federal regulations.

(2.6.4) The institution should assign at least one person to oversee appropriate browse material for the collection.

Chapter 6

(2.1.1) A full-time staff veterinarian is recommended. However, the Commission realizes that in some cases such is not practical. In those cases, a consulting/part-time veterinarian must be under contract to make at least twice monthly inspections of the animal collection and respond as soon as possible to any emergencies. The Commission also recognizes that certain collections, because of their size and/or nature, may require different considerations in veterinary care.

(2.1.2) So that indications of disease, injury, or stress may be dealt with promptly, veterinary coverage must be available to the animal collection 24 hours a day, 7 days a week.

(2.2.1) Written, formal procedures must be available to the animal care staff for the use of animal drugs for veterinary purposes and appropriate security of the drugs must be provided.

(1.4.6) A staff member must be designated as being responsible for the institution's animal record-keeping system. That person must be charged with establishing and maintaining the institution's animal records, as well as with keeping all animal care staff members apprised of relevant laws and regulations regarding the institution's animal collection.

(1.4.7) Animal records must be kept current, and data must be logged daily.

(1.4.5) At least one set of the institution's historical animal records must be stored and protected. Those records should include permits, titles, declaration forms, and other pertinent information.

(1.4.4) Animal records, whether in electronic or paper form, including health records, must be duplicated and stored in a separate location.

(1.4.3) Animals must be identifiable, whenever practical, and have corresponding ID numbers. For animals maintained in colonies or other animals not considered readily identifiable, the institution must provide a statement explaining how record keeping is maintained.

(1.4.1) An animal inventory must be compiled at least once a year and include data regarding acquisitions and dispositions in the animal collection.

(1.4.2) All species owned by the institution must be listed on the inventory, including those animals on loan to and from the institution. In both cases, notations should be made on the inventory.

(2.7.1) The institution must have holding facilities or procedures for the quarantine of newly arrived animals and isolation facilities or procedures for the treatment of sick/injured animals.

(2.7.3) Quarantine, hospital, and isolation areas should be in compliance with standards or guidelines adopted by the AZA.

(2.7.2) Written, formal procedures for quarantine must be available and familiar to all staff working with quarantined animals.

(11.1.2) Training and procedures must be in place regarding zoonotic diseases.

(11.1.3) A tuberculin testing and surveillance program must be established for appropriate staff in order to ensure the health of both the employees and the animal collection.

(2.5.1) Deceased animals should be necropsied to determine the cause of death. Disposal after necropsy must be done in accordance with local/federal laws.

(2.4.1) The veterinary care program must emphasize disease prevention.

(1.5.5) For animals used in offsite programs and for educational purposes, the institution must have adequate protocols in place to protect the rest of the collection from exposure to infectious agents.
(2.3.1) Capture equipment must be in good working order and available to authorized, trained personnel at all times.
(2.4.2) Keepers should be trained to recognize abnormal behavior and clinical symptoms of illness and have knowledge of the diets, husbandry (including enrichment items and strategies), and restraint procedures required for the animals under their care. However, keepers should not evaluate illnesses nor prescribe treatment.
(2.3.2) Hospital facilities should have x-ray equipment or have access to x-ray services.
(1.5.8) The institution must develop a clear process for identifying and addressing animal welfare concerns within the institution.

Chapter 8

(1.6.1) The institution must have a formal written enrichment program that promotes species-appropriate behavioral opportunities.
(1.6.2) The institution must have a specific staff member(s) or committee assigned for enrichment program oversight, implementation, training, and interdepartmental coordination of enrichment efforts.

Chapter 9

(1.5.4) A written policy on the use of live animals in programs should be on file. Animals in education programs must be maintained and cared for by trained staff, and housing conditions must meet standards set for the remainder of the animal collection, including species-appropriate shelter, exercise, social and environmental enrichment, access to veterinary care, nutrition, etc. Since some of these requirements can be met outside of the primary enclosure, for example, enclosures may be reduced in size provided that the animal's physical and psychological needs are being met.
(1.5.3) If animal demonstrations are a part of the institution's programs, an education and conservation message must be an integral component.
(1.5.5) For animals used in offsite programs and for educational purposes, the institution must have adequate protocols in place to protect the rest of the collection from exposure to infectious agents.
(10.3.3) All animal enclosures (exhibits, holding areas, hospital, and quarantine/isolation) must be of a size and complexity sufficient to provide for the animal's physical, social, and psychological well-being; and exhibit enclosures must include provisions for the behavioral enrichment of the animals.
(1.5.2) Animalsshouldbedisplayedinexhibitsreplicatingtheirwildhabitatandinnumbers sufficient to meet their social and behavioral needs. Display of single animals should be avoided unless biologically correct for the species involved.
(1.5.11) Animal transportation must be conducted in a manner that is safe, well planned, and coordinated, and minimizes risk to the animal(s), employees, and general public. All applicable local, state, and federal laws must be adhered to. Planning and coordination for animal transport requires good communication among all involved parties, plans for a variety of emergencies and contingencies that may arise, and timely execution of the transport. At no time should the animal(s) or people be subjected to unnecessary risk or danger.

Chapter 10

(5.3) Institutions should maximize the generation of scientific knowledge gained from the animal collection. This might be achieved by participating in AZA TAG/SSP sponsored research when applicable, conducting original research projects, affiliating with local universities, and/or employing staff with scientific credentials.
(5.2) Institutions must have a written policy that outlines the type of research that it conducts, methods, staff involvement, evaluations, animals to be involved, and guidelines for publication of findings.
(5.1) Research activities must be under the direction of a person qualified to make informed decisions regarding research.

Appendix B: Acquisition/Disposition Policy

I. Introduction: The Association of Zoos and Aquariums (AZA) was established, among other reasons, to foster continued improvement in the zoological park and aquarium profession. One of its most important roles is to provide a forum for debate and consensus building among its members, the intent of which is to attain high ethical standards, especially those related to animal care and professional conduct. The stringent requirements for AZA accreditation and high standards of professional conduct are unmatched by similar organizations and also far surpass the United States Department of Agriculture's Animal and Plant Health Inspection Service's requirements for licensed animal exhibitors. AZA member facilities must abide by a Code of Professional Ethics - a set of standards that guide all aspects of animal management and welfare. As a matter of priority, AZA institutions should acquire animals from other AZA institutions and dispose of animals to other AZA institutions.

AZA accredited zoological parks and aquariums cannot fulfill their important missions of conservation, education and science without living animals. Responsible management of living animal populations necessitates that some individuals be acquired and that others be removed from the collection at certain times. Acquisition of animals can occur through propagation, trade, donation, loan, purchase, capture, or rescue. Animals used as animal feed are not accessioned into the collection.

Disposition occurs when an animal leaves the collection for any reason. Reasons for disposition vary widely, but include cooperative population management (genetic or demographic management), reintroduction, behavioral incompatibility, sexual maturation, animal health concerns, loan or transfer, or death.

The AZA Acquisition/Disposition Policy (A/D) was created to help (1) guide and support member institutions in their animal acquisition and disposition decisions, and (2) ensure that all additions and removals are compatible with the Association's stated commitment to "save and protect the wonders of the living natural world." More specifically, the AZA A/D Policy is intended to:

- Ensure that the welfare of individual animals and conservation of populations, species and ecosystems are carefully considered during acquisition and disposition activities;
- Maintain a proper standard of conduct for AZA members during acquisition and disposition activities;
- Ensure that animals from AZA member institutions are not transferred to individuals or organizations that lack the appropriate expertise or facilities to care for them.
- Support the goal of AZA's cooperatively managed populations and associated programs, including Species Survival Plans (SSPs), Population Management Plans (PMPs), and Taxon Advisory Groups (TAGs).

The AZA Acquisition/Disposition Policy will serve as the default policy for AZA member institutions. Institutions may develop their own A/D Policy in order to address specific local concerns. Any institutional policy must incorporate and not conflict with the AZA acquisition and disposition standards.

Violations of the AZA Acquisition/Disposition Policy will be dealt with in accordance with the AZA Code of Professional Ethics. Violations can result in an institution's or individual's expulsion from membership in the AZA.

II. Group or Colony-based Identification: For some colonial, group-living, or prolific species, such as certain insects, aquatic invertebrates, schooling fish, rodents, and bats, it is often impossible or highly impractical to identify individual specimens. These species are therefore maintained, acquisitioned, and disposed of as a group or colony. Therefore, when this A/D Policy refers to animals or specimens, it is in reference to both individuals and groups/colonies.

III. Germplasm: Acquisition and disposition of germplasm should follow the same guidelines outlined in this document if its intended use is to create live animal(s). Ownership of germplasm and any resulting animals should be clearly defined. Institutions acquiring or dispositioning germplasm or any animal parts or samples should consider not only its current use, but also future possible uses as new technologies become available.

IV(a). General Acquisitions: Animals are to be acquisitioned into an AZA member institution's collection if the following conditions are met:

1. Acquisitions must meet the requirements of all applicable local, state, federal and international regulations and laws.
2. The Director or Chief Executive Officer of the institution is charged with the final authority and responsibility for the monitoring and implementation of all acquisitions.
3. Acquisitions must be consistent with the mission of the institution, as reflected in its Institutional Collection Plan, by addressing its exhibition/education, conservation, and/or scientific goals.
4. Animals that are acquired for the collection, permanently or temporarily, must be listed on institutional records. All records should follow the Standards for Data Entry and Maintenance of North American Zoo and Aquarium Animal Records Databases®.
5. Animals may be acquired temporarily for reasons such as, holding for governmental agencies, rescue and/or rehabilitation, or special exhibits. Animals should only be accepted if they will not jeopardize the health, care or maintenance of the animals in the permanent collection or the animal being acquired.
6. The institution must have the necessary resources to support and provide for the professional care and management of a species, so that the physical and social needs of both specimen and species are met.
7. Attempts by members to circumvent AZA conservation programs in the acquisition of SSP animals are detrimental to the Association and its conservation programs. Such action may be detrimental to the species involved and is a violation of the Association's Code of Professional Ethics. All AZA members must work through the SSP program in efforts to acquire SSP species and adhere to the AZA Full Participation policy.
8. Animals are only to be acquired from sources that are known to operate legally and conduct their business in a manner that reflects and/or supports the spirit and intent of the AZA Code of Professional Ethics as well as this policy. Any convictions of state, federal, or international wildlife laws should be reviewed, as well as any previous dealings with other AZA accredited institutions.
9. When acquiring specimens managed by a PMP, institutions should consult with the PMP manager.
10. Institutions should consult AZA Wildlife Conservation and Management Committee (WCMC)-approved Regional Collection Plans (RCPs) when making acquisition decisions.

IV(b). Acquisitions from the Wild: The maintenance of wild animal populations for education and wildlife conservation purposes is a unique responsibility of AZA member zoos and aquariums. To accomplish these goals, it may be necessary to acquire wild-caught specimens. Before acquiring animals from the wild, institutions are encouraged to examine sources including other AZA institutions or regional zoological associations.

When acquiring animals from the wild, careful consideration must be taken to evaluate the long-term impacts on the wild population. Any capture of free-ranging animals should be done in accordance with all local, state, federal, and international wildlife laws and regulations and not be detrimental to the long-term viability of the species or the wild or captive population(s). In crisis situations, when the survival of a population is at risk, rescue decisions are to be made on a case-by-case basis.

V(a). Disposition Requirements – living animals: Successful conservation and animal management efforts rely on the cooperation of many entities, both within and outside of AZA. While preference is given to placing animals within AZA member institutions, it is important to foster a cooperative culture among those who share the primary mission of AZA accredited facilities. The AZA draws a strong distinction between the mission, stated or otherwise, of non-AZA member organizations and the mission of professionally managed zoological parks and aquariums accredited by the AZA.

An accredited AZA member balances public display, recreation, and entertainment with demonstrated efforts in education, conservation, and science. While some non-AZA member organizations may meet minimum daily standards of animal care for wildlife, the AZA recognizes that this, by itself, is insufficient to warrant either AZA membership or participation in AZA's cooperative animal management programs. When an animal is sent to a non-member of AZA, it is imperative that the member be confident that the animal will be cared for properly.

Animals may only be disposed of from an AZA member institution's collection if the following conditions are met:

1. Dispositions must meet the requirements of all applicable local, state, federal and international regulations and laws.
2. The Director or Chief Executive Officer of the institution is charged with the final authority and responsibility for the monitoring and implementation of all dispositions.
3. Any disposition must abide by the Mandatory Standards and General Advisories of the AZA Code of Professional Ethics. Specifically, "a member shall make every effort to assure that all animals in his/her collection and under his/her care are disposed of in a manner which meets the current disposition standards of the Association and do not find their way into the hands of those not qualified to care for them properly."
4. Non-domesticated animals shall not be disposed of at animal auctions. Additionally, animals shall not be disposed of to any organization or individual that may use or sell the animal at an animal auction. In transactions with AZA non-members, the recipient must ensure in writing that neither the animal nor its offspring will be disposed of at a wild animal auction or to an individual or organization that allows the hunting of the animal.
5. Animals shall not be disposed of to organizations or individuals that allow the hunting of these animals or their offspring. This does not apply to individuals or organizations which allow the hunting of only free-ranging game species (indigenous to North America) and established long-introduced species such as, but not limited to, white-tailed deer, quail, rabbit, waterfowl, boar, ring-necked pheasant, chukar, partridge, and trout. AZA distinguishes hunting/fishing for sport from culling for sustainable population management and wildlife conservation purposes.
6. Attempts by members to circumvent AZA conservation programs in the disposition of SSP animals are detrimental to the Association and its conservation programs. Such action may be detrimental to the species involved and is a violation of the Association's Code of Professional Ethics. All AZA members must work through the SSP program in efforts to deacquisition SSP species and adhere to the AZA Full Participation policy.
7. Domesticated animals are to be disposed of in a manner consistent with acceptable farm practices and subject to all relevant laws and regulations.
8. Live specimens may be released within native ranges, subject to all relevant laws and regulations. Releases may be a part of a recovery program and any release must be compatible with the AZA Guidelines for Reintroduction of Animals Born or Held in Captivity, dated June 3, 1992.
9. Detailed disposition records of all living or dead specimens must be maintained. Where applicable, proper animal identification techniques should be utilized.
10. It is the obligation of every loaning institution to monitor, at least annually, the conditions of any loaned specimens and the ability of the recipient to provide proper care. If the conditions and care of animals are in violation of the loan agreement, it is the obligation of the loaning institution to recall the animal. Furthermore, an institution's loaning policy must not be in conflict with this A/D Policy.
11. If live specimens are euthanized, it must be done in accordance with the established policy of the institution and the Report of the American Veterinary Medical Association Panel on Euthanasia (Journal of the American Veterinary Medical Association 218 (5): 669-696, 2001).
12. In dispositions to non-AZA members, the non-AZA member's mission (stated or implied) must not be in conflict with the mission of AZA, or with this A/D Policy.
13. In dispositions to non-AZA member facilities that are open to the public, the non-AZA member must balance public display, recreation, and entertainment with demonstrated efforts in conservation, education, and science.
14. In dispositions to non-AZA members, the AZA members must be convinced that the recipient has the expertise, records management practices, financial stability, facilities, and resources required to properly care for and maintain the animals and their offspring. It is recommended that this documentation be kept in the permanent record of the animals at the AZA member institution.
15. If living animals are sent to a non-AZA member research institution, the institution must be registered under the Animal Welfare Act by the U.S. Department of Agriculture Animal and Plant Health Inspection Service. For international transactions, the receiving facility should be registered by that country's equivalent body with enforcement over animal welfare.
16. No animal disposition should occur if it would create a health or safety risk (to the animal or humans) or have a negative impact on the conservation of the species.

17. Inherently dangerous wild animals or invasive species should not be dispositioned to the pet trade or those unqualified to care for them.
18. Under no circumstances should any primates be dispositioned to a private individual or to the pet trade.
19. Fish and aquatic invertebrate species that meet ANY of the following are inappropriate to be disposed of to private individuals or the pet trade:
    a. species that grow too large to be housed in a 72-inch long, 180 gallon aquarium (the largest tank commonly sold in retail stores)
    b. species that require extraordinary life support equipment to maintain an appropriate captive environment (e.g., cold water fish and invertebrates)
    c. species deemed invasive (e.g., snakeheads)
    d. species capable of inflicting a serious bite or venomous sting (e.g., piranha, lion fish, blue-ringed octopus)
    e. species of wildlife conservation concern
20. When dispositioning specimens managed by a PMP, institutions should consult with the PMP manager.
21. Institutions should consult WCMC-approved RCPs when making disposition decisions.

V(b). Disposition Requirements – dead specimens: Dead specimens (including animal parts and samples) are only to be disposed of from an AZA member institution's collection if the following conditions are met:

1. Dispositions of dead specimens must meet the requirements of all applicable local, state, federal and international regulations and laws.
2. Maximum utilization is to be made of the remains, which could include use in educational programs or exhibits.
3. Consideration is given to scientific projects that provide data for species management and/or conservation.
4. Records (including ownership information) are to be kept on all dispositions, including animal body parts, when possible.
5. SSP and TAG necropsy protocols are to be accommodated insofar as possible.

VI. Transaction Forms: AZA member institutions will develop transaction forms to record animal acquisitions and dispositions. These forms will require the potential recipient or provider to adhere to the AZA Code of Professional Ethics, the AZA Acquisition/Disposition Policy, and all relevant AZA and member policies, procedures and guidelines. In addition, transaction forms must insist on compliance with the applicable laws and regulations of local, state, federal and international authorities.

Appendix C: Clinical Pathology and Blood Chemistry Values (ISIS)

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	13.37	4.379	5.000	31.20	649	301
RED BLOOD CELL COUNT	*10^12/L	7.86	1.23	3.80	15.40	567	272
HEMOGLOBIN	g/L	130	20	44	230	590	269
HEMATOCRIT	L/L	0.388	0.053	0.248	0.540	677	307
MCV	fL	49.8	4.2	21.4	76.0	559	266
MCH	pg/cell	16.7	1.5	7.2	27.2	539	254
MCHC	g/L	335	27	224	497	582	263
PLATELET COUNT	*10^12/L	.2800	.1090	.0000	.6060	137	75
NUCLEATED RED BLOOD CELLS	/100 WBC	1	2	0	11	49	38
RETICULOCYTES	%	0.0	0.1	0.0	0.2	20	12
SEGMENTED NEUTROPHILS	*10^9/L	10.00	3.699	0.038	26.50	592	266
LYMPHOCYTES	*10^9/L	1.998	1.232	0.007	8.340	599	272
MONOCYTES	*10^9/L	0.482	0.383	0.000	2.912	511	250
EOSINOPHILS	*10^9/L	0.464	0.413	0.000	2.880	503	243
BASOPHILS	*10^9/L	0.088	0.089	0.000	0.386	100	66
NEUTROPHILIC BANDS	*10^9/L	0.686	1.411	0.000	11.20	198	133
ERYTHROCYTE SEDIMENTATION RATE		14	0	14	14	1	1
CALCIUM	mMol/L	2.48	0.50	0.00	12.70	624	281
PHOSPHORUS	mMol/L	1.78	0.42	0.00	3.13	576	266
SODIUM	mMol/L	151	8	0	166	568	259
POTASSIUM	mMol/L	4.4	0.5	0.0	6.0	569	262
CHLORIDE	mMol/L	119	5	98	138	505	232
BICARBONATE	mMol/L	15.3	4.3	0.0	23.0	47	26
CARBON DIOXIDE	mMol/L	15.8	3.1	9.0	24.0	201	120
OSMOLARITY	Osmol/L	.3000	.0590	.0000	.3420	56	40
IRON	µMol/L	14.32	11.64	1.253	81.62	59	36
MAGNESIUM	mMol/L	0.679	0.284	0.000	1.140	38	29
BLOOD UREA NITROGEN	mMol/L	11.42	3.213	4.641	25.35	629	287
CREATININE	µMol/L	230	62	0	424	605	272
URIC ACID	mMol/L	0.012	0.018	0.000	0.095	254	123
TOTAL BILIRUBIN	µMol/L	3	3	0	31	571	269
DIRECT BILIRUBIN	µMol/L	2	2	0	5	175	96
INDIRECT BILIRUBIN	µMol/L	2	3	0	29	175	96
GLUCOSE	mMol/L	6.771	2.054	.0000	13.60	622	287
CHOLESTEROL	mMol/L	4.429	1.166	1.425	8.392	523	245
TRIGLYCERIDE	mMol/L	.4972	.3277	.0452	3.831	315	147

Reference Ranges for Physiological Data Values							
Test	Units	Mean	St. Dev.	Minimum Value	Maximum Value	Sample Size[a]	Animals[b]
CREATINE PHOSPHOKINASE	U/L	333	516	25	5261	229	128
LACTATE DEHYDROGENASE	U/L	142	135	21	917	344	172
ALKALINE PHOSPHATASE	U/L	33	36	0	168	582	269
ALANINE AMINOTRANSFERASE	U/L	51	25	0	195	573	263
ASPARTATE AMINOTRANSFERASE	U/L	38	23	0	173	589	271
GAMMA GLUTAMYLTRANSFERASE	U/L	3	3	0	17	251	122
AMYLASE	U/L	237.4	149.7	.0000	740.4	216	107
LIPASE	U/L	1.668	2.502	.0000	6.950	51	37
TOTAL PROTEIN (COLORIMETRY)	g/L	74	7	54	97	589	265
GLOBULIN (COLORIMETRY)	g/L	41	7	22	67	518	236
ALBUMIN (COLORIMETRY)	g/L	33	4	20	53	529	244
FIBRINOGEN	g/L	1.190	1.050	.0000	4.000	62	20
GAMMA GLOBULIN (ELECTROPHORESIS)	g/L	28	10	19	41	6	6
ALBUMIN (ELECTROPHORESIS)	g/L	31	3	27	36	6	6
ALPHA-1 GLOBULIN (ELECTROPHORESIS)	g/L	0.005	0.001	0.004	0.005	4	4
ALPHA-2 GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.001	0.007	0.010	4	4
BETA GLOBULIN (ELECTROPHORESIS)	g/L	0.008	0.002	0.005	0.010	4	4
TESTOSTERONE	nMol/L	242.6	325.3	36.78	617.7	3	3
PROGESTERONE	nMol/L	.1336	.2216	.0191	.5279	5	5
ESTROGEN	nMol/L	65.48	21.33	28.11	93.69	7	4
TOTAL TRIIODOTHYRONINE	nMol/L	1.035	0.671	0.011	2.141	8	6
TOTAL THYROXINE	nMol/L	18	8	6	31	10	8
Body Temperature:	°C	38.3	1.1	36.0	41.9	391	208
Weight: 0-1 days age	Kg	1.224	0.237	.7300	1.600	28	27
Weight: 0.9-1.1 months age	Kg	4.144	0.493	2.841	5.000	22	22
Weight: 5.4-6.6 months age	Kg	28.94	5.53	15.50	38.10	25	20
Weight: 0.9-1.1 years age	Kg	80.16	14.46	54.20	102.7	12	12
Weight: 1.8-2.2 years age	Kg	125.5	27.1	79.40	190.9	31	29
Weight: 2.7-3.3 years age	Kg	141.9	39.9	79.80	237.0	37	33
Weight: 4.5-5.5 years age	Kg	148.3	32.4	103.0	213.6	47	40
Weight: 9.5-10.5 years age	Kg	169.3	38.3	100.0	221.8	58	35
Weight: 19.0-21.0 years age	Kg	139.4	16.3	110.0	184.0	19	9

[a] Number of samples used to calculate the reference range.
[b] Number of different individuals contributing to the reference values.

Appendix D: Husbandry Survey Summary

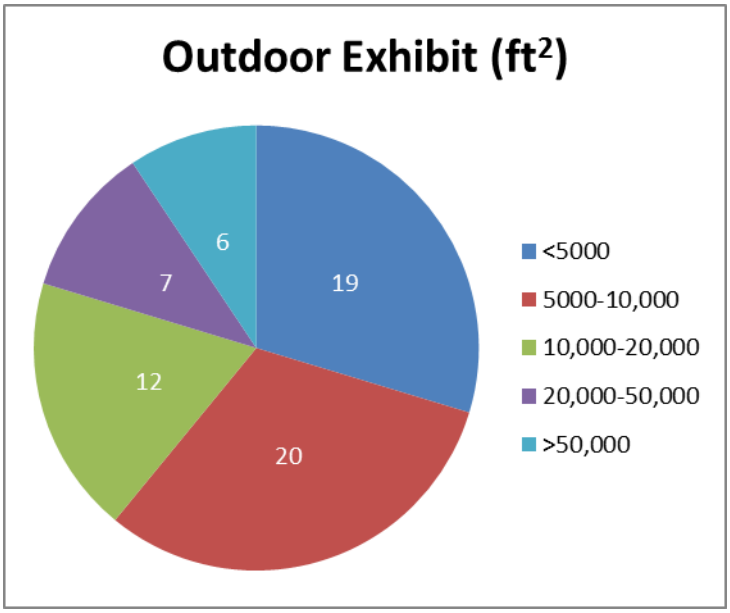
Lion Husbandry Survey

In December 2009, and extensive survey was sent to all AZA Lion SSP Institutional Representatives (IRs). The survey covered all aspects of lion housing and care and was completed by 79 institutions, which represents about 80% of the AZA population.

This information was used in the writing of this manual and some additional information is summarized here. In many cases the SSP does not make a specific recommendation or state a minimum requirement but instead draws on what is the current best practice in AZA zoos. While regulations will continue to change and husbandry practices continue to improve, this survey represents the current state of lion husbandry.

Current and future lion holding institutions are encouraged to review this information when considering exhibit renovations, new exhibit design, and when reviewing and updating their husbandry practices.

Exhibits and Holding
"Exhibit" was defined as any space with public viewing and "Holding" included off-exhibit space. Both exhibits and holding can be indoor or outdoor.



Seven institutions indicated they have more than one outdoor exhibit, although some of these are part of a rotation with other species. Only five institutions reported having indoor exhibits.

Nearly all of outdoor exhibits were open top, with wall heights ranging from 10' to over 25'. The majority of exhibits had walls over 15' high with an overhang.

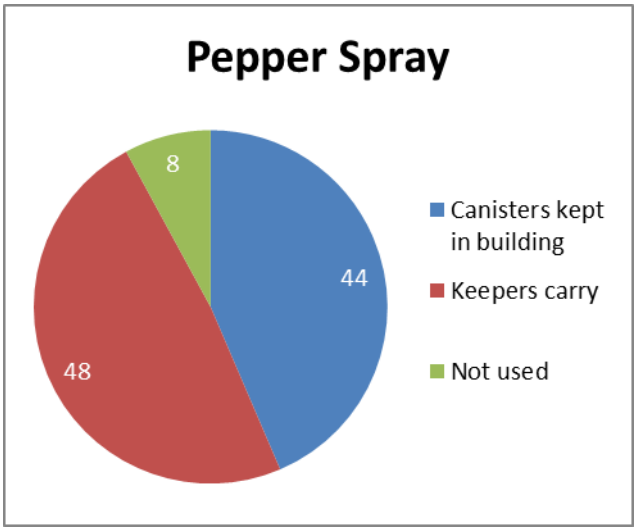
Twenty outdoor exhibits had water moat barriers that were 6'-15' deep. Twenty-nine exhibits had dry moats.

Only one institution used hot wire as a primary barrier but 48 use it to reinforce a primary barrier, protect vegetation, or restrict animal access to portions of the exhibit for various reasons.

About 1/3 of institutions had outdoor holding and many of those are a combination of indoor and outdoor holding areas. As with exhibits above, some of these spaces were shared with other species on rotational basis. Most indoor holding areas had 4 rooms or more and outdoor holding areas typically had fewer rooms than indoor.

Safety
Only 25% of respondents used a two-person rule in lion areas, and this procedure ranged from requiring two people all the time to only certain situations such as shifting. Over 75% of respondents allowed guests in behind the scenes for tours, but with various restrictions for age, group size, and location of the animals. Over half (60%) allow volunteers to work in lion areas but nearly all had age, experience and procedure restrictions.

Other safety procedures included cameras, signs indicating location of animals, alarm systems, lock-out procedures and requirements for notifying someone before shifting animals and/or entering the area. Some institutions keep CO_2 fire extinguishers, pepper spray, and/or weapons in building.



The majority of institutions use pepper spray, storing canisters in the building, carrying it with them, or both. No institutions reported intentionally discharging pepper spray to deter a lion, although several reported accidental discharges.

Safety procedures and recommendations are discussed in more detail in Chapter 2.2.

ANIMAL DATA TRANSFER FORM

1. Curator's copy of information on new arrival
2. Keeper's copy of information on new arrival Date:
3. Copy for zoo files and/or veterinarian

Please send a copy of this form to shipping institution and state condition of animal(s)

Previous Institution (s) _____
Current Institution _____
Contact Person _____
Title _____
Email _____ Phone/Fax _____
Receiving Institution _____

Common name: Scientific name:

Zoo ID#	House Name	Sex	Hatch/Birth Date*	Tattoo Band/Tag#	Weight*	Transponder	Studbook # (Regional/International)

*Note if it is actual or estimated

DIET: Present diet and supplements, favored items, problem foods, feeding procedures.

BEHAVIORAL HISTORY & SPECIFICATIONS: Please list any unique behavioral traits, problems with aggression, safety concerns, or other behavioral problems that may affect management.

General Disposition (skittish, prefers males over females, imprinted, aggressive, etc.):

Stereotypic behavior (frequency, severity, duration, triggers)

Methods used for managing stereotypic behavior:

Does the animal have a history of aggression towards keepers and/or other animals? ☐ no ☐ yes
If yes, please explain:

What are the conditions and behavioral precursors to the aggression?

What successful strategies are used for dealing with the aggression? .

General comments or describe other behaviors that require further explanation:

MEDICAL HISTORY OR PHYSICAL CONDITION: Medication techniques, immobilization techniques, chronic medical problems, Vet Contact.

ENCLOSURE DATA: Exhibit dimensions and description, disinfection/cleaning needs, temperature and climate control needs.

Exhibit Features: *(When offered or provided, please list or check where applicable. Add comments where necessary)*

Substrates: sand ☐ gunite ☐ mulch ☐ leaf litter ☐ soil ☐ other ☐

Exhibit Furniture: deadfall ☐ live trees ☐ rockwork ☐ perching ☐ termite mounds ☐ other ☐

Water features:

Holding Area: indoor ☐ outdoor ☐ none (see above) ☐

Substrates: sand ☐ mulch ☐ leaf litter ☐ soil ☐ other

Holding Furniture:

How frequently rotated:

SOCIAL HISTORY *(check all that apply)*

Rearing type: ☐ dam, parent or family reared ☐ hand reared (☐ with conspecifics ☐ without conspecifics) ☐ puppet
☐ supplemental ☐ foster reared (☐ by same species ☐ by different species) ☐ none ☐ autonomous
☐ colony/peer

Comments:

Animal housed:
☐ individually ☐ with conspecifics (list #_____) ☐ with mixed species [List species and # of each_____]
☐ other, please describe:

Housed on exhibit ☐ off-exhibit ☐ access to both ☐

Comments:

REPRODUCTIVE HISTORY: Relevant information, introduction techniques, behavior toward young, specific concerns.

ENRICHMENT HISTORY (Please attach any relevant schedules, approved item lists, sample calendars, etc.)

Goals for the enrichment:

Enrichment activities offered in exhibit:

Enrichment offered: daily ☐ weekly ☐ monthly ☐ scheduled ☐ other ☐

How frequently rotated:
Enrichment activities offered in holding (if different from those offered on exhibit)

Food Enrichment
Diet Presentation:
# of feedings per day: Varied times: ☐ When: Food scattered ☐ Hidden ☐

Novel Foods (please list or attach approved list of food items, frequency and amounts offered and presentation):

Enrichment Devices/Items

PVC feeders ☐ Tires ☐ Burlap/towels ☐ Plastic containers ☐ Puzzle feeders

☐ Cardboard boxes/tubes/bags ☐ Ropes/vines/fire hose ☐ Balls/kegs/barrels ☐ Toys (Kong®, dog chews, etc.)

Attachments methods used *(chain, rope, bungee)*:

Preferred enrichment for this animal (list):

Safety Concerns *(ingests cloth, has become impacted, displays at cage mates with large items, etc.)*:

General Comments (including expanding on any of the data entered, above):

TRAINING OR BEHAVIORAL CONDITIONING:
Training goals for this animal (list general behavioral goals and indicate which goals have been achieved and/or which goals were partially shaped but not complete at time of shipment):

How long has animal participated in a behavioral conditioning program?

Frequency and Duration of Training Sessions:
☐ once daily ☐ twice daily ☐ once weekly ☐ twice weekly
☐ other, please specify:

Average length of training session (minutes):

Animal attitude/demeanor towards/during training:

Level of contact between the keeper and animal: ☐ free contact ☐ protected contact

Social arrangement during training sessions:
☐ housed individually and trained individually ☐ separated from conspecifics for training
☐ trained with conspecifics present ☐ trained with mixed species present
☐ other, please describe:

Animal conditioned to enter crate/chute/cage for transport? (circle appropriate device*) ☐ No ☐ Yes

Length: Width: Height:

*Attach pictures if necessary to describe training area or device (crates, chutes, etc.).

Reinforcers: ☐ verbal ☐ food List type and amount used:
☐ tactile ☐ combination of all of the above

Bridging stimulus: ☐ clicker ☐ verbal, describe:
☐ whistle ☐ other, describe:

How are undesirable behaviors addressed? ☐ Time-out ☐ ignore ☐ re-direct ☐ incompatible behavior ☐ other (describe):

Which methods have been most successful?:

BEHAVIORS TRAINED (Please provide a brief summary – more detail can be added in subsequent section)

Behavior	Verbal cue/command	Visual cue	Criteria for reinforcement	Devices used

Please attach list of behaviors if more room is needed

General Training Comments: