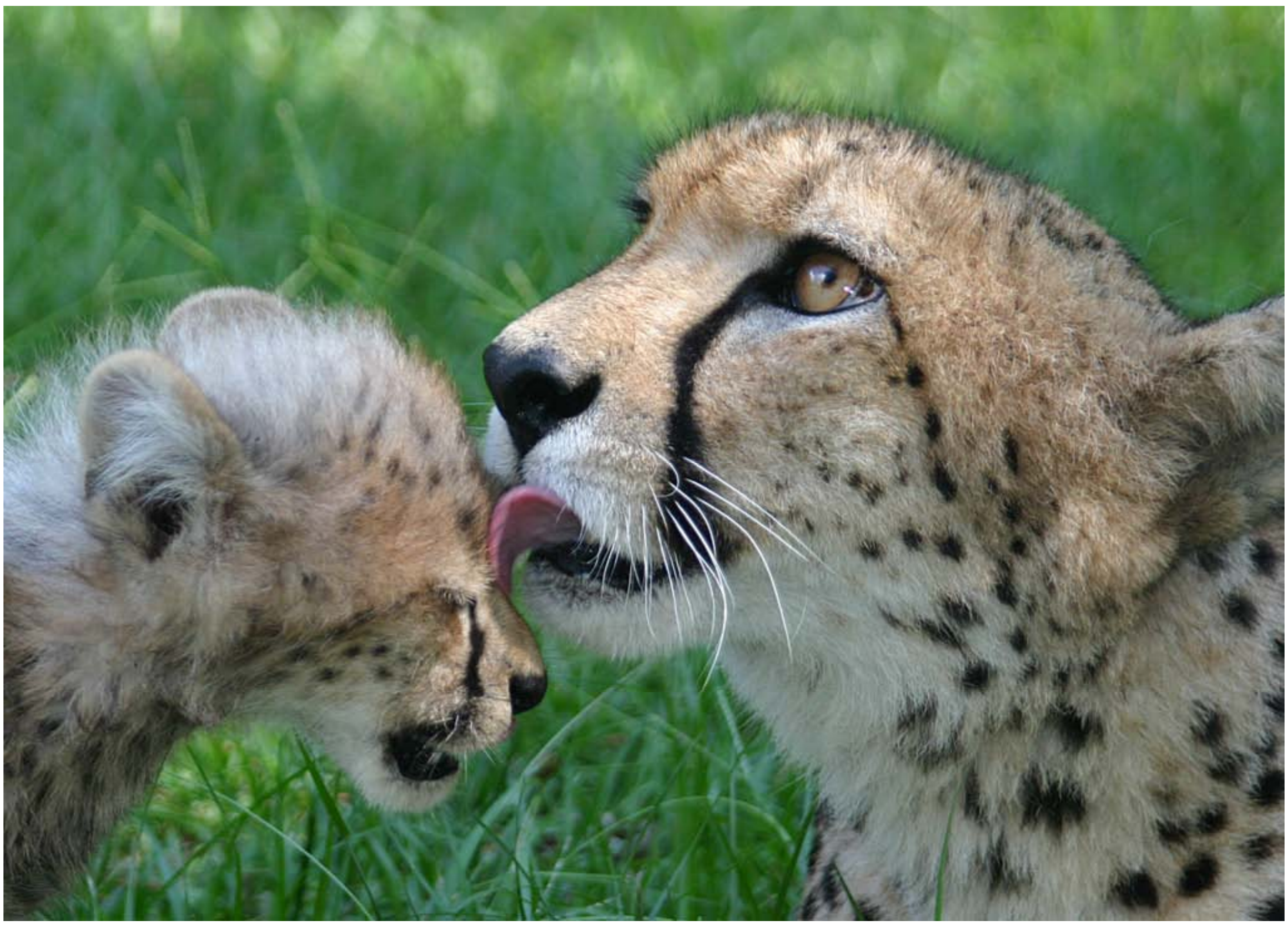
Husbandry Manual for the Cheetah

Acinonyx jubatus



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Cheetah Husbandry Manual
Volume III

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Overview of the Global Wild Cheetah Population

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2005

The status of the wild cheetah (*Acinonyx jubatus*) varies widely throughout its range with populations still occurring in perhaps only 32 countries of their total original range (Marker, 1998). All cheetah populations are classified as vulnerable or endangered by the World Conservation Union (IUCN) Red Data Book and are regulated by the Convention for International Trade in Endangered Species of Wild Fauna and Flora (CITES) as Appendix I (CITES, 1992). Although there has not been a comprehensive survey of African cheetahs since 1975, there is a consensus that the cheetah population is declining throughout the continent (Nowell & Jackson, 1996; Breitenmoser & Breitenmoser-Würsten, 2001). The number of cheetahs is currently estimated at < 15,000, which is based on a literature review and mail questionnaire surveys (Kraus & Marker-Kraus, 1991; Marker-Kraus & Kraus, 1996; Marker, 1998). These data have been used as the source for information that is also published in the IUCN Cat Specials group report, *Wild Cats* (Nowell & Jackson, 1996).

Free-ranging cheetahs inhabit a broad section of Africa including areas of North Africa, the Sahel, and eastern and southern Africa (Kraus & Marker-Kraus, 1991; Nowell & Jackson, 1996; Marker, 1998). Based on all current estimates, two strongholds remain for the cheetah: Kenya and Tanzanai in East Africa and Namibia and Botswana in southern Africa (Kraus & Marker-Kraus, 1991; Nowell & Jackson, 1996; Marker, 1998). In East Africa, the cheetah has been found to occur within the agriculture land of the Masai Mara region. This region is completely outside of the national parks and, interestingly, the inhabiting cheetahs were found to be co-existing with the Narok Masai, whose stock they left alone (Burney, 1980; Hamilton, 1986). Recent surveys conducted by Mary Wykstra and Sarah Durrant in Kenya and Tanzania, respectively, have indicated different challenges confronting cheetahs from surrounding communities resulting from livestock predation by cheetahs. In southern Africa, cheetahs are killed regularly in farming areas due to livestock predation and the negative perception of the farmers that their livestock is constantly under threat by cheetahs (Morsback, 1987; Wilson, 1987; Wilson, 1987; Stuart & Wilson, 1988; Lawson, 1991; Marker-Kraus et al., 1993; Marker-Karaus et al., 1996; Marker & Schumann, 1998; Marker et al., 2003). Conflict in southern Africa is also exacerbated by the increase in fenced game-farms and cheetah predation of valuable wild game animals (Marker, 2003; Marker et al., 2003). Over the past few years there is indication that cheetah populations have increased in Zimbabwe and South Africa bringing with it a reciprocal increase in conflict with livestock and game farmers (Van Dyke, pers. comm., 1999; Purchase, pers. Comm.., 2000). Several programs are now working actively towards censusing cheetah populations in southern Africa, Kenya and Tanzania (Bashir et al., 2004). Coordinating conservation and education programs also are being actively conducted in many of these countries (Bartels, et al., 2002).

Wild cheetah populations are nearly extinct in Asia, with approximately 100 animals surviving in small isolated areas throughout Iran (Nowell & Jackson, 1996; Marker, 1998; UNDP, 2001). There has been limited information from North or West Africa and the stability of the cheetah population in these areas is questionable (Marker, 1998; Breitenmoser & Breitenmoser-Würsten, 2001). As part of the IUCN Biodiversity Project, status surveys have been carried out in Algeria, Egypt, Libya, Morocco and Tunesia (Jackson, 2001). Cheetah populations were reported to occur in southern Algeria (O'Mopsan, 1998; Jackson, 2001) and in Egypt, where cheetahs were reported near the Libyan border, but surveys found no evidence in other parts of this former cheetah range (Saleh, 1997; Jackson, 2001). Interestingly, and unexpectedly, cheetahs have been reported in the tri-country W park in Niger, Burkino Faso and Benin (Van Syckle, 1996). In February 2005, a reconnaissance trip ventured into the D'Hoggars National Park in Algeria along with members of the Sahel-Saharan Interest Group on a mission to identify the presence of cheetahs in the area and to pin-point their survival risks (Wacher, et al., 2005). Park officials showed recent photos of live cheetahs as well as photos presented by a tour operator of a dead cheetah that had presumably killed livestock. During the reconnaissance trip, cheetah scat and cheetah marking trees also were found and recorded (Wacher, et al., 2005). Cheetahs continue to survive in small isolated groups throughout the Sahel, with a low estimate of 9,000 animals and an optimistic estimate of 12, 000 animals (Marker-Kraus et al., 1996; Nowell & Jackson, 1996; Marker, 1998). It has been suggest that, for the cheetah, individual numbers of animals may not be the important point, but rather the numbers of distinct viable populations in existence. Viable cheetah populations may in fact be found only in half or fewer of the countries where they originally ranged (Marker, 1998).

Over the past 30 years, the cheetah has suffered a devastating decline of available habitat and prey throughout its range. Further, as reported throughout Africa, cheetahs are not thriving in protected wildlife reserves due to increased competition from other larger predators such as lion and spotted hyenas (Laurenson, 1991; Morsbach, 1987; Mills, pers. comm., 1991, 2001; Caro, 1994; Marker-Kraus et al., 1996; Nowell & Jackson, 1996). Therefore, a large percentage of the remaining, free-ranging cheetah populations are outside of protected reserves or conservation areas (Marker, 1998). The cheetah traditionally has been considered to inhabit open country and grasslands. More recently, due to loss of natural habitat, cheetahs have been reported to use a wide variety of habitats and are more often observed in dense vegetation (e.g.: Kora Reserve in Kenya, Botswana's Okavango Delta, Serengeti woodlands and Namibian farmlands; Caro, 1994; Marker-Kraus et al., 1996; Marker, 2003). The last of these ecological systems is now considered highly vegetated due to recently developed extensive bush encroachment in the region (Muntifering, 2006).

The ability of the cheetah to adapt to a changing ecological system has been brought about primarily by conversion of its preferred habitat to farmland and is perhaps the critical question in estimating the population's survivability in Africa (Myers, 1975). In several studies during the past 25 years, the cheetah was reported to suffer a decrease in numbers as land developed and suitable habitat converted to agriculture (Wrogemann, 1975; Hamilton, 1986; Myers, 1975; Campbell & Borner, 1988; Wilson, 1988; Morsbach, 1987; Marker-Kraus & Kraus, 1990; Marker-Kraus et al., 1996; Nowell & Jackson, 1996). Factors determining cheetah survival include artificially small populations, restricted habitats with a limited prey base, conflict with nomadic herders and wars that have supplied guns and ammunition to the populace, which then poach all forms of wildlife for food and profit, poaching for pelts, and conflict with commercial livestock farmers and game farmers (Marker, 1998; Jackson, 2001).

Priorities for the Cat Specialist Group meeting in August 2001 (Breitenmoser & Breitenmoser-Würsten, 2001) include encouraging support for:

- a survey in North Africa, populations critically endangered due to fragmented habitats;
- a survey in Iran and the development of a conservation action plan for this region;
- the development of regional programs (Southern Africa, Central Africa, Northern Africa);
- a pan-African survey to refine population estimates and define current threats;
- conservation outside protected areas;
- conservation efforts to reduce livestock conflict;
- a census program in countries where cheetah trophy hunting is conducted;
- an increased need to develop prey base management throughout cheetah range;
- a tourism education program in parks to reduce stress (e.g.: Kenya);
- the increased cooperation between international captive population managers;
- a global master plan

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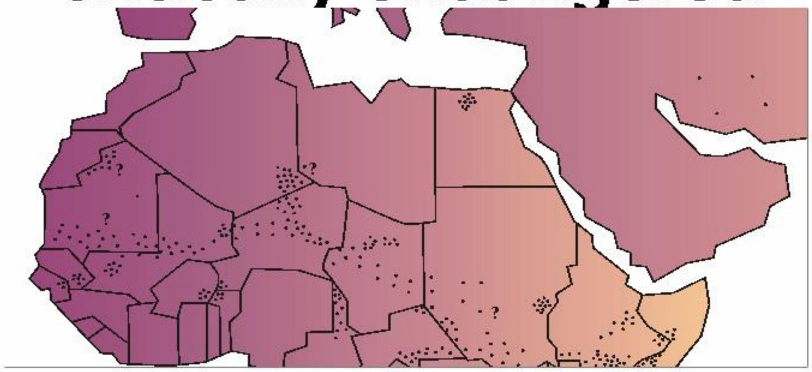
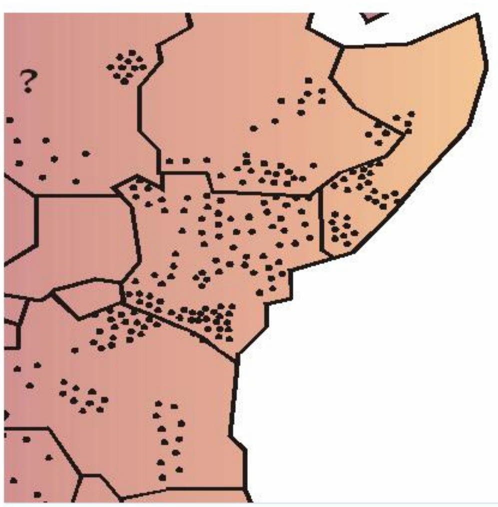
Cheetah populations that are critically endangered



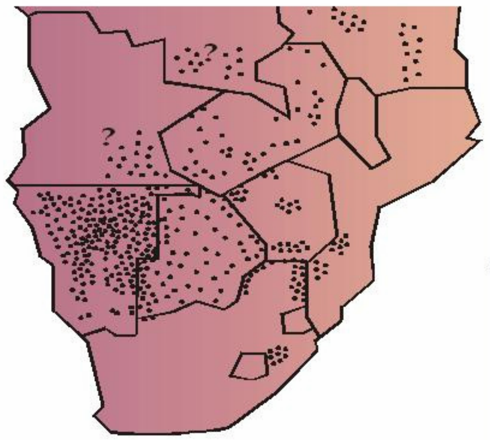
- North Africa and Asia: *A. j. venaticus* (<500)
- West Africa: *A. j. hecki* (~500)
- Central Africa: *A. j. soemmeringii* (500-1000)

East Africa
A. j. raineyii



- Kenya (~1000)
- Tanzania (~1000)
- Uganda (<50?)
- Somallia (<300?)

Southern Africa
A. j. jubatus



- Namibia (~3000)
- Botswana (~1500)
- South Africa (~1000)
- Zimbabwe (~1000)
- Zambia (~50)
- Mozambique (?)
- Malawi (?)
- Angola (?)

Position Statement on the Use of Program Cheetahs
Cheetah Species Survival Plan (SSP) – May 2006

The AZA Conservation Education Committee defines program animals as "… animals that are used outside their normal exhibit or holding areas for educational purposes; to help foster feelings of wonder, awe, and curiosity; or are intended to have regular physical contact with the public within their normal exhibits." Program cheetahs are generally leash trained cats habituated to people so that they can be safely handled and used with no barrier between them and the general public and/or cheetahs trained to perform behaviors for educational demonstrations.

Additionally, the Conservation Education Committee "supports the appropriate use of program animals as an important and powerful educational tool that provides a variety of benefits to zoo and aquarium educators seeking to convey cognitive and affective (emotional) messages about conservation and wildlife." The Cheetah SSP agrees with this statement and further acknowledges that the use of program cheetahs have been successful in increasing public awareness of the endangered status of the cheetah and the steps necessary for its future survival. The use of these cheetah cat ambassadors have also be instrumental in raising financial, political and public support for *insitu* and *exsitu* cheetah conservation.

The cheetah SSP also recognizes that inappropriate management or use of program cheetahs can have a negative impact on cheetah conservation and the SSP by removing animals from the managed captive population or by putting the cats, their handlers or the general public at risk.

Therefore, the cheetah SSP strongly supports the use of program cheetahs for education, public relations and fund raising under the following conditions:

Animals are acquired from sources consistent with the SSP management plan for the North American captive population. That is, cheetahs that are bred specifically to produce program animals from within the SSP managed population, cheetahs that are deemed surplus to the SSP managed population, or cheetahs that are acquired from reputable sources outside the SSP.

Use of cheetahs in programs is done in accordance with an Institutional Program Animal policy that:

1. Clearly identifies and justifies individuals approved as program animals.
2. Details their management (including safe handling procedures, training, animal health and welfare, etc.)
3. Outlines program objectives and parameters including appropriateness of program messages and venues.
4. Is consistent with AZA policy.

KING CHEETAH POLICY

The King Cheetah was first described by Pocock in the late 1920’s and has since been of great interest to zoologists. The first King Cheetahs to be borne in captivity were at the DeWildt Breeding Centre in South Africa during the 1980’s. In the late 1980’s, the first King Cheetah was imported by a North American facility and since then other institutions have imported King Cheetah.

The king cheetah is merely a color variant form of the common cheetah. The king coat pattern is controlled by a single gene, occurring in recessive form.

It is the ultimate goal of the Cheetah SSP to genetically manage the entire North American cheetah population. We do not oppose the importation of the King Cheetah into the captive population, but we are opposed to the deliberate inbreeding of this morph solely to promote the King Cheetah phenotype in North American facilities. We therefore recommend that the King Cheetah be managed only as an integrated part of the overall North American population and not bred to develop this phenotype.

De wildt Cheetah and Wildlife Trust; King cheetah

FACILITIES

The basic facility design is of the utmost importance for proper cheetah management and health care. From the outset, the team designing the structure should include input from a variety of disciplines from the veterinary staff, animal staff, architects, etc. Important considerations when designing a cheetah facility include: size, geometry, barriers, substrate, shelter, transfer areas, and climate which affect reproduction and health.

Enclosures for isolation and segregation should be incorporated into the enclosure design. All yards/exhibit spaces should be interconnected for easy transfer of cheetahs from one pen to another to allow for easy shifting for feeding, cleaning, observations/ monitoring, treatment or anesthesia. The use of guillotine doors and runway/chute systems to get cats from one place to another without crating or immobilizing them is highly recommended. Double door or secondary barriers are recommended to minimize the chance of escapes.

It is highly recommended that somewhere within the cheetah enclosure should include a squeeze or restraint cage to permit an alternative method of handling for procedures normally necessitating anesthesia. (see capture and restraint section) 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, or anesthetic drugs). The use of such a cage may be less stressful compared to the remote delivery methods such as darts or pole syringes. An accurate scale should be included in the off-exhibit area to allow for routine body weights so the animals condition can be monitored.

Housing cheetahs in small enclosures and/or in visual contact with other large carnivores has been anecdotally linked to stress related behaviors, medical conditions and reduced reproductive performance. Enclosures should be of an adequate size to allow for exercise and provide the animals with a variety of sites to stimulate activity. Enclosures should be as large as possible while still allowing for observation and management of the animals. Keeper viewing areas/slots, closed circuit television monitors and/or one-way glass aid in the management and observation of the animals. Exhibits should also be designed so that cats have adequate areas to retreat from the public.

It is also recommended that the cheetahs have visual contact with hoofed animals, by positioning the enclosure on a hillside or providing elevated areas for scanning to provide mental and visual stimulation. A wide view of the surrounding area, particularly of prey species, is thought by some to contribute to breeding success. Care must be taken that this proximity does not cause negative predatory or stress related behaviors (pacing fence lines or challenging barriers) or lead to escapes. This can be especially problematic when newborns are present in the prey species' enclosure.

Lighting optimally should be natural lighting or a combination of natural and artificial illumination.

Cheetahs are normally kept as single species exhibits, however, the Cleveland Zoo successfully housed cheetah with White Rhinoceroses (Ceratotherium simum) from 1989-1996.

Cheetahs housed with White Rhinoceroses at the Cleveland Zoo

ENCLOSURE DESIGN

It is recommended that you check your state regulations for enclosure requirements and the AZA 'Animal Care Manual' for enclosure size recommendations. The following are 'enclosure guidelines'.

Each individual cheetah has its own tolerance to stress with different living conditions. Some individuals are extremely laid back, seeming to adjust to just about any living condition, while others may be extremely high strung and reluctant to adjust. Therefore, it is recommended that you build your enclosures as large as possible.

Exhibit

Outdoor enclosure size varies widely between collections, as does the number of cheetah maintained in each enclosure. Where space is limited, elongated enclosures are preferable as they afford a greater opportunity for exercise. This would be especially important if you were planning on using a coursing lure in the exhibit.

Outdoor/ off exhibit

Off-exhibit enclosures are essential for proper management and health care. They allow for treatment areas and seclusion of a stressed or ill cheetah out of public view.

Holding yards maybe use for temporarily separating animals for cleaning or feeding, or night holding assuming that the animal also spends time in a larger enclosure with adequate area for them to exercise.
Cheetahs that are being introduced or pairs/groups that have not yet proven to be compatible, need much larger and complex enclosures with visual barriers and areas for animals to avoid each other.

Holding areas where more than one cheetah is fed need to be large and/or complex enough for cats to avoid each other while eating to prevent fights or dominant animals stealing feed. Separating cheetahs at feeding time is preferred.

Indoor holding / transfer area

Indoor facilities may be constructed for the housing and transfer of animals. These enclosures should be easily accessible to the outdoor facility. All animals should be able to be easily transferred from one indoor enclosure to the next with transfer doors operated from the keeper safety area. If animals are going to be locked in for a prolonged period of time, larger holding areas are highly recommended. Cheetahs seem to do much better when given free access to both indoor and outdoor facilities rather than being locked indoors.

Concrete floors with adequate drainage are recommended for ease in cleaning and disinfecting. Areas for easy collection of urine and feces should be considered. Bedding material such as straw, hay, or shavings (not cedar) may be used. Cheetahs like to be elevated so a raised platform should be provided for them to lie on. Any substrate used for platforms or floors should be easy to wash, quick drying and not slippery.

The surfaces must provide good traction, especially when wet, but not be so abrasive as to cause foot pad trauma. 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 chewing or scratching making it difficult to clean properly and can result in potential gastrointestinal foreign bodies if swallowed.

Proper ventilation is imperative in indoor areas to prevent the build up of ammonia, which can result in respiratory tract health problems.

BARRIERS
Cheetahs can be housed in open-topped enclosures behind moats (see water source) chain-link/wire mesh, solid walls, glass (lexan or acrylic) windows or a combination of these materials. Bars are not recommended since they may trap limbs or heads due to inadequate spacing and may permit trauma from adjacent cats.

"Glass front" exhibits (glass, lexan, plexiglass, etc.) have the advantages of providing an unobstructed and up close view of cats for zoo guests. Materials must be strong enough to withstand abuse from the public and should be minimally able to withstand the impact of a 150 lb object striking it at 60 mph. When introducing new cats to exhibits with glass viewing, visual barriers should be placed on the windows to prevent the cats from running into them because they are perceived as open space.

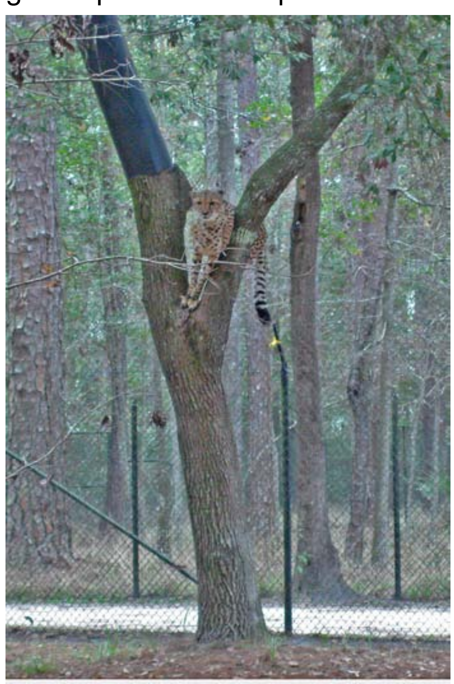
Solid walls can be used, but are more easily scaled and a greater height may therefore be required. When using a solid wall that does not have an overhang, it is recommended that the walls be a minimum of 12' high. Solid walls can be 10 ft high if they have a 2 ft overhang at 45 degree angle. The addition of electric wire along the top may help prevent escapes.

Cheetahs have been documented to jump 24' horizontally, so moats should be at least 25 ft wide. If the interior (cat side) surface of the exhibit is higher than the top of a moat wall, the width of the moat should be increased. Cheetahs can swim, so wet moats if used need to have an adequate barrier on the non exhibit side to prevent escapes. Wet moats should not be used in enclosures where young cubs will be housed.

Cheetahs are typically housed behind chain-link/ wire mesh. Wire mesh should be no lighter than 11 gauge and have spaces no larger than 2" x 4". Wire mesh barriers should be at least 8 ft tall with an inward, 45 degree overhang at least 24" wide. Wire mesh fences without an overhang should be at least 10 ft tall.
Cheetahs generally do not dig out of exhibits, so extensive dig barriers are not necessary; fences should be tight to the ground. Cheetahs will however take advantage of holes under fences dug by other animals so fence lines should be inspected regularly.

No matter what restraining material is used, the composition of the material and the external coatings applied must be non-toxic, non-irritating, or non-traumatic.

Adult cheetahs are not very agile and will rarely climb straight up vertical trees, but they can jump or climb up steeply angled trees, so care must be taken with trees growing near exhibit edges. Cheetah cubs are more agile and can climb up vertical trees and chain link fence. Collars should be placed on trees close to perimeter fences to prevent climbing and possible escapes. Collars may also be placed high up in a tree allowing cats access to the lower/safer parts of the tree while preventing them from going to high. Some cheetahs will get into a tree and are unable to figure out how to get down or may get injured in the process.



Any area that will be used to catch cubs for physical exams should be covered, as young cubs will climb just about anything to escape being captured.

Enclosures should not have corners tighter than 90 degrees or contain small spaces where cats can easily climb barriers or corner cage-mates.

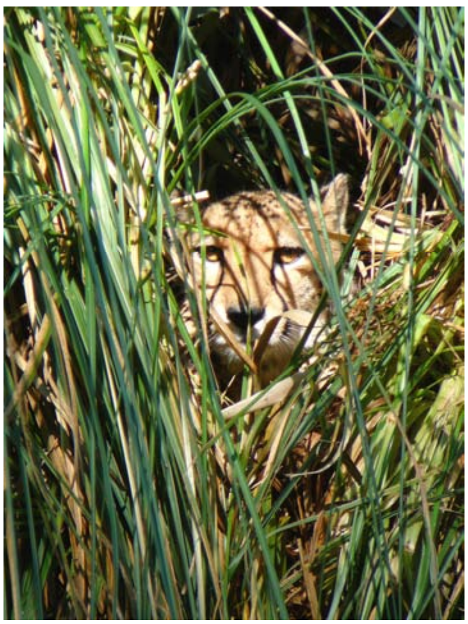
← *White Oak; collars on trees to prevent climbing*

SUBSTRATE & TOPOGRAPHY

Natural settings with vegetation, grasses, soil and forest litter provide good substrate for cheetah. The topography of the exhibit should be varied and naturalistic. Natural hiding areas, such as tall grasses and shrubs, should be included in the exhibit. There should be adequate shade, and seclusion.

Vegetation that hides exhibit barriers, creates visual barriers for the cats, provide shade, and otherwise enhance exhibit aesthetics are desirable exhibit features. Although cheetahs are carnivores, they (especially cubs) do sometimes consume exhibit plants so toxic species should be avoided. Toxic plant lists are easily accessible via the internet. (Some helpful sites include: http://www.ansci.cornell.edu/plants/ OR http://www.ces.ncsu.edu/depts/hort/consumer/poison/indcoa_e.htm).
Careful planning for exhibit plants is necessary to minimize hiding places for the cats that make observations or management of the cats difficult as well as hiding from guest viewing.

Varied terrain and furniture can greatly enhance a cheetah exhibit for both cats and viewers. Cheetahs like high areas where they have a good view of their surroundings. Earth/termite mounds, tree stumps, large rocks, elevated platforms, "play trees" or artificial structures that offer cheetahs an elevated surface will frequently be used by the cats as look outs, play areas and latrine areas.



White Oak; cheetah hiding in pampas grass

Saint Louis Zoo; cheetahs on artificial termite mound climbing structure

White Oak; cheetahs laying on large rocks on top of a hill

White Oak; cheetah play tree

White Oak; cheetah scratching tree

Logs or timbers allow the natural behavior of scratching for claw wear and maintenance.

The dirt substrate (in small enclosures/ holding areas) may become contaminated over time with microorganisms and parasites thereby exposing the cats to potential concentrations of pathogens. Contaminated substrate should be periodically removed and replaced with clean materials, or a cleansing regime could be followed to disinfect the substrate. Feces should be removed on a daily basis, as well as some of the soil around it. Animals that have been properly quarantined helps reduce the potential contamination load on the substrate, especially parasitic.

Enclosures can contain hard surface feeding pads (for ease of disinfecting), but cheetahs should not be housed on concrete or other hard surfaces for extended periods.

WATER SOURCE
Each enclosure must be provided with a water source that can be easily cleaned and is easily accessible to both the cheetah and keeper. Provisions should be made for the ability to monitor water intake and water deprivation in certain clinical situations, such as pre or post-anesthesia. The non-reservoir watering systems (such as lab animal self-waters) can malfunction and inadvertently deprive the cat of water, therefore must be checked daily. One facility reported using Lix-its with no problems once the cheetahs were conditioned to use them.

Phoenix Zoo; Adult cheetah swimming in moat

Shallow ponds, pools or streams add to the aesthetics of the exhibit and have been successfully used as watering sources. Aquatic components in the exhibits need to be designed for easily cleaning and sanitizing due to the tendency of some cats to defecate in water. These water sources must be drained if cubs are to be displayed in the exhibit to prevent accidental drowning.

DO NOT use rubber feed tubs for food/water bowls as cheetahs will chew on these. Ingestion of this material has proven fatal!

DISINFECTENTS
Disinfecting agents must be selected on the basis of effectiveness and low toxicity to cheetahs; they must not be used in concentrations exceeding the manufacturer's recommended effective dilution. Phenolic compounds must be avoided due to the susceptibility of felids to this chemical. For effective cleaning, hot water, a detergent plus physical effort is used to remove organic debris followed by or coupled with the disinfectant. In all cases, chemicals must be thoroughly rinsed to prevent animal exposure.

BREEDING FACILITIES

(see Behavior and Social Organization section for more information)

Facilities where cheetahs are to be bred should meet all of the requirements, be designed to hold large numbers of breeding animals, and allow for movement of animals for reproductive management (separation, mate selection, introduction, rotation through enclosures, etc.) as well as for birthing and housing cubs. Cheetah breeding facilities should ideally be off exhibit so management is not constrained by viewing hours and cats are not disturbed by the presence of large numbers of people. Cheetahs exhibit a high degree of mate selection, so having a facility that can hold a large number of cheetahs will greatly increase the odds of having compatible animals. Additionally, male and female cheetahs housed together or in close proximity for extended periods often form a sibling bond, become complacent and are less likely to breed. Facilities planning on breeding must allow for physical and visual separation of males and females. Smaller breeding facilities should consider building a separate holding facility located quite a distance from the rest of the cheetah collection.

The outdoor enclosure should measure one acre (43,560 sq ft) or more to be fully functional in the management of this species. This area should be subdivided into a main exhibit/breeding area and several holding yards for animals temporarily isolated/separated from the main exhibit. Cheetahs are often stimulated to breed by novel situations, so facilities should have maximum flexibility to move cheetahs into different enclosures and social groups.

Institutions should be prepared to house any offspring until they are placed by the SSP, which can be up to two years.

MATERNITY ENCLOSURES / DENS

(see Reproduction: Gestation, Maternal Behavior and Cub Development for more information regarding pregnant females)

Although a few institutions have reported reproduction in cheetahs housed in olfactory and visual contact with other carnivores, we recommend that they be isolated from these species.

A maternity area must be incorporated into all facilities that plan on breeding cheetahs. It should be adjacent to the females' enclosure so that she may access it and familiarize herself with the area prior to being confined to it for cubing. Maternity areas should be isolated from other enclosures and the public.

This area should contain at least two suitable maternity dens to allow the female to periodically move her cubs, as is typical in the wild. The location of the dens should be easily accessible to the keepers.

The dens must provide a secure, dry, warm and secluded environment for the birth and care of the cubs. Dens should allow the female to stand, turn and lay down with her legs out-stretched.

Wood floors are the most commonly used but can be difficult to clean and may become tainted with urine. Concrete floors will withdraw to much body heat and not recommended for birthing. Bedding material should be provided (straw, hay or shavings).

It is helpful if the dens contain both a front and rear access door so keepers/vet staff can access cubs for exams without going through the same door normally used by the mother.

Video monitoring equipment (with infrared capabilities) is strongly recommended for remote viewing.

SHELTER REQUIREMENTS

All outdoor enclosures must have shelter or access to indoor areas to escape inclement weather. A variety of commercially available shelters can be purchased, such as Calf-tel hutches, or you may construct your own den/shelter.

Healthy cheetahs do not need air conditioned or otherwise cooled shelters, but must be provided with access to shade in hot weather. Healthy cheetahs are surprisingly able to withstand low temperatures and can be kept in areas where temperatures drop below freezing if provided with a dry, well bedded, well insulated, wind proof shelter that is small enough to be warmed by the animal's body heat. In areas where temperatures routinely stay below freezing for extended periods, supplemental heat should be provided. Refrigerator flaps / freezer curtains have been used on cheetah den openings to block wind and retain heat. If chewing occurs then the flaps should be removed.

Care should be taken in cold climates that each cheetah has access to their own shelter so dominant animals do not exclude others from using a shelter. During cold periods, cheetahs have been observed to grow long coats and to consume an increased amount of food. Cheetahs are less able to withstand damp environmental conditions and therefore, heated areas must be provided. Heat may be provided through either electric heat in the floor, radiant heaters, heat lamps, forced air heat, or heat pads.

Fossil Rim Wildlife Center cheetah dens

Wildlife Safari cheetah den

San Diego Wild Animal Park Calf-tel hutch

White Oak cheetah dens/ shelters

Fossil Rim indoor cheetah area

EXERCISING CHEETAHS ON A LURE COURSING SYSTEM

Employing the use of a lure courser system to exercise cats can be an excellent addition as a management tool for any cheetah program. In addition to being a great tool for enrichment, running cheetahs can be a marvelous opportunity for public education and fund raising.

What is "lure coursing"?

Lure coursing is modeled after the greyhound lure system used on race tracks. It is a method of providing exercise/enrichment to any animal that has a high prey drive. Since they are so highly visual and naturally attracted to small quick moving objects, most cheetahs will voluntarily go after the lure.

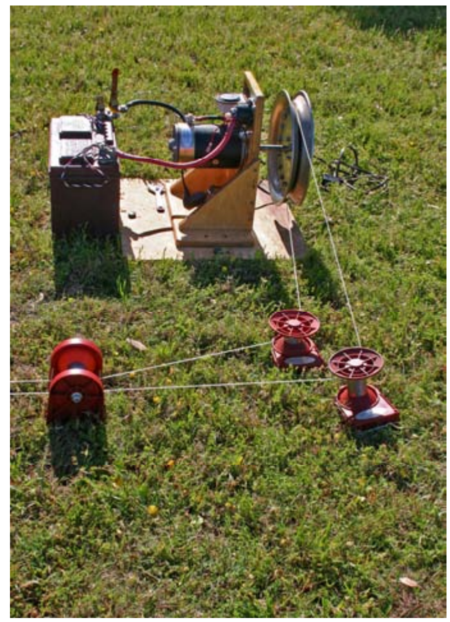
Several institutions use the Injoy system as a model which consists of a car starter motor operated by a hand held trigger switch (plugs into the motor machine), a string with a lure (cloth, or animal hide) that is pulled around a track at speeds of around 50 mph. The motor is powered by a regular car battery, although a deep cycle marine battery will last longer given the wear put on it from this particular type of motor.

There are numerous institutions using a lure system and it is highly recommended that you contact an experienced lure user before using one for the first time. Here are just a few you may wish to contact for further information: Cincinnati Zoo, White Oak Conservation Center, San Diego Wild Animal Park, Smithsonian National Zoo, Toledo Zoo, Caldwell Zoo, Chehaw Wild Animal Park, and Binder Park.

What equipment will I need ?
This equipment can be purchased through Injoy Wood Products www.injoy-1.com or MapleCreekRacing.com. Some facilities have developed their own system of a lure course, powered by electricity, battery or even an exercise bicycle for considerably less money.

First you need an enclosure large enough to set up a track. There should be at least two 50 yard straight lines to allow cats to get up to speed – although the larger and more elaborate the course, the better for a sufficient exercise session. Lure coursing equipment needed are as follows:
Standard OR reversible Lure machine (motor, trigger, cooling fan)
Battery
Pulleys (for guiding the string)
String (nylon or polyester)
Lures (T-shirt cloth/rags, felt, dog toys, and plastic bags are some of the lures used but non-digestible lures have been eaten and come with great risk! Digestible items such as rabbit, rat, deer, or Alpaca fur/hide or paper bags are highly recommended).

Bike system at Caldwell Zoo



Injoy System

National Zoo

What precautions should be taken when lure coursing cats?

The weather should always be a factor in determining when and if to exercise. Heat / humidity, cold and rain should all be considered since it can greatly effect the condition of the track and health risks to the cheetahs. Each facility that runs cheetahs have their own safety guidelines that are appropriate for their climate. The general consensus is that they do not run cats in the hot afternoons or in wet/muddy conditions.

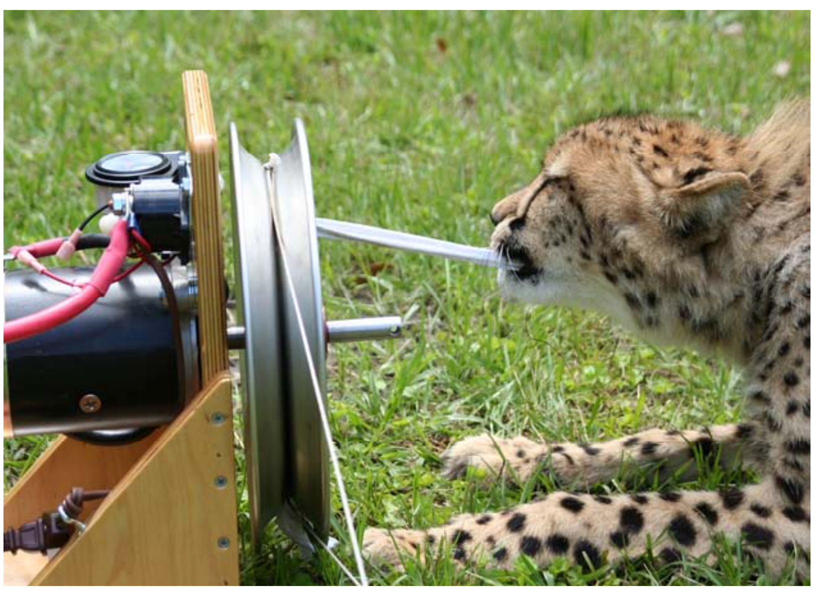
White Oak Conservation Center: Running multiple cats

Considerations should also be given to how frequently any individual cat is exercised. There is a chance for various muscular & skeletal injuries, therefore some conditioning would be helpful in minimizing these problems.

Cheetahs may be run on the lure as a single cat, multiple cats, and even cubs as young as 5-6 months have been run with no problems.

Most facilities that run cheetah use the 'continuous loop' course, while two facilities reported using the drag system/ strait racing set up.

While injuries are rare, they do occur; such as string burns on the legs or foot pads as well as pulled/strained muscles. It is important to give breaks as some, especially young cats, do not know when to stop and could over heat.

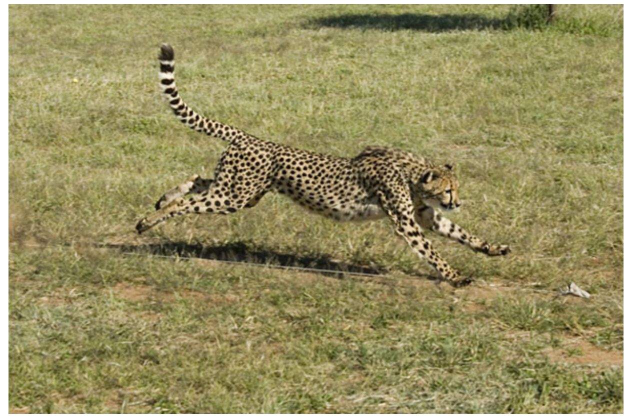


Hand-reared cheetah messing with the lure system!

If you are running 'hand-reared' cheetahs you may want to consider setting up the lure machine outside the enclosure and run the string through the fence, as many will focus on the equipment and want to chew on it.

It is a good idea for the staff carrying out the exercise session to be inside the enclosure with the cat(s) to be able to monitor them closely. Staff is then readily available to fix any problems that may arise, such as a broken string, or cats catching the lures or worse getting caught in the string. All staff that enter the enclosure should have a stick or device for keeping the animals at a safe distance, and either a knife or scissors to cut the string if an animal becomes entangled. By using the drag system / strait racing set up it will minimize your cats exposure to the string and thus reduces chances for string injuries.

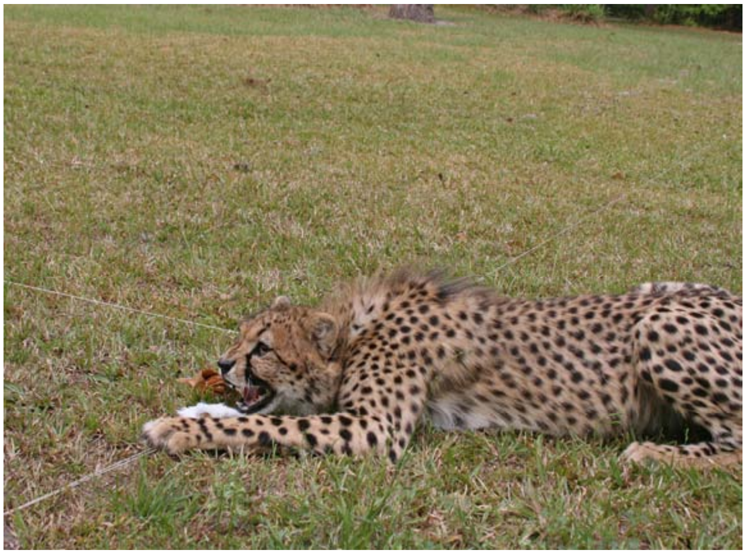
When setting up the track (especially the corners) it is very important to remember that some cats will become seriously focused on the lure and may run into objects such as fences, trees, and even the lure machine. Varying the track set up will help to keep some cats from getting bored or from anticipating the direction.



Cheetah Conservation Fund, Namibia

Cincinnati Zoo & Botanical Garden
Cat Ambassador Program

Chehaw Wild Animal Park



Cheetah with captured lure

Baiting cheetah off lure

Hand-reared cheetah; reluctant to let go of captured lure!

Baiting cheetahs off lure

Care must be taken when retrieving a captured lure. The personality of the cat, and the type of lure utilized will greatly influence the method used for retrieving the lure (food distraction/reward, toys, etc.). Most mother-reared cheetahs will release a captured lure with just the approach of the keeper but some hand-reared cats can be unwilling to let go. Some individuals can be extremely aggressive with a captured lure. Do not attempt to pull the lure from the cat's mouth with your hand! It is important to give them a minute or two to calm down and then offering a food treat in a bowl, long-handled spoon or pan attached to a stick usually works well. If a digestible lure is used then you can let them eat it or run off with it as a 'reward' thus avoiding any confrontation.

BEHAVIOR and SOCIAL ORGANIZATION

Cheetahs have historically been difficult to breed in captivity and as a result, some genetic lineages and age classes are disproportionately represented in the captive population. Breeding success must continue to improve if we are to maintain a healthy population in U.S. zoos.

Breeding success is associated with widely varying husbandry practices and no single method has proven successful across institutions (Caro, 1993). Inappropriate husbandry and management techniques are regarded as prime factors contributing to low breeding success (Lindburg et al., 1993; Caro, 1994; Brown et al., 1996). Breeding cheetahs requires a good understanding of cheetah behavior, a firm commitment from the institution, and good communication between animal managers and keeper staff. In any cheetah breeding program, keepers should be assigned to cheetah's long term so they learn the temperaments and behaviors of the individual animals. Keepers should also have the authority to proactively manage the animals; that is to move animals and do introductions based on behavior observations.

The following information and recommendations are based upon the collective experience of several animal managers who have worked extensively with cheetahs.

VOCALIZATIONS

One of their most distinctive calls is *yipping*, a high-pitched barking call that cheetahs use to locate one another. Mothers yip to find lost cubs and adolescent litter mates or male coalition members yip when separated from one another. In cubs, yipping sounds like a bird cheeping and is usually called *chirping.* Lost cubs chirp and also use this vocalization in moments of social stress. A variation of yipping, the *yelp* is used by adults when fearful. Cheetahs also *churr* (also known as *stuttering or stutter-barking*) during many social encounters. Cheetahs may churr as a social invitation, to express interest /anxiety, uncertainty or appeasement. Cheetahs *growl, hiss* and *spit* when annoyed or frightened. They also *purr* in pleasant social exchanges. (L Hunter, D Hamman, 2003)

SOCIAL GROUPING

Cheetahs that are not recommended for breeding may be housed in compatible mixed-sex pairs/groups with reliable birth control. (See chapter on birth control methods)

White Oak Conservation Center
Male coalition investigating a female enclosure for estrus

Males may be housed alone, or in a coalition of two or more individuals. Coalitions (alliances) are made up of littermates or compatible males. Unrelated adult males have been successfully introduced (See section on male introductions). Compatibility depends largely on the age and personality of the individuals involved and the size and quality of space provided. It is highly recommended that sibling males remain in life-long coalitions. (See section on coalitions). This type of management replicates how males live in the wild, and if coalitions are separated, extreme and unnecessary stress may be brought upon them. Coalitions conserve space and as a group they are more efficient at investigating enclosures for estrus. Coalition members appear more behaviorally "confident" than males that live alone, perhaps because they can rely on support in social situations. Confidence might contribute to enhanced reproductive performance.

Females may be housed in one of three ways: alone, with offspring, or in compatible female groups, though most adult females prefer to live alone. If reproduction is the goal, females should be housed alone, since studies have shown that forced social living with other females may lead to reproductive suppression (NC Wielebnowski et al., 2002).

While some pairs or mixed groups living together for long periods of time may eventually reproduce, this is a rare occurrence. Given the highly solitary nature of the female cheetah in the wild, the question arises whether or not close social proximity in captivity results in physiological suppression; chronic stress from the constant presence of conspecifics, or suppression in the presence of other females.

MATE SELECTION

Consideration should be given to the genetic representation of individuals, but realizing that there is a strong mate preference, among both sexes, with this species. Not all introductions will result in a breeding so it is important to have a sufficient number of unrelated animals available to enhance the possibility of successful pairings. We strongly recommend that a non-reproductive individual, after approximately two to three years be transferred to another AZA facility where other mates are available. All transfers must be approved by the cheetah SSP. A female that has not reproduced by 8-9 years of age is unlikely to get pregnant and should not be considered for a transfer for the sole purpose of breeding.

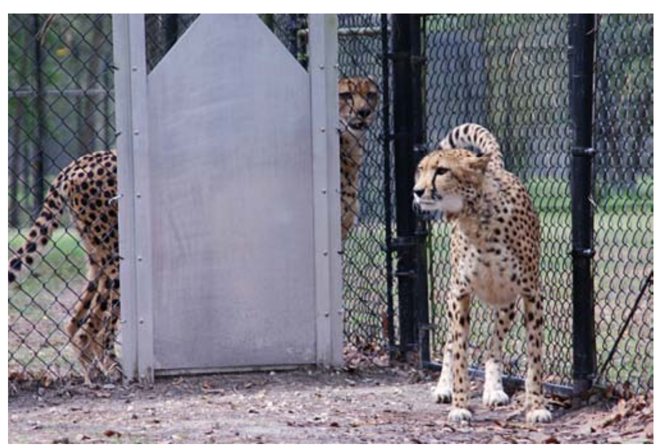
Male and female enclosures must be located in separate areas of the facility, or at least out of visual contact. The degree of necessary separation may vary from complete to only visual isolation. A solid wall may or may not be enough “separation” for some pairs. This is very important, as it seems that potential mates, who have become familiar with one another, quickly lose interest in mating. You must avoid over-familiarity with potential partners.

Some males will vocalize to a particular female that they ‘like’ (especially if they have bred before) regardless of her interest and apparent reproductive status. These “false responders” will repeatedly display interest in a specific female on almost every occasion. The consequences of introducing a pair with a false responding male are probably minimal.

Rolling

Face rubbing

Urine spraying (marking)



Soliciting / Lordosis posturing

COURTSHIP BEHAVIOR

A major factor contributing to poor breeding success is the difficulty in reliably identifying estrus based on the female's behavior to know when to proceed with an introduction. (e.g., Foster, 1977; Sarri, 1992). Some females, especially novice animals, may show no behaviors indicating estrus. Behavioral signs of estrus in the female vary greatly from one individual to the next and may include, but are not limited to the following:

- Rolling, face rubbing, urine spraying, vocalizations (chirping, stutter calling), ceasing to eat, Lordosis / copulatory posture

Cheetahs are polyestrous mammals. This means that they show reproductive receptivity (estrus) many times throughout the year. No seasonal patterns have been identified with regard to estrus cycle frequency. Cheetahs' estrus cycles are generally shorter than the ones reported for other large felids. However, there is considerable inter- and intra-individual variation in cycle length and length of estrus. Estimates of cycle length reported by various studies measuring vaginal cytology and hormone concentrations in plasma or feces, range from 5-30 days with an average cycle length of 11-14 days (as compared to 20-30 in other large felids) (e.g., Asa et al., 1992; Brown et al., 1996; Wielebnowski et al., 2002). The duration of estrus (i.e., period of sexual receptivity) also varies substantially from 1-18 days with an average of 3-4 days (Brown et al., 1996; Wielebnowski et al., 2002).

Several behaviors may be associated with a rise in estradiol levels (estradiol is the main reproductive hormone associated with estrus) during estrus: rubbing, rolling, urine spraying, sniffing, and vocalization (Wielebnowski and Brown, 1998). All these behaviors are associated with estrus "advertisement", either through scent marking or audible signals (e.g., meowing, chirping). A rise in behavioral frequency can sometimes be used to identify estrus activity. However, females do vary in the type and combination of behaviors that indicate estrus. While one female may vocalize more, another may show urine spraying. Also, the intensity of behavioral expression may increase with age (Wielebnowski and Brown, 1998). While estrus indicates female receptivity, ovulation in cheetahs usually only occurs after copulation. This phenomenon is called induced ovulation and is common among felid species. Some data indicate that certain social or environmental 'triggers' (e.g., moving a female next door to a male, or a male displaying courtship vocalizations) may occasionally stimulate ovulation in cheetahs (Brown et al., 1996).

Prolonged anestrus (i.e., no physiological estrus) has been observed in some captive female cheetahs lasting anywhere from 2-5 months (Brown et al., 1996). One study showed that females housed in pairs for prolonged time periods appeared to exhibit reproductive suppression (physiological anestrus) (Wielebnowski et al., 2002). After the females were separated, their estrus cycles resumed, however, in all cases of observed reproductive suppression agonistic behaviors (e.g., growling, hissing, displacement and other, mostly low level aggressive behaviors) were also present. It is therefore advisable to carefully monitor behavioral interactions in co-habiting females to identify even subtle forms of aggressive interactions which could underlie some of the observed reproductive suppression. In the wild, female cheetahs are largely solitary and cover vast territories in pursuit of prey. Given the observed incidences of reproductive suppression it may also be advisable to keep females housed in separate enclosures, especially when enclosures are relatively small and individuals are forced to interact frequently.

In the wild, adult females are not territorial and travel very broad distances. This allows the female a continuous change of scenery, along with "trespassing" though multiple male territories. In captivity however, females can become physiologically stagnant due to limited changes to her environment. Ways to jump start a previously quiescent (inactive or still; dormant) female into estrus include but are not limited to the following:

- Periodic visual, olfactory contact with otherwise unfamiliar/ separated males.
- Change in surroundings

Males are often used for estrus detection since the female's behavior alone is often times not enough to indicate estrus. Since estrus may occur very soon after a change is made, investigation of her enclosure should begin within one to two days following the change and continue daily for one to two weeks before another "change" is made.

It appears that it is entirely possible to "over stimulate" cheetahs and care must be taken to give them periods of shut down or quiet time. The amount of time necessary for these breaks will vary among individuals and may range from a few weeks to many months.

Males may or may not detect estrus from a common fence-line. Therefore, it might be necessary for the males to enter all or part of her enclosure for olfactory investigation. Having alleyways that join the enclosures affords easy and stress-reduced transfers. The female will need to be moved to another area while the male investigates her enclosure. It is best (but not always necessary) to move the female into an area that keeps her out of sight while the male(s) investigate her enclosure. This helps to prevent the males from getting distracted by or aggressive with the female before they have had the chance to investigate her enclosure. Letting the female investigate the males enclosure may also help stimulate her.
Once the male shows interest then its important that the pair have fence contact so mutual interest can be assessed.

Males moved to investigate female

White Oak; fence contact to asses interest prior to an introduction

When using multiple males to investigate an enclosure, it is not unusual for each of them to respond with varying degrees of interest and estrus detection. It is unclear whether motivational failure or sexually-unresponsive males are due to hormonal deficiencies, strong mate preferences, inexperience, inappropriate management, or the inability of some males to detect a weak cycle. A low level of excitement should not be mistaken for the absence of estrus or interest. An introduction should still be considered despite a weak male response. However, it is very important that the male show some response to indicate that he recognizes estrus & that he is visually focused on the targeted female. If this does not occur, introductions are risky and could result in severe aggression. Rarely will an aroused male attack a female in estrus however, inexperienced males may not always respond appropriately.

Several facility have reported that they have had novice males respond appropriately to estrus scents (vocalizations and erection) but failed to focus 'visually' on the targeted female, but instead became focused on other cheetahs in the area. Introductions in this situation can be risky. One facility reported a serious attack with this scenario.

Signs that the male has detected the proper olfactory clues indicating estrus may include but are not limited to the following:

- Excited pacing and running
- Maintaining visual contact with the female
- Staying within close proximity to the female
- An erection
- Ceasing to eat
- Vocalizations (chirping, stutter-calling/ barking)

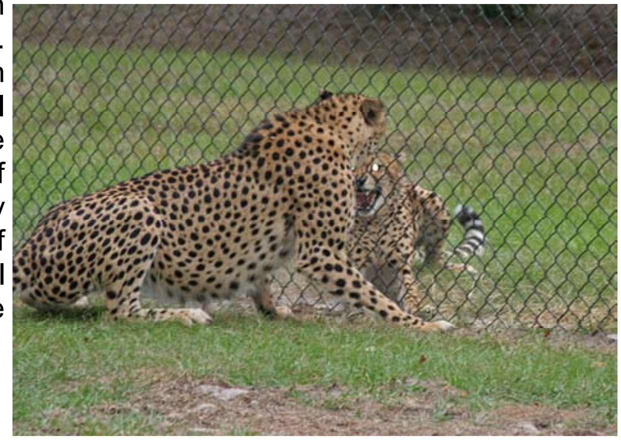
* Vocalizations are the most important indicators of estrus.

A male at a heightened level of excitement will tire quickly, so an introduction should take place as soon as possible (15-30 minutes). Females may or may not show estrus behaviors or apparent interested towards the excited male but an introduction should still be considered.

INTRODUCTION TECHNIQUES

Introduction methodology varies with each institution. Flexibility is the key to successful introductions. Individual personalities and animal characteristics are very important and must be considered.

It is not uncommon for pairs to show some aggression when in adjacent enclosures during non-estrus periods. This behavior will usually subside once the female is in estrus. However, some pairs are incompatible and you will have to alter pairings to accommodate this. Experience has shown that cheetahs can breed under a variety of conditions. There have been many, often contradictory theories that have been met with varying degrees of success. This has made it impossible to identify an "ideal cheetah breeding technique". The following methods have resulted in successful matings.



Aggressive interaction during non-estrus period

- male introduced to female in female's yard
- male introduced to female in male's yard
- male and female introduced in neutral yard
- male and female introduced with teaser male in adjacent yard
- multi-males introduced to female(s) *use extreme caution*
- pairs housed together long term

One facility reports leaving single females in the same enclosure "territories" for their entire breeding life time. The males are kept in separate areas that are out of sight, smell, and sound for most of the year. The males are brought to the female section for pen investigation between the months of Dec to March.

While it is common for multiple males to encounter a female in the wild, when this occurs in captivity, opportunities for escape are limited and injuries are more likely to occur. Two or more males competing for one female can be overwhelming for the female and could be especially frightening for novice females. Female deaths have occurred as a result of a multi-male introduction, so only consider multiple male introductions using animals that you can safely separate if necessary. When a number of males are introduced, inter-male aggression can occur. Inter-male aggression is regarded as a necessary factor by some (suggesting that it stimulates the female), while others regard it as unnecessary, even detrimental as competing males may prevent successful copulation.

With related or unrelated coalitions, for the purposes of maintaining genetic diversity, it is advised to only introduce a selected male for actual copulation so that parentage of the cubs can be confirmed. Separating coalition members for breeding can be challenging. The one that is held back is usually very stressed and will vocalize continuously, possibly distracting the male in the breeding situation. It is highly recommended that every effort be made to keep the coalition members in 'visual contact' the entire time.

Once the decision to introduce the pair is made, all doors should be opened to allow multiple escape routes. Make sure both cats are fully aware of each others presence before the door is opened as this will help minimize the possibility of one mistaking the other as a rival. It is suggested that the initial introduction take place in the enclosure containing the female scents. This is especially important with novice males in order to keep their excitement level elevated. If the timing is correct, breeding may take place immediately. Single and multiple copulations have been observed. A single copulation is not uncommon and can result in pregnancy.

While serious altercations are rare, certain precautions should always be taken. First time introductions need to be monitored closely. Adequate staff must be available to work shift doors and the following equipment should be on hand should a serious altercation occur:

- Air horns, fire extinguishers, push boards, rakes/brooms, water hoses.

Introductions that result in a seriously aggressive conflict causing trauma to the male or female will make future introductions with these individuals much more difficult or even impossible. Inexperienced males may be impatient and rough, while inexperienced females may be fearful or aggressive. If you have the option to introduce an experienced animal with a novice animal for their "traumatic first time", the chances of a successful mating are increased.

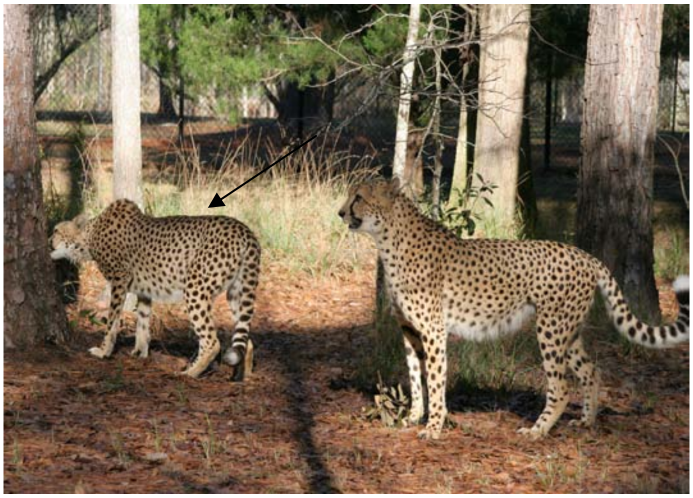
Once introduced, the female may react to the male with one or more of the following behaviors depending on if she is actually in estrus or not and/or how comfortable she is with the male:

•Fearful vocalizations (loud chirping), displacement activity associated with fear include: swatting her tail or excessive self grooming – this is typically seen with hand-reared females)
•Ignoring
•Aggression
•Play fighting
•Soliciting

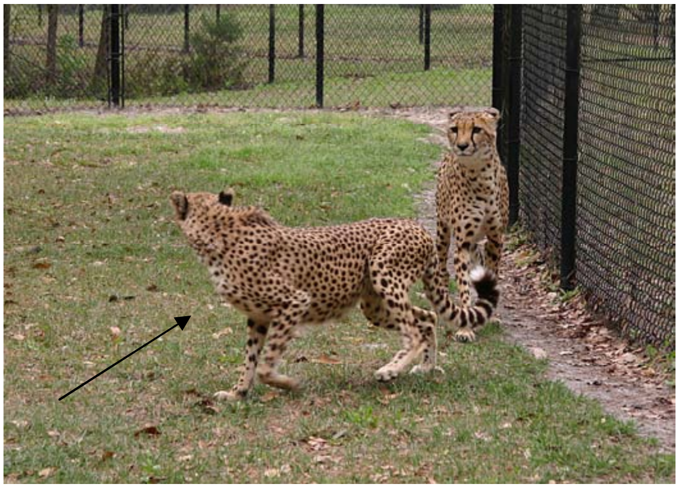
She may make an initial attempt to escape the male by running and a chase may ensue.
The male pursuing the female is acceptable as long as it is not aggression driven. Some chasing may provoke aggressive behavior.

Females may tease the male by rolling in front of him. Rolling can also indicate the females apprehensiveness and she may growl and /or strike at the male as he approaches. These behaviors usually subside as her comfort level and receptivity increases.

White Oak; Female chirping/yipping at approaching male



White Oak; Female ignoring the male

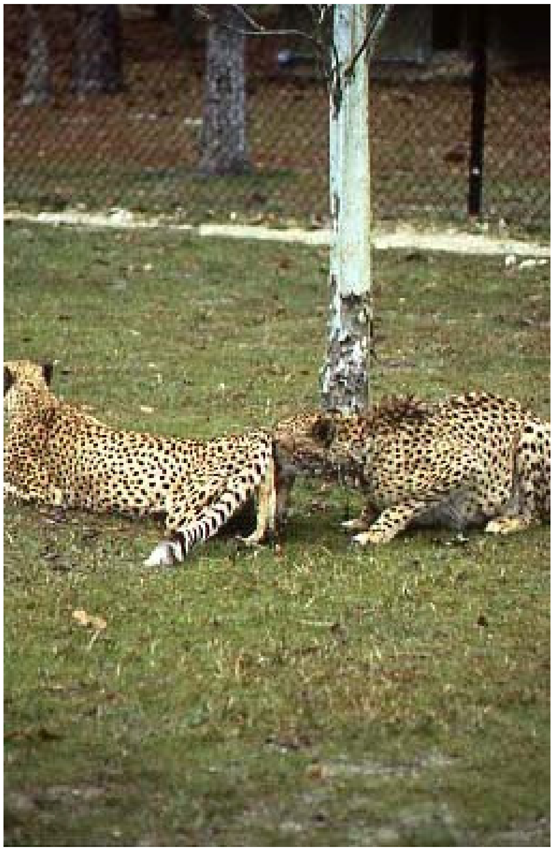


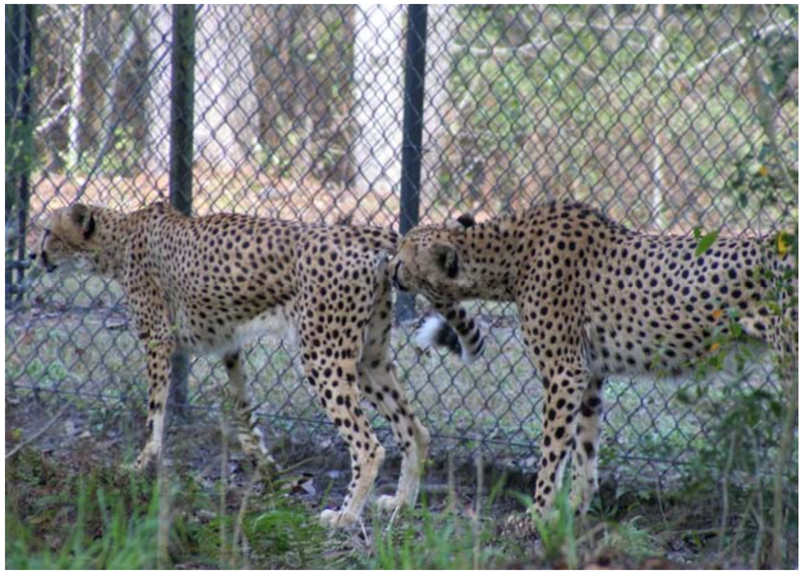
White Oak; Female trying to escape approaching male

EXAMPLES OF INCOMPATABILITY:
May include but not limited to: Fighting, aggressive chasing, females fear chirping or restlessness. If aggression by the male or female occurs, they need to be watched closely and separation considered. Aggression is usually a sign that the female is not in estrus or that this may be an incompatible pair.

White Oak; Female aggression towards an approaching male

White Oak; Female teasing male





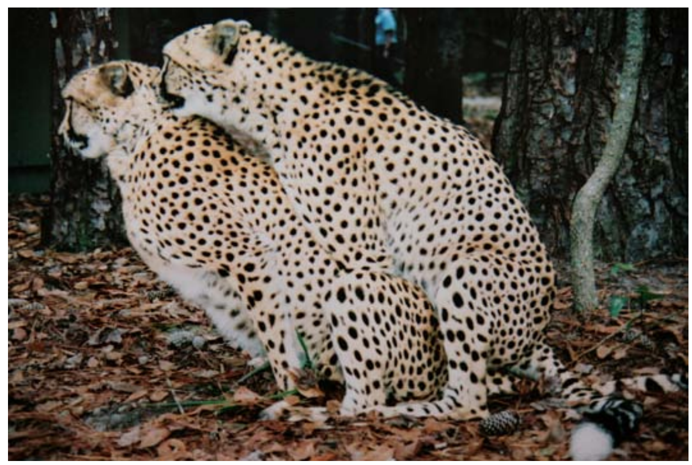
White Oak; Male smelling female's genital area.
This behavior is not commonly observed.

White Oak; Lordosis posture

A receptive female will typically adopt a copulatory posture / lordosis (elevated hind quarters while resting most of her weight on the forepaws and chest, with tail held to one side) when she is ready to copulate. The male will usually bite the scruff of her neck when mounting. Copulations are usually brief but may last several minutes and are terminated when the female rolls over or escapes, often swatting at the male

White Oak; Soliciting / Lordosis posturing

White Oak; Correct mounting position

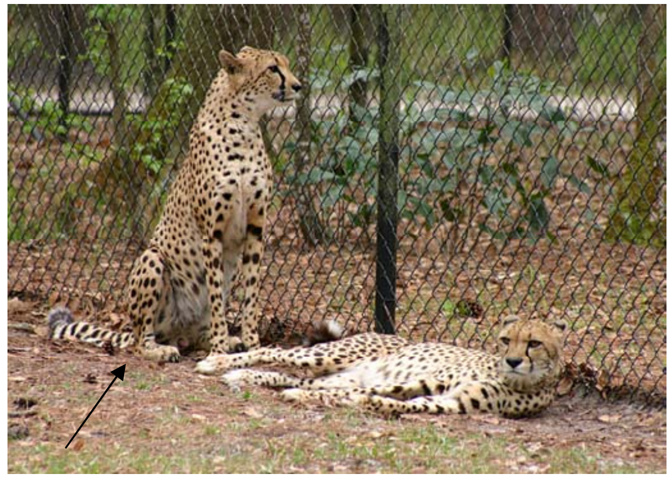


White Oak; Incorrect mounting position

White Oak; Female terminating mount

It appears as though with a non-successful copulation, the male will continue to pursue the female with an erection and stutter calling; while with a successful copulation, the male might get agitated (growling/hissing) as he follows her. If the growling seems frightening to the female, sometimes a brief separation (~1 hour) is enough time for the male to calm down and begin vocalizing again. Re-introductions may result in additional copulations. After a successful mating the female is frequently seen rolling.

EXAMPLES OF COMPATIBILITY may include but not limited to the following: Females not fear chirping, resting in close proximity, male submissive behavior (arrows pointed towards males)

White Oak; Animals resting in close proximity seemingly relaxed


White Oak; Male showing submissive behavior

If copulation occurs, it is recommended that the pair remain together until breeding interest subsides (usually 2-3 days). As long as the female is in estrus, the pair will spend time in close proximity with periodic mating attempts. If the pair does not breed right away, this could just be a timing issue. Consider separating the pair for a few hours and re-introduce, repeating this over the next few days. If they are separated more than a few hours, optimal estrus time may be missed since sexual receptivity many be as short as one day. If the pair appears compatible they may be left together overnight for several days provided that breeding interest continues. If the pair is left together for an extended period of time then preparing for parturition will be difficult if an exact breeding date is not known. If the pair does not breed it could also be a mate preference issue, if you have multiple males that are genetically compatible to use with a particular female, you could consider switching males as long as the pair was not left 'unobserved' for any period of time.

MALE COALITIONS
(to separate or not to separate?)

Does a psychological attachment (A relationship between individuals characterized by emotional dependency and contact-seeking behaviors) exist between coalitions members?

Results indicated that the increases in vocalization rates, pacing, and standing during separations and the increase in social activities during reunions indicate that psychological attachments, not just tolerance, existed between coalition members. Solitary coalition members seemed distressed, vocalized continuously, and actively searched for their partner(s); however, it was somewhat surprising to observe so little affiliative (affectionate) behavior during reunions.

Increased vocalization rate has been used as an indicator of distress during separation from companions in several social species of mammals and birds. The intensity and frequency of emission are thought to reflect the strength of attachments. These observations indicate that chirps are similar to barks which signal distress and promote contact between group members *(sensu Morton, 1982)*

Captive breeding is affected directly and indirectly by the psychosocial well-being of individuals. The social environment during rearing is among the strongest factors that influence the ontogeny (the course of development of an individual) of social preferences, communication, temperament, and general well being.

When possible it is better to allow coalitions to be housed together. If long-term separation is necessary, it would be better to ship out the animal rather than leaving coalition members separate and in close proximity.

"Vocalizations and Other Behavioral Responses of Male Cheetahs During Experimental Separation and Reunion Trials" C.R. Ruiz-Miranda, S.A. Wells, R. Golden, and J. Seidensticker, Zoo Biology 17:1-16 (1998)

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MALE CHEETAH INTRODUCTIONS AT THE BINDER PARK ZOO

Some facilities have found it very difficult to introduce unrelated males to each other due to aggression. The key here seems to be facility set up and patience. The males should be able to see and smell each other for several weeks before actually giving them nose-to-nose contact if possible. After two or three weeks let them to have access to adjoining pens that allow for nose to nose contact for several hours during the day. This has worked when introducing two individual males as well as introducing an individual male into an already established coalition. Watch for fighting through the fence, which can lead to torn claws, etc. This should be done on a daily basis for a few more weeks. Once the males appear to accept each other at this level, you can move on to physical introduction. The males are then let onto exhibit through a guillotine shift door, one at a time. The newest male or individual male usually goes out first and is given a few minutes to mark the area before the second male is released. The second male will usually spend a lot of time smelling and marking the area after the first animal, which seems to reduce aggressive incidents. If the introduction does include a coalition, only introduce one animal from the coalition to the newer male for the first several days, then allow another coalition male out with the first two animals for a few days and so on. You should expect a few minor slapping incidents where the fur flies, but things usually quiet down in a short period of time. The first few introductions should only last about an hour at most and then nose to nose contact given for the rest of the day. When physical introductions take place there is always at least two keepers on sight to handle the guillotine doors, fire extinguishers, etc, in case an animal needs to be separated right away. If there is too much aggression one animal is moved off exhibit right away and another attempt is made the next day. Minor aggression may take place for up to a week or so, but usually fades after the first day or two and the males usually end up ignoring each other for the most part. Recently, two, two male coalitions were introduced to each other with very little aggression. Though these animals maintain their original coalitions, they do tolerate each other very well, and will occasionally interact.

Cheetah Behaviors and Definitions

NON-SOCIAL BEHAVIOR:

Resting	Sitting or lying down with eyes closed and not exhibiting any other behavior
Rest – Alert	Sitting or lying down with eyes open
Sitting	As implied
Crouching	Standing with legs bend, body close to ground (sniffing the ground)
Stand	As implied
Walk	Forward locomotion at relaxed speed, includes trot
Pace	Walking back and forth across the same area repeatedly
Run	Forward locomotion greater than walking speed with full extension of limbs and tail
Stalk	Low, crouching advance with eyes orienting on prey object
Pounce	Springing motion from a crouch position directed toward prey object.
Rolling	Rolls on back, rubbing the back on the ground while all paws are in the air, or rolls from one side to the other. Either to scratch self, change position, or estrus behavior
Object rub/Head rub	Rubs face, head or neck on object
Self-groom / Autogrooming	Lick, chew or otherwise clean self
Urinate	Excretion of urine from sitting or squat position
Urine mark/spraying	Sprays urine from standing position with tail raised against a vertical structure
Defecate	As implied
Ground Scrape	Scraping ground with rear legs during defecation
Tread	Walking-in-place rear leg action during urine marking
Sniff object	Olfactory examination of ground or structures
Sniff partner	Olfactory examination of another cheetah

Flehmen	During olfactory examination of urine. A grimace with open mouth, wrinkled nose, retracted lips and tongue may or may not protrude past lips. Head is raised.
Eat/Drink	As implied

SOCIAL & BREEDING BEHAVIOR:

Playful	Chases, stalks and wrestles another cheetah without growling, hissing or any other aggressive behaviors
Approach	One animal walks up to another animal within 0-3 body lengths and focuses visually
Retreat/ Leave	Animal avoids proximity of approaching individual by walking away - Excluded fleeing
Flee	Rapidly runs away from pursuing animal
Follow	After approach, follows behind retreating individual to within one body length. Do not confuse with fleeing.
Chase	Rapidly pursues another cheetah
Paw Swipe or Strike	Strikes at another cheetah with its paw
Bite	As implies
Attack	Sudden run or jump towards another cheetah combined with growling and/ or hissing and any other signs of aggression (ears back, canines exposed)
Fight	May follow an attack: wrestling and biting each other aggressively
Sniff	Olfactory investigation of another. Do not confuse with object sniff
Allogrooming	Grooms another cheetah by licking
Ground Slap	Forceful lunge towards another individual with both front paws simultaneously and rapidly slapping the ground.
Submission	Attacked individual lies down ("flops" on its side) and avoids visual contact with attacking individual and chirps
Social rubbing/ head rub	Rubs head or cheek rubbed against another cheetah
Erection/ male erousal	Penile erection/Penis fully unsheathed
Anogenital sniff	Sniffs the anogenital region of another

Lordosis	Assumes female copulatory posture. Female elevates hindquarters while resting most of the weight on the forepaws and chest. Tail usually held to one side.
Neck hold	Male grasps the loose skin on the back of the females neck in his mouth during copulation.
Attempt mount	Puts leg over back, partner runs off
Mount	Copulation attempt with male on back of female. Bottom animal lying on sternum
Copulate	Penile insertion with thrusting
Anogenital self-grooming	Grooms own genitals
Post-copulation threat	Female turns abruptly on the male, hissing, striking with paw, and throwing him off her back

MATERNAL AND CUB BEHAVIOR:

Nurse	In nursing position alongside mother
Anogenital lick	Stimulation of cub to eliminate by licking under tail
Crawl	Forward locomotion with limbs primarily flexed, short strides taken (gait seen in infants prior to development of walking skills and in animals attempting to stalk an object)
Climb	Ascends up trees, branches, or other structures.
Carry	Mother moves young by grasping nape of the neck with mouth
Wrestle / spar	Restrained mouthing, biting, tumbling, swatting, etc., between young animals; play behavior
Object play	Bats, sniffs, chews or pounces on an inanimate object
Jump	Spring from the ground into the air

VOCALIZATIONS:

Purr	Same as domestic cat, but much louder
Stutter	Repetitive short throat calls usually made by mother calling cubs or soliciting male
Stutter-bark	Shrill, stutter-plus-bark, repeated in series. Commonly emitted by sexually aroused males

Chirp, agonistic	High pitched, short, often soft call, corners of mouth drawn back; emitted in defensive (agonistic) contexts. Often emitted by a threatened individual.
Chirp, soliciting	Same as above except used to indicate “friendly” state
Chirp, cubs	Bird-like chirp made by cubs to communicate with mother
Yelp	Same as chirp except much louder
Moan	Low, drawn out sound; mouth closed
Growl	Low, drawn out “snarling” sound; mouth open showing teeth
Miau / meow	Soft call, low pitched compared to chirp; very similar to a common vocalization of the domestic cat when waiting for food.
Spit	Directed expulsion of air, often with saliva
Hiss	Silent, drawn out expulsion of air with mouth and eyes wide open, body tensed for action.

EXAMPLE
CHEETAH CHECK SHEET

Animal ID# ____________________ Date: _____________________
Pen # ___________
Weather / Temp: _______________
Observer: ____________________ start / end time: _____________

States	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Laying															
Sleeping															
Crouching															
Sitting															
Standing															
Walking															
Pacing															
Running															
Out of sight															

Events	Note All Occurrences
Object rub	
Social rub	
Roll	
Object sniff	
Social sniff	
Flehmen	
Autogroom	
Allogroom	
Tail flick	
Lordosis	
Male arousal	
Mount attempt	
Copulation	
Urinate	
Urine spray	
Defecate	
Stutter	
Chirp	
Meow	
Growl	
Hiss	
Purr	
Approach	
Leave	
Follow/chase	
Play	
Attack	
Strike at	
Strike w/contact	
Bite	
Fight	

Notes:

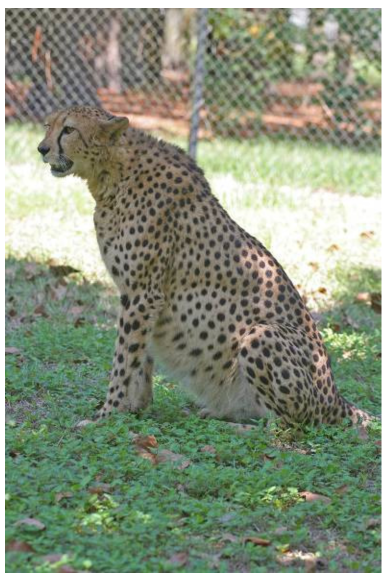
REPRODUCTION
Gestation, Maternal Behavior and Cub Development

Important Note: Every situation is different and depends on the individual cheetah. Common sense must be used along with these guidelines and each situation varied accordingly.

GESTATION
Cheetahs experience multiple estrous cycles throughout the year, allowing breeding and births to occur year-round. Gestation length is 89-97 days. The mean gestation period is 92-93 days.
Litter sizes have ranged from 1-8 cubs with 3-4 cubs being the average litter size. Litters may be produced at roughly a two-year interval, though if the litter is lost the female may re-cycle within a few weeks.

PRE-PARTUM BEHAVIOR
Pregnancy can be difficult to confirm, especially during the first trimester. Difficulty is heightened if the female is overweight or if she is carrying a small litter. The female should be separated and given privacy in the maternity yard, as soon as possible, whether or not pregnancy has been confirmed**.** Maternity enclosures should always be off exhibit, but not restricted to "indoors" if possible. Indications of pregnancy may include an increase in appetite and weight and during the third trimester, nipple development. Because an increased appetite may indicate pregnancy the quantity of food might need to be increased and fast days discontinued. Food provided during lactation should be increased once again to compensate for increased energetic demands.

90 days pregnant with one cub



82 days pregnant with seven cubs

Twice a day feedings are recommended during the last week of pregnancy. This will help the staff narrow down the time of impending parturition. The female may reduce her food intake one to five days prior to parturition, and often stops eating 24-48 hours before giving birth.

Pseudo-pregnancies do occur in cheetahs. The approximate length of a pseudo-pregnancy (non-pregnant luteal phase) ranges from 38-60+ days and the female can appear and behave pregnant for that length of time (increase in appetite and weight). Following 60-70 days, if pregnant she will continue to gain weight, as pseudo-pregnancy signs will quickly subside. Some facilities have reported what they believe to be full-term pseudo-pregnancies lasting 90+ days. Around 90 days their weight began to decrease prior to reducing the diet amount, suggesting a pseudo-pregnancy and not overweight. A female that was bred but does not give birth may also have reabsorbed the fetuses or experienced an early abortion. If a female continues to exhibit abnormal pregnancies then it is recommended that you consult one of the Cheetah SSP vet advisors.

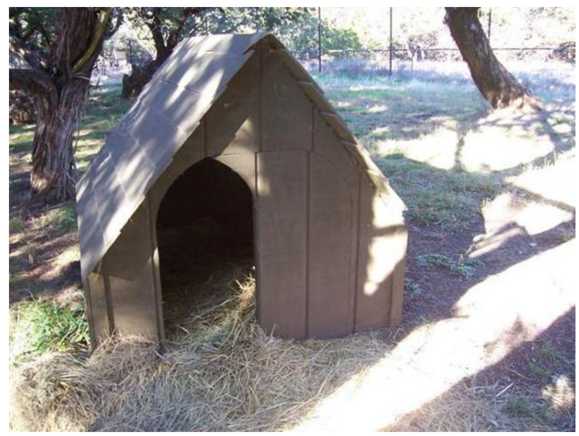
83 days pseudo-pregnant / did not give birth

Males commit infanticide (the killing of an infant) in a variety of free-living species of cats and probably do so in cheetahs, thus the presence or odor of males may be extremely stressful to a mother with cubs. And since female cheetahs are solitary, cheetahs of either sex, as well as other carnivores, should be moved as far away as possible from the maternity yard several weeks prior to the expected due date. Changes that need to be made to accommodate a pregnant female or cubs, regarding the enclosure, den box/ bedding, or camera installation, need to occur well in advance (at least 30 days prior to parturition) to minimize stress to the female.

White Oak Conservation Center

While a few facilities make only one den available and have had little problems; it is still recommended that the female be given access to more than one den for her to choose the birth location and to allow her to move the cubs from one den to another.

San Diego Wild Animal Park



Fossil Rim Wildlife Center

Dens are best placed in secluded areas where there is no human or vehicle traffic. Placement of the den is of utmost importance, for the den will not be used if the female does not find its location suitable. If she chooses to move her cubs and there is no other den available, she may choose to rear her cubs outside or carry the cubs excessively. Young cubs have little thermoregulatory ability (maintenance of a constant internal body temperature regardless of environmental temperature), so dens should be warm, dry, well ventilated and easily accessible to the keepers. If your facility has indoor housing/buildings then you should consider placing a den box or bed/ platform with sides, inside that area for her to use.

Wildlife Safari: Winston OR

Cheetah bed at Columbus Zoo

It is suggested that all dens or beds have a threshold / nipple board or sides that are ~4-6 inches high to keep the cubs from leaving the den too early and causing the mother stress. Once the cubs are climbing over the threshold then it can be removed so that they can return to the safety of the den easily.

White Oak Conservation Center; cubs successfully reared outside the den

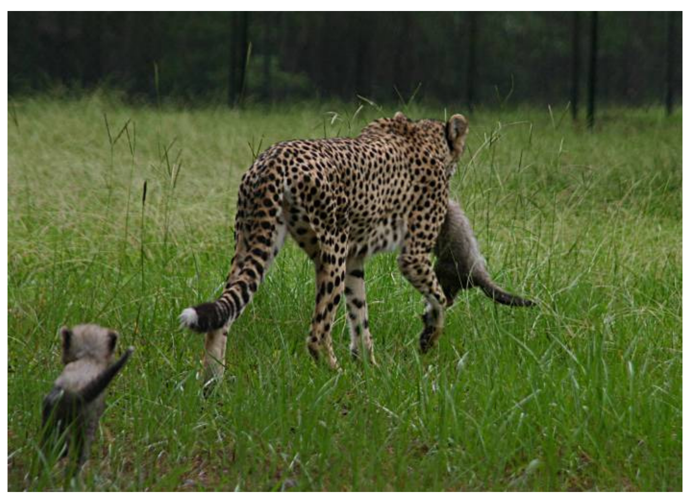
Winston Safari; cubs successfully reared outside the den

Fossil Rim Wildlife Center; cubs born outside the den and neglected

Some mothers are very nervous using an enclosed den and will choose to rear them outside of the den. Extra attention must be paid to mothers that choose to rear their cubs outside exposed to the elements. While some cubs have been successfully reared outside the safety of a den, some concerns would include ants, flies, heavy rains that cause flooding, direct sun light (heat), cold weather, or the cubs possibly ingesting dirt.

Another risk with cubs reared outside the confines of a den or bed is that the cubs begin to become mobile at about three weeks of age and this often drives the mother crazy! In an effort to keep all the cubs corralled in a "safe" area the mother may pick them up so frequently that it can cause serious or fatal injuries. Confining them to a smaller area until the mother calms down may be necessary to avoid injury to the cubs. As the cubs get older the mother will get used to the cubs desire to move around and become less nervous.

White Oak Conservation Center; video monitoring



White Oak Conservation Center; carrying cubs back to the den

White Oak Conservation Center camera set up

Wildlife Safari camera set up

Video equipment in the den is highly recommended so staff can monitor the birth and maternal care without disturbing the mother. It may be necessary to illuminate the den for camera viewing at night. One facility reported using the following bulbs with no problems (250w Infrared heat lamp red bulbs in the winter and 15w red bulb or a 7.5w frosted nightlight bulb in the summer). It is important that the light turned on at least one to two weeks in advance since a light in the den could potentially deter her from using the den.

If the camera has remote/zoom capabilities, it is recommended that you do not move the camera while the female is in the den or the movement/noise could frighten her out of the den and possibly cause her to move or abandon her cubs. All camera equipment must be protected from the cheetahs to avoid damage to the equipment.

If approaching the den for observations is the only option, then it should be made by an individual that the animal readily accepts and conducted in a manner of least disturbance to the female and limited to only one time per day, as long as there are no health concerns. Checking the den should be avoided until the mother leaves the den to eat. Infrequent checks on the cubs could result in the death of a cub; however, it is felt by some that it is better to give her a chance to rear the rest of her litter with minimal disturbance rather than increasing her chances of abandoning, cannibalizing or moving the remaining cubs because she feels harassed. It is important to find a balance between monitoring the cubs sufficiently without causing the mother so much stress.

PARTURITION

Staff should follow a regular routine to avoid disruption and ensure the female's sense of security.

A milk ridge is often evident a couple of days before parturition. Some facilities have reported that the female will begin having multiple, smaller piles of stools instead of one large pile.
Typical pre-parturition (<24 hr) behaviors may also include but not limited to the following

- Restlessness/pacing
- Entering and exiting the den repeatedly
- Smelling and pawing at the den bedding

It is not unusual for some females to avoid the den until just hours prior to parturition. As parturition approaches the female will remain in the den and self grooming and increased respirations may be observed.
Average parturition time has ranged from 30-60 minutes. Typical duration is 3-5 hrs. but has been reported to occur over 14 hrs. Parturition may occur at any time of the day or night. Pregnancy complications can and do occur. If she appears to be in distress (open mouth breathing, etc.) and is straining without progress, contact your veterinarian immediately to develop a plan for possible intervention.

POST-PARTUM BEHAVIOR

Each litter presents its own challenges, and changes will need to be made as situations arise. Some mothers may need to be treated differently than others. In general, try to maintain their seclusion and modify husbandry techniques as needed for the first few weeks. First time mothers must be monitored closely. It is recommended that a birth survey be filled out on every litter as a way of accurately and consistently documenting what occurred with each birth for in-house use. (See birth survey example).

In general, felid mothers require peace and quiet, along with seclusion. If compromised with disturbances, cheetah mothers may move, neglect, abandon, or cannibalize her cubs (Marma & Yunchis 1968). If the female is caring for her cubs, leave her alone! More often than not, given the necessary privacy, even first time mothers will care for their cubs without any problems. Some mothers may not settle down to care for/nurse the cubs until all cubs are born.

Typical behavior for a new mother, once all the cubs are born, is to remain in the den, except for short periods to eat, drink, or to defecate/urinate for the first 72 hrs following parturition. After 72 hrs cheetah mothers may begin spending brief periods away from the den with this time increasing as the cubs get older.

If the female is neglectful or harmful (ignoring the cubs, failing to clean or nurse them, frequent carrying, or cannibalizing a live cub) the cubs will probably need to be pulled and hand-reared. Cubs that are not being adequately nursed will often be restless, and heard vocalizing. Weight loss can also be an early indicator of inadequate nursing or illness. In the wild, mothers move young from den to den. This behavior has been observed in captivity; however, frequent or non-directed carrying of cubs indicates nervousness and should be cause for concern.

It is recommended that you be extremely cautious around the maternity yard/den for the first 24-48 hrs. It is not necessary to offer her food during this time, especially if she has not come out of the den. (Some institutions will offer food the same day, while others may wait 24 hrs). When she is seen out of the den you should offer her food in the usual location. Most females are nervous about venturing too far from the den when people are around so nervous mothers may need to be fed in the evening when it's quiet. It is not unusual for the female to go several days without eating (average 2-3 days). This must be monitored closely, especially with large litters. Water must always be readily available and not located in an area that the female is hesitant to enter.

If she refuses to eat for more than two-three days, you should first confirm that she has indeed given birth, is clean, and has healthy cubs with her. If all appears well then you might consider including some favorite food items, offer the food in a different location, or feed in the evening. If those efforts fail, giving her whole food items like a bone, meat chunk, or a rabbit that can be carried away and eaten close to the den, is another option. However, consider the fact, while unlikely, she may take the food inside the den where it could attract flies or ants. Do not do this unless you are able to retrieve the remains easily.

Some mothers are surprisingly tolerant of keepers observing them while others may not be. Best to let her behavior guide you, to some extent, on the amount of time you are able to observe. The death of a cub should not automatically be attributed to maternal neglect. If a death or disappearance occurs one must consider the possibility the cub was unhealthy, especially if the mother is being attentive to the rest of the litter. It is quite normal for large litters (4+) to include a runt, still born cubs, or premature births.

It is rarely necessary to clean or replace the bedding for the first few weeks as the den is usually kept clean by the mother. However, if the female is urinating in the den then the wet bedding must be removed as soon as possible.

Careful attention needs to be paid to single cubs (singletons), as these will be abandoned, even when the female appears to be attentive. Pulling will absolutely be necessary at some point early on. The amount of time the dam is attentive to the singleton will vary. The factors which influence abandonment of a single cub are not entirely clear. This abandonment of a single cub is not seen in other felid species (Wendy van Oorschot 1998). The milk supply is probably not stimulated enough by just one cub or the mother 'decides' not to rear but to recycle again. This usually occurs at two-five days of age (Range 1-23 days). Weight gain of a single cub is especially important to monitor on a daily basis. The cub can remain with its mother as long as its being cared for properly; understanding that the longer you wait to pull the more difficult it may be to get the cub to accept a bottle. If possible, leave long enough to receive colostrum (first milk) from the mother. Once there are signs of weight loss, disinterest or aggression from the mother the cub must be pulled immediately for hand rearing. (See hand-rearing and cross-fostering sections) Every effort should be made to avoid raising a cheetah cub alone. Contact the SSP immediately to see if other cubs have been born for cross-fostering options.

NEONATAL MORTALITY

Stillbirths, premature births and congenital defects account for a significant number of deaths. Maternal neglect, exposure, pneumonia and maternal trauma have also been identified as major causes of cub mortality. Cubs are most vulnerable in their first month. Disturbance, due to the presence of humans or conspecifics (of the same species), or excessive noise should be kept to a minimum, particularly in the case of the female's first litter. Abandonment and maternal trauma may occur with first litters due to the female's lack of experience.

White Oak Conservation Center;
Keeper performing daily cub check

CUB DEVELOPMENT AND REARING

Once the female has left the den voluntarily, secure her in another area to eat while her cubs are quickly examined. Most females will become aggressive towards anyone who enters the den or enclosure so it is essential to be able to isolate the female from the cubs when examining the cub's health and progress. If at all possible, it is best if the mother does not "see" you near the den or handling the cubs and it is recommended that you wear gloves when handling young cubs.

White Oak Conservation Center;
healthy cub

Fossil Rim Wildlife Center; healthy cubs

In the past, if all appeared to be going well, most institutions would avoid any hands-on with the cubs until their first vaccination (~ 6 weeks). With the re-emerging problem with feline herpes this protocol should be modified. It is now recommended that cubs be visually checked at three to four days of age and then daily for several weeks in order to detect the initial symptoms of herpes virus (sneezing, nasal discharge, watery eyes, third-eyelid protrusion). Cubs rarely develop any herpes symptoms before three to four days of age. Early detection provides and opportunity to minimize the severity of the lesions the cubs may develop. If symptoms are seen, it is critical that you monitor them very closely. Cubs exhibiting minimal herpes symptoms have been left with the mother and cleared up on their own, however, you should be prepared if the symptoms continue to worsen. In the past, leaving cubs with a mother who is shedding the virus have resulted in the cub's symptoms continuing to progress and become more severe (lesions of the eyes, nose, and skin) - Neonatal cubs are more likely to develop severe lesions than animals over one month of age. A portion of neonatal cubs that develop severe lesions may have persistent symptoms such as corneal scars, prolapsed third eyelids, or ocular discharge (see Veterinary section for more information)

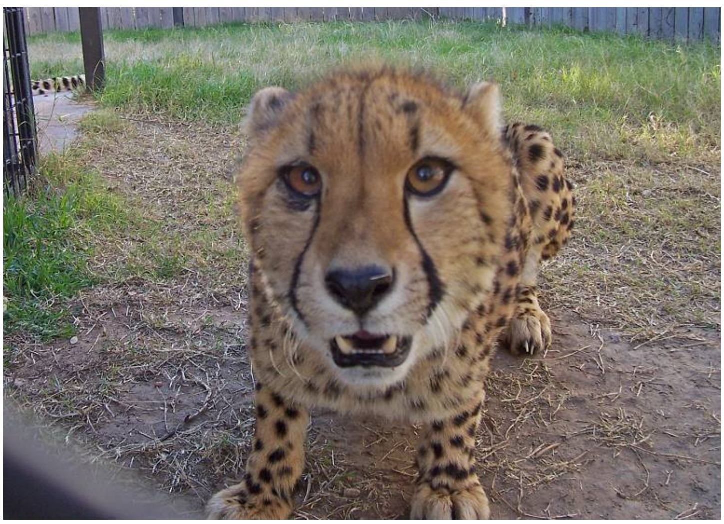
Cheetah cub with mouth lesion

Cheetah cub showing minimal herpes signs

Cheetah cub with minimal herpes signs

Cheetah cub with severe herpes symptoms

Young cheetah with severe herpes symptoms "Before"



Same animal "After" treatment

*Persistent symptoms; prolapsed third eyelids and ocular discharge
Six months old*

*Same animal 'After" treatment
4 1/2 years old*

Cubs can be temporarily marked for identification by shaving small patches of hair at different locations. Transponders can be inserted over the left scapula at first opportunity, though most facilities wait until 8-12 weeks of age.

National Zoo: cub shaved for identification

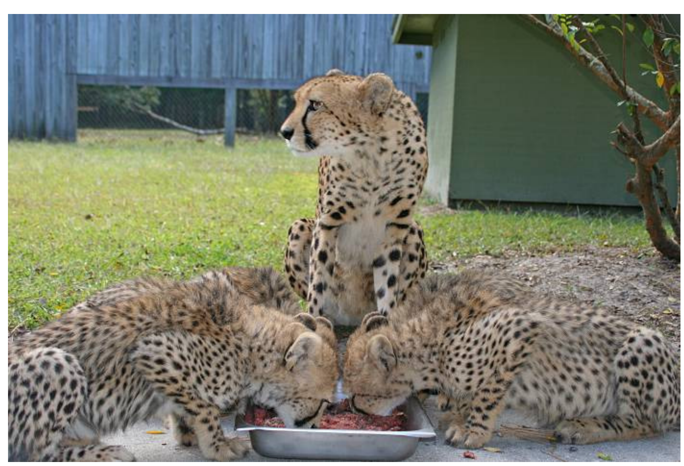
Cubs in the wild remain concealed in the den for an average of eight weeks, while captive cubs will begin to explore away from the den at approximately five-six weeks of age. It is critical that the maternity yard be void of large bodies of water (including ponds, moats, or other water-containing structures) in which drowning could take place. It is recommended that sharing a common fence line with any other adult cheetah be avoided or that the common fence line be secured with small wire mesh (for the first several months) to minimize the possibility of injury to the cubs. One facility reported a cub getting its head stuck in chain-link fence.

Weaning may occur between two to three months of age even though cubs may be seen suckling for many more weeks. Cubs may begin consuming solid food as early as four to five weeks. When this is observed, food (adult diet) should be made available to the cubs. Care should be taken to remove large chunks or solid pieces from the diet to prevent choking. Some facilities have offered large bones as early as three-four months with no problems. It is recommended that they be monitored for possible choking at this young age. Once solid food is being eaten, make sure there is a shallow water bowl available for the cubs.

Since mother and cubs are fed together, it might be necessary to overfeed in order to ensure the cubs are receiving enough food. It is normal for the mother to eat more than her share, thus gaining considerable weight during this time.

Separating mother and cubs, out of visual contact, to eat at an early age (under four months) may cause un-necessary stress to both mother and cubs and is not recommended. If separation is necessary for feeding, having a common fence-line between them with visual contact will minimize stress.

Fossil Rim Wildlife Center;
mother and cubs sharing food



White Oak Conservation Center;
mother and cubs sharing food

Young cubs love to climb; however, they are very awkward until about three months of age. Climbing structures (dirt piles, tree falls, termite mounds and large rocks) are great enrichment for the cubs, and might even keep them from climbing less desired objects (fence, trees). Make sure climbing structures are age appropriate so they are not injured if they fall. Three facilities have reported that cubs have gotten stuck in forks of branches/trees in which deaths have occurred. Climbing desire and ability decrease with age, even though the occasional cheetah will continue to climb even as an adult**.**

Saint Louis Zoo ↑

↑ *White Oak Conservation Center* ↓ ↗

National Zoo ↑

CROSS FOSTERING

Hand-rearing should take place in cases regarding maternal neglect, singleton births, or compromising health issues. If hand-rearing is required, it is important, that they are not reared as singletons. Every effort should be made to match up the single animal with another cub(s) of similar age and size as soon as possible. This might require them going to another facility.

Contact the SSP for other litters of similar age that could be available for cross fostering. Singletons often grow up reluctant to accept a mate and/ or show aggressive behavior towards other cheetahs. These issues may affect future pairings. If it is not possible to put the singleton with another cub(s), it should be placed in view of other cheetah preferably on a common fence-line but being careful to avoid any possibility of injury through the fence.

Fossil Rim Wildlife Center; Cross fostering of two cubs from two different litters to her original litter of three.

White Oak Conservation Center; Introduction of a 3 1/2 month old singleton hand-reared cub to 7 month old hand-reared cubs

The introduction of a sick/ injured cub back to its mother, or an orphaned or singleton cub to another mother with cubs, or cubs introduced to other cubs of similar age is possible, but with extreme caution.

Successful cross-fostering has occurred up to a 20 day age difference but still in the den. Once they have left the den it could be much more risky.

Several facilities have successfully cross-fostered. Forth Worth Zoo (1995), White Oak Conservation Center (2004 & 2006), Fossil Rim Wildlife Center (2006), Wassenaar Wildlife Breeding Center, the Netherlands.
Contact them directly for more information.

White Oak Conservation Center; Introduction of a 13 1/2 week old cub to eight 15 week old cubs

AGE OF DISPERSAL AND SEPARATION OF YOUNG

In the wild, mother and cubs normally separate when cubs are between 18-22 months old. Siblings then remain together until females reach sexual maturity (23-27 months) and leave the group to take up a solitary existence, often within the mother's home range. Male siblings usually remain together for life and are generally expelled from the female's range by other territorial males (Marker pers comm.)

Physiological data collected on almost 30 individual cheetahs between the ages of 14-26 months, living in either captive situations (in North America or in Namibia) or free-ranging in Namibia, revealed that the age at first sperm production is between 14-18 months (Wildt et al., 1993; Crosier et al., 2007) Further, based on evidence in both wild and captive cheetahs, although males have been reported to produce very low levels (~0.5×10^6/ml) of sperm at 14-16 months of age, they are rarely behaviorally capable of mating (Wildt et al., 1993; Crosier et al., 2007) Stud book data reported the youngest males to sire cubs were ~23 months old (Marker, 2005). Because the timing of the first production of spermatic samples observed in peri-pubertal cheetahs, separating males from their mothers by ~18 months should pose minimal risk for unwanted pregnancies (Wildt et al., 1993; Crosier et al., 2007). Separating cubs from their mother at too young an age could compromise their social development and cause unnecessary stress. It is recommended that cubs not be separated from their mother until at least one year of age.

While in the wild, final separation may be abrupt with no prior behavioral indications, such as increased aggression or extended periods apart (Bertram, 1978; McLaughlin, 1970) or it may also occur more gradually, over a period of several days (Frame & Frame 1977, 1981). An abrupt method of separation in captivity seems unnecessary. Separation of young should be done gradually (soft separation) by separating mother and cubs on an adjacent fence line for a period of time with this time being increased over several weeks. The mother can then be moved to another enclosure that is not on an adjacent fence line but still in view of the cubs. Then after a few weeks she can be moved out of sight. Leaving the cubs in a familiar area during the separation period may be less stressful. With this method, total separation without stress may be achieved.

Once the mother and cubs are separated the siblings should be allowed to remain together up to ~20-24 months. This soft separation method should also be applied when separating siblings to avoid unnecessary stress.

Female cheetahs enter puberty between 14-26 months of age (Wildt, et al., 1993). More clearly defining the age at which females first produce ovarian follicles and first begin reproductive cyclicity (as based on analysis of steroid hormones) is currently under scientific evaluation (Crosier, pers comm.). However, it is important to note that there is a significant difference between the age at which a female begins cycling (Puberty) and age at which they reach sexual "maturity' (Wildt, et al., 1993). The first several estrous cycles that a female experiences are likely sporadic and do not indicate that the female is physically mature enough to conceive and/or maintain a pregnancy. Sexual 'maturity' indicates that a female is cycling regularly / normally with an endocrine profile and uterine environment that would enable them to produce a litter (Wildt et al., 1993). The earliest reported age for giving birth is ~24 months (Marker, 2005)

Allowing siblings to stay together to ~20-24 months should be ok in most circumstances as long as there is no sexual interest or aggression. Early sexual interest could be stimulated by a brief period of separation, a move to a different enclosure, or the arrival of a 'new' / unfamiliar cheetah.

Sibling mounting (male/male and male/female) is often observed in cubs under two years of age, with this subsiding as they get older. This behavior could be play, a show of dominance, greeting after separation or mating practice. Regardless of the reason, a successful sibling breeding at this age would be a rare occurrence.

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REPRODUCTIVE REPORT

CHEETAH Studbook
ACINONYX JUBATUS
Analysis Set Created by SPARK-plug Studbook

Studbook data current as of 1/7/2008

Compiled by
Laurie Bingaman Lackey

PopLink Studbook filename: XXCHE08
PopLink User Who Exported Report: Kristin Kovar
Date of Export: 3/31/2008
Data Filtered by: Locations = N.AMERICA
PopLink Version: 1.3

Species Type: Live Bearing Gestation Period: 90 Days Maximum Birth Date Range For Litter Mates: 3 Days

DAM INFORMATION
128 reported dams, with 471.466.56 (993) offspring (not including 92 offspring of UNK/MULT dams)

Median size: 3 Mean size: 3.343

Litter Size	Fre- quency	Percent- age
1	47	15.82
2	53	17.85
3	56	18.86
4	70	23.57
5	41	13.80
6	24	8.08
7	5	1.68
8	1	0.34
Total	297	100.00

Dam Age at First Reproduction
Median age: 4.649 Mean age: 5.097

10 Youngest Dams at First Reproduction:

Studbook ID	Age At Birth	Dam's Birth Date	Esti-mate	First Offspring's ID
3064	2.029	7/9/1993	None	3450
5185	2.349	12/1/1959	Month	5187
73	2.396	7/1/1972	Year	111
1763	2.486	5/13/1988	None	2243
2440	2.519	5/12/1991	None	3150
255	2.653	2/12/1981	None	373
471	2.951	8/10/1983	None	474
152	2.973	11/4/1975	None	210
375	3.001	10/9/1983	None	510
170	3.044	10/7/1976	None	224

10 Oldest Dams at First Reproduction:

Studbook ID	Age At Birth	Dam's Birth Date	Esti-mate	First Offspring's ID
35	11.737	7/1/1969	Year	258
430	9.755	1/1/1983	Year	2897
2233	9.112	9/9/1990	None	4556
44	8.75	7/1/1969	Year	199
34	8.271	7/1/1969	Year	195
22	8.268	7/1/1968	Year	170
2425	8.216	1/21/1991	None	4056
3546	7.959	1/6/1996	None	5675
74	7.948	5/8/1972	Month	232
4121	7.89	7/25/1999	None	6593

Dam Age for All Reproduction
Median age: 6.019 Mean age: 6.165

10 Oldest Dams to Have Reproduced

Studbook ID	Age At Birth	Dam's Birth Date	Esti-mate	Offspring's ID
430	12.463	1/1/1983	Year	3518
35	11.737	7/1/1969	Year	258
34	11.381	7/1/1969	Year	247
522	11.326	1/27/1987	None	4009
7	11.274	7/1/1967	Year	208
431	11.077	5/1/1984	Month	3519
522	10.897	1/27/1987	None	3816
140	10.741	1/1/1975	Year	449
2983	10.574	2/25/1993	None	5668
432	10.464	5/1/1984	Month	3302

10 Dams with Most Offspring

Studbook ID	# of Off-spring
255	32
145	28
432	25
33	24
170	23
522	22
152	21
508	20
73	20
125	19

10 Shortest Interbirth Intervals

Intervals are calculated from the last of a litter to the first of the next litter.

Stud-book ID	Interval (Days)	Off-spring1	Birth Date	Birth Date Est.	Offspring2	Birth Date	Birth Date Est.
146	11	5179	4/4/1982	None	293	4/15/1982	None
483	31	1973	10/20/1989	None	1971	11/20/1989	None
164	89	305	7/10/1982	None	304	10/7/1982	None
270	104	547	11/26/1987	None	554	3/9/1988	None
4226	108	6334	4/23/2005	None	6474	8/9/2005	None
3978	109	6407	11/15/2005	None	6433	3/4/2006	None
3790	113	4573	5/29/2001	None	6507	9/19/2001	None
164	119	292	3/13/1982	None	303	7/10/1982	None
125	120	252	2/5/1981	None	272	6/5/1981	None
140	120	302	5/8/1982	None	301	9/5/1982	None

Birth Seasonality

First of litter must have a birth date estimate of None, Day, or Month to be counted.

Month	Number of Litters	Percentage
January	9	3.05
February	11	3.73
March	8	2.71
April	38	12.88
May	30	10.17
June	26	8.81
July	17	5.76
August	15	5.08
September	32	10.85
October	56	18.98
November	37	12.54
December	16	5.42
Total	295	99.98

SIRE INFORMATION
106 reported sires, with 433.434.48 (915) offspring (All ages are at dam conception)

Sire Age at First Reproduction
Median age: 4.745 Mean age: 5.159

10 Youngest Sires at First Reproduction:

Studbook ID	Age At Estimated Conception	Sire's Birth Date	Estimate	First Offspring's ID
89	0.81	11/17/1973	None	118
112	1.96	11/23/1974	None	183
307	1.963	7/24/1982	None	403
472	2.053	4/4/1984	None	474
390	2.119	5/10/1984	None	496
65	2.149	7/1/1972	Year	112
5184	2.185	11/1/1959	Month	5187
2444	2.275	5/24/1991	None	3157
365	2.338	6/2/1983	None	473
2235	2.349	9/13/1990	None	2991

10 Oldest Sires at First Reproduction:

Studbook ID	Age At Estimated Conception	Sire's Birth Date	Estimate	First Offspring's ID
541	13.199	5/9/1982	None	3524
108	12.821	11/1/1974	None	547
15	12.372	7/1/1968	Year	253
107	12.274	11/1/1974	None	524
3019	11.266	4/13/1993	None	6159
465	10.795	10/3/1983	None	3302
239	10.349	6/10/1980	None	2418
3340	9.944	5/13/1994	None	5993
3459	9.897	9/24/1995	None	6407
3304	9.854	10/18/1994	None	6179

Sire Age for All Reproduction
Median age: 6.0395 Mean age: 6.347

10 Oldest Sires to Have Reproduced

Studbook ID	Age At Estimated Concep-tion	Sire's Birth Date	Esti-mate	Offspring's ID
541	13.216	5/9/1982	None	3522
541	13.199	5/9/1982	None	3524
15	12.909	7/1/1968	Year	286
108	12.821	11/1/1974	None	547
2734	12.734	6/5/1992	None	6472
65	12.638	7/1/1972	Year	433
15	12.372	7/1/1968	Year	253
107	12.274	11/1/1974	None	524
469	11.866	3/10/1983	None	3414
65	11.748	7/1/1972	Year	395

10 Sires with Most Offspring

Studbook ID	# of Off-spring
426	53
364	38
158	36
112	26
17	24
65	24
469	24
4170	23
77	22
467	22

CHEETAH
Birth Survey Form
Example

Institution:
Survey filled out by:

Date litter was born _____/_____/_____ Sex ratio____.____.____
month day year

Sire studbook #______ Number of previous litters sired _______

Dam studbook #______ Number of previous litters _______

Breeding date(s):_____________ Gestation:_______

Most recent vaccinations and dates: (include brand names)
Dam:

Does dam have a history of medical problems?

Pen measurements:

Describe the enclosure: (*circle those that apply*)
on exhibit / off exhibit
outdoor / indoor
trees / bushes / grass
flat / terraced
other unique features?

How long before birth was the dam moved to this enclosure?______ pen # ______

Note the proximity of other cheetahs to the birthing enclosure:

Other species within visual / olfactory / vocal range:

How many den boxes were provided? _______
Den location(s): ____________________

After cubing were they given access to other houses or dens? Y / N *date*______

What material was the cubing box floor made of?_______

Was bedding provided? Y / N *describe*:
Was heat provided? Y / N *describe*:
Den box light source? Y / N *describe*:

Was the den box temperature and / or humidity monitored? Y / N *describe:*

Pregnancy confirmed by: (*check all that apply and give dates*)
______observed copulation
______weight gain
______X ray
______ultrasound
______fecal steroid / assays
______the birth itself
______other - *describe*

Describe & date any changes in dam **during pregnancy**:
appetite:
activity level:
behavior towards keepers:
behavior towards conspecifics:
other:

Describe & date any changes in dam **during lactation**:
appetite:
activity level:
behavior towards keepers:
behavior towards conspecifics:
other:

Describe usual diet & date of diet changes provided:

	usual	during pregnancy	during lactation:
diet items:			
diet amounts:			
feeding frequency:			
supplements:			
other:			

Was keeper routine changed prior to and following cubing? If so, note changes & when they were made.

Weather conditions at time of birth:

Indications that birth was imminent: (*check all that apply and time when first occurred*)
______dam off food
______in & out of the den
______pacing
______direct attention to hindquarters - AG licking
______contractions
______straining
______other – *describe*

Time frame from the first 'sign' (not eating, entering den, etc.) to the birth of the first cub? _________

Was the birth observed?
______not observed
______direct
______through peephole
______through one-way glass
______via video monitor
______other - *describe*

Was the birth video taped? Y / N

Was there audio coverage? Y / N

Note time each cub was born & intervals:

1_____	5______
2______	6______
3______	7______
4______	8______

Did dam require any intervention? (e.g. oxytocin, C-section, etc) Y / N *describe:*

Number of cubs, if any, eaten by dam:

Were any cubs stillborn? Y / N

At what time was cleaning of the cubs first observed?

At what time was nursing **first** observed?

Give *date and time* the dam is first observed leaving the den box without a cub:
with a cub:

Describe and date how often the dam moves the cubs to another location (for the first six weeks):

After giving birth when is the dam first **offered** food? *date* ______

When did the dam first **eat** after giving birth? *date* _____

Were any cubs pulled for hand-rearing?   Y / N   *date*_______

What indicators were used to determine that hand-rearing was necessary?
______restless behavior?   *describe*
______neglect
______disappearance of a cub
______traumatic injury to a cub
______SSP recommendation
______institution policy
______other - *describe*

Reason for **first** human physical contact with cubs: (*check all that apply & give dates*)
______sexing
______weight
______vaccinations
______pulling for hand-rearing
______other - *describe*:

Age in days for the death of a live born:

First weights obtained: (*note sex and age of each & temps if pulled for hand-rearing)*

Any physical deformities? (e.g. cleft palate, coat pattern, deformities etc.)   Y / N   *describe:*

Medication or medical procedures required on cubs?   Y / N   *describe:*

When were cubs first observed exiting the den box?

When were cubs first observed eating solids?

Date and age cubs were separated from dam:

Any suggested changes for future litters?

Current Knowledge about the Reproductive Biology of the Cheetah – 2008

Introduction

The worldwide *ex situ* cheetah (*Acinonyx jubatus*) population is comprised of approximately 1,350 animals [1], which traditionally exhibit poor reproduction [2, 3] compared with their free-ranging counterparts [4]. Cheetahs living in the Serengeti ecosystem, for example, reproduce quite efficiently in the absence of human perturbation [4]. Most reproductive failure in captivity likely can be attributed to sub-optimal management and husbandry practices [2, 5] based on the lack of differences in health, genetics or other physiological parameters between breeding and non-breeding captive cheetah populations [4, 6]. These factors, coupled with a high incidence of cub mortality [7], have negatively impacted the *ex situ* cheetah population, which is no longer self-sustaining [8].

The statistics on the worldwide captive cheetah population are taken from the most current addition of International Cheetah Studbook [1]. At the end of 2004, there were 1,387 (708.673.6) cheetahs living in captivity worldwide in 238 facilities in 47 countries and of these, 1013 (73%) were captive born (530.483) and 351 (28%) were wild-born animals (169.182). In 2004, only 78 of the 1,387 (or a mere 5.6%) reproduced with 12.2% (29 of 238) of all facilities reporting successful reproduction of 162 total cubs produced in 40 litters and an infant mortality of 20.3% (33 of 162). Between 1996 and 2002, the North American cheetah population declined by 33% (from 333 to 210 individuals). Currently, only 17.2% (21 of 122) of all females and 13.5% (15 of 111) of all males in the North American population have ever reproduced. Remaining in this captive population are a total of 10 (5.5) wild-caught animals, of which only 7 (1.2) have successfully reproduced. Another cause for concern is the advanced age structure of the North American population as 24.2% (32 of 132) of females and 22.8% (29 of 127) of males are 9 years of age or older. For all proven females, 8 of the 21 are now 9 years of age or older. .

In order to provide a comprehensive assessment of cheetah reproductive health, an SSP mandate was put forward to evaluate 128 cheetahs (60 males, 68 females) maintained in 18 institutions in North America over the 2-year period of January 1990 to June 1991 [6]. A mobile laboratory research team evaluated cheetahs using serial blood sampling, electroejaculation (males) and laparoscopy (females). Biomaterials also were collected for parallel studies of genetics, nutrition and health. There was no animal mortality associated with the research and cheetahs were found capable of reproducing naturally after these intense examinations. Males examined ranged in age from 15 to 182 months and females from 16 to 182 months.

In brief, the reproductive biology findings of this survey are as follows: No marked differences were observed in reproductive or endocrine characteristics between proven and unproven breeders. However, males consistently produced teratospermic ejaculates, and cheetah sperm were compromised in conspecific or heterologous *in vitro* fertilization systems. Structurally abnormal sperm were found to be filtered by the oocyte's zona pellucida.

More than 80 percent of the females were anatomically sound, but morphological and endocrine evidence suggested that approximately 50 percent or more of the population may have had inactive ovaries at the time of the examination. Males ranging in age from 15 to 182 months produced spermic ejaculates, but motile sperm numbers/ejaculate and circulating testosterone concentrations were highest in males 60 to 120 months old. Parovarian cysts were observed in 51.5 percent of the female cheetahs, but there was no correlation between the presence of these cysts and fertility. Fresh luteal tissue was not observed in any non-pregnant or non-lactating female. Overall, the survey report discussed findings in the context of the causes for reproductive inefficiency with respect to biological versus management factors. For more information, the full manuscript should be examined in detail [6]. This study represents the last formal systematic evaluation of cheetah reproductive health in the North American population.

Male Reproductive Biology

Considerable data are available on ejaculate characteristics in cheetahs (Table 1). Cheetahs traditionally produce high proportions of structurally abnormal spermatozoa (~80%) ranging from 40 percent to 98 percent pleiomorphisms/ejaculate (Fig. 1 and Table 2). It is presumed that this overall increase in teratospermia in cheetahs is related to a general loss of genetic diversity within the species [9-11], since inbreeding is known to compromise ejaculate traits in domestic and laboratory animals. Interestingly, there are no significant differences in the numbers of abnormal sperm between proven and unproven breeders [6]. Although cheetahs consistently produce a high proportion of abnormal sperm, ejaculates contain a high proportion of sperm with intact acrosomes (Fig. 2) [12]. However, it is known that these pleiomorphic sperm are unable to penetrate the zona pellucida and bind to this outer layer of the oocyte. Only structurally normal sperm are able to completely penetrate the zona pellucida and participate in fertilization [13]. In a conspecific *in vitro* fertilization system, incidence of successful fertilization in cheetahs is lower compared to those observed in domestic cats or non-domestic felids producing normospermic ejaculates [14-17]. Abnormal sperm in the cheetah may be typical, as pleiomorphic sperm are common in a number of wild species [18].

Seminal norms of North American captive cheetahs are based upon electroejaculation of 60 representative males ranging in age from 15 to 182 months [6]. Testes volume also was measured in these males with laboratory calipers, and these values were converted to combined testes volume [19]. Combined testes volume in these cheetahs was 13.9 ± 0.4 cm^3, with no difference in the volume of the left versus right testis. Combined testes volume was correlated to specific ejaculate characteristics including semen volume ($r = 0.46$; $P < 0.01$), motile sperm/ejaculate ($r = 0.33$; $P < 0.05$) and the proportion of structurally normal sperm/ ejaculate ($r = 0.41$; $P < 0.01$). An assessment of semen and sperm characteristics of wild-born cheetahs in Namibia, Africa, was based on 200 total ejaculates from 97 animals ranging in age from 14 months to 17 years). A summary of these results can be found in Table 1. The type and frequency of sperm malformations detected in the ejaculates of Namibian cheetahs are summarized in Table 2 [20]. The most prevalent morphological defects were a spermatozoon with a bent midpiece with retained cytoplasmic droplet or an abnormal acrosome.

Together these abnormalities comprised more than 40% of the structural defects observed (Table 2). The proportion of various types of pleiomorphisms also was similar to historic data collected for cheetahs living in North American zoos (Table 2). Cryptorchidism (unilateral or bilateral retention of the testes within the abdominal cavity) was not observed in any of these surveyed males, and thus, does not appear to be a common problem in the cheetah compared to the genetically compromised Florida panther [21].

Semen collection and sperm assessment also is influenced by the presence of bacterial cells, of which the prevalence and type must be considered when collecting samples for assisted breeding. Bacterial culture of semen from North American male cheetahs revealed numerous gram-negative and gram-positive organisms, many of which also were isolated in rectal cultures [6]. Similar to the domestic cat, hemolytic *Escherichia coli* was the most prevalent bacteria in the semen and rectum (Tables 3 and 4).

<u>Seasonality</u>

Based on evaluation of reproduction for free-ranging females in Namibia, which holds the largest wild population, seasonal affects on reproduction were observed [22]. For analysis, Namibian seasons were divided into hot - wet (Jan - Apr), cold - dry (May - Aug) and hot - dry (Sep - Dec). In the cheetah, gestation persists for ~90 days, and in Namibia approximately 70% of all free-ranging cubs are born between the months of March and July [22]. Therefore, it was determined that the seasons of lowest breeding would be composed of the entire cold-dry and most of the hot-dry seasons. This indicates the prevalence of reproductive seasonality (i.e.: breeding season primarily between December and April) in free-ranging female cheetahs. In the Serengeti ecosystem, cheetah births have been observed during all months of the year. However, a trend exists for adult females to breed more frequently during the wet season months (November-May) in East Africa, similar to that observed in Namibia, probably as a result of increased food availability [4]. At the DeWildt Cheetah Breeding Center near Pretoria, it has been reported that most cheetah breeding occurs during November and February [23].

Data from 1179 litters reported in the International Cheetah Studbook compiled from data collected from 1968-2005, revealed a bimodal distribution with peak numbers of births occurring from March to June and September to November (Table 5 and Fig. 3). The bimodal distribution of births in the entire cheetah population, however, may be due to differences in peak numbers of births between the northern and southern hemispheres. In the northern hemisphere, the peak occurs in September to November, whereas the peak in the southern hemisphere is March to June (Table 6). Utilizing non-invasive hormone monitoring through collection and extraction of feces, estrous cycles of female cheetahs were monitored in the North American population. It was found that 75% of all females evaluated displayed periods of anestrous that were unrelated to season. In addition, no correlation with season was found for those captive females that did exhibit estrous cyclicity [24].

An assessment of cheetah seminal quality revealed that male Namibian cheetahs also show some effects of seasonality [20]. Based on evaluation of 200 ejaculates from 97 males, it was found that the percent of motile sperm increased in the cold-dry season compared with the hot-dry season although there was no effect of season on overall ejaculate volume, sperm forward progressive status, sperm concentration or total motile sperm per ejaculate (Fig. 4). The percentage of sperm with intact acrosomal membranes increased during the cold-dry season compared with the hot-wet and hot-dry season, but the percentages of normal sperm and sperm with acrosomal abnormalities did not vary between seasons. For male cheetahs in North America, semen characteristics apparently do not change throughout the year in North American cheetahs (Table 7; Durrant et al., unpublished). Ejaculates collected throughout the year using an artificial vagina (n = 3 males) revealed similar seminal characteristics

Female Reproductive Biology

Currently, no data are available concerning the precise onset of ovarian cyclicity in female cheetahs. Age at first copulation for females varies from 18 to 52 months with an average age of 43 months. Records from the most recent International Cheetah Studbook indicate that the youngest and oldest females giving birth to offspring were 4 – 11 years of age, respectively [1]. Based upon changes in vaginal cytology, estrous cycle length varies markedly among individual females. Mean cycle length in three females was approximately 11 days (range, 3 to 27 days; (Asa et al., 1992). Behavioral observations have revealed an estrous cycle length of 10 to 20 days with the duration of behavioral estrus (sexual receptivity) ranging from 1 to 3 days. In the reproductive survey of 68 adult females, fresh luteal tissue from recently ovulated follicles was observed in only one female (inexplicably a female nursing cubs in the absence of an adult male). In contradiction, luteal scars were observed in four unproven breeders previously not housed with adult males. Additionally, one study of vaginal cytology suggested that females may occasionally spontaneously ovulate (Asa et al., 1992).

Based on endocrine profiles from extraction of fecal samples, data on estrous cycle length have been generated on a large scale, systematic basis [24]. Analysis of both fecal estradiol and progestogen from 26 adult cheetahs revealed that duration of the estrous cycle is 13.6 ± 1.2 days with increased estrogen concentrations lasting for 4.1 ± 0.8 days. For all females that were not exogenously stimulated with gonadotropins, 75% showed estrous cyclicity but, interestingly, none of the females that were evaluated for 1 year or more were continuously cyclic [24]. Females exhibited lengthy (often more than several months) periods of anestrous that were not related to season or to cycles of females at the same facility. Based on fecal hormone analysis, it was determined that gestation in cheetahs is 94.2 ± 0.5 days on average and the non-pregnant luteal period was 51.2 ± 3.5 days [24, 25]. Spontaneous ovulations occurred only 1.1% of all estrous cycles (2 of 184 total cycles) evaluated.

Vaginal cultures collected from 67 adult cheetahs during the reproductive survey revealed numerous gram-negative and gram-positive bacteria with an extremely high prevalence of hemolytic *Escherichia coli* (43 of 67; 64.2%, Table 8; [6]). Comparative studies in 49 domestic cats also demonstrated many different bacterial isolates and a high incidence of hemolytic *Escherichia coli* (33 of 49; 67.3%).

Because similarities exist between cheetahs and clinically healthy domestic cats, the presence of these bacteria are not considered abnormal in the cheetah. As in male cheetahs, females demonstrated a high incidence of hemolytic *Escherichia coli* in rectal cultures.

Behavior during estrus

Dedicated observation can identify increased rates of rolling, head rubbing, tail twitching, object sniffing, calling, frisky behavior, front crouching, treading, Flehman response, presenting to male, loss of appetite or even urine spray marking in certain females as indices of estrus (sexual receptivity). However, cheetahs have been reported to undergo a high incidence of silent estrus (ovarian cyclicity in the absence of behavioral signs). The most reliable clue to identifying estrus, however, is a change (either increase or decrease) in frequency of any of the above behaviors. In a study of four females observed daily (2 hours per day) for 36 months, a change in certain specific behaviors was associated with male breeding behavior. These signs in the female included increased frequency of object sniffing, urine marking, walking, front crouching, treading, Flehmen response and rolling. Breeding behavior in male cheetahs has included pacing, Flehmen response and distinctive vocalizations described as stutter barking and chittering. Changes in fecal estradiol concentrations correlate significantly with variation in the occurrence of several specific behaviors including rolling, rubbing, sniffing, vocalization and urine spraying [26]. Importantly, fecal endocrine data have revealed that pairing behaviorally incompatible females together may lead to suppressed ovarian activity and acyclicity (Fig. 6) [5].

Endocrinology

Basal concentrations of some reproductive hormones in adult male and female cheetahs have been assessed [6]. Serum concentration of luteinizing hormone (LH) in both male and female cheetahs was similar to that measured for other felids (leopard, tiger, puma, lion); whereas, follicle stimulating hormone (FSH) secretion is 30 to 50 percent lower than that observed in these same species [27, 28]. Young males (15 to 25 months) produce lower concentrations of serum testosterone than older males (60 to 120 months).

Based on evaluation of serum hormone levels, a few of the surveyed cheetahs (n = 7) produced circulating estradiol-17ß in excess of 10 pg/ml [6]. In general, those females producing more estrogen had greater ovarian activity. Endocrine differences between proven and unproven males or females were not detected in the survey. Based on noninvasive fecal hormone monitoring, female cheetahs produce concentrations of estradiol ranging from 7 – 420 ng/g dry feces with an average baseline estradiol concentration ranging from 41.2 ± 1.3 to 71.5 ± 2.4 ng/g dry feces [5]. Average peak estradiol concentrations ranged from 109.2 ± 15.5 to 269.2 ± 4.4 ng/g feces. For progesterone concentrations, average baseline levels ranged from 0.6 to 8.0 µg/g feces. During pseudopregnancy, peak progesterone concentrations for two individuals were reported to be 448.9 µg/g feces and 130.5 µg/g feces [5].

The secretion of LH, progesterone, estradiol-17ß and testosterone tend to vary during anesthesia. For example, LH, progesterone and estradiol-17ß often are secreted in an episodic fashion [6].

Testosterone secretion often changes over time demonstrating either a gradual increase or decrease. Therefore, a single blood sample is probably not an index of true basal concentrations for an individual. If anesthesia is to be used, it is recommended that one to three blood samples be collected within 15 minutes of the animal becoming tractable after induction. Results from a study of pituitary function in adult male and female cheetahs indicate that gonadotropin releasing hormone (GnRH)-induced LH secretion is two-fold greater in males than females [29].

As cortisol levels can be used as an index of "stress," circulating levels suggest that the cheetah is less stress-sensitive than other wild felid species maintained in captivity. For example, serum cortisol concentrations in cheetahs range from 33 to 184 ng/ml, whereas in tigers, leopards and pumas, cortisol ranges from 187 to 287 ng/ml [27]. Electroejaculation causes an acute rise in serum cortisol in the cheetah which returns to baseline within approximately 60 minutes [27]. Analysis of fecal corticoid revealed significantly varied patterns among individual females, but interestingly, cortisol levels appeared unrelated to behavioral or ovarian hormone patterns [5]. Average fecal corticoid levels ranged from 33.9 ± 1.3 to 68.5 ± 1.8 ng/g dry feces and peak corticoid levels ranged from 104.2 ± 2.6 to 289.5 ± 3.1 ng/g feces [5].

<u>Prevalence of anatomical abnormalities in female cheetahs</u>

The survey of 68 female cheetahs revealed that 57 (83.8%) were reproductively sound from an anatomical perspective [6]. Those females found to be reproductively unsound included: 1) 2.9% with degenerate/fibrous ovaries; 2) 1.5% with a single ovary; 3) 1.5% with a unilateral ovarian adhesion to adjacent omentum; 4) 1.5% with a 5 to 6 cm long mass within one uterine horn; 6) 5.9% with an abnormally small vaginal os; and 7) 1.5% with severe degenerative liver disease, so severe as to likely compromise reproductive cyclicity.

The most common abnormal feature of the cheetah reproductive tract was the presence of parovarian cystic vestiges of mesonephric ducts (single or multiple, fluid-filled pockets located in the mesovarium between the ovary and ovarian fimbria) immediately lateral to the proximal aspect of the ovary and usually adjacent or in close proximity to the oviduct. Histological studies have revealed that parovarian cysts did not occlude the oviduct. Of the 68 surveyed females, 51.5 percent had parovarian cysts (mean 3.7 ± 0.4 cysts/female) including 10 of 14 (71.4%) of the proven breeders compared to 25 of 54 (46.3%) of the unproven cheetahs. The range in cyst diameter was 2 to 35 mm with an overall mean of 8.9 ± 0.7 mm. Parovarian cysts were present in all age groups, although the condition was less prevalent in females 48 months of age or less. This condition likely does not contribute to reproductive inefficiency in the species.

<u>Appearance of the uterine horn, oviduct and ovary</u>

The average diameter of the bicornuate uterine horn in 68 female cheetahs was 8.2 ± 0.4 mm (range, 4 to 17 mm; [6]). The mean diameter of the oviduct was 3.8 ± 0.1 mm (range, 2 to 7 mm). There was no difference in the gross appearance or size of the uterine horns or oviducts in proven versus unproven breeder cheetahs.

Based upon laparoscopic observations, three ovarian shapes generally were observed and these have been classified as Type I, II or III [6]. Type I was considered ovaries of normal size and shape compared to the intermediate, slightly flattened Type II followed by Type III ovaries which are severely flattened and appeared to have reduced ovarian mass. Most (~60%) cheetahs have bilateral Type I ovaries, with approximately 19 percent of females having Type II and approximately 20 percent with the atrophic-appearing Type III gonads.

Ovarian follicles in cheetahs are clear, flat areas with or without a distinct border with the surrounding ovarian stroma [6]. Follicles range in size from <1 mm to >6 mm in diameter. The size of mature follicles is not precisely known, but, in general, they are believed to be ≥ 4 mm in diameter. Corpora hemorrhagica (CH; fresh ovulation sites) are bright red in appearance, 4 to 8 mm in diameter and raised approximately 4 mm above the ovarian surface [6]. Corpora lutea (CL; ovulation sites at least 48 hours of age) are orange-yellowish in coloration, 6 to 7 mm in diameter and raised to 1 to 2 mm above the ovarian surface. Luteal scars are flat-yellow spots, 2 mm or less in diameter. These remain on the ovary for months after ovulation and provide an index of whether the cheetah has ovulated.

Pregnancy and parturition

Analysis of fecal steroid hormones has been used to monitor steroid or steroidal metabolite concentrations during pregnancy [24, 25]. The mean gestation length in cheetahs is on average 94 days with a reported range of 90-96 days [24]. It has been shown that fecal estradiol increases from 5 days before to one day following copulation (Czekala et al., 1991; Gross, 1992). Estradiol remained low throughout gestation until 2 weeks before parturition when concentrations again increased. Progesterone increased following copulation and remained elevated above baseline throughout pregnancy. During pregnancy, the average basal estradiol and progesterone concentrations are 70.6 ± 15.9 ng/g dry feces and 4.6 ± 1.1 µg/g dry feces, respectively [25]. During pseudopregnancy, these values are 65.8 ± 5.9 ng/g dry feces and 5.0 ± 0.7 µg/g dry feces for estradiol and progesterone, respectively.

Data from 188 female cheetahs demonstrated that the mean age at first parturition is 58.0 ± 1.8 months (range, 24 to 120 months, Fig. 7). The mean number of litters produced over the lifetime of a female cheetah is 2.8 ± 0.1 (range, 1 to 9, Fig. 8). Based upon data from 332 birth intervals, cheetahs exhibit an average interbirth interval of 14.0 ± 0.4 months (range, 6 to 60, Fig. 9). Based upon 521 litters reported in the International Cheetah Studbook (1968-1991), litter size ranged from one to eight cubs with a mean size of 3.3 ± 0.1 cubs/litter (Fig. 10). Cubs generally are delivered at 30 to 120 min intervals during parturition but intervals of 7 hours have been reported. Data extracted from the International Cheetah Studbook on 1,606 newborn cheetahs reveal an overall sex ratio at birth of 1:1 (816 males:790 females). The mean birth weight of 39 captive-born cheetah cubs was 473.9 ± 12.1 g (range 296 to 640 g). The daily weight gain of 21 mother-raised cubs from birth through day 45 was 40 to 50 g/cub/day.

Effect of age on reproduction

In female cheetahs, reproductive success declines with age. Overall, following AI using either fresh or frozen-thawed sperm, a total of 11 pregnancies and 20 cubs have resulted [30, 31]. However, when examining these results based on female age, ~50% of animals < 8 years of age became pregnant and produced live offspring compared with < 10% of females $\geq$ 9 years of age. It is not known if this reduced incidence of pregnancy in older females can be attributed to compromised oocyte quality, leading to reduced fertilization and poor developmental competence. Alternatively, uterine health and subsequent fertility may be compromised in cheetahs of advanced age. Post-mortem evaluation of uterine pathology revealed that cheetahs ≥ 9 years of age had an increased ($P < 0.01$) incidence of uterine hyperplasia (77.1% of females) compared to 46.7% of females 6 – 8 years old and only 11.1% of 2 – 5 year old females (Munson et al., unpublished data; Fig. 11).

Male cheetahs begin producing sperm between 14 - 16 months of age [6, 20]. However, it was found that sperm and testosterone concentrations were lower in these younger males than in males 60 to 120 months old [6]. It was also determined that some 15 year old males still produce very low concentrations of sperm in the presence of baseline concentrations of testosterone. Age at first copulation for males varies from 20 to 46 months. Long-term records indicate that the youngest and oldest male to sire offspring were 2 and 15 years, respectively, however the majority of successful copulations occur between 3 and 10 years of age [1].

To analyze the effects of animal age on ejaculate characteristics, wild-born cheetahs in Namibia were divided into categories: juvenile (14 - 24 mo; n = 16 males, 23 ejaculates), adult (25 - 120 mo; n = 76 males, 175 ejaculates), and aged (over 120 mo; n = 5 males, 5 ejaculates) groups [20]. Of the five males in this study aged at 14 months, 2 were aspermic and 3 had spermic ejaculates. As expected, fully mature and aged animals (either between 24 - 120 months or over 120 months) had an increased ($P < 0.05$) body weight compared with juvenile animals (24 months and under; Table 9). Interestingly, there was no effect of animal age on total testicular volume. In addition, juvenile cheetahs produced ejaculates with reduced ($P < 0.05$) sperm motility (56.7 ± 3.3%, LSmeans ± SEM) and forward progressive status (FPS: scale = 0 – 5 with a five rating equivalent to rapid, straightforward progress, 2.9 ± 0.1; [18]) compared to adult (69.8 ± 1.4% and 3.4 ± 0.1, respectively) and aged (78.9 ± 6.7% and 3.7 ± 0.3, respectively) animals [20]. Ejaculates from juvenile animals also had reduced ($P < 0.05$) volume (0.7 ± 0.3 ml) and fewer ($P < 0.05$) total motile sperm ($7.1 \pm 9.3 \times 10^6$) compared to adult (2.2 ± 0.1 ml and $42.3 \pm 4.1 \times 10^6$) and aged (2.3 ± 0.6 ml and $23.5 \pm 20.0 \times 10^6$, respectively) males (Table 9).

Interestingly, there was no effect ($P > 0.05$) of animal age on sperm concentration, percent of sperm with intact acrosomal membranes or midpiece, flagellar or other abnormalities (Table 5; [20]); however, adult animals had an increased ($P < 0.05$) amount of total motile sperm per ejaculate compared with juvenile animals. Aged animals (over 120 months) had the highest ($P < 0.05$) proportion of normal spermatozoa per ejaculate compared with either juvenile or adult animals. Finally, animals under 2 years of age (juvenile) had an increased ($P < 0.05$) proportion of head abnormalities (macrocephalic, microcephalic, bi- or tri-cephalic) compared with their aged counterparts (Table 9).

Assisted Reproduction

Procedures such as artificial insemination (AI) and *in vitro* fertilization can be important for aiding in the reproductive management of the cheetah. These techniques are important: 1) for learning more about the basic reproductive biology of the species; 2) as a clinical tool for individual animals that cannot reproduce successfully on their own; and 3) for genome cryopreservation (sperm, oocyte and embryo banking).

In vitro fertilization

In vitro fertilization (IVF) techniques adapted to the cheetah have been useful for understanding follicular development, inducing egg maturation and ovulation, studying sperm function, gamete interaction and embryo development [14]. Following administration of single injections of pregnant mares' serum gonadotropin (PMSG) and human chorionic gonadotropin (HCG), twelve female cheetahs were evaluated by laparoscopy. Based upon the presence of ovarian follicles ($\geq$ 1.5 mm in diameter), all responded to exogenous gonadotropins (range, 11 to 35 follicles/female). Eight of the 12 donors produced more than 20 oocytes and a total of 277 oocytes were collected laparoscopically from 292 follicles (94.9% recovery; 23.1 $\pm$ 2.2 oocytes/ female). Of these, 250 (90.3%) qualified as mature and 27 (9.7%) as degenerate [14]. A sperm motility index (SMI) was calculated for each of nine cheetah sperm donors that produced ejaculates averaging 41.3 $\pm$ 22.9 x 10^6 motile sperm and 28.4 $\pm$ 4.9% structurally normal sperm. Each ejaculate was used to inseminate cheetah oocytes from one or two females. Of the 214 mature oocytes inseminated, 56 (26.2%) were fertilized, and 37 cleaved to the 2-cell stage *in vitro* [14]. The incidence of *in vitro* fertilization varied from 0 to 73.3 percent among individual males. Only 17.3 percent of all cheetah oocytes inseminated *in vitro* cleaved. When oocytes from individual cheetahs (n = 5) were separated into two groups and inseminated with sperm from a male with an SMI >0 after 6 h coincubation versus an SMI=0 at this time, the mean fertilization rate was 28/44 (63.6%) and 0/37 [32], respectively. Examining the data on an individual sperm donor basis reveals that effective gamete interaction in the cheetah is dictated, in part, by sperm motility.

Because sperm from cheetahs are highly abnormal (80% average) a study was undertaken to assess the potential of zona piercing for assisting *in vitro* fertilization rates in this species [33]. The proportion of oocytes contained spermatozoa within the inner zona pellucida was higher for oocytes that had a pierced zona compared with intact oocytes. However, altering the zona artificially did not increase the number of sperm in the perivitelline space, reiterating the role of the inner zona region as a filter for malformed sperm [33]. In summary, these results provide an improved and more focused understanding of the many factors that potentially can influence sperm-oocyte interaction in Felidae. These studies illustrate the importance of sperm quality, especially motility and structural characteristics, in achieving IVF in this taxon.

Artificial insemination

Early studies using follicle stimulating hormone (FSH-P) followed by administration of hCG were successful in stimulating follicular development and ovulation in the cheetah [34]. However, attempts to produce pregnancies by inseminating sperm vaginally before the expected time of ovulation were unsuccessful (n = 30 cheetahs) [35]. The lack of success may have been related to improper site of sperm deposition and/ or timing of insemination with respect to ovulation. Artificial insemination (AI) studies in domestic cats, ferrets and tigers revealed decreased sperm transport in the uterus of anesthetized females after vaginal deposition of sperm, suggesting that anesthesia may reduce uterine motility and compromise the ability of sperm to reach the site of fertilization [36, 37]. A laparoscopic intrauterine insemination technique for depositing sperm directly into the uterine horns via a catheter inserted through the abdominal wall was developed in ferrets and domestic cats to circumvent compromised sperm transport [30, 38, 39]. A study in domestic cats revealed that the time of insemination also influences conception rates in anesthetized, hormonally stimulated females [37]. When laparoscopic AI was performed under ketamine hydrochloride, acepromazine and halothane anesthesia before ovulation, the pregnancy rate was low (~14%). However, approximately 50 percent of all cats became pregnant and delivered live offspring when insemination was performed 6 to 14 hours after ovulation had begun [38].

The laparoscopic intrauterine AI technique has been used in the cheetah [30, 39]. Six females were given a single injection of PMSG (200 or 400 IU) and hCG (125 or 250 IU) 80 h later. At 42.5 to 47.0 h after HCG, all females were evaluated laparoscopically for ovulation and fresh ovarian corpora lutea (CL). Ovulation was induced successfully in all cheetahs (range, 3 to 13 CL among females) and freshly collected and processed spermatozoa were deposited transabdominally into the proximal aspect of each uterine horn. The AI procedure was simple and rapid, generally requiring only 30 min after laparoscope insertion. One female, induced to ovulate with 200 IU PMSG and 125 IU hCG and inseminated with 10×10^6 motile sperm at 42.5 h post-hCG, produced a pregnancy and a single live cub after a 95-day gestation. In a subsequent study comparing PMSG doses (100 vs. 200 IU), six females were inseminated laparoscopically *in utero*. Two post-ovulatory females, each receiving 200 IU PMSG and 100 IU hCG and inseminated with 3.4 or 14.2×10^6 freshly collected motile sperm, produced pregnancies and litters of two and four cubs, respectively [39]. In a second study comparing 100, 200 or 400 IU eCG and 100 or 250 IU hCG, nineteen laparoscopies intrauterine AIs were performed on cheetahs [40]. More than 70% of the cheetahs ovulated in the 200 and 400 IU eCG groups compared to only one of the six females in the 100 IU eCG. The number of freshly ovulated CL was not different among treatment groups. Two distinct types of CL were observed: small (2-4 mm in diameter) and large (5-8 mm in diameter). The only female to ovulate after receiving the 100 IU eCG dose had small CLs and no large as did all cheetahs receiving the 400 Iu dose. Interestingly, only 46.2% of females given the 200 IU eCG dose and all six cheetahs that became pregnant following AI with freshly collected sperm received the 200 IU eCG and 100 IU hCG dosage [40]. Laparoscopic AI has considerable potential as a tool for assisting propagation of the cheetah.

Gamete and embryo cryopreservation

To date, there have been no reports of successful cryopreservation of cheetah oocytes or embryos. Early studies provide preliminary data on the viability of frozen-thawed cheetah spermatozoa using *in vitro* function assays. In the first, semen was collected by electroejaculation, diluted with a 20% egg yolk-11% lactose extender containing 4 percent glycerol and frozen as pellets on a block of dry ice prior to storage in liquid nitrogen (Howard et al., unpublished). Viability of thawed spermatozoa was determined by measuring the post-thaw longevity of sperm motility, forward progressive motility and the ability of spermatozoa to penetrate the zona pellucida of domestic cat oocytes. Preliminary results indicated acceptable preservation of motility and ability to penetrate domestic cat zonae when compared to unfrozen spermatozoa.

Recently, a study was conducted to assess semen characteristics of wild-born cheetah as well as the impact of three types of glycerol influence (duration of exposure, temperature and method of addition) on sperm cryosensitivity [12]. To evaluate the impact of duration of glycerol exposure, spermatozoa were incubated in Test Yolk Buffer (TYB) with 4% glycerol at ambient temperature (~22°C) for 15 vs. 60 min before cryopreservation (Table 10). To evaluate the influence of temperature and method of glycerol addition, spermatozoa were resuspended at ambient temperature either in TYB with 0% glycerol followed by addition of 8% glycerol (1:1 v/v; at ambient temperature vs. 5°C) or directly in TYB with 4% glycerol. All samples were cryopreserved in straws over liquid nitrogen vapor and evaluated for sperm motility and acrosomal integrity after thawing. Semen samples ($n = 23$; $n = 13$ males) contained a high proportion (78%) of pleiomorphic spermatozoa. Ejaculates also contained a high proportion of acrosome-intact (86%) and motile spermatozoa (78%). Data from these studies are summarized in Tables 10 and 11. Immediately after thawing, a significant proportion of spermatozoa retained intact acrosomes (range, 48 – 67%) and motility (range, 40 – 49%). After thawing, incubation in glycerol for 60 min at ambient temperature before freezing decreased ($P < 0.05$) sperm motility and acrosomal integrity at one time-point each (pre-centrifugation and post-centrifugation, respectively). However, method or temperature of glycerol addition had no ($P > 0.05$) impact on sperm cryosurvival. In summary, 1) wild-born cheetahs produce high proportions of pleiomorphic spermatozoa but with a high proportion of intact acrosomes and 2) resuspension in 4% glycerol, followed by exposure for up to 60 min at ambient temperature, had minimal effect on sperm motility and acrosomal integrity after cryopreservation. Results indicate the feasibility of cryopreserving cheetah spermatozoa under field conditions, providing a user-friendly tool to capture and store gametes to enhance genetic management.

<u>Reproductive research priorities</u>

<u>I. Onset of Puberty</u>

Project Objectives & Rationale:

The hypothesis is that female cheetahs begin displaying signs of sexual maturity earlier than males (10-12 vs. 12-14 months, respectively). Semen collection data have shown that male cheetahs begin producing sperm at 14-16 months of age, but studies were not coupled with longitudinal behavioral or hormonal data. Minimal data collected on female cheetah behavior suggests that the first signs of puberty may begin as early as ~12 months of age. By combining three levels of evaluation (behavioral, hormonal, and commencement of sperm production), the physiological timeline of puberty onset can be established. A minimum of 8 each pre-pubertal male and female cheetahs will be included in the study. Objectives will be to determine the age at which male and female cheetahs reach sexual maturity by: 1) monitoring (sexual) behavior, 2) analyzing steroid hormone levels and 3) determining precise timing of onset of sperm production in males.

Expected Benefits:

Precise knowledge of the age at which cheetahs reach reproductive maturity will greatly benefit breeding programs by: 1) generating new fundamental information on cheetah biology; 2) improving the timing of placing males with females; and 3) enhancing overall husbandry and animal management.

<u>II. Influence of Age on Cheetah Oocyte and Embryo Quality and Uterine Morphology</u>

Project Objectives & Rationale:

The hypothesis is that the high incidence of reproductive failure in aged cheetahs is due to compromised ovarian activity (i.e.: acyclicity) combined with compromised oocyte quality and uterine health that results in low fertilization, embryo development and pregnancy. The North American *ex situ* cheetah population is not self-sustaining, largely due to reduced reproduction. Of particular concern is that ~33% of females in the extant population are 9 years of age or older. By examining three age classes, our objectives will be to [32] assess gonadal activity using noninvasive hormonal monitoring, (2) directly assess oocyte quality through *in vitro* studies that evaluate oocyte morphology, maturation, metabolism, fertilization and embryo development and 3) evaluate uterine health using ultrasonography. Using three age groups of female cheetahs (2 – 5 years, 6 – 8 years, 9 years and older), we will compare: 1) incidence of acyclicity, 2) uterine morphology by ultrasound, 3) ovarian and follicular activity following eCG and hCG administration and 4) oocyte viability, function and embryo development after *in vitro* fertilization.

Expected Benefits:

Results will provide new data on age-based reproductive fitness, information useful to determining the feasibility of propagating or recovering genetic material from older cheetahs that comprise a significant portion of the current North American SSP population.

III. Suppression of Male Reproduction

Project Objectives & Rationale:

The hypothesis is that group housing of males may result in a disparity in sperm quality between individuals (i.e.: improved sperm production in one male over the others in the social group). In zoos, male cheetahs are routinely housed in groups mimicking natural, wild living conditions. Interestingly, the impact of female cheetah social grouping on reproduction has been evaluated; however, no such assessment has been conducted for male cheetahs. Our hypothesis is supported by preliminary data on semen and sperm quality from males living in captive group situations in Africa. However, simultaneous evaluation of physiological processes including analysis of hormones (e.g.: testosterone and cortisol), evaluation of behavior as well as analysis of semen and sperm quality are needed to determine the physiology of possible reproductive suppression by group housing. The objectives will be to evaluate effects of group housing on male reproductive suppression using a minimum of 5 separate animal groups (2 - 4 males per group) by monitoring steroid hormones, behavior and sperm and semen quality.

Expected Benefits:

Information will improve overall cheetah management and breeding. Knowledge generated will benefit husbandry as well as assist with determining best housing situations for male cheetahs to improve reproductive performance for either natural or assisted breeding.

IV. Embryo Transfer and Cryopreservation

Project Objectives & Rationale:

The hypothesis is that embryos produced from oocytes of older and/or genetically valuable females can be successfully transferred to the uteri of recipient (either young and/or less genetically valuable) females. The ability to successfully transfer embryos, including from aged donors to young recipients or from genetically valuable females that may then produce several litters per year, needs to be established. The techniques involved include routine embryo production, monitoring of uterine health, and 'synchronizing' cycles of females which will serve as recipients. The procedures to cryopreserve embryos until ideal recipients are available also must be established. A total of 10 embryo donors, 20 embryo recipients and 8 sperm donors will be used. Fecal hormone levels will be monitored to determine reproductive cyclicity and efficacy of synchronization regimens. The objectives will be to develop cheetah-specific techniques for in vitro embryo production, cryopreservation and transfer.

Expected Benefits:

The ability to generate and store high quality embryos from genetically valuable females is crucial. In conjunction, developing systems for successful transfer of embryos and establishment of pregnancy in reproductively synchronized recipients will improve genetic management and the overall success of assisted breeding programs immensely.

V. Disease Screening

Project Objectives & Rationale:

Our hypothesis is that improved methods for screening of sexually transmitted diseases in cheetah semen samples will make a cheetah genome resource bank more efficient and will make the use of frozen sperm samples for assisted breeding more attractive to animal managers and veterinarians. Currently, managers and researchers are encouraging the use of artificial insemination using frozen sperm to prevent transmission of disease between institutions associated with live animal translocations. This approach also reduces the cost and stresses associated with moving animals as frozen sperm is more easily transported between institutions. However, little information is available about infectious agents in cheetah semen. Most important, among all transferred agents, are those causing feline immunodeficiency (FIV) and herpes viruses. Therefore, there is an urgent need to develop diagnostic tool for detection of these infectious agents in semen.

Expected Benefits:

This project will improve the bio-safety of genome resource banking by eliminating transmission of disease through semen samples.

T able 1. Ejaculate characteristics of wild-born Namibian cheetahs versus captive counterparts in North American zoos (Means ± SEM).

Trait	Namibian[a]	North American[b]
Total testicular volume (cm^3)	10.2 ± 0.3	13.9 ± 0.4
Seminal volume (ml)	2.1 ± 0.1	1.5 ± 0.1
Sperm motility (%)	69.0 ± 1.1	67.0 ± 2.0
Sperm forward progressive status (FPS)*	3.3 ± 0.1	3.6 ± 0.1
Sperm concentration/ml (x 10^6)	21.9 ± 1.7	29.3 ± 5.6
Total motile sperm/ejaculate (x 10^6)	36.2 ± 3.2	31.4 ± 5.6
Intact acrosomes (%)	73.9 ± 1.4	ND
Morphologically abnormal sperm (%)	81.6 ± 0.8	78.7 ± 2.0

[a]n = 97 males, n = 200 ejaculates, [20].
[b]n = 60 males, 60 ejaculates, [6].
*FPS scale 0 – 5, with 5 being the best forward progressive status.
ND = not determined.

Figure 1. Morphotypes of cheetah spermatozoa (1,000x). Spermatozoon with normal morphological structure (A). Pleiomorphic cell forms (B-P), including a spermatozoon with an abnormal acrosome (B); deformity of the sperm head, including microcephaly (C), macrocephaly (D) and bi/tri/tetra-cephaly (E); midpiece malformations, including a bent midpiece with retained cytoplasmic droplet (F), bent midpiece with no droplet (G), midpiece aplasia (H); anomalies of the flagellum, including a tightly coiled flagellum (I), bent flagellum with retained cytoplasmic droplet (J), bent flagellum with no droplet (K), bi/tri- flagellate (L), retained proximal cytoplasmic droplet (M) and retained distal cytoplasmic droplet (N); and a spermatid (O). Other severe developmental abnormalities also were observed, for example, a microcephalic tetra-flagellate spermatozoon (P); [20].

Table 2. Average percentage (± SEM) of normally and abnormally shaped spermatozoa in electroejaculates from wild-born Namibian and captive North American cheetahs.

Trait	Namibian cheetahs[a]	North American cheetahs[b]
Normal Sperm	18.4 ± 0.8	21.3 ± 2.0
Abnormal Sperm	81.6 ± 0.8	78.7 ± 2.0
Macrocephalic	0.8 ± 0.1	0.8 ± 0.2
Microcephalic	8.3 ± 0.6	4.4 ± 0.9
Bi/tri-cephalic	0.4 ± 0.1	0.4 ± 0.1
Abnormal acrosome	9.8 ± 0.5	3.7 ± 0.4
Abnormal or missing midpiece	3.3 ± 0.3	0.9 ± 0.2
Tightly coiled flagellum	7.5 ± 0.6	27.4 ± 2.5
Bi/tri-flagellate	0.3 ± 0.1	ND
Bent midpiece with droplet	30.3 ± 0.9	21.1 ± 1.1
Bent midpiece without droplet	4.5 ± 0.3	2.8 ± 0.4
Bent flagellum with droplet	1.6 ± 0.2	0.6 ± 0.1
Bent flagellum without droplet	1.8 ± 0.2	2.6 ± 0.8
Proximal droplet	3.6 ± 0.3	11.0 ± 0.9
Distal droplet	1.0 ± 0.1	3.0 ± 0.4
Bent neck	0.2 ± 0.1	ND
Spermatid	6.9 ± 0.6	ND

[a]n = n = 90 males, 177 ejaculates; [20]
[b]n = 60 males, 60 ejaculates; [6]

Figure 2. Coomassie blue staining of cheetah spermatozoa for assessment of acrosomal integrity (1,000x). Spermatozoa with intact acrosomes (IA) exhibited a uniform purple staining overlying the acrosomal region. Spermatozoa with non-intact acrosomes (NIA) displayed a clear or patchy staining pattern. Also depicted is a spermatozoon with an abnormal (knobbed) acrosome (AA); [12].

Table 3. Bacterial Isolates from Semen Collected by Electroejaculation in the Domestic Cat and Cheetah.		
Organism	Number of Isolates (%)[a]	
	Domestic Cats (n=27 males)	Cheetahs (n=40 males)
Gram Negative Bacteria		
Escherichia coli (hemolytic)	12 (44.4%)	7 (17.5%)
Escherichia coli (non-hemolytic)	3 (11.1%)	3 (7.5%)
Enterobacter cloacae	0 [32]	1 (2.5%)
Aeromonas hydrophila	0 [32]	1 (2.5%)
Klebsiella oxytoca	1 (3.7%)	4 [32]
mixed coliforms	5 (18.5%)	0 [32]
Pasteurella canis	0 [32]	1 (2.5%)
Pasteurella multocida	2 (7.4%)	3 (7.5%)
Proteus spp.	3 (11.1%)	6 (15.0%)
Pseudomonas aeruginosa	5 (18.5%)	3 (7.5%)
Gram Positive Bacteria		
Bacillus	1 (3.7%)	0 [32]
Lactobacillus	1 (3.7%)	0 [32]
Staphylococcus sp. (ß-hemolytic)	1 (3.7%)	4 [32]
Staphylococcus sp. (non-hemolytic)	4 (14.8%)	0 [32]
Streptococcus (ß-hemolytic)	0 [32]	1 (2.5%)
Streptococcus sp., Group D, *Enterococcus*	0 [32]	6 (15.0%)
Streptococcus spp. (non-hemolytic, non-*Enterococcus*)	6 (22.2%)	0 [32]
Mold	1 (3.7%)	0 [32]
No growth	1 (3.7%)	14 (35.0%)

[a] Number in parentheses indicates the percentage of males with the isolate.

Table 4. Bacterial Isolates from Rectal Cultures of Male and Female Domestic Cats and Cheetahs.

Organism	Number of Isolates (%)[a]	
	Domestic Cats (n=60 total) (11 males, 49 females)	Cheetahs (n=73 total) (33 males, 40 females)
Gram Negative Bacteria		
Escherichia coli (hemolytic)	42 (70.0%)	41 (56.2%)
Escherichia coli (non-hemolytic)	5 (8.3%)	4 (5.5%)
Campylobacter sp.	0 [32]	1 (1.4%)
Corynebacterium	1 (1.7%)	0 [32]
Klebsiella pneumoniae	1 (1.7%)	1 (1.4%)
Plesiomonas shigella	4 (6.7%)	0 [32]
Proteus	2 (3.3%)	7 (9.6%)
Gram Positive Bacteria		
Bacteroides	28 (46.7%)	0 [32]
Enterobacter	1 (1.7%)	0 [32]
Enterococcus	13 (21.7%)	1 (1.4%)
Lactobacillus	22 (36.7%)	0 [32]
Staphylococcus spp.	7 (11.7%)	0 [32]
Streptococcus spp. (non-hemolytic, non-*Enterococcus)*	3 (5.0%)	0 [32]
No growth	0 [32]	26 (35.6%)

[a] Number in parentheses indicates the percentage of females with the isolate.

Figure 3. Incidence of litters born by month for all captive facilities by hemisphere

Table 5. Incidence of litters born by month for all captive facilities from 1956 – 2005.

Month	Number of litters	Proportion of Total (%)
January	51	4
February	49	4
March	83	7
April	191	16
May	175	15
June	108	9
July	74	6
August	71	6
September	97	8
October	125	11
November	85	7
December	70	6

Figure 4. Influence of season (hot-wet, Jan-Apr; cold-dry, May-Aug; and hot-dry, Sep-Dec) on cheetah raw ejaculate characteristics: seminal volume (A), sperm motility (B), forward progressive status (C), sperm concentration (D), total motile sperm (E) and intact acrosomes (F). All values are least-squares means ± SEM. Within each trait, values with different superscripts differ ($P < 0.05$).

Table 6. Incidence of litters born by month for all captive facilities by hemisphere* 1956 – 2005

	Number of litters		Proportion of total (%)	
	Northern	Southern	Northern	Southern
January	35	38	5	5
February	35	22	5	3
March	37	59	5	8
April	80	143	11	19
May	73	124	10	16
June	59	75	8	10
July	48	46	7	6
August	44	43	6	6
September	74	53	11	7
October	93	64	13	8
November	72	49	10	6
December	46	43`	7	6

* Northern hemisphere includes North America, Europe and Japan and Southern hemisphere includes Africa and Australia.

Figure 4. Influence of season (hot-wet, Jan-Apr; cold-dry, May-Aug; and hot-dry, Sep-Dec) on cheetah raw ejaculate characteristics: seminal volume (A), sperm motility (B), forward progressive status (C), sperm concentration (D), total motile sperm (E) and intact acrosomes (F). All values are least-squares means ± SEM. Within each trait, values with different superscripts differ ($P < 0.05$); [20].

Figure 5. Influence of season (hot-wet, Jan-Apr; cold-dry, May-Aug; and hot-dry, Sep-Dec) on cheetah sperm morphology: normal (A) versus anomalies involving the acrosome (B), head (C), midpiece (D), flagellum (E) as well as other malformations (F). All values are least-squares means ± SEM. Within each trait, values with different superscripts differ ($P < 0.05$); [20].

Figure 6. Incidence of acyclicity due to group housing of female cheetahs in North American institutions [5].

Table 7. Ejaculate traits in cheetah semen collected by artificial vagina (3 Males, 12 Ejaculates/Male; Durrant et al., Unpublished)

Trait	Spring	Summer	Fall	Winter
Seminal volume (ml)	1.7 ± 0.6	2.2 ± 1.1	2.1 ± 0.6	1.9 ± 1.0
Sperm concentration (x 10^6/ml)	18.9 ± 11.4	28.9 ± 18.5	18.1 ± 10.3	33.2 ± 24.0
Motility Score	643 ± 105.5	696 ± 226.5	639 ± 80.1	547 ± 306.1
Morphologically abnormal sperm (%)	61.0 ± 6.1	64.6 ± 10.5	59.8 ± 14.5	57.8 ± 12.0

[a] Motility score = [(sperm progressive motility)^2 X (% sperm motility)]. Sperm progressive motility is based on a scale of 0-4, 4=best.

Table 8 Bacterial Isolates from Vaginal Cultures of Female Domestic Cats and Cheetahs.		
Organism	Number of Isolates (%)[a]	
	Domestic Cats (n=27 males)	Cheetahs (n=40 males)
Gram Negative Bacteria		
Escherichia coli **(hemolytic)**	**33 (67.3%)**	**43 (64.2%)**
Escherichia coli **(non-hemolytic)**	**0 [32]**	**1 (1.5%)**
Acinetobacter baumanii	**2 (4.1%)**	**0 [32]**
Proteus	**0 [32]**	**3 (4.5%)**
Corynebacterium spp.	**1 (2.0%)**	**3 (4.5%)**
Enterobacter	**1 (2.0%)**	**0 [32]**
Haemophilus	**1 (2.0%)**	**0 [32]**
Neisseria polysaccharea	**1 (2.0%)**	**0 [32]**
Pasteurella	**1 (2.0%)**	**0 [32]**
Pseudomonas fluoresces	**1 (2.0%)**	**0 [32]**
Gram Positive Bacteria		
Bacillus sp.	**4 (8.2%)**	**0 [32]**
Lactobacillus	**3 (6.1%)**	**0 [32]**
Micrococcus	**1 (2.0%)**	**0 [32]**
Staphylococcus sp. **(ß-hemolytic)**	**0 [32]**	**3 (4.5%)**
Staphylococcus sp. **(coagulase-negative)**	**5 (10.2%)**	**0 [32]**
Staphylococcus spp.	**5 (10.2%)**	**9 (13.4%)**
Streptococcus sp. **(ß-hemolytic)**	**0 [32]**	**1 (1.5%)**
Streptococcus sp.**, Group D,** ***Enterococcus***	**1 (2.0%)**	**6 (9.0%)**
Streptococcus spp.**, non-hemolytic, non-*****Enterococcus*****)**	**5 (10.2%)**	**4 (6.0%)**
No growth	**3 (6.1%)**	**18 (26.9%)**
Mycoplasma	**0 [32]**	**0 [32]**
Ureaplasma	**0 [32]**	**0 [32]**

[a] Number in parentheses indicates the percentage of females with the isolate.

Figure 7. Age at first parturition for captive female cheetahs from 1956 – 2005.

Figure 8. Lifetime number of litters per female for captive cheetahs 1956 – 2005.

Figure 9. Interval between births for captive female cheetahs from 1956 – 2005.

Figure 10. Average litter size for captive female cheetahs from 1956 – 2005.

Table 9. Effect of animal age on ejaculate characteristics and sperm morphology (LSmeans ± SEM).

	Juvenile (14 - 24 months)	Adult (25 - 120 months)	Aged (over 120 months)
Number of males	16	76	5
Number of ejaculates	23	175	5
Body weight (kg)	37.8 ± 1.1^{a}	43.5 ± 0.4^{b}	44.0 ± 2.3^{b}
Total testicle volume (cm^3)	9.4 ± 0.7	10.1 ± 0.3	10.3 ± 1.5
Ejaculate volume (ml)	0.7 ± 0.3^{a}	2.2 ± 0.1^{b}	2.3 ± 0.6^{b}
Percent motility (%)	56.7 ± 3.3^{a}	69.8 ± 1.4^{b}	78.9 ± 6.7^{b}
Forward progressive status (FPS)	2.9 ± 0.1^{a}	3.4 ± 0.1^{b}	3.7 ± 0.3^{b}
Sperm concentration/ml (x 10^6)	12.8 ± 4.9	25.3 ± 2.1	19.6 ± 10.5
Total motile sperm (x 10^6)	7.1 ± 9.3^{a}	42.3 ± 4.1^{b}	23.5 ± 20.0^{a,b}
Intact acrosomes (%)	67.6 ± 4.9	73.0 ± 1.8	87.6 ± 9.4
Morphologically normal sperm (%)	14.3 ± 2.3^{a}	18.2 ± 1.0^{a}	32.7 ± 5.8^{b}
Morphologically abnormal sperm (%)			
Acrosome abnormalities	10.2 ± 1.4	9.1 ± 0.6	10.6 ± 3.6
Head abnormalities	13.4 ± 1.5^{a}	9.9 ± 0.7^{a,b}	3.9 ± 3.9^{b}
Midpiece abnormalities	41.2 ± 2.4	45.1 ± 1.1	40.6 ± 6.2
Flagellar abnormalities	11.8 ± 1.9	10.7 ± 0.8	7.7 ± 4.8
Other abnormalities*	9.7 ± 1.4	7.0 ± 0.6	4.4 ± 3.6

* Other abnormalities include spermatid, bent neck, detached heads and flagella
[a,b] Within rows, values with different superscripts differ at $P < 0.05$; [20].

Table 10. Influence of duration of glycerol exposure at ambient temperature on sperm motility (% M) and intact acrosomal membranes (% IA).

	Control		Glycerol exposure 15 Min		Glycerol exposure 60 Min	
	%M	%IA	%M	% IA	% M	%IA
Raw ejaculate	73.8 ± 2.3	81.7 ± 2.5	73.8 ± 2.3	81.7 ± 2.5	73.8 ± 2.3	81.7 ± 2.5
Immediately post-thaw	49.4 ± 2.9†	53.1 ± 2.7†	44.4 ± 2.1†	50.2 ± 1.9†	42.8 ± 2.1†	48.1 ± 1.9†
Post-dilution in HF10						
Pre-centrifugation	53.8 ± 2.2[a]	37.7 ± 2.4†	51.3 ± 1.5[†,a,b]	39.8 ± 1.7†	47.5 ± 1.5[b]	37.4 ± 1.7†
Post-centrifugation	51.9 ± 3.8	33.1 ± 1.7[c,†]	43.8 ± 2.7†	30.0 ± 1.2[c,d,†]	44.4 ± 2.7	27.5 ± 1.2[d,†]
1 hour post-thaw	45.0 ± 3.2†	29.2 ± 1.7†	42.5 ± 2.3	27.1 ± 1.2	41.6 ± 2.3	24.1 ± 1.3†
2 hours post-thaw	40.0 ± 2.8	30.3 ± 1.8	38.4 ± 2.0	26.8 ± 1.2	37.2 ± 2.0†	25.0 ± 1.2
3 hours post-thaw	36.9 ± 2.4	27.2 ± 1.7	31.9 ± 1.7†	25.7 ± 1.2	34.7 ± 1.7	24.1 ± 1.2
4 hours post-thaw	33.8 ± 2.7	29.4 ± 1.7	28.8 ± 1.9	26.4 ± 1.2	27.8 ± 1.9†	24.3 ± 1.2

Values represent least square means ± SEM (n = 4 males; n = 8 ejaculates); [12]
[a,b] Within rows, % M values with different superscripts differ at $P < 0.05$.
[c,d] Within rows, % IA values with different superscripts differ at $P < 0.05$.
† Within treatment, values with different superscripts differ from the previous time at $P < 0.05$.

Table 11. Influence of temperature and method of glycerol (G) addition prior to cooling (ambient temperature; AT) on sperm motility (% M) and intact acrosomal membranes (% IA; [12]).

	Control Slow G addition 5°C Tube cool in 0% G		Slow G addition AT Straw cool in 4% G		Direct G addition AT Straw cool in 4% G		Direct G addition AT Tube cool in 4% G	
	% M	% IA	% M	% IA	% M	% IA	% M	% IA
Raw ejaculate	80.4 ± 1.7	88.4 ± 1.9	80.4 ± 1.7	88.4 ± 1.9	80.4 ± 1.7	88.4 ± 1.9	80.4 ± 1.7	88.4 ± 1.9
Immediately post-thaw	40.4 ± 2.1†	65.4 ± 1.6†	40.4 ± 2.1†	62.6 ± 1.6†	43.9 ± 2.2†	67.1 ± 1.7†	43.2 ± 2.1†	62.6 ± 1.6†
Post-dilution in HF10								
Pre-centrifugation	44.5 ± 2.1†	58.5 ± 1.8†	48.4 ± 2.1†	55.3 ± 1.9†	45.1 ± 2.2	55.7 ± 1.9†	44.5 ± 2.1	54.7 ± 1.8†
Post-centrifugation	45.6 ± 2.2	46.3 ± 1.8†	45.3 ± 2.2	44.4 ± 1.8†	45.7± 2.4	44.0 ± 1.9†	42.8 ± 2.3	41.7 ± 1.8†
1 hour post-thaw	42.0 ± 2.0	39.8 ± 1.5†	38.8 ± 2.0†	39.4 ± 1.5†	39.4 ± 2.1	40.5 ± 1.6†	36.6 ± 2.0†	36.6 ± 1.5†
2 hours post-thaw	36.5 ± 2.1†	39.1 ± 1.6	34.3 ± 2.1	37.0 ± 1.6	34.1 ± 2.2	37.5 ± 1.6	34.0 ± 2.1	33.6 ± 1.6†
3 hours post-thaw	32.4 ± 2.1†	35.5 ± 1.3†	33.8 ± 2.1	35.9 ± 1.3	32.9 ± 2.2	38.0 ± 1.3	30.6 ± 2.1†	35.7 ± 1.3
4 hours post-thaw	29.4 ± 2.1	38.5 ± 1.7†	28.3 ± 2.1†	37.1 ± 1.7	28.6 ± 2.2†	37.6 ± 1.8	24.4 ± 2.1†	34.0 ± 1.7

Values represent least squares means ± SEM (11 males, 15 ejaculates); [12].
AT (Ambient Temperature; 20 - 25°C)
† Within treatment, values with different superscripts differ from the previous time at $P < 0.05$.

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2008 CONTRACEPTION STANDARDIZED GUIDELINES: CHEETAHS

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 (Munson 2006). Instead, the AZA Wildlife Contraception Center now recommends GnRH agonists [e.g., Suprelorin® (deslorelin) implants, leuprolide acetate injectable implants, or Lupron®] as safer alternatives. Suprelorin has been used successfully in domestic cats (Munson et al. 2001) as well as cheetahs, lions, leopards, and black-footed cats (Bertschinger et al. 2001). In addition, tigers, pumas, 3 jaguars, ocelots, servals and a caracal have been treated but full results are not yet available (Contraception Database, 2006). Although GnRH agonists appear safe and effective, dosages and duration of efficacy have not been well established for all species. The 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.

Following is general information on contraceptive options for cheetahs. More details on each method and ordering information can be found at www.stlzoo.org/contraception.

<u>Gonadotropin releasing hormone (GnRH) agonists</u> [Suprelorin® (deslorelin) implants, leuprolide acetate injectable implants, or Lupron®]: 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, 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. 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.

A drawback of these products is that time of reversal cannot be controlled. Neither the implants (Suprelorin and leuprolide injectible) nor the depot vehicle (e.g., Lupron) can be removed to shorten the duration of efficacy to time reversals. The most widely used formulations are designed to be effective either 6 or 12 months, but those are for the most part minimum durations, which can be longer in some individuals.

Although they can also be an effective contraceptive in males, they are more commonly used in females, because monitoring efficacy in females by suppression of estrous behavior or gonadal steroids in feces is usually easier than ensuring continued absence of sperm in males, since most institutions cannot perform regular semen collections. If used in males, disappearance of sperm from the ejaculate following down-regulation of testosterone may take an additional 6 weeks, as with vasectomy.

<u>Progestins</u>: Melengestrol acetate (MGA) implants were previously the most commonly used method in cheetahs and other felids. Other synthetic progestins include Depo-Provera® (medroxyprogesterone acetate) injections and Ovaban® (megestrol acetate) pills. Although MGA has proven effective in felids, possible side effects include uterine and mammary pathology. Other progestins are also very likely to cause these same side effects, although data are not available for all of them.

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. Progestins are considered safe to use during lactation.

Vaccines: The porcine zona pellucida (PZP) vaccine may cause permanent sterility in felids after only one or two treatments. This approach is not recommended.

Ovariectomy or Ovariohysterectomy: 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.

Vasectomy: 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 approach is not recommended.

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Munson, L. (2006) Contraception in felids. Theriogenology **66**: 126-34.

Munson, L., J. E. Bauman, C. S. Asa, W. Jochle and T. E. Trigg (2001) Efficacy of the GnRH analogue deslorelin for suppression of oestrus cycle in cats. Journal of Reproduction and Fertility, Supplement **57**: 269-273.

Wright, P. J., J. P. Verstegen, K. Onclin, W. Jochle, A. F. Armour, G. B. Martin and T. E. Trigg (2001) Suppression of the oestrous responses of bitches to the GnRH analogue deslorelin by progestin. Journal of Reproduction and Fertility, Supplement **57**: 263-268.

White Oak Conservation Center

APPLYING FRONTLINE Top Spot for dogs (by Merial)
This is an easy task that can be done by the animal keepers behind the safety of the enclosure fence. A simple pole syringe stick used by your veterinarian can be used. Just transfer the frontline liquid to a syringe and apply to the neck while the cats are eating. Most cats will tolerate this well right from the beginning, while some might need a brief period of conditioning. For individuals that do not like to be touched, the liquid can just be dripped onto the neck area without touching the cat with the stick.

One facility reluctantly applied three drops of Frontline plus to each cheetah cub (one in a half & three in a half weeks of age) due to a severe flea infestation. They are not recommending others try Frontline at such a young age, but that they did use it with no harm to the cubs. The company Frontline reported that they have a spray that can be used on domestic cats as young as three days of age. However, some concerns with spraying the young cheetah cubs would be the mothers reaction to the smell and/or the mother or siblings licking the sprayed cub.

One facility reported shortening of the hairs and lightening of the area where frontline was applied with frequent application.

APPLYING SWAT fly repellent ointment (by Farnam):
This is an easy task that can be done by the keepers behind the safety of the enclosure fence. Using a stick (3 ft dowel rod) with a sponge wired to the end can be used to apply swat while the cat is eating up close to the fence. Most cats tolerate this well right from the beginning, while others might need a brief period of conditioning. Some cats will aggressively grab at the stick, especially hand reared cats that don't like to be touched while eating.

White Oak Conservation Center

IDENTIFICATION

National Zoo; cheetah shaved for identification

Cheetahs can generally be individually identified by appearance (size, spot /tail patterns) by experienced keepers, but they should always be permanently marked to assure animals are correctly identified for staff changes or an animal is transferred between institutions. Photographs of cheetahs can be helpful in visual identification. Full body profile images can be taken either of an awake, or anesthetized animal.

All cheetahs should also be permanently identified with a subcutaneous microchip (transponder) implanted between the shoulder blades. Prior to transponder insertion, marking of neonates can be safely and easily accomplished by using a livestock marker (a non-toxic beeswax product which clings to the fur) or by shaving.

White Oak; Obtaining a weight

Sunflower seed marker

Sesame seeds marker

FECAL MARKERS used in Cheetahs:
The collection or observation of individual's feces may be necessary for routine exams, parasite check, endocrine research or to help identify the culprit of abnormal stools.

To avoid unnecessary and stressful separation of bonded animals (coalition members, mothers w/cubs). Approximately half a tablespoon of marker can be mixed thoroughly in their diet 24 hours prior to collection need.

The following markers have been successfully used with no adverse effects:

- Green or blue food dye
- Finch bird seed
- Sesame seeds
- Raw sun flower seeds
- Lentils
- Cracked corn
- Uncooked white rice or wild rice

Bird seed marker

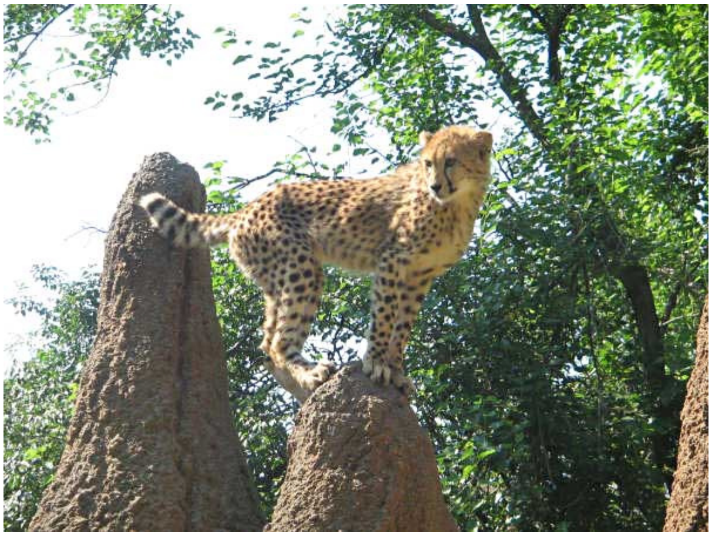
Lental markers

SELF-MUTILATION in Cheetahs:

Tail sucking or excessive wound licking can occur with cheetahs. While first appearing as an innocent occurrence it can quickly escalate into a serious situation. It is highly recommended that you always have sprays that discourage licking, available to apply at the <u>first</u> sign of tail sucking.

Bitter Apple & Bitter Mist have been successfully used to stop tail sucking if applied immediately, several times a day until tail sucking has ceased. If you wait too long to act on this behavior it can quickly develop into a habit that can be extremely difficult or impossible to break and has led to all or partial tail loss. If they are actually eating their tail, more aggressive measures are often necessary, such as bandaging with heavy tranquilization. One facility reported tail loss occurring overnight in two cheetah cubs without warning. The reason or the culprit (dam, siblings, or self) remains unknown.

Another problem is excessive wound licking. Spraying an open wound may not be recommended in this situation as this might draw attention to the wound. One facility reported using several different treatments including Diazepam, Naltrexone, Prozac, and Omega-3 fatty acid supplements for extended periods of time to stop self mutilation. While the behavior finally ceased it was not confirmed if these drugs were responsible for stopping this behavior.



Cheetah Husbandry Training

Michelle Templeton Skurski and Jennifer Hylton-Metzler
Disney's Animal Kingdom

A husbandry training program is considered an integral component of progressive animal husbandry programs in zoos today. Providing captive felids with choices and behavioral opportunities in their environments, by implementing a training program, can result in healthier animals and better educational experiences for the zoo visitors. Training cheetahs leads to a wide variety of animal management opportunities, from shifting to safer, less stressful medical procedures. Simply put, we believe implementing a husbandry training program into the animals' daily lives enhances the welfare of cheetahs.

The purpose of this chapter is to give trainers an idea of the types of behaviors that can be trained with cheetahs, (see Appendix A). This chapter will also give direction on starting a training program, ideas for shaping techniques and reinforcement, some specific challenges to training cheetahs, and resources for additional training information.

There are some facilities that utilize cheetahs on lead for educational presentations. This chapter will only provide guidance for the training of cheetahs through a barrier (i.e., protected contact) for general husbandry behaviors. For further information on techniques and advice on training cheetahs on a lead, please contact the Cheetah SSP Chair.

Setting up a training program

A well-planned, consistently delivered training process is critical to the success of any program. To achieve this type of program many facilities utilize a framework that is taught in American Zoo and Aquarium Association's (AZA) course, Managing Animal Enrichment and Training Programs, called the "SPIDER" model. Steps in this framework include Setting goals, Planning, Implementation, Documentation, Evaluation, and Re-adjusting. For more information on this process go to www.animaltraining.org. It is beneficial to start a training program by determining the overall behavioral goals (i.e. detailing the specific behaviors to be trained). During this goal development process it is important to include all parties involved with the management of the animals. This may include meeting with and seeking feedback from keepers, veterinary staff, nutritionist, behavioral husbandry staff, curators, and managers. Having everyone on the same page with clearly laid out plans, assignments, and timelines helps to facilitate a smooth process. Defining roles and creating clear avenues of communication among all participants is also important. This can be accomplished through regularly scheduled team meetings, a consistent method of documentation, and continual communication among all staff involved in training. Facility design can have an effect on setting up a training program. Discussions must also include how cats will be reinforced. The next two sections will discuss both of these topics further.

Facility

When beginning a training program, it is best to start training in an area that is safe for animal care staff and animal, and where the cat is comfortable. This is usually the night quarters or holding area. Training can also be done in crates, chutes, or even open exhibit areas. Because all facility designs are different, training staff will have to be creative and utilize the space available. For some body position behaviors [see Appendix A]. For many of these behaviors trainers will require several feet of mesh with no obstructions, which allows safe access to body parts.

A standard transfer crate can be used for training many of the body positioning behaviors. It is important to remember that a fancy, expensive facility is not necessary to accomplish a successful training program, just a creative mind.

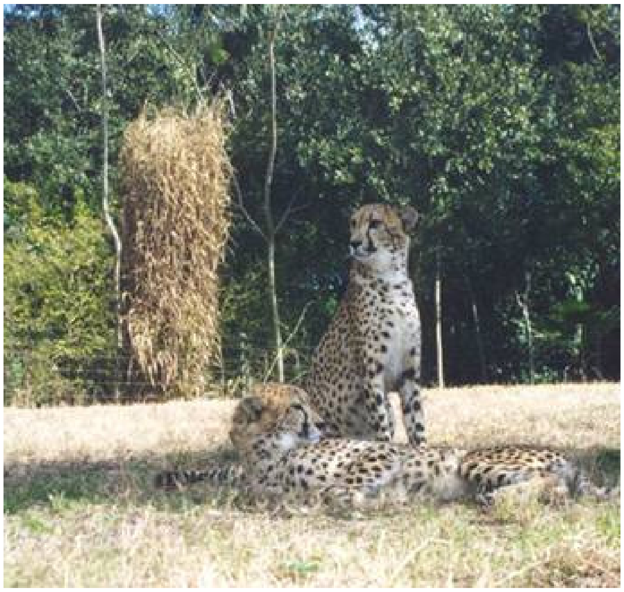
Disney's Animal Kingdom; Off-exhibit holding area

Reinforcement

A critical component to positive reinforcement training is finding a reinforcement or reward an animal is willing to work for. Because of the cheetahs' pre- disposition for stomach related illnesses choice of a food reinforcement can become an issue. In most cases, the cats' regular diet can be utilized for training. Another option for reinforcement can include blood in a syringe. If the diet is prepared meat, small meatballs can be made (~1 inch diameter) for easy use during a session. A helpful hint: the meat stays together better if it is cooler. If chunk meat is utilized, small pieces can be cut (~1 inch cubes) before a training session begins. It is helpful to wear a pouch on the hip containing the meat, so that reinforcement can be easily retrieved and delivered in a timely manner. Delivery of reinforcement can occur by placing meat on a meat stick and passing through the mesh barrier or by tossing meat through or under mesh. One type of meat stick that can be used is a fiberglass rod. This works well due to its durability (plastic can crack and break easily with large carnivores). Many facilities use meat sticks made from Hot Shot tm brand fiberglass rods also called "show sticks" or poles used for moving ranch animals. These are readily available from a feed store or the Nasco tm catalog (or www.nascofa.com). The sticks can be modified to any size by cutting with a saw and then shaping the cut end on concrete to the desired dull point (Binney, 2004). Hand feeding is not recommended. It can be a safety issue for the keeper, and can also cause the cat to become aggressive toward the trainer.

Training Methods

There are several steps to creating a husbandry training program for cheetahs. After the behavioral goals are set, a safe facility to work the cats is identified, and reinforcement type and how reinforcement will be delivered has been determined, next steps include learning about the animal to be trained, building a relationship with that animal, and designing a training plan.



Disney's Animal Kingdom

Natural History / Individual History

An understanding of natural history of cheetahs, paired with information about an individual animal's specific background, play an integral part in a husbandry training program. For example, hand-raised cheetahs may react differently to trainers when compared to parent-reared individuals. While hand-raised individuals are usually very interactive participants in training from an early age, parent-reared cheetahs tend to be more of a challenge. Despite the initial challenges trainers might encounter with parent-reared animals, these obstacles can be overcome. One common constraint encountered with parent-reared individuals is aggression towards trainers, often triggered by the greater personal space needs of these cats. To help with this challenge, training sessions can take place in a variety of locations (night holding, exhibit, crates or a combination of areas). It is helpful to start training in a location where the cat is most comfortable. Some animals need to have more space available around them to feel comfortable within the training environment. The personal space needs for a cheetah often center around the size of the enclosure in which the animal is being trained. Other relevant issues regarding an animal's space requirement may include proximity to other conspecifics, other species, and issues such as noise levels and extraneous activity. Another challenge, with both parent-reared and sometimes hand reared cheetahs, is that they can be aloof and distant in their relations with trainers/caretakers. Even with a food reward of a favorite item, they can seem indifferent to training or interacting with trainers. Keeping training sessions short and moving at a quick pace can help keep their focus. Increases in 1) feeding animals their diet with meat stick or through mesh, 2) allotment of time trainers spend in the cheetah's environment, and 3) enrichment items presented by trainers, may all help the cats to pair positive experiences with their trainers, and enhance interactions. Studying the animal's natural history is a great way to gain insight into the animal's behavior. For example, the mother cheetah leaves her cubs at around 18 months in the wild; the cubs then form a sibling group, which stays together for another 6 months. At about 2 years, the female siblings leave the group, and the young males typically remain together for life in coalitions made up of brothers from the same litter. In captivity, trainers will find some cheetahs are bonded with one another and are difficult to separate for training purposes, especially those individuals housed together for extended periods of time (typically siblings). With trainer cooperation, it is possible to work two or more animals simultaneously and in near proximity, so the animals do not have to be separated during training. Further progression of this training can lend itself to eventual separation of individuals if that is a desired goal for the training program. For more information on cheetah natural history, see the natural history section of this manual. Insight can be gathered from staff, the animal's ARKS records, or other institutions about the animal's individual history. Observing the animal is a great way to learn about the animal being trained. Trainers should spend time watching the cat's behavior in different situations, for example, what it looks like when the cat is calm or aggressive. Watch the cats on and off exhibit, at different times throughout the day, and when the cheetah is unaware it's being observed. This will help you to understand and interpret the cat's behavior during a training session.

Relationship

Developing a trusting relationship between the trainer and the animal being worked with can be very beneficial to training. If the animal is not comfortable being in close proximity to people, the cat might hiss or bat at the enclosure with front paw. Developing a relationship is an important step to help address these issues. A relationship can be developed through normal daily animal care, such as feeding, observing, regular cleaning routines, and avoiding negative interactions. The more positive interactions the animal has with staff, the more comfortable the cat will be. If the animal is particularly skittish, the trainer may start by placing the food in the enclosure and sitting near by while they eat. As the animal becomes acclimated to the trainer's presence, he/she can use a longer meat stick to deliver food and work their positioning closer and closer to the animal.

Training Plans

Creating a training plan can be a good process to help trainers think through what steps they are going to take to train a behavior. One way to do this is to establish what the final behavior will look like and then break down the behavior into a series of small steps; these small steps are called "successive approximations". For examples of what a training plan might look like see Appendix B.

Bridging Stimulus

Utilizing a bridging stimulus can be a very useful tool in training cheetahs, but not a necessity. A bridge is a signal that pinpoints the exact moment in time the behavioral criterion was met. First a trainer must select a bridge. Common bridges used are clickers or whistles. Once selected, the trainer needs to associate the sound with the delivery of reinforcement. For example, if the bridge selected was the clicker, The trainer would click and feed, click and feed, and continue this for several sessions with the cat. Once the association has been established, the sound of the clicker with a food reward, the trainer can begin to use the bridge shape behaviors.

Shaping Behavior

For consistency, one trainer should shape new behaviors with an animal. Once the behaviors are trained and performed on cue consistently, they can be passed off to other trainers to work. A shaping technique that works well with big cats is baiting; using the sight of food as a lure. In most cases, cats focus on the food and follow the food wherever it is placed. For safety of both the cat and trainer, the trainer should avoid reinforcing animals that are biting the mesh. Trainers can also use their body positioning when shaping behaviors. The animal will, on many occasions, shift its body position when the trainer moves. For example, if a cat is facing a trainer, and the trainer takes a step to the left, many times the cat will follow and shift its body to the left as well. Another useful tool in shaping process is a target. A target is an object that an animal is trained to touch a part of it's body to. Training a cat to target different parts of its body is a good method of shaping many body positioning behaviors such as standing, presenting a side of the body, or presenting a paw (see Appendix A). When starting a program it is best to begin by training some basic body positioning behaviors such as sit, down, and stand before moving on to more complex behaviors like blood collection.

Record Keeping

It is important for trainers to keep records of all sessions. Trainers can go back and look for patterns in the information, which helps keep consistency among trainers, and leaves a historical record for others. For examples of documentation methods go to www.animaltraining.org.

Summary and Resources

To review, the purpose of this chapter is to give trainers an idea of the type of behaviors that can be trained with cheetahs and what these behaviors might look like. This chapter provides direction on starting a training program, ideas for shaping techniques and reinforcement, some specific challenges to training cheetahs, and resources for additional training information. This chapter is meant as a reference for basic training information, and contains just a small amount of the information that is available.

The following is a list of just a few of the animal training resources that can be helpful in developing a training program:

- Pryor K. 1984. Don't shoot the dog! Simon & Schuster: New York.
- Ramirez K. 1999. Animal training: Successful animal management through positive reinforcement. Chicago: Ken Ramirez and The Shedd Aquarium.
- *Animal's Keeper Forum,* a publication of the American Association of Zoo Keepers
- www.animaltraining.org
- Animal Training Organizations –
  - -IMATA (International Marine Animal Trainers Association)
  - -AAZK (American Association of Zoo Keepers)
  - -IAATE (International Association of Avian Trainers and Educators)
  - -ABMA (Animal Behavior Management Alliance)
  - -PEM (Principles of Elephant Management)

Binney, A. (2004). Tools of the Trade: 'Meatsticks' Made Easy. Animal Keepers' Forum, 31(10), 106-110

APPENDIX A

Behaviors

The following is a list of behaviors and their criteria that have been successfully trained with cheetahs. The list is in alphabetical order and is not exhaustive.
The minimum in any program, cheetahs should be trained to shift on and off exhibit, into a crate, and are conditioned to come up to the mesh calmly for a body inspection.

- **Blood collection**: Cat holds in the down position with tail out of the access area while second person collects blood from the tail.

Disney's Animal Kingdom off-exhibit holding area;
Blood collection in crate

- **Crate**: Cat enters the crate and allows door to close.

- **Down**: Cat lays sternal facing trainer, and stays in position until released.

- **Foot**: The foot must be placed flat against the mesh until released.

- **Hold**: Cat stays steady in current requested position.

- **IM/SQ injection**: Cat holds in the down position with tail out of the access area while second person gives an IM injection in the upper thigh area.

- **Open Mouth**: Cat opens mouth and holds mouth open. Great care should be exercised to avoid reinforcing biting or holding teeth against the cage wire. The cat should be close to the mesh without touching. Thoroughness of the examination will be achieved through extended duration of the behavior. Cats should be given frequent breaks due to the difficult nature of holding the mouth open for an extended period.

Disney's Animal Kingdom off-exhibit holding area; Open mouth with syringe

- **Open Mouth with syringe**: Cat opens mouth and holds mouth open while a syringe full of fluid (blood, water, etc.) is squirted into the mouth.

- **Open Mouth with toothbrush**: Cat opens mouth and holds mouth open while a toothbrush is used to clean the teeth.

- **Over (left)**: Cat lays on left side, head toward trainer, feet facing to the trainer's left.

- **Over (right)**: Cat lays on the right side, head toward trainer, feet facing to the trainer's right.

- **Paw manipulation**: After the cat is in the stand position keeper then manipulates paw pads and claws with dowel or swab. Cat holds position until released.

- **Rectal temperature**: Cat holds the down position in the crate while rectal temperature is taken.

- **Scale**: Cat steps onto scale and holds position until released.

Disney's Animal Kingdom off-exhibit holding area; Paw manipulation

- **Shift**: Cat goes into desired stall or chute with no baiting.

- **Shift on/off exhibit**: After cue cat moves on or off exhibit.

- **Side (right and left)**: Cat lines up along cage front and presses side to the mesh and holds position until released.

- **Sit**: Cat sits with all four paws and buttocks on ground and holds until released.

- **Sit-up**: Cat is sitting with forepaws on the mesh.

- **Stand**: Cat stands on hind legs and places front paws on mesh in a way that allows trainers easy inspection. Cat will remain in position until released.

- **Tail manipulation**: Cat remains calmly in the down position while tail is touched until released from position.

- **Target**: Cat places the requested body part to the target.

- **Urine Collection**: Cat urinates when cued.

Disney's Animal Kingdom off-exhibit holding area; Sitting on scale

APPENDIX B

Crate Training Plan

Final behavior: Cue for crate is given, cat enters crate calmly, door is closed while cat remains calm.

1. Slowly open door of crate, while cat is sitting outside of crate reinforce cat for calm behavior while door opens and closes.
2. Reinforce cat for any movement toward crate, use food to lure cat towards crate as needed.
3. Say "crate" as cat enters through door, reinforce cat heavily once whole body is in crate. Bait cat into crate as needed.
4. Slowly move door up and down and reinforce cat for calm behavior.
5. Close door for increasing lengths of time (30 seconds, 60 seconds) and reinforce cat for calm behavior.
6. Bait cat out of crate and repeat step 3 while reducing the amount of baiting being done.
7. Cue by saying "crate", reinforce cat for entering crate calmly and close the door.

Blood Collection Training Plan

Final behavior: cat enters crate calmly, turns around and lays down in position while tail is manipulated and blood is collected.

1. Cat enters crate calmly. If cat does not enter crate on own, may need to bait with food.
2. Wait for cat to turn around in crate and facing the opening, or use food to lure the cat in that direction.
3. Once cat is in the right position, trainer asks cat for the down behavior (previously trained)
4. When cat is in the down position, have second trainer open the small sliding door on crate.
5. Have second trainer pull out the cat's tail using a snake hook.
6. Once the tail is in the hand of the second trainer, the first trainer asks the cat to back up while in the down position. This can be done by baiting the cat backwards.
7. Cat should allow the second trainer to hold the tail for increasingly long periods of time.
8. Cat stays in position and is reinforced while manipulation is increased. This will include parting the fur and poking with finger.
9. Cat stays in position and reinforced while tail is wet with water or alcohol, and tail is pricked with a paper clip.
10. Cat stays in position and reinforced while hair clippers are turned on.
11. Cat holds position while hair is shaved on a small area of tail.
12. Cat holds position and is reinforced while tail is pricked with a needle to increasing levels of pressure.
13. Cat holds position and is reinforced while tail is pricked at the vein with needle.
14. Cat holds position and is reinforced while needle is inserted and blood is drawn.

Cheetah Enrichment

Michelle Templeton Skurski & Joseph Barber

Enrichment can be defined as "a process for improving and enhancing animal environments and care within the context of their inhabitants' behavioral biology and natural history" (AZA/BAG, 1999). Defining enrichment as a process, rather than an object or event, is critical to ensuring that appropriate changes are made to the animals' environment and management to promote species-appropriate behaviors, and to provide the animals with control over their environment. Effective enrichment can enhance animal welfare. Based on the definition above, there are three main goals that should be considered when developing an enrichment initiative: 1) to promote species-appropriate behaviors; 2) to provide a wide range of behavioral opportunities for each category of behavior (e.g., foraging); and 3) to provide animals with control over their environment by (Mellen et al. 1998; Barber 2003a). The more behavioral opportunities an animal has within its environment, the greater the control it has over its environment.

Knowledge of an animal's natural and evolutionary history helps us to understand what motivates its behavior, and reveals how animals use their natural behavioral and physiological adaptations to cope with challenges within their environments. With information about these adaptations, a more appropriate captive environment can be created. For example, the physical, physiological and behavioral adaptations of cheetahs make them excellent at chasing prey over short distances; providing captive cheetahs with opportunities that require or allow the cheetahs to utilize their hunting adaptation can lead to enhanced physical and psychological well-being (Bond & Lindburg 1990). Animals unable to perform both appetitive (hunting) and consummatory (appropriate ingesting) phases of feeding behavior can develop abnormal behaviors such as stereotypic pacing (Carlstead 1998). Since the 'chase, trip, kill' sequence of behaviors is a critical element of the cheetah's evolutionary history, it is vital that enrichment initiatives be developed that promote these behaviors (e.g., Williams et al. 1996). Provision of a courser (Fig.1), plastic balls (Fig.2), hides (Prutzman 2000), fake prey objects (Neufeld 1999), and whole carcasses (Ziegler 1995; Houts 1999; McPhee 2002) would provide many opportunities for these behaviors.

Fig. 1: Cheetah lure (Photo from Smithsonian's National Zoological Park, Washington D.C.)

Behavioral goals: cheetah lures can promote chasing, stalking and running

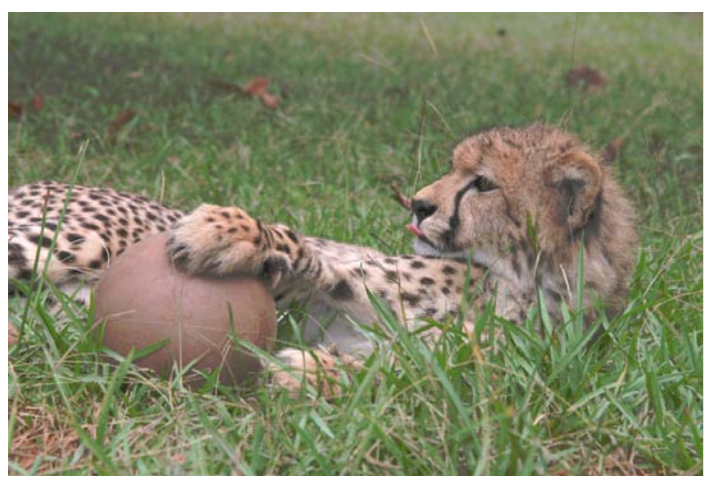


Fig. 2: Balls (Photo from White Oak Conservation Center, Yulee, Florida)

Providing opportunities for felids to display species appropriate behaviors has always been difficult to do in captive settings (Mellen et al. 1998), but creative caretakers have taken innovative approaches to create opportunities for cats to display behaviors such as stalking, pouncing, running, chasing, climbing, scratching and scent marking (Shepherdson et al. 1993; Mellen & Shepherdson 1997). It is important to remember that enrichment should not be confined to physical objects but should also include sensory opportunities such as sights, sounds and smells (Law 1993; Klomburg 1996; Bogdan & Conner 1998; Wells & Egli 2004), husbandry training, social opportunities, or environmental changes such as dirt mounds, rocky outcrops (Fig.3) or trees being added to an exhibit (Barber 2003b). Any change in the environment that promotes the expression of species-appropriate behaviors, and that the cheetahs are motivated to obtain can be called an effective enrichment initiative. It is important to remember the overall purpose of enrichment is to ensure animals have good welfare.

Fig. 3: Large exhibit rocks (Photo from Disney's Animal Kingdom, Orlando, Florida)

Hunting is just one of many behaviors that make up part of the cheetah's natural behavioral repertoire. In this chapter, a 'goal setting' tool that can be used to identify key behaviors to promote with enrichment will be presented. This tool can be customized and used by institutions as a key part of an enrichment program (recommended in AZA Accreditation Standards).

Creating a Program

An effective enrichment program is one of many animal care programs that should be in place within an institution in order to ensure that animals experience good welfare. Other animal care programs include: Veterinary, Habitat, Training, Nutrition, Research, and Husbandry - each of which can contribute greatly to an animal's welfare, especially when they are fully integrated with one another. For a program to be effective, it is necessary to identify and implement the key components that form the essential core of that program. In the current American Zoo and Aquarium Association's (AZA) Accreditation Standards, an enrichment program is defined as containing the following components, "goal setting, planning and approval process, implementation, documentation/record keeping, evaluation and subsequent program refinement". Understanding the importance of each of these components will help animal care staff develop effective enrichment initiatives that meet the needs of the animals. The components of the enrichment program listed above were originally developed at Disney's Animal Kingdom (see Mellen & MacPhee 2001), and form the basis of the SPIDER model that can be used to drive the creation and assessment of all enrichment provided to the animals at Disney's Animal Kingdom. SPIDER is an acronym for the following six programmatic components: Setting Goals, Planning; Implementing; Documenting Evaluating and Readjusting. A detailed description of the SPIDER model can be found at www.animalenrichment.org and is the foundation of an AZA Course, Managing Animal Enrichment and Training Programs. The following summary provides the key points of the model, with reference to cheetahs.

Setting Goals

Every enrichment initiative developed should have a behavioral goal in mind – a behavior that animal care teams would like to see the animal perform when interacting with the initiative. By setting behavioral goals for enrichment at the beginning of the process, it is possible to check to see how successful the enrichment is at promoting those goals, which provides a way of assessing how effective the overall enrichment program is. After all, even the most expensive and elaborate enrichment initiative will not meet any needs of the animals if they never interact with it. The only way to determine if the enrichment is successful is to document how the animals interact with it (see Documenting). It is important to remember that we often design enrichment (and identify behavioral goals) based on our very human perspective. The cheetahs may use enrichment initiatives in very different ways than originally intended. In fact, individual animals may have their own preferences for how they interact with enrichment. For example, large cardboard boxes filled with hay can be provided to promote hunting behavior (Fig.4). However, if some or all of the cheetahs prefer scent mark on the boxes, as opposed to hunting or dragging them, then the goal of the enrichment initiative can and should be updated based on this information. Having successfully promoted scent marking, it would still be necessary to develop initiatives to promote hunting as well. It is even possible that the cheetahs may eventually use the boxes for hunting – it may simply take time, patience and even training. Adapting the various strategies to promote natural behaviors is crucial, and is discussed further in the 'Readjusting' component of the enrichment program.

Fig. 4: A box of hay (Photo from Cango Wildlife Ranch, Oudtshoorn, South Africa)
Behavioral goals: Species-appropriate behaviors such as dragging or object carrying may be promoted by this initiative, along with general investigation and object manipulation.

The 'goal setting' tool, developed at Disney's Animal Kingdom, is a straightforward way to identify key species-appropriate behavior, highlight the needs of individual animals, and to adapt enrichment ideas to the specific facilities. In combination with the 'goal development matrix' (discussed below), this tool is a very useful way to ensure that opportunities are provided to promote the full range of behaviors performed by cheetahs as part of their natural behavioral repertoire (e.g., Volodina 2000; Stoeger-Horwath & Schwammer 2003). The tool (discussed in more detail at www.animalenrichment.org) provides a series of questions about natural history, individual animal histories, and about the facility housing the animals. The following list provides some examples of these questions:

- What is this species' wild habitat (e.g., desert, tropical rainforest, cover, concealment/ camouflage options, temperature ranges)?
- What are some self-maintenance/comfort behaviors (e.g., preening, grooming, bathing, dust-bathing, wallowing, sunning, panting)?
- When is it most active (diurnal, nocturnal, crepuscular)?
- What are its primary sensory modalities (e.g., sight, smell, sound) for communicating with conspecifics, detecting predators and for finding food, mates, or other social partners?
- What is the social structure of this species (e.g., solitary, dyads, "harem," colonial, leks, polyandry)?

The answers to the natural history questions for cheetahs can be found by researching the available literature (e.g., Stander 1990; Green 1991; Caro 1993, 1994; Turner & Anton 1997; Nowak & Paradiso 1999; Broomhall et al. 2003; Marker et al. 2003). It is not the purview of this chapter to provide the answers to these questions, as learning about the natural and individual history of cheetahs is one of the most informative exercises that animal care staff can go through. This process helps the staff to understand the needs of their individual cheetahs, and take ownership of the task to meet those needs.

An example of the questions asked about the individual histories of cheetahs within the 'goal setting' tool would be: 'does this animal have any behavioral problems (e.g., fearful/ aggressive to humans, stereotypy)?' Enrichment should be developed at the individual animal level, not the species or group level. The questions on the individual history of cheetahs are important, because while cheetahs may share the same general behavioral needs, their motivations, individual temperaments and life experiences are all different. Each animal requires the opportunity to perform species-appropriate behaviors; enrichment that is not used provides no such opportunity. In order for all cheetahs within a group to have an opportunity to scent mark, for example, several different types of wood and substrates may need to be provided in various locations, as different cats will have different preferences. As discussed above, providing behavioral choices to animals is a key goal of enrichment.

Once these questions have been answered, the 'goal development' matrix provides a useful way of listing and prioritizing the goals identified from the natural and individual histories. This matrix can be downloaded from www.animalenrichment.org. The behavioral goals identified can be continually updated and more goals can always be added. For each goal identified, animal care teams should begin to develop ideas for enrichment initiatives that can promote those goals. There is no limit to the number of enrichment initiatives that be thought up to promote each behavioral goal – the more the better, and the more choices that animals have within their environment, the more control they have over it. Control is an important aspect of animal welfare.

Planning

Facilities should have a planning and approval process in place for enrichment initiatives. A planning form gives the opportunity for animal care staff to describe their ideas, and identify exactly what behavioral goal they are aiming to promote. The approval process is also an ideal time to think about what method of documentation will be used to assess how effective the enrichment initiative is at promoting its behavioral goal. An approval process will also create a historical record of submitted initiatives, which will be useful for new members of staff and managers, and gives an opportunity for managers to approve initiatives before they are given. As cheetahs experience numerous digestive and health issues (Wack et al. 1997; Carlstead 1998; Lobetti et al. 1999; Munson et al. 1999; Collett et al. 2000), it is critical that the planning and approval of enrichment involves veterinarians and nutritionists where possible.

This is especially important for enrichment initiatives that can be ingested or have an impact on health (e.g., bones – see Fig.5). Having managers, veterinarians and nutritionists involved in the review process ensures that what is given to animals is safe, nutritionally adequate (see Dierenfeld 1993; Bechert et al. 2002), and has a behavioral goal in mind. Ultimately, enrichment needs to meet the behavioral needs of the animal without jeopardizing the health of the animal. This can be a fine line to tread, especially with cheetahs, but both behavioral and physical needs are important.

Fig. 5: Bones (Photo from Cango Wildlife Ranch, Oudtshoorn, South Africa) Behavioral goals: bones can promote carrying, dragging, gnawing and chewing.

Implementing

Once an enrichment initiative has been approved, it can then be implemented. For enrichment to be effective it must be scheduled (Shepherdson et al. 2003). How, where, when, and for what duration an enrichment initiative is provided can influence its effectiveness. By scheduling the delivery (and removal) of enrichment on a calendar system, it is possible to ensure that enrichment is provided on a variable schedule. If enrichment is provided at the same time each day, this can cause the development of abnormal, anticipatory behaviors in cheetahs, such as pacing. Care must be taken to prevent abnormal behaviors developing, because once these behaviors become established it becomes much harder to eliminate them. Scheduling the varied delivery of enrichment is even better than providing enrichment on a random schedule. Providing initiatives randomly can leave too much to chance; it may be that no one provides any enrichment because they thought someone else was doing it; or, an animal may receive the same initiative day after day. As some enrichment initiatives may need some preparation time, the calendar can also help staff schedule this work. For instance, a frozen item will need to be placed in the freezer ahead of time. The replacement of deadfall (Fig.6) within the exhibit may require that machinery is booked ahead of time.

Fig. 6: Logs and deadfall (Photo from White Oak Conservation Center, Yulee, Florida)

Behavioral goals: logs can promote climbing, scratching, scent marking, as well as acting as promontories for cheetahs to survey their home range and spot potential prey.

A calendar system can also provide a record of what was given to animals each day. One way to do this is to have animal care staff initial the initiatives that are provided to the animals. This is a great form of basic documentation, and a useful way of holding everyone accountable for providing enrichment.

Documenting

Documenting enrichment initiatives is as important as providing enrichment in the first place. Only by documenting the response to an initiative can we know the effect the enrichment has upon the animal – was it successful at promoting a particular behavioral goal? Documenting can also save time. If animal care staff document that an initiative has no effect or a negative effect, then the animal care team can discuss whether or not to provide that enrichment in the future. With limited amounts of time available to animal care staff, spending any amount of time putting together and providing an enrichment initiative that is not used must be minimize. Clear and consistent documentation can also save others time, as it creates a historical record of what has been tried and how the animals responded. In this way, no one wastes any time re-inventing the wheel each time, and information can be passed along if the animal is transferred to another institution. Collecting information on how each animal interacts with enrichment helps to build a cheetah's own personal enrichment portfolio, listing those initiatives that are the best at promoting behavioral goals, and those that have not yet been shown to be effective. The success, or otherwise, of enrichment initiatives can also be shared with other institutions via listservs or websites (e.g., www.enrichmentonline.org). When sharing information about enrichment, it is critical to identify the behavioral goals for each enrichment initiative.

When deciding what to document, animal care staff should consider what information would be most helpful. Here is a list of questions that can be asked about enrichment (Barber 2003a):

- Does the enrichment promote its behavioral goal?
- Do the animals use the enrichment?
- Which animals in a group use the enrichment?
- How much time do the animals spend using the enrichment?
- In what way do the animals use the enrichment?
- How do the animals react to a new enrichment item?
- Is the enrichment safe for the animals?
- Do the animals respond to the enrichment in an appropriate manner?
- Which enrichment initiative is the most preferred by the animals?
- Do the animals need more enrichment?

Evaluating

Evaluation is an important part of the enrichment process, and involves looking for trends or patterns in the information collected so that the effectiveness of the enrichment can be determined. Looking at the enrichment calendar, animal care staff can begin to see which initiatives are provided most often, and which are provided rarely. Using observations and documented information, teams can determine if it still possible to promote a behavioral goal if initiatives are provided frequently, or if their effectiveness begins to decrease over time. Similarly, it may be possible to increase the number of times that certain initiatives are provided if this does not decrease their effectiveness or reduce the animals' response to them.

Based on the goals identified in the goal-development matrix, the process of documenting and evaluating can help animal care teams determine if they are meeting all of the behavioral and physical needs of the animals with the currently provided enrichment initiatives. In most cases, it will always be important (and enjoyable) to develop more ways to promote species-appropriate behaviors, and to provide a greater range of behavioral opportunities to the animals.

Readjusting

There are many types of readjusting that can be done, and in most cases this will be based on the information that is collected. If an enrichment initiative promotes a different goal than the one expected, then the records can be changed to reflect this so that full advantage can be taken of this discovery. If the calendar reveals that a certain enrichment initiative is given over and over again, then the schedule can be adjusted so that different types of initiatives are provided on the same day. If it turns out that cheetahs only use certain enrichment initiatives in the summer, or early in the morning, then this can also be integrated into the enrichment schedule. The enrichment provided must be effective at promoting a behavior for it to be classified as enrichment at all. Animal care staff should also continually think about how best to make enrichment initiatives as effective as possible. Without a behavioral goal in mind, it becomes very challenging to know if enrichment has been successful at promoting species-appropriate behaviors, or providing animals with more control over their environment. This makes it harder to plan, document, evaluate and readjust.

Partnerships

Captive cheetahs are prone to behavioral and medical issues (Wack et al. 1997; Carlstead 1998; Lobetti et al. 1999; Munson et al. 1999; Collett et al. 2000), and so it is vitally important to create good partnerships involving keepers, managers, curators, scientists, nutritionists, and veterinarians throughout the entire process of setting goals, planning, implementing, documenting, evaluating, and readjusting. By itself, enrichment cannot meet all of the needs of cheetahs in captivity, but must be seen as one part of an integrated captive management approach.

Making it Work

The more an enrichment program is made a part of the daily routine, the easier it will be to provide effective enrichment. Even documenting and evaluating, which can seem fairly complex and time-consuming, can become second nature when animal care teams really think about what type of information they want to collect and why. It helps to think about how information can be used before starting to collect it.

All enrichment programs have their constraints and challenges. Cheetahs have been described as 'choosy' or 'picky' when it comes to enrichment (G. Noble, personal communication). Caregivers designing these programs need to be creative and patient in their pursuit of enrichment initiatives. Clearly, promoting hunting is a critical part of enrichment for a predator such as a cheetah. There are numerous ways to promote this, but they must be tailored to the needs of each individual animal. Even cheetahs at the same institution may respond differently to the same enrichment initiative, and so it is important to enrich each individual, and not just the group as a whole.

Many different lists of enrichment initiatives have been created for cheetahs, but these lists only serve as general guides. Cheetahs at each facility may respond differently, and so the only way to determine whether or not an enrichment initiative will be effective is to observe how the animals interact with it and collect information on their responses. Each institution will need to develop its own behavioral goals (many of which will be similar to other institutions), its own enrichment initiatives, and its own methods to document how effective these are at promoting their goals. We encourage you to use the resources provided in Appendix A to research what enrichment has been provided to cheetahs. However, we also strongly recommend that animal care staff go through the goal-setting process to understand and identify the physical and behavioral needs of cheetahs in captivity.

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Handling, Restraint and Safety Guidelines

Most cheetahs will quickly adapt to daily routines, shifting readily as well as accepting training to allow routine and non-routine tasks. They also quickly recognize familiar keepers by their voice, movement and other behaviors. Some will respond aggressively (hissing, growling, and charging) even during routine circumstances though direct eye contact or a forward movement is usually sufficient to induce a flight response.

Ongoing studies have identified a series of severe medical conditions that appear to be related to elevated cortisol (stress) levels. These elevated cortisol levels occur even in cheetahs that appear 'calm'. With this in mind the keeper should strive to eliminate or reduce potential stressors. Operant conditioning and protected contact training (see chapter on training) particularly if done by the same individual (s) will provide an opportunity for administering medications and will greatly assist veterinary examinations and procedures.
Cheetahs can also be conditioned to shift between adjoining enclosures to facilitate daily maintenance**.**

The cheetah is a potentially aggressive and powerful, medium-sized cat. Under most circumstances cheetahs will not readily attack an adult human, but have the potential to cause physical harm. Cheetahs are more likely to attempt an attack on a child or a person of small stature.

WORKING IN WITH CHEETAHS
Some facilities do not permit staff to enter cheetah enclosures for safety reasons and function just fine without ever going in with their cats. However, the majority of 'successful' breeding facilities do allow staff to work in with the cheetahs on a regular basis and feel that they can better manage their cheetahs in this manner. Working in with cheetahs on a regular basis will keep them conditioned to this routine and most cheetahs will pay little attention to staff while in the same enclosure. Optimum safety is achieved when there are two staff members present, especially when there is more than one animal in the enclosure.

Cheetahs have a wide variety of behavior, ranging from timid/shy to bold/aggressive although even timid cats can get aggressive in certain circumstances. It is unwise for institutions to have an 'all or nothing' policy in regards to allowing staff to work in with the cheetahs. Institutions must exercise care in determining the safety of keepers working in with each individual cheetah.

Keepers walking young cheetahs to another enclosure

Routine cleaning in with cheetahs

It will take some time for keepers to gain enough experiences working with cheetahs to allow them to work safely and confidently around them. Experienced keepers must always work with newer staff and train them thoroughly. Because cheetahs tend to disregard people unless their comfort zone is encroached upon, it is easy to assume that they are not aware or concerned with your presence or actions. Do not become too comfortable or complacent with your cheetahs and never let your guard down.

Keepers must always carry a tool of some sort when entering any cheetah enclosure. For most cheetahs a 4-5 ft long wood stick works fine, however, if you are dealing with an aggressive individual, it is recommended that you carry a rake or a broom. The tool is not a weapon; it is a tool which can help you manipulate the cats and keep them at a safe distance. As cheetahs are more likely to swipe at you rather then actually biting, they see the stick as an extension of you and thereby respect the extra distance provided by the stick.

WHAT TO EXPECT WHEN ENTERING THE ENCLOSURE

If the enclosure is small and does not give the cheetah an adequate flight distance then it would be better to shift the animal, rather than stress them by entering into too small an area. Flight distance will vary between animals and situations. Under typical circumstances a normal mother-reared cheetah has a very predictable response to humans and can be worked around safely by trained keepers. Entering this zone too quickly will cause the cheetah to bolt and/or challenge you aggressively. This situation will cause undue stress on the animal and put you at risk. Therefore it is important to move slowly around cheetahs and be aware when you have entered that zone. If you watch the animal closely, the cheetah's behavior will indicate to you when you are approaching its critical zone. Some of the behaviors to look for are: ears back, growling, hissing, spitting, ground slapping, or charging. Do not turn your back or bend down when in close proximity to the cheetah. This may trigger an instinctive response for them to stalk or perhaps even attack. Know where the cheetahs are at all times while inside their enclosure. A mock charge can occur at any time. It is characterized by a very fast run directly at you. The cheetah will be looking directly into your eyes as it runs towards you. They will get within a couple of feet and then do a "ground slap" and expel a very loud hiss while looking directly up at you and growling with teeth barred. In the event of a mock charge, it is necessary to stop the cheetah at a safe distance by presenting the stick to them at their eye level. Contact is rarely necessary, however if the cheetah does not retreat you must back them off by advancing towards them as you hold the stick out in front of you at their eye level. Be prepared as some cheetahs will smack at the stick, some hard enough to knock it out of your hand. The cheetah's goal for doing a mock charge is to get you to move away. Do not retreat from a mock charge or this might precipitate an attack.

Special consideration must be given to animals which are likely to behave unpredictably, like new arrivals, mothers with cubs, hand-reared cats, sick or injured cats, or cats in a new social situation.

MOVING CHEETAHS FROM ONE ENCLOSURE TO ANOTHER:

This is usually a simple and enriching process for most cheetahs. Male cheetahs look forward to 'checking out' a new enclosure and will readily leave their enclosure to enter any area that has an open door; as for females, some can be reluctant to leave the comfort of their area. This might require that keepers enter the enclosure to encourage her to move. Once a cheetah has begun to walk away from you, that animal is looking for the easiest route of egress away from you, if the keeper puts the stick out to the right, then the cat is almost certain to go to the left, allowing the keeper to direct the cheetah wherever they want. It is important that you be patient with cheetahs that are nervous or are not quite sure what you want them to do. Give them time to stand still and observe openings and corners until they are comfortable moving forward. If you force a nervous animal they could spook causing potential danger to the animal and/or the keepers and possibly make subsequent transfers more difficult. You want all moves to be a positive event so that future moves are easy and stress free.

Adult cheetah interacting with a group of cubs during a move

It is strongly recommended that you avoid 'walking' adult males through alleyways past other adult males, as most will fight through the fence. Sometimes these fights can be quite serious and the cats can become extremely agitated putting the keepers and animals at risk for injury. If you are in an alleyway with a cat that wants by you, by flattening yourself against the fence they will usually just run by you and not try to interact with you.

Do not back a cheetah into a corner where it has no escape route or no perceived escape route. This could cause them to panic and attempt to jump the enclosure barrier, or try to run past you, increasing the chances of keeper or animal injury.

Aggressive interaction during move

HANDREARED CHEETAHS

Extra care should be taken when working with hand reared cheetahs since they often have less fear of humans and therefore lack a clearly-defined proximity zone as mother-reared cats do. Hand reared cheetahs can be very unpredictable. Several facilities have reported that hand-reared cheetahs have attacked with no warning.

Hand-reared cheetahs should never be allowed to play, stalk, paw, bite or jump on keepers as they grow up. One should set strict guidelines on acceptable behaviors between cubs and keepers.

If hand-reared cubs are reared with discipline and strict guidelines then they can be easy to manage as adults. Hand reared animals are more likely to accept husbandry practices (such as blood draws, loading in a crate, etc) more calmly, especially if training starts early.

CATCHING / RESTRAINING

Cubs can be easily caught by hand for their first few vaccinations/exams, but as they grow older and wiser, capture and restraint becomes more difficult. Nets and gloves will be necessary for exams on older cubs.

It is suggested that you encourage the cubs to enter a small area like a chute, crate, den box, or a small covered stall/corral area where they can be easily netted; otherwise they may be injured while climbing trees or running and crashing into walls or fences while trying to escape. Stressed cubs will climb just about anything to avoid being caught. Once in the net they can be removed from the net and restrained or kept in the net for the exam. Vaccinations can be given through the net and blood taken from the rear leg or tail.

National Zoo; physical exam on four week old cub

White Oak Conservation Center; seven month old cub restrained in net for vaccination and blood draw

The use of a net will work up to about six months of age and then a restraint box of some sort should be used. Some facilities net cheetahs up to eight months of age however, this is only recommended for experienced cheetah handlers**.**

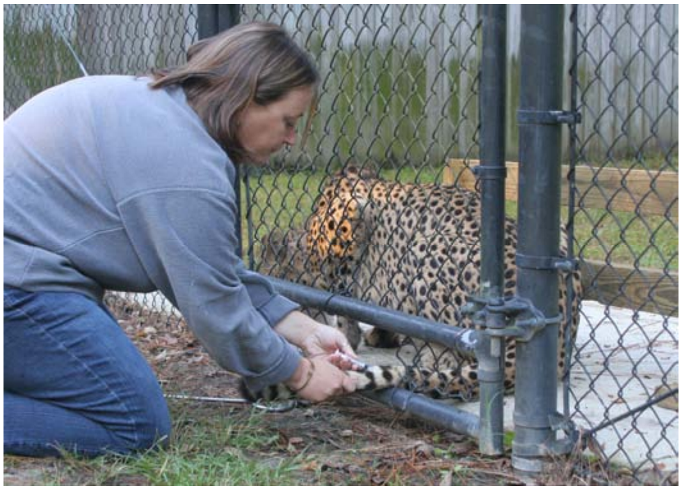
Chutes and/or restraint devices should be incorporated into your facility as a permanent fixture or a portable device to facilitate handling, routine blood collection and the administration of medication without necessitating anesthesia. They also provide an alternative method of drug injection to the remote delivery methods such as darts or pole syringes, especially when large volumes are required.

Restraint devices pin the cheetah, significantly reducing its range of motion, using either a drop ceiling or a collapsible wall. Animals should always be habituated to a restraint device prior to its use and exposed to it without experiencing any manipulative procedures. Animals can easily be habituated to entering cages like these especially if they are incorporated into the design of an area and the cheetahs have to go through them daily. Due to the possibility of injury to a cheetah, operators of such devices need to be very familiar with the specific equipment and able to judge when an animal's safety may be compromised.

Fossil Rim Wildlife Center; cheetah feeding chutes

White Oak Conservation Center; cheetah chutes

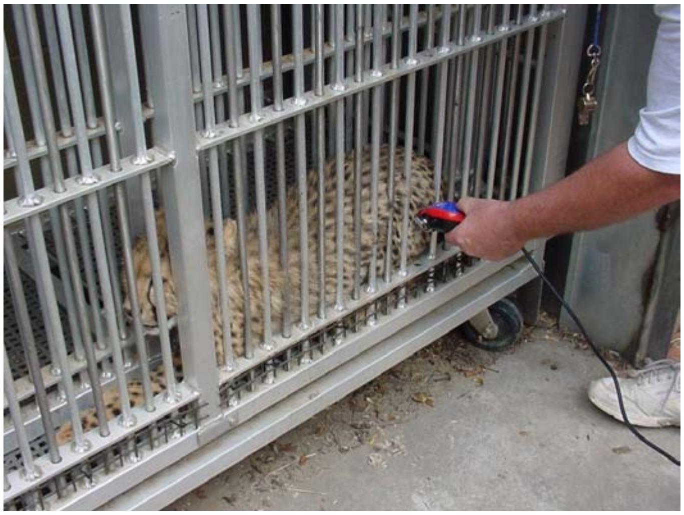
Disney's Animal Kingdom; cheetah blood collection



White Oak Conservation Center;
cheetah blood collection

Denver Zoo; cheetah blood collection

White Oak Conservation Center; cheetah restraint cage




National Zoo; Cheetah restraint cage


Wildlife Safari; Cheetah restraint cage


San Diego Wild Animal Park; Cheetah restraint cage

Kapama Game Reserve, Hoedspruit Center for Endangered Species, Hoedspruit, SA.; Cheetah restraint cage

Blood collection or intravenous anesthesia can be administered by pinning the cheetah down in a capture cage (this method is common in South African facilities) and then pulling the lower hind leg through the bottom gap. The femoral vein on the medial aspect of the leg is exposed.

When cubs are put in the crush, frames with smaller mesh should be tied to the sides to prevent cubs from putting their heads through the gaps.

Some facilities prefer to use anesthesia rather than physical restraint. Chemical anesthesia should only be performed under direct veterinary supervision. When anesthesia is necessary, the opportunity should be taken to perform physical examinations and collect blood samples for health assessment, serum banking and approved research projects.

De Wildt Cheetah and Wildlife Trust, South Africa;
Cheetah restraint cage

Cheetah Conservation Fund, Namibia;
Cheetah restraint cage

CHEETAH HAND REARING

Wildlife Safari

White Oak Conservation Center

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Introduction

1. When to make the decision to hand raise
    a. Maternal neglect
    b. Weight loss
    c. General sickness
    d. Education

2. Hand raising begins
    e. 1st 24 hours:
    - Get temp, weight, hydration check, general physical, blood draw.
    - Place in secure quiet environment with temperature ranging from 80's to 90's F° – to keep babies temp constant around 100°.
    - Hydration level of infant will determine the % of formula vs. water.
    - Bottles should be offered every 2 – 3 hours 10-15% of body weight for 24 hours. This should continue the 1st week – monitoring weight gain.
    - Baby cheetahs like their formula very hot. While an exact temperature has not been determined – keep in mind that the hotter the better and keep in consistent for every feeding.
    - Supplies –
        - Volufeeders – measured in one ml increments (Ross Lab)
        - Blue premie nipple (Ross Lab) – hole in nipple to allow milk to drip out not flow.
3. Crossfostering
   There has been some success with cross fostering. In the event of a singleton birth contact the SSP coordinator to see if there are cubs of the same approximate age in an attempt to place the cub with others. Integrating the cub into a litter will help insure proper socialization and developmental skills.

4. Stimulation
   After feeding stimulate to urinate and defecate. Using a warm cloth, rub anogenital area, taking care not to cause irritation. Record amounts and include color and consistency of stool. The cub should defecate a couple times a day. If constipation and bloating occur skip a feeding and adjust formula accordingly. It may be necessary to decrease volume or concentration of formula and then gradually increase as cub begins to defecate normally. If diarrhea occurs discontinue formula and give Pedialyte for approximately 12 hours then gradually reintroduce formula.

Collection and Analysis of Hand-reared Cheetah (Acinonyx jubatus) Records in the Captive North American Population

Celeste Lombardi, Kelly McFerron, Sravanthi Bates - Columbus Zoo and Aquarium

Hand-reared Cheetah Records

ABSTRACT

The purpose of this study was to collect data from all hand-reared cheetahs in North American institutions and to disseminate its findings. Records of 98 cheetahs were entered into a custom database and analyzed to determine factors that increase survivability. There were several factors that were found to influence survivability in this study such as; the cause for hand-rearing, type of formula fed and growth rate. The most notable finding of this analysis was that cheetah cubs that survived hand-rearing gained an average of 48 g/day, while those that did not survive gained an average of 5 g/day. We conclude that weight gain per day is one of the most important factors when hand-rearing cheetahs.

KEYWORDS

formula, growth rate, survivability

Saint Louis Zoo; weighing cheetah cub

INTRODUCTION

An old Zulu folk tale explains how the tear marks appeared on the face of the cheetah. The story begins when a hunter watched a cheetah while it was hunting. He saw the speed and agility of the cheetah. The hunter then saw that the mother had three cubs with her, and decided he would steal the cubs and train them to hunt for him. When the mother found that her cubs had been stolen, she cried until her tears made dark stains on her cheeks. An old wise man found out what the hunter had done and returned the cubs to their mother, but the tears had already stained her face permanently (Greaves 1988). Although hunters are no longer stealing cubs for their own use, people are still a primary threat. The main dangers to cheetahs are the loss of habitat due to human encroachment, being hunted as a livestock predator, and competition from lions and hyenas (Marker-Kraus, 1998; Laurenson, Weilebnowski, and Caro 1995).

Estimates of the wild cheetah (*Acinonyx jubatus*) population in 1975 ranged from 9,000 to 12,000 individuals (Myers 1975). Currently, it is known that cheetahs are extinct in sixteen African countries in which they previously existed. There are many difficulties in estimating the population of wild cheetahs since most countries have not completed censuses and the methods for these censuses vary widely. The Serengeti is the only area for which a census has been completed and it is now known that 250 cheetahs reside there (Ellis 2001). In addition to the African cheetahs, a small population of approximately 50 remains in Iran (Marker-Kraus 1998). The cheetah is considered an endangered species listed under CITES Appendix I (CITES 2003). Due to this status in the wild, zoological societies will need to play an important role in the conservation of the species. As of 2003, there were 223 captive cheetahs in North America (Bingham-Lackey 2002). Only 11.5% of the adults reproduce in captivity, thus the population is not self-sustaining (Marker and O'Brien 1989). Since the number of breeding adults is low, births are an integral part of establishing a genetically viable population.

In the North American population cheetah cubs were hand-reared when they were losing weight from maternal neglect, sickness, or for educational purposes. It should be noted that cubs removed from the dam for educational purposes will be compared to cubs removed for health concerns, since educational cubs were not removed from the mother due to life threatening issues. Currently, there is no standardized hand-rearing and record-keeping protocol among North American zoological institutions. The aim of this hand-rearing study is to collect data from hand-reared cheetahs in North American Institutions and to disseminate this information. In addition, the data was analyzed to see if there were common factors that increased survivability of cheetah cubs. Another objective was to create a system of standardized record keeping to improve consistency of data for future analysis.

METHODS

Hand-rearing records of cheetahs were collected from 15 North American zoological institutions. A total of 98 cheetah cubs had hand-rearing records that were entered into the database. Of the cubs that were included, categories of background information included in the database were:

- Studbook Number
- House Name
- Birth Date/Place
- Birth Weight
- Dam
  - Name
  - Studbook Number
- Sire
  - Name
  - Studbook Number

Data from the daily records were entered into the format seen in Table1. Example – Emphasize records and consistency of keepers.

TABLE 1. Daily records chart.

Date	Time	Stud-book Number	Liq-uids	Amount (ml)	Solids	Amount Solids (g)	Weight (lbs)	Temp	Urine	BMS	Grade	Medicine	Code	Comments

RESULTS

Formulas. KMR©, Esbilac©, goat's milk, and cow's milk were all used as formulas by the institutions in this survey. The percentage of cubs raised on each formula is shown in Table 2. As Figure 1 shows a significantly larger number of cheetahs survived on KMR© when compared to Esbilac© ($\chi^2 = 5.01$, df = 1, n = 95, $p < 0.05$). The growth rate of cubs on KMR© was 43.5 g/day while the growth rate for cubs on Esbilac© was 38.9 g/day. When analyzed there was no significant difference between the growth rates of cubs on KMR© versus Esbilac© (t = .84, n = 87, p = 0.4046). The expected values for goat's milk and cow's milk were too low to be included in the survival or growth rate analyses. When the hand-reared cubs that were removed for educational purposes were analyzed separately, it was found that there was no significant difference between the number of cubs that survived on KMR© versus Esbilac© ($\chi^2 = 0.35$, df = 1, n = 24, $p > 0.05$). The average growth rate of these educational cubs when raised on KMR© formula was 54.5 g/day, while the growth rate for educational cubs raised on Esbilac© was 38.3 g/day, there was no significant difference found between these growth rates (t = 1.67, n = 23, p = 0.1090).

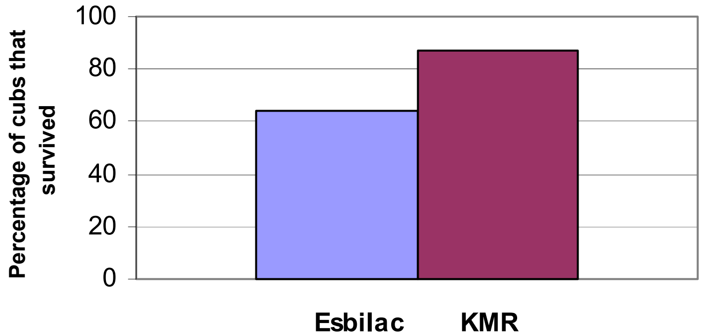

Fig. 1. Comparison of the percentage of cubs that survived on Esbilac[ã] and KMR[ã] formulas.

First solid food. Table 2 shows the variety of first solid foods offered to the cheetah cubs in our study. The first solid foods given to the cubs posed no significant effect upon survival ($\chi^2 = 12.93$, df = 1, n = 83, p = 0.0739). When the growth rates of cubs on each of the first solid foods were analyzed, the mean growth rate of cubs on beef, turkey, or chicken baby food was significantly higher than cubs raised on ground beef (F = 6.25, df = 7, n = 82, p < 0.0001). The mean growth rate of cubs on Commercially prepared diet was also significantly higher than those raised on ground beef (F = 6.25, df = 7, n = 82, p < 0.0001). Most cubs (56.6%) received their first solid foods at the age of four to five weeks as shown in Figure 2. The age the first solid food was given to the cheetah cubs had no statistical impact on survival (F = 0.79, df = 1, n = 81, p = 0.3781) or growth rate (r = 0.09, n = 81, p = 0.4206). When the cubs that were removed from the dam for educational purposes were analyzed separately, it was found that the age at which cubs were given their first solid had a significant effect on growth rate (r = 0.49, n = 22, p < 0.05). The age with the most positive effect on the growth rate of the cubs that were removed for educational purposes was between 30 and 35 days.

Both KMR© and beef, turkey, and chicken baby food had positive effects on cubs. These two factors were combined and it was found that cubs who were raised on KMR© formula and were given beef baby food as their first solid food had a significantly higher growth rate than cubs who did not receive this combination of foods (t = 3.00, n = 90, p < 0.005).

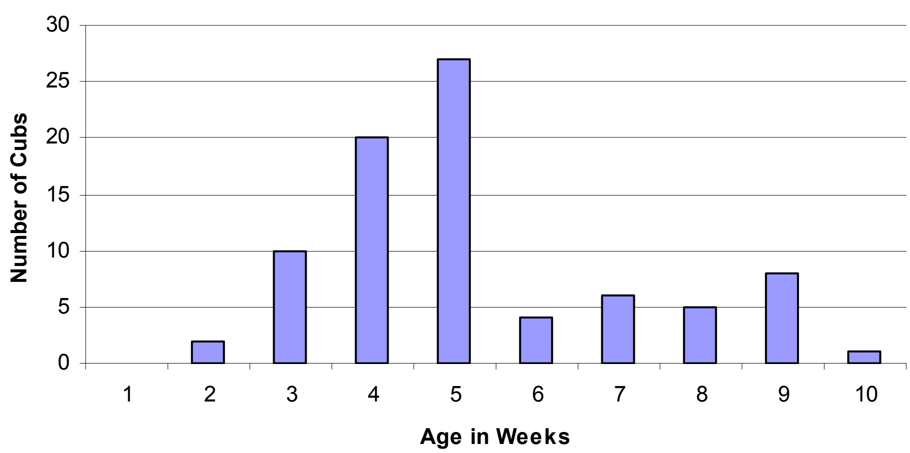

Fig. 2. The age first solid foods were given to cheetah cubs.

Adult solid foods. In this study it was found that almost half (48%) of the cheetah cubs were raised on Nebraska as shown in Table 2. However, the type of adult solid food had no significant effect on a cheetah cub's survival (χ^2 = 9.97, df = 1, n = 83, p = 0.2673) or growth rate (F = 2.87, df = 8, n = 82, p = 0.0079).

TABLE 2. Percentage of Cheetah Cubs on Different Foods

Formulas	First Solid Foods	Adult Solid Foods				
Brand	Percent of Cubs on Formula	Percent of Cubs that Survived	Brand	Percent of Cubs on First Solid Food	Brand	Percent of Cubs on Adult Solid Food
KMR©	71%	87%	Nebraska©	28%	Nebraska©	48%
Esbilac©	26%	64%	Ground Beef	17%	C/D©	10%
Goat's Milk	2%	50%	Zupreem©	14%	Wisconsin©	7%
Cow's Milk	1%	100%	Baby food	13%	Milliken©	7%
			Liver	8%	Dallas Crown©	6%
			C/D©	8%	Ground Beef	5%
			Milliken©	7%	Zupreem©	4%
			Other	4%	C/D© and Wisconsin©	4%
					Other	10%

Weights. In this study, any weight taken between birth and day 5 was considered a first weight. The average first weight was 474g. There is no significant difference between male and female first weights (t = 0.70, n = 37, p = .4877). The average weight of cubs at one month of age was 1.34 kg. Sex did not have a significant effect on the one-month weights of the cubs (t = 0.79, n = 81, p = 0.4332). At the age of two months, the average weight of the cheetahs was 2.62 kg. Male and female cheetah cubs did not have a significant difference in their weight at two months (t = 0.54, n = 73, p = 0.5927). When the weights of cubs removed from the dams for educational purposes at one month of age were compared to the weights of the other cubs in the survey at one month of age, it was found that the cubs removed for educational purposes had significantly higher weights (t = -2.42, n = 81, p < 0.05). However, when this comparison was made a two months of age, no significant difference was found between the weights of the cubs removed for educational purposes and the other cubs in the survey (t = -0.80, n = 73, p = 0.4265).

Growth rates. Figure 3 shows that the mean growth rate for the cubs that survived hand-rearing was 48g/day, while the mean growth rate for cubs that did not survive hand-rearing was only 5g/day. The difference between these mean growth rates was significant (t = 8.29, n = 90, p< 0.0001). The average growth rate for cheetah cubs in this study was 42g/day. The growth rates of males and females in this study were not found to be significantly different (t = 0.02, n = 90, p = 0.9872). The growth rates of cubs removed from the dams for educational purposes were found to be significantly higher than those of the remainder of the cubs in the survey (t = -2.18, n = 90, p < 0.05). When the cubs that were removed for educational purposes are not included the average growth rate is 39 g/day.

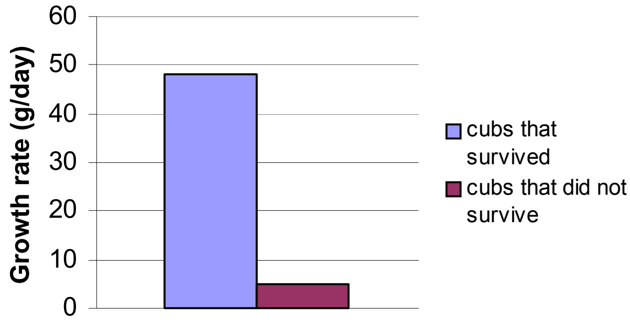

Fig. 3. Comparison of the average growth rates of cubs that survived hand-rearing and those that did not survive.

Mortality rates and necropsy results. Nineteen percent of the cheetah cubs studied did not survive hand-rearing. The causes of death in this sample of cheetah cubs are shown in Table 3.

Table 3. Causes of death in hand-reared cheetah cubs (n=19)

Cause of Death	Percentage of Deaths Attributed to Cause
Pneumonia	21%
Panleukopenia	15.8%
Trauma	10.5%
Septicemia	10.5%
Enteritis	10.5%
Bacterial Meningitis	5.3%
Congenital Abnormalities	5.3%
Milk Mass	5.3%
Undetermined	15.8%

DISCUSSION

TABLE 4. Comparison of the contents of KMR©, Esbilac©, and cheetah mother's milk

Milk	Water %	Fat %	Protein %	Carbohydrates %	Ash %
Mother's Milk	76.8	9.5	9.4	3.5	1.3
KMR©	81.7	4.68	7.7	4.74	1.18
Esbilac©	84.85	6.38	5.09	2.88	0.8

Formula. The KMR© formula did produce a higher survival rate than the Esbilac© formula, possibly this is due to the fact that KMR© more closely resembles the mother's milk (Ben Shaul 1962). While not significant, cubs raised on KMR© did have a higher average growth rate when compared to cubs raised on Esbilac©. When the contents of KMR© and Esbilac© were compared to the contents of cheetah mother's milk, it was found that KMR© had a composition closer to mother's milk than Esbilac© (Table 4).

Solid Foods. Four and five weeks of age were the most common time for introduction of solid food (Figure 1). This age is slightly later than the age of tooth eruption, which normally occurs around two to three weeks of age (Wildlife Decision Support 2002). Our data is in agreement with the findings of Helmut Hemmer; he suggests that it is typical for felid species to eat solid foods at about five weeks of age (1979). In addition, it has been found that wild cheetahs eat their first solid foods at 33 days of age (Gittleman and Oftedal 1987).

Neither the first solid food given nor the adult solid food fed effect survival, it seems that if a cub makes it to the age of 4 weeks that it has survived the most dangerous period. In our survey, it was found that the most vulnerable age of a cheetah cub's life is the first month, with eight times more deaths than at any other age. Marker and O'Brien also found the first month to have the highest death rate and in their sample, ten times more cubs died in the first month then at any other age (1989).

Weights. The average first weight of the cubs was 474 grams, which is higher than the weight of 463 grams reported by Wack for mother-reared, captive-born cubs (1991) and 350 grams for wild cubs reported by Laurenson (1995). However, in order to have a large enough sample size we had to include weights from animals up to the age of five days, which could have caused an increase in the first weight average. When the search was limited to weights taken within 48 hours of birth the average weight of the cubs was 451 grams, but only twelve cubs fit this requirement. The first weights of the male and female cubs in our study were not significantly different, however, other studies have found that male cubs tend to have higher birth weights than female cubs (Beekman et. al 1999; Laurenson 1995).

Growth rates. The average growth rate found for the captive-born, hand-raised cheetah cubs in this study was 42 g/day. This is comparable to the 40- 50 g/day found by Wack for captive-born, mother-raised cubs and the 44.2 g/day found by Laurenson for wild-born, mother-raised cubs (1991; 1995). This data shows that the cub's average daily weight gain appears to be similar to cubs that are left to be raised by their mother, whether that is in captivity or in the wild. Previously it had been predicted that hand-raised cheetah cubs would have a growth rate in the range of 25-30 g/day (Beekman et al. 1999).

When the growth curve of the captive-born, hand-raised cubs is compared to the growth curves of captive-born, mother-raised and wild-born, mother-raised cubs, it can been seen that they are similar, as seen in Figure 4 (Wack 1991; Laurenson 1995). While there are fluctuations in weight, the weight gains are similar.

No difference was found between the growth rates of male and female cubs. Laurenson also found that no significant difference existed between the male and female growth rates for cubs in her study (1995).

Neonatal growth rate has been found to be a factor in the survival of a cheetah cub (Beekman et al. 1999). Growth rate and survival were very much linked in our study as well; cheetah cubs that survived hand-rearing had an average growth rate of 48 g/day, while those that did not survive only gained an average of 5 g/day.

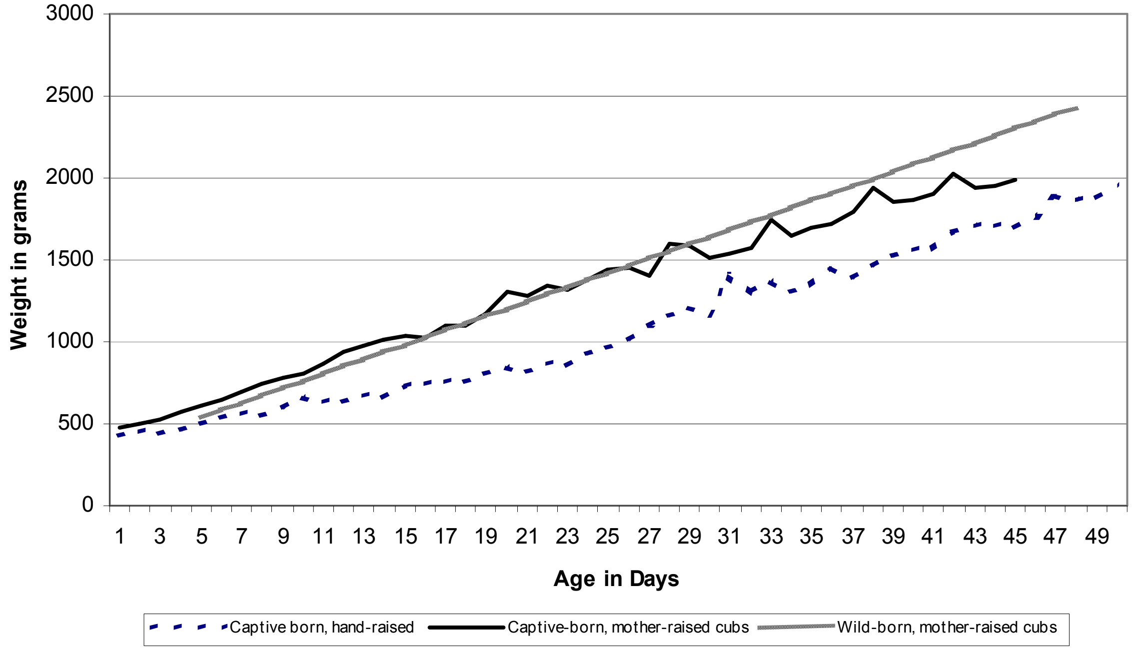

Fig. 4. Comparison of growth curves for captive-born, hand-raised cubs, captive-born, mother-raised cubs and wild-born, mother-raised cheetah cubs. Captive-born, mother-raised cheetah cubs graph adapted from (Wack,1991). Wild-born, mother-raised cheetah cubs graph adapted from (Laurenson 1995).

CONCLUSION

This survey collected data from hand-raised cheetahs in the North American captive population, to determine if there were common factors that increase the survivability of cheetah cubs.

1. A significantly larger number of cubs survived when raised on KMR© compared to those raised on Esbilac©.
2. When cubs were hand-raised for educational purposes there was no significant difference between the number that survived when raised on KMR© compared to those that were raised on Esbilac©.
3. The type of first solid food fed to the cubs had no significant effect on survivability.
4. The type of first solid food given to the cheetah cubs was shown to have a significant effect on the growth rate of the cubs.
5. The age that the first solid food was given had no statistical impact, except in the case of cubs that were hand-raised for educational purposes, where the age that the first solid food was given to the cubs affected the growth rates of these cubs.
6. The type of adult solid food offered had no impact on any measure of hand-rearing success.
7. The average growth rate of the hand-reared cubs in our survey is 42 g/day.
8. The average growth rate of cubs that survived hand-rearing is 48 g/day. While those cubs that did not survive had an average growth rate of only 5 g/day.
9. There was no overwhelming commonality in the causes of death of the hand-reared cubs.
10. The growth curve of the captive-born, hand-raised cheetah cubs in our survey is similar to the growth curves of both captive-born, mother-raised cubs and wild-born, mother-raised cubs.

Currently the data of all hand-raised cubs in captivity is being collected, to allow for more in depth analysis. Upon completion, it is anticipated that a standardized hand-rearing record keeping system will be available, and all findings will be submitted to the AZA Cheetah Husbandry Manual.

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The purpose of this study was to collect data from all hand-reared cheetahs in North American institutions and to disseminate its findings. Records of 98 cheetahs were entered into a custom database and analyzed to determine factors that increase survivability. There were several factors that were found to influence survivability in this study such as; the cause for hand-rearing, type of formula fed and growth rate. The most notable finding of this analysis was that cheetah cubs that survived hand rearing gained an average of 48 g/day, while those that did not survive gained an average of 5 g/day. We conclude that weight gain per day is one of the most important factors when hand-rearing cheetahs

Case Studies

2243 Ty (Where?)

Glucose feedings: He was one day old when he was pulled. The first five feedings were glucose. Offered 10 mls every two hours during the first day. By day two he was switched over to KMR (I need to look in his hand-written records to see if they say the dilution).

Weight Change in the first week:

Day	Weight (g)	Change (g)
1	680	--------
2	635	-45
3	515	-120
4	552	+37
5	574	+22
6	609	+35
7	633	+24

Summary: He lost weight for the first two days and then started to gain it back. However, by the end of the week he had a net change of –47 g.

Age of first solids: He was 23 days when he was first offered baby food.

Transition from milk to solids:
Day 23 – First solids offered
Day 23 – 50 – In this period both the milk and solids increase
Day 51 – 55 - Solids increase and milk is kept at the same level

His records end at day 55 so it is not known how much and when they backed off of the milk.

Amount fed as %age of body weight:
Day 1-2 – 10.2 %
Day 3-7 – 17.6%
Day 15-30 – 14.5%
Day 31-45 – 13.8%

2444 Mingo (Where)

Glucose feedings: There were no glucose feedings, she was three days old when she was pulled and was started on KMR. (I will check into what the dilution was for the formula).

Weight Change in the first week (of being pulled):

Day	Weight (g)	Change (g)
3	522	-----
4	542*	+20
5	562	+20
6	553	-9
7	576	+23
8	617	+41
9	642*	+25

* = I had to estimate from the day before and after this day because there was no weight taken

Summary: She gained weight all days except the third day of being pulled and overall her weight steadily increased.

Age of first solids: She was 30 days old when she was offered Nebraska.

Transition from milk to solids:
Day 30-33 – Both milk and solids increasing
Day 34 – 40 – Both milk and solid levels stay the same
Day 41 – Milk and solid level increase
Day 42 – Milk and solid levels decrease
Day 46 – Milk is decreased and Solids are increased by 4x
Day 51-52 – Milk is the same with solids increasing
Day 53 – Start reducing milk and increasing solids
Day 54-60 – Milk and solids are staying the same
Day 61 – Milk levels stay the same while solids double
Day 62-63 – Milk is reduced by 3x and solids stay the same
Day 64 – Milk is ended

Amount fed as %age of body weight:
Day 1-2 – 9.2%
Day 3-7 – 23.4%
Day 8-14 – 19.4%
Day 15 – 30 – 14.1%
Day 31-45 – 19.8%
Day 46 – 75 – 28.2%

3666 Masai (Binder Park)

Glucose feedings: She was pulled at 1 day of age and was never offered glucose. She was fed KMR from the beginning (I can look up the dilution in her paper records).

Weight change in the first week:

Day	Weight (g)	Change (g)
1	287	-----
2	184	-103
3	293	+109
4	286	-7
5	293	+7
6	334	+41
7	348	+14

Summary: There was a large weight loss from day 1 to day 2, but after that weight gain was rather steady.

Age of first solids: She was 13 days of age when she was first offered baby food.

Transition from milk to solids:
Day 13-34 – Increase formula with solids staying the same
Day 35-56 – Both solids and formula increase
Day 57 – 90 – Formula is reduced 50% and solids (Nebraska) steadily increase
Day 91 – Solids only

Amount fed as a %age of body weight:
Day 1-2 – 8.2%
Day 3-7 – 11.9%
Day 8-14 – 15.3%
Day 15-30 – 22.3%
Day 31-45 – 23.3%
Day 46-60 – 17.7%
Day 61-75 – 24.1%

The overall trends seem to be:

Glucose feedings:

Only one cat was given glucose feedings, this may be since it was pulled at 1 day of age (although the other cat of 1 day of age was not given glucose).

Weight changes in the first week:

For the most part the cats lost weight initially and began to gain weight around the third day, sometimes not recuperating all the weight initially lost by the end of the first week.

First Solids:

The ages for first solids did not seem consistent; they were 13, 23 and 30 days of age.

Backing off of milk:

The age for beginning to back off of formula ranged but is between 46 and 57 days of age. Formula was ended for one cat on day 64 and another on day 91.

Stimulation:

For the two cats that had stimulation records they were stimulated from the time they were pulled until days 44 and 45.

Incubation:

Only one cat had any incubation records, these said that on the first day of hand-rearing (3 days old) the incubator was set at 90 and the next day it was at 85. After four days of age there were no more incubation records.

Amount fed as %age of body weight:

The averages of all the cats produced the following:

Day 1-2 – 9.2%

Day 3-7 – 17.6%

Day 8-14 – 16.9%

Day 15-30 – 17%

Day 31-45 – 19%

Day 46-60 – 17.7% *only one cat had recorded feedings at this age

Day 61-75 – 26.2% *only two of the cats had recorded feedings at this age.

Hand-rearing Information

The information below was taken from the records of three cubs from our cheetah hand-rearing database.

Cub #1:

- No glucose feedings
- Weight loss was experienced in the first 2 days of hand-rearing and later in the week, the cub began to gain weight
- Formula fed was KMR, solid was Nebraska
- Baby food was offered on Day 13, Formula was discontinued at day 91
- The cub was stimulated from day 1-44
- Amount fed as a percentage of Body weight

Day 1-2	8.2%
Day 3-7	11.9%
Day 8-14	15.3%
Day 15-30	22.3%
1.5 months	23.3%
2 months	17.7%
2.5 months	24.1%

Cub #2

- No glucose feedings
- Gained weight in day one and two of hand-rearing, lost on day three, then steadily increased the rest of the week
- First solids offered on day 30, first solid was Nebraska
- Formula (KMR) was discontinued on day 64
- The cub was stimulated until day 45
- Amount fed as a percentage of Body weight

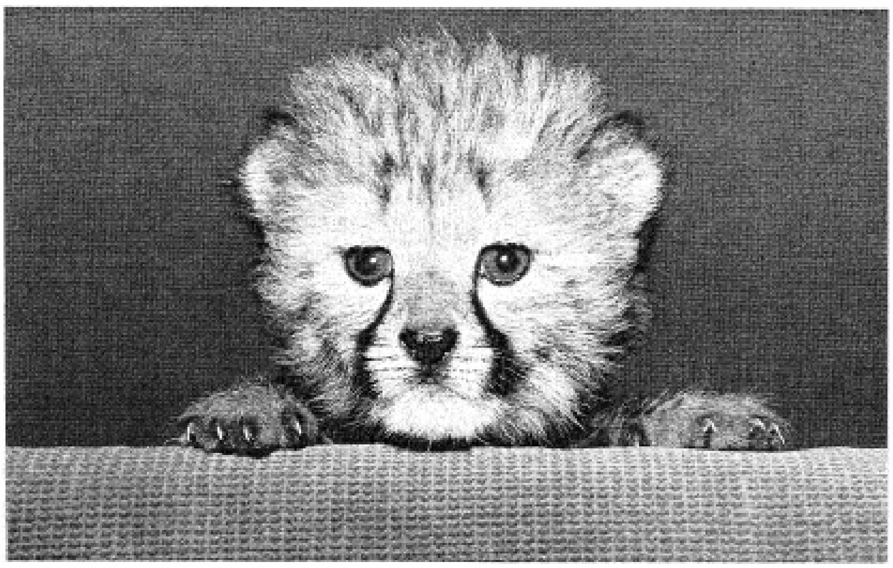
Day 1-2	9.2%
Day 3-7	23.4%
Day 8-14	19.4%
Day 15-30	14.1%
1.5 months	19.8%
2.5 months	28.2%

Cub #3

- Fed 10 mls of glucose every 2 hours for the first five feedings
- Formula fed was KMR
- Lost weight during day one and two of hand-rearing, then started to gain
- Baby food offered at day 23, Start to wean off formula at day 55
- Amount fed as a percentage of Body weight

Day 1-2	10.2%
Day 3-7	17.6%
Day 8-14	16%
Day 15-30	14.5%
1.5 months	13.8%

Cheetah single cub litters in captivity



Wendy van Oorschot
October 1998

Cheetah single cub litters in captivity

By order of Mr. And Mrs. Louwman from the Wassenaar Wildlife Breeding Centre

The Centre's experience has shown that, when a single cheetah young is born, the mother does not continue to produce sufficient milk. The cub needs to be removed within a few days after birth for hand-rearing, as soon as the weight of the cub will drop.
This study compares the experience of other institutions

Practical period Animal Management Van Hall Institute, Leeuwarden, the Netherlands.

Wendy van Oorschot
October 1998

Foreword

This project was done as a practical of the course Animal Management at the Van Hall Institute in Leeuwarden, the Netherlands.
By order of of Mr. And Mrs. Louwman from the Wassenaar Wildlife Breeding Centre I did a literature study on cheetahs single cub litters in captivity.

The experience in Wassenaar had shown that, when a single cheetah young is born, the mother does not continue to produce sufficient milk. The cub needs to be removed within a few days after birth for hand-rearing, as soon as the weight of the cub will drop.
In this study I have compared the experiences of other institutions and have tried to explain the mechanism which could be involved.
I am especially grateful to Mr. And Mrs. Louwman, without whose cooperation and advice this report would never have been completed.
Furthermore I would like to thank my supervisor Fred de Jong from the Van Hall Institute.
Thanks also to each and every person who took the time and effort to answer my inquiries and provided me with additional information.

Wendy van Oorschot

				Amersfoor	2-6-96	Transfer	
				WassBrC	10-6-96	Transfer	
3625	M	CC102	15-6-96	Oudtshorn	15-6-96	Birth	
3427	M	WO47	25-5-95	Yulee	25-5-95	Birth	
				Yulee	27-5-95	Death	Hypothermia
3456	M	PP3	5-5-95	Polarpark	5-5-95	Birth	
3507	F	ZLP11	30-12-95	LaPalmyr	30-12-95	Birth	
				LaPalmyr	31-12-95	Death	Maternal neglect
3229	F	AW72	27-4-94	Shirahama	27-4-94	Birth	
				Shirahama	29-4-94	Death	Dehydration
3242	U	TYZ9	20-5-94	Kraaifront	20-5-94	Birth	
				Kraaifront	20-5-94	Death	Aborted
3340	M	WO4	13-5-94	Yulee	13-5-94	Birth	
3354	U	HCP79	29-10-94	Himeji	29-10-94	Birth	
				Himeji	10-11-94	Death	Maternal neglect
2993	F	AW64	22-4-93	Shirahama	22-4-93	Birth	
2973	F	AW63	16-1-93	Shirahama	16-1-93	Birth	
				Shirahama	20-1-93	Death	Pneumonia
3007	U	OP1	11-4-93	Orano	11-4-93	Birth	
				Orano	11-4-93	Death	Stillborn
3022	F	WS109	23-6-93	Winston	23-6-93	Birth	
				Winston	25-6-93	Death	Trauma
3023	U	AZ3	18-4-93	Audubon	18-4-93	Birth	
				Audubon	18-4-93	Death	Stillborn
3034	M	PH8	26-10-93	Phoenix	26-10-93	Birth	
3035	M	CCZ7	24-9-93	Caldwell	24-9-93	Birth	
				Caldwell	25-9-93	Death	Acute Pulmonary Haemorrhage
3072	M	UC19	1-8-93	Dvurkralv	1-8-93	Birth	
				Dvurkralv	1-8-93	Death	No mother milk
3101	F	AW68	4-9-93	Shirahama	4-9-93	Birth	
3116	U	BP1	29-9-93	BattleCr	29-9-93	Birth	
				BattleCr	30-9-93	Death	Consumed by dam
3125	F	BP2	4-10-93	BattleCr	4-10-93	Birth	
				BattleCr	4-10-93	Death	Stillborn
3186	U	FR71	15-11-93	FossilRim	15-11-93	Birth	
				FossilRim	15-11-93	Death	Canabalised by dam
2700	M	DPZ3	24-4-92	Dickerson	24-4-92	Birth	
				Dickerson	24-4-92	Death	Stillborn
2865	M	NRZ15	21-9-92	Nieuwiedrh	21-9-92	Birth	
				Nieuwiedrh	22-9-92	Death	General weakness
2890	M	FWP85	11-12-92	Carrigtwo	11-12-92	Birth	
				Carrigtwo	22-12-92	Death	Eaten by dam
2434	M	WH130	8-5-91	Whipesnade	8-5-91	Birth	
				Whipesnade	8-5-91	Death	Neonate
2487	F	DEW372	30-4-91	DeWildt	30-4-91	Birth	
				Greulich	12-12-91	Transfer	
2514	M	SD95	21-1-91	SD-WAP	21-1-91	Birth	
				SD-WAP	21-1-91	Death	Stillborn
2568	M	CCZ1	1-9-91	Caldwell	1-9-91	Birth	
				Caldwell	2-9-91	Death	Killed by dam
2197	F	WAS69	10-3-90	WassBrC	10-3-90	Birth	
				WassBrC	12-3-90	Death	Eaten by dam
2242	F	TOR11	20-10-90	Toronto	20-10-90	Birth	
1908	M	WAS59	22-7-89	Amersfoor	22-7-89	Birth	
				WassBrC	22-7-89	Transfer	

				Amersfoor	30-7-89	Transfer	
1915	M	COL84	9-9-89	Columbus	9-9-89	Birth	
				Cincinnat	30-10-89	Transfer	
1925	U	QP1	28-5-89	Queenspk	28-5-89	Birth	
				Queenspk	28-5-89	Death	Eaten by sire
1933	U	KR10	19-9-89	Krefeld	19-9-89	Birth	
				Krefeld	28-9-89	Death	....
1975	U	VC6	4-11-89	Dvurkralv	4-11-89	Birth	
				Dvurkralv	4-11-89	Death	Killed By adult male
2011	M	PZ	23-9-89	ParisZoo	23-9-89	Birth	
2164	U	HCP29	15-7-89	Himeji	15-7-89	Birth	
				Himeji	15-7-89	Death	Stillborn

Table 1. Single cub litters born in captivity from 1988-1996 (International Studbook)

Studbook	Sex	Breeder	Birth date	Location	Since	Status	Cause of death
1441	F		12-5-96	Mulhouse	12-5-96	Birth	
					16-5-96	Death	Maternal neglect
1446	F		2-6-96	Amersfoor	2-6-96	Birth	
				WassBrC	10-6-96	Transfer	
1452	F		27-9-96	Moscow	27-9-96	Birth	
					27-9-96	Death	Stillborn
1454	U		15-10-96	Dvurkralv	15-10-96	Birth	
					15-10-96	Death	Stillborn
1465	U		3-1-97	Munster	3-1-97	Birth	
					28-1-97	Death	Eaten by dam
1472	M		11-1-97	WassBrC	11-1-97	Birth	
					11-1-97	Death	Stillborn
1490	M		11-5-97	WassBrC	11-5-97	Birth	
				Hamerton	31-4-98	Transfer	

Table 2. Single cub litters born in captivity from 1994-1997 (European Cheetah Studbook)

The causes for hand-rearing were not the same for every cub. A lot of different factors were mentioned, like inactivity, low temperature, abandonment and weight loss. Prey availability and the difficulty of securing food apparently affected whether cubs were abandoned in the wild (Caro, 1994). About the reasons for abandonment in captivity is not much known. Most of the cubs actually were hand-reared due to maternal neglect. This is a very general conception which, in fact, can mean a lot of things. Also the biological factor of the milk supply was mentioned. Not enough stimulation for the mother to produce milk. Only a few of the institutions thought that maybe a lot of the single births, or all of them are abnormal to begin with due to a genetic factor.

It appears that the number of days a single cub stays alive without any help from the outside differs very significantly. From as little as 1 to as much as 23 days. Therefore no recommendations can be given on the exact point of time the cub should be pulled for hand-rearing. It is however possible to detect this point of time by measuring the weight gain of the cub every day or twice a day. Apparently the cub gains weight the first couple of days, but then suddenly starts to lose weight. On the moment the cub loses weight for the first time it needs to be pulled. The advantage of this method is that the cub is able to receive the very important first mother milk, which contains all sorts of necessary antibodies.

It has been suggested that it usually happens in young females first litter and also with elderly females, circa nine or ten years old. But this is not based on any scientific data, perhaps mainly on coincidence.

While their are however a lot of records which suggest otherwise (International and European Cheetah Studbook).
Nor in the wild, nor in captivity has their ever been born a single cub which survived without any help from the outside. At least there are no records of any single cub being born in captivity, or in the wild for that matter, which was mother-reared. The only data of a single cub being partly mother-reared is that of Mr Spinelli in a private zoo on 13 January 1966 in Rome. But this was not solely without any help from the outside. After the cub was born, Mr Spinelli stimulated the nipples of the cheetah so that enough milk would be produced for the cub. Mr Spinelli had prepared the female cheetah's teats for suckling, first by sucking them in his mouth, then by sucking at them with a rubber hose ending in a suction cap (Florio and Spinelli, 1967). The reason why the mother cheetah allowed this was probably due to the close contact between the two. The female cheetah had always been with Mr Spinelli and she was very tame and extremely attached to her owner (Florio and Spinelli, 1967). So the cub was mother-reared, but as mentioned above not solely without any help from the outside.

2 Natural history of cheetahs

2.1 Reproductive activity in females

Female cheetahs are sexually mature at around two years of age (Frame, 1984; Kingdan, 1977; McLaughlin, 1970; Nowak & Paradisio, 1983; Schaller, 1972), though females may not conceive until their third year (Laurenson et al., 1992). Females raise cubs successfully approximately once every two years or in some cases more frequently. "Successful parentage has been reported with cheetahs as young as 2 years old or as old as 15. The majority of successful breeding for both sexes occurs between 3 and 10 years of age" (International Cheetah Studbook, 1996). Older females tend to have more 'worse' litters, more often defective cubs are born. Usually this is characteristic with females older than 12.
Being polyoestrus (Bertschinger et al., 1984), births can occur throughout the year. However seasonal peaks occur in certain areas in the wild and is therefore described as "seasonally polyoestrus" (Seager & Demorest, 1986).This seasonality is probably related to nutritional factors. For females, the principal factor limiting reproductive success in the wild is access to resources. In addition, seasonality of oestrus is an important issue for zoo managers since cheetahs' poor breeding performance in captivity has been attributed to disinterest on the part of females in numerous cases. Partly due to the fact that hand-reared females have a much lower mating success than mother-reared animals (Mellen, 1992). Furthermore difficulty in detecting oestrus behaviour has contributed to poor breeding performance. Only about one-third of zoo-maintained cheetahs have ever reproduced successfully. After a successful reproduction their is always the 'high mortality rate' which can decline a cheetah litter.
Long-term records show that the proportion of small litters increased as cubs grew older while the proportions of litters containing three, four, and five cubs declined (Caro, 1994). But nothing is mentioned about litters with one cub.

Gestation length is about 90 to 95 days (Eaton, 1970a, 1974; Nowak & Paradisio, 1983). Interbirth interval: 15-19 months (McLaughlin 1970, Schaller 1972). Females readily go into oestrus and conceive after losing a litter. Laurenson et al. (1992) found that the interval between the death of the previous litter and the next successful conception was longer for young (86.3 days, n=3) than adult females (17.8 days, n=9). So older females tend to re-cycle more quickly than young females. The reasons for this different interval between young and adult females is unknown. On average, adult females mated within 3 weeks of losing their previous litter (Caro,1994). Maybe it is more important for older females to receive a litter once more while it is biologically still possible. Previous studies of radio-collared animals have shown that females mated on average 19 days after losing a litter but could conceive as early as 2-5 days after the loss (Laurenson et al.,1992)

In cheetahs, the number of days a litter was alive multiplied by its size, an estimate of cost imposed on the mother, was positively correlated with the length of time from its premature loss or the next conception (Laurenson, 1992).

Rapid resumption of oestrus raises the possibility that males might gain reproductive advantages by killing a female's cubs fathered by other males, and then mating with her themselves. There are records of cubs being killed and eaten by males, which were not separated from the pregnant females (International Studbook, 1996). There has been no direct observation of infanticide in cheetahs (Caro, 1994).

2.2 Birth and cub development

The reported duration of parturition ranges from 1,5 hours (Florio & Spinelli, 1968) up to 11 hours (cited by Seager & Demorest, 1968), depending on the number of cubs, with intervals between each cub ranging from ¼ hour to 2 hours (Cupps, 1985. Between 1 and 8 cubs are born (Nowak & Paradisio, 1983), with average litter size slightly in excess of 3.5 (Laurenson et al., 1992). Felids in general require seclusion and quiet when they have cubs, and mothers are prone to neglect or eat cubs when disturbed or stressed (Husain 1966; Marma & Yunchis 1968). Their is however a difference between mothers who are hand-reared and mothers who are mother-reared. Hand-reared cheetahs are much more tame than mother-reared cheetahs and therefore probably less stressful against other cheetahs and humans.

The average birth weight in captivity lays around 450 gram, with a range of 320 to 700 gram. It is however very dependent on the number of cubs in a litter. The weight gain of a single cub is shown in table 3. The cub was born on 02-06-96 and was pulled for hand-rearing on 09-06-96. As shown in this table the birth weight of this single cub is very high in comparison with the average birth weight. They have a light grey, woolly coat which turns into its adult colours by four months.

Date	Weight (gram)	Growth (gram)
02-06-96	625	
03-06-96	625	0.0
04-06-96	654	29.0
05-06-96	699	45.0
06-06-96	761	62.0
07-06-96	821	60.0
08-06-96	886	65.0
09-06-96	862	-24.0

Table 3 Weight gain of a single cub measured every day (Louwman, 1996).

Cubs usually suckle within the first 24 hours (Eaton et al., 1978) though defecation may not occur until the second day (Florio & Spinelli, 1967). Though time spent nursing does not necessarily approximate to offspring weight gain (Mendl and Paul 1989), it is a reasonably good measure of weaning (Konig and Markl 1987). "Initial attempts to eat meat occur at just 18 days or not until 7 weeks. Cubs will readily eat meat when they are around 1 to 2 months old" (Florio & Spinelli, 1967, 1968; Standley, 1979; Tong, 1974).Cubs are weaned at six months, and leave their mother at about 13 to 20 months, but siblings often remain with each other for several more months (Internet, Cheetah survival page).

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Gestation length is about 90 to 95 days (Eaton, 1970a, 1974; Nowak & Paradisio, 1983). Interbirth interval: 15-19 months (McLaughlin 1970, Schaller 1972). Females readily go into oestrus and conceive after losing a litter. Laurenson et al. (1992) found that the interval between the death of the previous litter and the next successful conception was longer for young (86.3 days, n=3) than adult females (17.8 days, n=9). So older females tend to re-cycle more quickly than young females. The reasons for this different interval between young and adult females is unknown. On average, adult females mated within 3 weeks of losing their previous litter (Caro,1994). Maybe it is more important for older females to receive a litter once more while it is biologically still possible. Previous studies of radio-collared animals

3 Cheetah cub mortality

Juvenile mortality or cub mortality was defined as death prior to or at 6 months of age (Ralls et al., 1979; Ralls and Ballou, 1982a,b; Shoemaker, 1983; O'Brien et al., 19985; Marker and O'Brien, 1989; Marker-Kraus and Grisham, 1993).
Juvenile mortality is a critical selective force on most animal populations, with its extent, timing and causes influencing patterns of maternal care, life-history strategies, population dynamics and conservation biology (Laurenson, 1994).
Stillbirths, premature births and congenital defects account for a significant number of deaths (Marker & O'Brien, 1989; Marker-Kraus, 1990a). Maternal neglect, exposure, pneumonia and maternal or cagemate trauma have also been identified as major causes of cub mortality (Degenaar, 1977; Enke, 1960; Meier, 1986;Ulmer, 1957). Cubs are most vulnerable in their first month (Degenaar, 1977); Marker & O'Brien, 1989). Disturbance, due to the presence of humans, conspecifics or to excessive noise, has been mentioned as an important factor in many cases. Disturbance should be kept to a minimum, particularly in the case of the female's first litter (McKeown, pers. Comm.).
Abandonment and maternal trauma are often associated with the first or second litter and may reflect a lack of experience on the female's part (Degenaar, 1977). Apparently this experience is very important and therefore hand-reared females probably will have not as much success as mother-reared females. It has been suggested that social stress may inhibit lactation and disrupt appropriate olfactory responses resulting in the female cannibalising her cubs (Degenaar, 1977).
Developmental disorders due to nutritional deficiencies have also contributed to cub mortality in captivity. Typically these occur at around 4 to 6 months, the time of weaning. Insufficient calcium and in particular an imbalance of calcium and phosphorous in the diet, has been related to developmental bone malformation (Brand, 1980).

No study other than Laurenson's (in press-b) has measured postnatal mortality prior to emergence from the lair, but when this is included, 94-96% of cheetah cubs died between birth and independence (table 4). Of these, more than 50 percent are caused by predation by other animals, lions, hyenas, jackals and birds of prey (Internet, Cheetah survival page).

Location	Measure	% mortality	Sourse
Cheetah			
Serengeti	0-2 months	71	Laurenson, in press-b
	2 months to independence	81-86	
	Birth to independence	94-96	
Cougar			
Utah	3-10 months	28	Hemker et al. 1986
	10 months to dispersal	8	
	Contact to dispersal	33	
Leopard			
Chitwan	First year	42	M. and F. Sunquist, pers. Comm.
	On to dispersal	16	
	Contact to dispersal	58	
Kruger	Cubs	50	Hornocker and Bailey 1986
	Tagged subadults	32	
Lion			
Ngorongoro	12 months	29-42	Elliot and Cogan 1978;
	18 months	36-73	van Orsdal, Hanby, and Bygott 1985
Serengeti	12 months	48-73	Schaller 1972c; van Orsdol,
	18 months	56-78	Hanby, and Bygott 1985
Queens Elizabeth	12 months	14-60	van Orsdol 1981, 1982
	18 months	14-80	

Tiger			
Chitwan	First year	34	Smith and Mc Dougal 1991
	Second year	17	
	Contact to independence	58	

Table 4 Juvenile mortality among non-hunted felid populations

Litter losses in the lair are high and are caused by a variety of factors including predation, abandonment by mothers, and the elements. Also due to the fact that mother cheetahs sometimes have to leave their cubs alone for up to 48 hours to hunt for food. Cub mortality is also high after cubs emerge from the lair and before they reach 3 months of age. Schaller (1972c) observed that a third to a half died during this period. After 3 months of age most cubs survive to independence (Caro, 1994).
Infant mortality, death under 1 month of age, usually related to maternal neglect, averages 30-40% (Marker and O'Brien, 1989; Marker-Kraus and Grisham, 1993). In captivity cub mortality is also very high, but due to other causes. Based on the number of mentions made by 44 international zoos in response to a partially open-ended questionnaire, neonatal mortality stemmed principally from poor husbandry (10 mentions) and maternal neglect (10), with cannibalism (5), congenital defects (5), disease (4), and stillbirths (3) playing a lesser role." (Marker and Kraus 1990) or (Marker and O'Brien 1989). A big part of the mortality rate of cheetahs depends on husbandry.
Sources of mortality can be divided into extrinsic sources, such as fatal injury, husbandry and maternal problems, which are not sensitive to changes in reproductive decisions. Intrinsic causes, such as stillbirths, neonatal death, premature birth and congenital defects are dependent on reproductive decisions. High intrinsic mortality is a priori likely to be associated with fast life history schedules, high extrinsic mortality is not (Stearns, 1992). Unfortunately, data on mortality are poorly documented in the literature, and the extent to which its causes are intrinsic or extrinsic is often unknown (Caro, 1994).
Furthermore, genetics probably plays a role in the cheetahs survival, but the extent of this factor is not clear to scientists. As they begin to inbreed, congenital effects appear, both physical and reproductive. Often abnormal sperm increase; infertility rises; the birth rate falls. Most perilous in the long run, each animal's immune defence system is weakened (Internet, Cheetah Gene Problem). In the chapter on genetic variability in cheetah populations more detailed information will be available on this subject.
In short, infant mortality is a critical selective force on most animal populations, with its extent, timing and causes influencing patterns of maternal care, life-history strategies, population dynamics and conservation biology (Laurenson, 1994).

4 Genetic variability in cheetah populations

Every one of today's 20,000 cheetahs is genetically almost identical. They descend from survivors of a near-extinction catastrophe that resulted in generations of close inbreeding 10,000 years ago (Internet, Cheetah Gene Problem). Wild and zoo populations show almost no genetic variability, which may increase their susceptibility to disease and decrease their ability to reproduce (Internet, Acinonyx jubatus). Maybe a cheetah litter of one cub is some sort of genetic default to begin with. Most of the litters exist of three to four cubs and in some cases even more.
The possible consequences of such genetic uniformity would include high species vulnerability because such circumstances not only allow expression of deleterious recessive alleles but also limit adaptiveness to perturbations of the ecological niche (O'Brien et al., 1985). This in turn has been connected with: great difficulty in captive breeding; a high degree of juvenile mortality in captivity and in the wild; and a high frequency of spermatozoal abnormalities in ejaculates (O'Brien et al., 1985).There have not been any genetic investigations on females with a litter of one cub, so it is not sure to what extent genetics play a role in this phenomenon.

Darwin's law of natural selection predicts that individuals well adapted to an environment will leave more offspring than less well-adapted individuals will. Natural selection favours individuals that leave the most surviving offspring (Trivers 1985). When a species has little genetic variety, its ranks are unlikely to contain many members whose genetically determined traits are well suited to withstand ecological change; the species competes poorly for survival under changed conditions and may die out (O'Brien et al., 1986). It is not known how often cheetahs in the wild receive a litter of one cub. Perhaps it is not as often as in captivity, so a conclusion could be that cheetahs in captivity are not well-adapted to the captive environment.
Loss of heterozygosity has been shown to have a negative impact on components of fitness in many species (Frankel and Soule, 1981; Allendorf and Leary, 1986;Ledig, 1986;Mitton, 1993). In particular, studies have provided evidence that within a species more heterozygous individuals show higher levels of fitness than individuals that are less heterozygous (Schaal and Levin, 1976; Allendorf and Lesry,1986; Ledig, 1986; Danzman et al., 1988; Keller et al., 1994). A measure of fitness is reproduction, namely the number of healthy young. There is, however, very little evidence that individuals of one species with a higher level of average heterozygosity are more fit than those of another species with lower average heterozygosity (see Caughley, 1994). There appears to be no evidence for a significant effect of the extreme level of genetic monomorphism measured for part of the cheetah's genome on the juvenile mortality rate and reproductive performance of this species in captivity (Wielebnowski, 1996). There is, however, evidence for a significant effect of inbreeding on juvenile mortality suggesting that there may be more variation far certain loci than originally assumed, based on earlier measurements on genetic diversity (Wielebnowski, 1996).
In species depauparete in genetic variability for a number of generations, deleterious recessive alleles may have been purged and juvenile mortality may be no greater than in outbred species (Templeton & Read, 1983).
It is however not sure that for instance stillbirths, congenital defects and premature births are based on genetics. Also with infections it is difficult to determine to what extent they are based on genetics. Table 5 shows the results of a comparison of causes of cheetah juvenile mortality in inbred (F>0) and noninbred (F=0) cubs at five North American breeding facilities between 1970 and 1994. The main causes of mortality differ significantly between inbred and noninbred deaths.
Largely as a result of intrinsic causes, such as stillbirths and congenital defects, that may have a genetic basis. This indicates that in spite of the cheetah's homozygosity, effects of further inbreeding depression may still occur in the captive population, and deleterious recessive alleles are being segregated (Wielebnowski,1996).

Causes of juvenile mortality	F = 0 (%)	F > 0 (%)
Extrinsic		
Fatal injury	14.8 (13)	21.4 (6)
Husbandry	12.5 (11)	0
Maternal problems	8.0 (7)	0
Total	35.2 (31)	21.4 (6)
Intrinsic		
Stillbirths	19.3 (17)	35.7 (10)
Neonatal	9.1 (8)	10.7 (3)
Premature	3.4 (3)	0
Congenital	5.7 (5)	21.4 (19)
Total	37.5 (33)	67.9 (19)
Other		
Various infections	20.5 (18)	7.1 (2)
Various other	6.8 (6)	3.6 (1)
Total	27.3 (24)	10.7 (3)

Unknown	15	1
Total died	103	29

Table 5 Comparison of causes of cheetah juvenile mortality in inbred (F>0) and noninbred (F=0) cubs at five North American breeding facilities between 1970 and 1994.

Finally, it is worth noting that juvenile mortality is a poor measure of mortality arising from genetic defects, as so many other factors can be involved. For example, it is well known that poor mothering is an important source of offspring mortality in captive cheetahs (Cegenaar 1977). At present, then, there is no convincing evidence for elevated juvenile mortality in captive cheetahs as a result of their depauperate genetic variability (Caro, 1994).

5 Parental investment

Female cheetahs alter their behaviour after cubs are born in an attempt to ameliorate high mortality. The causes and timing of mortality appear to be critical, however, in determining the extent, type and timing of maternal strategies that are adopted. Like putting young into the world on which practically no expenditure has been wasted in order to prevent a big loss in case of mortality.
Parental investment is defined as "any investment by the parent in an individual offspring that increases the offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to invest in other offspring" (Trivers 1972). Since the effects of current reproductive effort in the parent's survival and future reproduction are difficult to measure (Clutton-Brock 1984;Reznick 1985), measurements of the amount of time or energy that parents expend on offspring (parental expenditure) or of behaviour that increases offspring's fitness (parental care) are often used instead (Clutton-Brock 1991). Maternal care is predicted to vary with environmental conditions, as well as with the characteristics of the mother and her offspring (see Sargent and Gross 1986;Montgomerie and Westherhead 1988).
Alternatively, it could be argued that parental expenditure will be greatest when offspring are young since its effects on offspring growth and survival are likely to be highest at this time (Clutton-Brock 1991). Cheetah cubs are helpless when they are born and are solely dependent on their mother. Evolutionary considerations predict that a mother will terminate parental care when its cost to her is more than half the benefit to her offspring. An offspring, however, should favour continued parental care until the costs of care to its mother's fitness exceed twice the benefits to itself (Trivers 1974).
When a litter of one cub is born, the costs for the mother will probably exceed twice the benefit for this one cub. For instance, cub mortality is very high, so the chance that any cub will survive to independence is relatively low.

5.1 Costs for mothers and benefits for cubs

Mothers produce offspring of low birth weight and have relatively light litters in order not to waste expenditure on young that have a low chance of survival (Caro, 1994). Large litters constituting little maternal expenditure can be viewed as an adaptation to circumstances in which offspring survival is unpredictable or unlikely (Caro, 1994). Thus a large litter of small cubs would yield high fitness in those few reproductive bouts that were successful, but a light litter would minimise losses in the majority of bouts that were unsuccessful (see Promislow and Harvey 1990). The average birth weight of a cheetah cub is 266.4, with an average litter size of 3.60 according to Caro's publication in 1994 (table 6). However the data he used for his own work might be out of data. A few of the references he used were from 1964. In consequence of the success in the last years there is reason to believe that there is a significant difference in the average birth weight published by Caro in 1994 in comparison with the average birth weight now. According to data in captivity the average birth weight appears to be much higher than the average birth rate which is mentioned in Caro's publications. The average birth weight in captivity lays around 450 gram, with a range of 320 to 700 gram, as also mentioned in a previous section. It can be assumed that there is no fundamental difference between the wild and captivity, at least not such a significant difference. Therefore it is questionable if this particular data of Caro is reliable.

Species	Female body weight (kg)	Birth weight (g)	Litter Size	Weaning (days)	Independence (days)	Maturity (days)	Gestation (days)	Interbirth interval (months)	Longevity (months)
European wildcat	4.3	114.3	4.00	79	131.3	352.1	65.8	10.0	171
African wildcat	3.7		2.90		150.0	300.0	57.0	12.0	192
Caracal	10.0		3.17	118	365.0	600.0	70.8	10.0	198
Ocelot	9.5	231.0	2.00		365.0	660.0	74.6		
Clouded leopard	11.4	160.0	3.25	145	270.0	730.0	89.7		
European lynx	14.5	70.0	2.40	150	425.8	743.3	67.4	11.6	172
Leopard	38.2	527.1	2.50	92	527.4	942.9	96.8	21.3	247
Snow leopard	37.5	474.6	2.60	107	365.0	730.0	98.2		159
Cougar	43.0	383.7	2.78	105	638.8	821.3	91.5	22.5	153
Cheetah	51.7	266.4	3.60	109	498.8	622.8	92.7	19.1	140
Jaguar	62.6	823.1	2.40	157	707.2	1026.5	100.8	12.0	220
Tiger	111.5	1253.3	2.80	135	632.0	1368.8	104.3	35.3	252
Lion	137.4	1231.0	2.90	211	759.1	1147.1	108.5	25.0	230
Black-footed cat	1.1		2.10			684.4	65.5	12.0	
Leopard cat	4.1	80.0	2.56			603.3	61.3	12.0	156
Jungle cat	4.7	130.9	3.50	96		435.0	62.6	5.5	114
Bobcat	7.2	285.6	2.84	59		517.1	57.3	11.3	155
North American Lynx	13.7		2.98		547.5		12.0		
Serval	11.6	200.0	2.62		60.0		72.6	6.0	192
Fishing cat	7.8	170.0	2.20				67.3		120
Margay	3.4		1.70				82.3		
Jaguarundi	2.7		2.60				67.1		
Rusty-spotted cat	1.6		2.50						
Geoffroy's cat		65.0	2.30	63			71.0	12.0	
Sand cat		39.0	3.25				61.0	6.0	93
Pallas's cat			4.25						
African golden cat									204
Asiatic golden cat		250.0	1.70				95.0		210
Tiger cat			1.50				74.8		
Pampas cat			2.00						
Marbled cat									198

Table 6 Life history variables of felid species

In mammals pregnancy and lactation impose great energetic demands on females but not on males (Gittleman and Thompson 1988). Female cheetahs met the energetic demands of lactation primarily by increasing their food intake. In the wild they also switch to larger prey and have greater success hunting it (Laurenson 1992). Cheetahs also met the demands of lactation by tapping body stores, judging from their elevated urea and lowered creatinine levels, which are indicative of protein catabolism and reduced muscle mass (Laurenson1992).

The number of cubs in a litter generally has little effect on maternal behaviour when cubs are young (Caro 1989b). Nothing is said about the maternal behaviour when only one cub is involved.
In the wild cubs benefited from the presence of their mother in a number of ways, and not solely through her provisioning. Young cubs gained from their mother's antipredator behaviour, vigilance and nutrition provided through milk and prey that she caught for them. Middle-aged and to some extent old cubs profited from her vigilance and hunting skills. In captivity most of these things are not as important as in the wild, sufficient food is available and their are no predators which can cause a direct danger.

Cubs that are mother-reared will have greater reproductive success than hand-reared cubs. It is not clear which specific behaviour of the mother is beneficial to cubs, but that the general care is important is clear.

Though parent-offspring conflict has been explored theoretically (e.g. MacNair and Parker 1978;Godfray 1991; see Mock and Forbes 1992), there are few empirical data on the short-term costs and benefits experienced by both parties at the time parental care ceases (but see Dacvies 1976). This is unfortunate, since the short- term cost- benefit ratios of both parties will help to determine the total reproductive costs. On this basis natural selection should decide about the termination of investment. Nevertheless, abandonment in the wild probably depended on short-term considerations, with food availability being the most important proximate factor. In captivity this is not the case, while sufficient food is available. Data collected by Laurenson (1992) show that the number of young taken by predators increases with litter size in the lair because the whole litter is killed in most cases. Hence Parental investment should increase with litter size (brood losses case of unshared investment: Lazarus and Inglis 1986). This could mean that parental investment must be very low when it involves a litter of one cub. Apparently so low that is has stopped.

6 Life history traits of cheetahs

Juvenile mortality may be a fundamental determinant of life-history traits; juvenile mortality is highly correlated with life-history parameters, such that species with high mortality reproduce and develop rapidly (Stearns, 1976; Promislow & Harvey, 1990; Lessells, 1991; Gittleman, 1993). The high mortality rates of cheetah cubs may, therefore, explain the evolution of the life-history strategy of the species. Cheetahs have large litter sizes compared to other felids (Caro, 1994), low neonate and litter birth weights for their bodyweight (Oftedal & Gittleman, 1989) and high growth rates (Laurenson, in press b). In addition, they return rapidly into oestrus after the loss of an unweaned litter (Laurenson et al., 1992). Thus cheetahs appear to have a fast reproductive rate, putting little effort, which might be wasted, into each reproductive iteration and investing rapidly in their young after birth, perhaps to minimise the period of vulnerability (Laurenson, In press b), but having large litters to increase the chance that some individuals might survive.
Recently, it has become apparent that variations in life history traits, such as age at maturity or interbirth interval (see Stearns 1976; Boyce 1988), can best be explained as adaptive solutions to differential patterns of mortality, not to differences in basal metabolic rate or brain size as assumed in the past (Harvey, Promislow, and Read 1989; Read and Harvey 1989; Promislow and Harvey 1990; Harvey, Pagel, and Rees 1991). Thus species, like the cheetah, in which mortality rates are high might be expected to reproduce faster than those in which mortality is low. Large litter size appears to be an independent evolutionary response to high mortality.

6.1 Comparison with other felid species

There are 37 species in the cat family (Felidae), and all except the domestic cat are considered threatened or endangered (CITES, 1973). The cheetah (Acinonyx jubatus) is the single surviving species of the genus Acinonyx (Neff, 1983).
The cheetah is quite different in both anatomy and behaviour from the other genera of Felidae (Marker and O'Brien, 1986). Comparative analyses of Felidae indicate similarities between the cheetah and the European wildcat and the jungle cat. These species reach sexual maturity relatively early and have large litter sizes for their body weight (table 6). Leopards are also interesting in that they show an opposite suite of characteristics from the cheetah, having a relatively long interbirth interval and small litter size for their body weight, perhaps in response to their longer life span (table 6). This data is however, as mentioned in a previous section, perhaps not completely reliable.
The cheetah, whose closest living relative is the puma (Caro, 1994). Probably because gestation length, 91,9with a range of 4 days, and age at independence, 12-18 months (Anderson, 1983), are practically the same. Hemker et al. (1986) estimated survival of cubs to dispersal at 67 % in a non-hunted population in the wild. The average litter size was estimated at 2.2-2.7 (Anderson, 1983; Currier, 1983; Ross and Jalkotzy,1992) with a range from 1 to 6. Very striking was the remark of Lindzey (1987) that the first litter of a puma existed possibly of only a single kitten. But a puma does not abandon this single cub. At least as far as data on this subject is available.
Hansen (1992) estimated a longevity of probably 8-10 years for pumas, but Currier (1983)estimated a longevity of up to 12-13 years. The average life span of the captive cheetah in North American zoos is 8.9 year (Setchell et all.,1987), a much shorter time span than is seen for other exotic cats kept in captivity.
In species in which juvenile mortality is high as a result of extrinsic factors, age at maturity is expected to be brought forward in order to keep the high-risk juvenile stage as short as possible (Horn 1978; Reznick and Endler 1982; Stearns 1992). In support of this idea, age at maturity in cheetahs was somewhat earlier than in other species or genera of equivalent body weight, paralleling that found across families of mammals (Promislow and Harvey 1990). The interbirth interval of a female puma can be one year (Robimette et al.,1961), but more generally 18-24 months (Lindzey, 1987). The cheetah's rapid resumption of breeding following the loss of an unweaned litter cannot be systematically compared with other free living cats as data are not available (Caro, 1994). Cheetahs have a much higher rate of reproduction than other big cats. Litter sizes are larger than those found in most other felids. The newborn cubs are helpless and blind, weighing about one half pound, but developing more quickly than other large cats (Internet, The Cyber Zoomobile).
Now the genetic variation of the cheetah will be compared with other felid species. It was possible that the cheetah's low genetic variation is characteristic of wild species of felids and that the cheetah is only one of several highly monomorphic species. This possibility prompted an examination of genetic variation in other species of the Felidae. A survey of seven cat species was undertaken in which the same 50 allozyme loci that had been examined in the cheetahs were sampled. The species included the leopard, lion, serval and caracal, which overlap the cheetah's range in Africa. The results are summarised in table 7 (Newman et al., in press). All species showed moderate to high levels of genetic variation, further emphasising the absence of genetic variability in the cheetah.

Species	Geographic range	Number of individuals	Number of loci	Polymorphic loci (%)	Average heterozygosity
Felidae					
Cheetah (Acinonyx jubatus)	South, East Africa	55	52	0.0	0.0
Domestic cat (Felis catus)	Worldwide	56	61	21.3	0.082
Lion (Panthera leo)	Africa, India	20	50	12.0	0.037
Serval (Leptailurus serval)	Africa	16	49	12.2	0.033
Leopard (Panthera pardus)	Africa, Asia	18	50	8.0	0.029

Caracal (Caracal caracal)	Africa, Asia	16	50	10.0	0.029
Tiger (Panthera tiglis)	India, Southeast Asia,Korea,USSR	40	50	10.0	0.035
Ocelot (Leopardus pardalus)	America	6	48	20.8	0.072
Margay (Leopardus wiedi)	America	11	50	16.0	0.047
Other mammals					
House mouse (Mus musculus)	Worldwide	87	46	20.5	0.088
Man (Homo sapiens)	Worldwide	>100	104	31.7	0.063
	Two-dimensional gel survey*				
Man (Homo sapiens)	Worldwide	28	185	10.8	0.024
Cheetah (Acinonyx jubatus)	South, East Africa	6	155	3.2	0.013

Table 7 Proportion of loci estimated to be polymorphic and proportion of the genome estimated to be heterozygous in species of felidae and other selected mammals.

Cheetah juvenile mortality was found to be lower than juvenile mortality of six other felids and higher than four species (table 8). When only noninbred juvenile mortality rates were compared, the results were similar, with the cheetah showing a lower mortality rate in three cases out of six (table 8). In addition, the cheetah showed the highest average litter size and the highest average number of cubs surviving per litter (table 8), suggesting relatively high levels of productivity when compared to other captive-bred North American felid populations.

Species	Studbook total: Juvenile mortality (%) (number of births)	Noninbred juvenile mortality (%) (number of births)	Average litter size (number born/litters)	Average number of cubs surviving/litter	Average Heterozygosity
Acinonyc jubatus (cheetah)	31.8 (723)	30.9 (534)	3.6 (667/185)	2.4	0.014
Panthera pardus (leopard)	39.9 (228)	58.7 (75)	1.8 (228/124)	1.1	0.029
Panthera uncia (snow leopard)	25.2 (432)	25.1 (338)	2.1 (432/208)	1.6	No Inbreeding
Panthera onca (jaquar)	26.7 (667)	No Inbreeding	1.6 (677/435)	1.2	No Inbreeding
Panthera tigris (tiger)	23.8 (122)	21.8 (55)	2.1 (122/158)	1.6	0.035
Panthera leo (lion)	35.6 (160)	No Inbreeding	2.3 (160/170)	1.5	0.037
Neofelis nebulosa (clouded leopard)	37.7 (471)	33.1 (320)	1.7 (396/228)	1.0	No Inbreeding
Lunx caracal (caracal)	40.3 (129)	No Inbreeding	1.8 (129/71)	1.1	0.029
Felis pardalis (ocelot)	34.9 (266)	No Inbreeding	1.3 (266/213)	0.8	0.072
Felis nigripes (black footed cat)	29.5 (44)	40.0 (25)	1.6 (44/28)	1.1	No Inbreeding
Felis margarita (sand cat)	50.0 (142)	No Inbreeding	2.5 (142/56)	1.3	No Inbreeding

Table 8 Parameters of captive breeding performance and levels of average heterozygosity for eleven felid species bred in North America (O'Brien er al., 1985).

Rates of juvenile mortality, however, can be expected to vary widely with respect to life history strategies and among different taxa. For example, a survey of neonatal mortality in 52 zoo species found lower average juvenile mortality in ungulates (~16%) than in carnivores (~33%) (Loudon, 1985). Cheetahs have the highest juvenile mortality yet recorded for nonhunted populations of cats in the wild. Also cheetah cub mortality was the highest reported for non hunted populations of felids (table 4). To compensate, cheetahs reach maturity relatively early, and have relatively larger litter sizes than other felids. Mothers produce offspring of low birth weight and have relatively light litters in order not to waste expenditure on young that have a low chance of survival (Caro, 1994).

Conclusion

The species exhibits an extreme lack of genetic variability which may, in theory, increase its susceptibility to disease and compromise its ability to adapt to future environmental conditions (O'Brien et al. 1983, 1985; but see Caughley 1994; Caro and Laurenson 1994). In short, genetic monomorphism was interpreted as being largely responsible for the cheetah's problems in captivity as well as in the wild (O' Brien et al., 1985; O'Brien, 1994a,b). But it is however not sure that for instance stillbirths, congenital defects and premature births are based on genetics. Also with infections it is difficult to determine to what extent they are based on genetics. Unfortunately, data on mortality are poorly documented in the literature, and the extent to which its causes are intrinsic or extrinsic is often unknown. So mortality is not necessarily based on genetics. Mortality is also not necessarily a measure of fitness; the relationship of fecundity rate and juvenile mortality rate needs to be examined to investigate fitness (Caughley, 1994). Ideally lifetime reproductive success should be assessed. However, this measure cannot be applied well to the captive situation since the amount of breeding is controlled by management decisions rather than by an individual's reproductive potential.

The fact that genetic uniformity poses a threat to the survival of a population or a species has been evident since Darwin formulated his theory of natural selection. Natural selection favours individuals that leave the most surviving offspring (Trivers 1985). One cub is not much. If the mother abandons it she could gain reproductive advantage by rapidly returning into oestrus. Perhaps the next litter consists of a lot more cubs. The factors which influence abandonment in captivity are not entirely clear. When the evolutionary considerations, as mentioned in a previous section, are taken into account, a litter with one cub is just not worth taking care of. Maybe the captive cheetahs which live in zoos now have inherited this life history trait from their ancestors in the wild. So it is genetically determined that parental care will be terminated when the costs for the mother exceeds the benefits for the cubs. This abandonment of a single cub is not seen in other felid species. When the life history traits of cheetahs are compared with other felid species some similarities are seen with the European wildcat , the jungle cat and the puma. Like sexual maturity at a relatively early age and large litter sizes for their body weight. But these species do not abandon their single cub litter.

In case of abandonment it seems that after two to five days the milk supply of the mother is not efficient enough. In result the cub dies from starvation. It could be that the mother "decides" not to rear but to recycle again. It has been suggested that social stress may inhibit lactation and disrupt appropriate alfactory responses resulting in the female cannibalising her cubs (Degenaar, 1977). Probably the milk supply is not stimulated enough by just one cub. The reason for this conclusion is the fact that the cub of Mr Spinelli was indeed raised with its mothers' milk. Combining the biological factor of 'not enough stimulation' with the evolutionary considerations of parental investment, the cause of abandonment of a single cub by its mother is given. Or it could be the case that all the single births are not normal to begin with. Maybe it is some sort of genetic error. It could be possible that this all is genetically based, but until research is being done this factor still remains unsolved.

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Wassenaar, 24 May 2002.

Columbus Zool. Gardens,
Att: Mrs Dr C. Lombardi,
Powell, Ohio, U.S.A.

Dear Dusty Lombardi,

Of course I remember our interesting discussions on cheetahs at the Global Cheetah Management Workshop and at De Wildt.

In your recent email you asked us information on our cheetah breeding results and our experiences.

The different Int. Cheetah Studbooks, compiled by Laurie Marker, give a rather good overview of our results. Also a few articles have appeared on our experiences breeding cheetahs here in Wassenaar, which also have been printed in this studbook.

Enclosed we have sent you 2 publications, which could also be useful to you. It was compilrd by a student of the Van Hall Institute here in The Netherlands.

Please do not hesitate to ask us, when you think we can be of any help to you. We know that your zoo has bred cheetahs in the past very well, but sometimes others can give some additional useful advice.

We wish you lots of success.

With kind regards,

Jan Louwman. W.W.B.C.

Hand-rearing cheetah (*Acinonyx jubatus*) cubs: milk formulas

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Artificial milk formulas manufactured for domestic kittens have traditionally been used as the hand-rearing milk formula for captive wild felids. This paper will compare the differences between the composition of cheetah (*Acinonyx jubatus*) maternal milk and that of the domestic cat. The differences are significant, especially regarding the carbohydrate (lactose) content. As a result, using a milk formula designed for domestic kittens does not closely match the composition of cheetah milk. However, modifications to kitten milk formulas may provide a more nutritionally balanced diet for cheetah cubs and contribute to increased growth rates and decreased incidence of digestive disorders.

The maternal milk composition of cheetahs is more concentrated in solids and fat and lower in protein and carbohydrates than the domestic cat (table 1). Kitten milk replacer (KMR®) has been used quite regularly at cheetah breeding facilities that hand-rear cubs. KMR®, in the liquid form, is most commonly used and many times is diluted with water or 5% dextrose for the first several feedings. Anecdotal reports indicate cubs have digestive problems (diarrhea or constipation) when the undiluted formula is used. Facilities have indicated the powder form of KMR®, which can be mixed with water at different dilutions, doesn't mix well and is more prone to cause digestive upset, presumably because the powder stays in a "lump" in the cub's stomach and can't be digested properly. Other facilities have chosen to use Esbilac®, which is a puppy milk replacer. Esbilac® is higher in fat and lower in carbohydrates than KMR®. Taurine, an essential amino acid for felids, is not in the Esbilac® formula, so must be added prior to feeding (250mg/cub/day) (McManamon and Hedberg, 1993). A recent survey on hand-rearing protocols of captive felids indicated there was equal preference for Esbilac® + taurine and KMR® + Multi-Milk® formulas (Hedberg, 2002).

Table 1: Comparison of the maternal milk composition of cheetah and domestic cat. Ben Shaul (1962)[1], Abrams (1950)[2].

	Cheetah[1] AF	Cheetah[1] DM	Domestic cat[2] AF	Domestic cat[2] DM
Solids %	23.7		17.7	
Protein %	9.4	39.7	7.2	40.5
Fat %	9.5	40.1	5.0	28.0
Carbohydrate %	3.5	14.8	4.9	27.8
Ash %	1.3	5.4	0.7	3.7
Kcal/ml*	1.4	5.8	0.9	5.3

* Kcals were calculated. AF = as fed basis. DM = dry matter basis

Cheetah milk is higher in dry matter content (total solids), fat and ash (mineral component) and lower in carbohydrates than domestic cat milk. In many of the species that are hand-raised, carbohydrate is the limiting nutrient. Many species are lactose-sensitive and lack the enzyme lactase to break down milk sugars. Because of that, milk formulas manufactured for domestic species must usually be diluted significantly to provide a formula that doesn't exceed the carbohydrate level wild species are able to digest. Such is the case with KMR®. The liquid form (canned) provides 18.2% solids, 42.2% protein, 25.0% fat and 26.1% carbohydrates (DM basis). That formula is comparable to the domestic cat's milk, but is very different from the cheetah's. If the carbohydrate component is the limiting factor, the milk must be diluted enough to make the carbohydrate portion approximately 14-15% of the total solids (on DM basis) or 3.5% (on "as fed" basis). Diluting KMR® liquid to a 2:1 ratio of formula to water gives a carbohydrate content of 3.2%. A ratio of 3:1 provides 3.6% carbohydrates, both of which would be acceptable for cheetahs. However, diluting the formula to reduce the carbohydrates also decreases the amount of protein and fat in the diet. See table 2 for the proximate analysis of KMR® canned formula dilutions.

Table 2: Comparison of nutrient composition of KMR® canned formula dilutions. Values are on an "as fed" basis. Ben Shaul (1962)[1], Pet Ag™ [2]

	Cheetah req.[1]	KMR® canned [2]	KMR® 3:1 dilution	KMR® 2:1dilution

Solids %	23.7	18.2	13.7	12.1
Protein %	9.4	7.7	5.8	5.1
Fat %	9.5	4.6	3.5	3.0
Carb. %	3.5	4.8	3.6	3.2
Kcal/ml	1.4	0.9	0.69	0.6

From the above data, it is apparent that while reducing the level of carbohydrates to the cheetah requirement, it also decreases the amount of protein to 54-62% of cheetah milk and fat provides only one-third the requirement. Felids obtain energy from protein and fat (Bechert, et al., 2002). The main effect that results from a diluted formula is delayed growth rates and/or skin and haircoat problems. Hair loss was noted in snow leopards that consumed an Esbilac® formula deficient in protein. The problem was resolved after adding chicken baby food, which increased the protein level (Hedberg, 2002).

Another issue with diluting the milk formula concerns the amount of calories the cub receives in a 24 hour period. Growing cubs require a minimum amount of calories for basic body functions, development and growth. Many hand-rearing protocols suggest feeding a certain percentage of the body weight (e.g. 15-20%) on a daily basis. However, there can be vast differences in the caloric content of formulas, especially when diluted.

For example: say we have three 600g (20 oz.) cheetah cubs. One is maternally raised, the other two, hand-raised. Of the hand-raised cubs, one is fed formula #1, as described below. The other cub is fed formula #2. Based on the recommendation that formula be offered in the volume equivalent to 15-20% of the body weight, each cub would receive between 90-120 ml (3-4 oz.) of formula/day. Cheetah milk provides 1.37 kcal/ml. At 15-20% body wt., the cub would receive between 123-164 kcal/day. In this example, we'll use that caloric range as the target for the two hand-rearing formulas.

Cheetah milk
Provides 1.37 kcal/ml of formula
Fed at 15-20% body wt: receives 90-120 ml formula/day
90 ml x 1.37 kcal/ml = 123.3 kcal/day
120 ml x 1.37 kcal/ml = 164.4 kcal/day

Formula #1 (canned KMR®, diluted w/ water at ratio of 3:1)
Provides 0.69 kcal/ml of formula
Fed at 20% body wt: receives 120ml formula/day
120 ml x 0.69 kcal/ml = 82.8 kcal/day

Formula #2 (KMR® & Multi-Milk® powders mixed w/ water at ratio 1: 1: 2½) -> in table 3
Provides 1.26 kcal/ml of formula
Fed at 17-20% body wt: receives 102-120ml formula/day
102ml x 1.26 kcal/ml = 128.5 kcal/day
120 ml x 1.26 kcal/ml = 151.2 kcal/day

The caloric content of formula #1 provides 50-67% of the calories in cheetah milk, when offered at 20% body weight. The caloric content of formula #2 falls within the range of cheetah milk, when fed at 17-20% body wt., and provides 1.8 times more calories than formula #1, when the same amount (20% of the cub's body wt.) is offered. Formula #2 is more nutrient dense than formula #1. In order to provide equivalent calories, formula #1 would have to be fed at 30-40% body wt. to match formula #2 and cheetah milk. Diarrhea has been reported in exotic felids that consume ≥ 25% body wt/day, so no more than 20% should be offered (Hedberg, 2002). As a result, without some type of supplement, formula #1 will likely result in delayed growth rates compared to cubs raised on a more nutrient dense formula, or maternally raised cubs.

The point of the above example is to demonstrate that formulas are not equal when it comes to determining feeding schedules. Offering 15-20% body wt/day is appropriate for formulas that provide adequate nutrient and energy concentrations, but may not insufficient with less nutrient dense formulas.

Many facilities have indicated that chicken or turkey baby food should be added to the formula early on in the hand-rearing process. The addition of baby food will provide supplemental protein and fat. Chicken and turkey are reportedly good sources of taurine (Hedberg, 2002; NRC, 1986). One jar (2.5oz.) of Gerber's® chicken 2nd foods contains 12.9% solids, 11.8% protein, 4.1% fat, 1.47% carbohydrates. 0.6% calcium, 0.09% phosphorus and 15 IU vitamin A and provides 66 kcal (USDA 2004). Taurine was not listed in the analysis. Gerber's® 2nd foods, turkey-flavored, is also a good source of protein and fat, and very low in carbohydrates. However, the calcium: phosphorus ratio is skewed towards phosphorus (1:6.5) so may alter the total Ca:P ratio of the diet to the point of requiring a calcium supplement.

Panthera spp. have benefited from the addition of poultry-based human baby food (e.g. Gerber's® 2nd foods), as early as 1-2 weeks of age. The baby food provides additional protein and calories, but should be limited to less than 17% (2.5oz baby food to 12.5oz prepared formula) of the diet (Hedberg, 2002). Baby food must be added gradually over one week to prevent digestive upset. This is not considered part of the weaning diet, but as an addition to the formula which increases protein, fat and calories to otherwise dilute formulas. Knox® gelatin has also been added to formulas to increase the protein content (D. Strasser, pers. com.).

It is not advisable to add meat-based baby foods to nutrient-dense formulas such as those presented in table 3. Laurenson (1995) stated that wild cheetah cubs had physiological limits on growth even when an unlimited food supply was available. However, the addition of protein and calories may promote a faster than optimal growth rate and contribute to potential bone growth abnormalities. Cubs that are consistently growing at >10% body wt/day may need to have their formula diluted to slow their growth. Fast growth promotes bone deformities and fractures because they are not able to support the additional body weight.

Compensatory growth, a phenomenon where young and/or malnourished animals are taken from a low plane of nutrition to a high plane with little or no transition period, has resulted in Degenerative Orthopedic Disease (DOD) in domestic horse foals and dogs (Owen, 1975;Hedhammer, et al, 1974). Factors that predispose animals to DOD include a combination of genetics, high energy intake and an early slow growth followed by a compensatory fast growth spurt (Lewis, 1995). There is a possibility that compensatory growth may contribute to the "ballet" stance that periodically develops in hand-raised cheetah cubs.

Wild cheetah cubs have average growth rates of 37 – 62.4g/day (1.2-2.1 oz.) (Laurenson, 1995, Beekman, et al, 1999; Wack et al, 1991).The recommended average daily weight gain (ADG) goal for hand-reared cheetah cubs is approximately 5% body weight while on milk formula, and 8-10% increase per day after solid foods are introduced (Hedberg, 2002). Formulas and weaning diets that do not match these goals may need to be modified in one or more ways to ensure proper growth rates of cubs.

Calculations associated with feeding schedules

The following calculations are provided to assist the caretaker in determining how much and how often the formula should be fed to provide adequate nutrition, energy and optimal growth rates.

The Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy (kcal) an animal needs for basic metabolic function at rest in a thermoneutral zone. In other words, the amount of calories it needs to stay alive, without having to use energy to maintain normal body temperatures. The formula to determine the BER/BMR is: 70 x body wt (in kg.)$^{.75}$ (Kleiber, 1947). For a 600g. (0.6kg) cub, the BER would be: 70 x $0.6^{.75}$ = 47.72 kcal/day.

Once we have the BER, we can determine the Maintenance Energy Requirement (MER). This determines the amount of calories the animal needs to function in a normal capacity at its life stage. For adults in the maintenance life stage, the BER is multiplied by 2. For infants that have a higher metabolism and are developing and growing, the BER is multiplied by 3 or 4 (Evans, 1987), depending on the species and other factors. The MER factor of 3 is appropriate for cheetahs that grow at a slower rate than small mammals.

The stomach capacity for most placental mammals is 5-7% of the total body weight (Meehan, 1994). Convert the body weight into grams to find the stomach volume in mls (cc's). To calculate the stomach capacity in ounces, convert body weight into the same units (30g ~ 1 oz). The key is to make sure units are the same for body weight and stomach volume. The stomach capacity is the amount of formula a cub can comfortably consume at one feeding. Offering much more than this value may lead to overfilling, which may lead to stomach distension and bloat. It also prevents complete emptying of the stomach between feedings and promotes the overgrowth of potentially pathogenic bacteria, diarrhea and enteritis (Evans, 1987).

The following calculations will determine the total volume and kcal to feed/day, as well as the amount of formula/feeding and the total number of feedings/day.

1. Calculate Maintenance Energy Requirement (MER): 70 x body wt (kg)$^{.75}$ x 3. See Appendix 1 for calculated MER's for various body weights.
2. Determine stomach capacity (amount that can be fed at each meal): Body weight (in grams or ounces) x 0.05.
3. Divide MER (number of calories required per day) by number of kcal/ml in the formula to determine the volume to be consumed per day. This value can be converted into ounces, by dividing it by 30.
4. Divide ml (or oz.) of formula per day by volume to be consumed at each meal (stomach capacity). This gives the number of meals to be offered per day.

Example: 600 gram (0.6 kg) cub

1. MER = 70 x 0.6 kg$^{.75}$ x 3 = 143 kcal/24 hr. period
2. Stomach capacity = 600g. x 0.05 = 30 ml/feeding
   OR: 20oz x 0.05 = 1 oz/feeding

**The following calculations are based on a milk formula that provides 1.26 kcal/ml. Formulas that provide more or less energy will result in different volumes of formula per feeding and number of feedings/day. A formula that provided 0.69 kcal/ml would require 207 ml of formula per day given over 7 feeding bouts.

3. $\dfrac{143\text{ kcal}}{1.26\text{ kcal/ml}}$ = 113 ml of formula to be offered in 24 hr. period (approx. 20% bw)

4. $\dfrac{113\text{ ml}}{30\text{ml/feeding}}$ = 3.76 feedings (round up to 4)

The cub in the above example would receive 30 ml (1 oz.) of formula at each feeding and would be fed 4 times over the course of the day. The total amount offered in 24 hrs. is approximately 20% of the cub's body weight. The number of feedings would be split by whatever time period caretakers are able to feed, with a minimum of 3 hours and maximum of 8 hours between feedings. In the above example, if the time frame for feeding was 16 hours, the cub would be fed every four hours with an eight hour break at night.

It is not unusual for infants to feed well at one meal and consume very little at another. Whatever is not consumed at individual meals can be made up by an additional meal later in the day. It is important to note that if a cub is expected to consume 30 ml at one meal, but only takes in 15 mls, the deficit can not be made up by offering 45 ml at another feeding. Even if the cub wants to take more than the calculated stomach capacity volume, it must be limited to that amount. Overfeeding may cause bloat and allow for pathogenic bacteria to proliferate in the digestive tract, which will increase the risk of diarrhea, gastric distension and enteritis (Evans, 1987). When cubs are hungry, many times they finish their bottle before the feeling of satiety occurs, but are sound asleep 10-20 minutes later. If the cub is still hungry after it has received its designated volume, shorten the time period to the next feeding by an hour.

With a very young or weak cub, it would be advisable to feed smaller amounts more frequently, although it is generally not necessary to feed more often than every 3 hours. Frequent feedings that cause the cubs to be repeatedly awakened is actually more stressful than letting them sleep for longer periods (Meehan, 1994). Generally, healthy cubs will start to get restless when they get hungry, which can be used to gage how frequently they need to be fed. In the wild, reports have indicated mother cheetahs may regularly stay away for nine hours between feedings without ill effect to the cubs (Laurenson, 1993).

FORMULAS

Pet Ag™ manufactures KMR®, Esbilac® and Multi-Milk®. Multi-milk® is a formulated powder with a very low carbohydrate content. Adding it to either KMR® or Esbilac® will maintain high levels of protein and fat while keeping the total carbohydrate content to a minimum. Table 3 provides two formulas using Multi-Milk®. One combines it with KMR®, the other with Esbilac®. The nutrient compositions are very close to cheetah maternal milk.

Table 3a: KMR®-based recipe for a cheetah hand-rearing milk formula

Formula Component		AF basis	DM basis
KMR (42/25): 1 part	Total solids:	22.4%	
Multi-milk (30/55): 1 part	Protein:	8.9%	39.7%
Water: 2 ½ parts	Fat:	9.5%	42.4%
	Carb:	2.5%	11.2%
	Ash:	1.5%	6.7%
	Calcium:	0.3%	1.4%
	Phosphorus:	0.2%	1.0%
	Magnesium:	0.02%	0.08%
	Kcal/ml:	1.26	5.63

AF = as fed, DM = dry matter

Table 3b: Esbilac®-based recipe for a cheetah hand-rearing milk formula

Formula Component		AF basis	DM basis
Esbilac (33/40): 1 ½ parts	Total solids:	23.0%	
Multi-Milk (30/55) : 1 part	Protein:	7.9%	34.2%
Water : 3 parts	Fat :	11.2%	48.8%
Taurine: 250mg/cub/day	Carb:	2.6%	11.2%
	Ash:	0.8%	3.5%
	Kcal/ml	1.4	6.0

As with all milk formulas, the ones described above should be diluted for the initial feedings and gradually increased in concentration until given as a straight stock formula. In an ideal situation, the cub would receive 2-3 feedings of electrolytes only, then a diluted milk formula (1:4 ratio of mixed formula: water) for 2-3 feedings, then 1:3 dilution for 24 hours, then the 1:2 dilution for 24 hrs, 1:1 dilution for 24 hrs, then the full-strength stock formula on the 5th day and from then on. However, in the real world, things don't always work out as planned. Cubs may periodically need to stay on a dilution a little longer, particularly when going from the 1:1 dilution to the full-strength formula. Intermediate steps may need to be added, such as going from 1:1 to 2:1, then full-strength to give the cub more time to adjust. Occasionally cubs need to take a step back if diarrhea occurs. For example, if the cub does well on 1:2 then develops loose stool on the 1:1 dilution, which gets worse at each feeding, delete the next feeding, give electrolytes (at 5-7% body wt) for 1-2 feedings, then go back to the 1:2 dilution step. Offer that formula for 2-3 feedings and progress to 1:1.5 if the stool improves. Healthy infants tend to resolve digestive upset/loose stool pretty quickly when dealt with appropriately. Compromised infants may have other issues that are compounding the problem. They may be stressed and immuno-suppressed. They may have bacterial or viral infections, particularly if they didn't receive colostrum before being removed from the mother. They may have parasites. Or there may be other factors that are adding to the cub's stress level which hampers its ability to adapt and adjust to the hand-rearing process. This is where the "art" of hand-rearing comes in, and the caretaker must make various adjustments to help an individual cub do its best.

Because the carbohydrate content of the full-strength formulas listed in table 3 is lower than that of cheetah milk, digestive problems should not be an issue. However, our ability to provide appropriate diets is limited by our knowledge at any point in time. Therefore, there is always the potential for new dietary issues to arise. One factor that has been reported is lactobezoars (milk clots in the abdomen) in cheetahs cubs. The cause of this condition is unknown. One facility indicated they thought the milk formula was too concentrated. However, at the time of the lactobezoar incident, they were feeding KMR® liquid as their stock formula, which was high in carbohydrates. Bloating and lactobezoars in two hand-reared polar bears was associated with a milk formula high in carbohydrates (Kenny, et al, 1999). The abdominal distension in the cheetahs may have been caused by fermentation of undigested carbohydrates.

The inability to digest certain types of fatty acids might also contribute to lactobezoars. Prior to 1993, Pet Ag™ used coconut oil as their fat source in the KMR®, Esbilac® and Multi-Milk® recipes. In 1993, the ingredients were changed and they replaced coconut oil with butterfat. The change was made due to research indicating butterfat was more digestible in domestic dogs and cats. However, wildlife rehabilitators and zoo facilities which hand- raised infants noticed that various species were developing digestive problems, even though the caretakers were using the same recipes as before. Lactobezoars were reported in tigers and leopards (Hedberg, 2002). Coconut oil has a high concentration of medium-chain fatty acids, which are generally more digestible than the long-chain fatty acids present in butterfat (Robbins, 1993). Wild felids may not be able to digest butterfat as easily as coconut oil.

Caretakers also reported that the new formula was difficult to mix and had a greasy residue. Pet Ag™ responded to the situation by marketing the Zoologic Milk Matrix® line of milk formulas. It is essentially the pre-1993 version of their milk formulas, and contains coconut oil instead of butterfat as the fat source. Therefore, the Milk-Matrix® version of KMR®, Esbilac® and Multi-Milk® may be preferable products to use in cheetah hand-rearing formulas, especially if lactobezoars are a concern. The Milk Matrix® line uses formula numbers, which refer to the concentration of protein and fat, as the product names.
KMR = Milk Matrix 42/25
Multi-milk = Milk Matrix 30/55
Esbilac = Milk Matrix 33/40

From personal experience, the Milk Matrix® line is easy to mix when the powder is added to cold water in equal parts and stirred in a "whisking" fashion .Then the additional water is added to the slurry and mixed completely. There are usually a lot of air bubbles right after mixing, but they dissipate within a few hours. The consistency is much thicker when the formula is cold, and thins out significantly when heated to 100°F. The formula must be refrigerated between feedings.

Many mammalian species lack the enzyme lactase which breaks down milk sugar (lactose) into glucose for absorption into the cells. Gas build-up in the gastrointestinal tract and diarrhea can result as the undigested sugar ferments in the small intestine. Species that have low carbohydrate levels in the maternal milk are generally considered lactose-sensitive or lactose-intolerant. Because commercial milk formulas made for domestic dogs and cats are generally higher in carbohydrates than the maternal milk of the species we're feeding, modifications to the diet are required to prevent digestive distress. Methods used to deal with this issue include:

1. Diluting the formula to reduce the amount of carbohydrates from being consumed
2. Including Multi-Milk® in the recipe to reduce the carbohydrate content
3. Adding lactase enzyme or lactose-eating bacteria (e.g. *Lactobacillus*) to the formula

<u>Growth rates in hand-reared cubs</u>

Hand-reared animals typically have a delayed growth rate compared to maternally-raised cubs. There are many factors which contribute to that.

1. Cubs receive maternal antibodies *in utero* (before birth), in the colostrum and in the milk. Mother-raised cubs receive considerably more passive immunity to a variety of pathogens than the hand-reared cubs.
2. Many times, hand-reared cubs are pulled because they are poor-doers and are nutritionally and/or immunologically compromised from the start, and simply don't have the ability to make up for lost time.
3. The hand-rearing formula, no matter how nutritionally sound it appears, is restricted to the nutrients in the powder mixes. As we learn more about nutritional idiosyncrasies of each species, we find that many times the form of protein, fat or carbohydrate in the artificial formula is not compatible with those in the maternal milk, and may not be as digestible. All we can do is our best with what we know at any given time. Over the years, milk formulas have improved vastly, and will no doubt continue to improve in the future.
4. Formulas given are not nutritionally balanced or are deficient in one or more major nutrients such as protein and fat. An average weight gain of approximately 5% body weight while on milk formula and 8-10% weight gains during the weaning process are the targets (Hedberg, 2002). There will always be some fluctuation where there may be a 2% gain one day and 8% the next. So the key is to see what the average is over a period of 3-5 days. If the cub is consistently maintaining weight for several days or only has slight gains, the formula composition and feeding schedule should be evaluated. Barring any health problems to explain a delayed growth rate in an individual, low weight gains are generally related to a diet that is not meeting the caloric and/or protein requirements.
5. Cubs that are weak may not have the energy to consume the target volume of formula at each feeding. In these cases, small, frequent feedings and the addition of LRS+ 2.5% dextrose given subcutaneously (SQ) may be more appropriate. Weak cubs may also take longer to transition onto the stock formula because of weakened organ function. Close monitoring of these cubs is warranted to ensure they begin gaining weight as soon as feasible, without stressing their immune system any more than necessary. Even in these cases, the cubs should ideally be on a formula at 80-90% full strength concentration within five days and possibly another two days to get to the full-strength stock formula. If diarrhea occurs when these cubs go onto the full-strength formula, they may do better on a 2:1 or 3:1 dilution (full-strength formula: water) as their stock formula.

Appendix 1: Calculated values for Kcal/day and ml/feeding

Weight	ME (Kcal/day) [70 x bw (kg)$^{.75}$ x 3]	ml/feeding (Stomach capacity)
450g. (15 oz.)	115 kcal/day	22.5 ml/feeding
500g.	125	25.0
550g.	134	27.5
600g. (20 oz.)	143	30.0 (1 oz.)
625g.	148	31.25
650g.	152	32.5
675g.	156	33.75
700g.	161	35.0
725g.	165	36.25
750g. (25 oz.)	169	37.5
775g.	173	38.75
800g.	178	40.0
825g.	182	41.25
850g.	186	42.5
900g. (30 oz.)	194	45.0 (1½ oz)
950g.	202	47.5
1.0 kg. (2.2 lb)	210	50.0
1.1 kg.	225	55.0
1.2 kg.	241	60.0 (2 oz.)
1.3 kg.	256	65.0
1.4 kg.	270	70.0
1.5 kg. (3.3 lb)	285	75.0 (2½ oz)
1.6 kg.	299	80.0
1.7 kg.	313	85.0
1.8 kg.	326	90.0 (3 oz.)
1.9 kg.	340	95.0
2.0 kg. (4.4 lb)	353	100
2.1 kg.	366	105 (3½ oz)
2.2 kg.	379	110
2.3 kg.	392	115
2.4 kg.	405	120 (4 oz.)
2.5 kg. (5.5 lb)	418	125
2.6 kg.	430	130
2.7 kg.	442	135 (4½ oz)
2.8 kg.	455	140
2.9 kg.	467	145
3.0 kg. (6.6 lb)	479	150 (5 oz.)

*A complete hand-rearing manual is available by request from the author at zoonutrition@msn.com.

Hand-rearing wild neonates is part "art" and part science. Over the years, neonate caretakers have given a variety of infant diets, some of which were nutritionally sound, and some were not. As our knowledge increases, so must the quality of the diet we provide. Many times animals "seem" to do fine on a particular milk formula, but when compared to maternally-raised infants are smaller and less robust. Because there are many individual idiosyncrasies of infants that contribute to the "art" of hand-rearing, providing diets that are the most nutritionally sound should contribute to the healthiest cub possible.

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Morbidity and Mortality in Hand Reared Cheetah Cubs

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Abstract
The mortality rate of artificially-reared cubs may be as high as 50% (Grisham, 1989; Kriek et al 1998) in some facilities. With only 20% of captive cheetahs known to reproduce (Marker-Kraus 1997) this mortality is a significant loss to the captive population. Noteworthy progress has been made since the earliest records of hand-rearing cheetahs, whereby mortality rates have been reduced from as high as 89% in the 1970's, to 37% in 1998 (CCF, 1998).

However, this figure is still high and evaluation of the major causes of death suggests a key role for husbandry and environmental factors in modern cub mortality. Congenital defects and stillbirths make up only a quarter of all cub deaths reported (CCF, 1998) whilst nutritional deficiencies, disease and infection, hypothermia and other husbandry-related events are among the remaining causes of death in cubs under the age of six months (CCF, 1998). Additionally, the role of management in so-called "natural" or "unavoidable" causes such as maternal abandonment and cannibalism, (accounting for 36% of deaths), must not be overlooked.

This paper does not purport to serve as a husbandry protocol (of which there are numerous), but instead examines the major problems reported during the hand-rearing of cheetah cubs. Review is made of the reported causes of morbidity and mortality among cheetah cubs, including congenital defects, nutritional deficiencies, gastrointestinal disturbances, immunological dysfunction, hypothermia and infectious pathogens. In association with recommended prophylactic schedules (i.e. vaccination and parasite control), appropriate sanitation, nutrition, careful monitoring of cub health and growth rate is likely to significantly improve cub survivorship.

Introduction
Cheetahs were first kept in captivity over 4000 years ago by the ancient Egyptians who used tame cheetahs as hunting companions and noble gifts (Hunter and Hamman, 2003). However, despite a long history of cheetahs in zoological facilities and private animal collections, it was not until 1956 that cheetahs were bred successfully in captivity (CCF, 1998). This litter did not survive past three days of age and although the earliest report of successfully hand-reared cheetah was from a European zoo in 1960, (Encke, 1960) it took another 10 years for the zoological community to report the successful rearing of a litter by its mother (CCF, 1998). Even today, only 15 - 20% of the captive cheetah population has reproduced, contributing significantly to the disproportionate genetic representation occurring within this population (CCF, 1998; Marker-Kraus, 1997; O'Brien et al, 1985).

Cubs are removed from their mother prior to weaning for a variety of reasons, including maternal neglect, injury, disease or for training/educational functions. Lombardi et al (2001) report that 75% of hand-reared cubs between 1964 and 2000 were removed due to illness or neglect, at an average age of seven days, and 24% of these cubs did not survive. The remaining 25% were healthy cubs, removed for educational purposes when much older (on average, 26 days) (Lombardi et al, 2001). It is not surprising that this latter proportion of cubs suffered a far lower mortality rate (4%) than cubs removed for medical reasons (Lombardi et al, 2001).

Infant Mortality
Neonates lack the reserves of adult animals and may show only slight changes in disposition prior to rapidly becoming moribund (Meier, 1986). The susceptibility of neonatal cheetahs is emphasized in the literature with infant mortality as high as 89% in the 1970's and 52% in the 1980's (CCF, 1998). With greater understanding of cheetah physiology, improved husbandry practices and increased inter-facility reporting, infant mortality rates among captive cheetahs have decreased significantly since then (CCF, 1998). However, the most recent statistics show that 36.7% of cheetahs still die before reaching adulthood and 23% of cubs die within their first year of life (CCF, 1998).

Causes of death are as varied as the reasons for removal from the mother, with nearly a quarter of cubs dying of unknown causes prior to 30 days of age (CCF, 1998). The difference between what may be termed "natural" deaths (i.e. congenital defects or stillbirths) and "environment-related" deaths (i.e. maternal neglect, cannibalism, nutritional deficiencies, exposure and trauma) is stark. O'Brien *et al* (1985) have suggested that genetic homozygosity is primarily responsible for high infant mortality rates in this species, although this conclusion has been strongly debated by other authors (Caro et al, 1987; Laurenson et al, 1995). Only 5% of deaths are due to congenital defects and 20% to stillbirths (CCF, 1998). However, as much as 51% of deaths were due to "environmental" causes (CCF, 1998) and the greater part of many medical conditions may be due to environmental and husbandry issues (McManamon, 1993). It is noted that maternal neglect and cannibalism may be considered as "natural" causes of death. However, the frequency of these mortalities in free-ranging, mother-reared litters is much lower than in captivity (8.2% and 17%, respectively, in the case of maternal neglect) (Caro, 1994; Laurenson, 1994). Maternal neglect is frequently associated with stress in both free-ranging and captive cheetahs (Caro, 1994; CCF, 1998; Laurenson, 1994). Captive females exposed to predator species within sight or smell of cubbing den, or housing with other conspecifics (specifically males) are more likely to abandon or cannibalize their cubs (CCF, 1998). These findings make it more likely that environmental, rather than innate, factors underpin these common causes of infant mortality in captivity. Nonetheless, environmental factors and genetics cannot be examined in isolation and large inter-facility variation in infant mortality may be the combined result of genetic lineages and husbandry factors (Marker-Kraus, 1997).

Marker-Kraus (1997) determined that the most vulnerable age for captive cheetahs is the period between birth and one month of age. The first six weeks of life are particularly important, as cubs are unable to efficiently thermo-regulate, are relatively immobile, unable to pass urine or feces without ano-genital stimulation, and commonly have an intestinal parasite burden after *in utero* transfer. Between 1956 and 1994, 21% of infant deaths were seen in cubs less than one month of age, and 28% in cubs less than six months of age, which is much higher than the values reported for other non-inbred zoo animals (Marker-Kraus, 1997). Yet, encouragingly, a recent survey of 15 North American facilities reported a mortality rate of only 19% in hand-reared cubs prior to three months of age (Lombardi et al, 2001).

A second period of susceptibility to disease may exist in captive situations for cubs between four to seven months of age. After four months of age, typical vaccination schedules should be completed and this may be the time that cubs are introduced into novel environments and therefore exposed to novel pathogens. Diarrhea is especially common in this age group (Caldwell, 2004). After approximately seven months of age, risk of infection appears to decrease as cub resistance matures.

Congenital defects
4.1% of free-ranging cubs deaths were recorded as due to the cubs being "unviable" (Caro, 1994), presumed to suffer some form of congenital defect, which is remarkably similar to the 5% reported in captivity (CCF, 1998). Failure of cubs to develop a suckling instinct may be indicative of central nervous system dysfunction, whilst palate deformities may also result in suckling difficulties (Weilemann, 1962). Milk seen expelled from the cubs' nose or mouth during suckling is often caused by cleft palate and the cub should be checked accordingly. Mother-reared cubs suffering congenital defects may be cannibalised prior to examination by zoological staff and as such the nature of many congenital defects is not described in the literature.

Nutritional Deficiencies
Nutritional deficits caused death in 7% of cubs born between 1829 and 1994 (CCF, 1998). Nutritional disorders are typically seen at approximately four to six months of age (i.e. the natural time of weaning) (CCF, 1998). One of the most common types of nutritional disorders is the imbalance of dietary calcium and phosphorus, commonly presenting as developmental bone malformation (osteodystrophy) due to insufficient supply of dietary calcium (CCF, 1998). Alternatively, excessive supplementation of calcium is known to contribute towards a developmental deformity of the forelegs (osteochondrosis dissecans), which is evident in forward bowing and outward turning of the paws, termed carpal valgus (CCF, 1998). The role of nutrition in metabolic bone disease is well covered in the literature. Investigation of the role of nutrition in carpal valgus of hand-reared cubs is currently underway by the author.

Post mortem examination of cubs at a South African facility suffering mortality rates in excess of 85% over a period of 18 months revealed clinical signs and lesions indicative of congenital vitamin E and selenium deficiency (Kriek et al, 1998). Concurrent *Salmonella* infections were deemed secondary in nature (Kriek et al, 1998), as it is likely that nutritional inadequacies rendered the animals' immune systems incapable of mounting sufficient defence against opportunistic parasites and pathogens.

Lethargy, ataxia and ventroflexion of the head are often seen in the critical stages of thiamine deficiency, whilst seizures and periods of tachycardia or bradycardia may also be exhibited (NRC, 1986). Although no dietary analyses were reported, the characteristic symptoms and response of surviving animals to parenterally administered thiamine led to the belief that thiamine deficiency was primarily responsible for a number of cheetah deaths at one Australian facility (Christie, 1997).

Hoff (1960) reports the occurrence of head tremors in hand-reared exotic felines between 10 – 20 days of age. Lateral head tremors in association with ataxia, partial collapse, loss of balance and a staggering gait are among the known symptoms of copper deficiency (CCF, 1998; Downes, 1997) and the condition has resulted in fatal respiratory distress in some cubs (Downes, 1997). Treatment with dietary copper is usually effective but chronic deficiency can render the effects permanent (CCF, 1998; Downes, 1997). Evaluation of chicken and guinea fowl carcasses demonstrated the greater copper content of the latter, suggestive of a wild-diet component capable of providing sufficient copper to growing cubs (Downes, 1997).

Exposure and Hypothermia
Abandoned cubs may be left outside of the den, where they are exposed to environmental elements and are at risk of pneumonia and hypothermia. Pneumonia is frequently reported as a major cause of neonatal death in North American facilities (Munson, 1993). Low body temperatures are often accompanied by low blood glucose (Reid and Meier, 1996). Although the central nervous system depends on glucose as its primary energy source, glucose requirements are reduced drastically during hypothermia (Reid and Meier, 1996). Sterile warm fluids administered per os and per rectum are efficient ways of raising the core body temperature, as well as stimulating gastrointestinal tract function (McManamon, 1993). However, during severe hypothermia, the gastrointestinal tract enzymatic systems function abnormally and as such hypothermic neonates should not be fed until core body temperature is returned to normal (Meier, 1986). In certain cases, bacterial overgrowth and bloat may result if milk formula or glucose is administered *per os,* whilst at best the formula is likely to be inadequately utilized by the cub (Meier, 1986).

Gastrointestinal Disturbance
Necrotizing enterocolitis, vomiting, ileus (gut stasis with bloat), severe parasite infestations and bacterial enteritis (e.g. salmonellosis) are the most serious of gastrointestinal disorders in neonates (Reid and Meier, 1996). Such problems can result in diarrhea, dehydration and electrolyte imbalances, all of which can quickly become fatal in young animals (Reid and Meier, 1996; CCF, 2000).

Diarrhea
Diarrhea represents one of the most common health problems in captive cheetah and is particularly prevalent in cubs under the age of seven months (Caldwell, 2004). Causes of diarrhea include ascarid infections, coccidiosis, giardia, trichomonas infection, dietary intolerance, environmental stress, enteric bacterial or viral infection, and lympho-plasmacytic enteritis (Caldwell, 2004). Identifying the cause of diarrhea, whilst treating the symptoms (i.e. fluid therapy), is an important step in treating diarrhea in cheetah (Caldwell, 2004).

Some commercial cat foods are known to result in chronic low grade diarrhea in cheetahs (Bell, 2004; Caldwell, 2004) and the addition of meat to these diets may see a return to normal stool consistency. If an animal's carbohydrate absorption ability is exceeded, the fermentative activity of gut enterobacteria upon the residue may result in osmotic diarrhea.

Often diagnosis of the cause of diarrhea can be made from dietary evaluation, fecal floatation for intestinal parasites, fecal smears and the nature of the stool (Caldwell, 2004). Diarrhea originating in the small intestine commonly presents as large amounts of liquid stool being passed infrequently, ranging from light orange to reddish in color (Caldwell, 2004). A red mucous may be present around the feces and initial segments of feces may be relatively well formed (Caldwell, 2004). Black tarry feces is indicative of hemorrhaging in the upper intestinal tract, since blood present in the small intestine will be digested as it passes along the gastrointestinal tract, giving the characteristic black color.

Large intestine disorders are less responsive to treatment and present as small amounts of liquid feces being passed frequently (Caldwell, 2004). Fresh (red) blood seen in the feces is indicative of hemorrhaging in the lower intestinal tract (e.g. colitis). Ultrasound, abdominal palpation and endoscopies or mucosal biopsies may be required to diagnose some causes of diarrhea. However, since these are invasive procedures, often requiring sedation, they are generally avoided due to the risks of sedation in young cubs (Caldwell, 2004).

Starvation for 12 – 24 hours is common practice and typically produces good results for diarrhea of large intestinal origin (Caldwell, 2004; McManamon, 1993; Schumann and Schumann, 1994; Reid and Meier, 1996). Alternatively, formula may be diluted with oral electrolyte solution and the total volume decreased by 20-40% for 8 – 12 hours if diarrhea is not severe or persistent (CCF, 1998). Dietary changes should be made gradually and food offered in small amounts frequently so as to prevent overburdening the gastrointestinal tract. Reasonable success has been seen with diets of raw and/or boiled chicken, as well as with formulas such as Iams® (Caldwell, 2004) or Hills Science Diet® Intestinal Diet© (pers. obs., 2004).

A variety of pharmaceuticals are available for the treatment of diarrhea in cheetahs. However, indiscriminate use of antibiotics should be avoided due to the risk of bacterial resistance and disruption to normal gastrointestinal microflora (Caldwell, 2004; van Zyl, pers. comm., 2004). Stool binding agents should be used with precaution whilst gut-lining pharmaceuticals may be advisable where risk of gastric ulceration is apparent. Cheetahs appear to have a similar intestinal microflora composition to the domestic cat (Caldwell, 2004) and as such the administration of commercially available pro-biotic preparations (e.g. *Lactobacillus* supplements) to promote regrowth of commensal gut bacteria may be beneficial during recovery (McManamon, 1993; Schumann and Schumann, 1994; Reid and Meier, 1996).

Dehydration and Electrolyte Imbalances
Electrolyte and fluid replacement is essential in treating cubs with gastrointestinal disturbances as cubs are especially prone to dehydration (Caldwell, 2004; Schumann and Schumann, 1994). Signs of dehydration include skin tenting, prolapse of the nictitating membrane (third eyelid), dull coat, and lethargy (Caldwell, 2004). Sodium deficits may cause convulsions, nausea, vomiting, anorexia, dehydration, and lethargy (Meier, 1986). Potassium deficits are also seen during illnesses involving vomiting or diarrhea and cause muscular, gastrointestinal and cardiovascular dysfunction (Meier, 1986). Conversely, excessive potassium induces symptoms such as restlessness, weakness and cardiac arrhythmias (Meier, 1986). Convulsions may also be due to calcium, glucose and/or magnesium deficiencies (Meier, 1986).

Internal Parasites
Internal parasites can cause diarrhea (CCF, 2000) and can be passed from mother to cub whilst *in utero*, via the milk or acquired soon after birth (Reid and Meier, 1996). Cubs may be infected with *Ascariasis* and *Ancylostomasis* before birth and typically exhibit symptoms such as weakness, poor weight gain, abdominal distension, dehydration, anaemia and bloody mucoid feces as early as three to four days of age (Meier, 1986). Whipworm infestations can be fatal and clinical symptoms of internal parasite infestations include loose, watery (sometimes bloody) feces, vomiting, anemia, fever, dehydration, weakness, inappetence, dullness and signs of abdominal pain (Reid and Meier, 1996). Tapeworm infections are not typically life-threatening. Diagnosis includes fecal examination and/or radiography (Reid and Meier, 1996).

Constipation
Young cubs require stimulation in order to defecate and urinate. Dietary changes, inappropriate stimulation or the ingestion of foreign material may cause constipation. Meconium (the first feces) can also cause constipation, bloat, inappetence, and abdominal distress if not passed (Reid and Meier, 1996). A warm enema can typically rectify the problem (Reid and Meier, 1996).

Intestinal blockages caused by a heavy worm burden are not uncommon in young animals. De-worming animals with a heavy parasite burden should aim to provide a graduated elimination of parasites. Large infestations that are treated with heavy doses of anti-helmintic drugs may cause intestinal obstructions as the parasites die off at the same time (van Zyl, pers. comm., 2004).

Immune System Dysfunction
Cubs may gain a degree of passive immunity by the transfer of maternal antibodies via the placenta but colostrum appears to be a more significant source of immunoglobulins (Meier, 1986). A neonatal intestine can absorb intact immunoglobulins for up to 36 hours after birth but after that the colostrum will have only local effects on the intestine (Reid and Meier, 1996). After this period, cubs are particularly vulnerable to bacterial, fungal and viral pathogens.

The thymus plays an important role in cell-mediated immunity through the maturation and release of large numbers of T-lymphocytes into circulation (Ross et al, 1995). The organ is particularly important in early life as the humoral immune system is developing. Premature thymic atrophy (PTA) has been observed in increasing frequency at a South African breeding facility (Caldwell, 2004). Since diagnosis is typically only made upon post-mortem after death due to apparently non-immune related causes, PTA may represent an, as yet, unidentified problem within other facilities around the world, where post-mortems are either not performed or the thymus was not examined.

Symptoms such as chronic watery diarrhea, wasting, vomition, suppurative pneumonia and perforating gastric ulcers have been seen in cubs that were later found to suffer from PTA (Caldwell, 2004). The cause of death in these specific cubs was peritonitis as a consequence of the perforated gastric ulcer (Caldwell, 2004). Although the gastrointestinal pathology in these cubs resulted in their deaths, the lack of functional immune system is likely to have played a significant role in the initiating pathogens successful infection, or alternatively may have mediated auto-immune mechanisms.

Diseases associated with immune suppression such as cadididasis, bacterial enteritis, pneumonia and pleuritis are also reported causes of morbidity and mortality amongst cheetah cubs (Lane, 2004). Hence, the role of immunosuppressive factors is deserving of further research and the involvement of dietary factors such as antioxidants, isoflavones and selenium in the functioning of the immune system should also be addressed. Isoflavone-induced perturbations in immunology are currently under investigation by the author.

A degree of passive immunity can be obtained from the administration of antibody-containing serum (collected from an immunocompetent, FIP and FIV negative animal) (CCF, 1998). Alternatively or in addition to this, homeopathic, nutritional (e.g. B-vitamin complexes) and herbal preparations (e.g. Moducare™ Plant Sterols) can be utilised to assist immune function (Hindmarch, B., pers. comm.).

Infectious Causes

Respiratory Infection

Young mammals must breathe through their noses when suckling and therefore, a respiratory infection can be life threatening; either causing dehydration and malnutrition or depriving the cub of oxygen and carbon dioxide exchange (Reid and Meier, 1996). Feline Upper Respiratory Disease (FURD) is a highly contagious viral disease, commonly referred to as 'cat flu'. Younger animals often show more marked symptoms including sneezing and nasal discharge, followed by anorexia, depression, fever and signs of nasal and ocular ulceration, hypersalivation and coughing (Reid and Meier, 1996; Simpson, 1996). Secondary bacterial infection causes thick mucopurulent ocular and nasal discharge, loss of olfaction and blocked nasal passages (Simpson, 1996). Diagnosis is based on clinical symptoms but the virus can be isolated from oropharyngeal swabs (Simpson, 1996). Treatment includes isolation and symptomatic relief, although many felines that recover from FURD become carriers of the disease (Simpson, 1996).

Protozoan and Bacterial Infections

All carnivores are susceptible to toxoplasmosis but it appears to be more common in felids (Meier, 1986). Symptoms do not always occur but may include anemia, retinitis, iritis, hepatitis, blindness, central nervous disorders, respiratory distress and diarrhea (Meier, 1986). Cubs with pre-existing conditions or under particular stress (e.g. worm burden, weaning) are most likely to show symptoms. Infection of felines may occur *in utero*, or from the ingestion of oocysts in contaminated feces or eating infected intermediate hosts e.g. mice or infected sheep meat (Meier, 1986). Toxoplasmosis is diagnosed through the presence of oocysts (fertilized cells of the protozoan) in feces and immunological tests. There is currently no satisfactory treatment for toxoplasmosis in felines.

Coccidiosis usually presents as marked diarrhea, particularly in young animals. Infection is often associated with stress and most typical in cubs between one to three months of age (Meier, 1986). Cubs with watery, mucoid or bloody diarrhea, dehydration and/or secondary bacterial infections should be evaluated for coccidiosis (Meier, 1986). Diagnosis is based on the presence of oocysts in the feces and treatment usually involves the use of anti-microbial drugs and re-hydration. Salmonellosis is commonly referred to as "food poisoning" and usually presents as vomiting, diarrhea and anorexia. Infection with *Salmonella* bacteria and toxins produced by such bacteria requires antibacterial drugs and symptomatic relief of dehydration associated with vomiting and diarrhea.

Septicemia may cause lethargy, jaundice (yellowing of the mucous membranes), weight loss, poor nursing, fever, hypothermia, irritability, increased respiratory rate, vomiting, diarrhea, and abdominal distention (Reid and Meier, 1996). Antibiotic therapy should be started immediately and bacterial culture/sensitivity tests are useful in determining the most effective antibiotic regime (Reid and Meier, 1996).

Omphalitis (umbilical infection) was the underlying cause in 1.4% of felid cubs that died at San Diego Zoological Park between 1964 and 1982 (Meier, 1986). Such infections may lead to renal, musculoskeletal and cardiac complications and prognosis for recovery is guarded if there is no rapid response to therapy (Reid and Meier, 1996). Redness, pain, swelling or discharge from the umbilical stump may appear as well as joint swelling and lameness (Reid and Meier, 1996). Local and systemic antibiotics are advised and sanitation must be of the highest standard (Reid and Meier, 1996).

Feline Panleukopenia

This highly infectious virus (a.k.a. feline infectious enteritis, feline distemper and feline parvovirus) has a high rate of infection and mortality, especially amongst young, unvaccinated animals. The disease may cause sudden death, depression, anorexia, persistent vomiting and painful palpation of abdomen (Simpson, 1996). Diarrhea may occur in the later stages and is usually yellow-brown liquid, possibly containing blood (Simpson, 1996). Diagnosis is based on vaccination status combined with clinical signs, hematological tests and detection of the virus in the feces (Simpson, 1996). Currently there is no treatment for the virus so therapy is supportive in nature (i.e. fluid therapy and broad spectrum antibiotics to prevent secondary bacterial infection) (Simpson, 1996).

Feline Infectious Peritonitis (FIP)

The corona virus responsible for this fatal disease is similar to that causing the commonly encountered enteric corona virus (Simpson, 1996). The virus is readily destroyed by most disinfectants and transmission is thought to generally occur through contact with infected feces or urine, rather than direct contact (Simpson, 1996). Early symptoms are often vague but may include fever, anorexia, weight loss and diarrhea. A prolapse of the nictitating membrane is also common, but symptoms soon progress to more specific signs (Simpson, 1996). Some cats are thought to be genetically predisposed to higher sensitivity to this disease than others. There are two forms of the disease and the more common, less severe of cases is termed effusive FIP where fluid accumulates in the abdomen (Simpson, 1996). Non-effusive FIP causes granulomatous lesions on abdominal organs and often results in organ failure (Simpson, 1996). Half of the cases with non-effusive FIP display central nervous signs and eye lesions may be associated with retinitis and uveitis (Simpson, 1996). The disease is difficult to interpret on serology and biopsy collection and histopathological examination of lesions is currently the only definitive diagnosis (Simpson, 1996). Prognosis is guarded and there is no specific treatment (Simpson, 1996). FIP is a significant cause of mortality in captive cheetahs worldwide.

Growth rates

Knowledge of normal growth curves in mother-reared cubs is critical to determining optimum growth in hand-reared cubs. Departure from normal growth rates may provide an early-warning system for the detection of medical problems in hand-reared cubs (Wack et al, 1991) and only small changes in weight may be significant (Meier, 1986). Recognition of potential medical problems provides the opportunity for earlier intervention, which is likely to decrease cub morbidity and mortality. Rough estimates of growth rates can be made from calculating the adult weight versus the infant weight and time taken to reach maturity (Reid and Meier, 1996). For the cheetah, this works out to be approximately 0.38kg weight gain per week (Average adult male weight taken as 40kg and average birth weight as 0.5kg).

An average growth rate of 40 – 50g/d, reported for hand-reared cubs (Pers. obs., Encke, 1960; Hall, N., pers. comm.; Lombardi et al, 2001) is consistent with the average growth rate observed in six mother-reared litters (21 cubs) at a North American facility (45g/d) (Wack et al 1991) (Fig. 1.). Whilst it may appear that no difference exists between mother-reared and hand-raised cubs (CCF, 1998; Lee, 1992) it is important to consider each individual animals' growth rate, rather than simply average growth rates for a litter or one cub over a long period of time.

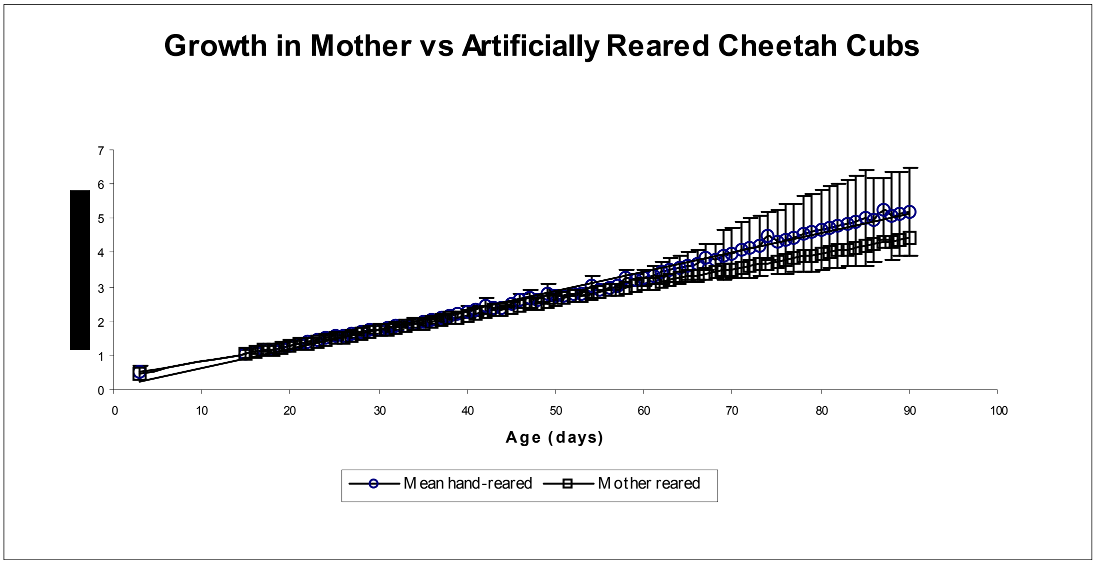

Figure 1. Growth rate of Cheetah Cubs reared artificially compared to mother-reared cubs
Hand-rearing data taken from Encke, 1960, Hall, N., pers., comm. (2004), Lombardi et al (2001), Schumann and Schumann (1994), pers. obs. (2004). Mother rearing data taken from Wack et al (1991).

Conclusion

Neonatal cheetahs removed from their mother due to illness or injury are at a weighty disadvantage, in terms of survivability, compared to healthy cubs removed for educational purposes. Even with access to specialist veterinary medicine, many cubs reach zoological nurseries in a severely moribund state, with little hope for survival. In order to reduce infant mortality rates in captive situations, focus must turn to the prevention and/or early detection of morbidity in cubs. Factors predisposing females to abandon, cannibalize or traumatize cubs must be identified and eliminated, or at least minimized. Litters born to females at risk of these behaviors should be considered for hand- rearing, prior to the onset of potentially fatal problems.

Vigilant monitoring of cubs, combined with careful management of the mothers' environment should promote recognition of initial warning signs of impending medical problems. Precipitating earlier intervention is likely to result in more rapid and effective responses than therapy initiated in the later stages of a disease process. Increased cub survival rates and reduced long-term consequences of morbidity during growth and development in cubs should be the priority when rearing cheetah in captivity.

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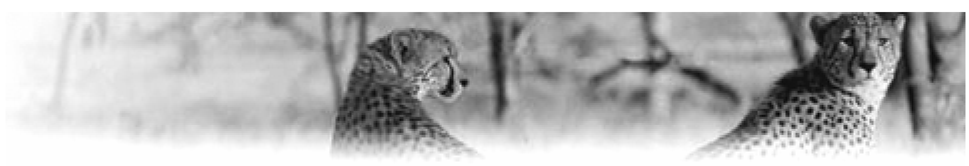

Hand-rearing cheetah (*Acinonyx jubatus*) cubs: milk additives

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The maternal milk composition of many wild animals is considerably lower in carbohydrates (lactose) than that found in the domestic counterparts. Milk powders manufactured for domestic animals are generally used as the base ingredient of milk formulas used in zoos and wildlife rehabilitation centers. Many times the milk formula provided contains a higher level of lactose than is found in the maternal milk. Mammals that do not have the lactose enzyme, lactase, have difficulty breaking down the milk sugar for digestion. The undigested particles ferment in the small intestine and allow for the proliferation of potentially pathogenic bacteria. The result is diarrhea and, in severe cases, enteritis (Evans, 1987).

The addition of specific products that either contain lactase or bacteria that produce lactase (e.g. *lactobacillus*) have been beneficial in assisting the neonate in digesting lactose in the milk formulas. This paper addresses several products available, which may be added to milk formulas, and describes their use and function as they relate to the hand-rearing of captive cheetah cubs.

Milk Additives

Lact-aid® is a product that contains the lactase enzyme. The dose is two drops to 100ml of formula. Lactase will begin breaking down the sugar in the formula and will be effective for 24 hours. Lact-aid® must be added to the formula 24 hours prior to offering it to the cub.

Simethicone is a de-foaming agent that reduces gas build-up in the intestinal tract, a symptom associated with the inability to break down lactose. But this product does not contain lactase, so it doesn't break down the milk sugar. Trade names for simethicone include Gas-X®, Mylicon® (pediatric formula) and Phazyme®.

Lactobacillus spp. is a group of bacteria that produce lactase and digest lactose. It is marketed as "*Acidophilus"* for humans and Probios® or Bene-bac® for animals. These bacteria live naturally in the gastrointestinal tract of mammals, and help maintain a healthy gut. They also help prevent the proliferation of pathogenic bacteria, such as *E.coli.* (Supplement Watch).

The maternal milk of cheetahs is comparatively low in carbohydrates. As an obligate carnivore, cheetahs obtain their energy source from proteins and fat, not carbohydrates (Bechert, et al., 2002). Diarrhea has been reported in *Panthera* spp. raised on milk formulas high in carbohydrates (Hedberg, 2002). It is a fair assumption that cheetahs also do not digest milk sugars efficiently. Therefore, it would be wise to add one or more products to assist in the breakdown of lactose to prevent gastric upsets, particularly in milk formulas that exceed 3.5% carbohydrates (14.8% DM). Lactaid® is commonly used prophylactically and is readily available. The main drawback of Lactaid® is that it must be added to the milk formula 24 hours in advance of feeding and refrigerated in order to be effective. But when used, it appears to be helpful in preventing the signs associated with lactose-intolerance.

Simethicone may be used to treat a cub with a distended "bloated" abdomen, or added to the formula to prevent the occurrence of a "gassy-stomach". The dose for rabbits with gastrointestinal stasis (ileus) is 67-133mg (1-2ml of pediatric formula) once an hour x 2-3 doses (Krempels, et al., 2000).

The addition of *Lactobacillus* spp. in conjunction with simethicone may be an effective alternative to Lact-aid®, if it is not available. It is unnecessary to add *Lactobacillus* spp. to the milk formula several hours in advance of feeding. The milk is mainly a vehicle for the bacteria to enter the digestive tract, where it will breakdown lactose into glucose and lactic acid, and the glucose is absorbed into the cells from the small intestine.

Probios®, a product manufactured for livestock, recommends a dose of 50 million bacteria (5 grams) for newborns of all sizes (lambs and calves). This product does contain vegetable oil (as the binding agent) and sucrose (in very small amounts). If given in too high of dose, it has the potential to loosen the stool, but may be helpful with cubs prone to constipation. The product comes in gel form and packaged in a calibrated syringe. The dose is squirted directly into the mouth of the animal.

Probios® is not required every day. The purpose of this product is to ensure there is an adequate population of lactose-consuming bacteria in the gut. They will be self-reproducing, so it is not required that they be completely replenished on a regular basis. A daily dose until the cub is on the full-strength stock milk formula may be advisable, and then every 2-3 days after that until the cub starts consuming solid food. Probios® can be discontinued during the weaning process, but given as needed if loose stool/diarrhea occurs.

Bene-bac® is a product similar to Probios®. It is manufactured by Pet Ag™ for birds and small animals. It comes in powder and gel forms. The powder form does not contain vegetable oil and may be added directly to the milk formula during preparation. Like Probios®, it also contains 10 million bacteria/g. Pet Ag's™ recommendation is to give it every two days from birth until seven days (or first week of hand-rearing) and then once a week until the introduction of solid foods. The dosing of *Lactobacillus* spp. bacteria is more about infusing an adequate number of bacteria into the gut rather than being weight-related, so the product recommendations should be considered reasonable guidelines ---- more is not necessarily better.

Acidophilus comes in tablet form and may be crushed and added to the milk formula. The dose for humans (adults and children) is one tablet (1 billion bacteria). From personal experience, I have given small mammals (rodents and rabbits) *acidophilus* at the rate of ½ - 1 tablet in a batch of formula which lasts 2-3 days and have had no ill effects from that dose. As a general guideline, one-half tablet/cub/day may be adequate. *Acidophilus* works the same way as Probios® and Bene-bac®. It is just another form, and does not contain vegetable oil or sucrose.

The addition of products that reduce the effects of lactase in lactose-sensitive or -intolerant species may be a beneficial component of the hand-rearing formula. There are a variety of products, each which have pros and cons attached to them. Each individual facility should consider their particular protocol when deciding which product will provide the most benefit to the animals, and then use it consistently to maximize its effects.

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*A complete hand-rearing manual is available by request from the author at zoonutrition@msn.com. and will be sent as an electronic document (MS Word).

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Hand-rearing cheetah *(Acinonyx jubatus)* cubs: weaning diet

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There are many different viewpoints regarding when and how to initiate the weaning process in exotic felids. The Felid TAG recommends adding chicken or turkey baby food to the milk formula at 4 weeks of age with small felids. Various zoo facilities recommend weaning when the cubs show interest in solid food. Gittleman and Oftedal (1987) indicated cheetahs first consumed solid food at 33 days of age and weighed 1.94 kg (4.27 lbs.)

As the cubs begin consuming solid foods in a measurable amount, the volume of formula can be reduced proportionately. Many times cubs will take the bottle at some feedings but refuse it at others. Eliminating specific feedings rather than reducing the volume at each feeding allow the cubs to get hungry enough to explore other food options available, such as a bowl of meat.

It is important to weigh cubs every 1-2 days to monitor weight fluctuations during the early stage of the weaning process, especially when multiple cubs are fed together. It is common for different levels of food consumption to occur amongst individuals in a litter. You may be providing an appropriate amount of food to feed four cubs, but two cubs are eating 60-80% of the food. Monitoring the weight will help caretakers determine if all cubs are consuming appropriate amounts of the weaning diet. Another clue that a cub may not be progressing in the weaning process is that it always seems very hungry at each bottle feeding compared to the littermates. In this case, adding pureed meat to the formula for that cub, or separating it to feed from its own dish will ensure the cub gets it share.

At this point, there are no nutrient requirements established by the NRC specifically for cheetahs. Therefore, until more specific data becomes available, the domestic cat is used as the reference model on which the cheetah requirements are based. Slab meat diets typically provide much higher levels of protein than the domestic cat requirement. The cat requirements are generally considered minimum requirements, and are used as a guideline until further research on cheetah nutritional requirements become available.

Table 4: Minimum nutrient requirements for domestic kittens. (DM basis) NRC (1986).

Crude protein = 24%	Zinc = $\leq$ 50mg/kg DM
Crude fat = 9%	Niacin = 40mg/kg DM
Calcium = 0.8% DM	Taurine = 400mg/kg DM
Phosphorus = 0.6% DM	Vitamin A = 3333 IU/kg DM
Magnesium = 0.04% DM	Vitamin D = 500 IU/kg DM
Iron = 80 mg/kg DM	Vitamin E = 30 mg/kg DM
Copper = 5 mg/kg DM	

Appropriate foods for weaning diet

Poultry-based human baby foods (chicken and turkey) are commonly used at the initial stage of weaning. The baby food is gradually added to the formula or placed in a shallow bowl with warmed formula poured over it to entice the cubs. Small amounts of baby food are provided at each feeding, and increased daily as long as the stool appears normal (Felid TAG). This is a common weaning strategy for small exotic cats. It may not be practical with the larger species, including cheetah, except in specific cases involving "poor-doers" or runts of the litter that need special attention and have chronic digestive problems. Chicken baby food has been beneficial in keeping the stool firm, whereas beef baby food is preferable in cubs prone to constipation (Felid TAG).

Poultry has the added benefit in that it is a good source of taurine, an essential amino acid in felids. The requirement for domestic kittens is 400mg/kg DM (NRC, 1986). Uncooked chicken muscle contains, on average, 991 mg/kg DM taurine. Cooking reduces the taurine concentration somewhat (NRC, 1986). However, the Felid TAG recommends cooking chicken prior to feeding to kill *Salmonella*, which can cause diarrhea.

Commercial feline diets for domestic kittens, ZuPreem™ and Nebraska Brand™ feline diets may be offered in a bowl with warmed milk formula poured on top, to entice exploration. As cubs start consuming the diet in measurable amounts, the addition of milk formula to the bowl may be discontinued.

Zoo facilities that feed slab meat to adult cheetahs may prefer to wean cubs onto a meat diet comparable to that of the adults. Muscle meat is low in calcium and high in phosphorus. See table 5 for a comparison of muscle meats and whole prey items. Chicken muscle meat has a 1:21 ratio of calcium: phosphorus, whereas whole chicken has a Ca:P of 1:1 (USDA, 2004).

Table 5: Comparison of muscle meat, organ meat and whole body prey. Values are on DM basis. Dierenfeld, et al (2002)[1]; USDA, (2004)[2]; Ullrey and Bernard, (1989)[3]

Meat	CP %	Fat %	Ca %	P %	Mg %	Fe mg/kg	Cu mg/kg	Zn mg/kg	Vit A IU/kg	Vit E IU/kg	Kcal/kg
Chicken, whole[1]	42.3	37.8	1.68	1.3	0.09	40	3.0	45	35600	51.3	5900
Chicken,muscle[2] meat only	77.5	22.9	0.04	0.76	0.07	39.6	3.2	50.9	3818	8.7	5382
Chicken heart[2]	58.9	35.1	0.05	0.68	0.06	225	13.1	249	1132	0	5774
Chicken liver[2]	72.3	20.4	0.03	1.26	0.08	383	20.9	114	471404	29.8	5064
Horse, meat only[3]	76	18	0.05	0.34	0.05	232	3.0	128	2593	0	n/a
Cow, meat only[3]	63	29	0.03	0.55	0.06	78	2.0	106	1428	3	n/a
Deer, meat only[3]	65	29	0.03	0.59	0.06	165	5.0	68	0	0	n/a
Rabbit, whole[1]	63.5	15.3	2.35	1.68	0.16	302	16	86	6200	16.2-60	5410
Rabbit, meat only[2]	74	20.7	0.05	0.8	0.07	58.2	5.37	58.2	0	0	1360
Rat, whole (≥50g.)[1]	61.8	32.6	3.45	1.91	0.15	195	7.5	92.1	35600	139	6370
Quail, whole body[1] (*Coturnix coturnix*)	71.5	31.9	3.43	n/a	0.06	74.9	2.6	53.0	70294	66.8	6790

n/a = data not available

Muscle meat and whole animals (birds, rats, rabbits) stripped of fur, tail, head, feet, beak, etc. can be ground up and provided in small amounts in a bowl with warmed formula poured on top at the initiation of the weaning process. Rabbits that were fed nutritionally balanced diets during their lives are considered a "complete food" in that it meets or exceeds the basic dietary nutrients of a kitten without the addition of vitamin or mineral supplements. This is with the assumption that the cub consumes the meat, bone and viscera (except stomach and intestine). Rabbit is generally accepted by cheetahs since it is similar to one of the wild cheetah's natural prey (springhare).

Vitamin A

Pre-formed vitamin A is an essential nutrient for felids, so must be provided in the diet (Irlbeck, 1996). However, as a fat-soluble vitamin, it is stored in the body, so it is not required on a daily basis. It is important not to provide excessively more than the requirement since it can accumulate in the body to toxic levels. In growing animals, vitamin A toxicity is associated with skeletal malformations and fractures, internal hemorrhage, enteritis, conjunctivitis, and reduced function of liver and kidneys (McDowell, 2000; Robbins, 1993).

In rabbits, vitamin A is contained in the organs, particularly the liver. While cubs are still consuming milk formula, additional vitamin A is generally not required (depending on the nutrient composition of the formula), so organ meat should not be provided at this stage. However, after completely weaned onto solid food, cubs must consume the liver of rabbits to meet the vitamin A requirement, if vitamin supplements or other food items high in vitamin A are not provided.

Vitamin A is relatively high in whole chicken, rat and quail, and in chicken liver. The whole animals exceed the kitten requirement by 11-21 times, and chicken liver exceeds it by 141 times, by weight (NRC, 1986). If these food items are frequently included in the weaning diet, a vitamin supplement containing vitamin A should not be provided. In addition, combining a diet of one or more of these items with another food item low in vitamin A, such as chicken meat, chicken heart and rabbit muscle meat will help offset the excess. On an "as fed" basis, one ounce (30 g.) of chicken liver provides the daily vitamin A requirement for domestic kittens.

Vitamin D

Natural sources of vitamin D are available in two forms - D_3 which is synthesized in the skin of animals with exposure to sunlight, and D_2, which occurs mainly in plant matter. Most carnivores are able to utilize both D_2 and D_3, although lions and tigers preferentially utilize D_3 (Robbins, 1993). It is unknown as to whether or not this is also the case with cheetahs. Vitamin D is not present in the milk of most mammals, with the noted exception of polar bears (Kenny, et al, 1999). Maternally-raised captive cheetah cubs have reportedly left the lair, for short periods, at 28-38 days of age (Stoeger-Horwath and Schwammer, 2003; personal observation). This may be the point at which cubs require a source of vitamin D_3.

Milk formulas based on KMR™ or Esbilac™ contain vitamin D_3 at levels which meet or exceed the domestic kitten requirement. As long as cubs are consuming the milk formula, D_3 supplementation is not required. In order to maintain proper bone growth, cubs that are weaned off formula at an early age may require access to sunlight (or indoor UV-B light) or a D_3 supplement if their diet contains less than 500 IU/kg DM of D_3.

Calcium and phosphorus

Whole rabbit, rat and chicken provide a balanced Ca:P ratio of 1.4:1 – 1.8:1. All other food items (muscle meat, liver and heart) have a skewed Ca:P ratio in favor of phosphorus. Not only do felids require an absolute amount of calcium and phosphorus (0.8 and 0.6% of the diet, respectively), but they also require a balanced ratio between the two minerals to promote proper calcium absorption. Ca: P ratios of 1:1 to 2:1 are the recommendations for growing infants. (Trendler, 1997). Grinding the skeleton of rats, rabbits and/or chickens and including them in the meat diet will provide a good source of calcium. Grinding must be thorough and large pieces of bone and sharp bone shards are removed before feeding. Cartilage, tendons and ligaments may be offered as a source of fiber.

Meat diets that do not contain bone require the addition of a calcium supplement. Table 6 compares various forms of calcium. It should be noted that supplements can not all be used interchangeably since they have different concentrations of minerals. In addition, calcium may have different absorption rates, depending on the form it's in. Limestone is the least available source of calcium, whereas calcium phosphate and bone meal are more readily absorbed into the body (E. Dierenfeld, pers. com). When adding a calcium supplement, it is important to provide only enough to balance the diet. Too much calcium can be as detrimental as not enough in growing animals. Excess calcium in the diet has been linked to osteochondrosis, enlarged joints, splayed feet, angular limb deformities and stunted growth (Hazewinkel, et al, 1985; Hedhammer, et al, 1974).

Table 6: comparison of calcium supplements. Values on DM basis. Kellems and Church (2002)

Supplement	DM%	CP%	Ca%	P%	Mg%	Cu mg/kg	Fe mg/kg	Zn mg/kg
Bone meal, steamed	97	13.2	30.7	12.9	0.3	-----	26700	100
Calcium carbonate	100	-----	39.4	0.04	0.05	-----	300	----
Dicalcium phosphate (Dical™)	97	-----	22.0	19.3	0.6	10	14400	100
Limestone, ground	100	-----	34.0	0.02	2.1	-----	3500	-----

DM= dry matter, CP= crude protein, Ca= calcium, P= phosphorus, Mg = magnesium,
Cu = copper, Fe = iron, Zn = zinc

As cubs continue to consume more and more of the meat diet, eliminate formula feedings from the daily schedule, one at a time. Late night feedings can be dropped first, if a bowl of food is provided to allow for self-feeding. The a.m. formula feeding should be the last bottle feeding dropped from the schedule, and may be eliminated by 5 weeks of age, in most cases. Continue offering warmed formula in a bowl with the solid feline diet. Complete weaning from formula should occur within 10 weeks of age, but cubs will probably lose interest in the formula before then.

Cubs that are weaned onto a slab meat diet may not require a vitamin supplement while they continue to consume formula, if the meat portion of the diet is a combination of chicken meat, whole chicken and rabbit. They will, however, require a calcium/iron supplement if meat only (no bone) is offered. A taurine supplement may be warranted if red meat is offered instead of chicken. Table 7 is an analysis of a diet composed of equal parts of milk formula and chicken meat for a 3.0 kg (6.6 lb) cub.

Table 7: Nutrient analysis of a weaning diet, combining chicken meat and milk formula.

Food Item	CP %	Fat %	Ca %	P %	Mg %	Fe mg	Vit A IU	Vit D IU	Vit E mg	Kcal
Chicken meat, 175g 48g DM	38.8	11.5	0.02	0.4	0.04	1.8	172	0	0.4	265.5
Milk Formula, 180ml 40 g. DM	19.9	21.2	0.7	0.5	0.04	3.1	4473	361	9.1	227.0
Calcium carbon-ate 1g.	-----	-----	0.4	-----	-----	0.3	-----	-----	----	------
Limestone, 1g.	-----	----	0.3	------	0.02	3.5	-----	-----	-----	------
Total	58.7	32.7	1.42	0.9	0.10	8.7	4645	361	9.5	492.5
Requirement	24-40	$\leq$ 40	0.8	0.6	0.08	7.0	290	43.5	2.6	479
Difference	HIGH	OK	OK	OK	OK	OK	HIGH	HIGH	HIGH	OK

The analysis indicates that the milk formula contains an excess of fat-soluble vitamins, so should not be supplemented in the chicken meat. This diet is, however, deficient in calcium and iron unless a supplement is provided. A combination of calcium carbonate and limestone is used to provide an adequate level of iron. Calcium carbonate, while a good source of calcium, is quite low in iron. Limestone, which is a lower quality calcium source, contains ten times the amount of iron as calcium carbonate. The combination of the two supplements provides the necessary concentrations of both minerals. The diet, with supplements, provides a Ca: P ratio of 1.6:1, which is optimal.

The protein concentration of the diet is higher than the NRC requirement. But healthy captive cheetahs typically consume a diet very high in protein, and will continue to consume protein in excess of 50% of the diet in adulthood. The one concern with growing cubs is that they will grow at a faster rate than recommended (8-10% body wt/day). Fast growth rates are associated with abnormal bone growth and deformities (Irlbeck, 1996). During the weaning process, the protein content of the diet may be reduced, if necessary, by mixing the slab meat diet with a commercial feline diet, such as ZuPreem™ or Nebraska Brand™, which contain 43 and 47% CP, respectively (on DM basis).

In general, animals feed to meet their energy needs. Felids metabolize protein and fat for their energy needs (Bechert et al., 2002). Cubs consuming high protein diets may consume fewer calories than expected, based on the maintenance energy requirement (MER). Cubs that maintain an average daily gain (ADG) of 8-10% are meeting their nutritional needs on more nutrient-dense diets. If feasible, continue weighing cubs, at one week intervals, as long as possible until weaned to ensure there is consistent growth.

The crude fat requirement for kittens has not been established by the NRC. For this example, since the cub is still consuming formula, the 40% fat content of formula was used as the maximum. Bechert, et al (2002) indicated a low protein: fat ratio (2:1 to 3:1) was consistent with that found in whole prey and was preferable to higher ratios. The protein: fat ratio of this diet is 1.8:1, which may be appropriate for growing animals.

The high levels of fat-soluble vitamins can not be lowered significantly while cubs are on the milk formula. The high level of vitamin E is actually beneficial in lowering the absorption rate of vitamin A. But it is important to note that the fat-soluble vitamins should not be supplemented until cubs are weaned off the formula, since more than enough is provided. Additionally, liver should not be included in the diet until cubs are weaned off milk formula completely. It should be noted that the milk formula used in this example is the KMR formula in table 3a. Different formulas, especially those that are less nutrient dense, will have a different nutritional analysis, and may be deficient in some nutrients. The purpose of this example is to show that it is important to know the nutrient composition of the diet prior to adding supplements, and to add only those that are required.

PRODUCT LIST

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* A complete cheetah hand-rearing manual is available by request of the author at zoonutrition@msn.com. Copies are provided as electronic documents (MS Word).

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**Summary of Infant Hand-rearing – Cindy Lamneck, Keeper, Columbus Zoo and Aquarium
August 2005**

The first step is to check for dehydration and hypothermia, then weigh infant to determine what course of action to take with formula. Infant needs to be warm and hydrated then begin to offer diluted formula, gradually increasing the amount of formula until you reach full strength. Lactated ringer, pedialyte, sterilized water are some examples of liquids that can be used to dilute formula.
Percentage of formula to body weight varies with species so I generally start with 10%, research and later increase. Record feeding time, formula, introduced solids and intake. Weigh infant daily to determine when to increase formula. Initially temperature, respiration and heart rate are recorded at each feeding. As the infant gets older, stronger and begins to thermo-regulate, then record temperature once daily, less often if it causes unnecessary stress. Ambient temperature is noted. Record how often the infant stools (include consistency), urinates and whether stimulation is needed. Medical records are noted (i.e. physicals, vaccines, medications, signs of illness, etc.). A comment section is helpful for notations such as whether the infant is defecating and urinating on own, appetite, milestones, etc. Amount of formula, range of temperature/ respiration/ heart rate, and the number of times the infant stools and urinates are totaled at the end of the day.

WHITE OAK CONSERVATION CENTER

HAND REARING PROTOCOL FOR CHEETAHS
October 2008

The following are guidelines for hand rearing cheetahs. Cleanliness, temperatures and first bottles are to be followed as stated below but when making changes in % body weight feed, timing for changes of bottles/day, adding solid foods must all be dependent on the health and growth of each individual cub.

1. Always wash hands with Nolvasan scrub solution prior to handling cubs. A foot dip should be used prior to entering nursery area and a clean smock, worn only in the nursery, provided for all personnel. Personnel should be limited to only those necessary.

2. The neonatal exam should include a body temperature (normal range 98-100°F) and a weight (normal range 350-500g). An iodine-based solution should be applied to the umbilical cord.

3. Place cubs in disinfected incubator (85-90°F) or into a clean box or playpen lined with towels over a heating pad and an adjustable heat lamp above. Container will depend on number of kittens presented. Box and playpen work well if cubs and container are closely monitored for correct temperature.

4. Use clean bottles and nipples for every feeding. Used bottles must be disinfected and rinsed well & every two weeks they should be sterilized (autoclaved). Small blue preemie nipples work well initially. Later the soft, red, regular-sized preemie nipples may be used.

5. At all times a bottle is offered ONLY if the kitten is stable, alert and responsive. First feeding will be Pedialyte or 5% dextrose in water. This is the time when the suckle response will be evaluated. If there is a strong suckle response the next feeding will be 25:75% Liquid KMR and Pedialyte. There should be at least 3 feedings at this strength before increasing to 50:50. 50:50 should be fed a minimum of 48 hours prior to increasing to 75:25. Digestive problems with KMR have occurred in cheetah cubs so each concentration change requires that cubs are monitored prior to the next increase. If diarrhea occurs, change concentration to previous % until manager or vet is consulted. Liquid KMR is preferable to powder but still presents problems so each cub should be monitored closely with regard to curds forming in the stomach. Lact-Aid should be added to the KMR (2 drops/100 ml) 24 hours prior to feeding.

6. Amount of formula per feeding should be determined by cubs weight. Initially, start with feeding 12% of the body weight divided by the number of feedings per day. If there are no problems, increases to 15% can be made gradually, and a second increase to 20% can be made gradually (although increases rarely exceed 18% BW), maintaining a 5% average daily body weight increase. All increases will be approved by the manager or veterinarian. Usually, concentration changes are made on one day and increases of % BW fed changed the next to avoid too many changes occurring simultaneously. Feedings of greater than 20% tends to contribute to loose stools and other secondary digestive problems. Cub's weight should be taken at the same time each day (stimulation for urine and feces prior to weighing) to determine if amount and strength of formula is adequate (should see an approx. 5% gain/day). If cubs are extremely hungry, in the past it has been acceptable to increase the amount given per feeding by adding Pedialyte up to 20%. Only add Pedialyte with consent of vet or manager. When cubs are still being fed less than 100% KMR, cubs may be hungry, remember that hungry is ok as long as the cub settles after a while but caution needs to be taken not to increase the amount or concentration too quickly.

7. Recommended feeding schedule:

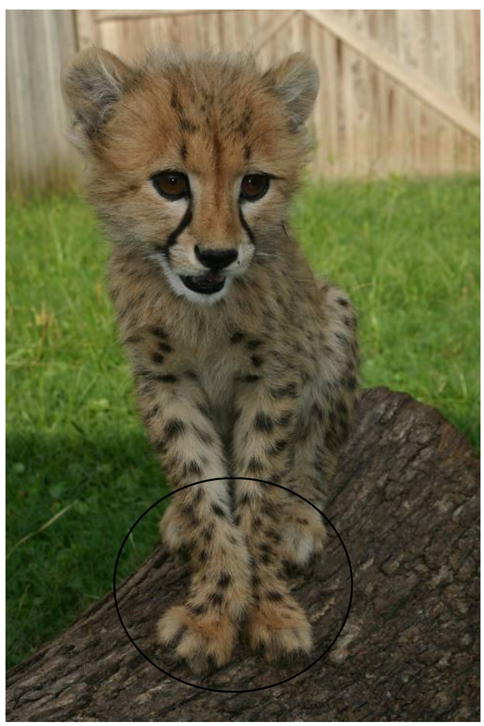
Week 1 & 2 - 9 x /day
Week 3 - 8 x /day
Week 4 - 6-7 x /day Introduce strained chicken or beef baby food – either alone or in formula. Adding to formula adds calories and helps cubs feel more satisfied without adding volume as the number of feedings decrease.
Week 5 - 5 bottles/day decreasing to 3 bottles/day by the end of the week. Continue weaning onto baby food and carnivore diet (Toronto & Natural Balance diet). When meat is first added to the diet, meat should be cooked thoroughly to minimize salmonella exposure. Meat will be cooked 100% for 3 days, 75% for 3 days, 50% for 3 days, then raw meat will be fed. Cubs should be weaned off the KMR by 6 weeks but each kitten will be evaluated by the Nursery Manager and Veterinarian.
Week 6 - Carnivore diet 5 x /day. And so on....

8. Vaccination schedule: 6-7 weeks, 9-10 weeks, 12-13 weeks; Felovax IV
15-16 weeks, 6 months, 1 year: Felovax IV + Merial Purevax Rabies

9. Vitamin supplement: if the kitten can tolerate it, Poly-Vi-Sol can be given once a day after the first week or so.

10. Colostrum-deprived cheetah kittens present a particular challenge and should be handled with great attention to cleanliness. Additionally, plasma should be administered as prescribed by the veterinarian for added protection.

This stuffed ‘momma cheetah’ (nipples are filled with cotton and sewed into the stuffed animals belly) was designed for this singleton cub that we planned on cross fostering to another litter that was expected a week later. This kept the cub in practice of ‘searching’ for nipples for when he was put with his new mom eight days later. This was a successful cross fostering. “Momma cheetah’ has been used with other hand reared litters and has helped minimize cubs sucking on each other and providing them comfort.



Several cubs have developed varying degrees of carpal valgus deformities when hand reared.
These are likely a nutritional problem associated with commercial kitten milk replacers. Early addition of meat to the diet and sufficient exercise will reduce the severity of this problem and allow self-correction.
(See medical section for more information)

Zoological Society of San Diego
Primate Nursery
(619) 685-3233

GUIDELINES/SPECIFIC CONCERNS for HAND REARING CARNIVORES

<u>Introduction</u>: When the decision is made to hand rear a carnivore, there are special challenges and concerns specific to this group of animals which must be addressed. The purpose of this document is to identify some of these concerns. Whenever possible, it is essential to prepare equipment, personnel and supplies prior to hand rearing need. A suitable nursery site needs to be identified and prepared, as well as stocked with equipment and materials such as milk substitutes, bottles, nipples, incubators, and bedding well in advance of the implementation of hand rearing efforts.

<u>Development of a Care Plan for Nursery Carnivores</u>: Research and development of a care plan for each animal to be hand reared is recommended. A care plan provides the framework to implement organized, careful management of the specimens. The plan should include reliable information on diet, how the animals will be housed, a weaning schedule, a personnel scheduling outline, transitional diets and health concerns which may be known. This plan should be considered a guideline, rather than an absolute since each hand reared individual will be different. Variable factors including, but not limited to, general health, appetite, vitality, weight gain can affect all management procedures ultimately used.

<u>Admission procedures</u>: A thorough examination should be conducted on all specimens upon arrival. The umbilical cord should be ligated as necessary. A mild tincture of iodine (2%) should be applied to the cord stump and continued until the entire stump has dried or fallen off. A veterinarian should evaluate general health status since poor early nutrition and hypothermia, as examples, can lead to sepsis. If an arriving neonate has low body temperature never plunge it into warm water in order to raise its temperature. Instead place it in an incubator set at 88-90 degrees F. Oral fluids should not be offered to the neonate until a normal or near normal body temperature has been restored.

<u>Clip Claws</u>: Upon arrival and at subsequent regular intervals, the claws of neonates should be clipped. Long curved or sharp claws can become entangled in bedding or cage furniture resulting in spiral bone fractures. A small human or dog nail clipper can be used. On larger species or as neonates increase in size a rotary dremel may become useful in managing claw length. When shortening claws, caution must be used to avoid the claws' blood supply. Any rough edges can be filed smooth using an emery board.

<u>Bedding</u>: Routine, regular checks made on all bedding and furniture items (blankets, towels, surrogates etc.) will eliminate potential hazards. Strings, or small holes in the bedding can contribute to serious injury. Animals can entangle themselves in small holes or on frayed edges of blankets while they root and search for the nipple. Strangulation and death may resulted. Any bedding with holes, frayed edges or strings should be repaired or replaced.

<u>Mark Litters for Easy Identification</u>: When litters of two or more are being hand reared, individuals should be marked so that they can be easily distinguished from each other. Marking individuals will eliminate confusion and makes feeding and record keeping easier and more accurate. Marking can be safely and easily accomplished by using a livestock marker. (A non-toxic beeswax product which clings to the fur) A small dot of color is applied on a visible part of the body such as a tail tip, ear tip or top of head. Re-application of the marker is periodically necessary as the product wears off.

Enrichment: Throughout the neonatal period it is important to provide a nursery reared animal with sufficient age appropriate enrichment. Initially, a suitable surrogate should be provided to simulate the maternal body. A stuffed animal works well, but any surrogate should be selected with the following criteria in mind: durable fake fur that is not easily pulled free and ingested, there should be no buttons, strings or other ornamentation that might be pulled free, and the surrogate should be completely machine washable. In addition to a surrogate, the neonate requires soft bedding and a hot water bottle wrapped in a blanket. Appropriate care should be taken to eliminate the possibility of suffocation as a result of the neonate rooting under the hot water bottle.
When the animal is moved from the incubator environment to a larger space, a soft "nest" should be provided. This "nest" can be a commercially available pet bed made of fake fur and stuffed with batting material. As the animal becomes more capable of moving about and it begins to explore its environment, a selection of suitable toys should be provided. Toys should be routinely inspected for safety and rotated to provide variety and novelty. Browse, wood and live items also make good enrichment items, provided they are sanitary and can not be ingested by the neonate. Toys for young carnivores should be removed if they are being chewed and ingested. Adequate space for exercise, and exposure to sunshine are equally important.

Nipple Holes: After the initial bottle adaptation process, carnivores are usually vigorous when nursing from a bottle. If the hole in the nipple is too large, they can easily suckle formula too quickly and inhale the milk into the lungs which may result in a serious and often fatal condition called aspiration pneumonia. Nipple holes should be drilled into the latex to let the milk formula pass through slowly. The procedure for making a hole in a latex nipple is as follows: heat a fine (26g) needle over a hot flame from a gas stove or Bunsen burner until red hot. Puncture the needle through the latex rubber of the nipple to form a small hole. If a slightly larger hole is required, the hot needle can be agitated gently to enlarge the hole, or a slightly larger diameter needle (25g) needle can be used. The rate of flow is difficult to gage as the neonate needs to consume it quickly enough not to become frustrated, yet slowly enough to avoid aspiration. Careful trial and error using several nipples may be necessary. When the need arises to enlarge a nipple hole, it should be done slowly and incrementally. Each enlargement should be only slightly larger than the hole previously used.

Feeding Position: The neonate should be fed when it is in a sternal recumbency position with the head elevated. Sparsely furred neonates should be fed in a warm room free of drafts and returned to the incubator promptly to avoid chilling. Formula is offered at or near the body temperature of the neonate. Warming techniques are important to avoid thermal burns. Heating formula in a microwave is not encouraged since unequal heating may create hot spots in the formula. The bottled milk should be warmed by placing it in a small receptacle containing warm water. Shake the bottle well to mix and equalize the temperature of the formula before offering the bottle. This is very important if the bottled formula had to be heated in a microwave.

Provide Manual Stimulation: Manual relief for urination and defecation must be provided at each feeding. There are two simple and effective methods for manual relief: The first is to prepare a warm rag or cotton compress and provide direct stimulation around the genital area. Be sure to select a soft cloth and use a gentle touch since anal and genital tissues are sensitive and can become abraded. Use only mildly warm water to prevent thermal burns. The second method is to provide manual stimulation under running warm water from a water faucet. Hold the neonate under the faucet allowing the water to flow over the anal-genital region while massaging with your fingers. When using either method, apply stimulation until the neonate is no longer straining. Manual stimulation is routinely continued until the neonate is reliably urinating and defecating on it's own. At that time, a litter box can be offered to help keep the enclosure clean.

Begin Vaccinations at Appropriate Times: Contact your veterinarian to set up a vaccination schedule for each nursery raised carnivore. In addition to vaccinations, regular fecal checks are important to detect the presence of enteric infections and parasites. Adhere to flea treatment recommendations made by your veterinarian once the animal is exposed to areas where flea infestation is possible.

Overfeeding: Overfeeding is perhaps the most significant risk when hand rearing carnivores. Many neonatal carnivores will nurse vigorously and continue to suckle even after ingesting what they require. Since they may not show signs of satiation it is easy to overfeed a young carnivore if one gauges the amount of food offered only by the animal's appetite or nursing enthusiasm. It is, therefore, prudent to calculate an appropriate amount of formula to be offered during a feeding, and not exceed that amount. This is achieved by weighing the animal using an accurate scale which measures at least to the gram. Weights should be taken in the morning before the first formula feeding. Using this weight and the desired percentage of formula to body weight, the total daily intake is calculated. This amount should be divided equally between the feedings offered and should not be exceeded. Each time feeding amounts are adjusted, check gastric capacity and do not exceed what the neonate can comfortable ingest. The guidelines for determination of gastric capacity are 50 ml. of fluid per kg. of body weight. Serious medical problems can arise when carnivores are overfed. These include but may not be limited to the formation of excessive gas, diarrhea, vomiting, blood in the stool, gut stasis and painful bloat. The possible effects and results of overfeeding should be discussed with staff members prior to the hand rearing of all animals so everyone has a clear understand of the importance of adhering to recommended nutritional guidelines.

Solid Food/Proper Handling: Milk and meat are excellent culture media for bacteria. When offering milk in a bottle or by pan, it should be warmed to the proper temperature just prior to feeding. Uneaten formula should be discarded after the feeding, never returned to the refrigerator or offered to the neonate after sitting at room temperature for more than 5 minutes. After measuring the required formula for each feeding, the formula stock bottle should be returned to the refrigerator immediately never allowing it to sit at room temperature for more than a few minutes. Formulas must also be prepared carefully to minimize the potential of contamination. Dishes and formula receptacles should be washed in clean hot water with soap and 2% bleach solution. Empty formula containers should be sterilized over boiling water for 3 minutes. Any milk formula which clings to the fur around the mouth or forelegs of an infant should be cleaned away. Thawed meat products should be offered for only a limited period of time standing at room temperature, not to exceed one hour in length. After the feeding, all uneaten food should be gathered and discarded. The food pan and floor should be sanitized. Caution should be used when thawing meat based diets and refrigerator thawing is recommended.

Behavior/Discipline: Guidelines for consistent handling should be established prior to or early in the hand rearing process. It is not advisable to allow a carnivore to suckle on any part of the caretakers hands, skin or arms. Occasionally, a finger can be used to elicit nursing reflex, but allowing prolonged non-nutritive suckling bouts on skin should be discouraged. Suckling interactions become increasingly dangerous and unpredictable as the carnivore becomes older. The neonate associates the comfort behavior with the keeper. Should it become necessary to end the suckling bout before the animal is willing, the neonate frequently becomes aggressive. (This has resulted in keeper injury, especially in bears). Regardless of the eventual destination of the carnivore being hand reared, it is not advisable to allow the animal to play bite or swat the caretaker. Instead, select toys, surrogates or other items for play sessions. One method that works well is to attach a favorite toy with a short length of rope to the end of a pole such as a broom handle. The handler can use the toy to lure the animal into a game of chase yet maintain an appropriate distance from the handler's body. This method discourages biting or associating the handler with a play item, while providing plenty of fun and exercise for both animal and handler. The toy should not be stored inside the animal exhibit since it could present a strangulation hazard. Some nursery raised carnivores will become aggressive before weaning age. If this occurs, it will be necessary to formulate a standard method for discipline. Whatever method is agreed upon, it should be applied consistently by all handlers. If one handler is encouraging rough play, the behavior will be repeated with other keepers. The animal will be confused about acceptable behavior. Discourage any behavior which will be undesirable as the animal gets bigger.

Record Keeping: Daily record keeping is important when hand rearing carnivores. Developmental data such as weight, eyes and ears opening, dental status and locomotion as well as appetite, vitality, stool and urine production should be noted. This data will be valuable for comparative study and early detection of medical problems. Effective communication between caretakers is essential. Any concerns or changes should be communicated among staff members.

Emphasis on Monitoring and Observing: Neonatal and young carnivores can make dramatic changes very quickly when ill. By the time the untrained eye has noticed that there is a problem, it may be too late for successful medical intercession. Note subtle changes in appetite, posture, vitality and stamina. Communicate concerns immediately to hand rearing staff and make thorough notations in the animal records. Report any suspicious changes to a veterinarian immediately so that appropriate investigations can begin promptly.

WILDLIFE SAFARI
CHEETAH HAND-REARING PROTOCOL

Kerrin Grant
2004

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The purpose of this paper is to give pertinent information to caretakers so that informed decisions can be made regarding hand-rearing programs at individual facilities. This paper will address the issues concerning a proper milk formula as well as weaning diets. Additionally, a general hand-rearing protocol is included which may be used as a reference guide for facilities needing this information. Hand-rearing wild neonates is part science and part art. It is necessary to have nutritionally sound diets from the nursing stage through weaning. But it is also important to understand that individual animals have different metabolic rates, food preferences, temperaments and health status, all of which affect the ability to successfully hand-rear an infant. The information in this manual is meant to be a guide and a starting point. It is not considered the "Right" or "Only" method, nor is it meant as a criticism to other protocols. It is just another viewpoint which will hopefully be a valuable asset in cheetah hand-rearing programs.

The maternal milk composition of cheetahs is more concentrated in solids and fat and lower in protein and carbohydrates than the domestic cat (table 1). Kitten milk replacer (KMR™) has been used quite regularly at cheetah breeding facilities which periodically hand-rear individual cubs or entire litters. KMR™, in the liquid form, is most commonly used and many times is diluted with water or 5% dextrose for several feedings. Anecdotal reports indicate cubs have digestive problems (diarrhea or constipation) when the straight formula is used. Facilities have indicated the powder form of KMR™, which can be mixed with water at different dilutions, doesn't mix well and is more prone to cause digestive upset, presumably because the powder stays in a "lump" in the cub's stomach and can't be digested properly. Other facilities have chosen to use Esbilac™, which is a puppy milk replacer. Esbilac™ is higher in fat and lower in carbohydrates than KMR™. Taurine, an essential amino acid for felids, is not in the Esbilac™ formula, so must be added prior to feeding (250mg/cub/day) (McManamon and Hedberg, 1993). A recent survey on hand-rearing protocols of captive felids indicated there was equal preference for Esbilac™ + taurine and KMR™ + Multi-Milk™ formulas (Hedberg, 2002).

Table 1: Comparison of the maternal milk composition of cheetah and domestic cat. Ben Shaul (1962)[1], Abrams (1950)[2].

	Cheetah[1] AF	Domestic cat[2] AF	Cheetah[1] DM	Domestic cat[2] DM
Solids %	23.7	17.7		
Protein %	9.41	7.17	39.7	40.5
Fat %	9.48	4.96	40.1	28.0
Carbohydrate %	3.51	4.92	14.8	27.8
Ash %	1.3	0.65	5.4	3.7
Kcal/ml*	1.37	0.93	5.79	5.25

* Kcals were calculated. AF = as fed basis. DM = dry matter basis

Cheetah milk is higher in total solids (less water), fat and ash (mineral component) and lower in carbohydrates than domestic cat milk. In many species that are hand-fed, carbohydrate is the limiting nutrient. Many species are lactose-sensitive and lack the enzyme lactase to break down milk sugars. Because of that, milk formulas manufactured for domestic species must usually be diluted significantly to maintain a formula that doesn't exceed the carbohydrate level wild species are able to digest. Such is the case with KMR™. The liquid form (canned) provides 18.2% solids, 42.2% protein, 25.0% fat and 26.1% carbohydrates (DM basis). That formula is comparable to the domestic cat's milk, but is very different from the cheetah's. If the carbohydrate component is the limiting factor, the milk must be diluted enough to make the carbohydrate portion approximately 14-15% of the total solids (on DM basis) or 3.5% (on "as fed" basis). Diluting KMR™ liquid to a 2:1 ratio of formula to water gives a carbohydrate content of 3.2%. A 3:1 ratio gives 3.6% carbohydrates, both of which would be acceptable for cheetahs. However, diluting the formula to reduce the carbohydrates also decreases the amount of protein and fat in the diet. See table 2 for the proximate analysis of KMR™ canned formula dilutions.

Table 2: Comparison of nutrient composition of KMR™ canned formula dilutions. Values are on an "as fed" basis. Ben Shaul (1962)[1], Pet Ag™ [2]

	Cheetah req.[1]	KMR™ [2] canned	KMR™ 3:1 dilution	KMR™ 2:1 dilution
Solids %	23.7	18.2	13.7	12.1
Protein %	9.4	7.7	5.8	5.1
Fat %	9.5	4.6	3.5	3.0
Carb. %	3.5	4.8	3.6	3.2
Kcal/ml	1.37	0.91	0.69	0.60

From the above data, it is apparent that while reducing the level of carbohydrates to the cheetah requirement, it also decreases the amount of protein to 54-62% of cheetah milk and fat provides only one-third the requirement. Felids obtain energy from protein and fat (Bechert, et al., 2002). The main effect that results from a diluted formula is delayed growth rates and/or skin and haircoat problems. Hair loss was noted in snow leopards that consumed an Esbilac™ formula deficient in protein. The problem resolved after adding chicken baby food, which increased the protein level (Hedberg, 2002). It should also be noted that not only will protein and fat levels be below the requirements for cheetah cubs, but essential amino acids, vitamins and minerals, including taurine, vitamins A and D, calcium and phosphorus, will be diluted as well. The concern here is that chronic nutrient deficiencies in growing cubs may develop into serious health problems such as retinopathy, cardiomyopathy and metabolic bone disease (Howard, et al, 1987; Robbins, 1993). For that reason, it is not advisable to maintain growing cheetah cubs on a diluted milk formula for longer than is absolutely necessary during the formula initiation phase, unless suitable vitamin/mineral and taurine supplements are provided.

Another issue with diluting the milk formula concerns the amount of calories the cub receives in a 24 hour period. Growing cubs require a minimum amount of calories for basic body functions, development and growth. Many hand-rearing protocols suggest feeding a certain percentage of the body weight (e.g. 15-20%) on a daily basis. However, there can be vast differences in the caloric content of formulas, especially when diluted.

For example: say we have three 600g cheetah cubs. One is maternally raised, the other two, hand-raised. Of the hand-raised cubs, one is fed formula #1, as described below. The other cub is fed formula #2. Based on the recommendation that formula be offered in the volume equivalent to 15-20% of the body weight, each cub would receive between 90-120 ml of formula/day. Cheetah milk provides 1.37 kcal/ml. At 15-20% body wt., the cub would receive between 123-164 kcal/day. In this example, we'll use that caloric range as the target for the two hand-rearing formulas.

Cheetah milk
Provides 1.37 kcal/ml of formula
Fed at 15-20% body wt: receives 90-120 ml formula/day
90 ml x 1.37 kcal/ml = 123.3 kcal/day
120 ml x 1.37 kcal/ml = 164.4 kcal/day

Formula #1 (canned KMR™, diluted w/ water at ratio of 3:1)
Provides 0.69 kcal/ml of formula
Fed at 20% body wt: receives 120ml formula/day
120 ml x 0.69 kcal/ml = 82.8 kcal/day

Formula #2 (KMR™ & Multi-Milk™ powders mixed w/ water at ratio 1: 1: 2½) -> in table 3
Provides 1.26 kcal/ml of formula
Fed at 17-20% body wt: receives 102-120ml formula/day
102ml x 1.26 kcal/ml = 128.5 kcal/day
120 ml x 1.26 kcal/ml = 151.2 kcal/day

The caloric content of formula #1 provides 50-67% of the calories in cheetah milk, when offered at 20% body weight. The caloric content of formula #2 falls within the range of cheetah milk, when fed at 17-20% body wt., and provides 1.8 times more calories than formula #1, when the same amount (20% of the cub's body wt.) is offered. Formula #2 is more nutrient dense than formula #1. In order to provide equivalent calories, formula #1 would have to be fed at 30-40% body wt. to match formula #2 and cheetah milk. Diarrhea has been reported in exotic felids that consume ≥ 25% body wt/day, so no more than 20% should be offered (Hedberg, 2002). As a result, without some type of supplement, formula #1 will likely result in delayed growth rates compared to cubs raised on a more nutrient dense formula, or maternally raised cubs.

The point of the above example is to demonstrate that formulas are not equal when it comes to determining feeding schedules. Offering 15-20% body wt/day is appropriate for formulas that provide adequate nutrient and energy concentrations, but may not be sufficient in less nutrient dense formulas.

Many facilities have indicated that chicken or turkey baby food should be added to the formula early on in the hand-rearing process. The addition of baby food will provide supplemental protein and fat. Chicken and turkey are reportedly good sources of taurine (Hedberg, 2002; NRC, 1986). One jar (2.5oz.) of Gerber's™ chicken 2nd foods contains 12.9% solids, 11.8% protein, 4.1% fat, 1.47% carbohydrates. 0.6% calcium, 0.09% phosphorus and 15 IU vitamin A and provides 66 kcal (USDA 2004). Taurine was not listed in the analysis. Gerber's™ 2nd foods, turkey flavored, is also a good source of protein and fat, and very low in carbohydrates. However, the calcium: phosphorus ratio is skewed towards phosphorus (1:6.5) so would not be a good choice unless another source of calcium is provided to give a Ca: P ratio of 2:1. Additionally, there is no vitamin A in the turkey baby food.

Panthera spp. have benefited from the addition of poultry-based human baby food (e.g. Gerber's™ 2nd foods), as early as 1-2 weeks of age (Hedberg, 2002). The baby food provides additional protein and calories, but should be limited to less than 17% (2.5oz baby food to 12.5oz prepared formula) of the diet (Hedberg, 2002). Baby food must be added gradually over one week to prevent digestive upset. This is not considered part of the weaning diet, but as an addition to the formula which increases protein, fat and calories to otherwise dilute formulas. Knox™ gelatin has also been added to formulas to increase the protein content (D. Strasser, pers. com.).

It is not advisable to add meat-based baby foods to nutrient-dense formulas such as those presented in table 3. Laurenson (1995) stated that wild cheetah cubs had physiological limits on growth even when an unlimited food supply was available. However, the addition of protein and calories may promote a faster than optimal growth rate and contribute to potential bone growth abnormalities. Cubs that are consistently growing at >10% body wt/day may need to have their formula diluted to slow their growth. Fast growth promotes bone deformities and fractures because they are not able to support the additional body weight. This phenomenon is common in giant breeds of dogs fed puppy food (Irlbeck, 1996).

Wild cheetah cubs have average growth rates of 37 – 62.4g/day (Laurenson, 1995, Beekman, et al, 1999; Wack et al, 1991).The recommended average daily weight gain (ADG) goal for hand-reared cheetah cubs is approximately 5% body weight while on milk formula, and 8-10% increase per day after solid foods are introduced (Hedberg, 2002). Formulas and weaning diets that do not meet these goals may need to be modified in one or more ways to ensure proper growth rates of cubs.

Calculations associated with feeding schedules

The following calculations are provided to assist the caretaker in determining how much and how often the formula should be fed to provide adequate nutrition, energy and optimal growth rates.

The Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy (kcal) an animal needs for basic metabolic function at rest in a thermoneutral zone. In other words, the amount of calories it needs to stay alive, without having to use energy to maintain normal body temperatures. The formula to determine the BER/ BMR is:

70 x body wt (in kg.)$^{.75}$ (Kleiber, 1947) For a 600g. (0.6kg) cub, the BER would be:
$70 \times 0.6^{.75} = 47.72$ kcal/day.

Once we have the BER, we can determine the Maintenance Energy Requirement (MER). This determines the amount of calories the animal needs to function in a normal capacity at its life stage. For adults in a maintenance life stage, the BER is multiplied by 2. For infants that have a higher metabolism and are developing and growing, the BER is multiplied by 3 or 4, depending on the species and other factors. The MER factor of 3 is appropriate for large felids (including cheetahs) that grow at a slower rate than small mammals.

The stomach capacity for most placental mammals is 5-7% of the total body weight (Meehan, 1994). Convert the body weight into grams to find the stomach volume in mls (cc's). To calculate the stomach capacity in ounces, convert body weight into the same units (30g ~ 1 oz). *The key is to make sure units are the same for body weight and stomach volume). The stomach capacity is the amount of formula a cub can comfortably consume at one feeding. Offering much more than this value may lead to overfilling, which may lead to stomach distension and bloat. It also prevents complete emptying of the stomach before the next feeding and promotes the overgrowth of potentially pathogenic bacteria, diarrhea and enteritis. (Evans, 1987).

The following calculations will determine the total volume and kcal to feed/day, as well as the amount of formula/ feeding and the total number of feedings/day.

1. Calculate Maintenance Energy Requirement (MER): 70 x body wt (kg)$^{.75}$ x 3. See Appendix 1 for calculated MERs for various body weights.
2. Determine stomach capacity (amount that can be fed at each meal): Body weight (in grams or ounces) x 0.05.
3. Divide MER (number of calories required per day) by number of kcal/ml to get the volume of formula to be consumed per day. This value can be converted into ounces, by dividing it by 30.
4. Divide ml (or oz.) of formula per day by volume to be consumed at each meal (stomach capacity). This gives the number of meals to be offered per day.

Example: 600 gram (0.6 kg) cub

1. MER = 70 x 0.6 $kg^{.75}$ x 3 = 143 kcal/24 hr. period
2. Stomach capacity = 600g. x 0.05 = 30 ml/feeding
   OR: 20oz x 0.05 = 1 oz/feeding

**The following calculations are based on a milk formula that provides 1.26 kcal/ml. Formulas that provide more or less energy will result in different volumes of formula per feeding and number of feedings/day. A formula that provided 0.69 kcal/ml would require 207 ml of formula per day given over 7 feeding bouts.

3. $\dfrac{143\ \text{kcal}}{1.26\ \text{kcal/ml}}$ = 113 ml of formula to be offered in 24 hr. period (approx. 20% bw)

4. $\dfrac{113\ \text{ml}}{30\text{ml/feeding}}$ = 3.76 feedings (round up to 4)

The cub in the above example would receive 30 ml (1 oz.) of formula at each feeding and would be fed 4 times over the course of the day. The total amount offered in 24 hrs. is approximately 20% of the cub's body weight. The number of feedings would be split by whatever time period caretakers are able to feed, with a minimum of 3 hours and maximum of 8 hours between feedings.

It is not unusual for infants to feed well at one meal and consume very little at another. Whatever is not consumed at individual meals can be made up by an additional meal later in the day. However, it is important to note that if a cub is expected to consume 30 ml at one meal, but only takes in 15 mls, the deficit can not be made up by offering 45 ml at another feeding. Even if the cub wants to take more than the calculated stomach capacity volume, it must be limited to that amount. Overfeeding may cause bloat and allow for pathogenic bacteria to proliferate in the digestive tract, which will increase the risk of diarrhea, gastric distension and enteritis (Evan, 1987). When cubs are hungry, many times they finish their bottle before the feeling of satiety occurs, but are sound asleep 10-20 minutes later. If the cub is still hungry after it has received its designated volume, shorten the time period to the next feeding by an hour, if necessary.

With a very young or weak cub, it would be advisable to feed smaller amounts more frequently, although it is generally not necessary to feed more often than every 3 hours. Frequent feedings that cause the cubs to be repeatedly awakened is actually more stressful than letting cubs sleep for longer periods (Meehan, 1994). Generally, healthy cubs will start to get restless when they get hungry, which can be used to gage how frequently they need to be fed. In the wild, reports have indicated mother cheetahs may regularly stay away for nine hours between feedings without ill effect to the cubs (Laurenson, 1993).

FORMULAS

Pet Ag™ manufactures KMR™, Esbilac™ and Multi-Milk™. Multi-milk is a formulated powder with a very low carbohydrate content. Adding it to either KMR™ or Esbilac™ will maintain high levels of protein and fat while keeping the total carbohydrate content to a minimum. Table 3 provides two formulas using Multi-Milk™. One combines it with KMR™, the other with Esbilac™. The nutrient compositions are very close to cheetah maternal milk.

Table 3a: KMR™-based recipe for a cheetah hand-rearing milk formula

Formula	Component	AF basis	DM basis
KMR (42/25): 1 part	Total solids:	22.4%	
Multi-milk (30/55): 1 part	Protein:	8.9%	39.7%
Water: 2 ½ parts	Fat:	9.5%	42.4%
	Carb:	2.5%	11.2%
	Ash:	1.5%	6.7%
	Calcium:		1.4%
	Phosphorus:		1.0%
	Magnesium:		0.08%
	Kcal/ml:	1.26	5.63

AF = as fed, DM = dry matter basis

Table 3b: Esbilac™-based recipe for a cheetah hand-rearing milk formula

Formula	Component	AF basis	DM basis
Esbilac (33/40): 1 ½ parts	Total solids:	23.0%	
Multi-Milk(30/55) : 1 part	Protein:	7.9%	34.2%
Water : 3 parts	Fat :	11.2%	48.8%
Taurine: 250mg/cub/day	Carb:	2.6%	11.2%
	Ash:	0.8%	3.5%
	Kcal/ml	1.4	6.0

AF = as fed, DM = dry matter

The above formulas should be diluted for the initial feedings and gradually increased in concentration until given as a straight stock formula. Because the carbohydrate content of the full-strength formula is lower than that of cheetah milk, digestive problems should not be an issue. However, since there is no way to control the ingredients of the milk powders, there is always the potential for problems to occur. One factor that has been reported is lactobezoars (milk clots in the abdomen) of cheetahs cubs. The cause of this condition is unknown. One facility indicated they thought the milk formula was too concentrated. However, at the time of the lactobezoar incident, they were feeding KMR™ liquid as their stock formula, which was high in carbohydrates. Bloating and lactobezoars in two hand-reared polar bears was associated with a milk formula high in carbohydrates (Kenny, et al, 1999). The abdominal distension in the cheetahs may have been caused by fermentation of undigested carbohydrates.

The inability to digest certain types of fatty acids might also contribute to lactobezoars. Prior to 1993, Pet Ag™ used coconut oil as their fat source in the KMR™, Esbilac™ and Multi-Milk™ recipes. In 1993, the ingredients were changed and they replaced coconut oil with butterfat. The change was made due to research indicating butterfat was more digestible in domestic dogs and cats. However, wildlife rehabilitators and zoo facilities which hand- raised infants noticed that various species were developing digestive problems, even though the caretakers were using the same recipes as before. Lactobezoars were reported in tigers and leopards (Hedberg, 2002). Coconut oil has a high concentration of medium-chain fatty acids, which are generally more digestible than the long-chain fatty acids present in butterfat (Robbins, 1993). Wild felids may not be able to digest butterfat as easily as coconut oil.

Caretakers also reported that the new formula was difficult to mix and had a greasy residue. Pet Ag™ responded to the situation by marketing the Zoologic Milk Matrix™ line of milk formulas. It is essentially the pre-1993 version of their milk formulas, and contains coconut oil instead of butterfat as the fat source. The Milk Matrix™ line uses formula numbers, which refer to the concentration of protein and fat, as the product names.

KMR = Milk Matrix 42/25
Multi-milk = Milk Matrix 30/55
Esbilac = Milk Matrix 33/40

Therefore, the Milk-Matrix™ version of KMR™, Esbilac™ and Multi-Milk™ may be preferable products to use in cheetah hand-rearing formulas, especially if lactobezoars are a concern.

From personal experience, the Milk Matrix™ line is easy to mix when the powder is added to cold water in equal parts and stirred in a "whisking" fashion .Then the additional water is added to the slurry and mixed completely. There are usually a lot of air bubbles right after mixing, but they dissipate within a few hours. The consistency is much thicker when the formula is cold, and thins out significantly when heated to 100°F. The formula must be refrigerated between feedings.

Many mammalian species lack the enzyme lactase which breaks down milk sugar (lactose) into glucose for absorption into the cells. Gas build-up in the gastrointestinal tract and diarrhea can result as the undigested sugar ferments in the small intestine. Species that have low carbohydrate levels in the maternal milk are generally considered lactose-sensitive or lactose-intolerant. Because commercial milk formulas made for domestic dogs and cats are generally higher in carbohydrates than the maternal milk of the species we're feeding, modifications to the diet are required to prevent digestive distress. Methods used to deal with this issue include:

4. Diluting the formula to reduce the amount of carbohydrates from being consumed
5. Including Multi-Milk™ in the recipe to reduce the carbohydrate content
6. Adding lactase enzyme or lactose-eating bacteria (e.g. *Lactobacillus*) to the formula

Lact-aid™ is a product that contains the lactase enzyme. The dose is two drops to 100ml of formula. Lactase will begin breaking down the sugar in the formula and will be effective for 24 hours. Lact-aid™ must be added to the formula 24 hours prior to offering it to the cub.

Simethicone is a de-foaming agent that reduces gas build-up in the intestinal tract, a symptom associated with the inability to break down lactose. But this product does not contain lactase, so it doesn't break down the milk sugar. Trade names for simethicone include Gas-X™, Mylicon™ (pediatric formula) and Phazyme™.

Lactobacillus spp. is a group of bacteria that produce lactase and digest lactose. It is marketed as "*Acidophilus"* for humans and Probios™ or Bene-bac™ for animals. These bacteria live naturally in the gastrointestinal tract of mammals, and help maintain a healthy gut. They also help prevent the proliferation of pathogenic bacteria, such as *E.coli.* (Supplement Watch).

The maternal milk of cheetahs is comparatively low in carbohydrates. As an obligate carnivore, cheetahs obtain their energy source from proteins and fat, not carbohydrates (Bechert, et al., 2002). Diarrhea has been reported in *Panthera* spp. raised on milk formulas high in carbohydrates (Hedberg, 2002). It is a fair assumption that cheetahs also do not digest milk sugars efficiently. Therefore, it would be wise to add one or more products to assist in the breakdown of lactose to prevent gastric upsets, particularly in milk formulas that exceed 3.5% carbohydrates (14.8% DM). Lactaid™ is commonly used prophylactically and is readily available. The main drawback of Lactaid™ is that it must be added to the milk formula 24 hours in advance of feeding and refrigerated in order to be effective. But when used, it appears to be helpful in preventing the signs associated with lactose-intolerance.

Simethicone may be used to treat a cub with a distended "bloated" abdomen, or added to the formula to prevent the occurrence of a "gassy-stomach". The dose for rabbits with gastrointestinal stasis (ileus) is 67-133mg (1-2ml of pediatric formula) once an hour x 2-3 doses (Krempels, et al., 2000).

The addition of *Lactobacillus* spp. in conjunction with simethicone may be an effective alternative to Lact-aid™, if it is not available. It is unnecessary to add *Lactobacillus* spp. to the milk formula several hours in advance of feeding. The milk is mainly a vehicle for the bacteria to enter the digestive tract, where it will breakdown lactose into glucose and lactic acid, and the glucose is absorbed into the cells from the small intestine.

Probios™, a product manufactured for livestock, recommends a dose of 50 million bacteria (5 grams) for newborns of all sizes (lambs and calves). This product does contain vegetable oil (as the binding agent) and sucrose (in very small amounts). If given in too high of dose, it has the potential to loosen the stool, but may be helpful with cubs prone to constipation. The product comes in gel form and packaged in a calibrated syringe. The dose is squirted directly into the mouth of the animal.

Probios™ is not required every day. The purpose of this product is to ensure there is an adequate population of lactose-consuming bacteria in the gut. They will be self-reproducing, so it is not required that they be completely replenished on a regular basis. A daily dose until the cub is on the full-strength stock milk formula may be advisable, and then every 2-3 days after that until the cub starts consuming solid food. Probios™ can be discontinued during the weaning process, but given as needed if loose stool/diarrhea occurs.

Bene-bac™ is a product similar to Probios™. It is manufactured by Pet Ag™ for birds and small animals. It comes in powder and gel forms. The powder form does not contain vegetable oil and may be added directly to the milk formula during preparation. Like Probios™, it also contains 10 million bacteria/g. Pet Ag's™ recommendation is to give it every two days from birth until seven days (or first week of hand-rearing) and then once a week until the introduction of solid foods. The dosing of *Lactobacillus* spp. bacteria is more about infusing an adequate number of bacteria into the gut rather than being weight-related, so the product recommendations should be considered reasonable guidelines ---- more is not necessarily better.

Acidophilus comes in tablet form and may be crushed and added to the milk formula. The dose for humans (adults and children) is one tablet (1 billion bacteria). From personal experience, I have given small mammals (rodents and rabbits) *acidophilus* at the rate of ½ - 1 tablet in a batch of formula which lasts 2-3 days and have had no ill effects from that dose. As a general guideline, one-half tablet/cub/day may be adequate. *Acidophilus* works the same way as Probios™ and Bene-bac™. It is just another form, and does not contain vegetable oil or sucrose.

Growth curve in hand-reared cubs

Hand-reared animals typically have a delayed growth rate compared to maternally-raised cubs. There are many factors which contribute to that.

1. Cubs receive maternal antibodies *in utero* (before birth), in the colostrum and in the milk. Mother-raised cubs receive considerably more passive immunity to a variety of pathogens than the hand-reared cubs.
2. Many times, hand-reared cubs are pulled because they are poor-doers and are nutritionally and/or immunologically compromised from the start, and simply don't have the ability to make up for lost time.
3. The hand-rearing formula, no matter how nutritionally sound it appears, is restricted to the nutrients in the powder mixes. As we learn more about nutritional idiosyncrasies of each species, we find that many times the form of protein, fat or carbohydrate in the artificial formula is not compatible with those in the maternal milk, and may not be as digestible. All we can do is our best with what we know at any given time. Over the years, milk formulas have improved vastly, and will no doubt continue to improve in the future.

4. Formulas given are not nutritionally balanced or are deficient in one or more major nutrients such as protein and fat. An average weight gain of approximately 5% body weight while on milk formula and 8-10% weight gains during the weaning process are the targets (Hedberg, 2002). There will always be some fluctuation where there may be a 2% gain one day and 8% the next. So the key is to see what the average is over a period of 3-5 days. If the cub is consistently maintaining weight for several days or only has slight gains, the formula composition and feeding schedule should be evaluated. Barring any health problems to explain a delayed growth rate in an individual, low weight gains are generally related to a diet that is not meeting the caloric and/or protein requirements.
5. During the initiation phase of the milk formula, diluted formulas are given over the course of a few days. Weight gains generally do not occur during this period. Cubs will either maintain or lose a small amount of weight until they are consuming the formula at 80-100% full strength. This is not of concern in otherwise healthy cubs. As soon as they transition to the stock formula, they will begin gaining weight. Additional formula is not required to provide the target amount of kcal, unless cubs are regularly restless in between feedings. If this occurs, an additional feeding can be supplied, which is eliminated as the cubs consume the more concentrated formula.
6. Cubs that are weak may not have the energy to consume the target volume of formula at each feeding. In these cases, small, frequent feedings and the addition of LRS+ 2.5% dextrose given subcutaneously (SQ) may be more appropriate. Weak cubs may also take longer to transition onto the stock formula because of weakened organ function. Close monitoring of these cubs is warranted to ensure they begin gaining weight as soon as feasible, without stressing their immune system any more than necessary. Even in these cases, the cubs should ideally be on a formula at 80-90% full strength concentration within five days and possibly another two days to get to the full-strength stock formula. If diarrhea occurs when these cubs go onto the full-strength formula, they may do better on a 2:1 or 3:1 dilution (full-strength formula: water) as their stock formula.

GENERAL HAND-REARING PROTOCOL

<u>Key stages of cub development/hand-rearing process (Meehan, 1994)</u>

7 days = eye open	28 days = introduce solid foods
7-14 days =teeth begin erupting	35 days = cease nursing from bottle, wean to bowl
14 days = walking unsteadily	70-80 days = completely weaned

NEWBORNS

<u>Colostrum</u>

Domestic kittens receive maternal antibodies *in utero*, and from the colostrum and milk (Casal, et al, 1996; Robbins, 1993). Colostrum contains 4000-8000 mg/dL IgG, and can be absorbed in the feline gut until 16 hrs. post-partum (Levy and Crawford, 2000; Casal, et al, 1996). IgG is the first line of antibody defense after birth to prevent and combat systemic infections in newborns. IgA provides more localized defense in the gastrointestinal, reproductive and respiratory systems and helps prevent enteritis in the newborn (Zuba, 1991). IgA can usually be absorbed for a longer period than IgG, although there is no data on the time period in felids (Miller-Edge, 1994).

Ideally the cubs should stay with the mother until at least 24 hrs. of age so they can receive colostrum and some maternal milk. Without access to maternal antibodies, the cubs will be immuno-suppressed and more susceptible to contracting various infections until they are vaccinated and can develop their own active immunity to pathogens. Additionally, weak cubs are prone to bronchopneumonia during the first few weeks of life (Hedberg, 2002). If cubs must be removed from the mother within the first day, adult cheetah (or other appropriate felid) serum may be administered to cubs at the rate of 150 ml/kg body wt. during the first 24 hours (Levy and Crawford, 2000). The authors suggest giving 75 ml/kg intraperitoneally (IP) or subcutaneously (SQ) in two separate doses within 16-24 hrs. postpartum.

Umbilical stump

Newborn cubs that are removed from the mother shortly after birth will need the umbilical stump cleaned to prevent infection. This area is the prime site of infection entry for newborns. Typically, povidone-iodine is used as the disinfectant. Chlorhexidine 0.5% solution (Nolvasan™ 2% diluted with 3 parts sterile water) is a preferable choice (Hedberg, 2002). Iodine (7%) is caustic and can trap bacteria in the stump. Chlorhex is not caustic and has greater residual antimicrobial activity than iodine (Madigan, 1997). Hedberg (2002) recommends that caretakers clean the umbilical stump every 6 hours x four treatments and monitor for heat and/or swelling at the site.

FORMULA FEEDING

Initiation Phase

1. At intake, weigh cub (in grams or ounces) and calculate stomach capacity (5-7% of body weight).

2. Take rectal temperature. Normal body temp. for felids are: (Hedberg, 2002)
   0-7 days = 95-96.8°F.
   7-28 days = 97-99°F.
   >28 day = 101-102.4°F.
3. Cubs with a normal body temperature may be offered an oral electrolyte solution, at 5-7% body wt. (stomach capacity). Electrolyte choices include: unflavored Pedialyte™, Lactated Ringer's Solution (LRS), LRS + 2.5% dextrose and Normosol-R. Electrolytes should be warmed to 95-100°F. to prevent lowering the body temperature from ingesting cold fluids.
4. Cubs with body temperatures below 94°F. should be warmed in a temperature -controlled incubator or placed in a box or other comparable container with a heating pad set on LOW underneath one-half of the container. Do not place cubs directly on a heating pad or have the heating pad inside the box. Allow the cub to warm up to the normal body temperature for its age before offering anything by mouth. SQ fluids (LRS+ 2.5% dextrose) may be given to slightly dehydrated cubs. Maintenance fluid level is 50-75ml/kg/day (Hedberg, 2002).The level of dehydration is added to this value. Divide the fluid volume for a 24 hr. period into 2-3 doses, with half given at the first dose and the remainder split equally between subsequent doses. Intravenous (IV) fluids (LRS with either 2.5% or 5% dextrose) may be warranted in weak or hypothermic cubs (body temp < 90°F.). Hypothermic cubs, especially those that are non-responsive, may also be hypoglycemic. It is advisable to take a small blood sample to determine blood glucose level at this time, and treat accordingly. The normal blood glucose level for most placental mammals is 90-130 mg/dL. (Fraser, 1991). Clinical signs of hypoglycemia, which include hypothermia, incoordination, cold and clammy skin, constant crying, and a poor or absent suckling response; may not be apparent until the blood glucose level drops below 50mg/dL (Fraser, 1991).
5. The first bottle feeding of oral electrolyte solution will rehydrate the cub, strengthen the suckling response and clear the stomach of the mother's milk (Hedberg, 2002). Offer an additional bottle of oral electrolytes (5% body wt) two hours later.
6. The third feeding should be the stock milk formula diluted with WATER, not electrolyte solution, at the dilution rate of 1:4 (formula: water). Electrolytes have the potential to interfere with milk absorpti mixed with the formula (Fettman, et al, 1986; Heath, et al, 1989). If the cub needs additional oral electrolytes, they can be given in between formula feedings. Regular tap water that does not contain excess minerals, or is otherwise contaminated, may be used to mix with formulas. Distilled water may be used as an alternative.

7. At the 4th feeding, the cubs should be put onto their regular feeding schedule. At this time, the caretaker should have calculated the number of kcal the cub requires over a 24 hr. period, the volume of fluids to offer at each feeding and number of feedings per day (see page 5 for calculations). The calculations should be based on the information from the stock formula, not the dilutions. Over the course of the first 72 hrs. the cub will receive fewer calories than required, but that is part of the transition process. Offering too much too soon increases the likelihood of digestive upset. The cub will be consuming the required nutrient composition and caloric content soon enough. The problem occurs when the time frame required to transition to the full-strength stock formula is extended beyond 3-5 days. If that occurs, for whatever reason, additional feedings or vitamin/mineral supplements may be warranted.
8. In an ideal situation, the cub will receive a 1:4 dilution formula for 2-3 feedings, then 1:3 dilution for 24 hours, then the 1:2 dilution for 24 hrs, 1:1 dilution for 24 hrs, then the full-strength stock formula on the 5th day and from then on. However, in the real world, things don't always work out as planned. Cubs may periodically need to stay on a dilution a little longer, particularly when going from the 1:1 dilution to the full-strength formula. Intermediate steps may need to be added, such as going from 1:1 to 2:1, then full-strength to give the cub more time to adjust. Occasionally cubs need to take a step back if diarrhea occurs. For example, if the cub does well on 1:2 then develops loose stool on the 1:1 dilution, which gets worse at each feeding, delete the next feeding, give electrolytes (at 5-7% body wt) for 1-2 feedings, then go back to the 1:2 dilution step. Offer that formula for 2-3 feedings and progress to 1:1.5 if the stool improves. Healthy infants tend to resolve digestive upset/loose stool pretty quickly when dealt with appropriately. Compromised infants may have other issues that are compounding the problem. They may be stressed and immuno-suppressed. They may have bacterial or viral infections, particularly if they didn't receive colostrum before being removed from the mother. They may have parasites. Or there may be other factors that are adding to the cub's stress level which hampers its ability to adapt and adjust to the hand-rearing process. This is where the "art" of hand-rearing comes in, and the caretaker must make various adjustments to help an individual cub do its best.

Urogenital Stimulation

Animals that are not fully developed and mobile at birth (altricial) require manual stimulation to urinate and defecate until their eyes are fully opened. A soft towel/wash rag should be moistened with warm water and massaged along the urogenital region either immediately before or after each meal. Some caretakers prefer to do it before feeding because it awakens the cub and encourages them to nurse. Others recommend stimulating after feeding because cubs tend to get fussy during the process and may not be able to settle down enough to take the bottle, if done beforehand. It's all a matter of choice on the part of the caretaker and the temperament of the cub. The important point is consistency. Cubs will likely urinate during each stimulation, but not always defecate. This is normal, particularly if they receive several feedings throughout the day. Normal defecation should occur at least 2-3 times a day.

Bottle Feeding Guidelines

Nipple selection is important to allow milk flow at the proper rate. Nipples that have a very slow flow rate will cause the cub to suck harder and harder, and eventually suck air into the stomach, which will lead to a distended, "bloated" stomach. Nipples with holes that are too large will cause too much milk to enter the mouth, and potentially be aspirated into the lungs, leading to aspiration pneumonia. Venting the bottle by loosening or tightening the cap rings will adjust the flow rate (Hedberg, 2002).

Felids feed sternally (lying on abdomen) with the neck extended and head tilted up slightly. It is important that the bottle be tilted up enough so there is always milk filling the cap to ensure the cub doesn't suck in air while nursing.

Many times, individual cubs will require their own nipple(s) as each cub suckles with different intensities and styles. *Panthera* spp. have responded well to the Mead-Johnson standard nipple as well as the "NUK" shaped orthodontic preemie-sized nipple, which are shorter and softer than the standard human infant nipple (Hedberg, 2002). The Evenflo™ preemie nipple has been successful with very young cubs because the flow rate can be easily adjusted. However, it does collapse with strong, aggressive suckling, so would not be advisable with older cubs or particularly aggressive nursers. Smaller felids (under 500g.) may be able to use the Pet Nurser™ bottle by Pet-Ag™, which come in 2oz. and 4 oz. sizes, or the elongated conical-shaped nipples from Four Paws™ (Hedberg, 2002).

Tips for feeding from the bottle (Meehan, 1994; Hedberg, 2002; Felid TAG):

1. Providing slight tension on the bottle while feeding may encourage suckling, particularly in the more difficult nursers.
2. Squirt a little bit of milk directly into the cub's mouth to start the suckling process.
3. Allow cub to push and "knead" a towel with its front paws as it suckles. This is how they stimulate milk flow when nursing from the mother. This behavior might also stimulate motor function in limbs.
4. If suckling action is weak, place the thumb and index finger on either side of the mouth to create better suction.
5. Make sure the milk formula stays warm (100°F). The digestibility of milk lowers as it cools, and some cubs will stop drinking if the formula temperature drops below a certain point. This is more of an issue with slow nursers. Having a second bottle in a warmer or cup of hot water for these cubs may be helpful. Always check the temperature of bottles sitting in hot water before feeding by shaking it a couple of times, then squirting a few drops on the back of your wrist ---- it should feel slightly warm, not hot. **** Milk formula must never be fed cold ---- it will lead to digestive problems.**
6. Some cubs will nurse better if the nipple is placed in the mouth before the cub is fully awake.
7. Mimicking the maternal behavior, such as scruffing the cub and swinging it gently, as it is lifted out of the incubator may stimulate the instinct of the cub to start nursing after being carried by the mother.
8. Weak and/or very young neonates will often suckle until tired, not full. Give these infants time to rest in between more frequent feedings, if necessary.

Digestive Problems

In most cases, loose stool and diarrhea are nutritionally related, either by providing a diet that is nutritionally imbalanced or by transitioning from a diluted to a concentrated formula too quickly. Stress is a factor that may come into play at certain stages, such as having new caretakers feed or when cubs begin eating solids.

Nutritionally-related digestive upset most commonly occurs at three different stages:

1. When the first 48 hours of the initiation phase is not followed. The initiation phase consists of offering 2-3 feedings of an oral electrolyte solution then giving diluted stock milk formulas that approximate 1:4, then 1:3, 1:2, and 1:1 dilutions (of stock formula: water) prior to giving the full-strength milk formula. Infants that are started immediately on a milk formula are more apt to have digestive problems than those that receive the electrolytes first.
2. When the cub transitions from the 1:1 to the straight formula. Sometimes the full-strength formula, even though it is nutritionally sound, may be too rich for the cub. This is more of an issue with individual cubs that may have sensitivities to nutrients in the formula or have a temperament that is stressed more easily, or other unknown factors. There may be times when it is more appropriate to feed 2:1 or 3:1 (mixed formula: water) dilutions rather than the full-strength formula in order to maintain normal stool. Cubs in this situation may also benefit from the addition of chicken baby food to a diluted milk formula (1:1 or 1:1.5). It should be noted that cubs which are maintained on a slightly diluted milk formula long term may have a delayed growth rate.

3. From time to time infants may have slightly loose stool as they transition from one dilution to another. Many times this situation clears up on its own within 1-2 feedings. Depending on the individual cubs (health status, temperament, etc.) the caretaker may want to continue offering the formula at that dilution rate for 2-3 feedings and monitor the stool color and consistency. If the color is normal and the consistency is slightly loose, but maintains that consistency or improves, the formula transitions may continue as scheduled. However, if the consistency worsens and begins looking like diarrhea, or if the color becomes pale, then it is appropriate to delete the next 2-3 feedings and offer oral electrolytes instead. The first formula feeding after that should be the dilution level just prior to the onset of diarrhea. Generally, 2-3 more feedings at the previous dilution is enough to improve the condition of the stool and it may then transition to the next step. In the past, Kaopectate™ has been used to successfully treat diarrhea in young animals, including kittens. However, the ingredients of this product were recently changed and it now contains salicylates (like Pepto-Bismol™). Salicylates may cause adverse reactions in felids (Plumb, 1991), so this product should not be administered to cheetah cubs.

Infants that are receiving dilutions of a stock formula low in total solids (compared to maternal cheetah milk) may experience bouts of diarrhea, not because the formula is too rich, but because it is too low in total solids (analogous to a human living on a liquid diet). When there is an excessive amount of fluids going in, excess fluid will be excreted with the waste products and appear to be very watery. Also, diets that contain higher levels of carbohydrates than the maternal milk may also cause diarrhea.

Common causes of diarrhea: (Marcum 1997; Hedberg, 2002)

1. Introducing concentrated formula too quickly without transitional stages
2. Offering formula with a carbohydrate (milk sugar) content that exceeds that found in the maternal milk composition
3. Providing a diluted formula too long (lack of adequate total solids in diet)
4. Overfeeding (> 7% body wt/feeding and/or >20% body wt/day)
5. Sudden change in diet or addition of new food (during weaning process).
6. Nutritionally imbalanced diet
7. Unclean feeding utensils
8. Stressful conditions

Stool consistency:

Loose stool: is not well-formed and is excreted in a pile. Milk stool is naturally softer and less well-formed than stool excreted when on solid food diets because of the high water content of the formula. Loose milk stool is of pudding consistency. Diarrhea is watery stool and can lead to dehydration.

Stool color: (Marcum, 1997)

1. Normal milk stool: tannish-yellow or light brown. First stool of the newborn is dark, greenish-brown (meconium) and indicates the cub has not nursed yet. During the hand-rearing process, after 1-2 doses of electrolytes, many times the first stool to appear will be dark brown and more solid than typical milk stool. This is because the cub hasn't eaten for an extended period and the stomach is empty. The color and consistency will become softer and lighter as the cub starts consuming the formula.
2. Black, tarry stool: may indicate intestinal bleeding. Cubs that are fed fresh, raw meat during the weaning stage may have black stool on occasion, which is not necessarily a concern. It may be from consuming meat with blood on it that has passed through the digestive tract.
3. Green stool: may be caused by enteritis (inflammation of the intestine) or by a particular food.
4. Red stool: may be caused by hemorrhaging or presence of blood in colon. Small amounts of blood may be seen during the weaning stage if cubs are eating bones, which can scrape the intestinal lining.
5. White stool: may indicate bile disorder or enteritis

Constipation

Cubs that fail to defecate within a 24-hr period may be constipated. Massage the abdomen with a warm, dry cloth. Sometimes inserting a lubricated thermometer into the rectum will loosen stool and stimulate it to be excreted. If the cub is constipated, or if lactobezoars (milk clots in abdomen) occur, delete the next 1-2 formula feedings and replace them with oral electrolytes (5-7% body wt.) If condition doesn't resolve after the second electrolyte feeding followed by manual stimulation, consult a veterinarian for further treatment.

HOUSING

Heat Sources

Incubators provide an environment where the temperature and humidity may be controlled for severely compromised neonates. An incubator may not be a reasonable option for a litter of healthy, active cubs, but is preferable to other heat sources for very young and/or
weak cubs. It is important to provide 50% humidity for cubs in incubators because the process of heating air reduces its relative humidity and can lead to dehydration (Meehan, 1994). It is also important that the temperature in the incubator not become too warm. Monson (1987) gave the following recommendations for ambient temperatures with hand-reared kittens, which are reasonable guidelines for cheetah cubs.

0-7 days of age = 88-92°F.
8-14 days of age = 80-85°F.
15-28 days of age = 80°F.
28-35 days of age = 75°F.
≥ 35 days of age = 70°F.

Signs of insufficient heat are: burrowing deep into blankets, rolled up tightly in a ball. Cubs may also experience gassiness and constipation from an inability to completely digest food when hypothermic. Cubs that are too warm may lie fully stretched out, panting with nose and mouth near incubator air vents; are fussy and may have diarrhea (McManamon and Hedberg, 1993).

Heating pads and heat lamps may be appropriate alternatives for providing ambient heat to healthy, active cubs. They are not good alternatives for very young and/or weak cubs that are unable to move away from the heat, as needed. Severely compromised cubs will tend to sleep in one position for extended period which can result in thermal burns from either a heating source directly above or below the animal. Active cubs are able to move toward or away from heat sources more easily.

Heat lamps should be positioned far enough above the animal so it can't jump up and contact the heat lamp directly or knock it down into the enclosure. Only half of the cub's enclosure (or area large enough for all cubs to have access) should be heated. An equivalently-sized unheated area must also be provided so the cub(s) can move away from heat, as needed. Ideally there would be a 5-10°F heat range from the warmest to the coolest area of the enclosure (Hedberg, 2002). Monitor the temperature of the heat lamp by placing a room thermometer in the enclosure, below the heat lamp and at approximately the same height the cub's body would be in relation to the lamp when sternal. Adjust the lamp as needed to maintain an appropriate temperature.

Heating pads provide a heat source that comes from below the animal. This may more closely simulate the heat coming from lying along side of or on top of the mother's abdomen. Heating pads should never be placed directly in an enclosure with an infant. The two problems that occur are thermal burns from direct contact with the pad, and chewing on electrical cords. The disadvantage of heating pads is the inability to regulate the temperature as well as heat lamps and incubators. Heating pads have settings of low, medium and high, and have a wider variance of temperatures within those settings. The general recommendation for using heating pads with animals is to wrap the pad in a regular bath towel (not overly thick) and place UNDER the enclosure, such as a box or pet carrier.

The heating pad is ALWAYS set on LOW. The heating pad should only provide heat to approximately half of the enclosure so the infant can move away from the heat source, as needed, to prevent overheating. When setting up, a room thermometer should be placed on the enclosure floor after the heating pad has reached its designated temperature to determine how much heat is available to the cub. Adjustments can be made with the thickness of the towel wrapped around the pad to increase or decrease the temperature. The towel should always be under the heating pad to prevent excess heat loss from the pad into the floor or table that it sits on. Providing a cloth barrier between the pad and the housing container is not always necessary. Having the container directly on the heating pad will provide additional heat, if needed. Care must be taken if the cub is housed in a cardboard container, which can become quite hot if set directly on a heating pad.

Bedding

Polyester fleece and fake fur are good sources of bedding that are easily washed and sanitized. Sewing fleeces together into pillow-shapes and stuffed with small towels can be placed in the incubator or other enclosures. They simulate the soft feel of the maternal abdomen. Cubs reportedly sleep on top of fleeces, which may reduce stress and give the cubs a sense of security (Hedberg, 2002). Care should be taken to ensure cubs do not chew on and consume fabrics, which have the potential to cause an intestinal obstruction.

Color coding feeding utensils, including nipples, is a good way to distinguish supplies for each cub when litters are hand-reared together. Applying different combinations of colored nail polish to one or more toenails of each cub will aid in identification until definitive physical characteristics are determined (Hedberg, 2002).

Physical/mental stimulation

Cheetah cubs become quite active within two weeks of age. Physical movement may assist with motor function stimulation and proper development/growth of bones, muscles and nerves. Cubs confined to an incubator or small enclosure, which limits movement, may benefit from manual stimulation of limbs several times a day. Taking a few minutes before or after each feeding to manipulate limbs or allowing cubs to run, jump, pounce and stretch forelimbs may assist with proper development. The Felid TAG recommends moving cubs to larger enclosures that allow for movement by 21 days of age.

Play behavior between cubs may serve several useful purposes, including the development of predatory skills, developing strength/endurance, social bonding and communication skills (Caro, 1995). Cheetah cubs have been observed to engage in several types of aggressive play behavior, including crouching, stalking, pouncing and chasing with littermates, which may be important motor activities related to future hunting skills. Caro (1995) observed wild, mother-raised cheetah cubs and noted that cubs engaged in contact social play behavior with littermates on a daily basis until eight months of age. Play behavior was separated into five categories: Locomotor play (running, rushing about) was the most common play behavior at two months of age, and was thought to serve the purpose of escaping predators (Caro, 1995). Social (contact and non-contact), and object play categories increased between two and three months of age. Exploratory play behavior continued to rise until one year of age. The author made connections between play behaviors and predatory skills used later in life. Stalking and crouching observed in non-contact social play was associated with approaching prey. High levels of object and contact social play were associated with higher rates of patting, biting and grasping live prey.

WEANING

There are many different viewpoints regarding when and how to initiate the weaning process in exotic felids. The Felid TAG recommends adding chicken or turkey baby food to the milk formula at 4 weeks of age with small felids. Various zoo facilities recommend weaning when the cubs show interest in solid food. Gittleman and Oftedal (1987) indicated cheetahs first consumed solid food at 33 days of age and weighed 1.94 kg (4.27 lbs.)

As the cubs begin consuming solid foods in a measurable amount, the volume of formula can be reduced proportionately. Many times cubs will take the bottle at some feedings but refuse it at others. Eliminating specific feedings rather than reducing the volume at each feeding allow the cubs to get hungry enough to explore other food options available, such as a bowl of meat.

It is important to weigh cubs every 1-2 days to monitor weight fluctuations during the early stage of the weaning process, especially when multiple cubs are fed together. It is common for different levels of food consumption to occur amongst individuals in a litter. You may be providing an appropriate amount of food to feed four cubs, but two cubs are eating 60-80% of the food. Monitoring the weight will help caretakers determine if all cubs are consuming appropriate amounts of the weaning diet. Another clue that a cub may not be progressing in the weaning process is that it always seems very hungry at each bottle feeding compared to the littermates. In this case, adding pureed meat to the formula for that cub, or separating it to feed from its own dish will ensure the cub gets it share.

At this point, there are no nutrient requirements established by the NRC specifically for cheetahs. Therefore, until more specific data becomes available, the domestic cat is used as the reference model on which the cheetah requirements are based. Slab meat diets typically provide much higher levels of protein than the domestic cat requirement. The cat requirements are generally considered <u>minimum</u> requirements, and are used as a guideline until further research on cheetah nutritional requirements become available.

Table 4: Minimum nutrient requirements for domestic kittens. (DM basis) NRC (1986).

Crude protein = 24%	Zinc = $\leq$ 50mg/kg DM
Crude fat = 9%	Niacin = 40mg/kg DM
Calcium = 0.8% DM	Taurine = 400mg/kg DM
Phosphorus = 0.6% DM	Vitamin A = 3333 IU/kg DM
Magnesium = 0.04% DM	Vitamin D = 500 IU/kg DM
Iron = 80 mg/kg DM	Vitamin E = 30 mg/kg DM
Copper = 5 mg/kg DM	

<u>Appropriate foods for weaning diet</u>

Poultry-based human baby foods (chicken and turkey) are commonly used at the initial stage of weaning. The baby food is gradually added to the formula or placed in a shallow bowl with warmed formula poured over it to entice the cubs. Small amounts of baby food are provided at each feeding, and increased daily as long as the stool appears normal (Felid TAG). This is a common weaning strategy for small exotic cats. It may not be practical with the larger species, including cheetah, except in specific cases involving "poor-doers" or runts of the litter that need special attention and have chronic digestive problems. Chicken baby food has been beneficial in keeping the stool firm, whereas beef baby food is preferable in cubs prone to constipation (Felid TAG).

Poultry has the added benefit in that it is a good source of taurine, an essential amino acid in felids. The requirement for domestic kittens is 400mg/kg DM (NRC, 1986). Uncooked chicken muscle contains, on average, 991 mg/kg DM taurine. Cooking reduces the taurine concentration somewhat (NRC, 1986). However, the Felid TAG recommends cooking chicken prior to feeding to kill *Salmonella*, which can cause diarrhea.

Commercial feline diets for domestic kittens, ZuPreem™ and Nebraska Brand™ feline diets may be offered in a bowl with warmed milk formula poured on top, to entice exploration. As cubs start consuming the diet in measurable amounts, the addition of milk formula to the bowl may be discontinued.

Zoo facilities that feed slab meat to adult cheetahs may prefer to wean cubs onto a meat diet comparable to that of the adults. Muscle meat is low in calcium and high in phosphorus. See table 5 for a comparison of muscle meats and whole prey items. Chicken muscle meat has a 1:21 ratio of calcium: phosphorus, whereas whole chicken has a Ca:P of 1:1 (USDA, 2004).

Table 5: Comparison of muscle meat, organ meat and whole body prey. Values are on DM basis. Dierenfeld, et al (2002)[1]; USDA, (2004)[2]; Ullrey and Bernard, (1989)[3]

Meat	CP %	Fat %	Ca %	P %	Mg %	Fe mg/kg	Cu mg/kg	Zn mg/kg	Vit A IU/kg	Vit E IU/kg	Kcal/kg
Chicken, whole[1]	42.3	37.8	1.68	1.3	0.09	40	3.0	45	35600	51.3	5900
Chicken,muscle[2] meat only	77.5	22.9	0.04	0.76	0.07	39.6	3.2	50.9	3818	8.7	5382
Chicken heart[2]	58.9	35.1	0.05	0.68	0.06	225	13.1	249	1132	0	5774
Chicken liver[2]	72.3	20.4	0.03	1.26	0.08	383	20.9	114	471404	29.8	5064
Horse, meat only[3]	76	18	0.05	0.34	0.05	232	3.0	128	2593	0	n/a
Cow, meat only[3]	63	29	0.03	0.55	0.06	78	2.0	106	1428	3	n/a
Deer, meat only[3]	65	29	0.03	0.59	0.06	165	5.0	68	0	0	n/a
Rabbit, whole[1]	63.5	15.3	2.35	1.68	0.16	302	16	86	6200	16.2-60	5410
Rabbit, meat only[2]	74	20.7	0.05	0.8	0.07	58.2	5.37	58.2	0	0	1360
Rat, whole (≥50g.)[1]	61.8	32.6	3.45	1.91	0.15	195	7.5	92.1	35600	139	6370
Quail, whole body[1] (*Coturnix coturnix*)	71.5	31.9	3.43	n/a	0.06	74.9	2.6	53.0	70294	66.8	6790

n/a = data not available

Muscle meat and whole animals (birds, rats, rabbits) stripped of fur, tail, head, feet, beak, etc. can be ground up and provided in small amounts in a bowl with warmed formula poured on top at the initiation of the weaning process. Rabbits that were fed nutritionally balanced diets during their lives are considered a "complete food" in that it meets or exceeds the basic dietary nutrients of a kitten without the addition of vitamin or mineral supplements. This is with the assumption that the cub consumes the meat, bone and viscera (except stomach and intestine). Rabbit is generally accepted by cheetahs since it is similar to one of the wild cheetah's natural prey (springhare).

Vitamin A

Pre-formed vitamin A is an essential nutrient for felids, so must be provided in the diet (Irlbeck, 1996). However, as a fat-soluble vitamin, it is stored in the body, so it is not required on a daily basis. It is important not to provide excessively more than the requirement since it can accumulate in the body to toxic levels. In growing animals, vitamin A toxicity is associated with skeletal malformations and fractures, internal hemorrhage, enteritis, conjunctivitis, and reduced function of liver and kidneys (McDowell, 2000; Robbins, 1993).

In rabbits, vitamin A is contained in the organs, particularly the liver. While cubs are still consuming milk formula, additional vitamin A is generally not required (depending on the nutrient composition of the formula), so organ meat should not be provided at this stage. However, after completely weaned onto solid food, cubs must consume the liver of rabbits to meet the vitamin A requirement, if vitamin supplements or other food items high in vitamin A are not provided.

Vitamin A is relatively high in whole chicken, rat and quail, and in chicken liver. The whole animals exceed the kitten requirement by 11-21 times, and chicken liver exceeds it by 141 times, by weight (NRC, 1986). If these food items are frequently included in the weaning diet, a vitamin supplement containing vitamin A should not be provided. In addition, combining a diet of one or more of these items with another food item low in vitamin A, such as chicken meat, chicken heart and rabbit muscle meat will help offset the excess. On an "as fed" basis, one ounce (30 g.) of chicken liver provides the daily vitamin A requirement for domestic kittens.

Vitamin D

Natural sources of vitamin D are available in two forms - D_3 which is synthesized in the skin of animals with exposure to sunlight, and D_2, which occurs mainly in plant matter. Most carnivores are able to utilize both D_2 and D_3, although lions and tigers preferentially utilize D_3 (Robbins, 1993). It is unknown as to whether or not this is also the case with cheetahs. Vitamin D is not present in the milk of most mammals, with the noted exception of polar bears (Kenny, et al, 1999). Maternally-raised captive cheetah cubs have reportedly left the lair, for short periods, at 28-38 days of age (Stoeger-Horwath and Schwammer, 2003; personal observation). This may be the point at which cubs require a source of vitamin D_3.

Milk formulas based on KMR™ or Esbilac™ contain vitamin D_3 at levels which meet or exceed the domestic kitten requirement. As long as cubs are consuming the milk formula, D_3 supplementation is not required. In order to maintain proper bone growth, cubs that are weaned off formula at an early age may require access to sunlight (or indoor UV-B light) or a D_3 supplement if their diet contains less than 500 IU/kg DM of D_3.

Calcium and phosphorus

Whole rabbit, rat and chicken provide a balanced Ca:P ratio of 1.4:1 – 1.8:1. All other food items (muscle meat, liver and heart) have a skewed Ca:P ratio in favor of phosphorus. Not only do felids require an absolute amount of calcium and phosphorus (0.8 and 0.6% of the diet, respectively), but they also require a balanced ratio between the two minerals to promote proper calcium absorption. Ca: P ratios of 1:1 to 2:1 are the recommendations for growing infants. (Trendler, 1997). Grinding the skeleton of rats, rabbits and/or chickens and including them in the meat diet will provide a good source of calcium. Grinding must be thorough and large pieces of bone and sharp bone shards are removed before feeding. Cartilage, tendons and ligaments may be offered as a source of fiber.

Meat diets that do not contain bone require the addition of a calcium supplement. Table 6 compares various forms of calcium. It should be noted that supplements can not all be used interchangeably since they have different concentrations of minerals. In addition, calcium may have different absorption rates, depending on the form it's in. Limestone is the least available source of calcium, whereas calcium phosphate and bone meal are more readily absorbed into the body (E. Dierenfeld, pers. com). When adding a calcium supplement, it is important to provide only enough to balance the diet. Too much calcium can be as detrimental as not enough in growing animals. Excess calcium in the diet has been linked to osteochondrosis, enlarged joints, splayed feet, angular limb deformities and stunted growth (Hazewinkel, et al, 1985; Hedhammer, et al, 1974).

Table 6: comparison of calcium supplements. Values on DM basis. Kellems and Church (2002)

Supplement	DM%	CP%	Ca%	P%	Mg%	Cu mg/kg	Fe mg/kg	Zn mg/kg
Bone meal, steamed	97	13.2	30.7	12.9	0.3	-----	26700	100
Calcium carbonate	100	-----	39.4	0.04	0.05	-----	300	----
Dicalcium phosphate (Dical™)	97	-----	22.0	19.3	0.6	10	14400	100
Limestone, ground	100	-----	34.0	0.02	2.1	-----	3500	-----

DM= dry matter, CP= crude protein, Ca= calcium, P= phosphorus, Mg = magnesium, Cu = copper, Fe = iron, Zn = zinc

As cubs continue to consume more and more of the meat diet, eliminate formula feedings from the daily schedule, one at a time. Late night feedings can be dropped first, if a bowl of food is provided to allow for self-feeding. The a.m. formula feeding should be the last bottle feeding dropped from the schedule, and may be eliminated by 5 weeks of age, in most cases. Continue offering warmed formula in a bowl with the solid feline diet. Complete weaning from formula should occur within 10 weeks of age, but cubs will probably lose interest in the formula before then.

Cubs that are weaned onto a slab meat diet may not require a vitamin supplement while they continue to consume formula, if the meat portion of the diet is a combination of chicken meat, whole chicken and rabbit. They will, however, require a calcium/iron supplement if meat only (no bone) is offered. A taurine supplement may be warranted if red meat is offered instead of chicken. Table 7 is an analysis of a diet composed of equal parts of milk formula and chicken meat for a 3.0 kg (6.6 lb) cub.

Table 7: Nutrient analysis of a weaning diet, combining chicken meat and milk formula.

Food Item	CP %	Fat %	Ca %	P %	Mg %	Fe mg	Vit A IU	Vit D IU	Vit E mg	Kcal
Chicken meat, 175g 48g DM	38.8	11.5	0.02	0.4	0.04	1.8	172	0	0.4	265.5
Milk Formula, 180ml 40 g. DM, (table 3)	19.9	21.2	0.7	0.5	0.04	3.1	4473	361	9.1	227.0
Calcium carbonate 1g.	-----	-----	0.4	-----	-----	0.3	-----	-----	----	------
Limestone, 1g.	-----	----	0.3	------	0.02	3.5	-----	-----	-----	------
Total	58.7	32.7	1.42	0.9	0.10	8.7	4645	361	9.5	492.5
Requirement	24-40	≤ 40	0.8	0.6	0.08	7.0	290	43.5	2.6	479
Difference	HIGH	OK	OK	OK	OK	OK	HIGH	HIGH	HIGH	OK

The analysis indicates that the milk formula contains an excess of fat-soluble vitamins, so should not be supplemented in the chicken meat. This diet is, however, deficient in calcium and iron unless a supplement is provided. A combination of calcium carbonate and limestone is used to provide an adequate level of iron. Calcium carbonate, while a good source of calcium, is quite low in iron. Limestone, which is a lower quality calcium source, contains ten times the amount of iron as calcium carbonate. The combination of the two supplements provides the necessary concentrations of both minerals. The diet, with supplements, provides a Ca: P ratio of 1.6:1, which is optimal.

The protein concentration of the diet is higher than the NRC requirement. But healthy captive cheetahs typically consume a diet very high in protein, and will continue to consume protein in excess of 50% of the diet in adulthood. The one concern with growing cubs is that they will grow at a faster rate than recommended (8-10% body wt/day). Fast growth rates are associated with abnormal bone growth and deformities (Irlbeck, 1996). During the weaning process, the protein content of the diet may be reduced, if necessary, by mixing the slab meat diet with a commercial feline diet, such as ZuPreem™ or Nebraska Brand™, which contain 43 and 47% CP, respectively (on DM basis).

In general, animals feed to meet their energy needs. Felids metabolize protein and fat for their energy needs (Bechert et al., 2002). Cubs consuming high protein diets may consume fewer calories than expected, based on the MER. Cubs that maintain an ADG of 8-10% are meeting their nutritional needs on more nutrient-dense diets. If feasible, continue weighing cubs, at one week intervals, as long as possible until weaned to ensure there is consistent growth.

The crude fat requirement for kittens has not been established by the NRC. For this example, since the cub is still consuming formula, the 40% fat content of formula was used as the maximum. Bechert, et al (2002) indicated a low protein: fat ratio (2:1 to 3:1) was consistent with that found in whole prey and was preferable to higher ratios. The protein: fat ratio of this diet is 1.8:1, which may be appropriate for growing animals.

The high levels of fat-soluble vitamins can not be lowered significantly while cubs are on the milk formula. The high level of vitamin E is actually beneficial in lowering the absorption rate of vitamin A. But it is important to note that the fat-soluble vitamins should not be supplemented until cubs are weaned off the formula, since more than enough is provided. Additionally, liver should not be included in the diet until cubs are weaned off milk formula completely. It should be noted that the milk formula used in this example is the KMR formula in table 3a. Different formulas, especially those that are less nutrient dense, will have a different nutritional analysis, and may be deficient in some nutrients. The purpose of this example is to show that it is important to know the nutrient composition of the diet prior to adding supplements, and to add only those that are required.

SUMMARY OF POINTS

1. The initial 2-3 feedings should be electrolytes only.
2. Gradually transition to the stock milk formula over a period of 3-5 days, starting at 1:4 dilution of formula: water and increasing the formula concentration by increments. 1:4 x 2-3 feedings, 1:3 x 24 hrs., 1:2 x 24 hrs, 1:1 x 24 hrs, full strength.
3. Determine the number of kcal, amount of food that can be offered at each feeding and number of feedings/day on the first day and adjust every few days as the cub grows, to maintain optimal growth rates. See Appendix 1 for calculated values.
4. It is preferable to provide a nutrient dense milk formula with a carbohydrate content comparable to cheetah milk (14-15% DM).
5. The Zoologic Milk Matrix™ line of milk formulas may be preferable to KMR™ and Esbilac™, especially if lactobezoars or constipation becomes an issue.
6. Digestive problems (diarrhea and constipation) can initially be dealt with by offering 1-2 doses of oral electrolytes, and going back to the formula dilution rate prior to when the problem first occurred. Give 2-3 feedings at that rate and then go to the next more concentrated level. Seek veterinary attention if problem doesn't resolve within 24 hours.
7. Solid foods (in pureed form) can be introduced at approximately 1 month of age. Do not include the calories from this food in the cub's daily caloric allotment until the amount consumed is measurable.
8. Start decreasing formulas feedings, by a proportional amount, when solid food consumption becomes measurable.
9. During the weaning process, analyze the nutritional composition of the diet to determine if vitamin/mineral supplements are warranted.
10. Calcium, iron and taurine are nutrients that may need to be supplemented as soon as cubs start consuming solid food.
11. With nutrient dense milk formulas, vitamin A should not be supplemented in the diet until cubs are completely weaned off milk formula.
12. Weaning can be completed, in most cases, by 8-10 weeks of age.

Appendix 1: Calculated values for Kcal/day and ml/feeding

Weight	ME (Kcal/day) [70 x bw (kg)$^{.75}$ x 3]	ml/feeding (Stomach capacity)
450g. (15 oz.)	115 kcal/day	22.5 ml/feeding
500g.	125	25.0
550g.	134	27.5
600g. (20 oz.)	143	30.0 (1 oz.)
625g.	148	31.25
650g.	152	32.5
675g.	156	33.75
700g.	161	35.0
725g.	165	36.25
750g. (25 oz.)	169	37.5
775g.	173	38.75
800g.	178	40.0
825g.	182	41.25
850g.	186	42.5
900g. (30 oz.)	194	45.0 (1½ oz)
950g.	202	47.5
1.0 kg. (2.2 lb)	210	50.0
1.1 kg.	225	55.0
1.2 kg.	241	60.0 (2 oz.)
1.3 kg.	256	65.0
1.4 kg.	270	70.0
1.5 kg. (3.3 lb)	285	75.0 (2½ oz)
1.6 kg.	299	80.0
1.7 kg.	313	85.0
1.8 kg.	326	90.0 (3 oz.)
1.9 kg.	340	95.0
2.0 kg. (4.4 lb)	353	100
2.1 kg.	366	105 (3½ oz)
2.2 kg.	379	110
2.3 kg.	392	115
2.4 kg.	405	120 (4 oz.)
2.5 kg. (5.5 lb)	418	125
2.6 kg.	430	130
2.7 kg.	442	135 (4½ oz)
2.8 kg.	455	140
2.9 kg.	467	145
3.0 kg. (6.6 lb)	479	150 (5 oz.)

PRODUCT LIST

Evenflo™ Co. Inc.
1801 Commerce Drive, Piqua, OH 45356
1-800-233-5921
www.evenflo.com

Four Paws Product Ltd
50 Wireless Blvd. Hauppauge, N.Y. 11788
1-516-434-1100
www.fourpaws.com

Gas-X™
Novartis
www.novartisconsumerhealth.ca

Gerber's baby food
1-800-4-GERBER (1-800-443-7237)
www.gerber.com

Kaopectate™
www.pfizer.com

Knox™ Gelatin
Kraft Foods™
www.kraftfoods.com/knox

Lact-aid™
McNeil Nutritionals
Ft. Washington, PA
1-800-LACTAID (1-800-522-8243)
www.lactaid.com

Mead Johnson Nutritional
1-812-429-6339
www.meadjohnson.com

Mylicon™
Johnson & Johnson-Merck Consumer Pharmaceuticals
Ft. Washington, PA.
1-800-222-9435
www.mylicon.com

Nebraska Brand Feline Diet
Central Nebraska Packing, Inc.
PO Box 500, North Platte, NE 69103
1-877-900-3003
www.nebraskabrand.com

Nolvasan™
Wyeth Animal Health Products
5 Giralda Farms, Madison N.J. 07940
1-973-660-5500
www.wyeth.com

Pedialyte™
Ross Consumer Relations
625 Cleveland Ave., Columbus, OH. 43215
1-800-986-8510
www.ross.com

Pet Ag™
261 Keyes Ave., Hampshire, IL. 60140
1-800-323-0877/ 1-800-323-6878
www.petag.com

Phazyme™
GlaxoSmithKline
www.phazyme.com

Probios™
Valley Vet
1118 Pony Express Hwy., Marysville, KS 66508
1-800-419-9524
www.valleyvet.com

ZuPreem™
PO Box 2094
Mission, KS 66202
1-800-345-4767
www.zupreem.com

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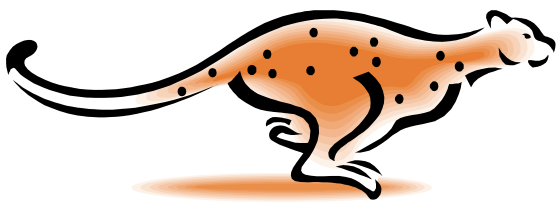
To Juma, Ratel, Tabia and B.C.
May you all live long and (re)productive lives!



Cheetah Cub Hand Rearing Protocol

Mary Jo Stearns
Infant Care Coordinator
Fossil Rim Wildlife Center

- Incubator: We use the “AICU” (Animal Intensive Care Unit), made by Animal Care Products Co. This is a portable unit originally designed for birds but works very well for small carnivores. Disinfect and set on 85-88 degrees. Use sterile water in the humidifier. Use flannel sheeting for padding on the bottom and roll up small sheets of flannel or toweling to use as a “nest”. (The flannel does not as easily entangle small claws like toweling can.) If it is a single cub, a water bottle or bag of fluids can be warmed and wrapped in a cloth and placed next to the infant.

- Always maintain strict hand washing protocols as well as foot baths both in and out of neonatal area. When dealing with certain medical problems i.e. herpes virus, latex gloves and smocks should be worn when handling infants.

- Neonatal exam by the Veterinary staff. Weight, body temperature, and general condition should be recorded in both medical records and hand rearing record charts. Medical conditions or concerns as well as age can vary the feeding protocol. The following guidelines are for newborn cubs that have been declared healthy by the Veterinary Department. Older cubs and/or medical cases may need specific protocols.

- When the neonate has a normal body temperature, is active, stable and has a suckling reflex, bottle-feeding of fluids can be initiated.

- For infants that have not had colostrum, please refer to the Medical section of this Protocol.

- Nipples and bottles: I have had very good results starting newborn cheetah cubs with Borden Pet Nip Nurser nipples. At 7-10 days you can switch to the blue “preemie” human nipple. After that, the soft red human infant nipple is usually well taken. Bottles and nipples can be disinfected, autoclaved or washed in a dishwasher between each use.

- First feeding should be 5% Dextrose mixed with sterile water. Amount should be calculated according to each cub’s weight. 10% of body weight divided by number of feedings per day should be used to start with. Feed newborns every three hours around the clock. If you have more than one animal, be sure to mark each with a marker or shave a portion of fur off for identification. After several (3 or 4) feedings of 5% Dextrose, you can begin using Liquid KMR (Kitten Milk Replacer made by Pet-Ag Co.) at a 25%: 75% KMR to 5% Dextrose ratio. After 3 feedings KMR ratio can be increased to 50:50. Over several days, ratio can be adjusted until full strength KMR is being tolerated well. Digestive problems have occurred while using KMR. Using liquid KMR instead of the powdered form can help as well as using Lactaid drops in the formula. Add 2 drops per 100mls of formula 24 hours before feeding.

- Warm the bottle in a larger container of hot water. Microwave heating can cause uneven heating or “hot spots” which can burn an infant. After warming, shake bottle well and test the milk on your wrist or arm. It should be warm but not hot. After a few feedings you will learn what temperature the cub (s) prefers.

- Feeding position: Cheetah cubs should be fed in a sternal recombinant position with the head raised. NEVER position a cub on its back to feed.

- Do not force a cub to eat. It may take many attempts before the nipple is accepted. It may be necessary to place drops of liquid on the tongue for a feeding or two to stimulate a sucking response. Patience can prevent aspiration. Be careful not to overfeed. It is sometimes tempting to give a neonate more than the calculated amount but overfeeding can result in diarrhea and/or painful gastric upset.

- Weights should be recorded at the same time each day and formula amounts calculated according to weight gains.

- After feeding, patting between the shoulder blades can release stomach gas build up. Manually stimulate genital/anal area to induce urination and defecation. Use warm water and a soft cloth or cotton ball. Pat rather than rub the area. If redness develops, use a small amount of mineral oil on the cloth. Clean any fur or skin that may have been soiled by formula with a wet cloth.

- Any uneaten formula should be discarded. Formula should be made fresh every 24 hours and refrigerated immediately. Never let formula sit at room temperature more than a few minutes.

- Weaning: Solid foods such as Baby Beef can be given at 3 to 4 weeks. Small amounts can be placed directly in the mouth or mixed with formula. After a 2 or 3 days, adult meat products such as Dallas Crown can be fed in a bowl with formula. Separate into very small pieces and discard any gristle or fat. Some cheetah cubs will lap a meat and formula mixture. Others prefer to eat the two separately.

Hand reared cheetah cubs using litter box

Hand Rearing Cheetah Cubs
Medical Care
Fossil Rim Wildlife Center
11 November 2005
Holly Haefele, DVM

- Veterinary input on pulling/hand rearing (ie in a case with herpes lesions, or other illness).

- Physical Exam- fill out standardized Neonatal Exam Form; perform a complete exam (including cleft palate check and umbilicus check).

- Blood Work
  - CBC
  - Chemistry Profile
  - Protein Electrophoresis (if concerned about partial failure of passive transfer)

- Plasma- can help to raise IgG levels in cubs with partial failure of passive transfer or in sick cubs.
  - Dr. Scott Citino (White Oak) recommended up to 10% of cubs body weight in plasma every 2-3 days.
  - FRWC protocol: for the first 2 weeks, give 10cc plasma orally everyday and 10cc SC every other day.
  - Can use electrophoresis/IgG levels to monitor efficacy.
  - Use males or nulliparous females as donors.

- Carpal Abnormalities- common in hand reared cubs.
  - Usually a supination or buckling at the carpus, can be severe and require splinting.
  - Possibly related to a micronutrient deficiency, and therefore White Oak tries to wean onto meat starting at 3 wks of age. However, FRWC has seen carpal supination in a day old cub (resolved after about 3-4 wks), and at 3.5-4 weeks in cubs that where mother raised for the first 2 weeks, and then ate Dallas Crown with KMR on top.
  - Usually seen around 4 weeks of age.

- Normal Values-
- Vaccination Schedule-
  - Fort Dodge Felovax PCT- 1cc IM or SC every 2 weeks from 6 weeks through 16 weeks
  - Merial ImRab3 Rabies- 1cc IM or SC at 16 weeks

- Deworming Schedule-
  - Pyrantel Pamoate- 10mg/kg orally every 2 weeks from 6-16 weeks
  - Heart worm prevention- start at 16 weeks

NUTRITION

XV. Nutrition (Ellen S. Dierenfeld, PhD, SSP Nutrition Advisor, Saint Louis, MO, USA; Kristina Johansen, DVM, EEP Nutrition Advisor, Copenhagen, DENMARK; Michelle Shaw, MS, Taipei, TAIWAN; Lorna Fuller, Johannesburg Zoo, SOUTH AFRICA)

Executive Summary

Species: Cheetah *Acinonyx jubatus*

Expected body mass:
Adult female 30 – 50 kg
Adult male 40 - 60 kg

Recommended energy need for maintenance: (based on surveys):
Adult female (30 kg) 800 kcal [3350 kJ]/day
Adult male (45 kg) 1000 kcal [4200 kJ]/day

Diet in nature:
Impala, springbok and Thomson's gazelle are the most commonly caught prey of the cheetah, although both smaller and larger prey is taken occasionally. Smaller prey is consumed whole with exception of the skin whereas the red meat is preferred in the larger species.

Zoo diet:
Supplemented meat diet, whole prey, and/or commercial carnivore diets. Approximately 1.2-1.5 kg meat per animal per day for maintenance during summer months or indoor housing, with appropriate increases (10-20%) in colder environments to maintain body condition standards.

Literature Review:

Wild Diets and Feeding Ecology:

Recorded prey species for cheetahs in the Serengeti and the national parks of Southern Africa vary from hares and newborn warthogs to wildebeest and zebras – a range of <2 to >300 kg body mass. Thomson's gazelle, impala and Grant's gazelle are the most abundant prey species. Potentially dangerous species such as zebra are mainly hunted by inexperienced cheetahs.

Hunting strategies are very diverse. Most often females with cubs hunt alone whereas adult group hunting does occur when the group is unaccompanied by immature animals.

Unlike the other larger cats, cheetah do hunt during the day as well as early morning and dusk. Other carnivores such as lion, leopard and hyena will chase cheetahs off their kill if they get a chance, and thus take over the kill. The competition can be intense.

Cheetahs are built primarily for speed and strength comes second. Their small jaws and lean body gives them a disadvantage when fighting competing carnivores. The relatively weak jaws also make it difficult for a cheetah to break through tough skin and they cannot chew or break larger bones. They do not always consume the whole kill.

Digestive Strategies

Cheetahs are obligate carnivores. The domestic cat seems to be the best available model to use, with certain adaptations.

A. Dietary Requirements

Unique nutritional requirements of felids must be recognized in feeding captive cheetahs, including the need for high protein and fat diets, inclusion of dietary vitamin A (as retinol), arachidonic acid, taurine, and niacin. General reviews of felid nutrition compared with specific studies on cheetahs (see, for example Davidson et al., 1986; MacDonald and Rogers, 1984; Zoran, 2002) provide indirect evidence that the domestic cat remains the best model for establishing dietary composition parameters (National Research Council (NRC), 1986) for the cheetah, but a detailed summary of feeding habits with chemical analysis of natural prey items would supply useful comparative data.

The exact nutritional requirements for all nutrients are not known specifically for cheetahs; therefore, requirements are extrapolated from data on domestic felids (NRC 1986). Formulated or prepared diets that do not meet dietary needs result in cheetahs with nutritionally related medical problems (e.g., chronic disease, nutritional disorders or poor reproductive performance). Fortunately, most nutritional disorders are of only historical significance due to improved nutritional management (Slusher et al., 1965). This does not exclude other possible nutritionally related disorders observed in cheetahs such as veno-occlusive disease (Gosselin et al., 1989) and copper deficiency. Copper deficiency has been reported as a common occurrence in cheetahs and may be responsible for ataxia in cubs and paralysis of the hind limbs (Dierenfeld, 1993; Bechert et al., 2002). Although there is a decrease in nutritional disorders, 7% of mortality in captive cheetahs younger than 6 months of age is still due to nutritional deficiencies (Bechert et al., 2002).

Commercially prepared carnivore diets (see table of product composition comparisons insert) or properly supplemented carcass meat should be considered the dietary staple for cheetahs. Whole prey can be used when practical - as long as strict veterinary and hygienic precautions are followed. Composition should closely adhere to nutrient specifications as outlined for felid nutrient requirements (see Table 1). Earlier studies with zoo felids reported excesses of vitamin A and phytoestrogens (Gosselin et al., 1989), and deficiencies of taurine (Howard et al., 1987) in various commercial preparations. Responsive manufacturers resolved these potential health problems by reducing vitamin A concentrations to levels of approximately 15,000 IU/kg (dry basis), minimizing the addition of estrogenic plant materials, and increasing the addition of taurine, particularly in heat-processed meat products. No additional supplements should be necessary with properly formulated and stored commercial diets.

The commercial preparations are formulated from the comparative dietary requirements of domestic cats, and have received field-testing for varying periods, but no side-by-side trials have been conducted to recommend specific products over another. Nor have controlled comparative studies been done to assess differences in various meat types (i.e. horse vs. beef) on health or animal responses of cheetahs. One advantage of commercial diets is that they are readily available, require little or no labor in preparation, and are assumed to be formulated with a sound nutritional basis. On the other hand, the guaranteed analysis label does not guarantee that the ingredients of the diet are actually utilized or available for utilization by the cheetah. Commercial diets are also typically the same consistency throughout the year, even though wild cheetahs eat different animals that may vary substantially in nutrient composition depending on the season.

In order to mimic the natural diet, captive cheetahs are sometimes also fed meat from carcasses or solely fed whole carcasses or supplemented meat (Bechert et al., 2002). This is the most common feeding regime in many European zoos. Chunk meat-based diets fed to captive cheetah typically comprise skeletal muscle (examples: turkey drumstick, beef, deer, or horse) (Bechert et al., 2002). The meat can be fed intact with bones and skin or without either and can be sprinkled with vitamin, mineral and/or vitamin /mineral supplements. One must be extremely cautious in using a supplement product that is properly designed to supplement meat as the primary diet, and targeted for felids specifically due to their unique nutrient requirements. There appears to be great variability across many products that have been reportedly used for supplementing meat-based diets fed to cats (see Table 2), and controlled studies of nutritional adequacy of various supplements have not been reported in the literature. Chicken as a dietary staple may be deficient in copper compared to red meats; additionally, supplemented chunk meat diet components also tend to have a high ratio of protein to fat, which can be reduced by using whole prey diets rather than strictly skeletal meat diets (Bechert et al., 2002).

Diets may comprise a mixture of whole prey, supplemented chunk meat, nutritionally complete meat-based (wet), and/or dry feline diets as some portion of the overall feeding plan. At this time, commercially prepared diets balanced for feline requirements, whole prey (if fully consumed), and/or or a combination of both, appear to provide the most suitable diets for captive cheetahs.

B. Practical Applications: Daily Diet/Quantities

Adult cheetahs are fed to maintain body condition (see Standardized Body Condition Score). Based on survey information and some experimental data (Allen et al., 1995), generic energetic equations may substantially over-estimate metabolizable energy (ME) requirements for the cheetah, and it appears that many animals can maintain healthy body condition by consuming as few as 800-1000 kcal/day. Estimated energy requirements for cheetahs are about 63 kcal [264 kJ] per kg body weight (Allen et al., 1995). Using commercial diets containing about 2000 kcal/kg (as fed basis) daily, with a digestibility coefficient of 0.84, meal size equals 1.2-1.4 kg daily for adult cheetahs.

Most US management programs have found that cheetahs' appetites and body conditions improve if they are fasted one to two days a week, although the practice could be controversial. Either no food is fed on these days or shank or other large bones are fed. Feeding bones (femur or neck bones, oxtails, chicken necks) has an additional function in promoting periodontal health (see Dental section). In North America, one fast day per week is recommended, which increases the meal sizes to 1.4 and 1.6 kg for females and males respectively. Some European zoos/vets feel that potential stress associated with fasting could contraindicate the practice if gastritis is suspected. Since gastritis often is undetected at early stages, some zoos never fast cheetahs completely, but incorporate one or two days per week with reduced amounts of food offered.

Diet quantities should be increased 10-20 percent in animals housed outdoors during winter months, and decreased by the same amount during summer months when appetite drops. Increase diet to *ad libitum* during lactation; consider lower fat diets and/or diets formulated for senior felines for geriatric animals.

A study conducted on 12 cheetahs at Wildlife Safari in Winston, Oregon compared digestion and health of cheetahs fed a commercial diet, or mixed supplemented meats. The commercial diet fed contained much higher concentrations of fat, vitamin A, vitamin E, Se, Fe, Cu, Na, P, and Mn than the supplemented meat diets. The exception was turkey, which possessed similar concentrations of

fat content and Se concentrations to the commercial diet fed due to the inclusion of skin. Mg was the only element with lower concentrations in the commercial diet. The highest concentration of taurine was found in turkey, the lowest concentration was found in beef, and the commercial diet had the most consistent amount of taurine. Ca and P concentrations in the supplemented meat diets components were highest in deer meat and lowest in horsemeat. Out of all the supplemented meat diet components, horsemeat tended to have the lowest concentrations of minerals and deer meat the highest, except for Se and Zn. It is also probable that cheetahs, like other felids, cannot synthesize adequate vitamin D_3 simply through sunlight exposure, thus this nutrient must also be included in diets provided. Commercial diets and turkey contained greater amounts of vitamin D_3 than supplemented meat diets (Bechert et al., 2002).

C. Food Preparation

Food preparation and handling is an area of special concern. If the diet is mixed within the institutions, all ingredients should be scrupulously maintained free of contamination from chemicals, pests, or microorganisms. Frozen ingredients should be properly thawed to reduce bacterial growth and diets fed as soon as possible after mixing (USDA, 2007; see http://www.fsis.usda.gov/Fact_Sheets/Meat_Preparation_Fact_Sheets/index.asp Commercial diets should also be thawed under clean conditions, free from external contamination, and fed immediately after thawing. Some institutions actually feed the diet while still partially frozen allowing cheetahs to eat as it thaws. Avoid allowing raw diets to warm to room temperature for long periods of time prior to feeding, as this practice can lead to rapid growth of bacterial organisms.

It is possible that supplemented raw meat diets have a greater degree of fatty acid deterioration than commercial diets. To make sure that there are appropriate amounts of essential fatty acids in the diets of captive cheetahs, plant and fish oil mixtures can be added to the meat diet as supplements but should be based upon analysis and documentation of a specific need for supplementation. Storage method and length of time in storage can also affect antioxidant levels such as vitamin E.

The food should be weighed and daily records kept as to how much is offered to each individual cheetah and how much is consumed. Determination of ration amounts is a dynamic process to meet changes in metabolic needs, such as in seasonal needs, Illness, pregnancy and lactation, and growth. Proper body weight, especially to avoid obesity (see Standardized Body Condition Score section), should be maintained by diet alterations. These changes should reflect not only energy needs, but also vitamin and mineral needs. Records of stool consistency assist in determining if the diet is poorly digested or possibly inducing diarrhea indicative of enteric disease. The food should be offered on a non-contaminated surface. In most situations feeding is done on the floor of the enclosure. Feeding stations should optimally be off the floor or substrate.

D. Chunk Meat Supplements (for examples of specific products used, refer to Table 2)

If diets are mixed within the institution, they should be supplemented to provide ~1% calcium (dry matter basis), particularly important if bones are not consumed. This is equivalent to about 7 g Ca per kg meat; a non-phosphorus containing supplement such as $CaCO_3$ (40% Ca) should be used. For this particular example, 17.5 g of $CaCO_3$ would be added/kg of fresh meat. If meat is lean (<25 percent fat) and/or well trimmed, lipid-soluble vitamins (A, D & E), as well as the suite of B vitamins may need to be supplemented at recommended levels. Do not supplement with vitamin A if liver is consumed in any amount. Ten to twenty grams fresh liver per thousand grams lean meat supplies about 10,000 IU Vitamin A/Kg dry matter, similar to felid requirements. Multi-B vitamin supplements

and additional vitamin E (as an antioxidant) may be particularly necessary for diets based on meats containing higher levels of polyunsaturated fats (any non-ruminant tissues).

Whole prey items should be small enough, or fed at suitable intervals, to permit consumption in total. Although little information concerning the contribution of gut contents in prey items to overall nutrition of predators is available, complete rather than selective consumption of prey species is recommended to prevent previously documented nutrient imbalances (i.e., rickets in carnivores fed muscle or organ meat exclusively; hypervitaminosis A from excess liver ingestion). (USDA, 2002; see http://www.nal.usda.gov/awic/zoo/WholePreyFinal02May29.pdf).

Observations of captive cheetah feeding suggest gut contents are not consumed in total, especially if carcasses are larger than about rabbit-sized.

E. Feeding Behavior

Lindburg (1988) presented excellent arguments for the augmentation of live prey to animal exhibits to enhance natural behaviors, as well as health effects previously discussed. Certainly obesity due to lack of activity in captivity is a major problem for zoo carnivores, including cheetahs. The above suggestions require commitment in terms of labor and/or capital investment, but may prove valuable. Note: the feeding of live prey is illegal in some countries, where only invertebrate prey can be fed alive. Many zoos have a lure coursing device where the cheetahs run at high speed to mimic hunting and to keep them in good condition. It is also valuable for educational purposes.

Intraspecific competition at feeding may be minimized by providing more feeding stations, or separating animals for meals.

The ultimate goal of any managed feeding program is proper diet formulation based on sound nutritional concepts and quality sources of dietary components, presented in ways to promote natural feeding behavior. Excellent communications among the source of the diets (manufacturers as well as Nutrition personnel), the veterinary staff, and the keepers will allow monitoring of health status, early evidence of nutritional deficiencies, or potential toxic problems. Only then can dietary inadequacies be assessed. The most common type of poisoning in large felids is from barbiturates used to euthanize feed animals. Felids feeding on such carcasses may show varying signs from mild ataxia to general anesthesia that may last for days. The liver from such carcasses is especially high in barbiturate levels and causes more severe signs (Bush et al., 1987).

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Table 1. Composition of Various Commercial Meat-Based Products and Carcass Meats Fed to Cheetahs (alphabetical).

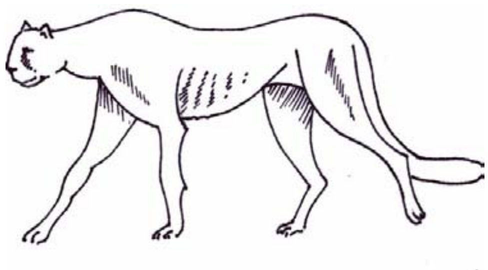
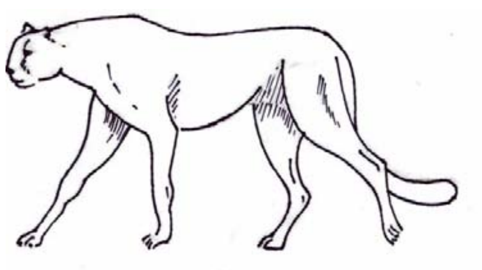
	Water	Fat	Protein	Ash	Ca	P	Vit A	Vit D	Vit E
	%	---- % dry matter basis ---					--- IU/g DM ---		
Commercially-Prepared Meat Mixtures:									
Bravo Meat Eater	63	27	51	11	2.8	1.5	46	0.8	0.1
Dallas Crown Carnivore	66	20	56	8	1.3	1.2	14	2.4	0.5
Natural Balance 5	70	17	60	11	2.3	1.1	23	na	0.5
Natural Balance 10	62	26	47	8	1.8	0.9	19	na	0.4
Natural Balance 15	62	22	61	7	1.9	1.3	19	na	0.4
Nebraska Canine	67	23	59	8	1.6	1.1	14	0.5	0.4
Nebraska Premium Canine	64	19	56	na	2.1	1.1	13	2.2	0.5
Nebraska Feline	62	32	50	13	1.4	1.1	7	1.1	0.1
Nebraska Premium Feline	66	21	58	na	2.2	1.1	14	2.4	2.4
Toronto Zoo Canine	70	30	50	na	0.7	0.6	16	2.2	0.1
Toronto Zoo Carnivore	70	25	50	na	0.7	0.6	18	3.5	0.2
Toronto Zoo Feline	70	30	50	na	0.8	0.7	11	2.2	0.2
Feline Nutrient Requirements		**9**	**26**		**0.6**	**0.5**	**5**	**0.5**	**0.1**
Carcass and/or Whole Meats:									
Beef (chunk)	55 -75	9-58	36-84	2-6	0.01-0.02	0.34-0.76	na	na	4-5
Chicken (whole carcass)	61-67	36-38	54-69	3-9	0.03-2.3	0.58 1.5	na	na	na
Deer (chunk)	72-74	9-10	83-87	4-6	0.02	0.76	na	na	7.6
Horsemeat (chunk)	71-73	10-20	51-78	4-5	0.02-0.07	0.67-0.81	2.6	na	na
Rabbit (whole)	75	9	85	4	0.05	0.89	na	na	na
Turkey (meat)	69-75	6-27	68-90	3-5	0.05-0.07	0.61-0.78	0.2-11.6	na	12-28

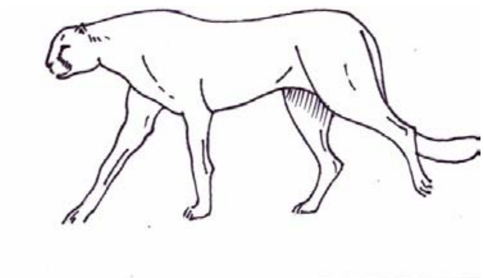
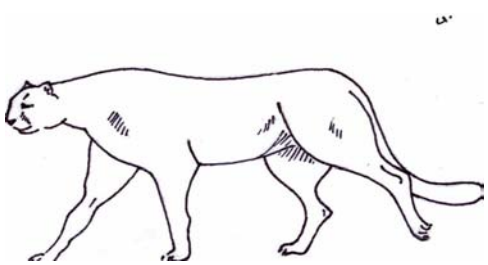
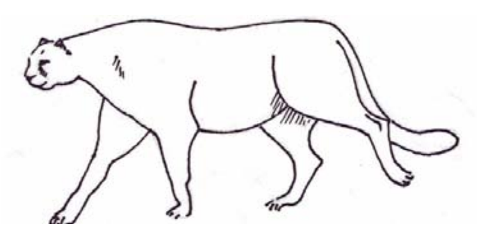
na = not available

Table 2. Comparative composition of selected nutrients in some mineral and/or vitamin/ mineral supplements utilized with meat-based diets for cheetahs and other large felids.

Nutrient – dry matter basis	%	IU/g		
Product	Ca	P	Vit A	Vit D
Bonemeal	30	13	-	-
Carmi (Kasper Faunafood)	11.4	0.5	275	45
Carnivore Supplement (Mazuri)	19	-	200	40
Carnizoo (Twilmij B.V.)	20	0.4	500	85
Centrum Multivitamin	11.6	7.8	3570	286
Chaparral Zoological Vitamins	2	1.6	642	428
Meat Complete (Central Nebraska)	28	4	582	60
Oasis Carnivore	1.5	1.5	555	58
Sundown Vit/Mineral	11	5	5000	400
Theralin VMP for Cats	5.2	5.5	499	20
Vet-A-Mix Carnivore Supplement	30	17	364	36
Wildtrax Feline Supplement	3-5	1.9	660	66

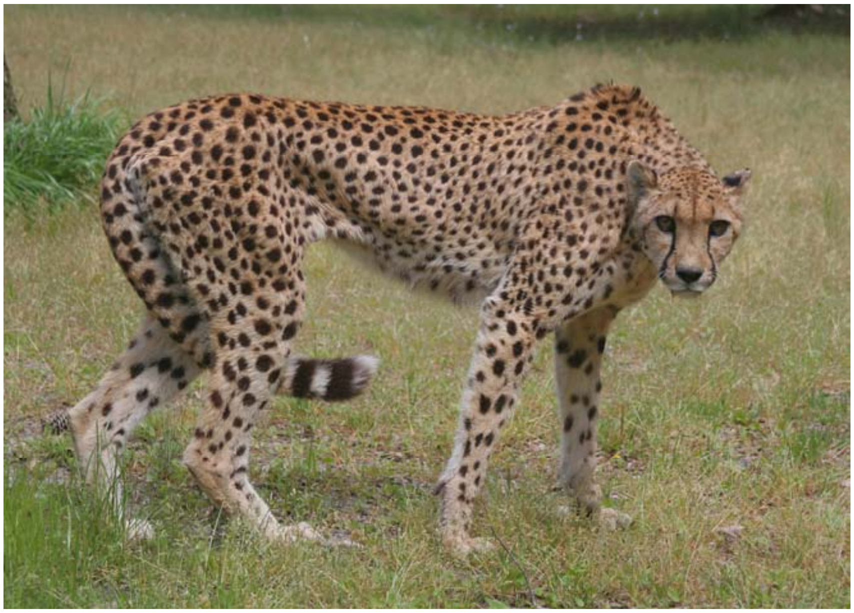
ZIMS Standard Terms for Body Scoring - Cheetahs

Term	Definition
1 – Emaciated 	Animal extremely emaciated; spinous processes, ribs, tail head, hip joints and lower pelvic bones projecting prominently; bone structure of shoulders and back easily noticeable; no fatty tissue can be felt.
2 - Very underconditioned	Animal emaciated; slight fat covering over base of spinous processes; transverse processes of lumbar vertebrae feel rounded; spinous processes, ribs, tail head, hip joints and lower pelvic bones prominent; shoulders and back structure faintly discernible.
3 - Moderately underconditioned 	Fat buildup about halfway on spinous processes; transverse processes cannot be felt; slight fat cover over ribs; spinous processes and ribs easily discernible; tailhead prominent, but individual vertebrae cannot be identified visually; hip joints appear rounded but easily discernible; lower pelvic bones not distinguishable; shoulders and neck accentuated.
4 - Slightly underconditioned	Slight ridge along back; faint outline of ribs discernible; tailhead prominence depends on conformation, fat can be felt around it; hip joints not discernible; shoulders and neck not obviously thin.

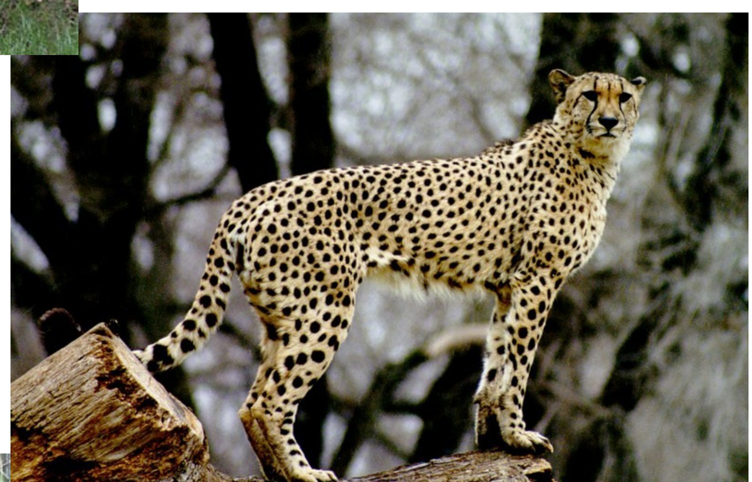
5 - Ideal condition 	Back is flat (no crease or ridge); ribs not visually distinguishable but easily felt; fat around tailhead beginning to feel spongy; shoulders and neck blend smoothly into body.
6 - Slightly overconditioned	Slight crease down back; fat over ribs spongy; fat around tailhead soft; fat beginning to be deposited behind shoulders and along sides of neck.
7 - Moderately overconditioned 	Crease down back; individual ribs can be felt, but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along behind shoulders and along neck.
8 - Very overconditioned	In mammals, crease down back; difficult to feel ribs; fat around tailhead very soft; area behind shoulder filled with fat; noticeable thickening of neck; fat deposited along inner thighs.
9 – Obese 	Obvious crease down back; patchy fat appearing over ribs; bulging fat around tailhead, behind shoulders and along neck.; fat along inner thighs may rub together; flank filled with fat.

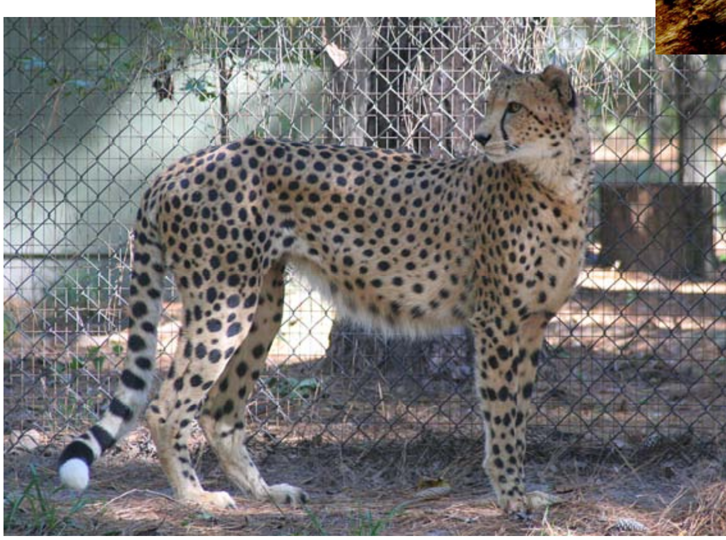
EMACIATED — 1

VERY UNDER CONDITIONED — 2

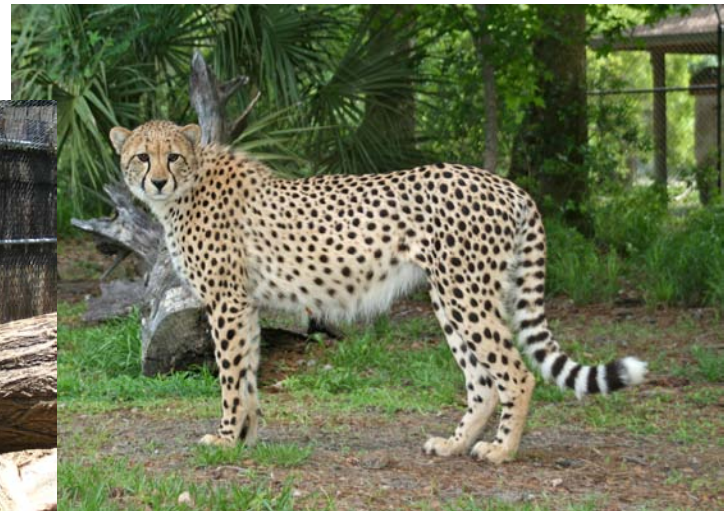


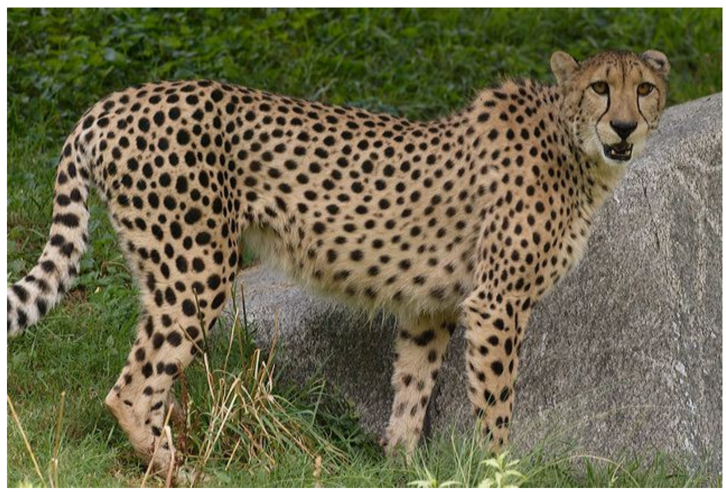
MODERATELY UNDER CONDITIONED — 3

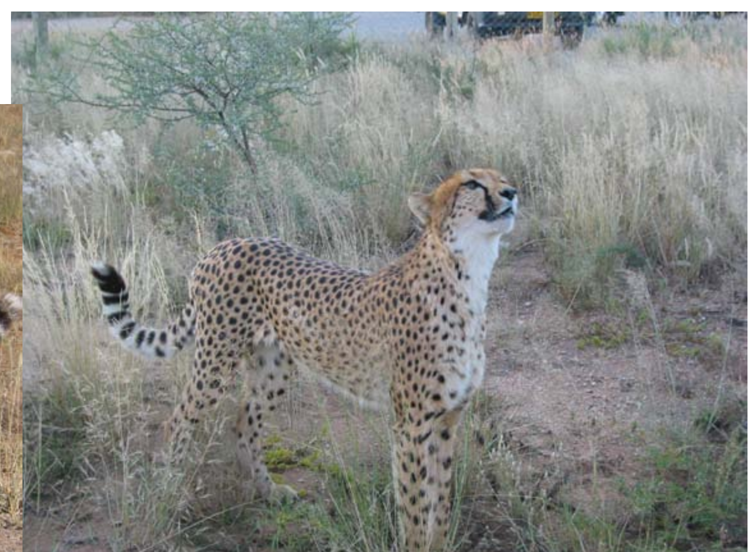


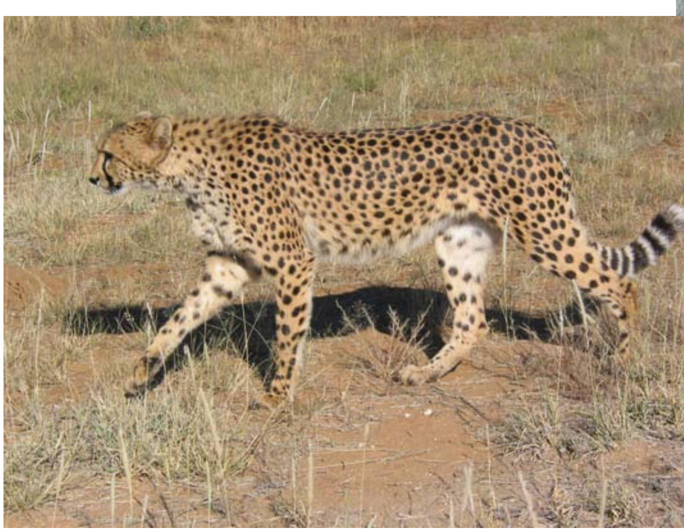


IDEAL CONDITION — 5

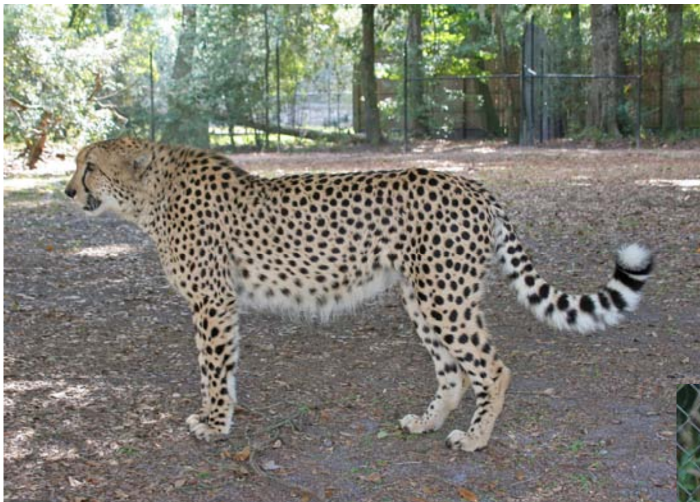


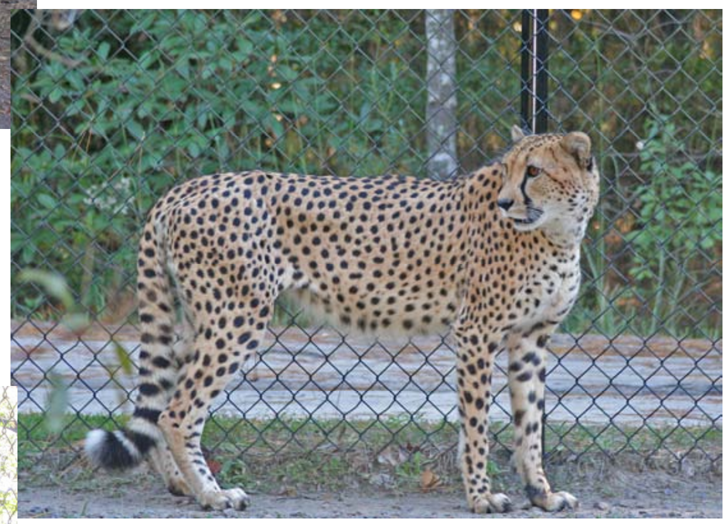




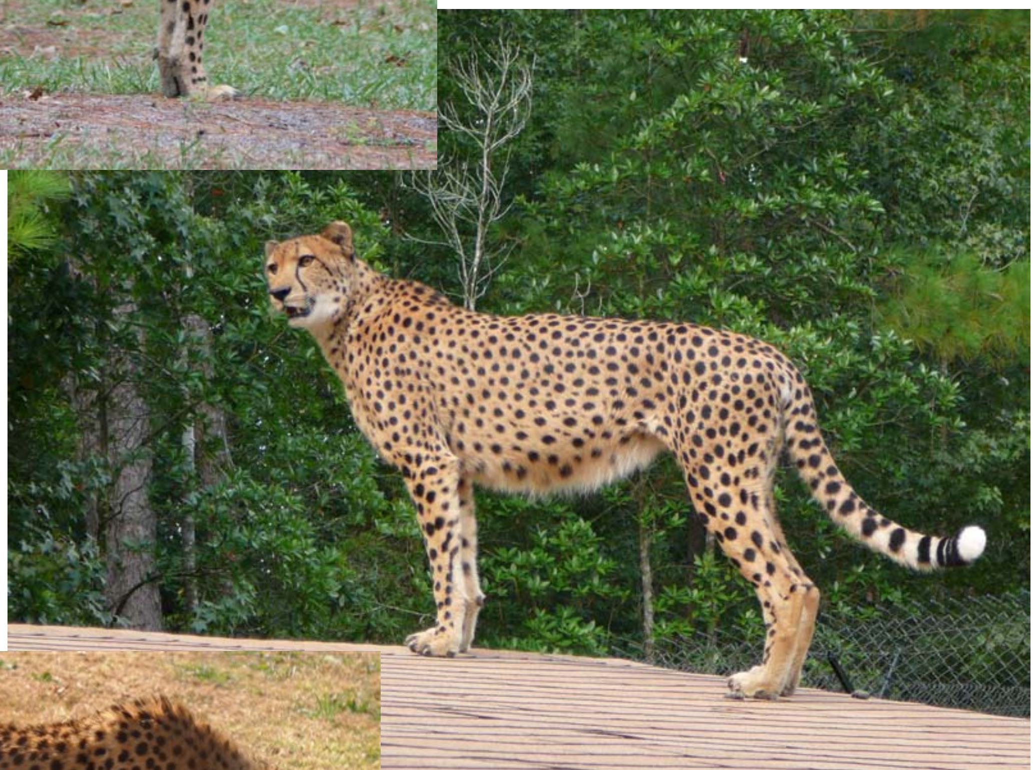


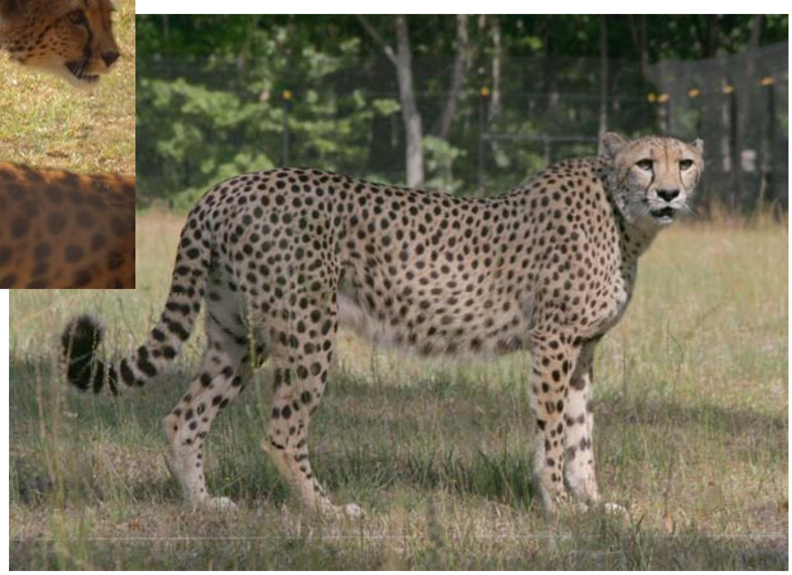
MODERATELY OVER CONDITIONED — 7



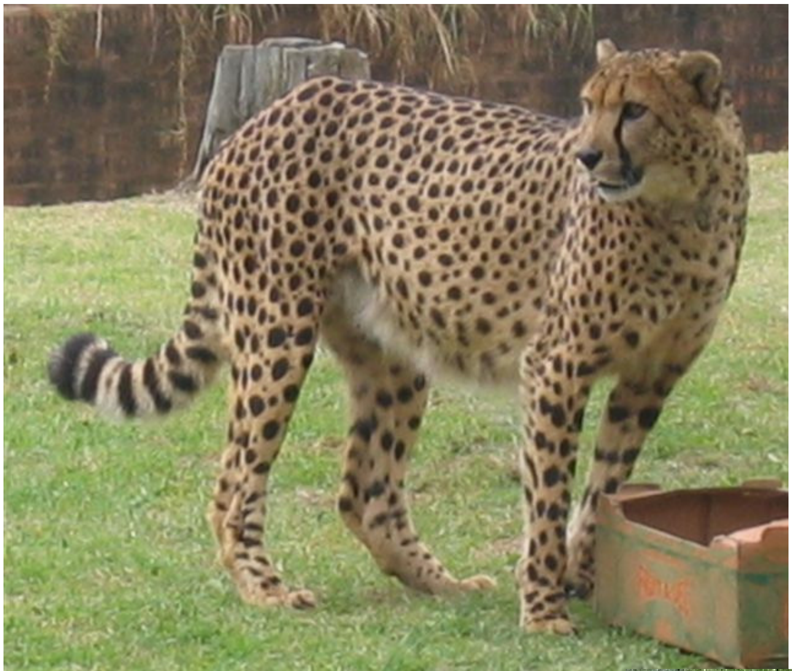


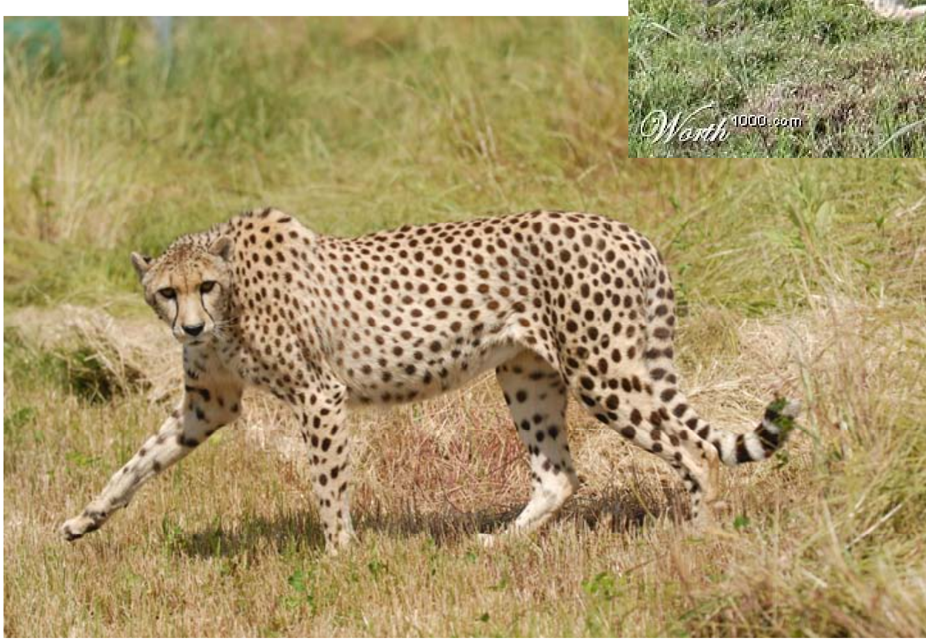
VERY OVER CONDITIONED — 8



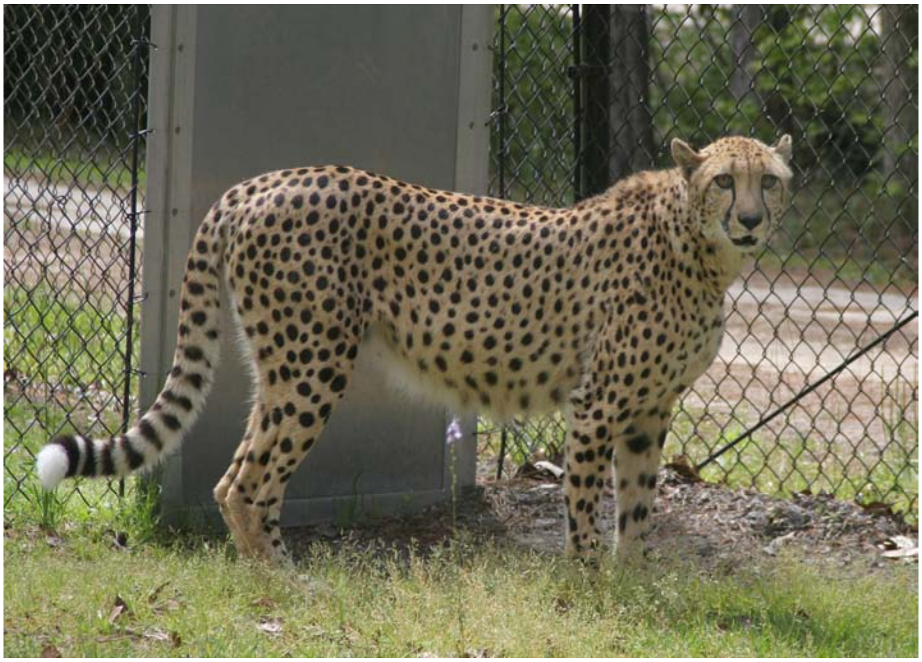


OBESE — 9

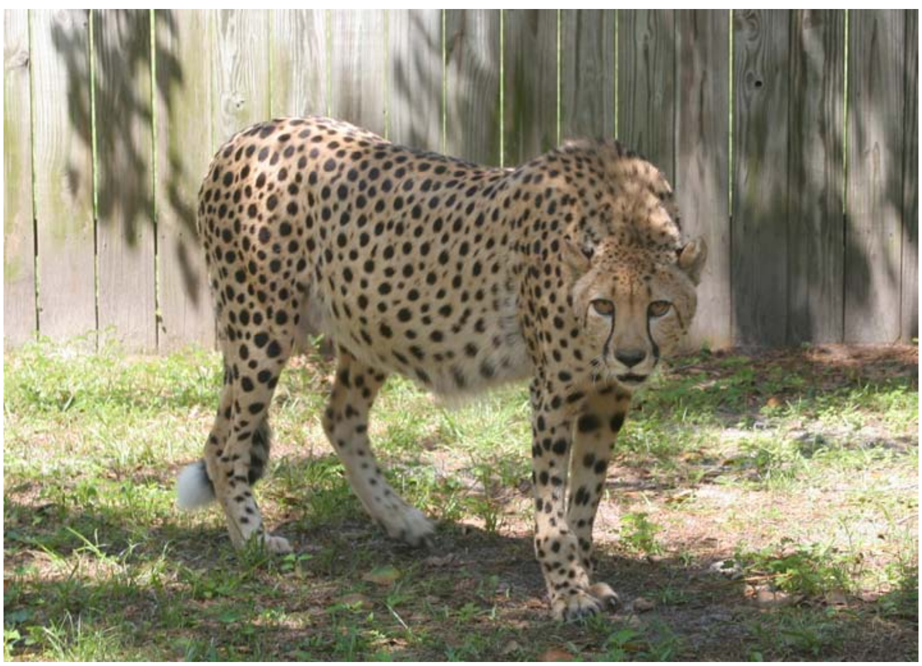




PREGNANT

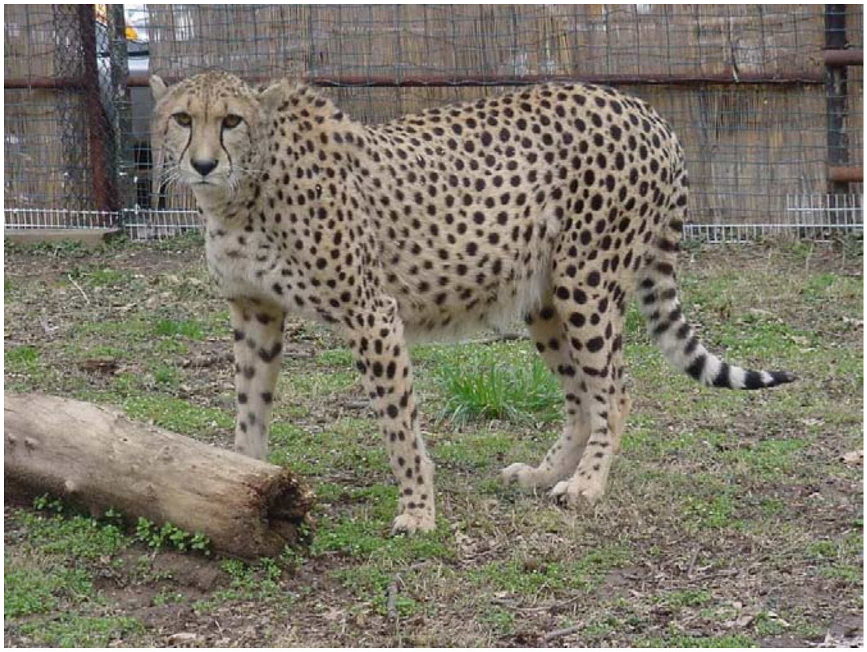


76 days pregnant with one cub

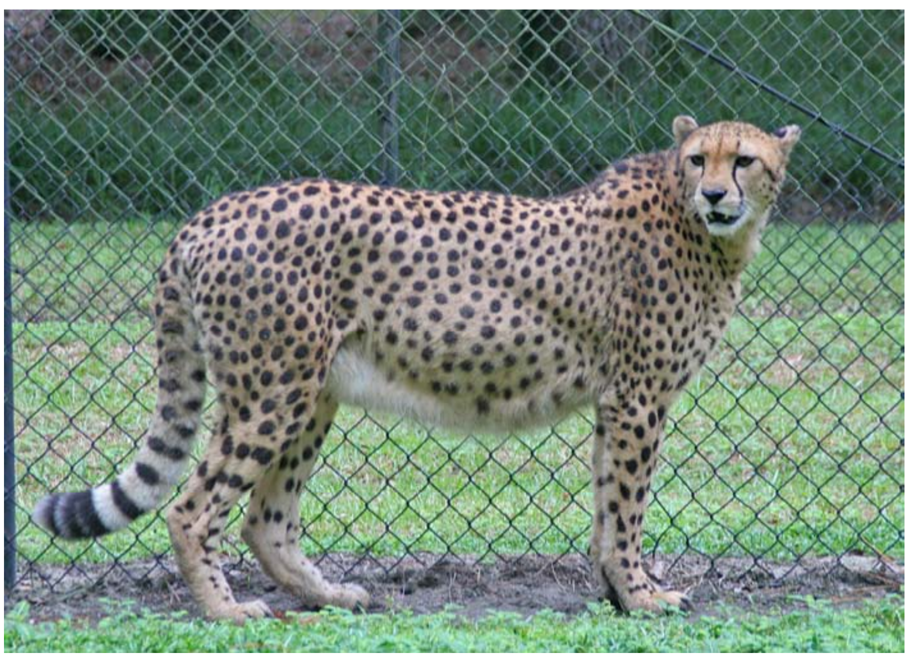


89 days pregnant with four cubs

PREGNANT



80 days pregnant with six cubs



87 days pregnant with seven cubs

CHEETAH SSP HEALTH CHAPTER

Revised 15 September 2007 by Drs. Scott Citino, Holly Haefele, Randy Junge, Nadine Lamberski, Modesto McClean, and Carlos Sanchez.

PREVENTIVE MEDICINE

A comprehensive and consistent medical program should be instituted in all facilities with cheetahs. Consistent programs will help to facilitate movement of cheetahs when they are transferred between institutions (e.g., for breeding) and will also facilitate disease monitoring of the SSP population.

A protocol of regular physical examinations should be established for ongoing preventative medical care. Complete physical examinations should also be performed at the time of more targeted examinations for specific health problems. The following tables provide required and recommended procedures to be performed during quarantine, pre-shipment, and routine physical exams. Appendix I describes the Standard Health Evaluation Protocol. Institutions may add other procedures to this list at the discretion of their veterinary team.

SSP Required Medical Procedures

Procedure	Quarantine	Routine Exam	Pre-shipment
Physical exam	x	x	x
CBC, blood smear for hemopara-sites, serum chemistries	x	x	x
FCoV, FIV, FeLV serology	x	x	x
Heartworm testing			x
Serum bank	x	x	x
Survey radiographs			x
Fecal ova and parasite screening	x	x	x
Fecal FCoV PCR	x		x
Immunizations	If needed	If needed	If needed
Dental prophylaxis	If needed	If needed	If needed
Body weight	x	x	x
Permanent identification (placement or verification)	x	x	x
Urinalysis	x	x	x

FCoV=Feline enteric coronavirus, FIV=Feline immunodeficiency virus, FeLV= Feline leukemia virus

SSP Recommended Medical Procedures

(These procedures are recommended in addition to the required procedures above)

Procedure	Quarantine	Routine exam	Pre-shipment
FPV, FHV, FCV, *Toxoplasma* serology	x	x	x
Heartworm testing	x	x	
Survey radiographs	x	x	
Fecal culture for enteric pathogens	x		x
Fecal FCoV PCR		x	
Gastroscopy and gastric biopsies	x	x	x
Abdominal ultrasound	x	x	x
Approved research requests	x	x	x

FPV=Feline parvovirus/panleukopenia, FHV=Feline herpesvirus, FCV=Feline calicivirus

<u>Recommended vaccinations</u>

- **Cubs**: Vaccinate for FHV, FPV, and FCV using a killed product (eg. Fel-O-Vax®, Fort Dodge) at 6 wks, 9 wks, 12 wks, 15-16 wks. Booster at 6 months. Vaccinate with killed (Imrab 3®, Merial) or canary pox-vectored subunit (PureVax Rabies®, Merial) rabies at 4-6 months and booster at approx. 1 year of age. The canary pox-vectored rabies vaccine (PureVax Rabies, Merial) appears to be safe and produces antibody titers in cheetah cubs (16 weeks and older) and adults (Citino, unpublished data).
- **Adults**: Regular vaccination with FHV, FPV, and FCV using a killed product (e.g., Fel-O-Vax®, Fort Dodge), and killed (Imrab 3®, Merial) or canary pox-vectored subunit (PureVax Rabies®, Merial) rabies (at 1-3 year intervals). Serum antibody titers can be monitored to evaluate response to vaccination and duration of titers.
- **Pregnant females**: Re-vaccinate for FHV, FPV, and FCV with a killed virus vaccine (eg. Fel-O-Vax®, Fort Dodge) three weeks pre-partum. Use of a MLV vaccine (PureVax Feline, Merial) is under investigation. If MLV vaccines prove safe, then vaccinate females 3 to 4 weeks prior to breeding with MLV vaccine and booster with a killed FHV, FPV, and FCV vaccine (eg. Fel-O-Vax®, Fort Dodge) at 3 weeks pre-partum.
- Vaccination for FCoV, CDV (Canine distemper virus), FeLV and FIV is not recommended at this time.

<u>Endoparasite control</u>

A parasite-monitoring program includes periodic, regular fecal examinations. Most internal parasite ova are from relatively common parasites from the orders Ascarididae and Strongyloidae (i.e., *Toxocara*, *Toxascaris*, *Ancylostoma*). Fecal examinations should be repeated after treatment to assess treatment efficacy. Not all eggs or larva observed in fecal examinations may be parasitic. The cheetah may be serving as a transport host depending on what it has been fed or what wild animals are consumed. *Coccidia* may be associated with feeding whole carcass specimens (e.g., whole rabbits). This emphasizes the need for specific identification of parasite species seen in feces and an awareness of the cheetah's diet.

The following anthelmintics are considered effective and safe when administered at the dosages listed:

- Pyrantel pamoate: 3-5mg/kg per os. Can be given at this level for 3-5 consecutive days.
- Fenbendazole: 5-l0mg/kg per os. Single day treatment most common, but can be given 3 consecutive days at this dosage.
- Ivermectin: 0.2mg/kg, subcutaneous or per os. Use of ivermectin monthly at a dose of 0.1 to 0.2 mg/kg has eliminated ascarids and kept a large collection ascarid free, as well as being used as a heartworm preventive (Citino, personal communication).
- Praziquantel: 5.5-6.6mg/kg per os or subcutaneously for a single treatment. Higher doses may be necessary, especially if treating cestodes such as *Spirometra* spp.(Citino, personal communication).
- Sulfadimethoxine: 50mg/kg SID parenteral or per os, as a coccidiostat.
- Trimethoprim-sulfa: 15mg/kg BID or 30 mg/kg SID per os, as a coccidiostat.

Heartworm prophylaxis

Heartworm testing (feline heartworm antibody test) and prophylaxis should be considered in endemic areas. Products and doses for prevention and treatment are extrapolated from domestic animals.

Ectoparasite control

Fleas, ticks, mites (*Cheyletiella* spp., *Otodectes* spp., *Notoedres* spp., *Sarcoptes* spp., *Demodex* spp.) chiggers, lice, biting flies, and hippoboscid flies (*Hippobosca longipennis*) can infest cheetahs. Fly strike (myiasis) can also occur in cheetahs with external wounds and lesions. The following products have been used on/in cheetahs (dosages similar to domestic animals) to control ectoparasites with no apparent side effects:

- Fipronil
- Methoprene
- Imidocloprid
- Lufenuron
- Nitenpyram
- Permethrins
- Ivermectin
- Lime Sulfur

Quarantine

The quarantine period allows observation and testing to monitor animals for infectious diseases and/or parasites before introducing them into the resident animal collection. A 30-day period is adequate to cover the incubation period of most infectious diseases. The evaluation of a new cheetah begins with a review of its past medical history, including details of any previous medical problems, past immunizations, fecal examinations, anesthetic episodes, serology results, and blood values. Medical history reports should be part of the health certificate and must be sent to the new facility before or when animals are transported. Newly captured animals or animals from non-accredited facilities may require a longer quarantine. Refer to: “AZA’s Guide to Accreditation of Zoological Parks and Aquaria and Accreditation Standards” (http://www.aza.org/Accreditation/Documents/AccredStandPol.pdf) or AAZV’s “Guidelines for Zoo and Veterinary Medical Programs and Veterinary Hospitals” http://www.aazv.org/associations/6442/files/zoo_aquarium_vet_med_guidelines.pdf.

Ideally, transition to a new diet should occur prior to shipment. If this does not occur, the cheetah's diet should be gradually changed to the new diet to minimize food refusal and gastrointestinal upset. It is not unusual to have a newly arrived cheetah stop eating because of the environmental change. In some cases it is advantageous to have some of the animal's previous diet accompany it, especially if the food is not available locally. To stimulate appetite, whole carcasses of rabbits may be offered. Feeding chickens is no longer recommended.

Following an acclimation period, a complete physical examination and diagnostic evaluation should be performed under general anesthesia. In addition to the Standard Health Evaluation Protocol (APPENDIX I), required procedures during quarantine include serology for FCoV, FIV, and FeLV and fecal FCoV PCR. Recommended procedures include vaccine serology (FPV, FHV, FCV), *Toxoplasma* serology, heartworm testing, enteric pathogen culture, survey radiographs, abdominal ultrasound, gastroscopy and gastric biopsies, and approved research requests. During the quarantine period, cheetahs should be screened for enteric parasites by repeated fecal examinations. Three exams are recommended. Body weights should be obtained on all cheetahs entering and leaving quarantine. Frequent assessment of body condition is recommended.

Pre-shipment

In addition to the Standard Health Evaluation Protocol (APPENDIX I), required procedures include heartworm testing, serology for FCoV, FIV, and FeLV and fecal FCoV PCR plus survey radiographs. Recommended procedures include vaccine serology (FPV, FHV, FCV), *Toxoplasma* serology, enteric pathogen culture, abdominal ultrasound, gastroscopy and gastric biopsies, and approved research requests. Cheetahs should be screened for enteric parasites by fecal examinations. Body weights should be obtained.

Post-mortem examination

Complete gross and histopathologic examination of all cheetahs that die is required. Samples should be archived for future use. Information on tissue collection, sampling, and storage, and on post-mortem examinations is provided in APPENDIX III. A standard necropsy protocol can also be found at http://www.vetmed.ucdavis.edu/whc/.

The Cheetah SSP also recommends ongoing comprehensive pathology surveillance by the SSP veterinary pathology advisor, Dr. Linda Munson (http://www.aazv.org) to monitor the prevalence of important cheetah diseases and detect the emergence of new diseases. Of particular importance at this time is determining the prevalence of FIP and coronaviral enteritis, as well as monitoring for new manifestations of coronaviral infection. This information will be critical toward improving our understanding of the prevalence of coronavirus, the risk of disease, and the types of disease that occur in infected cheetahs.

DISEASES (Much of the information for this section is taken from the Proceedings of the AZA Cheetah SSP Disease Management Workshop, June 8-12, 2005)

Extensive disease surveys and the extensive database maintained for cheetahs provide useful information on significant health and disease issues. There is considerable definitive and circumstantial evidence that chronic stress contributes to many of the health problems in captive cheetahs. The major causes of mortality in captive cheetahs in North America include gastritis, glomerulosclerosis, amyloidosis, veno-occlusive disease, and leukoencephalopathy. Disease agents of concern include *Helicobacter* spp., FCoV, FHP, FPV, and canine parvovirus (CPV). Foreign body ingestion has been documented in several institutions.

Noninfectious Diseases

Gastritis

Most North American captive cheetahs (99%) have lymphoplasmacytic gastritis and 65% have moderate to severe lesions. Gastritis also is prevalent in South African and European cheetahs (99 % and 81 %, respectively). Affected cheetahs may vomit/regurgitate, have chronic weight loss, pass abnormal feces, or have no clinical signs. Although gastritis is associated with *Helicobacter* spp. colonization, a direct cause-effect relationship has not been established, because gastritis does not resolve with antibiotic treatment and wild cheetahs have abundant *Helicobacter* spp., but only rarely develop gastritis.   Based on this notable contrast in prevalence between wild and captive populations and the character of the inflammation, an altered immune response to commensal bacteria is postulated. The role of chronic stress in modulating the immune response is under investigation.

Gastroscopy and gastric biopsies (see APPENDIX II) are the only definitive ante-mortem diagnostic tools to test for the presence of gastritis. There are multiple diagnostic tests for *Helicobacter* spp. infection including histopathology, impression smears, and urease testing of gastric biopsies, breath tests for labeled CO_2, serum antibodies, and fecal PCR. However, *Helicobacter* spp. are ubiquitous within the population, and their presence does not correlate with gastritis.

There are multiple published protocols for treatment of gastritis (Wack et al, 1997; Lane at al, 2004; Citino and Munson, 2005). Treatment for gastritis is only recommended in cheetahs with clinical signs (i.e., weight loss, persistent vomiting/regurgitation). Cheetahs with persistent vomiting/regurgitation should be evaluated for the presence of a hiatal hernia and/or abnormal lower esophageal sphincter function. Currently, the most effective treatments for gastritis are triple therapies using a proton pump inhibitor and two antibiotics such as lansoprazole-clarithromycin-amoxicillin, omeprazole-clarithromycin-amoxicillin, etc. (Lane, et al. 2004; Citino and Munson, 2005). Most treatments are effective in reducing clinical signs and to some degree temporarily eradicating *Helicobacter* spp. Currently, no treatments have been proven to provide long-term reduction in gastritis or eradication of *Helicobacter* spp. Cheetahs with chronic gastritis and/or regurgitation may need to be fed multiple times per day to provide adequate caloric intake.

Renal Disease

Systemic AA amyloidosis affecting the kidney, liver, and other organs is highly prevalent in all captive populations (38% NA; 82% SA; 48% Europe) and is the cause of death in many cheetahs. The amyloid is deposited in the interstitium of the kidneys, along sinusoids in the liver, in the lamina propria of the GI tract, and in the interstitium of endocrine organs. The occurrence of amyloidosis is highly correlated with chronic gastritis. There are no specific tests, other than organ biopsy, to detect amyloid at this time. Standard diagnostic tests for renal function are helpful, but these tests cannot differentiate renal failure due to glomerulosclerosis or pyelonephritis from that due to amyloidosis. Endogenous creatinine clearance and fractional excretion of electrolytes (i.e., Na, K, P, Ca) may provide earlier diagnosis of decreased renal function than BUN/creatinine. The sensitivity of serum AA and urine or serum osmolality is not known. Ultrasound is an insensitive diagnostic tool for this disease. Dietary management and standard therapies for managing renal disease may be beneficial. Changes in management to reduce stress may be recommended as the risk factors for gastritis are identified.

Glomerulosclerosis is characterized by progressive thickening of the glomerular basement membrane that leads to glomerular ischemia and sclerosis. The lesion resembles that of diabetic nephropathy which results from hyperglycemia and subsequent glycosolation of basement membrane proteins. The lesion also is similar to rat nephropathy which has both genetic and dietary predisposing factors. The reason for the high prevalence in captive cheetahs is not known, but the relative absence of this lesion in wild cheetahs, suggests an extrinsic cause. Either diet or metabolic changes due to chronic stress are suspected. The prevalence in NA cheetahs is 67% (23% with moderate to severe disease); 80% in European cheetahs; and 71% in South African cheetahs.

Standard diagnostic tests for renal function will detect end stage lesions. Endogenous creatinine clearance and fractional excretion of electrolytes (i.e., Na, K, P, Ca) and possibly urine protein/creatinine ratio may provide earlier diagnosis of decreased renal function than BUN/creatinine. Dietary management and standard therapies for managing renal disease may be palliative. Changes in management may be recommended if risk factors are identified.

Veno-Occlusive Disease (VOD)

Veno-occlusive disease is caused by fibrous occlusion of the afferent blood supply of the liver (central and sublobular veins), resulting in progressive liver failure and ascites. The cause of this condition is not known. The prevalence varies by region and over time, features that may elucidate risk factors in a meta-analysis across all populations. The prevalence in the NA population is 63% with 18% having moderate to severe disease, whereas only 10% of SA cheetahs and one wild cheetah had moderate to severe VOD. No European cheetahs with moderate to severe VOD have been identified.

The most sensitive ante-mortem diagnostic test is a wedge liver biopsy. Ultrasound may also provide information in chronic or severe cases. Liver enzymes are not sensitive indicators of chronic disease. Standard therapies for liver disease may improve clinical signs. S-adenosylmethionine may be of benefit.

Leukoencephalopathy

Leukoencephalopathy is a serious degenerative disease affecting only North American cheetahs. The lesion is characterized by bizarre astrocytosis and loss of white matter in the cerebral cortex. The most common clinical signs are blindness or visual abnormalities, obtundation, behavior change, and ataxia. The disease emerged in 1996, peaked between 1998-2001, and is now rare. Sixty-seven animals have been affected to date at 28 different facilities. Most affected animals are at least 10 yrs old. The cause is unknown, but epidemiological features suggest exposure to an exogenous agent through diet or medical management. MRI is the most sensitive ante-mortem diagnostic. Histopathology can confirm the disease. Rule out feline spongiform encephalopathy and CDV. Treatment is supportive.

Myelopathy

Myelopathy is a serious neurological disease found principally in young European cheetahs. At least 60 cases have been identified, many of which resulted in death. The disease is characterized by axonal and myelin loss in the spinal cord without associated inflammation. A few cheetahs with similar lesions have been identified in the SA and NA populations, but these cases were attributed to copper or other dietary deficiencies. The clinical onset can be acute and has been linked to stressful events and/or herpesvirus infection.

Diagnosis is based on characteristic clinical signs (ataxia, paresis) and histopathology. Feline spongiform encephalopathy should be ruled out. MRIs have not been shown to be useful in detecting cases. Supportive care and symptomatic treatment are the only available therapies.

Lipomas/lipomatosis

- Lipomas, myelolipomas and lipomatosis (infiltration of normal adipocytes) are common in the liver and spleen of captive cheetahs (51% NA; 54% Europe; 13% SA), but only one case has been identified in wild cheetahs. These lesions are not clinically important, but should be recognized because they have been misdiagnosed as metastatic cancer. The cause is not known, but dietary or stress-induced metabolic alterations are suspected. These lesions are easily identified using standard imaging procedures such as ultrasonography. Treatment is unnecessary as these lesions do not interfere with organ function.

Mastocytosis

Mast cell “tumors” and generalized mastocytosis are being seen with some frequency in captive cheetahs. Cheetahs may present with single or multiple firm raised skin masses. Uninformed pathologists may grade these out as highly malignant mast cell tumors and give a poor prognosis, however, they generally disappear on their own. They may be associated with insect bites. A few cheetahs have been seen with generalized or regionalized severe exudative dermatitis with mast cell infiltration. These cheetahs are often uncomfortable and lose weight. This lesion has been very responsive to short term corticosteroid therapy and may have an allergic etiology.

Foreign body ingestion

The use of enrichment items such as rubber toys, plastic boomer balls, cardboard boxes, lures, inappropriately sized bones, horse tails, etc. have resulted in choking and gastrointestinal obstructions. Vomiting and anorexia are common clinical signs of impactions. A careful history may help diagnose this condition.

Toxicities

- Drugs known to cause adverse reactions in cheetahs include griseofulvin and metronidazole.
- The use of neuroleptics (such as haloperidol and zuclopenthixol acetate) may result in extrapyramidal effects.
- Several occurrences of oxalate nephrosis have occurred in North American cheetahs. Cheetahs of all ages have been affected. Clinical signs are typical of acute renal failure. The source of oxalates is frequently not identified, although accidental contamination of food is suspected. A definitive diagnosis can be made by urinalysis, serum chemistries, and a Heska test. In addition to supportive treatment, cheetahs could be treated with ethanol.

Nutritional considerations

- Due to disease concerns (Avian Influenza), the feeding of poultry carcasses to carnivores is no longer recommended.
- There have been numerous reports of carpal valgus deformities in hand-raised cheetah cubs. Cubs show varying degrees of carpal enlargement, carpal valgus deviations, and loosening or weakness of the carpal support structures with hyperextension. These growth deformities are likely a nutritional problem associated with commercial kitten milk replacers (KMR, maybe others). Early addition of meat to the diet (3 weeks), early weaning (6 weeks), and sufficient exercise will reduce the severity of this problem and allow self-correction. More severe deformities are often seen in cubs with other health issues and reduced growth rates. Splinting is generally only required in older cubs with more severe deformities.
- One of the most common types of nutritional disorders is the imbalance of dietary calcium and phosphorus, presenting as a developmental bone malformation (osteodystrophy) due to insufficient supply of dietary calcium. Excessive supplementation of calcium is also known to contribute towards a developmental deformity of the forelegs (osteochondrosis dissecans), enlarged joints, splayed feet, angular limb deformities (in cubs, may not be due to Ca:P alone), and stunted growth. Food items such as muscle meat, liver and heart have a skewed Ca:P ratio in favor of phosphorus. It is probable that cheetahs, like other felids, cannot synthesize adequate vitamin D_3 simply through sunlight exposure, thus this nutrient must also be included in diets provided. Commercial diets contain greater amounts of vitamin D_3 than supplemented meat diets.
- Milk clots can occur in hand-reared cubs and gastric impactions can occur when hand-reared cubs are first fed commercial meat products. Pancreatic enzymes, fluids, abdominal massage, exercise, and metoclopramide have been effective in medically managing these cases.
- Lateral head tremors in association with ataxia, partial collapse, loss of balance, paralysis of the hind limbs, and a staggering gait are among the known signs of copper deficiency in cheetahs. The condition has also resulted in fatal respiratory distress in some cubs. While treatment with dietary copper is usually effective in reversing any symptoms, chronic deficiency can render the effects permanent. Feeding copper deficient diets to pregnant cheetahs can result in severe long bone deformities in cubs.
- Pre-formed vitamin A is an essential nutrient for felids, so must be provided in the diet. As a fat-soluble vitamin, it is stored in the body, so it is not required on a daily basis. Excessive amounts of vitamin A can accumulate in the body to toxic levels, and are associated with skeletal malformations and fractures, internal hemorrhage, enteritis, conjunctivitis, and reduced function of liver and kidneys, in growing animals. There is a potential for hypervitaminosis A if feeding organ meat (esp. liver) along with commercial diets.

- Cheetahs can be very difficult to switch to new diets, so diet transitions should occur slowly and with caution. Some animals may not convert over to new diets. Diet transitions should occur prior to shipping to a new institution so any problems in diet transition can be identified.

- Cheetahs are very sensitive to changes in commercial diet formulation so if cheetahs refuse to eat the diet, diet analysis may be indicated.
- Consider feeding higher fat diets to promote weight gain on an individual animal basis.
- Food-born diseases, such as salmonellosis and clostridial disease, have been associated with raw meat diets. When feeding hand-raised cubs, cooking the meat may reduce these infections.
- Due to inconsistencies in formulations, it is recommended that commercial meat diets used to raise cubs be analyzed to ensure nutritional content.
- Fragments from rib bones can pack into palatine recesses and oral-nasal fistulas can result.
- Consider freezing carcasses (esp. deer) for 48hrs to reduce exposure to viable *Toxoplasma* cysts.
- Good nutrition is needed to maintain healthy oral structures. Offering bones helps promote good gingival health when cheetahs are maintained on a soft diet.
- Appetite stimulants that are effective in cheetahs include benzodiazepines and B vitamins. Feeding whole prey or live prey may also be effective.

Infectious Diseases

<u>Feline Coronavirus (FCoV)</u>

Feline enteric coronavirus is widespread in the North American cheetah SSP population, despite previous efforts to prevent infection. Based on limited surveillance, it can be estimated that at least 50% of the North American SSP population has been exposed to coronavirus because of the presence of virus in feces (fecal shedding) and/or positive serology. Even with this high prevalence, the SSP pathology surveillance has detected only 6 cases of FIP since 1988, indicating that FIP is very rare in cheetahs. However, coronaviral-induced colitis may be an emerging disease of concern in the population. Coronaviruses change in pathogenicity over time, so it is important to get a current picture of the extent of infection in the SSP population and to be vigilant for new clinical manifestations of FCoV infection. FCoV should be considered a differential in cases of neonatal diarrhea.

Given that it is unfeasible for an active SSP to maintain a population that is totally free of FCoV, our aim is to manage the population to minimize disease, but not prevent or eliminate the infection.

FCoV Management Recommendations

Cheetahs may be transient, intermittent, or persistent shedders of coronavirus. Shedding status may not correlate with serology and even persistently shedding cheetahs do not necessarily develop disease. The SSP requires testing prior to movement of cheetahs between institutions (during the preshipment and quarantine examinations). Animals that test positive should be retested to determine if they are persistent shedders. **However, evidence of the virus, either from serology or fecal PCR, should not be a significant deterrent to the movement of cheetahs between institutions.** Remove persistent shedders (animals shedding FCoV for at least one day monthly over a 6 month period) from breeding facilities. Persistent shedders are more likely to have replicating virus, providing more opportunities for a pathogenic virus to emerge through mutation. If a persistently shedding cheetah is genetically valuable, consider artificial reproductive techniques (ART) to enable them to contribute to the population. House persistent shedders away from other susceptible animals. Persistent shedders would best be placed as exhibit (not breeding) animals.

- If disease were to appear within a population, the facility should implement standard disease control protocols. Testing for persistent shedders should be implemented.
- If a cheetah develops colitis, coronavirus should be considered a possible differential and testing to rule out coronavirus should be pursued (preferably by biopsy and immunohistochemistry). Tissue biopsies for histopathology should be submitted to the AZA Cheetah SSP Pathologist (Dr. Linda Munson, University of California, VM-PMI, 4214 VM3A, 1 Shields Ave, Davis, CA 95616).
- Cheetahs with abnormal stool should be tested for coronavirus by PCR.

FCoV Surveillance Recommendations

All cheetahs in the SSP population are to be screened pre-shipment and during quarantine plus during routine examination if possible. Testing should include 1) serology for both Type I and Type II coronaviruses and 2) PCR for fecal shedding (5 consecutive fecal samples stored at -20 or -70^{o}C). A cheetah that has a positive PCR test should have 3 consecutive fecal samples retested monthly for 6 months to determine if it is a persistent shedder. All serology and fecal PCR should be conducted at the University of Tennessee College of Veterinary Medicine Virology Lab by Dr. Melissa Kennedy (submission information and forms can be downloaded from http://www.vet.utk.edu then click on Diagnostic Services, then Virology; or email Melissa Kennedy at mkenned2@utk.edu.

Feline Herpesvirus (FHV)

Infection with feline herpesvirus is widespread in the SSP population and possibly ubiquitous in cheetahs. Initial signs of disease from FHV infection are sneezing and watery eyes. In most animals over a month of age, these mild signs will be self-limiting. A small percentage of neonatal cubs may die from acute infection (usually from FHV-associated pneumonia) or may develop severe and persistent lesions such as corneal ulcers or scars, chronic keratitis, blindness, prolapsed third eyelids, chronic epiphora, or ulcerative dermatitis. All infected animals become chronic FHV carriers, and a small percentage will have a recrudescence later in life. Rarely, chronic carriers develop severe ulcerative dermatitis at sites exposed to lacrimal and salivary secretions or persistent, non-resolvable ocular signs such as prolapsed third eyelids or corneal scarring. Cubs that are exposed and develop lesions prior to two weeks of age appear to develop the worst and most persistent lesions. These infections are probably the result of failure of passive transfer of specific anti-herpes antibodies to the cubs. It appears that having large numbers of highly vulnerable naive cubs of all ages at one time exacerbates the spread of the disease in populations. Certain females appear to consistently infect their young at an early age, leading to severe lesions. The source of the virus in cubs is suspected to be the dam. In most cases, the infection is self-limiting. However, in collections where severe or repeated cases have occurred, removing the cubs from the dams and hand raising them can control the disease.

Current vaccination protocols have not proven to be a reliable preventive measure. Therefore, we recommend that blood be taken for serology at routine exams and submitted to the Cornell University Diagnostic Laboratory to determine the level of protection in the vaccinated population with the understanding that these tests cannot distinguish between natural and vaccine viral exposure. Most currently available tests are serum neutralization tests. Submission information is available at http://www.diaglab.vet.cornell.edu and any questions on cases can be addressed to Dr. Dubovi at 607-253-3923. PCR tests on conjunctival biopsies or swabs may be necessary to determine active shedding. Viral isolation from conjunctival biopsies or swabs of the conjunctiva, nasal or oropharygeal region followed by sequencing is recommended to identify and characterize the virus. Swabs should be sent in transport media or saline and shipped overnight on cold pack. Treatment with corticosteroids before biopsy may increase the detection of low level or latent shedders.

Evidence of the virus, either from testing or prior clinical signs, should not be a significant deterrent to the movement of cheetahs between institutions. The Cheetah SSP will make recommendations to manage the cheetah population to minimize disease, not prevent or eliminate the infection. Cheetahs within institutions should be managed to minimize potential virus transmission with other species susceptible to feline herpesvirus, such as the Pallas cat.

FHV Management Recommendations

Management of Outbreaks

- Identify clinical signs consistent with the disease. In order to learn more about the typical course of disease in cheetahs, we recommend mapping any lesions that develop and recording the time course of these lesions. Recording the location of affected animals and contact animals also is recommended.
- Implement isolation or quarantine procedures immediately. The virus is spread by fomites, often carried

by caretakers, and can be difficult to contain. Control procedures may include minimizing contact of the affected animal with other susceptible animals via spatial separation, physical barriers, or other mechanisms. Animal caretakers should use maximum hygiene methods that promote isolation of the infection to one area. Methods include separate coveralls, foot baths, boots and gloves, separate tools for animal care, and temporal separation of care of sick from healthy animals, such as care taking for the symptomatic cat at the end of the day. Alternatively, assign keepers solely to infected animals.

- Confirm the infection via virus isolation from intranasal swabs and/or biopsies of lesions. All samples from Cheetah SSP institutions should be submitted to Cornell University Diagnostic Laboratory for viral isolation. Submission information can be found at http://www.diaglab.vet.cornell.edu, and Dr. Dubovi can be reached to address questions on cases at 607-253-3923. The laboratory will bank the isolated virus and store it in a -70 degree freezer for future characterization. Serum samples should be collected for measuring antibody titers. Tissue biopsies for histopathology should be submitted to the AZA Cheetah SSP Pathologist (Dr. Linda Munson, University of California, VM-PMI, 4214 VM3A, 1 Shields Ave, Davis, CA 95616).
- Therapies: Antibiotics such as amoxicillin or doxycycline are beneficial to prevent secondary bacterial infections. Interferon may be helpful if available. Most guanine analogue antiviral drugs (e.g., acyclovir) do not seem to be helpful and carry some risk of bone marrow suppression (especially in young cubs), requiring monitoring if used. Famciclovir has shown some efficacy in treatment of herpesvirus infections in domestic cats and has been used in a few cheetahs without side effects (Haefele, personal communication). Many standard ophthalmic treatments (e.g., trifluridine, Viroptic®) seem to be painful to use in affected cheetahs. Idoxyuridine, formulated by a compounding pharmacy, causes less pain and seems to be beneficial. An ophthalmic preparation of cidovovir has been found effective in domestic cats. Cidovovir must be compounded (0.5% in carboxymethyl cellulose) and is expensive, but is effective when administered only twice a day. The dietary supplement l-lysine at up to 2,500 mg/day may reduce lesions or shedding of virus. Cryotherapy can be effective in treatment of skin lesions.
- Domestic cats shed virus for about 20 days, however some cheetahs have shed virus for much longer. Keep cheetahs isolated for a minimum of 7 days after all lesions and symptoms have cleared. The virus is probably only viable in the environment for less than 72 hours after a shedding animal has been removed from the enclosure.

Management of Pregnant Females

- Minimize stress for the dam and cubs.
- Temporally space breedings and births of litters in order to minimize the number of susceptible cubs at any one time.
- Physically separate pregnant females as much as possible from other animals.
- Utilize isolation/quarantine procedures as much as possible to prevent potential transmission to the pregnant female.
- Vaccinate females before breeding and then 2-3 wks before cubbing date because colostral antibody enhancement may be beneficial to neonates by reducing severity of lesions if exposed to the virus. Use of MLV vaccine is under investigation. If MLV vaccines prove safe, then vaccinate females to be bred with MLV vaccine and then vaccinate again with a killed FHV vaccine at 3 weeks pre-partum.
- Possibly administrating banked hyperimmune serum from recently vaccinated animals to susceptible cubs could prevent or minimize infection.
- Provide l-lysine as a dietary supplement at up to 2,500 mg/day to dams.

Management of Cubs

- Early detection provides an opportunity to minimize the severity of the lesions the cubs may develop. Visually check cubs at 3 days or as soon as the behavior of the female will allow it. Most animals are managed completely hands off in the first few days after cubbing. Cubs will not develop herpesvirus signs until 3 to 4 days of age at the earliest.
- If lesions develop, document the character and progression of lesions with photographs if possible and provide that information to the Cheetah SSP veterinarian, so that FHV disease can be better characterized in cheetahs.
- If severe lesions are developing, consider removing the cubs from the dam and hand rearing the cubs. Experience indicates that if cubs are removed from the mother, the lesions will immediately

begin to subside. If cubs remain with a female that is shedding virus, lesions in the cubs will continue to progress and become more severe.

- When checking cubs, perform a complete exam and consistently record the information including body weight. Collect blood samples for antibody titer research if possible. Bank serum from cubs for future immunoglobulin quantification.
- Provide cubs l-lysine (120 mg) orally.
- Keep herpesvirus-positive cubs strictly isolated from herpesvirus-negative cubs. Implement some level of isolation or quarantine procedures immediately, according to institutional circumstances.

Management of cats just prior to and after shipment

- Since stress may precipitate clinical disease from FHV, known positive cats should be treated with L-lysine for several weeks before and after shipment. Shipping animals with active lesions should only be done if clinical signs are mild and if stress can be minimized.

Enterocolitis

Acute enteritis associated with fever has been seen at White Oak Conservation Center (WOCC). Astrovirus was diagnosed using fecal electronmicroscopy and PCR. This may be an emerging disease in captive cheetahs.

Uncomplicated colitis is a very common health problem in adult captive cheetahs. Cheetahs with uncomplicated colitis generally have abnormal stool and, otherwise, appear completely normal. Abnormal stools vary greatly, but generally, are soft, larger in volume than normal, discolored, and have varying amounts of mucus and fresh blood present. These abnormal stools are generally intermittent and associated with tenesmus. The most common etiologies seen at WOCC are *Clostridium perfringens* enterotoxicosis (CPE), *Plesiomonas shigelloides*, salmonellosis, and feline enteric coronavirus (FeCoV). Definitive diagnosis of CPE requires the identification of *C. perfringens* enterotoxin in feces by latex bead agglutination or PCR. Cheetahs should be screened for *Salmonella* ssp. and *Plesiomonas shigelloides* in cases of enteric disease. Infection with *Salmonella* bacteria may require antibacterial drugs and supportive care. Salmonellosis is a zoonotic disease. FeCoV can be identified in feces by electron microscopy or PCR.

Canine Parvovirus (CPV) or Feline Parvovirus/Panleukopenia Virus (FPV) Infections

Chronic diarrhea and mild necrotizing enteritis have been associated with canine parvovirus and feline panleukopenia virus in cheetahs. These infections occurred in vaccinated cheetahs, although serum titers of antibodies against parvovirus were not measured. Most cases that have been followed up with genetic sequencing have been CPV-2b strains. Transmission from dogs has been likely. FPV has been less common probably due to recommended vaccination programs. Parvoviral-associated deaths have occurred in neonatal cheetah in South Africa, probably related to prolonged vaccination intervals in the dam. Current vaccination protocols for feline parvovirus may be inadequate to prevent infection with canine parvovirus (CPV-2b strains) in most cheetahs. Late pregnancy booster with a killed vaccine may enhance antibody titers in colostrum. Ante-mortem diagnostic tests include rising antibody titers on paired serum samples and antigen capture ELISA, virus isolation, electron microscopy or real-time PCR assays on feces, services provided by the University of Tennessee virology laboratory (for submission forms and information visit *www.vet.utk.edu* – click on Diagnostic Services, then Virology).

Feline Leukemia Virus (FeLV) and Feline Immunodeficiency Virus (FIV)

Subclinical infections have been reported rarely in captive cheetahs. One Namibian cheetah infected with FeLV developed viral-associated lymphoma. This animal presumably acquired the virus from an infected cheetah in the adjacent enclosure. There currently is no recommendation to vaccinate, but screening sera from all cheetahs at routine exams and isolation of infected animals is recommended.

Canine Distemper Virus (CDV)

There is widespread CDV exposure (confirmed by serum antibodies) of cheetahs in some regions (wild cheetahs in Namibia, all cheetahs tested in Europe to date), but clinical disease has not been noted. Because of the low apparent disease risk, there is no recommendation to vaccinate at this time.

Dermatophytes

Microsporum spp. is a common cause of hair loss in young cheetahs. *Trichophyton* spp. have also occasionally been found. Treatment is similar to that in the domestic cat. There is potential for zoonotic disease exposure, particularly from hand-reared cubs.

Toxoplasmosis

Cheetahs with neurologic and respiratory signs or with myositis should be screened for systemic protozoal infections by serologic tests. Symptoms do not always occur but may include anemia, retinitis, iritis, hepatitis, blindness, central nervous disorders, respiratory distress, and diarrhea. Cubs with pre-existing conditions or under particular stress (e.g., worm burdens, during weaning) are most likely to show symptoms. Infection of felines may occur in utero, or from the ingestion of oocysts in contaminated feces or eating infected intermediate hosts such as mice or infected meat. Toxoplasmosis is diagnosed through the presence of oocysts (fertilized cells of the protozoan) in feces or through histopathology. Immunological tests are available to determine exposure.

ANESTHETICS AND ANALGESICS

Appropriate preparation for anesthesia enhances the safety of the procedure. Cheetahs should be fasted for approximately 8-12 hours prior to an elective procedure. Water should be withheld for at least 6-12 hours, unless medical concerns or weather are a factor. Drug administration should be done in a small area, preferably a restraint cage. Animals that are calmer usually require lower drug dosages and have a smoother induction. If remote drug delivery is necessary, it is best to use the less traumatic lightweight plastic darts or pole syringe.

Injectable anesthetic recommendations (intramuscular unless specified)

Drug(s)	Dosage(s)	Comments
Ketamine	K: 0.2-1 mg/kg IV	6, 7, 11
Ketamine:xylazine	K: 5-10 mg/kg X: 0.5-1.1mg/kg	1, 6, 7, 9, 10
Ketamine:xylazine:midazolam	K: 3-4 mg/kg X: 0.75-1.5 mg/kg Mi: 0.03-0.04 mg/kg	1, 4, 6, 7, 9, 10
Ketamine:medetomidine	K: 2.5mg/kg Me: 0.05 mg/kg	2, 6, 7
Ketamine:medetomidine:butorphanol	K: 3 mg/kg Me: 0.03 mg/kg B: 0.3 mg/kg	2, 3, 6, 7
Medetomidine:midazolam:butorphanol	Me: 0.035 mg/kg Mi: 0.15 mg/kg B: 0.2 mg/kg	2, 3, 4
Tiletamine-zolazepam (TZ)	TZ: 3-5 mg/kg	5, 6, 8
Medetomidine:TZ	Me: 0.03 mg/kg T: 1.6 mg/kg	2, 6, 8
TZ:ketamine:medetomidine	TZ: 1.3-1.5 mg/kg K: 1.3-1.5 mg/kg Me: 0.013-0.15 mg/kg	2, 6, 7, 8
TZ:ketamine:xylazine	TZ: 1-1.3 mg/kg K: 1.6-2.1 mg/kg X: 0.4-0.52 mg/kg	1, 6, 7, 8, 9, 10
Propofol	P: 0.5-4 mg/kg IV	11, 12

1. Antagonize xylazine with yohimbine (0.125 mg/kg).
2. Antagonize medetomidine with atipamezole (five times the medetomidine dose).
3. Antagonize butorphanol with naltrexone (1mg per mg butorphanol).
4. Midazolam can be antagonized using flumazenil (0.2 mg per cheetah or 0.03 mg/kg) but may not be necessary.
5. Flumazenil can be used to antagonize the zolazepam fraction of tiletamine-zolazepam during prolonged recoveries.
6. Ketamine and tiletamine-zolazepam should be avoided in cats with known or suspected renal disease.
7. Ketamine can result in seizures (use of diazepam or midazolam may be necessary). Ketamine alone is not recommended for anesthesia in cheetahs.
8. Tiletamine-zolazepam may result in prolonged recoveries.
9. Xylazine may result in urine contamination during electroejaculation
10. Avoid xylazine in late term gestation.
11. Intravenous ketamine or propofol can be used as an adjunct.
12. May result in apnea.

<u>Inhalation anesthesia</u>

For prolonged medical treatment or surgical procedures, especially in aged and/or ill patients, inhalation anesthesia is recommended following induction with injectable agents. Isoflurane is the recommended inhalation anesthetic for cheetahs. Intubation of cheetah is not difficult and usually does not require application of a topical anesthetic to the larynx. Laryngeal anesthesia also should be avoided because gag reflexes are suppressed and aspiration may occur if the cheetah vomits during anesthesia. Most cheetahs do well on spontaneous respiration with occasional assisted respiration; positive pressure ventilation may be needed in some situations.

Anesthetic monitoring

Physiological monitoring of the anesthetized cheetah is an integral part of the anesthetic procedure. The anesthetist should monitor responsiveness to stimuli, respiration rate, color of mucous membranes, pulse rate and intensity, and muscle tone. Blood pressure, pulse oximetry, capnography, and electrocardiogram (EKG) readings can also be taken. Body temperature must be monitored during anesthesia, especially during prolonged surgical procedures where hypothermia may occur. Forced air thermal heaters are useful for preventing hypothermia in cheetahs. Elevation of temperature may be seen with convulsions, pre-anesthetic excitement, high environmental temperature, and exposure to direct sunlight. Severe hyperthermia (>40.6°C, 105°F) may require aggressive therapy, including water immersion, cold water enemas, IV fluids (colloids), and antibiotics.

Tranquilizers

Drug(s)	**Dosage(s)**	**Comments**
Diazepam	0.5-2 mg/kg PO SID-TID	Can be used long-termed.
Acepromazine	0.5-1 mg/kg PO	
Perphenazine enanthate	3 mg/kg IM	Long-acting (5-7 days)
Zuclopenthixol acetate		Not recommended due to severe extrapyramidal effects, ataxia, anorexia.

Analgesics

Drug(s)	**Dosage(s)**	**Comments**
Meloxicam	0.1-0.2 mg/kg PO or IM SID	Oral dose recommended for repeat treatments. 0.2 mg/kg is used as a single loading dose.
Fentanyl	50 mcg/hour SQ osmotic pump 100 mcg/hr patch	Used for short term post-op analgesia.
Carprofen	1-2 mg/kg PO SID	
Etodolac	6 mg/kg SID	
Butorphanol	0.2-0.4 mg/kg SQ or IM	
Tramadol	2.0-2.5 mg/kg PO BID	Used for short and long-term analgesia.
Morphine	0.1 mg/kg epidurally	Administer 45 min pre-op for rear limb orthopedic procedures.

NEONATAL MEDICAL CONCERNS

Monitoring cubs using a den box camera is strongly recommended. A cursory physical exam should be done early in life, typically when the dam begins to leave the den (1-2 weeks of age). Dams can inadvertently traumatize cubs (especially back and neck from being carried) and these lesions can result in myiasis. A complete neonatal exam should be conducted on all cubs that must be removed for hand-rearing. This exam should include body weight, rectal temperature, individual identification, and sex determination. Neonates do not thermoregulate well during the first two weeks of life and must be kept warm. Exams should be conducted for congenital abnormalities (e.g., cleft palate, heart defects). Mucus membranes and skin turgor can be evaluated for dehydration. A blood sample should be collected at an early age for a baseline value, but the timing of this sample depends on the preference of the medical staff. Other optional practices include administering prophylactic antibiotics.

If a deficiency in passive immunity is suspected, the cubs should be given subcutaneous and oral serum. This serum can be collected aseptically from the mother if she is healthy. If the mother is not available, serum from a healthy adult cheetah that has been in the collection for at least 1 year can be used as an alternative. The serum should be filtered to remove bacteria, and given at the rate of 150ml/kg subcutaneously divided over several days, and orally at 2-5ml/feeding for 3-5 days.

Pneumonia is frequently reported as a major cause of neonatal death in North American facilities. Additional concerns include angular limb deformities, coronavirus, and herpesvirus which have been addressed above. Additional information and protocols can be found in the hand-rearing sections.

APPENDIX I

Standard Health Evaluation Protocol

Physical examination: A thorough evaluation of each organ system, body weight, and assessment of body condition are essential. The oral cavity should be inspected for papillomatous plaques under the tongue and other lesions such as ulcers. The use of a flea comb may help identify mild flea infestations. Foot pad lesions (superficial ulcers) can be characteristic of calicivirus infection in cheetahs.

Dental examination: The teeth and soft tissue structures of the mouth and throat should be examined for abnormalities. Odor from the mouth may indicate dental problems. The area of the hard palate adjacent to the carnaissal teeth should be examined for erosions and punctures of soft tissues and possibly the underlying bone that extends into the nasal cavity (palatine erosions). These lesions can be treated by rounding off and shortening the points on the mandibular molar without exposing the root canal. This can be done prophylactically once the permanent teeth have erupted. Foreign bodies lodged between teeth, such as bone fragments, sticks, etc., can predispose oral disease. These should be removed and infections or traumatic lesions treated as indicated. Calculus accumulation should be removed, with care taken to remove material from the subgingival sulcus. Regular prophylactic dental care is important in preventing bacteremia of oral origin that can contribute to, or promote systemic disease. If an ultrasonic scaler is used, the scraped surfaces should be polished to smooth the surfaces. This will deter future calculus accumulation.

Identification: It is recommended that each cheetah be individually identified with a subcutaneous microchip (transponder). The location and placement of the transponder has been directed by the SSP. Currently, the specified location for a transponder is between the scapulae (shoulder blades). Prior to transponder insertion, marking of neonates can be safely and easily accomplished by using a livestock marker (a non-toxic beeswax product which clings to the fur) or by shaving. A small dot of color can be applied on a visible part of the body such as a tail tip, ear tip or top of head. Reapplication of the marker is periodically necessary as the product wears off.

Immunizations: Vaccination status should be reviewed and necessary vaccinations should be given as needed. Severely stressed animals may not mount appropriate titers and should be revaccinated if conditions indicate.

Blood collection for baseline values and disease monitoring: This includes complete blood count, serum chemistry panel, serum banking, and serologic testing. Cheetahs should also be evaluated for hemoparasites by a blood smear exam. Reference values for captive cheetahs are available through International Species Inventory System (ISIS).

Urine collection: Urine can be collected by expressing the bladder, catheterizing the bladder, or by cystocentesis. Urine samples should be submitted for routine urinalysis and sediment exam.

Fecal ova and parasite screening: Routine screening should include fecal flotation and direct smear.

APPENDIX II

Association of Zoos and Aquarium
CHEETAH SSP GASTRIC BIOPSY PROTOCOL

Institution/owner ____
Veterinarian____
Address ____
Cheetah name or ISIS # ______________stud book # ______________sex ______________
Birth date/age ______________Weight______________
Date of biopsy______________

History of vomiting or weight loss:

Please attach a copy of appropriate medical record
Treatment (Drug, dose, duration of treatment):

History of vomiting or gastritis in other cheetahs at this institution:

Other institutions this cheetah has resided:

Previous endoscopy and/or biopsy (including dates and results, please include pathologist/lab to whom samples were sent):

Sample Acquisition, Handling and Shipment

Biopsy procedures
Animal with lesions: Take 20 pinch biopsies (the use of a sharp 2 mm biopsy instrument is recommended) of the mucosa from the **affected** areas and adjacent regions.
Animals without lesions: Take 20 pinch biopsies, most of which should be from the fundic (body) region, but also take representative biopsies from the cardia and pylorus.

Biopsy handling
Fix the 20 pinch biopsies in formalin for histopathology.

Shipping formalin-fixed tissues: *please obtain proper cites and export permits before shipping tissues.*
After 72 hrs in fixative, ship tissues in a leak-proof container in adequate formalin to keep tissues moist.
Formalin fixed tissues can be shipped by U.S. Mail or by courier to:

Dr. Linda Munson
Dept. VM-PMI
4214 VM3A
1 Shields Ave
University of California
Davis, CA 95616
Phone: 530-754-7567
Fax: 530-752-3349
E-Mail: lmunson@ucdavis.edu

Gross endoscopy evaluation

Cheetah ID #

Date:

Endoscopist:

Gross lesions	Cardia	Body	Pylorus
Number of hemorrhages			
Number of ulcers/erosions			
Rugal folds 0 = appear normal 1 = thickened 2 = thickened and flattened 3 = cobblestone			

Comments:

Please note location of the lesions below

APPENDIX III

Association of Zoos and Aquarium
CHEETAH SSP NECROPSY PROTOCOL
May 2007
(http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=91)

INSTITUTION/OWNER

ADDRESS

CHEETAH NAME OR ISIS #
STUD BOOK #
SEX
WEIGHT
BIRTH DATE/AGE
DATE OF DEATH
DATE OF NECROPSY

HISTORY: (briefly summarize clinical signs, circumstances of death and attach MedARKS records):

SHIPPING TISSUES: *PLEASE OBTAIN PROPER CITES AND EXPORT PERMITS BEFORE SHIPPING TISSUES.*

After 72 hrs in fixative, please ship formalin fixed tissues in a leak-proof container with adequate formalin to keep tissues moist by U.S. Mail or courier to:

Dr. Linda Munson
Dept.VM-PMI
4214 VM3A
1 Shields Ave
University of California
Davis, CA 95616 U.S.A.
Phone: 530-752-5274
Fax: 530-752-3349
E-MAIL: lmunson@ucdavis.edu

FIXED TISSUE CHECK LIST: Preserve the following tissues in 10 % buffered formalin at a ratio of 1 part tissue to 10 parts formalin. Tissues should be no thicker than 1 cm. INCLUDE SECTIONS OF ALL LESIONS AND SAMPLES OF ALL TISSUES ON THE SSP SURVEILLANCE TISSUE LIST.

SSP SURVEILLANCE TISSUES and recommended tissue sampling procedures:

__ Brain - cut longitudinally along midline. Submit entire brain for leukoencephalopathy evaluation
__ Liver - sections from 3 lobes, including gall bladder
__ Spleen - Cross sections including capsule
__ GI Tract - 3 cm long sections of: Esophagus
Stomach - multiple sections from cardia, fundus (body), and antrum of pylorus
Small intestines - duodenum, jejunum, ileum
Large intestines - cecum, colon
__ Omentum - ~3 cm square
__ Pancreas - representative sections from two areas including central ducts
__ Adrenal - entire gland with transverse incision.
__ Kidney -cortex and medulla from each kidney
__ Urinary bladder, ureters, urethra - cross section of bladder and 2 cm sections of ureter and urethra.
__ Reproductive tract - Entire uterus and ovaries with longitudinal cuts into lumens of uterine horns. Both testes (transversely cut) with epididymis. Entire prostate, transversely cut.
__ Salivary gland
__ Oral/pharyngeal mucosa and tonsil -plus any areas with erosions, ulcerations or proliferative lesions.
__ Tongue - cross section near tip including both mucosal surfaces.
__ Lung - sections from several lobes including a major bronchus
__ Trachea
__ Thyroid/parathyroids - leave intact
__ Lymph nodes - cervical, mediastinal, bronchial, mesenteric and lumbar. Cut transversely
__ Thymus
__ Heart - longitudinal sections including atrium, ventricle and valves from right and left sides.
__ Eye - both eyes intact. Remove extraocular muscles and periorbital tissues
__ Spinal cord (if neurologic disease) - sections from cervical, thoracic and lumbar cord
__ Diaphragm and Skeletal muscle - cross section of thigh muscles
__ Opened rib or longitudinally sectioned ½ femur - marrow must be exposed for proper fixation
__ Skin - full thickness of abdominal skin, lip and ear pinna
__ Neonates: umbilical stump - include surrounding tissues

GROSS EXAMINATION WORKSHEET

PROSECTOR:____

GENERAL CONDITION: (Nutritional condition, physical condition)
Neonates: examine for malformations (cleft palate, deformed limbs, etc)

SKIN: (Including pinna, feet)

MUSCULOSKELETAL SYSTEM: (Bones, joints, muscles)

BODY CAVITIES: (Fat stores, abnormal fluids)
Neonates: assess hydration (tissue moistness)

HEMOLYMPHATIC: (Spleen, lymph nodes, thymus)

RESPIRATORY SYSTEM: (Nasal cavity, larynx, trachea, lungs, regional lymph nodes)
Neonates: determine if breathing occurred (do the lungs float in formalin?)

CARDIOVASCULAR SYSTEM: (Heart, pericardium, great vessels)

DIGESTIVE SYSTEM: (Mouth, teeth, esophagus, stomach, intestines, liver, pancreas, mesenteric lymph nodes). Neonates: is milk present in the stomach?

URINARY SYSTEM: (Kidneys, ureters, urinary bladder, urethra)

REPRODUCTIVE SYSTEM: (Testis/ovary, uterus, vagina, penis, prepuce, prostate, mammary glands, placenta)

ENDOCRINE SYSTEM: (Adrenals, thyroid, parathyroids, pituitary)

NERVOUS SYSTEM: (Brain, spinal cord, peripheral nerves)

SENSORY ORGANS (Eyes, ears)

PRELIMINARY DIAGNOSES:

LABORATORY STUDIES:(List bacterial and viral cultures submitted and results, if available)

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Recommended Crating and Transport Procedures

PRIOR TO SHIPMENT

Cheetah shipments require good organization and coordination to minimize stress and to ensure the animal's safety. Prior to shipment, the health status of the cheetah should be evaluated by an examination under anesthesia, which includes a physical examination, routine blood work and fecal analysis. (see medical chapter)

The animal should have access to its shipping crate for at least two weeks prior to shipment and preferably be fed in it.

AIR TRANSPORT CONTAINER SPECIFICATIONS

All containers for cheetahs must be of such a size to allow the animals to turn around, stand upright with head extended and to lie down in the full prone position. Actual container dimensions vary according to the size of the animal.

The International Animal Transport Association (IATA) designates container types and sizes for each species. These requirements are updated frequently so it is recommended that you obtain up to date container requirements prior to each shipment.

The design of the crate must meet the requirements and be strong enough to safely hold the cheetah. If an extended trip is anticipated (>12 hours), provisions should be made for the shipper to water and feed the animal while it is in the crate. Specific instructions concerning the food and water requirements are affixed to the outside of the container. The transport crate must be marked or labeled as specified by the carrier. Relevant languages must be taken into account when providing written instructions on care and when labeling the crate.

National Zoo;
Two brothers in crates positioned so that they can 'see' each other during land transport

Cheetahs over six months should be transported in their own crate. Younger compatible cheetahs can be transported together. Coalition members or any cheetahs that might be extremely stressed if they can't 'see' each other should be shipped in crates that have a window of some sort so they can be in visual contact during shipment. This might not be possible via air transport.

Animal Data Transfer Forms should accompany all cheetah transfers along with their medical records.

The AAZK Animal Data Transfer Form should be completed and sent to the receiving institution prior to the cheetah leaving a facility. These forms can be obtained by going onto the American Association of Zoo Keepers, Inc. website.

It is strongly recommended that the forms be completed by the head keeper or the keeper(s) that spends the most time with this animal. Moving a cheetah from one facility to another can be extremely stressful to the animal. The stress of a shipment can be minimized if the receiving facility is prepared to accept the animal by having a chance to review the information on the form and discussing the individual animal with a keeper. Information that needs to be on the form includes personality of the individual – is it aggressive to people or other cheetahs, does the animal climb/jump walls or trees, is it easily frightened, also include any information on types of enrichment and any trained behaviors. The more information that is sent or discussed with the receiving institution will result in the cheetah settling in faster to it's new home. Include as much information as you would want to know if this animal was arriving at your institution.

Since cheetahs are being fed a variety of diets at different facilities, it is strongly recommended that information on the new diet that will be fed at the future facility is received several weeks in advance as some individuals can be extremely difficult to change over, especially during a stressful quarantine situation. If diets are different between the two institutions, it would be beneficial to receive diet prior to the shipment to start the transition from one diet to the other.

It's important that a copy of all forms are in the animal's individual file with easy access to the keeper staff. It is also important that if that animal is transferred out of your facility then to include the forms from all previous facilities, so the new facility has the complete history for this animal.