

Appendix II – Husbandry Manual for Cheetahs (from Marker & Schumann 1998)

Chapter 1: Housing and Enclosure Requirements

A major component of cheetah management and health care programs is the facility design. From the outset, the team designing the structure should include input from the veterinary staff. Important considerations when designing a facility include: size, geometry, barriers, substrate, shelter, transfer areas, climate, reproduction and health. Problems in design and construction lead to unfavorable facilities which promote health problems. Cramped concrete cages of the past are not acceptable and will not promote the physical or psychological health of any animal kept under these conditions.

A. Enclosure Design

Enclosures should be of an adequate size to allow for exercise and provide the animals with a variety of sites to stimulate activity. Logs should be provided to allow the natural behaviour of scratching for claw wear and maintenance. The cheetahs should have adequate hide areas in the exhibit for limited seclusion. Shaded areas should be provided.

To facilitate the task of keepers and veterinarians, provision should be made to allow observation of the entire enclosure. Keeper viewing areas/slots, closed circuit television monitors and/or one way glass are strongly suggested to aid in the management and observation of the animals. Facilities for restraint (positioned so that the cheetah regularly pass through them), isolation and segregation should ideally be incorporated into the enclosure design.. Also consideration should be given to areas for collecting faeces.

1. Building Materials

- a) Wire of sufficient strength is acceptable for cheetah enclosures. This material, through improper installation or selection of material, may trap limbs or heads or teeth, especially in young animals.
- b) Metal bars have the advantages of strength and relatively low maintenance. These are, however, aesthetically unpleasant, decrease public visibility, may promote trauma from biting or running into them, may trap limbs or heads due to inadequate spacing, and may permit trauma from adjacent cats due to improper design. These are fortunately rarely used in cheetah facilities at this time.
- c) Glass is aesthetically pleasing, allows better viewing of cheetah, but requires more maintenance, expense, and is vulnerable to fracture.

The composition of the material used and the external coatings applied must be non-toxic, non-irritating, and non-trauma inducing.

2. Outdoor Enclosures

Cheetahs do not generally climb very well, but have been observed to jump to a height of 2,4 m. Young animals are also capable of easily climbing a 2,5 m fence. Cheetahs can be housed in open-topped enclosures, but these should have an overhang of 0.5 to 0.6 m at a 45° angle, or electrification. Perimeter fences should be 2,5 to 3 m high, and be constructed of chain link fence (5 cm gauge).

Solid walls can be used, but are more easily scaled and a greater height may therefore be required. When using a solid wall, it is recommended that the walls be a minimum of 3.7 m high. The addition of electric wire along the top prevents climbing. Overhangs or collars should be placed on trees close to perimeter fences to prevent possible escapes. Cheetahs do not typically dig, but fences should be sunk at the perimeter. A concrete apron which the fence is cemented into is recommended.

Outdoor enclosures should be furnished with objects such as rocks and tree stumps to serve as vantage points and marking areas. Elevated areas, such as a mound, are also used as vantage points. A wide view of the surrounding area, particularly of prey species, may be advantageous. All yard/exhibit spaces should be interconnected for the easy transfer of animals. Larger enclosures with multiple holding areas are recommended for a breeding programme.

Outdoor enclosure size varies widely between collections as does the number of cheetah maintained in each enclosure. The outdoor exhibit should measure at least one half hectare or more to be fully functional in the management of this species. Most successful breeding facilities provide one hectare. A relatively large enclosure size has been associated with male fertility and breeding success, though further research would be required to validate this link.

The selected data presented in Table 1 are provided simply as an indication of what enclosure sizes have been used. Spatial density ranges from 1/86.67m² to 1/17241m². Where space is limited, elongated enclosures are preferable as they afford a greater opportunity for exercise.

Table 1: Enclosure sizes that have been used.

Area (m ²)	No. Cheetah	Source
500,000	29	Bertschinger et al., 1984; Brand, 1980
60,703	14	Fitch et al., 1985
40,000	10	Tong, 1974
18,802	6	Eaton et al., 1978

3. Indoor Enclosures

Indoor facilities (in some climates, heated to between 10° and 16° with electric heat in the floor, radiant heaters, heat lamps or forced air heat) should 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 enclosure to the next with transfer/guillotine doors operated from the keeper safety area. If animals need to be confined for a prolonged period of time, larger holding areas are highly recommended.

Concrete floors with straw bedding are recommended for ease in cleaning and disinfecting. Wooden floors are generally warmer though are difficult to clean and may become tainted with urine.

The aggressive display of cheetah includes stamping; to avoid leg injury as a result of this, it is suggested that wire mesh, or similar barriers, within indoor quarters should be covered at their base with timber.

Lighting optimally should be a combination of natural and artificial illumination. Varying day-night light cycles are beneficial in reproductive cycling and health. Proper ventilation is imperative in indoor areas to prevent the build up of ammonia which results in respiratory tract health problems.

4. Shelter Requirements

All outdoor exhibits must have sufficient shelter for all animals in the enclosure. Wooden or earth covered culverts may be used, though the latter have the disadvantage of being difficult to access and clean.

Adult cheetahs are able to withstand remarkably low temperatures, though some collections do provide heated dens or indoor quarters. An unheated wooden shed with straw bedding is adequate where winter temperatures drop to -15°C to -27°C. All shelters should be draft free and have adequate drainage to facilitate cleaning.

During cold periods, cheetahs have been observed to grow long coats and to consume an increased amount of food. Under damp conditions, which cheetahs are less able to withstand, heating should be provided to enable their coats to dry.

5. Maternity Enclosures

A maternity unit should be incorporated into all facilities. A maternity unit provides a secure environment for the birth and care of the cubs. A general increase in enclosure size since the 1960s has been associated with increased success in the rearing of cubs as the female can avoid disturbance. However, enclosures should not be so large as to preclude careful monitoring of mother and cubs.

This unit should consist of twin cubbing huts in adjacent pens to allow the female to move her cubs, while at the same time providing an area to confine her in while cleaning and feeding. The vacated cubbing hut can then be cleaned and lined with fresh bedding. Inspection of the cubs can also be safely carried out as the female may become defensive.

Cubbing huts are generally between 1m² and 4m², though indoor pens may be as large as 6 m². Cubbing huts need not be too large, but should allow the female to stand, turn and lay down with her legs outstretched. Both front (guillotine) and rear access doors should be built into the cubbing hut. The female may be coaxed into the yard through the front door while cubs may be accessed for health checks through the rear. All dens should be dry and draft proof, and well ventilated to reduce the risk of infection of the upper respiratory tract due to ammonia build up.

The maternity unit should be adjacent to the females' enclosure so that she may access it prior to confining her for cubbing to allow her to familiarize herself with the area. Maternity units should however be screened from the public viewing areas.

Cubbing huts should be easily accessible to keepers, ideally with provision for observation, one way glass or power points for the installation of monitoring equipment. The use of video monitoring equipment is strongly suggested in this area for routine observation of the female and her cubs. A regular routine should be followed by staff when the dam is confined to the maternal area so that she feels secure.

6. Off-Exhibit Enclosures

The off-exhibit enclosures are essential to proper management and health care and include working, holding and quarantine areas. They allow for treatment areas out of the public view and seclusion of a stressed or ill cheetah. Within this area, squeeze or restraint cages permit an alternative method of handling for procedures normally necessitating anaesthesia.

The surfaces of working areas must provide good traction, especially when wet, but not abrasive as to cause foot pad trauma during normal movement or exaggerated pacing. If the surface is too hard, trauma to bony prominence in normal resting or sleeping positions can result. Rubberised flooring, although soft, may be damaged by chewing or scratching and thus be difficult to clean properly.

B. Substrate/Topography

Natural settings with vegetation and soil provide good enclosures 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, shelter, and seclusion provided.

The plants used within the enclosure must be chosen carefully to avoid toxic species. The dirt substrate may become contaminated over time with micro-organisms and

parasites thereby exposing the cats to potential concentrations of pathogens. Contaminated substrate could be periodically removed and replaced with clean materials, or a cleansing regime could be followed to disinfect the substrate. Placing animals that have been properly quarantined helps reduce the potential contamination load on the substrate, especially parasitic.

C. Water Source

Each enclosure must provide a cleanable water container accessible to both the cheetah and keeper. Provision could be made for monitoring water intake and water deprivation in certain clinical situations, such as pre- or post-anaesthesia. The non-reservoir watering systems (such as lab animal self-waters) can malfunction and inadvertently deprive the cat of water if not checked daily. Shallow ponds, pools or streams have been successfully used as watering sources and add to the aesthetics of the exhibit.

The aquatic component of exhibits, such as pools and moats, need to be designed for maintaining high water quality and sanitizing due to the tendency of cheetahs to defecate in water. Deep water sources must be drained if cubs are to be displayed in the exhibit.

D. Isolation From Similar or the Same Species

Cheetah are usually kept in single species exhibits, though have been maintained with rhinoceroses (*Ceratotherium simum*), and with white-handed and pileated gibbons (*Hylobates lar* and *H. pileatus*) where considerable interspecific interaction occurred. This arrangement was terminated prior to the onset of a serious breeding programme.

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.

It is also recommended that the cheetahs have visual contact with hoofed animals to simulate the natural surroundings and 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 and provision is made for such by, for example, citing the enclosure on a hillside and providing elevated areas for scanning.

E. Housing and Enclosure Requirements References

- Adamson 1969
Ashton & Jones, 1979
Benzon & Smith, 1975
Bertschinger et al., 1984
Birkel, 1980
Degenaar, 1977
Brand, 1980
Cupps, 1985
Eaton, 1974
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Silberman et al., 1977
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Wrogemann, 1975
Vallat, 1971
Vaneysinga, 1970
Veselovsky, 1975
Volf, 1974

Chapter 2: Management

A. Individual Identification Methods

It is recommended that each cat be individually identified. The following methods may be used:

- a) implanting a subcutaneous microchip (transponder);
- b) a tattoo of the studbook number ;
- c) photographic record of the facial, flank, chest or tail markings, which are unique to each animal.

Placement of the transponder and the location of the tattoos have been directed by the CBSG. The usual site for implantation is between the scapular, or alternatively behind the left ear. However, in the absence of a universal standard, it is suggested that cheetah should additionally be tattooed on the inner thigh (Marker, pers. comm.). Cubs may be temporarily marked for positive identification and later transpondered (at three months).

B. Recommended Quarantine Procedure

Prior to the introduction of a new cheetah to an existing population, the newcomer should be quarantined for at least 30 days. Ideally the cheetah is held in a separate facility and cared for by keepers who do not care for other felids. Unfortunately, this may not always be possible. In these instances, the cheetah is separated from other cats as much as possible and keepers work with it after working with the existing collection. Personnel working with or near a quarantined cat should wear coveralls and rubber boots designated for the quarantine area. A foot-bath going to and from the quarantine helps prevent spread of potential contamination. The quarantine area should have separate drainage that will not cross-contaminate other cat areas.

The quarantine period allows observation and testing to monitor the animal for infectious diseases and/or parasites. The 30-day period is adequate to cover the incubation period of most infectious diseases. Newly captured animals or animals from foreign zoos may require a longer quarantine.

When moving cheetah between collections care should be taken to avoid the transmission of parasites, disease or infection. International Regulations usually state that animals imported/exported must be accompanied by a veterinary health certificate. The appropriate procedure before transfer should include the administration of relevant vaccinations and a thorough physical and haematological examination prior to departure. The animal should be treated for internal and external parasites prior to departure. Particular care should be taken when transferring animals into or from FIP seropositive populations. Upon arrival the animal should remain isolated until the absence of infectious disease can be confirmed.

C. Recommended Methods of Handling and Restraint

Handling: Cheetahs are seldom aggressive and keepers can normally enter the enclosure without difficulty, though care should be taken in the case of a female with cubs as she may become defensive. Cheetah may occasionally use threat displays or charge to within 1 to 3 metres, though direct eye contact or a forward movement is usually sufficient to induce a flight response. Some keepers carry a broom or similar object as a precaution. Cheetah can be trained to walk between adjoining enclosures to facilitate daily maintenance or food incentives may be used. Temporary free access to these areas during undisturbed periods will facilitate moving animals as they will have had an opportunity to become familiarized with these areas.

Restraint: Crushes are incorporated into some enclosures to facilitate handling, routine blood collection and the administration of medication without necessitating immobilization. The use of this cage provides an alternative method of drug injection to the remote delivery methods such as darts or pole syringes, especially when large volumes are required. Animals should always be habituated to a restraint device prior to its use.

The inclusion of a third gate in the middle of a standard crush or trap cage facilitates the handling of animals under a year, which are difficult to pin down in the larger trap cage. The cage may have a third side panel built into it to facilitate squeezing the cheetah, i.e. trapping him against the side of the cage, or poles may be used to pin a cheetah to the floor of the cage. The cage may either be built into a substrate, or be portable. It should be bolted or otherwise securely attached to the substrate to prevent a cheetah lifting it and escaping. The gates should be covered with diamond mesh, not rigid bars: cheetahs usually enter the crush at high speed and can injure themselves on a door with rigid bars.

There should be a gap of about 80 mm between the base of the door and the ground. This is to prevent the door from accidentally crushing the animal's tail. 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. Cheetahs can be handled effectively using this system. Intravenous anaesthesia can be administered by pulling on the tail and then pulling the lower hind leg through the bottom gap. The inside part of the leg is then facing upwards, exposing the femoral vein which is used for the injection.

Some collections prefer to use chemical immobilization rather than physical restraint. Details of the appropriate methods and chemicals can be found in the International Wildlife Veterinary Services (1991) Wildlife Restraint Series; the Annual Proceedings of the AAZPA (1990); Fowler (1986); McKenzie (1993). Chemical immobilization should only be carried out under veterinary supervision. When immobilization is necessary, the opportunity should be taken to collect blood samples for health assessment.

D. Recommended Crating and Transport Procedures

Prior to shipment: Shipment procedures for cheetahs require good organisation and coordination to minimize stress. Prior to shipment the health status of the cheetah is evaluated by a pre-shipment physical examination to help ensure the animal's safety. The animal should have access to its shipping crate for at least two weeks prior to shipment and preferably be fed in it.

Transport container specifications: The design of the crate must meet International requirements and be strong enough to safely hold the cheetah. If an extended trip is anticipated (>12 hours), provisions should be made to water and feed the animal while it is in the crate. Food and water containers with adequate access for replenishment must be made available by the shipper, taking into account the duration of the flight. Animal shipments must have written instructions concerning the food and water requirements of the animal affixed to the outside of the container. The transport crate must be marked or labelled (in the relevant languages) as specified by the carrier.

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 size of animal. The International Animal Transport Association (IATA) designates container types and sizes for certain species.

The doors on each end of the crate should be guillotine style to facilitate animal transfer, and contain a secure locking system. The top third of one door should contain an observation area formed of steel welded mesh or strong iron bars. The bars must be spaced in a manner that will prevent the animal from pushing its forelegs through the spaces between the bars. To prevent disturbance to the animal and to provide protection for the handling personnel, wooden slotted shutters with adequate ventilation slots or holes should be placed over the front opening, approximately 7.5 cm away from steel weld mesh of iron bars. Loosely woven burlap or fine nylon or similar mesh, stretched over the front opening, with a batten on the bottom, can be used in lieu of the wooden shutters. Burlap covering must be readily removable to allow increased air flow, as necessary.

The floor should be constructed in grill form over a liquid-proof tray in a manner to permit the animal's excreta to fall into the tray. When a grill floor is not feasible, the floor of the container must be liquid-proof and be covered with sufficient material to absorb the animal's excreta.

Basic design allows free flow of air through both ends of the container. Animal Welfare Act requires that one-third of the container ventilation holes (2,5 cm diameter) must be in the lower half of the container and one-third in the upper half. Ventilation openings may be on two opposite walls, composing at least 16 percent of the area of each wall. Alternatively, ventilation openings may be on all four walls, composing being at least 8 percent of the area of each wall. The total combined ventilation opening area must be at least 14 percent of the total combined area of all four walls. The outside of the wall with

ventilation openings must have a rim or other separation device 1.9 cm deep to prevent obstruction of ventilation openings during transport.

Specific guidelines exist for the animal holding area in cargo terminals. According to the Animal Welfare Act, a temperature range of 7.2° C to 23.9° C is normally acceptable. Note a temperature range of between 23.9° C to 29.5°C is acceptable for a 4-hour time period only. Animals being moved between the animal holding areas in cargo terminals and planes on the ramp may be subjected to temperatures exceeding 29.5° C or below 7.2° C for no more than 45 minutes.

A maximum of one live cheetah, 6 months or more of age shall be transported in a primary enclosure. Two live kittens, 8 weeks to 6 months may be carried in the same primary enclosure. Weaned live kittens less than 8 weeks of age and of comparable size, or kittens which are less than 8 weeks of age, and litter-mates, may be shipped in the same primary enclosure. When a cheetah is moved, where possible one of its keepers should accompany it to care for it and advise on its new environment.

E. Cleaning

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 are thoroughly rinsed to prevent exposure.

Care should be taken when cleaning indoor quarters as cheetah are susceptible to poisoning by phenolic compounds as contained in some disinfectants. Access to any toxins should obviously be prevented. A wire basket can be used to cover electrical fittings within enclosures. Bones and faeces should be collected at least every second day.

F. Pest Control

Feral and domestic animals, or pests with access to the cheetah or its enclosure may serve as a potential sources of pathogens such as the feline viral diseases, rabies, yersiniosis, leptospirosis, salmonellosis, toxoplasmosis, feline infectious peritonitis, and others. The external and internal parasites of these feral animals can be transmitted to cheetahs as well.

Well-maintained perimeter fencing provides an initial deterrent to the larger feral animals, particularly dogs, but not to climbing animals, such as cats. Areas around cheetah enclosures should therefore be monitored regularly for feral animal activity. Live trapping provides a method of removing some feral animals and is acceptable to the public and humane animal interest groups. Local animal shelters will usually assist in removal of domestic animals captured this way. Removal of wildlife trapped in this

manner may be coordinated through state agencies or local rehabilitation groups. Trapping does not provide a total eradication of pests, therefore, the design of the cheetah enclosures should be such that it prevents exposure to feral animals.

Rodent pests must be handled through a well-planned, supervised, continuous pest control program. Safe rodenticides are available for use around cheetahs when they are applied according to their directions. Care must be taken in choosing compounds that are effective, yet not highly toxic, especially when considering secondary toxicities. It may seem too obvious, but it should be emphasized that at no time should cheetahs have primary access to any rodenticide. In addition, the program should be designed and instituted to minimize secondary exposure (i.e., consuming rodents that have been feeding on poisonous baits).

Good sanitation aids in reducing insect populations, but all facilities experience insect pests. Insecticide applications can be made around cheetah enclosures with chemicals that are safe when applied in a proper manner. Examples of insecticides include: piperonylbutoxide, natural and synthetic pyrethrins, carbonates, chlorpyrifos; example of growth inhibitor is Gencor. Cheetah enclosures are treated by removing the cheetahs, applying chemicals that have been deemed safe to use in primary enclosures, and then cleaning the enclosure to avoid exposure to returning cheetahs. The residual chemicals in cracks and crevices should have no contact with the cheetahs but, if so, exposure levels should be minimal.

All personnel involved with the cheetahs should participate in the planning stage of the pest control program so everyone is aware of the compounds being used, where and how they are applied, and have knowledge of the safety of the compounds.

Inadvertent use or misuse of insecticides (and herbicides and miscellaneous toxic compounds not intended for use around animals) by inexperienced personnel can lead to accidental exposure to cheetahs and possibly fatal results. Organophosphates have led to death in cats.

G. Management References

Bertram, 1978 p.167
Bertschinger et al., 1984
Birkel, 1980
Burney, 1980
Button et al., 1981b
Caro & Collins, 1986
Caro & Durant, 1991
Cupps, 1985

Eaton, 1969a
Eaton, 1970c
Eaton & Craig, 1973
Fowler, 1986
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Herdman, 1973
Holeckova et al., 1990

Manton, 1979a
McKenzie, 1993
McKeown, 1991
McLaughlin, 1970
Schumann, 1991
Standley, 1979
Wrogemann, 1975

Chapter 3: Behaviour and Social Organisation

A. Optimal Social Grouping

Cheetahs have been successfully maintained under a variety of social conditions. Interaction is generally amicable within groups, though intense fighting has been reported in mixed-sex, adult groups at feeding times and where males are courting an oestrous female. Social affinities exist within groups; a dominance hierarchy may or may not be apparent. Where dominance hierarchies have been observed it is noted that wild-caught cheetah tend to be dominant over captive-born. Within social groups, mutual grooming frequently occurs, often accompanied by purring. Antagonistic interaction between cheetahs includes a number of threat displays and foot stamping.

1. Males

Males may be housed either singly or in coalitions of two to four individuals. Coalitions are made up of littermates or compatible males. Among males, the larger male tends to be dominant. Mixing different groups of adult males is not advised as this usually leads to intense fighting with potentially disastrous results. Males should be integrated into social groups or coalitions prior to sexual maturity to avoid intense fighting.

2. Females

Females may be housed individually, with dependent offspring, or in compatible groups. Although some facilities advocate housing females in isolation for breeding purposes, other facilities have had breeding success despite females being housed in pairs allowing social contact with other females. Females housed together may come on heat simultaneously, or one shortly after the other. However, dominant females may also inhibit other females from coming on heat.

3. Mixed-sex Groups

Mixed-sex groups have been maintained at a number of collections, though in terms of reproduction it is beneficial to maintain males and females separately until introduced for mating.

4. Juvenile Groups

Upon separation from their mother, young cheetah can be maintained in juvenile groups or integrated into adult groups, the females eventually being removed for breeding.

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

B. Age of Dispersal/Removal of Young

In captivity, females become disinterested in their cubs when they are 12-14 months old. When that occurs, the cubs should be removed from the mother but kept with siblings or with other similarly aged cubs and out of sight of the mother. Male and female cubs can be separated as early as 14 months if desired, and definitely separated by 18 months at the latest. Males have been reported to produce sperm at 15 months.

In the wild, mother and cubs normally separate when cubs are between 18 and 20 months old. Research in East Africa suggests siblings then remain together until females reach sexual maturity and leave the group to take up solitary existence, often within the mother's home range. Male siblings may remain together for life and are generally expelled from the female's range by territorial males.

C. Introductions and Removals

Individuals can generally be returned to the social group without difficulty following a temporary separation. Likewise, cubs can normally be integrated into a social group. A mother and her 12 week old cubs were maintained in an enclosure adjacent to an adult group then introduced to the group without difficulty five and a half months after the birth, the other adults merely showing interest in the cubs. Two females with cubs were apparently forming one social unit with cubs suckling from either female. However, certain individuals may be forcibly evicted from the social group in which case re-integration may be impossible.

D. Seasonal Changes in Social Behaviour

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), probably as a result of increased food availability. At the De Wildt Cheetah Breeding Center near Pretoria, most breeding occurs during November and February. Cheetahs in North America, almost entirely South African stock, breed throughout the year. Data from 521 litters (1710 offspring) reported in the International Cheetah Studbook 1968-1991, revealed a bimodal distribution with peak numbers of births occurring March to June and September to November. 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 hemisphere. In the northern hemisphere, the peak occurs in September to November, whereas the peak in the southern hemisphere is March to June. Information is needed to determine if seasonal trends in the captive population are influenced by management and/or due to normal fluctuations in environmental factors.

Limited information is available on whether season affects reproduction in cheetahs. Vaginal cytology data, obtained from four females 1 to 2 years, have suggested that cheetahs continuously cycle throughout the year. In this same colony, breeding activity was observed year around; however, the majority of births occurred from March to June and from October to November. Semen characteristics apparently do not change throughout the year in cheetahs. Ejaculates collected circannually using an artificial

vagina (n=3 males) revealed similar seminal characteristics throughout the year with no discernible influence of season.

E. Behavioural and Social Organisation References

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|---------------------------|----------------------|-------------------------|
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| Benzon & Smith, 1974 | Eaton, 1970b | Lindburg, 1991 |
| Benzon & Smith, 1975 | Eaton, 1970c | Manton, 1975b |
| Bertram, 1978 | Eaton, 1974 | McLaughlin, 1970 |
| Bertschinger et al., 1984 | Eaton & Craig, 1973 | McVittie, 1979 |
| Brand, 1980 | Eaton et al., 1978 | Myers, 1975 |
| Burney, 1980 | Eriksen, 1990 | Nowak & Paradisio, 1983 |
| Burney & Burney, 1979 | Ewer, 1973 | Pienaar, 1963 |
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| Caro, 1989 | Frame, 1984 | Pettifer, 1981a |
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| Caro & Durant, 1991 | Guggisberg, 1975 | Tong, 1974 |
| Caro & Laurenson, 1989 | Herdman, 1973 | Vallat, 1971 |
| Cupps, 1985 | Kruuk & Turner, 1967 | |

Chapter 4: Reproduction

Reproductive efficiency in captive cheetahs is relatively poor. On a facility basis, 44 % of the zoological institutions attempting to breed cheetahs have succeeded. Only 20 % of the captive bred population and 15 % of the wild-caught animals have reproduced, and only a few cheetahs appear to be contributing to the gene pool. The non-producing wild-caught individuals in the captive population today are numerous and should be encouraged to reproduce to increase founder representation.

Breeding cheetah in captivity has been notoriously difficult. The first captive birth occurred at the Philadelphia Zoo, USA in 1956, though all cubs died within three days. Only a handful of litters were born prior to the late 1960's, and it was not until 1966 that a litter was successfully raised by the mother. The first second-generation birth did not occur until 1973, at Whipsnade Park in England. Although more successful in recent times, populations in captivity are still not considered to be viable, with a low N_e (percentage of the population breeding), disproportionate representation and poor founder representation. Infant mortality is high (36.7%) whilst fecundity is low; male sperm counts are low with a high percentage of abnormalities.

Many of the problems associated with breeding, including infertility and high infant mortality, have been related to management techniques. These may in some way be responsible for the cheetahs' poor reproductive record in captivity as well as the species genetic impoverishment. Outbreeding has been recommended by Marker & O'Brien (1989), particularly "hybridisation" between the East and southern African lineages, although even these geographically separate populations exhibit remarkably little genetic variation. The use of the International Studbook is also encouraged so as to increase the effective population size.

In response to the reported infertility, artificial techniques have been attempted. Some collections monitor the sperm quality of males or the oestrous condition of females as an indication of when to introduce the pair to mate. Vaginal smear techniques have limited applicability for captive management though the development of faecal-based assays may prove to be a more useful, non-invasive technique. Hormonal induction of oestrous has met with some success and recently several litters were born as a result of artificial insemination.

A number of factors that may affect cheetah reproduction have been identified and suggestions made as to how breeding potential might be enhanced. Experience has shown that cheetah can breed under a variety of conditions. Whilst it is not possible to identify an "ideal cheetah breeding technique" from the various and often contradictory theories, all of which have met with some degree of success, an assessment according to 1) nutrition, 2) enclosure size and design, 3) human contact, 4) segregation and re-introduction, and 5) sex ratio might usefully serve to identify the most suitable conditions for each collection.

It has been suggested that when maintained in close proximity to males, female reproduction is inhibited. In the wild, females tend to be solitary and it is suggested that they should therefore be maintained in isolation, particularly from males, except for a brief period during oestrous, a technique successfully employed at a number of collections. Contact with other females does not seem to inhibit breeding and may in fact be beneficial. Successful breeding has however, also occasionally occurred in mixed sex groups.

A. Breeding Behaviour

Based on observations of 9 courtship's involving 3 females, Herdman (1972) produced the data in Table 2.

Table 2: Cheetah courtship in relation to the oestrous cycle (Herdman, 1972).

PROESTRUS	FEMALE	MALE
	No behavioural change	Spraying
	Vaginal discharge	Increase "wiping" behaviour*
		Initiation of courtship; smelling.
	Stutter call	Erections observed. Stutter call.
	Submissive vocalizations at lunging males	Intra-male aggression begins
Non-receptive; slap at males. Lie down often	Testing female receptiveness	
OESTRUS	Pausing to allow male to approach	Intra-male aggression peak; dominant male established
	Lateral tail displacement	Partial mountings
	Copulation	Copulation
METOESTRUS	Hormonal change	Interest wanes
	No apparent vaginal discharge. Males-females not together	Courtship ceases
ANOESTRUS	Minimal male/female interaction	Intra-male aggression ceases i.e. mutual grooming, feeding fights

* Increased "wiping" or "mound building", whereby males, using their hind feet, scrape together a mound of earth onto which they urinate and defecate, has been observed in the vicinity of oestrous females and ascribed a communicative function (Herdman, 1972).

B Mating system, courtship, and copulation

1. Male Behaviour

A male will thoroughly scent mark his own territory and especially any new territory or territory previously inhabited by females or other males. When allowed access to the female, a male might show intense interest towards the female by following, maintaining visual contact, and staying within close proximity, even while resting. Breeding behaviour in male cheetahs has included pacing, Flehmen response and distinctive

vocalizations described as stutter barking and chittering. Intense aggression shown by the male towards the female is an indicator that the female is not in oestrus.

Readiness to mate has been assessed by observing the behaviour of males in the vicinity of a female, or following their release into a temporarily vacated female's enclosure. Others feel that the male's behaviour is not necessarily a good indicator of female receptivity and prefer to assess the female's response to the male before introducing the pair.

2. Female Behaviour

Ooestrous cycle behaviour

Ooestrous can occur throughout the year though, as in the wild, births in captivity show seasonal peaks according to location. The factors determining the oestrous cycle are not fully understood. Based upon changes in vaginal cytology, oestrous cycle length reportedly varies markedly among individual females. In one study, mean cycle length in three females was approximately 11 days (range, 3 to 27 days); whereas, in another study, oestrous cycle lengths of 25 to 29 days were reported. Endocrine profiles (serum, urine or faecal) during the oestrous cycle have not been generated. Behavioural observations have revealed an oestrous cycle length of 10 to 20 days. The duration of behavioural signs of oestrus (sexual receptivity) range from 1 to 3 days.

It remains unknown if ovulation in this species is spontaneous or induced (provoked by copulation). However, all available evidence strongly suggests that this species is an induced ovulator. 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), suggesting that this species is an induced ovulator. Low mean serum progesterone concentrations in these same females also support this hypothesis. However, this same survey reported luteal scars in four unproven breeders previously not housed with adult males. Additionally, one study of vaginal cytology suggested that females may occasionally spontaneously ovulate. This issue requires resolution in further studies.

Identification of oestrous is difficult. There may be physical signs, a slight swelling and discoloration of the vulva or vaginal bleeding, though these are not always obvious and behavioural indicators, in both male and the female may be more reliable. These include increased activity, vocalisations (particularly the "stutter call"), mutual grooming, chasing, some aggression, female rolling and rubbing and increased male spraying.

Signs of oestrous in the female include, but are not limited to, rolling and/or rubbing on the ground or fence, vocalizations such as chirping, chattering and/or stutter barking, interest in the female towards the male(s), and ceasing to feed. Dedicated observation can identify increased rates of rolling, head rubbing, tail twitching, object sniffing, calling, frisky behaviour, front crouching, treading, Flehman response, presenting to male, or even urine spray marking in certain females as indicators of oestrous. However,

cheetahs have been reported to undergo a high incidence of silent oestrous (ovarian cyclicity in the absence of behavioural signs). The most reliable clue to identifying oestrous, however, is a change (either increase or decrease) in frequency of any of the above behaviours.

3. Courtship Behaviour

Courtship behaviour is typified by the male following the female, sniffing the ground where she has sat and investigating her genital area; the female may solicit or repulse the male, and grooming, chasing and play-fights often occur. Initial interaction may be initially be aggressive (though not physical, i.e. biting or fighting), but where the female is receptive this gives way to playfulness.

4. Introduction Techniques

The following techniques have resulted in successful matings:

- a) male introduced into female yard;
- b) male introduced to female with teaser male in an adjacent yard;
- c) female introduced to male (with or without teaser in adjacent yard);
- d) multi-males introduced to female(s) (use extreme caution);
- e) male and female introduced into neutral yard;
- f) single male introduced to multi-females.

One or more males may be introduced to an oestrous female. Where a number of males are introduced, inter-male aggression typically occurs, though during actual mating the other males may remain in the vicinity without aggression. For the purposes of maintaining genetic diversity it is advised to only introduce a selected male for actual copulation (or remove the other males) so that parentage of cubs can be manipulated.

Constant separation and re-introduction has been highlighted as the key to breeding success. This strategy is employed at a number of collections where breeding often occurs shortly after the introduction or re-introduction of a male to a female. Whilst according to one survey the male should ideally be introduced into the female's enclosure following the period of isolation for successful mating to occur, the opposite technique, whereby the female is introduced into the male's enclosure, is preferred by some and has been used successfully. Novelty, for example a new enclosure, a new breeding partner or periodic visual or olfactory contact between otherwise separated animals, has also been related to renewed sexual interest and breeding success.

Where behaviours are indicative of an aroused male and/or a female coming into oestrous, an introduction could be considered. Where these behaviours are not noted, an introduction can be attempted with caution.

For any introduction, adequate staff should be available to intervene, keeping in mind that aggression may occur. Methods of intervention and separation could include the transferring of the animal(s) to another enclosure, the use of safety equipment (e.g.,

broomsticks, rakes) or water spray. Staff should not enter the enclosure without some form of protection.

In an attempt to stimulate mating behaviour, different male:female ratios have been tried. Successful breeding does occur in a 1:1 situation, though some suggest that at least two males should be introduced as a large number of males, and in particular inter-male aggression, stimulates the female. Whilst inter-male aggression is regarded as a necessary factor by some, others regard it as unnecessary, even detrimental as competing males may prevent successful copulation. Once a pair has become established, the removal of competing males will facilitate successful copulation.

A conservative approach would involve introducing a male to a female in her enclosure. Prior to the introduction, the male should have visual access to the female, through a common fence line or by allowing him into the female's empty enclosure. Introduction methodology varies with each institution. Flexibility is the key to successful introductions. Individual personalities and animal characteristics must be considered. Successful introductions that result in breeding may last from 15 minutes to 14 days. First time introductions should be carefully monitored, and should be limited to hours when staff are available. Copulation is not always observed. If copulation occurs, the pair should remain together until breeding interest subsides. If copulation does not occur, but aggressive behaviour is seen, the introduction should be terminated. Complacency may be another reason for separation. Introductions should be attempted on a frequent basis.

Although the female can be left in her pen with the male to determine if she is still cycling or until pregnancy is suspected, it is advisable to remove the male.

All females believed to be pregnant should be separated by the start of the third trimester. The female should be separated into the maternity yard at least two weeks prior to giving birth. Good indications of pregnancy include: observation of a bulge below the ribs in an animal 24-36 hours after feeding, nipple development, weight gain and behavioural changes such as relaxation, increase in appetite, vocalization, and more solitary behaviour.

5. Mate Selection

Mate selection is an important factor in the breeding of cheetahs. Consideration should be given to genetic representation of individuals, realizing that there is a strong mate preference within this species. Not all introductions will result in breeding so it helps to have a sufficient number of unrelated animals available to enhance the possibility of successful pairings. The transfer of unproductive individuals to alternate between facilities where additional mate selections can be attempted is strongly recommended. A time limitation of 2 years to enhance the reproductive possibilities of all animals should be adequate. All transfers should be recommended/approved by the coordinator of the Regional Management Program.

Compatibility is an important consideration and mate selectivity is demonstrated by both males and females. It is therefore desirable to maintain at least 2.2 cheetahs for breeding purposes.

C. Basic Characteristics

1. Age-Specific Fecundity

Although sexual maturity can be reached as early as 15 months, introductions for breeding should not begin until the animal is 24 months old. Data from 188 female cheetahs demonstrated that the mean age at first parturition is 58.0 \pm 1.8 months (range 24 to 120 months). The mean number of litters produced over the lifetime of a female cheetah is 2.8 \pm 0.1 (range, 1 to 9). Based upon data from 332 birth intervals, cheetahs exhibit a mean interval of 14.0 \pm 0.4 months (range, 6 to 60). Based on 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 \pm 0.1 cubs/litter.

Litters may be produced at roughly two-year intervals, though if the litter is lost the female may re-cycle and mate again within few weeks thus producing a second litter just four months after the loss. Older females tend to re-cycle more quickly than young females. Females May begin to cycle again when cubs are 10 to 14 months old and may conceive prior to departure of previous litter, though birth invariably occurs after family has separated.

Table 3: Lifetime number of litters per female cheetah. Data from 188 females reported in the International Cheetah Studbook. Mean number of litters/female is 2.8 \pm 0.1.

Number of litters per female	Number of females	Percentage
1	71	37.8
2	26	13.8
3	32	17.0
4	25	13.3
5	15	8.0
6	10	5.3
7	6	3.2
8	2	1.1
9	1	0.5

As in the wild, captive females re-cycle quickly upon losing, or following the removal of a litter. It has been suggested that the reproductive rate in captivity could be increased, without compromising the development of cubs through early removal from their mother, by introducing a male to a female with large cubs.

Table 4: Interbirth interval in female cheetahs. Data from 332 birth intervals out of 521 litters reported in the International Cheetah Studbook. Mean interbirth interval is 14.0 ± 0.4 months.

Interbirth Interval (months)	Number of Intervals	Percentage
≤ 6	48	14.4
7-11	122	36.7
12-24	134	40.3
25-36	24	7.2
37-48	3	0.9
49-60	1	0.3

Litter size is comparable to that reported for the wild with between 3 and 5 cubs typically born (range 1 to 8).

Table 5: Litter size in cheetahs. Data from 521 litters (1,710 young) reported in the International Cheetah Studbook. Mean litter size is 3.3 ± 0.1 cubs/litter.

Litter size	Number of Litters	Percentage
1	83	16
2	93	18
3	105	20
4	118	23
5	74	14
6	36	7
7	9	2
8	3	1

2. Breeding and Birth Season Statistics

Being polyoestrus, births can occur throughout the year. However, seasonal peaks occur in certain areas probably related to nutritional factors, particularly to availability of prey, therefore described as "seasonally polyoestrus".

3. Gestation Period

Gestation length is commonly 89-93 days (earliest reported: 85 days, latest reported: 96 days). Mean gestation is 93 days (n=22 pregnancies).

Pregnancy is often difficult to detect. An enlarged abdomen may be apparent, the teats may become visible and the female's behaviour, notably feeding behaviour, may change during pregnancy or prior to parturition.

4. Birthing

When pregnancy is confirmed or suspected the female should be confined in the maternity unit, away from other cheetah and with observational facilities if possible. Ideally she should already be familiar with this area. Placing food in the entrance and gradually moving it inside will encourage a reluctant female to enter her den.

An impending birth may be indicated in some cases by a disruption of the feeding routine, The female may begin cutting back on food 2-5 days before parturition, and often stops feeding 24-48 hours before birth. This is a strong indication that she is about to deliver. A milk ridge is often evident a couple of days before parturition. Restlessness and tail twitching occur on the day of parturition.

Nest building behaviour (scratching in bedding of cubbing hut) and a stiffness of gait have also been noted, and in some cases abdominal movement may be seen. Following the birth the female may become more or less tolerant of human presence.

Close monitoring of the female is strongly recommended during the week prior to anticipated parturition. Television monitoring is highly recommended and observations should be made every 2 hours. If it is not possible to monitor remotely, keeper watches are necessary twice a day after key indications of parturition are observed. More frequent observations can be made if it is possible to do so without inflicting undue stress upon the female. Observations should be made by an individual that the animal readily accepts and conducted in a manner of least disturbance to the female.

Whatever maternity design is used, the female must be familiar with it prior to parturition.. If the female is comfortable with the indoor facilities, she may be closed into the den (10 x 12 foot room) each night beginning 2 weeks before parturition. If access to the maternity unit is optional and the female remains in the den, this is a strong indication that she may be near parturition.

Disturbance should be kept to an absolute minimum with cleaning around the den area suspended from at least one week before the expected birth up until the cubs are 5 to 6 weeks old. Alternatively, where the design of the maternity unit includes two adjacent yards each with a cubbing hut, yards may be cleaned alternately every few days.

The female should receive appropriate vaccinations and be treated orally for internal parasites a few weeks prior to parturition so as to ensure that the cubs are protected.

Cubs generally are delivered at 30 to 120 min. intervals during a parturition; however, intervals of 7 hour have been reported between cubs. Typical duration of parturition is 3 hours; the maximum reported is 10 hours.

The placenta may be eaten or buried by the female and the umbilicus normally dries and falls off after a few days. Different behaviours are observed for first time mothers more than experienced mothers. They may be more erratic and need to be carefully observed.

5. Parental Care

Birthing and maternal care are similar in the cheetah as in other cats. If the female is caring for her cubs, leave her alone. After all cubs have been born, if the female is not caring for her cubs (ignoring them instead of licking or nursing), the cubs must be pulled and hand-reared. Nursing is normally observed immediately after birth.

It is strongly suggested that the female be provided access to more than one den site to allow her to move her cubs from one den site to another. In the wild, mothers move young from den to den so this behaviour must be important for them. However, non-directed carrying of cubs indicates nervousness and should be cause for some concern.

Cubs may be weighed at 2 days of age if convenient and if the female allows you access to the den. A drop in weight can be an early indicator of illness or inadequate nursing. Careful attention should be paid to single cubs as these do not often survive due to the mother's milk drying up because of too little stimulation. In many cases these cubs need to be hand-reared.

6. Sex Ratio at Birth

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).

7. Birth -Weight Statistics

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. Males and females begin to show a difference in weight after about 6 weeks. There is no significant difference between mother-raised and hand-reared cubs (McKeown, pers. comm.).

8. Physical Development and Growth Characteristics

Cubs usually suckle within the first 24 hours though defecation may not occur until the second day. The eyes usually open between 2 and 8 days of age, though in some cases may not open until 10 to 15 days. Cubs begin crawling and vocalizing shortly after birth and over the next 2 weeks they stand and walk, unsteadily at first, prior to venturing from the nest, usually between 3-4 weeks of age. Initial attempts to eat meat may occur at just 18 days, or not until 7 weeks.

A suitable diet, providing sufficient calcium, should be provided for the lactating female to ensure correct nutrition of the cubs. When they begin to eat meat, this can be dusted with additional calcium supplement; care should be taken to ensure that each individual's intake is sufficient whilst avoiding over-supplementation. Bones may be provided for cubs to chew on as early as 2 month of age. Cubs may continue to suckle until around 6 months. Mother and cubs may be introduced to another family, or to an adult group when the cubs are about 6 months old.

It is critical that the maternity yard contains no pond, moat or other water-containing structure in which cubs could drown once they start exploring. The animals should, however have water freely available to them. Care must be taken to secure the perimeter fence to avoid the threat of injury to the cub by an animal in an adjoining yard.

9. Neonatal Mortality

Although infant mortality is a reality, rates have decreased significantly over the past few decades. During the past 5 years, 23 percent of the cubs died in the first year compared with 89 percent in the 1970's and 52 percent in the 1980's.

Stillbirths, premature births and congenital defects account for a significant number of deaths. Maternal neglect, exposure, pneumonia and maternal or cage-mate 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, or to excessive noise for example, has been postulated as a precipitating factor in many cases. Disturbance should be kept to a minimum, particularly in the case of the female's first litter, by providing a suitable nest box(s) offering maximum privacy, suspending cleaning around the den and avoiding as far as possible visual or auditory contact with conspecifics.

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. It has been suggested that social stress may inhibit lactation and disrupt appropriate olfactory responses resulting in the female cannibalising her cubs. Cannibalism has also occurred where the male has remained with the female, though in other cases he has remained for up to 2 months without harming the cubs. Nevertheless, it is advisable to isolate pregnant females. Degenaar (1977) and McKeown (unpub.) analysed causes of cub mortality; the results where known, excluding stillbirths and are show in Table 6.

Table 6: Cub Mortality in the Republic of South Africa, 1973-1976 (Degenaar, 1977) and in the British Isles, 1963-1990 (McKeown, unpub.)

CAUSE	McKeown ¹ No.	Degenaar No.
Maternal Neglect/Abandonment	13	7 ²
Eaten by Dam	12	8
Enteritis/Hypothermia or Exposure	7	8 ³
Killed by Male	-	2
Insufficient Milk	-	2
Hand-rearing	5	-
Injury	3	-
Cleft Palate	1	-

¹ All but one of the deaths are attributed by McKeown (unpub.) to inadequate husbandry. The 5 cubs that died whilst being hand-reared had presumably been neglected or abandoned by the female, and so cause of death can be attributed to inadequate maternal care which may of course, in itself, be related to inappropriate husbandry.

² In one case resulted in pneumonia, in another the cub drowned. A total of 11 cubs were abandoned, but 4 were hand-reared.

³ In two cases led to pneumonia

Developmental disorders due to nutritional deficiencies have also contributed to cub mortality. Typically these occur at around 4 to 6 months, the time of weaning. Insufficient calcium, and in particular an imbalance of calcium:phosphorous in the diet, has been related to developmental bone malformation (osteodystrophia fibrosa). A calcium:phosphorous ratio of at least 1:1 should be available in the diet. Calcium supplementation of the female's diet, and later that of the cubs, has been found to be beneficial. The administration of calcium phosphate is advocated by Leclerc-Cassan & Moutou (1986). The development of such conditions can be monitored in the case of hand-reared cubs through the periodic assessment of bone density using radiography if available. Over-supplementation should be avoided; too much calcium in the diet apparently contributed to a developmental deformity of the forelegs (osteochondrosis dissecans), characterized by forward bowing and an outward turning of the paws.

Ataxia, notably of the hind quarters, has been related to a copper deficiency and is characterized by a swaying gait, weakness of the hind legs, loss of balance, partial lameness and periodic collapse with lateral head shaking, sometimes in association with anemia. Copper supplementation, typically in the form of copper sulfate, can usually correct this condition, though if treatment is delayed the effects may be permanent.

Cubs have also succumbed to a number of diseases (e.g. toxoplasmosis, salmonellosis, coccidiosis), many of which can be diagnosed in their early stages through an examination of faecal cultures; regular collection and examination is advocated.

10. Age of Weaning/Sexual Maturity

Male cheetahs start producing sperm at 15 months of age. However, lower sperm concentrations and testosterone are observed in these males than in males 60-120 months old. Some males at 15 years of age are still producing 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. Records indicate that the youngest and oldest male to sire offspring were 24 and 147 months, respectively. The majority of successful copulations occurs between 3 and 9 years.

No data are available concerning the onset of ovarian cyclicity in female cheetahs. Age at first copulation for females varies from 18 to 52 months with an average of 43 months. Records in the International Cheetah Studbook (ICS) indicate that the youngest and oldest females giving birth to offspring were 21 months and 163 months, respectively, with an average of 57 months.

TABLE 7: Age (months) at first parturition in female cheetahs. Data from 188 females reported in the International Cheetah Studbook. Mean age a first parturition is 58.0 +/- 1.8 months.

Age at first parturition	Number of females	Percentage
<24	11	5.9
24-36	33	17.6
37-48	42	22.3
49-60	37	19.7
61-72	20	10.6
73-84	23	12.2
85-96	14	7.4
97-108	2	1.1
109-120	1	0.5
>120	5	2.7

11. Copulation Characteristics

Actual copulation is rarely observed and may tend to occur at night (frequency is low, 2 to 3 per oestrous, copulation typically occurring at intervals of between 1 and 8 hours and lasting for one minute or less).

D. Artificial Reproduction

Procedures such as semen collection, artificial insemination (AI) and in vitro fertilization can be important techniques for aiding in the reproductive management of the cheetah. These tools 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) as a vehicle for making the genome cryopreservation program functional. Further information may be obtained from the references provided on Reproduction.

1. Contraception Techniques

A number of contraceptive techniques are available, however, keeping sexes separate is advised due to the harmful, and in many cases irreversible effects of many oral contraceptives.

E. Reproduction References

- | | | |
|---------------------------|--------------------------|---------------------------|
| Asa et al., 1992 | Goodrowe et al., 1988 | Miller et al., 1989 |
| Barone et al., 1991 | Goodrowe et al., 1989 | Miller et al., 1990 |
| Bertram, 1978 | Grisham, 1988 | Nowak & Paradisio, 1983 |
| Bertschinger et al., 1984 | Guggisberg, 1975 | O'Brien et al., 1987 |
| Bertschinger et al., 1985 | Herdman, 1972 | Phillips et al., 1982 |
| Birkel, 1980 | Herdman, 1973 | Rawlins, 1972 |
| Benzon & Smith, 1974 | Holeckova et al., 1990 | Richardson, 1988 |
| Benzon & Smith, 1975 | Howard et al., 1981 | Seager & Demorest, 1986 |
| Benzon & Smith, 1977 | Howard et al., 1991b | Schaller, 1972 |
| Brand, 1980 | Howard et al., 1991c | Schumann, 1991 |
| Blyde, 1991 | Howard et al., 1992a | Setchell et al., 1986 |
| Caldwell & Howard, 1991 | Howard et al., 1992c | Skeldon, 1973 |
| Caro & Laurenson, 1989 | Howard and Doherty, 1992 | Standley, 1979 |
| Cupps, 1985 | Johnson et al., 1991a,b | Stearns, 1991 |
| Degenaar, 1977 | Kingdon, 1977 | Tennant & Craig, 1977 |
| Divyabhanusinh, 1987 | Lasley, 1985 | Thomas, 1965 |
| Donoghue et al., 1990 | Laurenson et al., 1992 | Thompson & Landreth, 1973 |
| Donoghue et al., 1992a | Lindburg, 1982 | Thompson & Vestal, 1974 |
| Donoghue et al., 1992b | Lindburg et al., 1985 | Tong, 1974; |
| Dresser et al., 1985 | Lindburg, 1991 | Ulmer, 1957 |
| Durant et al., 1985 | Lotshaw, 1980 | Vallat, 1971 |
| Durant et al., 1991 | Manton, 1970 | Van de Werken, 1968 |
| Eaton, 1970a | Manton, 1971 | Veselovsky, 1975 |
| Eaton, 1974 | Manton, 1974 | Volf, 1974 |
| Eaton et al., 1978 | Manton, 1975a | Wildt et al., 1983 |
| Eaton & Craig, 1973 | Manton, 1979a | Wildt et al., 1986 |
| Enke, 1960 | Manton, 1979b | Wildt et al., 1987b |
| Eriksen, 1990 | Marker, 1985 | Wildt et al., 1989 |
| Fitch et al., 1985 | Marker-Kraus, 1990a | Wildt et al., 1992 |
| Florio & Spinelli, 1968 | McKeown, 1991 | Wildt et al., 1981 |
| Florio & Spinelli, 1967 | McLaughlin, 1970 | Wrogemann, 1975 |
| Frame, 1984 | Meier, 1986 | Zwart et al., 1985 |

Chapter 5: Nutrition

The following factors are critical: Correct calcium phosphorous balance, inclusion of bone for chewing to promote periodontal health, a varied diet so that occasional whole carcass of e.g. rabbit is included and organ meat is fed (source of vitamins such as vitamin A in liver). In addition, communication between the source of the diets, the veterinary staff, and the keepers will allow monitoring of health status, early evidence of nutritional deficiencies, or potential toxic problems.

A. Nutritional Requirements

Unique nutritional requirements of felids must be recognized in feeding captive cheetahs, such as the inclusion of dietary vitamin A (as retinol), arachidonic acid, taurine, and niacin.

The exact nutritional requirements for all nutrients are not known specifically for cheetahs; therefore, requirements are extrapolated from data on domestic felids (NRC 1978). Diets are formulated, prepared, and fed; some meet dietary needs while others do not and result in cheetahs with nutritionally related medical problems (e.g., chronic disease, nutritional disorders or poor reproductive performance).

Commercially prepared carnivore diets or properly supplemented carcass meat should be considered the dietary staple for cheetahs. Recent studies with zoo felids have reported excesses of vitamin A and phytoestrogens, and deficiencies of taurine in various commercial preparations. Responsive manufacturers are correcting these potential health problems by reducing retinol 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 vitamin supplements should be necessary with properly formulated and stored commercial diets.

If chuck meat supplement diets are mixed within the institution they are supplemented to provide one percent calcium (dry matter basis), particularly if bones are not consumed. This is equivalent to about 7 g Ca per kg meat; a non-phosphorus containing supplement such as CaCO₃ (40% Ca) should be used. For this particular example, 17.5 g of CaCO₃ would be added/kg of fresh meat. If meat is lean (<25 percent fat) and/or well-trimmed, vitamins A and E 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. Vitamin E may be particularly necessary in diets based on meats containing polyunsaturated fats (any non-ruminant), at levels providing 50-150 IU/kg dry matter.

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). Observations of captive cheetah feeding suggest gut contents are not consumed in total.

In the absence of whole carcass supplementation, particularly with calcium, iron and vitamins A, D2, D3, and E, is required though care should be taken to avoid over supplementation. Commercially prepared supplements, are available and should be given under veterinary supervision. Felids are unable to convert carotene to Vitamin A and preformed Vitamin A should therefore always be available in their diet. A deficiency of vitamin A has been associated with retinal degeneration and infertility, whilst an excess has been linked to liver disease. According to Ullrey (1983) the B-sulfonic amino acid, taurine, should also be included in the diet of exotic felids; retinal degeneration in one cheetah was attributed to possible taurine deficiency. Unable to utilize essential fatty acids (EFAs) from plant sources, where cheetah are fed a commercial diet containing plant material, fish oil can be used as a supplement.

Females require additional food when pregnant or lactating. Any changes to the diet should be effected gradually. Calcium supplementation is particularly important for mothers and growing cubs and vitamin and mineral supplementation can be incorporated into the diet. Particular care should be taken to ensure sufficient calcium during weaning. Nutritional bone disease has been related to a low calcium:phosphorous ratio and a ratio of 1:1 should be available in the diet. Too much calcium, however, can also result in deformity. Copper deficiency has also been related to developmental defects; supplementation with copper sulfate has been found to correct this. Additional provisioning is likely to be required during cold periods to cater for an increased appetite.

B. Food Preparation and Feeding Location

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 are properly thawed to reduce

bacterial growth and diets fed as soon as possible after mixing. Commercial diets are thawed under clean conditions, free from external contamination, and fed immediately after thawing. Some institutions actually feed the diet while still 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. The practice promotes the rapid growth of bacterial organisms.

The food is offered on a non-contaminated surface. In most situations feeding is done off the floor of the enclosure. Feeding stations should optimally be off the floor or substrate. Feeding bowls can be used to reduce the risk of parasitic re-infestation. It is usual to feed in the outdoor pen, though controlled feeding indoors allows the amount consumed by each individual to be determined more accurately. Intraspecific competition at feeding may be minimized by providing more feeding stations, or separating animals for meals. Cheetah should be fed regularly to ensure that meat is fresh.

Where enclosures are extensive it is advisable to feed in a subdivided area of the main enclosure so that animals become accustomed to entering this area which may serve as a handling area should the need arise.

C. Quantities and Feeding Schedule

Determination of ration amounts is a dynamic process to meet changes in metabolic needs, such as seasonal needs, illness, pregnancy and lactation, and growth. Proper body weight, especially to avoid obesity, should be maintained by dieting alterations. These changes should reflect not only energy needs, but also vitamin and mineral needs. Obesity due to lack of activity in captivity is a major problem for zoo carnivores, including cheetahs.

Commercially prepared compound foods, such as Feline ZuPreem (Table 9), are available, though many collections prefer to feed meat supplemented with vitamins and minerals and/or whole carcasses. Oral disease has been associated with diets based solely on soft-textured commercial food. Horse meat or beef are most commonly used, together with a suitable supplement e.g. Calsup. Rabbit and chicken carcasses are also commonly used. Other carcasses, including goats, sheep, donkeys and ostriches. Where possible, freshly killed carcasses should be provided as these are nutritionally superior, providing essential fatty acids, a deficiency of which has been associated with infertility. Meat should be fed on the bone to promote periodontal health.

Adult cheetahs are fed to maintain body condition, with general maintenance energy requirements = 140 kcal (body mass in kg). Thus a female averaging 30 kg requires 1800 kcal/day, whereas a 40 kg male requires 2200 kcal. Based on survey information, however, the general energetic equation may substantially over estimate metabolizable energy (ME) requirements for the cheetah, and it appears that animals can maintain healthy body condition by consuming 800-1000 kcal/day. 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. As a baseline, females should receive around 1.3 kg of meat daily and males around 1.5 kg. Where one fast day per week is practiced, the meal sizes should be increased to 1.4 and 1.6 kg for females and males respectively. Diet quantities should be increased 10-20 % 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.

The food is weighed and daily records kept as to how much is offered to each individual cheetah and how much is consumed.. Records of stool consistency assist in determining if the diet is poorly digested or possibly inducing diarrhea indicative of enteric disease.

Some collections incorporate fast days, though this does not appear to be necessary. However, some management programs have found that cheetahs' appetites and body conditions improve if they are fasted one to two days a week. Either no food is fed on

these days or shank or other large bones are fed. Feeding bones (femur bones, oxtails, chicken necks, rawhide) has an additional function in promoting periodontal health.

D. Behaviour Related to Feeding

Behavioural as well as nutritional requirements should be considered when determining cheetah diets. Exercise and hunting activity can be encouraged by mechanically dragging a carcass through the enclosure or making use of a mechanical lure. Where possible whole or portions of carcass should be fed at least once a week to add a measure of variety to the standard diet. Whole carcasses have the advantage of requiring considerably more processing than do prepared diets or cuts of meat, promoting both oral and psychological health

E. Diet Under Quarantine Conditions

When in quarantine, the cheetah's diet is gradually changed to the new diet if different from its original. Any dietary alterations should be gradual to minimize 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 if the food is not available locally. To stimulate appetite, whole carcasses of rabbits or chickens may be offered.

F. Nutrient Content of Commercially Prepared Compound Diets

The commercial preparations are formulated from the comparative dietary requirements and received some field testing for varying periods. The advantage of the commercial diets is that they are readily available, require little or no labour in preparation, and are assumed to be formulated with a sound nutritional basis. Economics determine the components of these diets as the ingredients vary with the change in cost of producing the diet. Thus, the guaranteed analysis remains the same, but the diet may vary in raw ingredients. The guaranteed analysis label does not guarantee that the ingredients of the diet are actually utilized or available for utilization by the cheetah.

Table 8: ZuPreem: Analysis and Ingredients (Herdman, 1973)

Protein	18 %	Horse meat, liver, spleen; beef kidneys; whole ground chicken; whole egg; fish flour; yeast
Fat	15%	Animal fat; corn oil
Ash	3%	Calcium carbonate; dicalcium phosphate; trace minerals
Carbohydrate	5%	Rice, glucose
Calcium	0.5%	
Phosphorous	0.35%	
Vitamins & Mineral		Calcium, iron, manganese, magnesium, zinc, copper, cobalt, vitamin A, Vitamin B12, vitamin D2, Vitamin E, Vitamin K, thiamin, riboflavin, pyridoxine, niacin, pantothenic acid, folic acid, biotin, choline

Nebraska Brand Feline Diet (a product of Animal Spectrum Inc., PO Box 6307, Lincoln, NE 68506-0307) has been formulated to be fed as the sole ration to non-domestic carnivores, principally in the family Felidae. Nebraska Brand feline food is a complete and balanced diet fortified with all the necessary vitamins and trace minerals, as well as proper levels of calcium and phosphorus. Ingredients include horsemeat, horsemeat by-products, bone meal, liver, fish meal, soy grits, dried beet pulp, dried eggs, brewer's dried yeast, salt, D-activated animal sterol (source of vitamin D3), vitamin B12 supplement, vitamin E supplement, menadione, sodium bisulfite (source of vitamin K activity), riboflavin supplement, niacin, calcium pantothenate, cholin chloride, thiamine, pyridoxine hydrochloride, folic acid, copper oxide, cobalt carbonate, manganous oxide, ethylene diamine dihydriodide, zinc oxide.

Table 9: Nebraska Brand: Analysis and Ingredients

Crude protein	Min. 19%
Crude fat	Min. 7.0%
Crude fiber	Max. 1.5%
Ash	Max. 2.5%
Calcium	Min. 0.6%
Phosphorus	Min. 0.5%
Moisture	Max. 69.0%
Vitamin A	Min. 2500 IU/lb
Vitamin D3	Min. 750 IU/lb

G. Diets Which Have Caused Problems

The most common type of poisoning in large felids is from barbiturates used to euthanise feed animals. Felids feeding on such carcasses may show varying signs from mild ataxia to general anaesthesia that may last for days. The liver from such carcasses are especially high in barbiturate levels and cause more severe signs.

An essential fatty acid deficiency has been associated with spermatozoa abnormality and a suppressed oestrous cycle and may contribute to poor reproductive potential in captivity. Fish oil and evening primrose oil were added to the diet of two females to compensate for this deficiency. Obesity may inhibit conception.

The increased incidence of focal palatine erosion has been attributed to the feeding of soft commercial diets. Therefore regular feeding of bones is recommended to maintain oral health.

CHAPTER 6: HAND-REARING

Hand-rearing cheetah cubs is specialized and should not be attempted unnecessarily. Mother-reared cubs are better adjusted behaviourally and are less likely to suffer from nutritional deficiencies and other problems often associated with hand-rearing.

A. Care of Cubs Suffering From Maternal Neglect

Due to maternal neglect or health reasons, it may be necessary to hand-rear cubs. Hopefully the cubs can remain with the mother long enough to receive colostrum, but this is not always possible. If a deficiency in passive immunity is suspected, the cubs may be given subcutaneous and oral serum. This serum is collected sterile from the mother, (FIP and FIV negative), serum that has been in the collection for at least 1 year can be used as an alternative. The serum is filtered to remove bacteria and given at the rate of 5-8 ml/kg subcutaneous for 2 days and orally 2-5 ml/feeding for 3-5 days.

Where hand-rearing is necessary it is likely the cub may be hypothermic, dehydrated and hypoglycemic. Initially respiration and circulation should be checked and established artificially if necessary. When body temperature is near normal (mean 37.2° to 37.8° C), the cub may be gradually warmed being careful not to burn the skin where peripheral circulation is not fully established. Very young cubs are unable to maintain their body temperature and should initially be placed into an incubator or heated room, using the following temperature guidelines with a humidity of 50% to 60%:

- Week 1 32-30 °C
- Week 2 30-28 °C
- Week 3 28-26 °C
- Week 4 26-24 °C

As the cubs develop a heating pad or better still, infra-red bulbs which allow the cubs to adjust their position and thus regulate their own temperature may be used. A suitably sized box turned on its side provides a secure place from which cubs can start venturing out when they are settled enough.

Towelling can be used as a substrate, though it may be necessary to trim the claws to prevent their catching. Tightly woven material is preferable as cubs may try to suckle on the cloth and ingest loose pieces of material which can lead to gastrointestinal blockage or upset.

The cub is stimulated to urinate and defecate for the first month or two at each feeding by massaging the ano-genital area with cottonwool moistened with warm water. Cubs should be fed in their natural suckling position, laying on their front with their head slightly elevated. A human infant bottle, or special animal feeder, with a suitable nipple may be used. Depending on the cub's requirements it may be necessary to enlarge the nipple hole, taking care not to make it too large. Following each feed, gentle patting on the back will help to expel any air and prevent regurgitation. Hand-raised cubs should be weighed regularly to monitor weight gain and calculate necessary food intake.

Most hand-reared felids develop hair loss at 6-8 weeks of age. This is thought to be due to a deficiency in the diet. The addition of liver homogenate to the diet has been helpful in preventing and correcting this alopecia. Weaning cubs to solid food also usually enhances hair growth, and general appearance. *Microsporum* spp is not an uncommon cause of hair loss in young cheetahs. Treatment is similar to that in the domestic cat with equally as good results. Griseofulvin is given orally at 20 mg/kg/24 hour or it can be given weekly at 140 mg/kg. There is a reported case of a drug induced anemia in one group of cats treated with griseofulvin. Again it is best to monitor carefully all felids who are receiving medication.

Imprinting on humans can result in behaviour problems at adulthood. This is less of a problem where cubs are raised in sibling groups instead of alone. If hand-rearing is required, reintroduction of the cub to its mother as soon as possible is strongly recommended. If hand-rearing requires more than 4-5 days, the cubs should be located within sight, sound, and smell of other cheetahs, preferable mother and cubs, as soon as possible. Watch the reaction of the other cheetahs to the hand-reared cub through a fence or other safe barrier and then initiate gradual introduction of the cub as early as possible.

To facilitate re-integration, cubs should ideally be reared with siblings or cubs of a similar age. If only one cub is being hand-reared a young carnivore of another species, or a domestic dog, can serve as a substitute. To facilitate full social integration the cub may then be housed adjacent to conspecifics, ideally a potential mate, with limited contact through the boundary fence. Behaviour should be monitored and when positive responses are noted, such as eating and sleeping near to each other, mutual head-rubbing, vocalizations and male spraying, access between the enclosures can be allowed under observation.

B. Feeding Schedule

Schedule suggestions vary between various institutions, which have all successfully hand-reared cheetahs, and they must be adapted to the animal and institution. Small, regular feeds are preferable so as to avoid over feeding and to prevent cubs suckling on inappropriate objects, including litter-mates. The cub should not be fed for the first 12 hours following its birth so as to allow the meconium to be passed. Thereafter, the cub should be fed every 2 to 3 hours for at least 16 hours a day. Where colostrum has not been received from the mother it should be fed for the first few feeds. If possible, it should be collected from the mother though gamma globulin may be used instead, or the mother's serum may be administered orally or subcutaneously.

Two schedules are included for reference.

Example 1: 10% glucose for the first 3 feedings and on the 4th feeding 10% dextrose is added to milk replacer at a 1:1 ratio. Fifth feeding is milk replacer.

Days	Feedings
1-2	12
3-10	11
11-15	10
16-29	9
30-40	8
41-55	7
56-60	6
61-70	4
71-73	2
74-75	1

Example 2:

Day	Volume (cc)	Feedings
1-3	10	8
4-8	12	8
9-19	15	8
20-27	18	8
27-30	23	6
31	25	6
32-58	30	6

C. Diet

1. Milk Mixture

There are numerous protocols for hand-raising cheetahs using various products. Initially the cubs should receive 10% dextrose for the first 3 feedings then started on milk replacer. For the first 2 days, cubs should be fed a diluted milk replacer formula (half strength, diluted with sterile water) in volumes of 8-10 cc every 2-3 hours to keep the cubs hungry to help minimize gastrointestinal problems. Over the subsequent days, the volume is increased and frequency decreased if the cub continues to gain weight and gastric impaction or distention does not occur. Concentration of the milk replacer may be increased stepwise over several days to full strength. Addition of an enzyme to break down lactose (Lactaid) is added which seems to decrease the incidence of gastrointestinal problems (diarrhea, blood in stool, formation of gastric milk curds).

Various commercial milk replacers are available. Alternatively a milk substitute, based on supplemented goats milk or evaporated milk for example, can be prepared on site. Analyses of cheetah milk have suggested a high fat (40% dry matter) and protein (40% dry matter) content as shown in Table 10 which may be used as a guide when selecting a replacer. However, milk

analyses are not always accurately produced and composition changes over the period of lactation. It may therefore be better to assess each diet according to the cub's development and to adapt composition and amounts fed according to individual requirements. Milk should never be forced into a cub as aspiration pneumonia may result. Until the cub is suckling well it is safer to feed warmed electrolyte-glucose solution which is less irritating to the lungs; lactose should not be used as cubs are unable to mobilize it. Very weak cubs may initially require a stomach tube or a saline drip.

Table 10: Composition of cheetah milk and these values as a percentage of dry matter.

	Milk	Dry Matter
Solids	23.7 %	
Fat	9.5 %	40 %
Protein	9.4 %	40 %
Carbohydrates	3.5 %	14 %
Ash	1.3%	6 %

Intolerance to milk may develop in some cases. If this is not alleviated by changing milk type it may be necessary to replace several feeds with an electrolyte-glucose solution. Special products are available and weaning should be encouraged as soon as possible.

In the absence of well established calorific requirements or growth curves, the amount to feed will depend to a large extent upon the development of each cub. Calorific requirements will obviously vary according to many factors including activity level and health status. Meier (1986) suggests an energy requirement of 3 to 4 times the basal rate; the basal rate can be estimated using the following equation:

$$y = 70W^{0.75}$$

Where y = kcal/day and W = body weight in kg.

As a rough guide, fluid intake should be in the region of 10% to 15% of body weight per day. The amount fed should not exceed 30% to 35% of body weight; overfeeding can result in renal overload, fluid accumulation and gastrointestinal upset.

2. Meat

Solid food (meat diet) should be introduced at between 2 and 4 weeks of age. Weaning from milk should occur at 10-11 weeks.

Meat products can be gradually incorporated into the diet to facilitate weaning. Beginning at around 2 weeks, as more meat is blended, the milk-based diet can be gradually reduced and the intervals between feeds lengthened until the cub is fully weaned onto the adult diet. Using a sharp knife, meat can be "shaved" to form a smooth paste which the cubs can lap.

Finely minced, skinned chicken carcass (including the bone) can be used initially and red meat gradually introduced. The minced chicken bones provide an excellent source of calcium. Lapping can be encouraged by pouring milk over solid food in a bowl. Weaning may be completed by 3 months of age. If meat products are used instead of a commercial diet, special care should be taken to ensure correct supplementation, particularly of calcium, to promote healthy bone growth.

D. Diarrhea

Diarrhea in young cheetah can be potentially lethal within a short period of time and needs immediate treatment. The formula is diluted with oral electrolyte solution and the total volume decreased by 20-40% for 8-12 hours. A stool culture prior to antibiotic therapy is obtained to check for pathogenic bacteria. If diarrhea is severe and persistent, all oral intake is stopped for 12-18 hours and the cub supported with subcutaneous fluids, and then started on oral electrolytes followed by dilute formula and returned to normal feeding over the next 12-24 hours.

To prevent diarrhea occurring all meat and milk must be fed fresh. Meat warmed for feeding and not consumed should be thrown away and not fed the next day. Meat fed should be obtained and processed under aseptic conditions away from the general food preparation areas. All working areas and bottles, etc. should be sterilized regularly. Changes in diet must be brought about gradually.

E. Nutrition and Hand-rearing References

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Chapter 7: Health

The evaluation of a new cheetah begins with a review of its past medical history which should be part of the health certificate. It is unacceptable to send an animal to a new collection without its medical history. This data alerts the clinician to previous and potential problems and documents past vaccinations, faecal examinations, anesthetic episodes, and blood values. Body weights are obtained on all cheetahs entering and leaving quarantine. It is recommended that each cat be individually identified with a subcutaneous microchip.

A. Inoculations

Vaccinations are given during quarantine to allow time for antibody response prior to release of the cheetah into the collection. Severely stressed animals may not mount appropriate titers and should be revaccinated if conditions indicate. There is one vaccine that provides good antibody titers to three major infectious viral diseases: 1) panleukopenia (feline distemper), 2) rhinotracheitis, and 3) calicivirus. This is a killed product and provides apparent protection at a 1 ml dose in adult cheetahs. Cubs are vaccinated every 2 weeks from 8 to 16 weeks of age, with a booster vaccination at 40 weeks to insure that protective titers are maintained during the first year of life. A single annual vaccination appears to be adequate to maintain protective antibody titers in adults.

The use of a rabies vaccine is dependent on local situations. In endemic rabies areas, a killed vaccine is recommended (at a dose of 1ml) for protection of the animal. This dose has produced, in captive cheetahs, what is reported to be a protective titer in many non-domestic species. This vaccine should be repeated yearly in rabies endemic areas.

Leptospirosis is a potential disease in all mammals, but has not been reported in cheetahs, but in environments where leptospirosis exist, vaccination with a bacterin may be indicated. Two problems arise: first, the correct vaccine serotype may not be available; and secondly, the duration of protection is usually short lived, 2-3 months.

Vaccination of several species of non-domestic Felidae with feline leukemia vaccine have produced appropriate titers. The use of this vaccine as a regular procedure, however, requires more consideration since no cheetahs have been found to be positive for this virus, and neoplastic and immunosuppression syndromes, as occur in domestic cats with feline leukemia virus, have not been documented in cheetahs. Vaccination-induced titers could also impair epidemiological studies in place.

Vaccines, developed for use in domestic cats, are available for panleukopenia, or feline enteritis, (FEV), rhinotracheitis (FVR), calicivirus, feline leukemia (FeLV) and rabies. An assessment should be made of the possible costs and benefits associated with their use and great caution should be exercised if live vaccines are used.

A number of collections routinely vaccinate against FEV, FRV and calici-virus infections. Unless there is information to the contrary, vaccination schedules should follow the regime recommended by the manufacturers for domestic cats. All vaccines should be administered under veterinary supervision.

A commercial modified live virus vaccine is marketed for use in the domestic cats for the Feline Infectious Peritonitis. At the present time, this vaccine is not recommended for use in cheetahs due to questions about its safety and efficacy. Though, as with feline leukemia, FIP may be detected through regular monitoring of blood serum antibody levels at 2 to 3 year intervals.

B. Neonatal Examinations

Following birth, newborn cubs are allowed to bond with their mother for the first 24 hours prior to their first physical examination. This complete neonatal exam should be conducted on all cubs including animals to be left with their mother and animals that must be removed for hand-rearing. This exam includes body weight, rectal temperature, temporary individual identification (clipping hair) and sex determination.

Transpondering of cubs can be done at about 3 months. The navel is disinfected and a complete physical exam is conducted for congenital abnormalities (e.g., cleft palate, heart defects). Mucous membranes and skin turgor are evaluated for dehydration. A blood sample should be collected during the first few days 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, usually a long-acting penicillin.

C. Parasites

1. Screening Schedule

During the quarantine period, cheetahs are screened for internal parasites by repeated faecal examinations. If present, parasites are eliminated, with appropriate anthelmintic, before the cheetah is released into an exhibit. This is extremely important in naturalistic exhibits (i.e., dirt and grass) which can become contaminated with parasite eggs. Screening for enteric pathogens by stool culture may help identify cheetahs that are carriers of *Salmonella* spp.

A parasite monitoring program provides periodic, regular stool examinations to detect parasitic infections. Most internal parasites found in stool examinations are relatively common and ubiquitous in captive situations, with some less frequent infections reported. Treatment, which may be oral or intramuscular, should be administered under veterinary supervision.

2. List of Commonly Observed Parasites

Commonly identified species are from the orders Ascarididae and Strongyloidea (i.e., Toxocara, Toxascaris, Ancylostoma).

Neonatal mortality and poor growth rate have been linked to infestation with *Toxocara* eggs.

3. Recommended Treatments

It is seldom possible to eliminate ascarids totally in cheetahs, but they are controllable with periodic administration of oral anthelmintic. These agents can be more effective when the full recommended dosage is given for more than one day, such as three consecutive days, rather than as single treatments. Post-treatment faecal examinations are necessary in assessing efficacy of the initial treatment. Follow-up treatments to remove larval stages not susceptible during the initial treatment may be required.

The following anthelmintic programs are effective and safe when administered using appropriate dosage regimens:

- a) Pyrantel pamoate (Strongid-T, Pfizer Inc., New York, NY 10017) - 3-5 mg/kg per os. Can be given at this level for 3-5 consecutive days;
- b) Fenbendazole (Panacur, American Hoechst, Somerville, NJ 08876) - 5-10 mg/kg per os. Most commonly single day treatment, but can be given three consecutive days at this level;
- c) Ivermectin (Ivomec, Merck & Co., Rahway, NJ 07065) - 0.2 mg/kg, subcutaneous or per os. We have used injectable cattle formulation orally at this dose for 1-3 days. Limited use in cheetahs with the parenteral route;
- d) Praziquantel (Droncit, Haver-Lockhart, Shawnee, KS 66201) - 5.5 - 6.6 mg/kg. Either as the oral or parenteral form for cestodes;
- e) Sulfadimethoxine (Albon, Roche Chemical Div., Nutley NJ 07110) - 50 mg/kg, parenteral or per os, as a coccidiostat.

Not all eggs or larvae observed in faecal examinations may be parasitic. The cheetah may be serving as a transport host depending on what it has been fed or what feral animals it consumed. Coccidia observed may be associated with feeding whole carcass specimens (e.g., whole rabbits). This emphasizes the need for specific identification of parasite stages seen in stool and an awareness of the cheetah's diet. It is important to ensure that food items such as rabbits are parasite and disease free themselves.

D. Major Disease Problems And Treatments

Results of necropsies, Table 12 & 13, highlight infant mortality, kidney and liver disease and feline infectious peritonitis (FIP) as major causes of mortality.

Table 11: Result of 214 necropsies of North American cheetah (Marker & O'Brien, 1989).

Cause of Death	No. Died	Percentage
Infant Mortality	79	36.9
Liver/Kidney Disease	41 ¹	19.0
FIP	39 ²	18.2
Euthanasia	11	18.2
Injury/Trauma	8	3.7
Pneumonia	8	3.7
Anesthesia	4	1.9
Other	24	11.2

¹ Symptoms of FIP were also present in some cases and it is therefore suggested that FIP may have accounted for a number of deaths prior to the 1982 epizootic which were not diagnosed as such.

² Most of these deaths occurred as a result of the 1982 epizootic.

Table 12: Cheetah mortality 1963-1990 in the British Isles (McKeown, unpub.).

Cause of Death	No. Died	Percentage
Infant Mortality	41	28.0
Unknown	28	25.7
Euthanasia	14	12.8
Nephritis	12	11.0
FIP	8	7.3
Injury/Trauma	8	7.3
Liver/Kidney Disease	5	4.6
Anesthesia	4	3.7
Septicemia	4	3.7

With tuberculosis, pneumonia and enteritis each accounting for 3 deaths (total 8.3%), pox infection, heart failure, parasitic toxins and convulsions accounting for 10 deaths (total 9.2%) and peritonitis, panleukopenia, anemia, meningitis, pancreatic atrophy and gersinia accounting for 7 deaths (total 6.4%). Of particular concern is kidney nephritis as its etiology is unknown; it only affects animals over 4 years of age and is twice as common in captive bred animals as in wild caught. Strict protocols for testing for FIP and other viruses should be adhered to when animals are to be moved between institutions.

1. Feline Infectious Peritonitis

Feline Infectious Peritonitis (FIP) is of major concern in captive cheetahs due to its impact on individual and group health and inter-zoo (including international) movement for reproductive, exhibit, and potential reintroduction purposes. Although clinical incidence of the disease in the captive cheetah population in North America has decreased from 1989 through 1991, coronavirus seroconversion during this period

increased to a level of nearing 70 percent seropositivity. Serum titers of <1:25 are seronegative. Serum titers \pm 1:25 indicate exposure to a coronavirus. But positive antibody titers are not necessarily predictors for development of clinical disease or an animal's potential for disease transmission. The populations of individuals which appear to be at greatest risk are those expressing possible clinical disease and/or have a rising serum titers.

In addition to serological monitoring, feces can be examined for coronavirus shedding; evidence of feline leukemia should also be assessed as this apparently predisposes domestic cats to fatal forms of FIP. Based on the results of serological/faecal assessments, various management recommendations have been made so as to reduce the risks of infection. An animal with titers of less than 1:25 is classes as seronegative and therefore unprotected. Briggs et al. (1986) suggest that animals with titers of up to 1:100 can be accepted into a collection, up to 1:400 is acceptable if the animal is from a facility with no history of FIP, or in cases where titers are stable or declining and the animal is negative for faecal shedding. Animals with titers of 1:600 should not be accepted into the collection as there is a high risk of their developing FIP. Such an individual should be isolated from other animals, particularly those that are seronegative.

The epizootiology of FIP is not fully understood; the virus may be cheetah specific or transferred between species in view of which access to cheetah enclosures by domestic cats should be prevented. The orinasa route is the most likely mode of transmission, or by direct contamination as a result of a bite or other wound becoming infected. It is advisable to isolate individuals in the event of an outbreak of any viral disease and to take adequate precautions to avoid the transmission of disease when moving animals between collections.

An epizootic of FIP in North America between 1982 and 1985, and the results of a number of serosurveys, highlight the cheetahs' susceptibility to this virus. Their apparent susceptibility to viral disease has been related to immuno-deficiency as a result of a qualitatively inadequate diet or the species genetic impoverishment.

Pfeifer et al. (1983) describe the symptoms and pathology associated with FIP in an 8.5 year old female, the individual identified as the source of the 1982-1985 epizootic. Following a period of anorexia, a fight with a conspecific led to sudden depression and near collapse. Rectal temperature was recorded at 39.7°C with 7 % to 8 % dehydration. Renal and hepatic failure were diagnosed and death occurred after 7 days. Blood serum was analyzed for feline coronavirus antibodies; titers of 1:1600 were found. Major lesions within the liver, spleen and kidneys were identified.

FIP is often associated with symptoms of liver dysfunction, a condition frequently diagnosed at necropsy.

We recommend that all zoos continue to monitor their collections annually for Feline Infectious Peritonitis by sending serum samples to: Dr. Jim Evermann, Washington State University, Washington Animal Disease Diagnostic Laboratory, College of Veterinary

Medicine, Pullman, WA 99164, USA. Additionally, serum titers for FIP should be obtained on individual cheetahs just prior to shipment, and compared to their post serologic history. Cheetahs with rising serum titers should not be transferred to seronegative facilities. Prospective transfer of seropositive individuals to another seropositive facility will be evaluated on an individual basis, with consideration of the possible impact to the receiving facility. Continuous and shared knowledge of FIP status of all facilities and individual animals is essential in the long term management of the species. Results of serology will be identified with studbook number and institution and will be maintained by Dr. Evermann and the Cheetah SSP Veterinary and Pathology Advisors. The goal is to identify and maintain seronegative populations and isolation of seropositive individuals in an attempt to develop a larger seronegative population over time, or optimally, eliminate the disease from captive cheetahs.

2. Feline Immunodeficiency Virus and Feline Leukemia Virus

The clinical significance of these viruses in the cheetah is unknown at this time; there are confirmed cases of positive FIV titers in cheetahs in North American zoos, but no known associated illness. It is recommended that serum titers for both viruses be determined in conjunction with FIP testing as a method of continuous screening.

3. Toxoplasmosis

This condition has not been reported in cheetahs, but the potential exists; therefore, it is often included in feline serology panels.

4. Veno-Occlusive Disease

Veno-occlusive disease (VOD) is a progressive disease caused by gradual obstruction of the efferent veins of the liver with fibrous tissue eventually resulting in liver failure and ascites. The cause is unknown, but a toxin that damages endothelial cells is suspected.

Veno-occlusive liver disease has accounted for a significant number of deaths. It occurs primarily in cheetah between 6 and 11 years of age. The etiology is not fully understood though in humans it has been associated with the ingestion of certain alkaloids of plant origin. Plant toxins, while considered an unlikely cause of VOD by some, are given serious consideration by others who have identified biologically active plant estrogens, present in some commercial diets, as a possible cause. Chronic levels of vitamin A in the diet have also been identified as a possible pre-disposing factor. It has further been suggested that a lack of exercise in an animal whose liver is superbly adapted for the sudden mobilization of energy may be a contributing factor. Lack of exercise has also been related to coronary defects.

5. Renal Disease

Renal diseases that progress to end-stage kidney disease in cheetahs can be due to one of three distinct disease processes: glomerulonephritis (GN), chronic interstitial nephritis

(CIN), and pyelonephritis. Any of these diseases can result in fibrosis and renal failure. The etiology of CIN and GN are unknown. Pyelonephritis is due to ascending infections.

6. Feline Herpesvirus (Rhinotracheitis)

Feline herpesvirus (rhinotracheitis) is a disease of neonatal cheetahs when maternal passive antibody levels decline at 8 to 12 weeks of age. Typical rhinotracheitis lesions are seen with subsequent appearance of ulceration at mucocutaneous junctions extending to epithelial tissues in a small percentage of animals. Once present, the lesions often persist and expand through adulthood. The source of the virus is suspected to be the dam; prevention of contact with the virus during the period of immune susceptibility by removing the cubs from the mother until vaccination confers immunity is the present method of control.

7. Salmonellosis

Salmonellosis was thought to be endemic in the captive population but this was not substantiated by the recent survey of normal faecal flora during the SSP reproductive/medical survey. Confirmed cases of salmonellosis have been associated with clinical disease, therefore animals should be screened for salmonella in cases of enteric disease, prior to shipment, and during quarantine. The incidence of positive salmonella cultures from frozen carnivore diets would suggest periodic faecal culturing for the presence of salmonella is indicated. It must be also recognized that salmonella is a potential public health hazard.

8. Chronic Gastritis

Chronic gastritis with vomiting in cheetah has been associated with spiral bacteria. Gastric mucosal hyperplasia and the presence of spiral bacteria (Helicobacter pylori, Gastrospirillum sp.) was also seen in necropsy tissues from cheetahs dying from unrelated causes with no history of vomiting. These organisms cause gastritis in humans and are associated with peptic ulcers and gastric carcinoma; evidence suggests these organisms can also cause gastritis in mammals. The presence of one or both of these bacteria has been documented in a wide variety of mammals and in cheetahs from six North American zoos. No deaths have been related to these bacteria. The significance of the relationship of gastritis and these bacteria in cheetahs is being investigated.

9. Pancreatitis

Supplementary fat in the diet and obesity has been implicated in the etiology of Pancreatitis.

E. Common Injuries and Treatments

A potential surgical problem is lacerations from fight wounds. Usually lesions are small and are left to drain and granulate in. Antibiotics should be given orally for 7-10 days

after such fights to minimize local infection and bacteremia that may shower to other organs. Common isolates from the mouths of cheetah are Pasteurella spp. with Staphylococcus aureus and Streptococcus viridens as potential problems. Pasteurella spp. usually shows good sensitivity to a wide range of antibiotics with cephalosporins being the drug of choice.

Abscesses should be clipped and prepped for a sterile culture in order to determine the etiology and guide the choice of antibiotic therapy. The abscess is then opened and drained. Flushing of the lesion with hydrogen peroxide and a disinfectant is recommended. The cheetah should be treated with systemic broad spectrum antibiotics for 7 to 10 days.

F. Physiological Norms

Usually 2 to 3 weeks into the quarantine period a complete physical examination is performed under general anesthesia. This exam includes evaluation of each organ system following a regular protocol to assure completeness to include: 1) external: eyes, ears, oral cavity, pelage, feet, and claws, 2) palpation of limbs, including movement of joints, and abdomen to detect organ enlargement, fluid, or masses, 3) auscultation of the thorax for pulmonary and cardiac assessment (rate and rhythm), 4) body weight. A second blood sample is collected for hematological and clinical chemical screening, and for serum banking which has proven vital for past and future retrospective monitoring of new epizootics.

The oral examination should include dental structures for fractures, periodontal disease, malocclusion, carnassial tooth status. A complete set of survey radiographs is recommended to assist in the overall assessment of the cheetah and as a future reference. Semen collection via electroejaculation is recommended for unproven adult males destined to be breeders. Complete physical examinations should also be performed at the time of more targeted examinations for specific health problems. A protocol of regular physical examination is established for ongoing preventative medical care.

Preventative medical programs during quarantine have been stressed and it is important to continue this concept as an ongoing program in the captive maintenance of the cheetah. An important portion of this preventive approach should include routine observation of the cheetahs in the collection, not only by the keepers, but also by the veterinary staff. Routine rounds through the area are made to remain familiar with the cheetah, to evaluate their overall appearance, activity, and facility conditions, and to talk with the keepers. The veterinarian's experience allows him/her to detect an abnormality or develop an impression about the cheetahs' health and management that may not be obvious to the keeper staff. Familiarity with normal conditions and cheetahs will allow a better comparison when the animal is suspected of having an abnormality. As well, a good relationship with the keepers promotes open communications between the animal and veterinary staff which is vital to any medical program. There are potential limitations to these visits, since many large felids recognize the veterinarian and associate them with some past negative situation usually involving a manipulative procedure.

These cheetah can react aggressively which masks the subtle first signs of many medical problems; therefore the medical staff must carefully consider keepers observations concerning subtle changes in their cheetah.

1. Heart and Respiratory Rates

Adaptations for speed reflected in respiratory and cardiovascular capacities. Variable respiratory rates ranging form 9 breaths/minute when resting in shade to 156 breaths/minute after chase, with 206 breaths/minute on record. Rapid heart rate: normal rate 100 b.p.m. with 195 b.p.m. recorded after field immobilization.

2. Blood Chemistries

During quarantine a blood sample is obtained to evaluate the animal's health status and provide a baseline for future comparison. An initial blood sample is taken prior to anesthesia by placing the cheetah in a squeeze cage and bleeding it from the medial saphenous vein. This will help evaluate the animal's status prior to anesthesia for a complete physical examination. Clinical parameters of primary interest at this time are total WBC count and differential, hematocrit, BUN, creatinine, liver enzyme values and an examination for red blood cell parasites. It should be recognized that values might differ between various laboratories and the best set of values is the one that your laboratory compiles. Values such as BUN also may vary from collection to collection in response to diet.

3. Temperature

Rectal temperature is 39.0°C for adults, 36.0° to 38.0°C for neonates.

G. Immobilization

Anesthesia is a critical component of the overall medical program in all nondomestic felids which allows the veterinarian safe access to the patient for diagnostic, therapeutic, surgical, and research procedures. The state of the art and science of anesthesia in this species has advanced so that the procedure is expected to be a routine safe procedure. When Problems occur overall medical and research programs are potentially endangered, therefore safe anesthesia through appropriate techniques and appropriate physiological monitoring is mandatory.

Pre-anesthetic preparation enhances the success and safety of the procedure. The cheetah is fasted for at least 24 hr prior to the procedure. Water should be withheld for at least 12 hours unless medical concerns or weather precludes it. The patient should be shifted to a small area, preferably a squeeze cage, for drug administration. Animals that are calmer at this time usually require less drug and have a smoother induction period.

We consider the drug of choice for cheetah anesthesia is Telazol (Telazol, A H Robins, Richmond, VA 23220) (Zoletil, Laboratories Reading, A.Z.C. 17, rue des marronniers,

94240 L'Hay-Les-Roses), a 1:1 combination of tiletamine HCL and zolazepam HCL. An advantage of Telazol is its availability as a dry powder which can be concentrated to 500 mg/ml rather than the recommended 100 mg/ml. Telazol produces rapid induction of anesthesia requiring only 2-3 minutes for the initial onset of effects. The drug is remarkably safe in that respiration is not depressed and the cardiovascular integrity is maintained.

Salivation is minimal and the swallowing reflex is well preserved. As with other anesthetics, the dosage varies with the activity and status of the patient. In a captive situation with a calm cheetah 0.5 mg/kg is usually adequate while in an excited patient or in a field situation a dose of 3-8 mg/kg are required. Recovery is smooth and slightly prolonged. The disadvantages are occasional minor CNS signs, usually in the form of mild tremors and there is no direct antagonist available for Telazol. A re-sedation 3-4 days following Telazol anesthesia has been observed in two cheetahs. Both cheetahs had prolonged anesthetic episodes which required several supplements with Telazol. Similar situations have been reported in some tigers. These animals usually show mild sedation with stumbling and may require supportive treatment for 12-24 hours before they return to normal.

Ketamine (Vetalar, Parke-Davis, Morris Plains, NJ 07950) is a major anesthetic drug used for cheetah. With ketamine alone problems include, poor muscle relaxation and a tendency to produce CNS signs (tremors and grand mall seizures); also, a large delivery volume (4-5 ml) is required. Ketamine induced seizures are often self-limiting; therefore, it is advisable to monitor the patient and permit one or two seizures to pass before administering anticonvulsants, unless the seizures are severe or prolonged. To control ketamine induced convulsions diazepam at 0.02 mg/kg is given IV. The addition of other drugs to ketamine not only helps control side effects but decreases the amount of ketamine required for anesthesia. Ketamine is usually combined with a second drug, i.e., diazepam (Valium, Hoffman LaRoche, Inc., Nutley, NJ 07110), or xylazine (Rompum, Haver Lockhart, Shawnee, NS 66201). Two and one half mg/kg ketamine and 0.2 mg/kg xylazine in combination is a commonly used anesthetic technique for cheetah.

Intravenous ketamine (50-75 mg) will rapidly deepen anesthesia to facilitate endotracheal intubation or extend anesthesia for brief periods (15-20 minutes). The advantage of the IV versus the IM route for supplementation is the rapid onset, lower total dose and more rapid recovery.

Atropine may be used to prevent xylazine induced bradycardia and help control salivation. One half to one mg of atropine is the dose for an adult cheetah.

The steroidal anesthetic Saffan (Saffan, Glaxo Ltd. Middlesex, England) has limited availability especially in North America, is a safe and effective anesthetic agent for cheetah. The main disadvantage is the necessity to inject the drug intravenously, at a dose of 2 mg/kg, which requires placing the cheetah in a squeeze cage.

Administration of anesthetic drugs is facilitated by using a squeeze cage which allows the use of a hand syringe. If remote drug delivery is necessary it is best to use the less traumatic lightweight plastic blow darts or pole syringe rather than the aluminum darts with the powder charged drug injection devices to minimize the pain of injection and impact trauma.

For prolonged medical treatment or surgical procedures, especially in aged and/or ill patients, inhalation anesthesia is recommended. Following initial anesthesia with injectable dissociative anesthetic which allows intubation with a cuffed endotracheal tube, either halothane (Halothane USP, Holocarbon Labs., Hackensack, NJ 07601) or isoflurane (Forane, Ohio Medical Anesthetics, Madison, WI 53713) can be given, depending on the preference of the clinician. We feel that isoflurane is the inhalation anesthetic of choice in cheetah. Intubation of cheetah is not difficult. Topical anesthetic to the larynx is not usually necessary and it has the disadvantage of blocking gag reflex which protects the airway in case the patient vomits. Most patients do well on spontaneous respiration with occasional assisted respiration; but sometimes positive pressure ventilation is indicated.

Physiological monitoring of the anesthetized cheetah is an integral part of the anesthetic episode. Initial observations include: responsiveness to stimuli, respiration rate, color of mucous membranes, pulse rate and intensity, and muscle tone. More sophisticated monitoring can include blood pressure, pulse oximetry and electrocardiogram (EKG).

A helpful and easy parameter to measure is indirect blood pressure using a regular sphygmomanometer attached to the foreleg. The systolic pressure is read at the point where the needle continues to fall and the bounce stops at about the level of diastolic pressure. There are commercially available instruments (Dianamap, Critikon, Inc., Tampa, Fl 33607) that measure indirect blood pressure. These machines make recordings every minute and transcribe the reading to a printer. Data obtained include systolic, diastolic and mean blood pressure, and heart rate. The machine is also equipped with alarms that can be set for high or low reading. Indirect blood pressure values may not be as accurate as an intra-arterial transducer, but rather these values are to note trends in the pressures during the anesthesia period. Blood pressure also provides a more functional evaluation of the cardiovascular system than an EKG recording.

Pulse oximetry has become an indispensable physiological monitor during human anesthesia and has recently been adapted for use in zoological species. This non invasive technique uses a sensor which transmits a beam of light through a pulsatile capillary bed to instantaneously determine oxygen saturation of the blood and the pulse rate. The sensor, designed for humans, is modified to clip on the lip, ear, tongue or nasal septum in a non pigmented area. Due to the popularity of pulse oximetry in human anesthesia, the price is continuing to drop which should allow many zoo veterinarians to purchase this vital piece of equipment.

Another often overlooked parameter is body temperature, especially during prolonged surgical procedures where hypothermia may occur. Elevation of temperature may be

seen with convulsions, preanesthetic excitement, high environmental temperature, and exposure to direct sunlight. Body temperatures greater than 39.4° C is an indication for cooling with water and air circulation. Severe hyperthermia, >40.6° C, requires more aggressive therapy including water immersion, cold water enemas, IV fluids, corticosteroids, and antibiotics.

H. Oral Examination

A thorough oral examination is an integral part of a physical examination, either planned or done whenever anesthesia is performed. This examination becomes more important as a cheetah ages to prevent dental problems from causing systemic diseases.

During the examination the teeth and the soft tissue structures of the mouth and throat are examined for abnormalities. The odor from the mouth may prove to be an important indicator of a dental problem. The area of the hard palate adjacent to the carnassial teeth are examined for erosions and penetrations of the soft tissue and possibly the underlying bone (into the nasal cavity), a condition known as focal palatine erosion. Foreign bodies lodged between oral structures, such as bone fragments, sticks, etc., can be incidental findings but definite predisposes to oral disease.

These should be removed and infections or traumatic lesion treated as indicated. Calculus accumulation is removed from the teeth surfaces with care taken to remove material from the subgingival sulcus. If power equipment is available, the scraped surfaces are polished to smooth the surfaces which deter future calculus accumulation. At this time, the subgingival sulcus, gingiva, and teeth are examined for evidence of gingivitis or periodontal disease.

Each tooth is examined, once thoroughly cleaned, for evidence of fractures. Teeth fracture longitudinally or transversely, thus exposing the pulp tissue and periapical structures to infection. The canine teeth are especially prone to fractures or wear because of their location and length. Exposure of the root canal is a common finding in dental fracture or excessive wear. A variety of endodontic procedures provide an option to extraction, which is disfiguring, especially with canine teeth. Teeth can be salvaged by performing vital or non-vital pulpotomies and filling the root canals. The remaining crown is left intact. Restorative procedures are available to provide an artificial crown, but they are not always necessary or practical. For subgingival fractures, vital and non-vital root retention is applicable. Radiological examinations of the teeth and bony structures are invaluable in determining the extent of disease or trauma and the course of therapy to pursue. Extractions must still be considered with advanced disease. Veterinarians are becoming increasingly proficient in dealing with dental problems; as well, local dental surgeons can be utilized for consultation.

Sound, regular prophylactic dental care is important in preventing bacteremia or oral origin that can contribute to, or promote systemic disease. Good nutrition is needed to maintain healthy oral structures. The feeding of bones - twice weekly helps promote good gingival health when cheetahs are maintained on a soft diet.

I. Focal Palatine Erosion

Focal Palatine Erosion (FPE) is a severe palatine disorder caused by maloccluded molars. This defect consists of a self-inflicted wound through the palatine bone or roof of the mouth, medial to the upper first molars. In unaffected cheetahs, there is normally a slight indentation of the palatal mucosa in this general area, apparently to accommodate the cusp tip of the lower first molar. The extent of this defect may range from a minor injury in this natural indentation in mild cases, to penetration all the way through the palate into the nasal passage. Particles of food which lodge in the focal palatine defect result in localized infection and further tissue damage. In captive animals, FPE has been linked to renal failure and other life-threatening conditions.

Possible Causes:

1. Diet

The occurrence of this defect in captive cheetahs is exaggerated by feeding of commercial soft diets or meat without bone. These diets do not allow for wear on the molars as would occur in feeding off carcasses in the wild. It is thus recommended that meat be fed on the bone regularly to allow for wear on the teeth.

2. Genetic

Current research being conducted on free-ranging cheetahs in Namibia by the Cheetah Conservation Fund recorded FPE in wild cheetahs for the first time (Marker-Kraus, 1997).

Developmental and morphological defects have been reported in highly inbred animals. Dental anomalies which have been seen in the Namibian wild cheetah population have been observed in the highly inbred populations of captive white tigers (Emily, P., pers. comm.).

The high occurrence of FPE in free-ranging Namibian cheetahs was first reported in captive cheetahs and continues to be prevalent in the captive population, 90% of which are descendants of Namibian founders.

Diagnosis, control and treatment.

Diagnosis is done by direct visual observation of the lesion and lower first molars. Early lesions are characterized by localized cellulitis and inflammation. The depth of the indent may be rated as follows: 1= slight indent; 2= medium indent; 3= deep indent and often showing signs of loss of pigmentation, inflammation and sparse cellulitis.

Behavioural signs accompanying FPE are not always evident or easily observed and in most cases only observed if an animal is immobilized. In moderate cases, holding of the jaw unnaturally with the tongue out, excessive salivation, and bad breath accompany the

disease. In extreme cases, a blood-tinged mucous discharge from the nose, snorting and sneezing in an attempt to dislodge the irritant from the nasal chamber have been reported.

Since FPE was first discovered in captive cheetahs, zoo veterinary dental specialists have developed standard treatments and surgery to correct the problem. Dental initial treatment should include removing the cusp tips (bilateral) of the first mandibular molar as well as the mandibular of the fourth premolar and doing a pulpotomy or pulp capping. The access opening can be sealed with amalgam or a hybrid composite (Visser, Pers. comm). Following oral surgery, antibiotics are necessary to encourage soft tissue repair and regeneration. Diet recommendations include feeding meat on bone along with vitamin and mineral supplementation.

J. Life Span

Average longevity following maturity probably 7.5 to 8 years in the wild, though may live up to 12 years and up to 17 years in captivity with 19 years on record. Longevity in captivity initially poor though has increased over last 40 years or so.

Table 13: Longevity in captivity 1947-1988 (adapted from Marker-Kraus, 1990a).

Survival beyond	1947-66	1967-1977	1978-1988*
5 years	22%	29%	38%
10 years	5%	8%	18%
15 years	-	-	3%

* Deaths where age unknown (N=118) excluded from analyses.

K. Post Mortem Protocol

A complete postmortem examination of animals dying in a zoological collection should be carried out as a matter of course, as preventive medical programs may depend on these results. This service should provide rapid tentative diagnosis from the gross pathological examination to allow immediate medical care of the remaining collection if indicated. Histopathological examination of tissues is mandatory and should be done in a timely manner to make those findings relevant to the health care of the collection. Concurrent cultures may be indicated for bacteria, fungi, and viruses. Appropriate tissues not formalin fixed may be frozen for future studies (i.e., viral, toxicology, genetics). Besides determining the cause of death a complete postmortem examination allows review of anatomical structure, assessment of nutritional status and parasitic burden of the animal.

All cheetahs that die are necropsied, including partial carcasses. The Cheetah SSP (Species Survival Plan) Necropsy Protocol is followed and one complete set of fixed tissues submitted to the Cheetah SSP pathologist (Dr. Linda Munson) for the ongoing disease survey in captive cheetahs. A necropsy work sheet, list of required tissues, and instructions for tissue harvesting are on the following pages. The prosector should be alert for the following lesions or diseases commonly identified in cheetahs:

Hepatic fibrosis (veno-occlusive disease)

Renal disease
Chronic gastritis/ulcers
Pancreatitis
Palatine erosions
Parovarian cysts
Myelolipomas of spleen and liver
Feline infectious peritonitis
Feline herpesvirus
Cryptococcus

L. Health References

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| Button et al., 1981a | Haberstroh et al., 1984 | Schaller, 1972 |
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