Husbandry Guidelines For
The Tiger
Panthera tigris

(Mammalia: Felidae)

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Status: endangered

Tigers are always to be considered

DANGEROUS

*You should never be alone with a tiger when in close proximity, even when they are under anesthetic.

*You should never attempt to physically handle a tiger.

*Never enter a tiger enclosure or den unless you have checked that they are secure elsewhere.

*Never cross over the warning line around dens or exhibits when a tiger is in residence.

*Any locks should always be double checked by another keeper before bringing an animal into a den and after putting it out on exhibit.

*Do not handle cubs unless you have double checked the mother is secure.

First, it is clear that tigers in captivity are dangerous animals that can cause serious harm to visitors and handlers alike any time they come in direct contact with these animals. Despite the appearance of pseudo-domestication in some trained tigers, these animals retain their predatory instincts and neural-visceral reflexes, and they can inflict serious wounds using their teeth or claws suddenly and without forewarning. Tigers (and other large cats) have the ability to cause significant trauma and hidden injuries. The most common location for these injuries is the nape of the neck—tigers and other large cats can realign their jaws so that they can bite down between a victim's vertebrae and into the spinal cord. Bite wounds can also result in significant bacterial infections (Nyhus et al, 2003).

It was apparent in the majority of attacks that the victims probably underestimated the dangers posed by direct contact with these animals. Safety precautions, such as cages or chains, were often not sufficiently robust, or people ignored basic safety precautions by circumventing the effectiveness of these barriers. Most attacks occurred when the visitors or handlers approached the animals (e.g., they came too close to the cages, entered the cages to clean them or feed the animals, or were trying to move or otherwise handle the animals) (Nyhus et al, 2003) .

Second, in the United States the probability that fatal attacks or injuries will occur is highest in situations where tigers are kept as exotic pets, whether in households or in private ‘‘roadside zoos.’’ This may reflect in part the likelihood that facilities and training are less controlled and there may be a greater opportunity for people, particularly children, to come in contact with these animals through petting, feeding, photo opportunities, and other situations that are less likely to occur in accredited institutions (Nyhus et al, 2003).

The number of children killed and injured by privately-owned tigers is notable. Children are at particular risk for several reasons. Young children are naturally curious and may not have the same inhibitions as adults when approaching a large carnivore inside or outside a cage. A child's smaller body size increases the potential for serious or lethal injury. Size also appears to influence the attack response of tigers. Large cats instinctively strike the neck and shoulder of their prey to disable it, resulting in serious craniofacial and cervical spinal injuries. The small size of children may help to trigger this attack response. Predatory behavior is also triggered by movement, making human children particularly stimulating as ‘‘prey’’ for big cats. For example, large cats, such as tigers and leopards, can frequently be seen stalking small children running and playing outside the animals' enclosures at zoos. In the United States, the majority of attacks by mountain lions in the wild involve children, and 86% of fatal attacks are on children (Nyhus et al, 2003).

Third, people are at considerable risk when they visit international zoos. In part, this may reflect a lack of respect for the power of these animals by the victims. In several instances the tigers were provoked by visitors (e.g., people threw stones at or urinated on the tiger) or the victims actually entered the tiger's enclosure (Nyhus et al, 2003). At present, no international zoo associations have accreditation programs similar to those administered by AZA; however, accreditation programs are being developed by the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA) and the European Association of Zoos and Aquaria (EAZA) (Nyhus et al, 2003). It is likely that tigers seriously injure and kill their private owners in countries outside the United States as well, but this information is probably even less likely to be reported by the mainstream media than it is in the United States (Nyhus et al, 2003).


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Chapter 1: Introduction

The tiger is an animal whose majesty and prowess has inspired the peoples of the world for millenia. For thousands of years this creature has roamed the regions of Asia and yet in just a century we have managed to drive this species almost to extinction. This species once consisted of eight subspecies, three of which are now extinct, and three more of which are registered as critically endangered or endangered (www.iucnredlist.org). Laws are now in place to protect this species throughout most of its range, however it is constantly being threatened by illegal hunting and the encroachment of humans into the constantly dwindling wilderness. All of which means that it is not only beneficial for the education of people, but necessary for this species survival, that individuals be kept in captivity.

Over time the focus of zoos, and thus the way exhibits are designed, has changed. Today zoo exhibits are designed with the two primary goals in mind, the education of visitors and the satisfaction of the animals being their primary goals.However, even while it provides us with the chance to study this magnificent animal and maintain its genetic diversity captivity for animals who require so much space and who are so dangerous represents a challenge for zoos throughout the world.

This being the case it may be important in the future to consider the value of the subspecies being maintained. Many endangered species exhibit geographic variation formally recognized by subspecies designation. Modern taxonomists reserve subspecific names for geographically restricted populations that differ consistently over a number of characters (e.g., size, pelage, skeletal measurements). Many previously named subspecies, however, differ in only one or a few characteristics; these may not correspond to geographic distribution and may show little concordance with other variable traits. For other species, geographic variation with adaptive significance for local populations has no formal taxonomic designation. Whether recognized by taxonomy or not, the genetic basis and adaptive significance of differences among subspecies and geographic races are often unclear. Yet, conservation of intraspecific variation is an important part of efforts to preserve diversity. Resources for conserving diversity are limited and scarce resources must be allocated among a subset of the species and subspecies needing help. Because information on the population and genetic status of endangered species and subspecies is limited and the outcomes of management decisions uncertain, it is rarely obvious how to do this (Macguire, L.A and Lacy R.C., 1990).

All remaining subspecies of tigers *(Panthera tigris)* are endangered in the wild and space for captive breeding in western zoos is limited How should this space be allocated to enhance survival and retention of genetic variation in the face of uncertainty about genetic relationships among tiger subspecies and about the future of tigers in the wild? Expert judgments were solicited on subspecies population trends and on the ratio of effective to census size in captivity and analyzed different scenarios for dividing the 1000 captive spaces among four tiger subspecies To maximize survival and retention of gene diversity in individual subspecies, it is best to divide the space equally among the four subspecies To maximize retention of gene diversity for the species as a whole, it is better to allocate more space to the subspecies that appears most variable on the basis of limited electrophoretic data (*p. t. tigris*). Allocating half of the captive space to *tigris* and dividing the remainder equally among the other three subspecies (*altaica, sumatrae and Corbett*) is a satisfactory compromise between species welfare and subspecies welfare that ensures survival of all four subspecies (at least in captivity) and retains about 80 percent of existing gene diversity within subspecies and about 93 percent of diversity for the species as a whole. Sensitivity analyses showed that our recommendations were robust to uncertainty about the demographic and genetic status of tiger subspecies (Macguire, L.A and Lacy R.C., 1990).

Chapter 2: Taxonomy

2.1 Nomenclature

Kingdom = *Animalia*

Phylum = *Chordata*

Subphylum = *Mammalia*

Order = *Felidae*

Genus = *Panthera*

Species = *Panthera tigris*

2.2 Subspecies

This husbandry manual will be looking at the requirements of the species *Panthera tigris* as a whole and not as a particular subspecies. This being said all subspecies must be considered within this manual, and these subspecies include:

Panther tigris tigris (Bengal tiger)

Panthera tigris corbett (Indochinese tiger)

Panthera tigris amoyensis (South China tiger)

Panthera tigris attaica (Amur or Siberian tiger)

Panthera tigris sumatrae (Sumatran tiger)

Panthera tigris sondaica (Javan tiger)

Panthera tigris balica (Bali tiger)

Panthera tigris virgata (Caspian tiger)

However, of the eight subspecies of tiger only five are now in existence. The Caspian tiger is believed to have succumbed to extinction sometime during the 1950s, the last Javan tiger was seen in 1972, and the last Bali tiger was believed to have been killed in 1937 (www.mnzoo.com). Thus these three subspecies will not be considered in the content of this manual.

Chapter 3: Natural History

3.1 Morphometrics

3.1.1 Mass And Basic Body Measurements

Table 1.

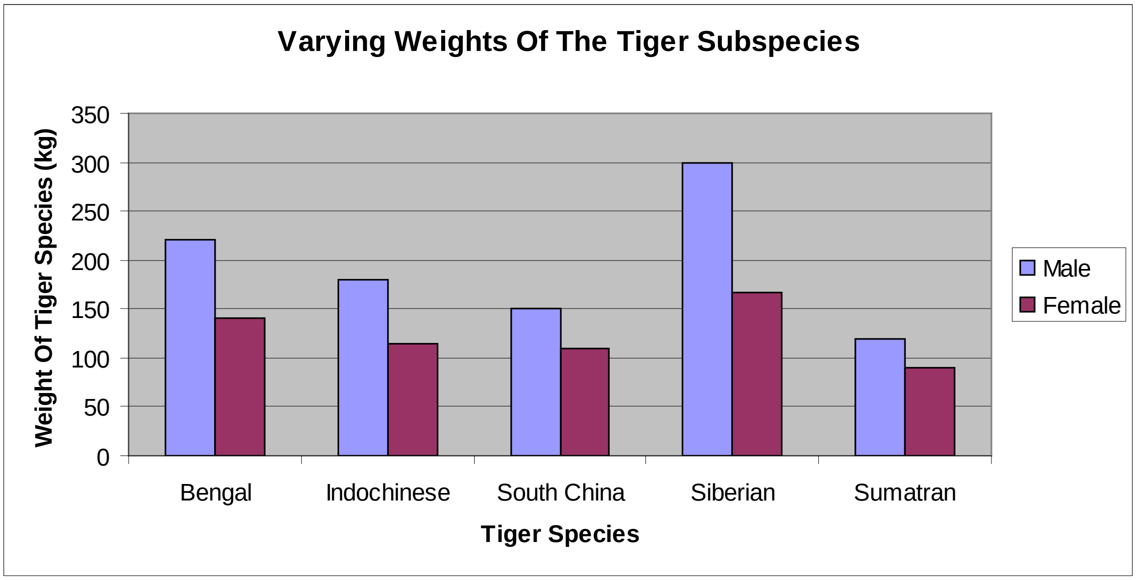
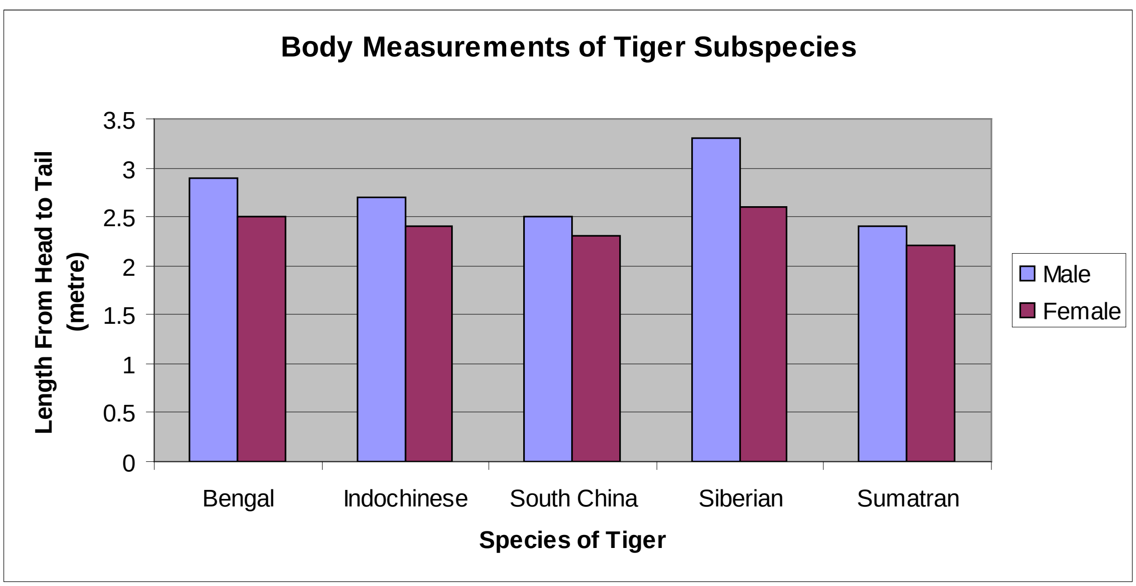


Table 2.



As shown by tables one and two the Siberian tiger is the largest and heaviest of the tiger subspecies. This has to do with the fact that they live in a cold climate and so need the extra body weight to stay warm. The Sumatran tiger is the smallest and lightest of the tiger subspecies, and this is probably due to the fact that it inhabits hot climate regions with poor food supply. However, no matter the subspecies of tiger the tables show that the females are always smaller and lighter than the males. There is more difference in weight than in size, and in the case of Siberian tigers the females are still heavier than the males of the Sumatran and South Chinese tigers (www.mnzoo.com)

3.1.3 Distinguishing Features

Tigers can be distinguished in several ways, most commonly involving differences in their size, colour and coat. However the differences between subspecies can be so subtle that not even tiger biologists can say for certain which subspecies a tiger belongs just based on its appearance (www.mnzoo.com).

Though size can differ quite dramatically among not only subspecies but also among individuals, those tigers living in the cool climates of the northern regions are much larger that those which live in equatorial climates. This is due to the fact that those tigers living in colder climates need a larger body size to stay warm (www.mnzoo.com).

The colouring of tigers is often used as a distinguishing feature as both the intensity of their coloured stripes and the stripes themselves differ between the subspecies (probably as a form of camoflague). Tigers which live in dense tropical forests have darker and denser stripe patterns than tigers living in grasslands. In the same way tigers living in grasslands have darker and denser stripe patterns than tigers living in northern forests (www.mnzoo.com).

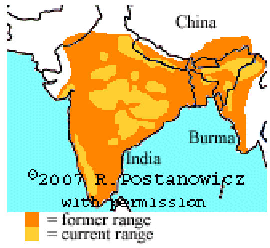
Coats can also be used as a distinguishing feature as length does vary by subspecies and some males have a white ruff around their necks. However, apart from the Siberian tiger whose coat length is approximately 40-105mm, all other subspecies tend to have a coat length of 7-35mm, and that length may change with the seasons (www.mnzoo.com). Thus this is not the most reliable method.

3.2 Distribution and Habitat

All wild tigers live in Asia, and apart from Siberian tigers they inhabit the warm, usually equatorial regions. Tigers prefer to live in habitats of thick forests or areas with tall grasses to hide in and plenty of prey to eat. They do not like the open grasslands lions prefer, and like their morphometrics their distribution varies between the subspecies.

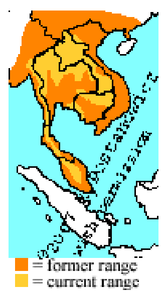
Most Bengal tigers live in India, though some are known to range through Nepal, Bhutan and Myanmar.

Fig 1. Bengal Range (www.lioncrusher.com)



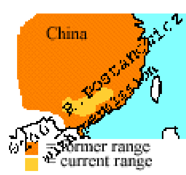
Indochinese tigers however are widely distributed. They live in remote forests in hilly to mountainous terrain in Thailand, Myanmar (Burma), Southern China, Cambodia, Laos, Vietnam and peninsular Malaysia.

Fig 2. Indochinese Range (www.lioncrusher.com)



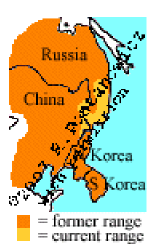
The South China tiger is found in central and eastern China, and it is thought to be the tiger from which all the other subspecies have evolved.

Fig 3. Southchinese Range (www.lioncrusher.com)



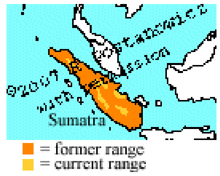
The Siberian tiger inhabits a much cooler region than the other subspecies and they are found in eastern China, with a few found in northeastern China and North Korea.

Fig 4. Siberian Range (www.lioncrusher.com)



Unlike the other subspecies however the Sumatran tiger is found only on the Indonesian Island of Sumatra (www.mnzoo.com).

Fig 5. Sumatran Range (www.lioncrusher.com)



It is important to remember though that over the last century the distribution of tigers has become continually fragmented and their populations isolated.

3.3 Conservation Status

Apart from the Javan, Bali and Caspian tigers which are all listed as extinct, there are three subspecies of tiger in existence which are currently listed on the IUCN red list. The South China tiger is listed as critically endangered with a population size estimated at less than 50 mature individuals in the wild. The Sumatran tiger is also listed as critically endangered with a population estimated at fewer than 250 individuals in the wild. It has an estimated continuing decline of at least 25% within 3 years or one generation, whichever is longer (up to a maximum of 100 years in the future), and a continuing decline, observed, projected or inferred by numbers of mature individuals, with no subpopulation estimated to contain more than 50 mature individuals.

The last tiger to be listed is the Siberian tiger. It is also listed as critically endangered with a continuing decline in observed, projected or inferred by numbers of mature individuals, but with at least 90% of the mature individuals existing in one subpopulation (www.iucnredlist.org).

However it should be noted that while the Bengal and Indochinese tigers are not listed this does not put them in the clear. The wild population of the Bengal Tiger is approximately 3,250-4,700, with about another 300 captive tigers mostly in Indian zoos. When compared to its numbers of a century ago though, that of about 40,000, this number does not seem large. The wild population of the Indochinese tiger, approximately 1,050-1,750, also seems relatively healthy in comparison to those that have been red listed (www.mnzoo.com). However it should not be forgotten that both these tigers have wide population distribution, which may partly account for the wild population numbers, and that their habitat is being constantly fragmented and their populations isolated.

Chapter 4: Housing Requirements

4.1 Exhibit/Enclosure Design

When building an enclosure for tigers it should be noted that tigers are solitary animals whose peak activity ranges from crepuscular to nocturnal (www.agric.nsw.gov.au). They should always be considered dangerous requiring stringent safety protocols and never be handled alone. And it is important to remember that the design of the enclosure and off exhibit area can greatly add to the enrichment of the tiger (as is further discussed in *appendix 2*).

If the enclosure should contain a moat of at least 8m wide and 1.8m in depth, and it should be a wet moat. The wall adjoining the moat should be smooth and 1.8m in height (www.agric.nsw.gov.au). If wire mesh is used it should be at least 4.5m in height with a diameter of 5mm and a mesh space of 75*50mm. A mesh overhang is required and the depth of the overhang should be 1m with an inhang of 45^0. The wire is also required to extend under the terrestrial substrate for at least 1m around the perimeter. It should also be noted that a roof is not needed and that glass fronts are permissible (www.agric.nsw.gov.au).

Years ago metal bars were used for most zoo exhibits, but today the majority of barriers are built of wire, glass, or include moats so as not to impede the visitors view and to help maintain the illusion of a wilderness like enclosure. Wire fences are not as strong as bars, however if they are made of a heavy gauge welded wire, it can be strong enough for tiger enclosures. And while glass is aesthetically pleasing and can give visitors a good nose to nose view of the tiger, it does require more maintenance, expense, and it may fracture. It can also prevent visitors from being able to experience smells and sounds from the exhibit. Moats can keep tigers in the exhibit while giving visitors a clear view. However a small ledge should be provided so cubs don't fall into the moat. Also moats must contain a large drain, as especially in the cold climates the moats will need to be drained lest the water freeze providing the tigers with an escape route. It is also imperative to ensure that the moat be used in conjunction with other barriers and not on its own (www.mnzoo.com).

It is important that visitors be able to see the tigers from several vantage points, as ideally they should be able to experience the thrill of a close encounter. In some zoos the big cats are given the high ground so both the tigers and the visitors can see each other easily. Other zoos put the tiger in lower areas and allow visitors to view them from above (www.mnzoo.com).

4.2 Holding Area Design

Zoo exhibits must have a night room/off exhibit den adjoining the exhibit. This is important for safety and care, and to allow the keepers to monitor their health closely. They may spend the night in this room which must be at least three metres (10 feet) by four metres (12 feet). Every tiger must have its own night room equipped with a water source, and some bedding or a platform on which to sleep. For zoos participating in an approved breeding program they must have at least three off exhibit rooms: one for the adult male, one for the adult female, and another for the cubs (www.mnzoo.com).

Taronga zoo for example does not lock the tigers in the dens of a night time as it is known that they tend to be nocturnal in the wild and so like to give the tigers the option of being active when it is more natural for them. The dens are still essential however as it allows the keepers to clean, feed and add enrichment to the exhibits. The dens are also big enough that the tigers can be kept in them while the exhibit undergoes short periods of routine maintenance. The night dens also allow for the management of individuals who need to be separated. For example a new male was brought in for the female at Taronga and initially they are unable to be housed together. The night dens allowed for the keepers to rotate the male and female, usually on a daily basis, with one being put on display and the other being kept in the dens.

The Taronga zoo tiger dens consist of two dens joined together, the front of which is a heavy metal wire so that the keeper has full visual while the animal is inside. Each den has its own access to the exhibit so that keepers can control who is on exhibit. The dens are joined by a small sliding door as shown in figure 6 which is just large enough for the tiger to move through comfortably. This door is also made of a heavy metal wire as this allows limited contact between the animals, which is great for introductions, while keeping them from being able to harm one another. These dens are not complex but they are effective in the management of the tigers at Taronga.

Fig. 6

Off exhibit rooms also provide a good opportunity for the instalment of restraint methods in their design and for training. For example a squeeze cage/crush offers a simple way to administer vaccinations, antibiotics and other shots. As the tiger moves through the cage it is briefly squeezed against the bars so the keeper can inject its shoulder with medicine. This is a quicker, safer and less stressful method than a dart gun which might hit a bone or an eye. Or total immobilization, which requires additional drugs. By using a squeeze cage/crush the tiger is freed almost before it realises what has happened (www.mnzoo.com).

4.3 Spatial Requirements

For tigers kept in captivity the minimum standards require that the enclosure be 300(30)sq.m with a maximum number of two animals. For each extra animal an additional area of $20m^2$ is needed, though in a medium term holding yard it need only be $15m^2$ (www.agric.nsw.gov.au).

4.4 Position of Enclosures

When choosing the site for a tiger enclosure it is important to ensure that it is not positioned too close to prey animals. Though it would probably provide good stimulation for the tiger it would be unnerving for the prey animals. However if the environmental conditions and topography permit, you could place the exhibit where it would be downwind thus providing enrichment for the tigers while not subjecting other animals to a constant stress.

You should also decide on the site for the exhibit before you finalise the design, especially in terms of viewing and off exhibit areas. As building to fit in with the topography instead of in spite of it can save a lot of money. Especially when having to build to such a large scale, as is required with tigers.

4.5 Weather Protection

Most tiger habitats are in heavily vegetated jungle regions and so they would not be used to exposed weather conditions. If possible you should try to build some protected areas into your exhibit design where the tiger may take refuge e.g. rock overhang and shaded areas. As well you should include some vegetated areas like small bamboo forests as they will help with the look of the exhibit as well as with weather protection for the animals. However if this is not possible in extreme weather you may have to leave their night dens open so that the animal can take refuge.

4.6 Temperature Requirements

Apart from the Siberian tiger all the other subspecies inhabit warm habitats. So as long as they have refuge from the sun and a pool to cool off in zoos in warm locations should not have many problems. However if the zoo is located in a cool region heat pads should be placed round the exhibit and in the dens to provide warmth, and sheltered areas should be provided. It should be noted tigers do tend to be very adaptable.

4.7 Substrate

Suitable substrate for tigers can include a range of things such as soils, grasses, mulch and leaf litter all of which can be used in combinations or alone. Tigers have often been seen to be chewing grass however and it also has the added advantages of being fairly easy to maintain and aesthetically pleasing.

4.8 Nestboxes And/Or Bedding

Adult tigers do not require nest boxes, except when rearing cubs, and they don’t usually require bedding. Though in their night den there should be a ledge or raised platform for them to sleep on.

4.9 Enclosure Furnishings

Something that should be considered an essential element of every tiger exhibit is a water feature. While a source of clean drinking water is needed in every exhibit, tigers should also have a pool in which they can bathe. While they are a cat tigers are in fact very good swimmers and enjoy being able to immerse themselves in hot weather. Thus pools provide a very important source of environmental enrichment for these felids. It is also important that the pools be easy to drain and to clean as the tigers tend to make it quite dirty after swimming in it.

Tiger exhibits should also include platforms on which they can bask in the sun, not only is this beneficial but it can also aid in the publics viewing. Large tree trunks should also be included which cubs can climb and which older adults can use as scratching posts. Just ensure that these trunks are not located near any fences or moats, are very secure and can be replaced.

Plants can also be used not only to add to the appeal of the exhibit and increase environmental enrichment, but also to conceal fences and other features which can detract from the exhibits overall appearance. However it is important to remember that tigers may dig up new plants. To avoid this happening some zoos favour plants which the tigers dislike, such as Thorny Barberry (*Berberis sp*.), Locust (*Robina sp*.), Hawthorne (*Crataegus sp*.), Pampas Grass (*Cortaderia sp*.), smelly bad tasting Cedar (*Cedrus sp*.) and Juniper. Other zoos opt for hardy plants like Mexican Bamboo, Morning Glory and Mint, which can withstand the attention of tigers. No matter what plants are used it is important that Poison Ivy and Poison Sumac always be avoided as they are toxic to tigers. Some grasses should always be included as the tigers will chew on it occasionally (www.mnzoo.com).

Some furniture is also very important as environmental enrichment, as it makes the tigers life more interesting and offers interesting activities for visitors to observe. It is also a good idea when building the exhibit to include some permanent fixtures on which you can attach furniture or hang things such as boomer balls or food toys.

Toys such as Boomer balls and barrels are popular pieces of furniture to add to the enclosure as the tigers enjoy playing with them, though they can disrupt from the natural appearance. The advantage however is that they can easily be moved in an out of the exhibit and can be made more interesting by hanging of by hiding food in them. Scratching logs are an option which not only encourages the natural behaviour of scratching for claw wear and maintenance, and helps prevent ingrown claws, but also helps keep the natural appearance. Another piece of furniture which can be used is heat pads. They are warmed by hot water running through the underground pex tubing and the warmth of the pads attracts the tigers in cold weather, and by placing them near the public viewing areas keepers encourage the tigers to be more active and visible (www.mnzoo.com).

Chapter 5: General Husbandry

5.1 Hygiene and Cleaning

It is important to note that while hygiene is incredibly important you don't want to make the environment so sterile that the animal is uncomfortable living in it. And when using substances like bleach to clean that they are thoroughly rinsed of as residue can be harmful to the animals.

All faeces, leftover food and old bones should be removed from the enclosure and the den every day, as well their water bowls scrubbed and refilled.

In the actual exhibit the natural elements will with sterilisation, though you will need to scrub down and wash of with water their eating and sometimes sleeping areas. Their pools will need to be drained, scrubbed and refilled at least once a week, and depending on the lining of the pool it may need to be cleaned with bleach at least once a month, perhaps even weekly, to prevent excessive algae growth and maintain cleanliness. Depending on the substrate you may need to remove it or add to/replace it on a regularly scheduled basis. It is important in the exhibit that you not remove all traces of their habitation as this will make them uncomfortable, so it is good to leave at least some of their markings undisturbed unless it happens to be in an inconvenient spot. For example the tigers at Taronga like to spray the inside of the viewing glass and so the glass needs to be cleaned every morning.

The night dens are usually made out of concrete as cat urine is quite strong and very corrosive and the concrete holds up against the cats claws. Softer flooring like rubber is usually destroyed and the cats can end up ingesting it which can cause problems. On a daily basis the dens usually only need to be hosed out with water and perhaps scrubbed on a daily basis. They will need to be degreased weekly however as the cats coats and their food tends to leave a greasy residue over time, Taronga uses a product called "animal house" for this. They should also be bleached but probably not more than once a month as that would make the dens to sterile.

5.2 Record Keeping

Detailed records should be kept for any animal but it is especially important for animals as expensive and endangered as tigers. The most important details to keep track of are births, deaths, arrivals and the animals parnetage. But a daily diary should also be kept and the filed for any notable events such as weight gain or loss, changes in behaviour, diet changes, inappetite, symptoms of illness, treatments etc. You should also keep records of any training done with the animals and the methods involved so that all keepers involved with the animal use the same methods.

Depending on the institution what happens with these records will change. If it is a small zoo the records may just be filed in house, but it is still essential to keep them for the well being of the animals and the success of the zoo. If you are part of a breeding program then the stud book keeper will need the records of at least any births, deaths, arrivals, animal parentage and of the success and health of offspring. If the zoo is larger then the records may be filed at an international level on ISIS where they can be accessed by other zoos.

5.3 Methods of Identification

Male and female tigers are quite easy to tell apart once they are adults as their genatalia is quite prominent but there are several ways to distinguish individuals and tiger subspecies from one another, which consist of size, colour and coat. Though these physical characteristics can be quite subtle. However, the fact that tigers are usually solitary and are not kept together in large numbers means that the physical differences are usually enough for keepers to identify individuals and records of their individual markings are usually kept.

It is standard procedure though for a permanent method of identification to be used and in the case of the tiger the two methods of identification usually employed are tattoos and electronic transponders (www.mnzoo.com).

Zoos have previously had their tigers tattooed with a three or four digit number (usually on its inner hind leg), and this number is registered in the tiger studboook and identifies the tiger for the rest of its life (www.mnzoo.com). However this method has many drawbacks. It is painful, it requires the sedation of the patient and removal of any hair from the intended area, it has the risk of infection, and the tattoo is often hard to see. This method is not used in Australia.

The electronic transponders are small microchips which are placed under the tigers skin as a permanent identification marker, tiger cubs are usually microchipped from 8 weeks of age. Zookeepers can then use a scanner to read the unique twelve digit number that identifies the tiger. The transponders are often placed in between the shoulder blades where they are easy to scan. They are easier to use than tattoos since with a scanner they can be read quickly and easily without immoblilzing the tiger. though it is painful and they can migrate throughout the body the patient does not need to be sedated and the wound is not large, visible or as prone to infection.

5.4 Routine Data Collection

Routine data collection usually consists of keepers recording notable events such as those mentioned in section 5.2. However when given the chance it is also important to perform animal watches where someone makes note of the animals activity throughout the day. This is especially important when something like any introduction, breeding, or mother rearing is occurring.

Animal watches can be performed by anyone who is familiar enough with the animal to recognise unusual behaviours. Firstly you need to watch the animal for a couple of hours at different times of the day to make a list of its behaviours. Then you watch the animal for periods of time (it can just be whatever time is available) during different parts of the day and over a length of time e.g. a month. This data can then be used to identify things such as stereotypic behaviour, conflict between the animals, active times etc.

Keepers may also on occasion have to collect faecal samples. These samples are usually used to determine if the animal has worms, whether a female is in estrus, and can help give an overall picture of the animals health.

Chapter 6: Feeding Rquirements

6.1 Diet In The Wild

Tigers are carnivorous, they are solitary hunters and in the wild they will often chase their prey down into the water (www.lioncrusher.com). The only chance for the tiger to catch its prey is to stalk it silently within 9 to 21 meters through dense cover with great stealth, crouching to a low profile, taking advantage of the natural camouflage provided by the dark stripes on its yellow coat, and the ability to freeze for long periods if the prey gets suspicious. It is said that the tiger generally approaches its prey from downwind to avoid detection. Hence out of sheer necessity, the species has to lead a solitary life (except when courting or with young), as the hunt would be almost impossible if attempted in groups (Sinha, 2003).

Tigers usually attack the largest prey available because though they are able to knock down animals more than twice their own weight, they have a fairly low hit/kill ratio of only approximately one in twenty attempts (Dreamworld). Sambar for example, grow as large as 300kg, larger than many tigers, and provide enough food for many days (www.mnzoo.com).

When it comes to large prey, a look at the kinds of animals tigers eat gives the impression that tigers from different areas specialise on different prey species. In some regions they feed primarily on sambar and rarely take chital; in other places they live chiefly on chital, while in still other areas they may kill mainly barking deer, gaur, or domestic stock. But despite these place-to-place variations, wild pigs and deer of various species are the two prey types that make up the bulk of the tigers diet, and in general tigers require a good population of these species in order to survive and reproduce (M and F Sunquist, 2002).

Various species of deer are the mainstay of the tigers diet. Sambar which are related to the European Red Deer and American Elk are common prey in India. Chital or Spotted deer also live in India. In Siberia and Northern China tigers prey on Maral or Siberian wapiti. Another species of deer which tigers prey upon is the swamp deer (www.mnzoo.com).

Asian wild boar (closely related to the European wild boar) are another primary prey species for tigers. However this prey is a formidable match for a tiger, they are armed with sharp tusks and an aggressive manner, and have been known to mortally wound tigers (www.mnzoo.com).

Tigers rarely prey upon peacocks or other birds, as the energy required to catch them is often to great compared to the reward (www.mnzoo.com).

In general tigers do not prey upon the larger mammals such as rhinoceroses, elephants and buffalo. If the opportunity presents itself though they will prey upon the young of these mammals (www.mnzoo.com).

Tigers are not normally recorded as being fish eaters. However in the Sunderbans, a densely forested river delta area in India and Bangladesh, tigers are reported to eat fish, frogs and crabs (www.mnzoo.com). Tigers will also eat grass for roughage like other cat species.

As far as tigers viewing humans as prey is concerned, it is generally thought that this only occurs when the tiger is sick, injured, or old and can no longer catch their own prey. For example one of the more common occurrences is for a tiger trying to prey upon a porcupine and to get a broken quill caught in its paw, thus making hunting difficult. However in the Sunderbans tiger attacks are notorious, and arguments are still going as to whether this is just a result of tigers defending their territory, or whether for some reason they have a taste for humans. No matter the reason the general consensus is that once a tiger has a taste for human flesh, they will continue to prey upon them (www.mnzoo.com).

6.2 Captive Diet

Captive diets must be constantly monitored and is often undergoing small changes for the animals health, for enrichment purposes or due to the availability of certain food. Please note that the information given here is fairly general as tiger diets are usually worked out on individually based on sex, weight and any special requirements. A diet schedule should be maintained for each individual within the collection.

In the wild, carnivores typically eat all or most of the prey they capture and kill, including bones, fat, viscera, and other parts. Muscle meats are quite different in composition from whole prey. Although they are typically good sources of amino acids, some minerals (eg., sodium, potassium, iron, selenium, and zinc), and some B vitamins (eg., niacin, B_6, and B_{12}), they are very low in calcium (calcium:phosphorus ratios are about 1:15 to 1:30), manganese, and fat soluble vitamins (vitamins D, vitamin E, and in most cases, Vitamin A) (Ed. Kleiman et al, 1996).

Use of muscle meat as the sole diet of carnivores was once widespread in zoos, and remains common among pets, with a predictable result: severe and often nutritional bone disease. In both exotic and domestic animals, pathological bone conditions resulting from dietary imbalances of calcium, phosphorus, and vitamin D are most frequently in growing or lactating animals. The feeding of unsupplemented muscle meats also may lead to vitamin A deficiency in some circumstances (Ed. Kleiman et al, 1996).

In the United States, commercially prepared, complex carnivore rations are now widely used for felids and other carnivores in zoos. They are quite similar in proximate analysis to whole vertebrate prey. Most are formulated to comply with recommended nutrient levels for either cats or dogs, although supplemental vitamins or minerals may be included at higher levels and in some products they may be a matter of concern (Ed. Kleiman et al, 1996).

Nutritional and metabolic bone disease has largely disappeared in zoo carnivores with the use off commercial meat-based diets. However, oral disease associated with the exclusive feeding of soft diets has become a significant problem. When consumed for prolonged periods, rations that require no chewing or tearing may contribute to excessive dental plaque and calculus formation. This in turn may lead to gingivitis, loose teeth, adscesses in the oral cavity, and ultimately, bacterium. It has been suggested that recurrent sepsis resulting from dental infections may contribute to or cause compromised renal function, liver abscesses, or endocarditis (Ed. Kleiman et al, 1996).

In some zoos, rats, chickens, rabbits, or other vertebrate prey are offered on a regular or periodic basis instead of or in addition to commercial preparations. While presumably better for oral health, these items are costly and may inadvertently introduce parasites or infectious diseases (Ed. Kleiman et al, 1996).

For the purpose of a general diet and cost analysis I will be looking at the diet given to the tigers of Tiger Island at Dreamworld, though the diet of Taronga zoo mentioned later is preferable These tigers are fed approximately 4 to 5 kilograms of raw meat five days a week. Their daily meat diet comprises a combination of horse, chicken and Kangaroo in mince form, with added vitamins and minerals. As well as the minced diet the tigers also receive a 'chunk' night consisting of a variety of meats; mutton, venison, horse, emu or rabbit are some of their choices. The tigers are also fasted twice each week, receiving only bones on these nights (usually knuckle bones). This not only helps to stimulate a tigers normal feeding pattern it also assists in cleaning their teeth and gums. And though it is not part of their regular diet the tigers used for intimate experiences are often given milk ice cubes as a treat and as a distraction (Dreamworld).

Using this as a basis for a very general diet, and obtaining prices from butchers and animal suppliers a rough cost analysis was conducted.

5kg of minced Kangaroo = $16.00
5kg of minced chicken = $12.00
Knuckle bone = $0.50
A 'chunk' of meat including the bone is approximately $7.00 per kg but this can vary so;
5kg chunk = $35.00

*Weekly diet cost of one tiger = ($16.00*2)+($12.00*2)+($0.50*2)+$35.00
= $92.00 per week

*Yearly diet cost of one tiger = $92.00*52
= $4784.00 per year

It should be noted that the cost analysis has been done on the most basic diet which should be offered to a tiger and has not taken into account added supplements, cub diets and other sources of food etc, due to the fact that most of this information is usually worked out on a case by case basis, and that tiger diets vary widely between individuals and institutions. It has also not taken into account man hours for the keepers involved in acquiring, preparing and presenting the food.

There are other alternatives however. Mogo zoo for example operates very differently from Tiger Island. Their tigers receive 5kg-8kg of meat per day but they never used minced meat. They are in a position which gives them access to whole animals and so the portions always consist of hair and bone as well as meat.

This is also true of Taronga zoo. They receive split portions with the main portion being given in the morning and the smaller in the afternoon. The portions are whole consisting of bone, meat and hair and they receive a variety of meat similar to that of Dreamworld, with half a rabbit for their afternoon portion on their starve day. The meat is also sprinkled with petvite to make sure that they are not lacking in vitamins. For enrichment the meat is sometimes cut up and spread around the exhibit. They are also on occasion offered other food items such as chicken mince, milk iceblocks and blood ice blocks.

Out of the diets mentioned the Taronga zoo one would seem the most preferable, keeping in mind the benefits and draw backs mentioned earlier, though each zoo tends to make changes due to its own logistics. The commercial diets like those used in the United States seem to be inadequate on their own if for no other reason than lack of environmental enrichment.

According to Chapter 4 of www.tigerlink.org/husbandry/ an adult tiger should be fed to maintain body condition, with general energy requirements = 140kcal (body mass in kg)$^{.75}$. Thus a female averaging 123kg requires 5170kcal/day.

It is also important to consider water requirements. Water is the single most important nutrient for the proper function of all living cells, yet it is sadly neglected in many nutritional programs. Cats drink very little free water, instead fulfilling their fluid requirements from normal dietary or metabolic sources. Carcass meats contain approximately 70% water; semi-moist (30% moisture) or dry diets (10% moisture) fed to domestic cats often do not contain adequate moisture to maintain physiological function and exacerbate problems of mineral deposition in the urinary tract (Tilson and Seal, 1987).

6.3 Supplements

Vitamin and mineral supplements are many and varied with regards to tiger diets. They change not only depending on the condition of the tiger, but also with the methodology of the institute where they are located.

For example the keepers at Tiger Island at Dreamworld begin the care of their tigers at three weeks of age. Initially the cubs require feeding 6 times daily and demanded similar attention to that of a newborn baby. The milk replacement formula they receive at the early stages was an artificial tiger milk made to be as similar to the mother tiger milk as possible. As they grow older small amounts of feline food and vitamins are blended into the milk mixture and steadily increased. By the age of 5 months the cubs are beginning to eat raw minced meat, as well as the formula. They are then moved up to the adult diet alone and slowly increased in amount until they are eating the same diet as the adult.

At Mogo zoo their tigers also occasionally are fed kidneys, heart and liver. Though liver must never be given in great amounts as it is very rich in vitamin A. Also depending on the individual dietary supplements like calcium and petvite may need to be added two to three times a week.

And at Taronga zoo petvite is added to all portions to ensure they are receiving enough vitamins. The dose required is worked out on the individual weights of the tiger, though in the case of petvite it will do no damage to the tiger if they receive a dose slightly larger than recommended on occasion as their body will excrete it out through their urine. They also receive a liver weekly.

Chapter 4 of www.tigerlink.org/husbandry/ goes on to state that diet quantities should be increased 10-20% in animals housed outdoors during the winter months, and decreased by the same amount during the summer months. With increases to diet being *ad libitum* during lactation. And that if diets are mixed within the institution they should be supplemented to provide 1% calcium (dry matter basis), particularly if bones are not consumed. This is equivalent to about 7g Ca/kg meat; a non-phosphorus containing supplement such as $CaCO_3$ (40%Ca) should be used. For this particular example 17.5g of $CaCO_3$ (per kg meat) would be added. If meat is lean 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. Vitamin E may be necessary in diets based on meats containing polyunsaturated fats (any non-ruminant), at levels providing 50-150IU/kg dry matter. One reviewer suggested that meat on the bone or whole carcasses can also be supplemented with a good powdered supplement used in conjunction with cod liver oil, even for females with cubs.

Taking this into account if I was to add a calcium supplement three times a week for example the cost of a tigers diet would rise to:

2kg bag of calcium = $11.50

ratio is 7gCa/kg thus: 35g per serve 3 times a week = 105g per week

would get 19 weeks from a 2kg bag, but would need enough for the 52 weeks = 2.7 bags for a year

*Yearly cost of one tiger with calcium supplement = (2.7*$11.50)+$4784.00 = $4815.05

6.4 Presentation of Food

Some zoos like the Minnesota zoo in USA prefer not to give their tigers whole meat as they take the approach that while it is good for environmental enrichment it can add bacteria and parasites to the exhibit which can later make the animal sick. Though there is currently work being conducted which will hopefully minimise this risk (as discussed in *appendix 3*). Instead they feed them commercial feline food which has been designed by nutritionists and biologists to fulfil the tigers nutritional needs. They do however still give them a knucklebone at least one a week for good dental hygiene.

However most Australian zoos prefer to feed their tigers raw meat either in ‘chunks’ or in mince form. I feel this is the best approach, with a diverse diet, as food can be used to great advantage as a form of environmental enrichment, and can go a long way in maintaining a happy and healthy tiger (This is discussed in greater detail in *appendix 4*).

Whenever meat-based diets are used, proper storage, handling, and preparation methods are imperative. Meat-based products and dead rodents are very susceptible to bacterial growth and subsequent spoilage. Frozen products should be thawed under refrigeration, not at room temperature, so that the temperature at the surface (where bacterial growth is apt to be greatest) remains low. Feeding times should be set so as to minimise exposure of food to high ambient temperature (Ed. Kleiman et al, 1996).

While mince form is often the most available form for feeding tigers as they require a lot of meat, they should be fed ‘chunks’ still attached to the bone whenever the opportunity presents itself. It is even better if occasionally you can get hold of very large ‘chunks’ perhaps even whole carcasses. Though this may be difficult if feeding them on exhibit, as many people in the public would not be comfortable seeing them feasting on a carcass, it is quite manageable if you can feed them in their dens.

In general the food should be prepared in a sanitary environment, the keeper should then try to place the food so that the tiger actually has to go to some effort to locate it. This is especially good for ‘chunks’ as you can usually hang them off things. In hotter weather however you may want to leave the meat frozen or even make ‘meat popsicles’ out of them so that the tiger has to work harder to get at the food. Though it should be noted that frozen meat should not be given in large quantities as this can lead to regurgitation. You could even try frozen fish or an occasional blood and milk iceblock.

However the food is presented though you must be able to keep a fairly accurate record of what the tiger is eating, as one of the best indicators of any animals condition is its appetite.

Chapter 7: Handling and Transport

7.1 Timing of Capture and Handling

While tigers can be active during the day most of their habits tend to be crepuscular to nocturnal. This being the case the best time to arrange for the capture and handling of Tigers would be early morning.

Arranging for the capture to take place in the early morning has numerous advantages, including not having the public present. If they are being captured for a procedure or short transport capturing them early means that you are usually able to release them that same day at a time which is comfortable to them. It should give you enough time to do what is necessary, while still being able to give them the chance to recover from the ordeal and to adjust back to their surroundings. It may also have the added advantage of making capture easier. Locking them away in night dens will make capturing easier but if left till later in the day the animal may become stressed as this is outside of their routine. An early morning capture would eliminate this stress.

The most important thing to remember however is always try to take advantage of their routine as this usually limits the stress for both you and the animal.

7.2 Catching Equipment

Catching bags and nets should never be used for an animal as large and dangerous as the tiger. Though restraint methods like an animal crush can be used and are discussed in further detail in 7.3

7.3 Capture and Restraint Techniques

At no time are manual capture and restraint techniques to be employed with regards to an adult tiger. Manual methods like those used to handle domestic cats may be used with cubs, especially during cases of handrearing. These methods should not be used once the cubs have reached a certain age however as they become too large and boisterous. Taronga recommends no manual capture or restraint past the age of 16 weeks.

An animal crush or raceway is the best for restraining tigers for short periods, such as those required for physical examinations. This method has the advantage of being less stressful for the animal than being anesthetised and it is something the animal can be conditioned to. They also have the added benefit of allowing keepers to get close e.g. for injections, while limiting the risks to both the keeper and the tiger.

For longer and more intensive examinations tigers will need to be anesthetised by a vet. It should be noted that when anesthetising any of the felid species they must be subjected to a starve period, preferably for at least a day, as they are prone to regurgitation. The starve will not hurt them as they can go for days without food, and a starve day is usually part of their routine in any case.

With animals such as these darting is the preferred method, though with conditioning you may be able to use a hand injection. It is the safest method for the keeper/vet and the drug usually takes affect quickly. However darting should only ever be attempted by trained individuals as the darts themselves can cause serious injury to the animal if not targeted properly. If they need to remain unconscious for long periods gas inhalation can be safely used after the initial dose.

Oral medication is not advised as you cannot hand deliver it to a tiger, and if you put it in food you can't guarantee that the animal will ingest all of it. This adds danger as the tiger would then have to be dosed again and an overdose could occur. Also all felid species suffer from laryngo reflex when put under anesthetic, and if the animal goes into distress it would be extremely dangerous for a keeper/vet to try and approach a partly drugged tiger.

It should also be noted that when capturing a tiger for transport the tiger should be given access to the box prior to is transportation. You may even consider feeding the tiger in it. This approach has many advantages. It is less stressful for the animal as the box is now familiar, and if given enough time you may be able to condition the animal so that they will enter of their own volition, eliminating the need for the tiger to be tranquillised. The added advantages being that you will not need time for the tiger to recover from the tranquiliser, as they need to be fully conscious before transportation, and that you can feed them closer to transportation.

7.4 Weighing and Examination

Some tigers have been known to weigh as much as 300kg, so conventional methods of weighing that require man handling are not recommended. By far the most safe and effective means is installing scales in the raceway or crush. This means that no physical effort is required on the part of the keeper and the animal is put under very little stress. Portable weigh boards are also very effective, as the animal can be conditioned to stand on the scales and it can be made part of their routine though. You may need to plan for more then one session however as the animal may not cooperate on the first go. Either method allows staff to keep very accurate records.

For routine physical examinations again the crush or raceway is the best option. Good examinations can be conducted using this method on a regular basis with little stress to the animal. If a very thorough examination is required the animal would have to be sedated, as the risk to the keeper would be just too great.

7.5 Release

Release of a tiger should ideally take place during early morning or late afternoon. While many of their habits are nocturnal they do still tend to be active during the day, mostly in the early morning or late afternoon. By releasing at one of these options you are giving the tiger the chance to become acquainted with its environment before it begins its regular nocturnal activities. They also have the advantages of allowing for an easy watch during the initial release, as well as regular monitoring over the next day or so, and they erase the stress of public viewing.

Their transport box should be placed in their night den or exhibit so that they can exit when they feel comfortable. This is especially important when introducing them to a new environment. The opening of the box should be very obvious and they should have plenty of room opposite the opening in case they exit the box with speed.

Also if the tiger is in a shared exhibit it is best that the release be done without the presence of any other exhibit inhabitants, even if the inhabitants are animals that the captive is familiar with.

7.6 Transport Requirements

7.6.1 Box Design

The animal must be provided with the space to lie comfortably but not turn around, and there must be at least a 10cm clearance around the animal when standing in a normal position. The height of the container must allow the animal to stand erect with its head extended and the length must permit it to lie in a prone position. Though the measurements will vary with the species involved (IATA, 2000).

The frame must be made from solid wood or metal bolted or screwed together with a spacer bar requirement of 2.5cm depth to the sides for air circulation. When the weight of the container plus animal exceeds 60kg, or the animal is very aggressive the frame must have additional metal re-enforcing braces (IATA, 2000).

Suitable plywood or similar material must line the frame to give a smooth and strong interior. The floor must either be constructed in a narrow slatted form over a liquid proof tray in such a manner that all the excreta falls onto the floor. Or if a slatted floor is not require for that species, it must be leak proof and covered by sufficient absorbent material in order to prevent any excreta escaping. The roof must be solid with ventilation openings (IATA, 2000).

Sliding or hinged entry and exit doors must be provided, the front exit door must be made of steel welded mesh or strong iron bars. The iron bars must be spaced in such a way the animal can’t pass its legs between them (IATA, 2000).

The front of the doors must also be provided with a light sliding wooden shutter with either ventilation openings of 10cm or be slatted with 7cm spaces between the slats over the upper two thirds of the shutter, in order to reduce the disturbance to the animal and to protect the handlers. Both doors must be fastened with screws or bolts in order to prevent accidental opening (IATA, 2000).

Ventilation openings must be placed at heights that will provide through ventilation at all levels, particularly when the animal is lying down in a prone position. Exterior meshed ventilation openings, with a minimum diameter of 2.5cm must be made on the sides, entry door and roof (IATA, 2000).

Spacer bars/handles must be made to a depth of 2.5cm, and formed from the framework of the container (IATA, 2000).

Bears and other strong clawing animals must have the container totally lined with sheet iron or other hard metal sheeting with ventilation openings punched through to the exterior (IATA, 2000).

Forklift extrusions must be provided if the total weight of the container plus animal exceeds 60kg (IATA, 2000).

These species must be kept in darkened containers to avoid stimulus from their surroundings. They have the tendency to become aggressive and belligerent if disturbed by outside interference or noise (IATA, 2000).

Figures 7 and 8 show a Taronga transport box that was used to transport one of the Sumatran tigers to another zoo as part of the breeding program.

Fig 7.

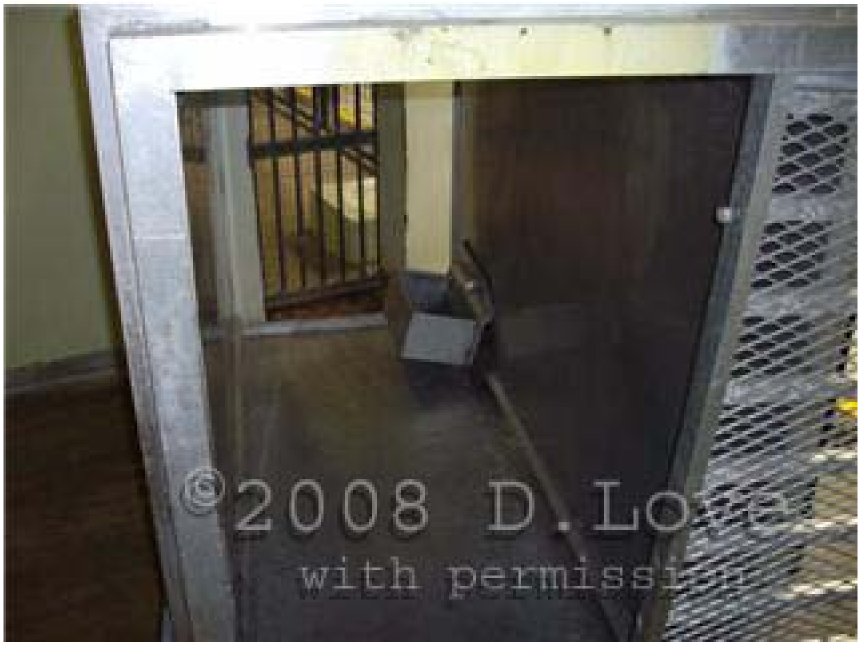
Fig 8.

7.6.2 Furnishings

Food and water containers must be fixed off the floor, to prevent soiling, at the front of the container. Safe outside access must be provided for filling in an emergency (IATA, 2000).

Figure 9 shows the interior and fixtures of a Taronga transport box used to transport one of the Sumatran tigers.

Fig 9.



7.6.3 Water And Food

Food intake must be reduced 2 to 3 days before shipment, though a light meal may be provided before dispatch, and food must be provided in case of emergency (IATA, 2000).

Animals do not usually require feeding or watering during the 24 hours following the time of dispatch. If feeding or watering is required due to an unforseen delay, feed once daily, preferably during the late afternoon, 1kg of meat per 20kg of live weight (IATA, 2000).

7.6.4 Animals Per Box

When more than one animal is to be carried in a container, multiples of the above requirements must apply. The container can be divided into compartments by the use of partitions made of metal grills. There must be a separate access into each compartment. Compatible animals that are not likely to harm each other during shipping need not be separated by a partition (IATA, 2000).

7.6.5 Timing of Transportation

If Possible transportation should begin during the early morning, thus hopefully avoiding the animal having to endure being left anywhere during the hottest part of the day. This also hopefully ensures that the majority of the travelling at least takes place during the part of the day in which the tiger is least active. If while under transportation there are to be numerous stops, or the tigers being transported are young, you should consider sending a keeper along. However the timing of transportation, especially when it is by air, may be out of your control.

7.7.7 Release From Box

When releasing a tiger from its transport box the box should be placed so that once the door is open the tiger can immediately access its new enclosure, or night den, depending on your set up. The tiger should be allowed to exit in its own time, as it will likely be cautious at first. However you should leave plenty of space opposite the opening in case it does exit at speed. You may also want to leave the box set up, perhaps for just a few hours, so that the tiger has access to something familiar while it is coming to terms with its new surroundings.

Chapter 8: Health Requirements

8.1 Daily Health Checks

Routine health monitoring of resident animals makes it possible to detect illness earlier, thus increasing the chance for successful treatment and preventing the problem in other animals, and these are usually monitored visually (Ed Kleiman et al, 1996).

Symptoms which should be looked for while performing your daily duties include changes in behaviour, appetite, water consumption, urine, faeces (Ed Kleiman et al, 1996).

The overall appearance of the animal is a key factor in a keepers ability to monitor an animals health, and any changes to its appearance should be noted and kept an eye on. Changes in overall appearance can include; coughing, sneezing, gagging, shortness of breath, regurgitation, vomiting, or lameness; the appearance of any lumps; or unusual discharges from the eye, ear, nose, penis or vulva (Ed Kleiman et al, 1996).

It is also imperative that the animal undergoes periodic weighing. Because even if the animal appears normal unexplained weight loss may indicate a health problem such as an inadequate diet, dental disease, neoplasia, or tuberculosis (Ed Kleiman et al, 1996). It may also be an indication that the animal is suffering from undue stress.

Regular weight checks are also very important for determining the individual diet of a tiger. Tigers often suffer from obesity in captivity and institutions will feed a tiger based on its weight in order to prevent obesity and the health problems that are associated with it. Health problems are compounded in tigers due to the fact that they are very large and very dangerous which can make treatments difficult. So in animals such as these the daily monitoring of their health is extremely important to keep the animal in good health and to reduce the risk and stress to both the animals and the keepers.

It is also very important that any mating behaviour be noted and recorded, and once the cubs are born a close eye kept on both parent and offspring. It will be necessary to remove the cubs on a regular basis for more thorough examinations. Though as long as the mother is weighed periodically, visual monitoring should suffice for her.

8.2 Detailed Physical Examination
8.2.1 Chemical Restraint

Carnivores greater than 5kg in body weight are considered dangerous if handled without anesthesia. Physical restraint can usually be achieved in a squeeze cage, where minor procedures and a cursory examination can be conducted. Blood samples can be obtained from the lateral tail vein in tigers, and IM injections of medication, vaccines, or anesthetics are facilitated by squeeze cages (Ed. Kleiman et al, 1996). However for more manipulative procedures the animal would need to be anesthetised, and if a squeeze cage is not available this should take place in its den where it is easy to separate and access, there are not too many obstacles and where the animal will be safe and warm during the recovery process.

For medium to large carnivores the drugs of choice are dissociative anesthetics. This is a type of injectable anesthetic, and its site of action is the frontal or dissociative cortex of the brain. These anesthetics have analgesic and amnesic properties while simultaneously preserving the laryngeal and pharyngeal reflexes. The effect can vary from sedation with low doses to surgical anesthesia with higher doses. When used alone in many species, however, dissociative anesthetics stimulate the central nervous system and produce poor muscle relaxation. Even at a level of anesthesia with adequate analgesia, animals may appear to be partially awake. Dissociative anesthetics are safe, fast acting, and effective in a wide variety of species. They stimulate the cardiovascular system and maintain adequate respiration. These drugs are secreted by the kidney in many species and should be used with care in animals with suspected renal problems. There are no direct antagonists to dissociative anesthetics (Ed. Kleiman et al, 1996).

One drug of choice for carnivores is Telazol. It can be concentrated to 500 mg/ml so that the largest carnivore can be anesthetized using only 1-2ml of fluid volume, a considerable advantage when using a remote injection system, as is often done with tigers. The usual dose of Telazol is 2-3 mg/kg. The induction period is rapid and smooth, and the onset of signs usually takes 2-4 minutes. If only a single injection is required the recovery period is not long, usually 3-4 hours. Occasionally a patient may undergo a re-sedation effect within 24 to 36 hours of the initial Telazol injection. Siberian tigers, and Bengal tigers with the white colour mutation, responded to Telazol in this fashion. The dosage of Telazol can also vary with the activity and status of the animal. For example, calm captive tigers require 0.5 mg/kg for adequate anesthesia, while free ranging tigers require 3-11 mg/kg (Ed. Kleiman et al, 1996).

It is important to note that tigers (*Panthera tigris*) appear to be sensitive to the effects of certain drugs (which is discussed further in *appendix 5*). And that while ketamine can be used fairly safely for tigers it is deadly to humans.

For prolonged medical treatment or surgical procedures, gaseous anesthesia is recommended. Following initial anesthesia with injectable drugs and tracheal intubation, either halothane or isoflurane can be used depending on the preference of the anesthetist. Intubation of larger carnivores is facilitated by a long laryngoscope blade. Most animals do well on spontaneous respiration with occasional assisted respiration, but sometimes positive pressure ventilation is indicated (Ed. Kleiman et al, 1996). It is important to remember that cats are prone to laryngo reflex, and so their eosophagus should be sprayed with Xylocaine (a local anestheic) to keep their airway open during any procedures. They should also be starved at least 12 to 24 hours before, as they are also prone to regurgitation.

8.2.2 Physical Examination

It should be noted that in the case of the tiger a detailed physical examination usually requires that the animal be sedated, though a squeeze cage or conditioning may help with some aspects eg. blood tests.

Physical examinations should include visual monitoring for any of the symptoms listed in section 8.1, as well as a very thorough investigation of their body eg checking the feet for sores. It should also include dental examinations, body weight measurement, identification marking (eg tattoo), and a blood sample which can be used for comparative or baseline values, as well as for any serological and heartworm testing. It is also important that at some point a baseline serum sample be taken and stored indefinitely as a reference for any future studies (Ed. Kleiman et al, 1996). You should also take the time to make note of any prominent physical characteristic (eg markings or deformities).

The animal should also be checked and treated for any ectoparasites, and a stool sample should be taken regularly to check for any endoparasites (Ed. Kleiman et al, 1996). The sample should be fresh and it should be taken directly to your vet without being placed in a fridge or freezer. Physical examinations are also a good opportunity for any vaccinations, tests regarding a females reproductive status, or the administration/implentation of contraceptives.

8.3 Routine Treatments

Apart from being regularly checked and treated for endo and ecto parasites, which should be on the advice of your vet, tigers should be vaccinated annually against canine distemper, feline rhinotracheitis, calicivirus, pan-leukopenia (feline distemper), and depending on the region rabies (http://ocw.tufts.edu). And where possible these vaccines should be 'killed' vaccines. Which means that unlike modified 'live' vaccines these do not cause disease, however they may not stimulate as strong a protective immune barrier (Ed Kleiman et al, 1996).

You may also want to vaccinate the tiger against feline leukemia, but this should not be a regular vaccination as no tiger has yet to test positive.

In tigers, as with other carnivores, maintaining good dental hygiene is of extreme importance as their having to undergo dental procedures is a major event. The majority of problems are caused by soft diets or trauma from chewing an object eg. like a fence. Apart from preventing these the best treatment is to give them large bones to chew on a regular basis, as they are a good 'chew toy' which helps maintain dental hygiene.

8.4 Known Health Problems

Unfortunately many of the health problems suffered by tigers in captivity can be linked to their diet. Tigers often suffer from obesity, periodontal disease, calcium/phosphorus imbalance which can result in skeletal problems and feline urinary syndrome which can block the ureters and urethra (Tilson and seal, 1987). Of these dental problems are probably the most common and problematic, especially if fed soft food. Their teeth and gums should be checked and cleaned regularly and they should be given bone and 'chew toys' to help prevent problems. Fractures can be especially problematical and surgery for dental work is not uncommon in tigers.

Tigers can also suffer from kidney disease, the most common of which is chronic interstitial nephritis. As well as gastrointestinal diseases such as gastric ulcers, pyloric stenosis (gastric impaction with straw), diaphragmatic hernia, cricopharyngeal achalaisa, gastric hairballs and liver disease (Tilson and Seal, 1987). The causes of these diseases could be stress, diet or infectious agents. Which can also be linked with kidney, liver and respiratory problems in aged tigers. While studies are still being conducted into the cause in aged tigers, it could just be the result of getting old, as many tigers in captivity live far longer than would be their span in the wild.

They are also subject to bacterial diseases like tuberculosis, anthrax and systematic diseases such as bacterial meningitis, Colisepticemia and Salmonella (which is potentially zoonotic). As well as viral diseases such as meningoencephalitis, upper respiratory viral dieases, Panleukopenia and Feline infectious peritonitis (FIP) (Tilson and Seal, 1987).

Recently some tigers have been diagnosed with Hemobartonellosis. This disease is typically diagnosed through evaluation of complete blood counts and peripheral blood smears. Unless blood is collected during the parasitemic phase, infections are difficult to diagnose and distinguish from primary immunemediated hemolytic anemia. Depending on the severity of infection, cats may have regenerative or nonregenerative anemia, with a packed cell volume of 8–20%, mean cell volume .50 fl, and anisocytosis (Haefner et al, 2003) (see *appendix 6* for further information).

The two most common fungal diseases are Microsporum canis, which is not an uncommon cause of hairloss in young tigers and Dermatophilosis cargolensis (Tilson and Seal, 1987).

And unfortunately tigers also seem to be prone to central nervous signs with a wide variety of disease conditions. As well as some congenital problems which may be related to inbreeding in some cases (Tilson and Seal, 1987).

The protozoan parasite *Toxoplasma gondii* commonly infects warm-blooded animals, including humans, following ingestion of food or water contaminated with infective oocysts from cat feces or of tissue cysts in uncooked or undercooked meat. Nondomestic and domestic felids are the only hosts that excrete this parasite’s oocysts and antibodies against *T. gondii* have been reported in several wild felid species (Silva et al, 2001). As well as posing a health problem to the tiger, it poses one of the biggest zoonotic risks with dealing with a feline species, not only to the keepers but potentially to other animals in the zoo as well, such as New World Monkeys (as discussed in *appendix 7*). Pregnant women are especially at risk as infection with toxoplasmosis can lead to birth defects and miscarriage.

Due to their very nature lacerations and abscesses are a constant problem with tigers. If the wound is not deep you may just want to leave it and monitor it, or put the tiger on a preventative course of antibiotics. If the wound starts to look angry it should be treated regularly with external medication to keep the wound clean. If it turns into an abscess it will need to be lanced and drained, along with a course of antibiotics. If the wound is deep or nasty however it is likely that the tiger will need to be anaesthetized for it to be treated.

Also tiger pads are very sensitive, which is what allows them to move so quietly. So care needs to be taken to ensure that they are not subjected to excessively hot or abrasive surfaces. Their dens need to be cleaned thoroughly as urine is quite corrosive and can damage a tigers pads if they spend a lot of time walking on it. Care should also be taken that they are not spending excessive amounts of time pacing in their dens as the concrete surfaces are quite harsh. If this is a problem some rubber surfaces may be suitable but will likely have a short life span due to the tigers claws. For example a captive adult male Bengal tiger (*Panthera tigris tigris*) was treated for chronic footpad ulcers associated with pacing on concrete cage surfaces. Combination therapy of oral fluoxetine and acepromazine administration to eliminate pacing behavior, daily application of moisturizing ointment, and oral vitamin E supplementation resulted in complete resolution of all footpad lesions. Subsequent clinical episodes completely resolved with similar treatments (Baker, 2002).

Although the anatomy of the domestic housecat has been examined in meticulous detail, comparative observations on the anatomy of the larger wild cats is scant and information about particularities in their cranial complexes rarer still. In the course of dissecting sets of masticatory muscles in five large felids, all older zoo animals, Duckler and Binder had the opportunity to note muscular attachments in the head and jaw apparatus that appeared significantly broader and more distal in their insertion sties than expected. Further investigation may determine whether these masticatory peculiarities are functional adaptations of felids, or instead are associated in some manner with the specialized diets large felids receive in captive Environments (Duckler and Binder, 1997) (as further discussed in *appendix 8*).

8.5 Quarantine Requirements

Proper quarantine of newly arrived animals is an essential part of a preventative medicine program. Although the animal may have been considered free of transmissible diseases at the previous facility, it may have been exposed during transport. Alternatively if a disease is slowly progressive (such as tuberculosis) or subclinical (such as the early stages of many parasitic diseases), the facility shipping the animals may not realise a health problem exists (Ed. Kleiman et al, 1996).

Ideally, new animals should be housed in separate quarters from those of the resident animals for a predetermined length of time. While this length of time depends on several factors, the usual length is for 30 days for transport within state, 45 days for transport interstate and up to 6 months for transport between countries. Or alternatively until a treatment has proved successful, whichever is longer.

The new animals should be cared for by keepers who have no contact with the resident animals. And the air and waste disposal systems should be isolated from resident animal systems. However these stringent requirements are not always feasible. In that case close physical contact should be prevented between the animals, such as an empty den between the new tiger and the resident group. Cleaning and feeding of the new animal should be done after the resident group's to avoid carrying material back and forth, and with separate tools assigned for use only with the new animal. A disinfectant footbath, in conjunction with coveralls and rubber boots will also minimise transfer through dust and manure (Ed. Kleiman et al, 1996).

Quarantine protocols usually include a thorough physical examination, such as mentioned in section 8.2.2, as well as testing for tuberculosis. However it should be noted that you will need three consecutive faecal examinations taken a day or so apart, and taken at least two weeks after the last treatment before releasing the animal. This is because some endoparasites shed ova intermittently, and because de-worming medications may not kill all stages of some parasites (Ed. Kleiman et al, 1996).

It should also be noted that quarantine may not be the best time for vaccinations. This is because the efficacy of a vaccine depends on the animals immune competence. The most beneficial response to the vaccine develops in a healthy animal under minimal stress. Transport to a new facility and the subsequent period can be stressful; therefore, necessary vaccines should be administered at least two weeks before shipment, or two to four weeks after quarantine (Ed. Kleiman et al, 1996).

For resident animals that are ill with a presumed or confirmed illness, the quarantine measures mentioned above should be applied. While exposed, susceptible animals should be monitored closely and prophylactic treatment instituted if appropriate (Ed. Kleiman et al, 1996).

Chapter 9: Behaviour

9.1 Activity

In many parts of their range tigers have become totally nocturnal in response to human activities; however, where they are undisturbed, they can be found hunting at any time of the day or night. In general the tiger’s activity patterns tend to mirror those of its major prey. However, in the hot season tigers were much less active, and they frequently rest from early morning until late afternoon in dense cover in or near water (M and F Sunquist, 2002).

Where females are concerned observations of early maternal behaviour in captivity show that in the first days after giving birth a tigress spends 70% of the daylight hours engaged in nursing her young. By ten days after the birth this proportion drops to 60%, and by the time the cubs are forty days old, about 30% of daylight hours are spent in suckling. The proportion drops to 10% by the time the cubs are three months old, which corresponds to the time of weaning at 90-100 days old (M and F Sunquist, 2002).

A tigress with cubs not only has to spend more time hunting and make more kills, but also has to contend with interference from her cubs, who by this time are following her around. To satisfy the needs of two cubs a tigress must increase her killing rate by an estimated 50% (M and F Sunquist, 2002).

The extent to which the presence of zoo visitors influences animal behavior, and the ways in which animal activity influences visitor interest and perception, are of great interest to zoological parks (see *appendix 9* for further information).

9.2 Social Behaviour

Tiger society, like that of most felids, is characterised by individuals living and hunting by themselves. Individuals encounter one another when travelling, associate for mating, and occasionally share a kill, but the only long term day-to-day association is between a female and her offspring. Although each tiger hunts alone, it lives its life embedded in a social system that is maintained through a combination of visual signals, scent marks and vocalisations (M and F Sunquist, 2002)
(as discussed further in *appendix 10*).

While cubs are weaned at approximately 90-100 days they remain with their mother for seventeen to twenty four months of age, where they learn hunting and social behaviours. However they may remain in their natal range anywhere from eighteen to twenty four months, moving independently. And their dispersal seems to be keyed to the mother’s reproductive state, as subadults they usually leave when their mother’s new litter is about six weeks old and mobile (M and F Sunquist, 2002).

9.3 Reproductive Behaviour

Scent marks also serve to bring animals together for mating purposes. Females appear to be receptive to a male’s advances for only two or three days of each oestrus cycle, so it is important that the male find the female and that his visits coincide with her peak of receptivity. Studies in captivity show that tigresses scent-mark more frequently just before they are ready to mate, which in the wild would function to ensure that a male is in attendance at the correct time (M and F Sunquist, 2002).

When tigresses are reproductively active, they come into oestrus about every twenty five days. Typically, a tigress would increase her rate of scent marking, the resident male would arrive, and the couple would spend two days together, after which the male would leave. If the mating did not result in conception, the female would continue to cycle, and the male would return twenty five days later (M and F Sunquist, 2002).

In captivity, oestrus in tigers is usually signalled by an increase in the frequency of calling and rolling and rubbing on objects (M and F Sunquist, 2002).

A receptive tigress is both provocative and aggressive, alternately vocalising and rolling on the ground in front of the male, then spitting and striking at him with her claws. The male has to be accepted by the female, so he does not retaliate, but presses on with his advances. Gradually the females behaviour changes and she permits him to approach (M and F Sunquist, 2002).

The amount of aggressive behaviour on the part of the female varies depending on the individual, her age and experience, and whether she is familiar with the male. If pairs are accustomed to each other, females usually show less aggressive behaviour. There is less snarling and spitting during the preliminaries, and the tigress often does not strike at the male after copulation. When a tiger is in oestrus for the first time, she may be intimidated by the male and rebuff his advances; data from zoos suggest a period of familiarization must occur before mating is successful (M and F Sunquist, 2002).

Shortly before the birth, the tigress will select a secluded place to have her young. The birth den may be in a rock crevice or a cave, an impenetrable thicket, or a shallow depression in dense grass. Tigresses are extremely cautious and secretive when they have young cubs, and will often move them to a new den if disturbed or threatened (M and F Sunquist, 2002).

9.4 Bathing

Tigers can swim well, and during the hot season in India and elsewhere they often spend most of the day lounging half-submerged in streams and ponds. There are also records of tigers periodically visiting islands in the Sunda Strait, despite a strong tidal current of more than 4 km per hour (M and F Sunquist, 2002).

9.5 Behavioural Problems

Tigers don’t tend to have many behavioural problems. Like any other animals stereotypic behaviours such as pacing and licking can occur if poor husbandry is involved. Spending too much time asleep is also another sign of poor husbandry but unlike others they are not prone to self destructive behaviours such as self mutilation.

However you will need to keep an eye on aggression towards keepers and other tigers in the collection. As they are such a dangerous animal any untoward aggression towards a keeper or tiger can be problematic as they are difficult to manage, and extreme measures such as darting may need to be resorted to in order to prevent serious injury or death. Management of tigers should be geared towards avoiding this.

Their propensity to chew can also result in health issues such as torn gums or broken teeth, especially if they decide to have a go at the fence. This can result in the animal needing to be anesthetized in order to repair the damage. In order to prevent this provide plenty of safe and interesting 'chew toys'.

9.6 Signs of Stress

In tigers panting can often be a sign of stress, as can withdrawn or overly aggressive behaviour, a lack of appetite, and extreme alertness.

Some stereotypic behaviour can also be seen as a sign of stress. For example pacing up and down along the rear wall may be a stress response to not being able to hide from scrutiny, it does not always have to mean boredom.

9.7 Behavioural Enrichment

Food is often used as enrichment because it solicits the natural foraging and hunting behaviours of animals. Food with interesting textures or new flavours, and food that is hidden in hard to reach places make good enrichment items. Many animals have 'popsicles' blocks of ice with food or bone inside (www.mnzoo.com). A popular tiger treat used in Minnesota zoo was a snowman that had eyes, mouth, buttons and a necklace all made of meatballs. For tigers the occasional feeding out of a whole carcass, possibly suspended would be great not only for enrichment but also for health.

The sense of smell is extremely important to animals and helps them to understand their surroundings, and it gives them a way to mark their place in their world. Providing new smells in an animals exhibit can cause excitement or alarm and often triggers territorial behaviours like rubbing and scent marking. A wide variety of scents can be used for enrichment, including catnip, spices and perfumes (tigers have been known to like 'charlie' and 'obsession'), urine and even animal fur (www.mnzoo.com). Scent trails are incredibly useful as they can renew the tigers interest in its surroundings by introducing new smells from time to time. And the scent trail may lead to a food reward which will encourage the tiger to be more active

Placing unusual objects into an animals exhibit can cause the animal to display all kinds of natural behaviours ranging from play to aggression (as further discussed in *appendix 11*). Paper made piñatas with food hidden inside, boomer balls for bouncing, a telephone book or box for shredding, kong toys (perhaps attached to a chew rope) can all be lots of fun (www.mnzoo.com).

Depending on the size of the animal, branches or whole trees are put in the exhibit for the animals to investigate, move around, and tear apart. Natural items are often provided to help animals perform necessary behaviours during natural seasonal cycles (www.mnzoo.com). For tigers large vertically or horizontally placed poles wrapped with rope offer great climbing and scratching posts.

For tigers having a 'pool' is very important for their enrichment. In the wild they like to swim and to cool themselves in the water, so having something in which they can swim and splash around in is very important. You could also add ice cubes as floating ‘toys’ with which the tiger can play with.

Training and enrichment are closely linked. In both cases once the animals figure out that a game behaviour leads to a reward (in the form of food or fun) they are enriched by the mental stimulation of playing the ‘game’ and the feeling of being in control of their environment (www.mnzoo.com). So far from being detrimental training helps with the management of the tigers and at the same time works as enrichment.

9.8 Introductions and Removals

The potential for things going wrong with introductions regarding tigers is quite high. They are very dangerous and in the wild they are usually solitary though they do engage socially. The most important factors are to give them time and to give them space. The timetable set should be done with regards to the individuals within your collection, not with regards to outside forces.

They should be denned separately, not only because this is a natural behaviour but because if it is in the same general area the tigers will be able to see and smell each other, without being able to engage in any physical contact.

Before physically introducing the new tiger to the exhibit you should introduce its scent on a few occasions so that the other tigers have a chance to get used to it. And you may want to introduce the scents of the collection to the new tiger for the same reason. You may want to do this by exchanging furniture, bedding, or marking scent trails.

With the initial introductions the tigers should be housed in the same general area as mentioned previously where they can see and smell each other but cannot have any physical contact. During this time you will have to rotate the individuals on and off exhibit. To increase the exposure the best way is to house them next to each other or have them on exhibit together separated only by a fine mesh of suitable strength. This allows them full interaction while preventing them from physically harming one another. For example the sliding door shown in figure 6.

When ready for full introduction you should ensure that the new tiger has had access to the exhibit to become familiar with it, as this is one less stress for it to deal with. You should start to introduce it to the collection an individual or two at a time slowly leading up to the whole group as this way it is easier to manage if things go wrong.

During any introductions keepers should be present with contingency plans if the tigers get aggressive. All behaviours should be carefully monitored.

Removals involve much less stress as tigers are naturally solitary. If it is a young tiger being removed form a large group this should have no real impact on the group as young tigers naturally disperse once a mother has a new litter, and males and females only usually socialise during mating.

If however it is a dominant tiger or the group is small the group structure will undergo change and some stress. So the group should be carefully monitored until everything is settled to avoid any serious injury to the animals.

9.9 Intraspecific Compatability

Throughout most of its range the tiger coexists with leopards and Asiatic wild dogs, or Dholes. The tiger is generally the dominant predator, with the leopards being socially subordinate to tigers, and there being little interaction between tigers and Dholes. Dholes are diurnal hunters while tigers are crepuscular or nocturnal hunters (M and F Sunquist, 2002).

When it comes to captivity however it would be inadvisable to house any of these species together, as there coexistence depends on their being able to avoid situations in which encounters are likely (M and F Sunquist, 2002). And prey species should not even be considered.

No enclosure which could be provided by a park or zoo is large enough for intraspecific housing arrangements. The animals would fall into either the prey category or the competition category. And being well fed does not mean a tiger won't hunt!

9.10 Interspecific Compatability

While tigers are usually solitary in the wild, except for mothers with cubs, they can be housed together in an exhibit. Competition in the wild is usually a result of competition for food, as it has been shown in the wild that home ranges where food is abundant are much smaller than those where food is scarce. Therefore if food is abundant tigers should be able to exist quite happily. Separate dens should be maintained because as well as making management easier it may help lessen any competitiveness, as even if they occasionally socialise in the wild they do not den together in the night.

Mothers should be separated when their cubs are young, as infanticide by males has been known to occur in the wild when cubs are brought into a social situation. The introduction of the cubs should be handled with time and patience to lessen the impact on the dynamics of the group.

9.11 Suitability to Captivity

Tigers live in a great variety of habitat types and can cope with a broad range of climates. Tiger density and home range size are directly related to the abundance and distribution of large terrestrial prey (M and F Sunquist, 2002).

Looking at these two facts, as well as taking into consideration the fact that they can cohabitate it would seem that they are suitable for captivity, as they can adapt to different climates and it seems that the area they occupy depends mostly on the availability of food.

It is important to remember however that tigers are a large animal who spends a great deal of time hunting in the wild and who can travel large distances. They spend a lot of their time hunting, not eating. Proper facilities would require enough room for the tiger to move freely, and enjoy quick sprints (they are not distance runners) it should also be able to swim and climb. It is also imperative that the enclosure be large enough that you can provide proper enrichment, for example scent trails, to be able to keep them active.

In conclusion tigers can be kept in captivity, but they are high maintenance and need a lot of room to move. The addition of them into your collection should only be undertaken after a great deal of thought and they are not suitable additions for every park or zoo. Perhaps one of the most important considerations is that they are extremely dangerous! They require high security and very well thought out enclosures.

Chapter 10: Breeding

10.1 Mating System

Tigers, like lions, copulate frequently. Despite some records of spontaneous ovulation, the general consensus is that felids are induced ovulators. This means that females require a certain number of copulations within a critical time to stimulate ovualtion. Most of the information on copulation frequency comes from zoos. Sankhala reports, 'on the first day of oestrus the frequency of copulation is low, increasing on the third day to as many as 52 times. From the fifth day on it declines.' Another observation of Bengal tigers records seventeen copulations in a day, and in the wild, eight copulations were seen in eighty-eight minutes. The duration of each copulation is short, typically less than fifteen seconds (M and F Sunquist, 2002).

The male tigers have a small cone-shaped penis which has a special bony-like structure called a baculum, and which is covered in hundreds of sharp backwards facing spines. These both serve to stimulate the female to ovulate, since the female does not ovulate until after mating. During the time she is in oestrus, she may copulate with several males, thus the litter may be comprised of cats with different fathers (www.lioncrusher.com).

10.2 Ease of Breeding

A receptive tigress is both provocative and aggressive, alternately vocalizing and rolling on the ground in front of the male, then spitting and striking at him with her claws. The male has to be accepted by the female, so he does not retaliate, but presses on with his advances. Gradually the females behaviour changes and she allows him to approach.

The amount of aggressive behaviour on the part of the female varies depending on the individual, her age and experience, and whether she is familiar with the male. If pairs are accustomed to each other, females usually show less aggressive behaviour. There is less snarling and spitting during the preliminaries, and the tigress often does not strike at the male after copulation. When a tigress is in oestrus for the first time, she may be intimidated by the male and rebuff his advances; data from zoos suggest that a period of familiarization must occur before mating is successful (M and F Sunquist, 2002).

Virtually all of the captive breeding programs use natural methods of reproduction. However there is still much we need to know (as is further discussed in *appendix 12*), and while biologists are researching other methods they have had little success so far.

One zoo has successfully produced a litter of 2 cubs with in vitro but it remains experimental. And despite many attempts only one cub has been successfully produced through artificial insemination. Due to the fact that tigers don't ovulate spontaneously but are induced to ovulate by mating the concentration and timing of hormonal injections to stimulate ovulation, and the timing of insemination is critical to success. More research is needed to refine these procedures (www.mnzoo.com) (see *appendix 13* for more information)

10.3 Reproductive Condition
10.3.1 Females

Unlike many other mammals most species of tiger can come into oestrus at any time. This is probably due to the fact that the climate ensures plentiful food all year round. Females do not require a big weight gain before breeding, however they do need to be in good condition if they are going to survive once the cubs are born. She needs to be physically fit and healthy, and of a sufficient weight to survive the first few weeks after the cubs are born with very little food and the enormous physical toll of this time. This is because her energy requirements will more than double once she begins lactating.

During the first few weeks of the cubs' lives the tigress spends most of her time at the den, leaving for only short periods to drink or hunt. Her movements are also greatly curtailed by the need to attend her small cubs, and for the first month after the cubs' birth her range shrinks dramatically to a fraction of its former size (M and F Sunquist, 2002). She will also need to hunt more frequently to adequately feed both herself and the cubs during this time.

10.3.2 Males

Reproductive males undergo no physical hardship during the reproductive phase, but they are those who can hold a territory, and thus breeding rights, against other wandering males. They also need to be accepted by the female. This being the case these males tend to be those in their prime. Physically fit and able to defend a territory from other males, or to win a territory off another male, and able to gain the females acceptance. If not in peak shape due to injury, malnutrition or age, they will loose the breeding rights of the female to competition, or even suffer the refusal of the female.

Therefore males tend only to be able to reproduce in their prime, and perhaps not even then if there is stronger competition around.

10.4 Techniques Used to Control Breeding

Long term but reversible suppression of oestrus cycles in felids would be highly beneficial for the management of reproduction in both domestic cats and zoo felids. Recurrent oestrus can lead to development of endometrial hyperplasia and mammary cancer, and these effects are exacerbated by progestin contraceptives. The ideal contraceptive would suppress ovarian function without having a direct steroidal effect on genital tract tissues. Deslorelin, a GnRH agonist available as an implant for long-term use, successfully suppressed reproductive functions in male and female dogs by downregulating GnRH receptors at the gonadotrpes in the pituitary gland without adverse reactions and is a potentially useful contraceptive for cats (L. Munson et al, 2001).

GnRH analogues are used to downregulate LH and FSH receptors in the pituitary gland. Treatment with the GnRH analogue deslorelin in long-acting implants resulted in a reversible cessation of male and female reproduction functions in dogs and cats. Captive housing of wild carnivores in zoos or holding in wildlife conservancies or sanctuaries often requires temporary contraception or suppression of aggression (H.J. Bertschinger et al, 2001).

Deslorelin has proven to be a very effective contraceptive where female felids are concerned. And though they are not as effective as a contraceptive in males it does reduce aggression, and so males are often treated with it as well, especially when housed in a group environment.

Previously one of the most frequently used reversible contraceptive methods was the melengestrol acetate (MGA) implant. This subcutaneous implant is a reversible control of reproduction, which has been successfully and easily accomplished. It is a medical grade silastic compound impregnated with melengestrol acetate. Each implant is usually effective for a two year period after which the implant can be replaced if further contraception is desired (Ed. R.L.Tilson and U.S.Seal, 1987). However the problems associated with this large implant have since made this an unpopular choice (see *appendix 14* for further information).

Apart from these the only other method to control breeding, which would still allow selective breeding to occur, would be to find the environmentally induce anestrus, the period when oestrus is suspended. This is because unlike many other mammal species a tigress will continue to come into oestrus until impregnated. Separating the female while she is in oestrus, or allowing her to mate with a male who can't produce sperm is not an option.

Thus once a female has finished her reproductive life span, either naturally or by breeding management, it is recommended that she be de-sexed, so as to prevent further hassle. Though this is a permanent solution and should not be carried out unless absolutely certain.

10.5 Occurrence of Hybrids

More so in the Felidae family than in any other family is the occurrence of hybridisation, or the resulting offspring between a male and a female of two completely separate species (www.lioncrusher.com).

In the wild hybridisation is almost non-existent. Even in areas where similar species overlap hybridisation does not occur because animals are generally only stimulated by sexual cues from their own species. However, in captivity, animals can usually be easily hybridised with other species because they are not in a wild state (www.lioncrusher.com).

The most common hybrids created in captivity in Felidae are tiger-lion crosses, also known as Tigons (male tiger x female lion) or Ligers (male lion x female tiger). Tigers and lions are very similar genetically, though they are not the same species. They were one of the last to diverge from one another in the cat family. Male tiger-lion crosses are always sterile, but a very small percentage of females have the ability to procreate, and are often mated to another lion or tiger, creating li-ligers and ti-tigons. All varieties of hybrids can be much larger than their parents. Some tiglons weigh over 900lbs. They display a mix of physical traits from their parents, often having darker tawny background, sometimes with an orangish tinge, with faint to medium to dark brown tiger stripes, and lighter colouration around the eyes, muzzle and undersides. The markings are not as prominent on the hybrids, and are usually restricted to the face. Males often sport manes, although they are much shorter and less dense. Females and males that lack manes also lack the thick ruff seen in tigers (www.lioncrusher.com).

10.6 Timing of breeding

In subtropical and tropical parts of the world tigers may mate and give birth at any time of the year, but Siberian tigers appear to be seasonal breeders, and there may be a seven or eight month anestrous between breeding seasons. While new born Siberian cubs have been found in the wild in all months of the year, in captivity most births occur between April and June, which would seem to ensure that cubs are not born in the depths of winter or when food is least available (M and F Sunquist, 2002).

10.7 Age at First Breeding and Last Breeding

Males become sexually mature at three to four years of age, and they generally take longer then females to acquire breeding territories. Females, on the other hand, become sexually mature when they are about three years old, but do not generally conceive until about six months later. Thus, a young tigress might have a first litter by the time she is three and a half or four years old (M and F Sunquist, 2002).

The reproductive tenure of males is not as well known, but appears to be shorter than females. This is largely due to their ability to maintain control over an area of females (M and F Sunquist, 2002).

In general however a male tiger will remain fertile until fourteen or older, while a female will remain fertile until about eleven or twelve years of age. It is important to keep in mind though that tiger mortality begins to rise at the age of twelve (www.mnzoo.com).

10.8 Ability to breed every year

Mating opportunities for males are limited because in areas where food is plentiful, tigresses are usually pregnant or accompanied by dependant young. During this time the female is in anestrus, and as a result, she may be sexually receptive only once every two years (M and F Sunquist, 2002).

10.9 Ability to Breed More Than Once Per Year

Tigresses have a high reproductive potential. They normally give birth to a new litter every two years but are capable of having more than one litter in a year if their cubs die. In zoos where cubs are removed for hand rearing, there are records of tigresses having as many as three litters in one year.

Also, as observed in lions, following the takeover of a male tiger's territory, the new male is likely to kill the small cubs of any tigresses in his territory, thereby inducing the females to come into oestrus and mate (M and F Sunquist, 2002).

10.10 Nesting, Hollow or Other Requirements

Shortly before the birth, the tigress selects a secluded place to have her young. The birth den may be in a rock crevice or cave, an impenetrable thicket, or a shallow depression in dense grass (M and F Sunquist, 2002).

Tigresses are extremely cautious and secretive when they have young cubs, and will often move them to a new den if disturbed or threatened (M and F Sunquist, 2002).

10.11 Breeding Diets

Lactation imposes enormous caloric demands on a female. Zookeepers remark that it is almost impossible to overfeed growing cubs and lactating females, and in the wild this period corresponds to a time when females are under enormous stress. Even when lactation ends, meeting the energy demands of growing young requires a great deal of effort. A tigress with cubs not only has to spend more time hunting and make more kills, but also has to contend with interference from her cubs, who by this time are following her around. To satisfy the needs of two cubs, a tigress must increase her killing rate by an estimated 50 percent. In Chitwan, for example, a tigress with two eight-month-old young made a large kill every five to six days, compared with one kill every eight days when she was on her own (M and F Sunquist, 2002).

However, taking this into account, zoos may not need to greatly alter the feeding regime during pregnancy. Energy, vitamins and minerals can be supplemented while lactating, by removing fast days, increasing meat and/or through the addition of multi-vitamins, calcium lactate and milk replacer supplements. They may also need to feed the female more than once per day to ensure adequate and continual energy supplies, as energy needs more than double during lactation to up to 250 kcal/kg (Ed. R.L.Tilson and U.S.Seal, 1987).

Deficiencies of particular vitamins and minerals have been known to affect pregnancy maintenance and fetal development. Low reproductive success in felids has been attributed to deficiencies in dietary taurine, an essential amino acid (Ed. Kleiman et al, 1996).

Also insufficient water intake can result in decreased food intake and undernutrition. In addition, limited water intake can suppress gametogenesis independently from food intake (Ed. Kleiman et al, 1996).

And it is important to note that the apparent paradox of the deleterious effects of both high and low planes of nutrition can perhaps be explained by finding that maximum conception rates are associated with moderate progesterone levels. Because progesterone concentration is inversely related to nutrition level, only a moderate feeding level will optimise contraception (Ed. Kleiman et al, 1996).

10.12 Oestrus Cycle and Gestation Period

There is no particular season for the female to come into oestrus. Once in oestrus, the male locates the tigress from her distinctive scent markings that leave a trail advertising her condition. She roars persistently attracting many males. The ultimate winner is generally the territorial tiger. Mating spreads over 5 to 6 days. The male then leaves and the female is completely on her own during the gestation period of 102 to 105 days, and in the rearing of the cubs (Sinha, 2003).

When tigresses are reproductively active, they come into oestrus about every twenty five days. Oestrus is preceded by an increase in scent marking, which presumably ensures that a male will be present at the appropriate time. Typically a tigress will increase her rate of scent marking, the resident male would arrive, and the couple would spend two days together, after which the male would leave. If the mating did not result in conception, the female would continue to cycle, and the male would return twenty five days later (M and F Sunquist, 2002).

In captivity, oestrus in tigers is usually signaled by an increase in the frequency on calling and rolling and rubbing on objects (M and F Sunquist, 2002).

Although the average length of oestrus in studies conducted at the Minnesota Zoological Gardens was five days, there are other observations of males and females consorting for weeks and even longer, and in some zoos tigers have continued to mate for as long as twenty one days. Individual differences may account for some of the variation in how often and for how long the pair stays together, and prolonged associations have also been noted for sexually inexperienced animals, suggesting familiarization is an important prelude to mating (M and F Sunquist, 2002).

10.13 Litter Size

The litter is between one and seven cubs, although the average generally comprises three to five cubs. The cubs are born blind and the eyes open after about a week (Sinha, 2003). Although a tigress in the wild is rarely accompanied by more than two or three cubs (M and F Sunquist, 2002).

10.14 Age at Weaning

While the cubs will continue to suckle for as long as they are allowed they should be fully weaned by six months of age. At this time, however, they are still unable to make their own kills.

10.15 Age of Removal From Parents

Young tigers become independent of their mothers at seventeen to twenty-four months of age, but continued to hunt in their natal range. This pattern is common to many mammals and allows the young to hone their hunting skills in a familiar area. After moving independently within their mother's range for a few months, the young dispersed, usually when they were eighteen to twenty-eight months old. Dispersal seems to be keyed to the mother's reproductive state, as subadults usually leave when their mother's new litter is about six weeks old and becoming mobile (M and F Sunquist, 2002).

Young males disperse farther than females. They are also more likely to get into a serious fight or be killed during this phase of their lives (M and F Sunquist, 2002).

It is not uncommon for daughters to settle next to their mothers, or even to usurp parts of their mother's territory. This results in a neighborhood of closely related females, like a dispersed lion pride (M and F Sunquist, 2002).

10.16 Growth and Development

The cubs are born blind and helpless, weighing 785 to 1,610 grams, but they grow fast and often quadruple their birth weight buy the time they are a month old. Their eyes may open at any time between six and twelve days of age, but they remain shortsighted and somewhat bleary-eyed for another month (M and F Sunquist, 2002).

Although tiger cubs have a full set of milk teeth by the time they are a month old, they do not begin to eat solid food until they are six to eight weeks old. At this age their mother brings them pieces of meat or leads them to kills near the den (M and F Sunquist, 2002).

Cubs continue to suckle as long as they are allowed to, sometimes until they reach five or six months old, but by the time they reach this age most of their nutritional requirements are met by solid food (M and F Sunquist, 2002).

Cubs begin to follow their mother when they are about two months old. At this age they do not join her in the hunt, but wait quietly until she calls them (M and F Sunquist, 2002).

At four months of age a tiger cub is about the size of a setter dog, and spends its time play wrestling with its siblings, jumping on its mother, and pouncing on unwary insects and sticks about the den. By six months the cubs are weaned, but lack the ability or skill to kill for themselves. Though they sometimes succeed in killing small animals and birds, they lack permanent canine teeth needed to dispatch larger prey. These long, daggerlike teeth are essential for delivering the killing bite and are also important instruments for slicing through the tough skin of a carcass (M and F Sunquist, 2002).

Cubs put on weight rapidly, and males grow faster than females. At six months of age males way 90 to 105 pounds, whereas females are about 30 pounds lighter. The weight difference increases as they get older, and by the time they are eighteen months old a male may weigh a hundred pounds more than his sister. The appearance of permanent canine teeth between twelve and eighteen months of age heralds a period of rapid weight gain, and the young are now physically equipped to make their own kills, though they still have to refine their hunting techniques (M and F Sunquist, 2002).

Young tigers learn to kill for themselves through imitation and practice, and their mother provides them with opportunities to test their skills. Partly because they lack permanent canines, but also because of inexperience, even quite large cubs are unable to kill a tethered Buffalo. They bite and claw the unfortunate beast, sometimes managing to pull it down, but they do not seem quite sure where or how the killing bite should be delivered (M and F Sunquist, 2002).

Male cubs learn to kill on their own and become independent sooner than females. By fifteen months of age males often leave their mother for several days at a time while they test their independence. Females seem to develop more slowly and stay with their mother for longer (M and F Sunquist, 2002).

Young tigers continue to grow and put on muscle until they are about five years old; this prolonged period of growth is more evident in males than in females (M and F Sunquist, 2002).

Evidence exists that deficits in early development (most notably social development) have far reaching and often permanent consequences. The best way to promote normal behavioural development is to allow infants to be mother reared in a diverse and spacious physical environment that closely approximates that in the wild. When mother rearing is not possible, other alternatives, in order of their desirability, are (1) using another lactating female as a foster mother, (2) hand-rearing the infant without removing it from the social group, and (3) hand-rearing the infant with conspecific peers.

Hand rearing infants in isolation should be considered as a last resort, and the techniques of artificial rearing should be based on the normal developmental patterns of the species in question. Understanding the natural course of development is critical for ensuring that captive-born infants grow into competent adults (Ed. Kleiman et al, 1996).

Chapter 11: Artificial Rearing

11.1 Housing

The initial housing requirements of tiger cubs are quite simple. A cub box should be prepared in an area isolated from other felids and free of draughts and any other weather conditions. This box is usually made of wood and is essentially the same as a nest box, though usually done on a smaller scale (Ginman, 2001).

The cubs will need to have some form of exercise available to them from the moment they emerge from the nest box, which will begin from 4-6 weeks onwards. It is important that the cubs be kept fairly isolated from any other felid species during these first few weeks as this is when disease transmission can occur if the young cubs have only limited immunity to diseases such as Feline Enteritis etc. They will also be susceptible to endoparasites such as roundworm. For these reasons, the exercise area for the cubs should be kept clean at all times from faeces/food scraps. The area should be for the exclusive use of the young until such a time as they can begin their course of vaccinations at approximately 8 weeks of age (Ginman, 2001).

The size of the exercise yard will depend on the number of cubs to be housed within it and the overall availability of space. The cubs should be provided with enough space to freely move around and exhibit normal behaviours (Ginman, 2001).

11.2 Temperature Requirements

It is important to note that hairloss has been experienced at several zoos for handreared tiger cubs at about 6-8 weeks old. This has also been noted in other cat species that have been hand raised as well as, such as snow leopard cubs. It is believed that the causes of this may be high environmental temperature and nutritional deficiencies (Ginman 2001, Ed. R.L.Tilson and U.S.Seal 1987).

A zoo in China hand rearing South Chinese cubs found that at one month old the optimal ambient temperature for cubs was 20-22^{0}C, if it was decreased to below 18^{0}C the cubs shivered. Suitable humidity was 60-80%; if too high, the cubs showed shortness of breath, if too low the cubs mouth and tongue felt dry. It was also found that the cubs suffered from respiratory tract infections if the ventilation was poor, and that the cubs seemed to benefit from natural lighting (Ed. R.L.Tilson and U.S.Seal 1987).

While this provides a good baseline the required temperature and humidity may change slightly depending on the subspecies you are rearing. In all cases it is best to let the cubs themselves be your guide. Monitor them closely and adjust the temperature and humidity based on their responses. Though generally the most you will need to do is provide a cosy nest box, and if they are less than one month of age a heat pad in a corner of the box which they can move onto if they get cold.

11.3 Diet and Feeding Routine

The amount of milk to be fed to each cub will vary according to size and interest in suckling. There is no hard and fast rule on milk feeding but growth and weight must be monitored carefully to ensure that each cub is receiving enough milk. In general the cub should continually and steadily increase in weight during the handrearing process (Ginman, 2001) (For milk preparation and feeding method see *appendix 15*).

Biolac Kitten milk formula will be used in this instance. Using this formula, the cubs should be fed at every 2 - 3 hours for the first 7 days, feeding as much as the cubs will drink. The dilution rate is as follows (Ginaman, 2001):

1000 ml cool boiled water
170 g of Biolac Kitten formula (or 10 heaped scoops)

A good guide for amounts to be fed are as follows (Ginman, 2001):

Body Weight	Total Volume per day
500 g	100 ml
1000 g	200 ml
2000 g	400 ml
3000 g	600 ml
4000 g	800 ml
5000 g	1000 ml
6000 g	1200 ml

It is advised to feed the cubs between 10-20% of their body weight per day. E.g. 1 kg body weight: 10% = 100mls, 20% = 200mls. Always aim for the 20%. This daily amount is then divided into the total amount of feeds throughout the day (Small, 1997). Weigh cubs on a daily basis and adjust accordingly. Always weigh at the same time every day prior to feeding to give an accurate and consistent weight. For increased accuracy of weight, digital scales that weigh in 1 gram increments should be used until the cubs reach 5 kg. After this time, ‘stand on’ digital scales may be used although the accuracy is then decreased (Ginman, 2001).

FEEDING SCHEDULE

The following feeding schedule will be used for the tiger cubs (Ginman, 2001).

Feeds from 0 – 1 week of age will be done at –

7 am 9 am 12 pm 3 pm 6 pm 9 pm 12 am 3.30 am

Feeds at 1 - 3 weeks will be done at –

7 am 10 am 1 pm 4 pm 7 pm 10 pm 2 am

Feeds at 3 - 4 weeks will be done at –

7 am 10 am 1 pm 4 pm 8 pm 1 am

Feeds at 4 – 6 weeks of age will be done at –

7 am 10 am 1.30 pm 5.30 pm 9 pm

Feeds at 6 – 8 weeks will be done at –

7 am 10 am 1.30 pm 4 pm 7 pm

Feeds at 8 – 10 weeks will be done at –

7 am 10 am 1.30 pm 5 pm

Feeds at 10 – 12 weeks will be done at -

7 am 10 am 2 pm 5 pm

Over this entire period the amount fed at each feed should continue to increase. The young should be offered as much as they will drink each feed without exceeding the recommended total volume per day/body weight (ie of up to 25%) (Ginman, 2001).

Night feeds are an important part of the handrearing process. Staff resources will be required to cover those staff members that are needed for latenight/early morning feeds. While these night feeds present a staff management problem, the feeds should not be dismissed on this basis. They are essential for monitoring the cubs after hours, ensuring the daily intake of food is met and providing the initial strict management of the cubs while in this early vulnerable stage (Ginman, 2001).

11.4 Specific Requirements

In order to promote optimal growth, health and psychological well being, handrearers must be available to the cubs at all times to provide the care, husbandry and comfort that is afforded by the natural mother. Handrearing involves more than feeding and cleaning. Natural mothers while providing nutrition and hygiene, also provide cubs with warmth, security and comfort. Psychological studies have been conducted on Rhesus Maqacue infants. Infants were removed from their natural mother and given a choice of a wire 'mother' that provided food and a sheepskin covered 'mother' that only provided comfort. The infants chose the sheepskin 'mother' over food showing the importance of comfort and security to the developing young. The presence of a mother figure is important to the young for this reason and should not be understated. Absence of a mother figure can lead to young developing anxiety disorders, neurosis and stress. Tigers are an endangered species and therefore the cubs will be expected to play a role in captive breeding, it is important that the cubs are reared in optimal conditions during their development so that they will become successful and well adjusted adults (Ginman, 2001).

11.5 Data Recording

A Hand rearing data sheet for each cub should be formulated and is to be used to record daily times of feeding, amount of milk offered and amount taken. Faeces and urine is also to be recorded. Consistency of faeces must be recorded as diarrhea and constipation can rapidly lead to death in young cubs or be a sign of disease. Cubs should be weighed at the same time each day and any other comments should be recorded. Comments should include behaviour, development, treatments and health related information. Data should also be recorded in the section diary and daily report (Ginman).

The data sheet should also include parentage, so that if any medical problems with the cubs arises it can be determined if it is due to their lineage. And the means of identifying each cub should be recorded on the sheet somewhere where it is easy to see.

11.6 Identification Methods

Cubs are too young to be microchipped or tattooed so in most cases their sex, size, individual markings, and perhaps even behaviour are used to identify the cubs.

However in cases where it is extremely difficult to tell them apart they could be marked on the back for example with a non toxic colour, though the other cubs may lick it off. Or they could perhaps be collared, making sure it is a soft flexible collar which is checked daily. These methods are usually not required though.

11.7 Hygiene

Cubs up to 12 – 15 weeks of age will need to be stimulated to urinate and defecate. It is best to use a warm damp terry towelling cloth. The rough surface of terry towelling cloth simulates the mothers tongue. For young cubs, cotton wool may be used until the cubs are 6 – 7 weeks of age as it is soft and easily discarded. Toileting can be stopped when each cub is seen to produce faeces on their own. This will vary for each individual (For further information see *appendix 15*) (Ginman, 2001).

Stimulating prior to feeding may incite the cubs appetite. Cubs will usually need to eliminate after feeding and so should be stimulated at this time. The young should be kept clean at all times to prevent disease and any soiled bedding should be immediately replaced. When bottle feeding, any milk remaining on the animals fur should also be wiped with a warm damp cloth to prevent matting of the fur and bacterial infections. Bacterial infections from milk residue appear as dark crusty areas and can occur around the mouth, whiskers and between the toes. The use of 1% chlorhexidine solution on a clean cloth after cleaning of fur can reduce the possibility of infection (Ginman, 2001).

Faecal matter will appear of "toothpaste" consistency and be a mustard color though will firm up as the cub matures and solids are introduced. It is a good idea to get the faeces checked for yeast infection. A positive result could be indicative of ill health or poor hygiene techniques (Ginman,2001).

Diarrhoea can cause death in young cubs if left unchecked in the first few days of life. Diarrhoea can be caused by poor quality milk or if the milk formula is too strong. Likewise constipation can be fatal and can be caused by failing to stimulate the young correctly or infrequently. The veterinarians should always be contacted if the cubs show any signs of ill health eg. diarrhoea, constipation, conjunctivitis, lethargy, coughing etc. In general the cubs should urinate after each feed and defaecate at least once daily although may only do so every 1 – 3 days. Provided the cub has a good appetite and is bright and alert, there is no need to worry if faeces is not seen daily. Always consult the veterinarians if concerned (Ginman, 2001).

Cubs coats can be brushed daily to massage the skin and help increase the bond between the cub and keeper. If the coat becomes greasy or soiled, cubs may be bathed in kitten shampoo if needed but must be thoroughly rinsed with warm water to remove all traces of shampoo. After towel drying, cubs should be blow dried to ensure that they are thoroughly dry or alternatively placed in a warm/sunny area to dry (Ginman, 2001).

To ensure good hygiene and disease prevention, the den area should be kept clean at all times. While cubs are kept on display in the exhibit, the den area can be hosed, disinfected or bleached. No traces of any chemical should be left within the den area after cleaning. The exhibit 'cub box' should be kept clean at all times. Once cubs are taken off display, the exhibit should be cleaned and the box can be hosed and disinfected/bleached. Again no traces of any chemical should be left after cleaning (Ginman, 2001).

11.8 Behavioural Considerations

Where possible cubs should be raised in a litter so that they can play and interact with each other. In domestic cats, the critical period of socialisation occurs between 2 – 7 weeks of age (Fogle, 1991). During this period of development the cubs should be given the opportunity to encounter a range of stimuli that they will come across as adults. This will help the cubs to develop both mentally and physically so that they become well adjusted adults (Fogle, 1991). Failure to expose cubs to different stimuli at this time can lead to adverse behavioural problems later in life (Ginman, 2001).

HANDLING /SOCIALISATION

The aim of handrearing cubs that have been mismothered should include socialising the Sumatran Tiger cubs with humans to provide ease of handling once mature. Continued contact with the cubs will be assessed as they develop. Depending on the cubs individual temperament, handling will be continued until the cubs become too boisterous for staff. To allow the cubs to be handled for an extended period the following must be followed at all times (Ginsman, 2001)-

- Cubs are to be encouraged to play only with siblings
- Cubs are to be discouraged from using claws or biting keepers at any time
- Cubs are to be discouraged from jumping on keepers
- Cubs are not to be restrained or held if showing aggressive/defensive behaviour
- Keepers are not to encourage excitable behaviour in any cub
- Keepers are not to play roughly/play fight with cubs
- Keepers must not at any time handle the cubs in a harsh manner
- Keepers are not to smack cubs – to discipline cubs they can be – ignored or the keeper may use their voice as a deterrent.
- Cubs should always be rewarded for good behaviour.
- Cubs should never be rewarded for unwanted behaviour
- Consistency in handling techniques is extremely important.
- Cubs should only be handled by keepers that they feel comfortable with.

11.9 Use of Foster Species

While it is possible to foster a cub with another female tiger it has not yet been determined whether it is possible to successfully foster a tiger cub with another species feline or otherwise, apart from humans.

11.10 Weaning

The cubs will solely be bottle fed until they are 8 weeks of age.

Feeds at 8 – 10 weeks -	7 am	10 am	1.30 pm	5 pm

At 8 – 9 weeks of age, the cubs will be introduced to meat. Initially the cubs will be given one feed of mince meat daily at the 5 pm feed. Mince must be warmed to room temperature prior to feeding. Chicken, beef, horse and kangaroo mince will be supplemented with Petvite (vitamin/mineral supplement) and fed as per a Big Cat diet. Feeding a range of meat at this time will lead to the cubs accepting a wider range of meat as adults (Ginman, 2001).

One feed of mince daily at 5 pm will continue until the cubs are 10 – 12 weeks

Feeds at 10 – 12 weeks -	7 am	10 am	2 pm	5 pm

From 10 weeks of age, bottle feeds will only be done at 7 am and 10 am. Cubs will be fed mince mixed with milk for the 2pm and 5 pm feeds (Ginman, 2001).

From 12 weeks of age, the cubs will be introduced to small chunks of meat. Initially the meat chunks will be offered with milk until the cubs are accepting the meat on its own. Once the cubs are accepting meat alone they will be fully weaned and will no longer receive any bottle feeds. At this stage the cubs will be introduced to the normal Big Cat diet which contains muscle meat with fur and bones supplemented with Petvite daily. The cubs will not be given a starve day until they are mature at 2 – 3 years of age (Ginman, 2001).

Initially the cubs, will receive three meat feeds daily –

7 am 11.30 am 2.30 pm

At 16 weeks of age the feeds will be decreased to twice daily

7 arm 2.30 pm

By 6 months of age, the feeds can then be decreased to one feed daily (without a starve day)

7 am

The second feed at 2.30 pm may be retained if needed (as has been done with the African Lion cubs) to provide behavioural enrichment for the animals and also provide the public with an on display big cat feed (Ginman, 2001).

Initially only small amounts of mince meat should be offered at frequent intervals for e.g. 100 g offered 3 times daily. The amounts to be fed will vary according to the size of the cubs, but as a general rule the cubs abdomen should not look bloated at the completion of a meal. Overfeeding will cause diarrhoea and make the young uncomfortable. Once cubs have been introduced to meat with fur and bones, the amount to be fed will again be determined by the growth rates of the cubs (Ginman, 2001).

11.11 Rehabilitation and Release Procedures

The World Zoo Conservation Strategy emphasises- in accordance with the IUCN Guidelines for Reintroductions- that reintroductions, when properly applied, can bring great benefits to natural biological systems. The Strategy reported that reintroductions (and restocking projects) have been undertaken with more than 120 species. Although it is too early to assess the outcome of all the projects, 15 projects have established self sufficient populations. In a more specific review of carnivore reintroductions, Reading and Clark (1996) list 55 attempts of which 29 were judged successful by the practitioners (no fixed definition of success was used). Tiger conservationists should review these case studies for possible future direction while there is still time and sufficient number of tigers (Ed J. Seidensticker et al, 1999).

From our perspective the primary mandate of captive tiger programmes is to reinforce, rather than replace, wild populations. The Tiger GCS implicity states that the protection and continuance of *in situ* populations is the highest priority. All too often the general public expects individuals of endangered species at their local zoo to be released back into the wild. For tigers, this is not the case for biological, political and practical reasons. Rather the captive population needs to be perceived as a resevoir of genetic material representing the species, not just individuals. They represent a 'genetic insurance policy' against extinction in the wild. The potential biological role of these individuals is to help re-establish populations that have vanished from their natural range or to revitalise wild populations that have genetic or demographic problems. Until then, our primary concern must be to continue to maintain, or even increase, what is left of the tiger's natural habitat (Ed J. Seidensticker et al, 1999).

The Strategy specifies that reintroduction, restocking or translocation projects will always be carried out in agreement with IUCN guidelines and within regulations of the conservation authorities of the recipient countries, as well as in co-operation with IUCN/SCC Specialist Groups for Reintroduction, Veterinary, Conservation Breeding, and others relevant to the situation. Taken together, these documents list a daunting set of preconditions and necessary precautions, precluding any haphazard approach, and zoos must operate within these constraints (Ed J. Seidensticker et al, 1999).

A tiger reintroduction would, like all reintroduction projects, be difficult, time-consuming and expensive. The evidence argues, however, that it is feasible in the right circumstances. Reintroduction of tigers is not a tool that will be used in the foreseeable future, but the problems of securing a future for the tiger are vast and we must be prepared to use every tool available to us if we are to succeed in the long term (Ed J. Seidensticker et al, 1999). (For further information see *appendix 16*).

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References

Adaska, J.M. and Lynch, S. (2004) *Fibrocartilaginous Embrolic Myelopathy in a Sumatran Tiger (Panthera tigris sumatrae),* Journal of Zoo and Wildlife Medicine 35(2): 242–244, Copyright 2004 by American Association of Zoo Veterinarians.

Chagas e Silva, J.N., Leita˜o, R.M., Lapa˜o, N.E., da Cuncha, M.B., da Cuncha, T.P., da Silva, J.P. and Paisana, F.C. (2000) *Birth of Siberian Tiger (Panthera Tigirs Altiaca) Cubs After Transvaginal Artificial Insemination,* Journal of Zoo and Wildlife Medicine 31(4): 566–569, Copyright 2000 by American Association of Zoo Veterinarians

Crissey, S.D., Slifka, K.A., Jacobsen, K.L., Shumway, P.J., Mathews, R. and Harper, J. (2001) *Irradiation Of Diets Fed To Captive Exotic Felids: Microbial Destruction, Consumption, And Fecal Consistency*, Journal of Zoo and Wildlife Medicine 32(3): 324–328, Copyright 2001 by American Association of Zoo Veterinarians

Curro, T.G., Okeson, D., Zimmerman, D., Armstrong, D.L. and Simmons, L.G. (2004) *Xylazine-Midazolam-Ketamine versus Medtomidine-Midazolam-Ketamine Anesthesia In Captive Siberian Tigers (Panthera Tigris Altaica)* Journal of Zoo and Wildlife Medicine 35(3): 320–327, Copyright 2004 by American Association of Zoo Veterinarians

Baker, D.G. (2002) *Combination Therapy For Footpad Lesions In A Captive Bengal Tiger (Panthera tigris tigris), Journal of Zoo and Wildlife Medicine* 33(4): 389–391, Copyright 2002 by American Association of Zoo Veterinarians

Bashaw, M.J., Bloomsmith, M.A., Marr, M.J., Maple, T.L. (2003) *To Hunt or Not to Hunt? A Feeding Enrichment Experiment With Captive Large Felids,* Zoo Biology 22:189–198

Bertschinger, H.J., Asa, C.S., Calle, P.P., Long, J.A., Bauman, K., Dematteo, K., Jochle, W., Trigg, T.E. and Human, A. (2001) *Understanding the basic reproductive biology of wild felids by monitoring of faecal steroids,* Journal of Reproduction and Fertility Supplement 57, pg275-283, Cambridge, UK.

Brown, J.L., Graham, L.H., Wielebnowski, N., Swanson, W.F., Wildt, D.E. and Howard, J.G. (2001) *Understanding the basic reproductive biology of wild felids by monitoring of faecal steroids,* Journal of Reproduction and Fertility Supplement 57, pg71-82, Cambridge, UK.

Dreamworld; Tiger Island Information Pack

Duckler, G.L. (1998) *An Unusual Osteological Formation in the Posterior Skulls of Captive Tigers (Panthera tigris),*
Zoo Biology 17:135–142

Duckler, L. and Binder, W. (1997) *Previously Undescribed Features in the Temporalis and Masseteric Musculature of Several; Large Felids Raised in Captivity,* Zoo Biology 16:187–191

Ginman, L. (Ed) (2001) *Sumatran Tiger Cub Handrearing.* Taronga Zoo

Haefner, M., Burke, T.J., Kitchell, B.E., Lamont, L.A., Schaeffer, D.J., Behr, M. and Messick, J.B. (2003) *Identification of Haemobartinella Felis (Mycoplasma Haemofelis) in Captive Nondomestic Cats,* Journal of Zoo and Wildlife Medicine 34(2): 139–143, Copyright 2003 by American Association of Zoo Veterinarians

IATA (2000) *Live Animal Regulations 27th edition,* International Air Transport Association, Montreal Geneva

Jenny, S. and Schmid, H. (2002) *Effect of Feeding Boxes on the Behaviour of Stereotyping Amur Tigers (Panthera tigris altaica) in the Zurich Zoo, Zurich, Switzerland,* Zoo Biology 21:573–584

Kleiman, D.G, Allen, M.E., Thompson, K.V. and Lumpkin, S. (Eds) (1996) *Wild Mammals In Captivity; Priciples and Techniques,* The University of Chicago Press, Ltd., London

Macguire, L.A. and Lacy R.C. (1990) *Allocating Scarce Resources for Conservation of Endangered Subspecies: Partitioning Zoo Space for Tiger,* Conservation Biology Volume 4, No. 2. June

Margulis, S.W., Hoyos, C. and Anderson, M. (2003) *Effects of Felid Activity on Zoo Visitor Interest,* Zoo Biology 22:587–599.

Markowitz, H. and LaForse, S. (1987) *Artificial Prey as Behavioral Enrichment Devices for Felines,* Applied Animal Behaviour Science, 18 pg31-43 31, Elsevier Science Publishers B.V., Amsterdam -- Printed in The Netherlands

Miller, M., Weber, M., Neiffer, D., Mangold, B., Fontenot, D. and Stetter, M. (2003) *anesthetic Induction of Captive Tigers (Panthera Tigris) Using a Medetomidine-Ketamine Combination,* Journal of Zoo and Wildlife Medicine 34(3): 307–308, Copyright 2003 by American Association of Zoo Veterinarians

Munson, L., Bauman, J.E., Asa, C.S., Jochle, W. and Trigg, T.E. (2001) *Efficacy of the GnRH analogue deslorelin for suppression of oestrus cycles in cats,* Understanding the basic reproductive biology of wild felids by monitoring of faecal steroids, Journal of Reproduction and Fertility Supplement 57, pg269-273, Cambridge, UK.

Nyhus, P.J., Tilson, R.L. and Tomlinson, J.L. (2003) *dangerous Animals in Captivity: Ex Situ Tiger Conflict and Implications for Private Ownership of Exotic Animals,* Zoo Biology 22:573–586

Pope, C.E. (2000) *Embryo Technology in Conservation Efforts for endangered Felids,* Theriogenology 53:163-174

Seidensticker, J., Christie, S. and Jackson, P. (Eds) (1999) *Riding The Tiger: Tiger Conservation In Human Dominated Landscapes,* Cambridge University Press

Silva, JC.R., Ogassawara, S., Marvulo, MF.V., Neto, F. and Dubey, J.P. (2001) *Toxoplasma Gondii Antibodies In Exotic Wild Felids From Brazilian Zoos, Journal of Zoo and Wildlife Medicine* 32(3): 349–351, Copyright 2001 by American Association of Zoo Veterinarians

Sinha, V. R. (2003) *The Vanishing Tiger: Wild Tigers, Co-predators and Prey Species,* Salamander Books Ltd, London, United Kingdom.

Sunquist, M. and F. (2002) *Wild Cats of The World*, The University of Chicago Press, Ltd., London

Tilson, R. L. and Seal, U. S. (1987) *Tigers Of The World: The Biology, Biopolitics, Management, and Conservation of an Endangered Species,* Noyes Publications, Park Ridge, New Jersey, U.S.A.

White, B.C., Houser, L.A., Fuller, J.A., Taylor, S., Elliott, J.L.L. (2003) *Activity-Based Exhibition of Five Mammalian Species: Evaluation of Behavioral Changes,* Zoo Biology 22:269–285.

www.agric.nsw.gov.au

www.iucnredlist.org

www.lioncrusher.com

www.mnzoo.com

http://ocw.tufts.edu

www.tigerlink.org/husbandry/

Appendices

Appendix 1

Annual Cycle Of Maintenance Activities

Maintenance	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Breeding Season (10.6)												
Vacciantion (8.3)												
Contraception Renewal/check (10.4)												
Major Renovation or Maintenance (4.9)												
Changing Furniture (4.9)												
Vegetation Check (4.9)												
Faecal collection (8.3)												

Note
While having an annual calendar is very important in the case of a large dangerous animal like the tiger what you can schedule annually is limited.

Most small maintenance issues are taken care of on a weekly or monthly basis so as to stop them from becoming a major issue and these are usually noted on a monthly or weekly roster e.g. clean pond or degrease dens .

As for the Tigers themselves most procedures are only done if needed, they are not scheduled. This limits the trauma to both the animal and the keepers involved.

Appendix 2 – Exhibit and enclosure design

In the past few decades, the design of captive animal enclosures has increasingly incorporated features that approximate the animals' natural habitats. Activity-based exhibits are a recent example of this trend. This approach features a naturalistic setting wherein several animals may occupy the exhibits simultaneously or serially. The animals may be moved from exhibit to exhibit within a single day or from one day to the next. Over the course of these movements, the animals encounter a variety of environmental stimuli, including physical variation among the exhibits and the stimuli of previous animals. Movement within the activity-based design requires a structurally complex system of chutes and gates. Animals must be trained to move readily through these areas, providing additional stimulation for the animals. This contrasts with the traditional single-animal exhibit in which movement is limited to travel between holding areas and exhibit areas (White et al, 2003).

Enrichment through moderate arousal may be accomplished by variation in exhibits, encounters with other animals and their stimuli, and the training required to move through the structure. Training is likely to increase the amount of interaction between keepers and animals. It also elevates the quality of the interaction, as keepers make cognitive demands on the animals. The benefits of the activity-based design may be decreased when the number of animals rotated through the exhibits exceeds the number of exhibits. In that case, an animal may spend more time in the holding area than it would in a single-species exhibits. Consequently, the greater holding time may produce a longer period of low arousal than the traditional single-species exhibit. On the other hand, when an animal can spend some time off-exhibit, the efficiency of this method of exhibition can be realized. Eventually, we will need to determine the appropriate balance between increasing the number of animals and decreasing the exhibit time (White et al, 2003).

Appendix 3 – Bacteria and parasites in food

Irradiation is a cold pasteurization procedure that eliminates bacteria, including some potentially harmful strains (e.g., *Listeria*, *Salmonella*, *Escherichia coli* 0157:H7, and *Campylobacter*), by exposure of food to ionizing radiation. This procedure has been approved for treating refrigerated or frozen uncooked meat, particularly poultry, red meat,eggs, and fish products intended for human use. Radiation treatment doses of 2–7 kilograys (kGy) can effectively eliminate harmful non-spore-forming pathogens in meats (Crissey et al, 2001).

At present, most captive exotic felids are fed raw horse meat–based diets. Because of growing concern regarding bacteria found in such diets, the effectiveness of irradiation in eliminating microbial populations is of interest. Two frozen, raw horse meat–based diets fed to captive exotic felids at Brookfield Zoo were irradiated to determine the extent of microbial destruction and whether radiation treatment would affect consumption and/or fecal consistency in exotic cats. Fifteen cats, two African lions (*Panthera leo*), two Amur tigers (*Panthera tigris altaica*), one Amur leopard (*Panthera pardus orientalis*), two clouded leopards (*Neofelis nebulosa*), two caracals (*Felis caracal*), one bobcat (*Felis rufus*), and five fishing cats (*Felis viverrinus*), housed at Brookfield Zoo were fed nonirradiated and irradiated raw diets containing horse meat with cereal products and fortified with nutrients: Nebraska Brand Feline and/ or Canine Diet. Baseline data were obtained during a 2-wk control period (nonirradiated diets), which was followed by a 4-wk period of feeding comparable irradiated diets. Feed intake and fecal consistency data were collected. An estimated radiation dose range of 0.5–3.9 kilograys reduced most microbial populations, depending on specific diet and microbe type. Irradiation had no overall effect on either feed consumption or fecal consistency in captive exotic cats, regardless of species, age, sex, or body mass. Data indicate that irradiation of frozen horse meat–based diets (packaged in 2.2-kg portions) result in microbial destruction in these products but that product storage time between irradiation and sampling may also affect microbial reduction. However, irradiation would be an appropriate method for reducing potentially pathologic bacteria in raw meat fed to exotic cats (Crissey et al, 2001).

Appendix 4 – Presentation of food and enrichment

It is often difficult to promote the successful performance of feeding behaviors in zoos, especially for carnivores. Feeding enrichment provides these opportunities and often improves behavioral indications of an animal's well-being and the experience of the zoo visitor. The effectiveness of two different feeding enrichment techniques was evaluated on five subjects in two species of felids: African lions and Sumatran tigers. The activity budgets of each cat were compared before, during, and after enrichment, focusing on activity levels, frequency and variety of feeding behaviors, and occurrence of stereotypic behaviors. The presentation of live fish increased the variety and frequency of feeding behaviors, while presentation of horse leg bones increased the frequency of these behaviors. Fish reduced the tigers' stereotypic behavior from 60% of scans to 30% of scans on the day of presentation, and this change was maintained for 2 days following enrichment. Bone presentation also reduced stereotypic behavior and increased nonstereotypic activity in both species. Both of these techniques appear to have sustained effects on behavior lasting at least 2 days after presentation, which may indicate their ability to alter the animals' underlying activity patterns (Bashaw et al, 2003).

The stereotyped pacing shown by the two Amur tigers in the Zurich Zoo was hypothesized as being caused by permanently frustrated appetitive foraging behavior. Several electrically controlled feeding boxes were installed and access to each box was possible only twice a day for 15 min at semi-random times. The boxes had to be opened actively by the tigers. Two trials were carried out: one with solitary confinement, and one with paired confinement. During box feeding, the female's stereotyped pacing was significantly reduced from 16% (solitary confinement, conventional feeding) and 7% (paired confinement, conventional feeding) to 1% (solitary confinement) and less than 0.01% (paired confinement) of the daily observed time. The female's sleeping increased significantly in both solitary and paired confinement. The male only showed a significant reduction in stereotyped pacing behavior when kept with the female (conventional feeding: 10%; box feeding: o0.01% of the daily observed time). On days with a boxfeeding regime in paired confinement, the male spent 25% (83 min) of the observed time with active behavior at the feeding boxes. The results support the hypothesis that permanently frustrated appetitive foraging behavior causes stereotyped pacing in adult tigers (Jenny and Schmid, 2002).

Providing bones and live fish successfully elicited behavioral changes in captive lions and tigers. Consumptive behaviors increased with bone provision, and live fish presentation elicited capturing, killing, consumptive, and caching behaviors on the morning of presentation. There was also a nonsignificant trend toward reduced pacing with both fish and bone presentations, and a trend toward an increase in nonstereotypic activity with bone presentation. Although these findings did not reach statistical significance, changes were as much as 50% from baseline values. The trend toward an increase in time spent visible to zoo visitors with bone presentation may be large enough to have practical significance for the visitor experience. The enriched conditions had a few long-term effects, including a significant effect on resting in lions when they were given bones. Nonsignificant long-term trends were also present in stereotypic behavior (for both species and both conditions), in visibility (for both species and both conditions), in activity (for both species in the bone condition), and in consumption (for lions in the bone condition) (Bashaw et al, 2003).

These effects corroborate and extend the results of several other enrichment procedures evaluated on felids. First, they emphasize that although they spend much of their time sleeping or engaged in stereotypic behavior, big cats do benefit from enrichment opportunities. Two advantages of these techniques are their small demand on keeper time and the lack of a mechanical apparatus, which obviates the need for repairs or maintenance by keepers on a tight schedule. The presentation of bones and fish in this experiment also allowed the appetitive behaviors expressed to be rewarded with feeding opportunities. The increase in appetitive behaviors over those observed in baseline indicates that our enrichment procedures provided the cats with an opportunity to successfully express appetitive behaviors. The presentation of live fish was the more effective of the two techniques at increasing the variety of appetitive behaviors performed. These empirical data on the response of tigers to live fish, suggest that the presentation of live fish should be evaluated in a larger population to increase the generalizability of the results (Bashaw et al, 2003).

This study provides an example of the importance of evaluating the long-term effects of enrichment. In addition to studying the reaction of an animal to the enrichment procedure or device when it is present, evaluation of behavioral changes that occur in the animals' overall activity budgets is also important. In this study, the increase in feeding behaviors constitutes a reaction to the physical addition of the enrichment, but the changes in stereotypic behavior, used in part to monitor welfare, were not limited to periods in which the enrichment was present. Without evaluation at times when enrichment is not present, it is impossible to distinguish between procedures that cause a temporary behavior change only while they are present and those that cause sustained change outside the time at which enrichment is present. In the current study, bone provision is an example of a more sustained and generalized enrichment effect, as the resulting changes in resting and trends in stereotypic pacing, nonstereotypic activity, consumption, and visibility over the 3-day period of observation suggest that bone provision altered the underlying behavior pattern of the cats (Bashaw et al, 2003).

Enrichment in zoos must strike a balance between the optimal living conditions of the animals and the quality of the visitor experience. The effect of enrichment projects must therefore be evaluated on both of these scales. Stereotypic behavior and inactivity may indicate compromised animal well-being and produce a compromised visitor viewing experience. The decrease in stereotypic behavior and the trend toward increased nonstereotypic activity in our study should affect both sides of this balance. It has been suggested that stereotypies arise in environments that do not allow the performance of a highly motivated behavior pattern to reach its endpoint. If stereotypies result from a lack of connection between an animal's behavior and its environment, it is not surprising that creating an environment in which the reward of eating is contingent upon hunting behavior (as in nature) reduces the performance of these stereotypies (Bashaw et al, 2003).

The increase in variety and occurrence of appetitive behaviors with the presentation of fish, and the increase in frequency of appetitive behaviors with the presentation of bones are also positive changes for the animals' well-being. Many of the Lion and Tiger Feeding Enrichment anecdotal accounts of carnivore enrichment have highlighted the feeding of whole- or partial-carcass meat. The physiological consequences of feeding only processed meat diets include reduced influence of the jaw and neck muscles on skull shape in development, greater gingival health problems, greater plaque formation, and more focal palatine erosion. All of these problems are alleviated by carcass feeding opportunities. Carcass feeding has been demonstrated to increase feeding behaviors and decrease stereotypic behaviour, increase approaching, feeding, exploring, and processing food, and increase feeding duration and produce a wider variety of feeding behaviors. Considering the similarity of these behavioral results to those obtained with bone presentation in this study, bones may function as a simplified and convenient form of carcass feeding (Bashaw et al, 2003).

The time the animals spent in areas visible to zoo visitors in this study may have increased because the on-exhibit manipulations all rewarded the cats for going to the area of their exhibit where they were most easily seen. In fact, the intermittent nature of the presence of the stimuli may have resulted in a greater increase in visibility than continuous reinforcment for being in the same area would have. That the trend toward increased visibility was present even with bone presentation is especially interesting, since the bones were not restricted to visible areas of the exhibit. The cats could easily have picked up the bones and moved them to a different resting place, but anecdotal observation suggests that the animals spent most of their day where the enrichment was placed (Bashaw et al, 2003).

The results of this study support prior investigations into the role of feeding enrichment in improving the psychological well-being of animals and the visitor viewing experience. Carnivores in zoos should continue to be provided with their food in ways that allow the successful expression of a variety of appetitive behaviors to promote more naturalistic behavior. This naturalistic behavior will help educate the public about how these animals interact with their environment in the wild, thereby promoting conservation of not only the animals, but also their habitat. In addition, maintaining a more complete behavioral repertoire is a contribution to preserving behaviorally competent animals in zoos, in case these animals should be needed to reinforce the wild population (Bashaw et al, 2003).

Appendix 5 – Chemical restraint

Tiletamine–zolazepam and ketamine (alone or in combination with other drugs) have successfully immobilized some large exotic felids but have been associated with complications when used in tigers. Medetomidine, a potent and specific alpha-2 adrenergic agonist, has been used in carnivores in place of xylazine, and medetomidine–ketamine combinations provide general anesthesia for minor procedures and surgery in a variety of domestic and nondomestic species. There is a limited amount of information available on the effects of this combination in tigers but six adult female tigers (*Panthera tigris*) were anesthetized repeatedly for elective medical procedures using 3 mg medetomidine and 200 mg ketamine i.m. Inductions were rapid and smooth, although supplemental ketamine was needed for safe transport after induction in 6 of 17 procedures. Reversal of the medetomidine-induced sedation with 15 mg atipamezole i.m. 59–232 min after induction resulted in smooth, rapid recoveries (Miller et al, 2003).

Two α2-adrenoceptor agents, xylazine and medetomidine, in combination with midazolam and ketamine safely and effectively immobilized Siberian tigers (*Panthera tigris altaica*). The medetomidine protocol used smaller drug volumes, and induction and recovery times were shorter. Although cardiopulmonary abnormalities were noted, none were likely to be life threatening (Curro et al, 2004).

Appendix 6 - Hemobartonellosis

This first documentation of *H. felis* in captive nondomestic cats suggests that uncomplicated *H. felis* infection is rare and is associated with little or no clinical disease. Of the 13 mildly anemic animals, two were positive for *H. felis*, and each of these was positive in only one of the three samples. Thus, there may be an association between chronic *H. felis* infection and mild anemia in nondomestic cats. The mode of transmission of hemobartonellosis in nondomestic cats is still obscure. The two young infected sibling females may have acquired the infection from their mother. Animals housed with these positive animals tested negative repeatedly, so there was no evidence for horizontal transmission.The absence of the parasites in blood smears from the two infected females underscores the sporadic occurrence of *H. felis* organisms in circulation, and PCR appears to be more sensitive than blood smear examination in detecting infection. The two negative samples obtained from each of the positive animals suggest that organisms may be intermittently sequestered or present at levels below detectability by PCR (Haefner et al, 2003).

Clinical signs of hemobartonellosis have not been described previously in nondomestic cats. Clinical disease in nondomestics may be underreported, or nondomestic cats may be more resistant to disease than domestic cats. It is not clear if nondomestic cats with *H. felis* need treatment. Further study of the extent and significance of this infection in North American felids is needed (Haefner Et al, 2003).

An adult, captive-born Sumatran tiger (*Panthera tigris sumatrae*) had been ataxic for approximately 3 months and had been self-mutilating after an acute onset of unilateral paresis and Horner's syndrome. Histologic lesions in the cervical spinal cord were consistent with fibrocartilaginous embolic myelopathy (FCEM), and they included the presence of cartilaginous occlusion of spinal blood vessels. This is the first reported case of FCEM in a large felid and specifically a Sumatran tiger, (Adaska and Lynch, 2004).

Appendix 7 - Toxoplasmosis

Toxoplasmosis has been reported in one captive Siberian tiger (*Panthera tigris altaica*) in Belgium and two captive lions (*Panthera leo*) in Nigeria.17 The tiger, which died of systemic toxoplasmosis, had diarrhea, and oocysts were identified by bioassay in mice. *Toxoplasma gondii*-like oocysts were seen in the feces of both Nigerian lions, and diagnoses were confirmed by necropsy and histopathology. Oocysts resembling *T. gondii* were reported in a jaguar (*Panthera onca*) in Belize, but their identity was not confirmed by bioassay. It appears, therefore, that some of the species we surveyed can shed *T. gondii* oocysts (Silva et al, 2001).

Toxoplasma gondii has both public health and clinical significance in captive cats. Both domestic and nondomestic cats can excrete environmentally resistant oocysts. Although cats can become infected by ingesting sporulated oocysts from the environment or *T. gondii*-infected animal tissues or transplacentally by passage of tachyzoites from a dam to the fetus, the ingestion of infected tissue is the most efficient means of transmission of *T. gondii*, at least in experimentally infected cats.2,6,10 Domestic cats fed as few as one bradyzoite can shed millions of *T. gondii* oocysts, whereas 100 or more oocysts may be needed to infect a cat. Therefore, fecal contamination is not considered an important mode of transmission of *T. gondii* in the definitive host (cat), whereas one oocyst can infect a pig or a mouse (intermediate host) (Silva et al, 2001).

Thus, *T. gondii* is biologically adapted in felids to be transmitted more efficiently by carnivorism (cat–mouse cycle) than by fecal contamination. There are no epidemiologic data on acquisition of *T. gondii* infection by captive cats in zoos. Laboratory data indicate that heating meat until the internal temperature reaches 66^{0}C or freezing meat to -12^{0}C overnight kills *T. gondii* tissue cysts. Among food animals, *T. gondii* is less prevalent in beef than in other animals. Therefore, feeding frozen beef to cats is likely to reduce *T. gondii* infection in the zoo environment (Silva et al, 2001).

Appendix 8 – Masticatory peculiarities

The skull can be a highly informative component in the reconstruction of a felid's behavioral history. Osteopathologies in the heads of larger zoo cats in particular can apprise the observant anatomist of events that otherwise might pass unrecorded during an individual's life in captivity. While assessing pathological conditions in the skulls of wild and captive felids as part of a paleopathology research project, one particularly unusual structure recurred sufficiently to warrant more detailed examination. Noticeably abnormal formations appeared in the posterior sagittal crest, an area of complex muscle attachment (G.L. Duckler, 1998).

Examination of pathologies in a series of felid skulls from a museum collection spanning the past century revealed distinctively malformed external occipital protuberances in zoo specimens of *Panthera tigris*, a condition that was not present in the skulls of wild-caught individuals. Myological studies and comparative dissections together support a conclusion that the condition most likely arose from heightened rotation of the head and neck in the lateral plane, combined with reduced jaw activities during the lives of the affected individuals. Historical records in turn indicate that such activities were possibly consequences of the nonnatural diets and increased grooming behaviors fostered in captive environments (G.L. Duckler, 1998).

Appendix 9 – Influence of visitors on animal behaviour

Visitors have been variously characterized as being enriching for zoo animals, as being stressors, and generally as influencing behavior in measurable ways. Most studies have focused on primates, and have assumed a ‘‘visitor effect’’ paradigm (i.e., visitors influence animal behavior). Here we present findings from a study of a nonprimate group (felids), and examine the ‘‘visitor attraction’’ model, which assumes that visitors are attracted to active animals. We assessed visitor interest and number at seven cat exhibits at the Brookfield Zoo during the spring and summer of 2002. Data were collected during 1-min scans of each exhibit at 10-min intervals. The results indicate that visitor presence per se did not influence cat activity, and that visitor interest was generally greater when cats were active. Various species differences may be explained by visitor familiarity with the species, variations in exhibit design, and species-specific activity budgets. We conclude that the visitor attraction model may be more appropriate for taxa, such as large cats, that tend naturally to be largely inactive and to respond little (if at all) to visitor disturbances or efforts to engage. The relationship must be viewed as bidirectional: visitors influence animal behavior, and animal behavior influences visitor interest. However, the strength and primary direction of this relationship is likely taxon-specific. We suggest that a visitor attraction model may be more appropriate not only for felids, but for other taxa with similar behavioral patterns and responses as well (Margulis et al, 2003).

Appendix 10 – Social system

While some signals and advertisements serve to bring tigers together, others serve to maintain spatial separation and to indicate occupancy of space. The pattern of space used by tigers has not, however, been extensively studied. The general impression is that the tiger's land tenure system is flexible and varies with environmental circumstances (M and F Sunquist, 2002).

Within this social system, both male and female tigers communicate via a combination of scent marks, visual signals, and vocalisations. Of these communication signals, scent marks are probably the most important. Scent is deposited as an odorous musky liquid known as 'marking fluid', which cubs apparently do not produce. Marking fluid, which is often mixed with urine, is sprayed backward onto upright objects from a standing position, resulting in an enhanced odour field. Scent may also be deposited on the feces from the anal glands, the secretions of which are chemically superior to marking fluid. Tigers also rub the head and cheeks on objects that they have sprayed, possibly as a way to enhance their own 'odour field.' Visual signals include spots that have been sprayed; scrapes, which the animal makes by raking the ground with its hind feet; claw marks; and faeces left in conspicuous places (M and F Sunquist, 2002).

No one knows what these marks and signs convey to another animal, but there is evidence that the information includes individual identity, sex, reproductive condition, and the time the mark was made (M and F Sunquist, 2002).

Tigers also communicate by vocalising. Some of those vocalisations are capable of travelling long distances through dense vegetation, others are used at close quarters to exchange information during face-to-face encounters. These vocalisations may be modified by varying the intensity, duration, and rate of emission. Overall, the tiger's vocal repertoire is as varied as that as a social lion (M and F Sunquist, 2002).

Appendix 11 - Enrichment

Felines are clearly responsive to behavioral enrichment opportunities. The apparatus tested in the pilot project met most of the requirements for enrichment apparatus. Although accomplished on a limited budget with less than ideal equipment, the project provided information that will be of use in building more acceptable apparatus. Several key features of enrichment apparatus for small felines have been identified (Markowitz and LaForse, 1987).

(1) Novelty. Prey/play objects should be removed from the cats' view when they are not in use.
(2) Control. The accessibility of the prey objects should be contingent upon the cats' behavior.
(3) Motion. Artificial prey should be animated. The serval was instantly attracted by the motion of the artificial prey in the tube. Stationary prey were ignored.
(4) Food. Attention should be paid to effects of feeding schedules. The serval continued to hunt in the presence of free food, but hunted more actively when the only food available was that associated with the apparatus.
(5) Sound. Where possible, acoustic stimuli should be included. The sound of potential prey had a significant effect in maintaining the cats' interest in the hunting apparatus.

Appendix 12 – Natural reproduction

Practical reliable methods for monitoring gonadal status are essential for assessing the reproductive potential of individuals animals and for developing and using assisted reproductive technologies when natural breeding fails. Despite a long history in captivity, a significant challenge continues to be determining how to house these generally secretive animals in environments that allow them to thrive and at the same time satisfy the public's viewing needs. In relatively naturalistic enclosures, reproduction in captive felids remains poor, except in most *Panthera* species. Part of the problem is our poor understanding of the basic biology of the taxon as a whole, especially reproductive physiology. A review of felid reproduction revealed that the duration of the oestrus cycle (the most basic female reproductive trait) was known for only 16 of 36 non-domestic felid species. There is a growing need to avoid removal of endangered animals from the wild to supplement captive populations, and it has become more important to develop breeding strategies that sustain *ex situ* populationsrown. As hormones are the essence of reproduction, understanding the factors that influence endocrine function is key to maximizing reproductive success (J.L.Brown et al, 2001).

Early reports describe oestrus cycle dynamics in a few wild felid species using repeated anesthesia and blood sampling. These studies raised awareness of the diversity in reproductive characteristics and hormonal patterns within the Felidae, but were limited by infrequent or short-duration blood collection protocols. Advantages of non-invasive faecal or urinary steroid metabolite analyses for assessing reproductive function are well recognized, and have eliminated the need for anesthesia or restraint during serial sampling. Results also provide a more accurate average or 'pooled' value of hormonal activity, as metabolites are excreted over a period of hours. Small fluctuations in hormone concentrations are dampened; thus, the ability to distinguish between normal secretory dynamics and genuine physiological responses is improved. The decision to measure faecal or urinary hormones is determined by which sample is the easiest to collect, process and analyze. However, in felids, urinary analyses of reproductive steroids are not an option because steroids are excreted almost exclusively in faeces (J.L.Brown et al, 2001).

The advantages of non-invasive faecal hormone monitoring (that is, the ease of sample collection, the ability to conduct long term studies, demonstration that excretory patterns clearly reflect physiological function) give this technique enormous utility. The primary goal is to have clearly defined normative data for all Felidae, ranging from the onset of puberty to reproductive senescence. The identification of the type of ovulation (induced versus spontaneous) and the impact of season on each species are high priorities. Undoubtedly, the most practical advantage of this technology for the future of felids is improved management strategies. The ability to assess reproductive easily and safely will allow the identification and mitigation of reproductive problems, whether the cause is physiological or environmentally induced. Long-term evaluation of adrenal activity in the context of changing exhibit traits and management actions should eventually allow the identification of the optimal captive environment compatible with animal welfare needs and maximum reproductive potential. Lastly, knowledge of how reproductive and adrenal traits of free-ranging felids in natural habitats compared with those of the captive felids could have a tremendous impact on our ability to manage these species in zoos effectively (J.L.Brown et al, 2001).

Appendix 13 – Artificial reproduction

Since the birth of the first litters of kittens after transfer of IVF-derived embryos in 1988,considerable progress has been made in further development of ART in domestic cats. These advances have enabled investigators to begin using similar techniques in selected species of wild cats As a potential means of enhancing propagation rate and maintaining genetic viability. Most wild cat Species do reproduce in captivity, but behavioural or genetic incompatibilities frequently occur. The application of IVF/ET and AI, in conjunction with gamete and embryo cryostorage will allow for more effective breeding management of captive populations of some species. With further development, exchange of gametes or embryos, between animals in captivity and in the wild should be possible, permitting incorporation of previously unavailable genetic material (Pope, 2000).

The response to the induction of ovulation through exogenous hormone administration has been considered a limiting factor for the systematic use of assisted reproduction programs for wildlife species. The female Siberian tiger (*Panthera tigris altaica*) has responded positively to equine chorionic gonadotropin (eCG) but not to follicle-stimulating hormone The combination of eCG/human chorionic gonadotropin (hCG) stimulated Siberian tiger ovulation, although responses varied among individuals (Silva et al, 2000).

Anesthesia seems to interfere with ovulation in the gorilla (*Gorilla gorilla*) and the domestic cat (*Felis catus*). Additionally, the anesthesia event itself may inhibit semen from reaching the site of fertilization, which may be due to reduced contractility of the myometrium in the domestic cat and the Siberian tiger. The cervical barrier has been bypassed by laparoscopic intrauterine AI to produce a healthy male Siberian tiger cub after 111 days of gestation.3 Similar results have been reported in the puma (*Felis concolor*), domestic cat, cheetah (*Acinonyx jubatus*), clouded leopard (*Neofelis nebulosa*), and ocelot (*Felis pardalis*). The current study reports the birth of three Siberian tiger cubs after transvaginal AI with diluted fresh semen in a female treated with eCG/hCG (Silva et al, 2000).

Appendix 14 – MGA implant

The most significant problem reported with its use was implant loss, due to infection, social grooming, and intramuscular migration (approx 6%). The loss rate can be reduced by gas sterilization of the implant, preferably with ethylene oxide, followed by degassing for 1 week, and strict adherence to sterile procedures during implant insertion. Identification microchip transponders can be placed in implants prior to their insertion in the animals to facilitate confirmation that the implant is in place or location in the event it migrates (Ed. Kleiman et al, 1996).

Concerns regarding the long term safety of MGA in felids were supported by a retrospective study. Histological examination of reproductive tracts revealed an association between MGA use and uterine pathology. It is hoped that further analysis can determine the importance of variables such as species, length of use, and age during use. Meanwhile if used, it is recommended that MGA treatment be interrupted periodically to give the uterus time for recuperation and that permanent surgical sterilization be considered (Ed. Kleiman et al, 1996).

Appendix 15 – Milk preparation, feeding and hygiene

MILK PREPARATION

- Milk formula must always be made according to the manufacturers directions.
- Cooled boiled water will be used to mix with the milk powder
- After each feed, boiled water is to be obtained from the Asian Division office and stored in containers
- Prior to feeding, the milk formula must be heated to approximately 38 ^{o}C and tested on the wrist to make sure that milk is not too hot.
- Heating can be done in a microwave oven or by standing the bottle/s in hot water
- Each cub must be fed from a separate bottle/teat
- Milk formula must be made up fresh daily and refrigerated.
- Discard any remaining milk after 24 hours.
- Once heated, all left over milk should be discarded if not consumed during feeding.

BOTTLE/ TEAT PREPARATION AND CARE

- **After feeding, bottles and teats should be disassembled, emptied and rinsed with water**
- **Bottles/teats must be washed in dishwashing detergent in warm water prior to sterilising to remove the fatty deposits left by the milk.**
- Use bottle brush to clean bottles and teats thoroughly. Salt can be used to remove further fatty build up on teats (pers comm C. Shemwell).
- Bottles/teats should be rinsed with clean water before placing in Milton solution
- All teats, bottles and measuring equipment should be sterilised between each feed
- Use Milton sterilising agent according to label and replace the solution every 24 hours. Correct dilution for Milton liquid is 25 mls per 2 L of water
- All bottles/teats and equipment must be thoroughly submerged in Milton solution so that no bubbles remain inside bottles etc.
- Rubber teats tend to perish in some solutions so keep a fresh supply or only soak for the minimum recommended time – 60 minutes in Milton solution.
- Bottles/teats do not need to be rinsed with water prior to use after sterilisation.
- Handling of teats once sterilised should be kept to a minimum to prevent contamination.
- Teat holes should be small enough so that milk does not drip from them once bottle is inverted.
- Teats must be securely fastened to bottles to prevent cubs from pulling teat off and ingesting the teat.

FEEDING METHOD

Any young under the age of 8 - 10 weeks will need to be bottle fed until they can be introduced to solid food. A human baby bottle will be needed (pers comm C. Shemwell) with a suitable teat alternatively a small animal bottle and puppy teat (supplied by Biolac) can be used. Initially a human baby teat and bottle and puppy teat with small animal bottle should be offered so that the cubs are encouraged to select the preferred choice. Once the cubs have accepted a type of teat, the teat type cannot be changed. A hole should be placed in the teat so as to allow a slow flow of milk to the young.

Cubs should always be fed with the head in an upright or elevated position (Marples 1985, Hawcroft 1992). The milk should warmed to body temperature before feeding (Taylor 1990, Hawcroft 1992) and should only be placed in a clean or sterile bottle with teat to prevent infection. All young should be fed from separate bottle/teats also. The teat should be gently inserted into the mouth and a small amount of milk should be expressed to stimulate suckling (Hawcroft 1992). If the young fail to accept the bottle, they can be tube fed (Hawcroft 1992) until such a time as they start to suckle, but all efforts should first be made to accustom the animal to the teat. A data sheet with the amounts to be fed per cub per weight should be made, all amounts offered and taken must be recorded for each cub on the individual data sheets so that accurate records are on hand at all times.

To ensure that the milk is not too hot, feel on the wrist prior to feeding. Only mix milk powder with pre-boiled, cooled water, then warm up to correct temperature (eg. by sitting bottle in a jug of boiled water). Milk needs to be made up fresh daily (Ginman, 2001).

TOILETING

- Gently but firmly rub dampened cloth/cotton wool over genitals in upward motion.
- Male cubs will need the penis and anus regions to be stimulated separately for best results.
- Continue to stimulate until cub has urinated/defaecated
- Use a separate clean cloth for each cub and change cloth once soiled
- Soiled bedding must be replaced immediately
- Soiled cloths must be rinsed thoroughly and soaked in Napisan solution
- Follow Napisan manufacturers directions when making up solution
- Napisan solution must be changed daily after each use.
- Soiled cotton wool must be placed in garbage bin
- Keeper is to wash hands with Hibiclens between toileting each cub
- Cloths soaked in Napisan must be rinsed, spin dryed and put in dryer prior to reuse.
- If cubs develop an irritation (inflammation) on genital region during stimulation, use cotton wool to toilet and report to veterinarians

After each milk feed, cubs fur/mouth must be gently wiped with a clean cloth to remove any milk – a separate cloth must be used for each cub – soiled cloths must be placed in Napisan solution (Ginman, 2001).

Appendix 16 – Tiger reintroduction

Most remaining populations of wild tigers are small, and much of their habitat is fragmented. In such small populations, inbreeding and the consequent reduction in heterozygosity may expose the effects of deleterious alleles, thus generating the 'extinction vortex' – a positive feedback loop between the size of the population and the average fitness of its members. No mammalian species has yet been shown to be unaffected by inbreeding, and supplementation of the gene pool in small populations of wild tigers may therefore be desirable in the future. It may also be necessary to replace tigers in areas from which they have disappeared altogether as a result of the extinction vortex or other factors. Long-term, holistic tiger conservation strategies should include options capable of addressing these aspects of the problem (Ed J. Seidensticker et al, 1999).

In any future scenario where supplementation or reintroduction is deemed desirable, three options are available: translocation, release of captive-born animals, and genetic supplementation through artificial reproductive techniques. The last of these could in theory, when fully developed, be used to replace either of the first two options in cases of supplementation; but it is beyond the scope of this short discussion which considers the relative suitability of wild and zoo bred tigers for release. Reintroduction is now accepted as a conservation tool, provided that it is carried out in accordance with the IUCN Guidelines for reintroductions. Preconditions such as control of the causes of decline, availability of sufficient suitable habitat and food, a commitment to long-term post-release studies and many more must first be met. In the case of the tiger such conditions are as yet far from fulfilled, and it is argued here only that tiger reintroduction is feasible in the right circumstances, not that it should be attempted in the near future. For reintroduction of large carnivores such as the tiger, the possibility of adverse reactions from local people must be given special attention; accusations that conservationists put wildlife before people can do immense damage (Ed J. Seidensticker et al, 1999).

Genetically, there may be little advantage in choosing either wild or captive tigers for such a project. In behavioural terms, it is often argued that zoo-bred animals would be incapable of learning how to survive in the wild, and that translocated wild tigers would be more suitable (Ed J. Seidensticker et al, 1999).

Recent work has shown that captive-born large carnivores can learn to adapt. Basic hunting behaviour is essentially instinctive. There is little doubt that zoo-born tigers could learn to hunt, though it is acknowledged that the finer points – such as appropriate resource use inside the home rang – may be usefully learned from a wild mother (Ed J. Seidensticker et al, 1999).

Captive-born large carnivores have been used, for example, in red wolf, European lynx and European wolf reintroduction projects; and in a feasibility study for reintroduction of the Florida panther. Between 1993 and 1995, 19 mountain lions of varied origin were released in northern Florida. Ten of these were wild-caught nad relesed within three months of capture, three were wild-caught and held in captivity for some years prior to release, and the remaining six were captive bred. The cats caught deer within a week of release and successfully hunted throughout their time in the wild. Seven of the nine captive-bred or captive-held cats settled within two months as opposed to only three of the ten wild-caught animals. The captive-bred animals settled closer to the release site, and all of them settled in a social system while only two of the wild-caught specimens did so. They also showed significantly lower mortality and higher breeding success – three of the six captive origin cats were known to have bred at the time of writing. While there was only inconclusive evidence of breeding for three of the ten wild-caught animals. The disadvantage of captive-born mountain lion was, predictably, that they were significantly more likely to be involved in lion-human conflicts (Ed J. Seidensticker et al, 1999).

Based on these observations, captive-born large cats might in fact be better candidates for reintroduction than those from the wild-provided it were possible to overcome the familiarity with humans, and the concomitant problem of negative perceptions on the part of the local people. One way to achieve this with tigers would be to use not zoo-bred tigers themselves but their offspring, born in large natural enclosures deep in suitable habitat pairs of zoo tigers would be allowed to breed in such enclosures, with live prey of appropriate species supplied and sight and sound of humans kept to an absolute minimum. The cubs would reach dispersal age relatively unaccustomed to humans and knowing what and how to kill. At this stage, the parents would be removed and the juveniles radiocollared and given veterinary check-ups prior to release. In order to ensure that released tigers completely avoid human habitation, negative reinforcement might be advisable, and two options are touched on below. Released tigers would be closely monitored and any that did cause problems with humans would be immediately removed (Ed J. Seidensticker et al, 1999).

Aversive conditioning of large carnivores has been attempted through both conditioned taste aversion and electric shock.

Conditioned taste aversion, the inhibition of food consumption by association of illness with taste, is a well documented behavioural phenomenon but is sensitive to variations in methodology, which have tended to confound field testing. Forthman *et al* list several factors which must be controlled, of which the most important is that illness-inducing substance (lithium chloride) should be undetectable by taste or odour. The objective is an aversion to the food item (here, domestic livestock), and if the additive can be detected the animal will simply avoid that substance in the future while continuing to consume the untreated item. Intensity of illness is also important but the desirable effects of high dosages are reduced if they also induce vomiting; delivery in cellulose-acetate-coated capsules, which dissolve only on reaching the duodenum, can eliminate both taste and vomiting (Ed J. Seidensticker et al, 1999).

Peripheral stimuli such as noise and electric shock inhibit not consumption but approach behaviour. Remote-control shock collars are used in police dog training, and collars triggered by crossing underground wires confine domestic dogs to their owners' property in the U.S. Few applications of this technique to wild carnivores are on record, but one wolf reintroduction project in Georgia, Europe, reported some success. Shocks were administered to the wolves at the sight or scent of humans or domestic livestock and Badridze reports that avoidance behaviour begun to appear on the fifth or sixth day and was established after 20 days (Ed J. Seidensticker et al, 1999).

Badridze's approach also had the virtue of involving local people in the project. There was considerable hostility to begin with, and two project wolves were shot in their enclosures. By using local people as volunteers in the avoidance training, the researchers demonstrated that wolves were not in fact the ravening beasts of popular myth; attitudes were completely changed and some volunteers continued to assist in monitoring the released wolves for several years. Though tigers have killed humans while wolf damage is limited to livestock, the key point is that villagers' perception of wolves as being more vicious and dangerous than they are was successfully altered, which provides welcome encouragement for large predator conservation in general (Ed J. Seidensticker et al, 1999).