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Modern Naturalistic Enclosures: Comparatively an Enhanced Management Practice of Captive Felids in the Zoological Park

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ABSTRACT

Due to the expansion of human population, threat for existence of all wild animals is gradually increasing. They are driven to exist in smaller areas and in the worst case scenario extinction. Zoos are being encouraged to improve the animal's physical and social surroundings. In this study, the modern naturalistic enrichment introduced to large felids tiger, lion and leopard at Gandhi Zoological Park, Gwalior, Madhya Pradesh, was studied. The study has envisaged evaluating if the modern naturalistic enclosures could increase activity levels and how the felids opted to these enclosure. The enclosures were divided into menageries and natural enrichment, which had a varying degree of opportunities for the animals to climb, hide and rest above ground level. The environmental enrichment effects on the proportion of time spent engaging in active behaviors and stereotypic pacing in the large felids were compared and recorded using instantaneous scan sampling. The results of this study revealed clearly that large felids kept in more natural and complex enclosures performed less stereotypic pacing (unnatural behavior), and more exploratory (natural) behaviour than those housed in less natural enclosures reducing the stress level in captive tigers will enhance the animals' overall physical and psychological well being, which will in turn increase the success of captive breeding programs. Furthermore, these results suggest that captive tigers should be housed in large enclosures containing natural substrate and vegetation, water pools, ample shade, a variety of resting locations and enrichment items.

Keywords: Naturalistic Enclosures, zoological park, captive tiger, leopard

Humans maintain wild animals in zoological parks for the purposes of education, conservation, research, and recreation. However, abnormal behaviors may develop in animals where the captive, human-made environment is not suitable for them to carry out their natural or instinctive behaviors (Carlstead, 1996). Felids generally have extensive natural home ranges in the wild and carry out "hide, stalk and chase" hunting behaviors. The captive environments of most zoological parks do not, and cannot, provide for these behaviors due to spatial constraints and negative human reactions to predatory behaviors (Mellen *et al.,* 1998). In the past 30 years, a number of zoological parks have implemented major changes in the management of felids to enhance their lives (Law *et al*., 1997). However, enrichment plans for felids are notoriously difficult to develop due to their natural hunting behaviors and spatial requirements. Further research on the effects of enrichment on felid well being is needed (Mellen *et al*., 1998).

Zoological parks depend on the expression of "normal" behaviors by the animals displayed to successfully achieve their goals (Baldwin, 1991). In captivity, these "normal" behaviors are often replaced by abnormal, or "stereotypic" behaviors such as pacing (Carlstead, 1996) which stressed need of human-animal-environment relationship.

A sense of imbalance in the conservation programmes has been accompanied by a rapid and continued application of current biological science to the problems of genetic and demographic management of captive felids. Large felids were chosen as the research animals in this study for

two reasons. First, within the human-animal-environment literature available on felids, almost none was focused specifically on large felids. Second, through personal observations of these species performing stereotypic behaviors in captivity, we have observed that this project could provide specific recommendations for enriching and managing captive tigers. Further study on the effect of enclosures, husbandry and other aspects in our conditions on these large felids well being is needed. In this approach technology and knowledge from felid studies are combined to make the naturalistic environment with four objectives viz displaying of the "natural" habitat of the species; encouragement of breeding; offering settings for research that are approximate to the wild and providing information from researchers who have the time to systematically observe behavior.

MATERIALS AND METHODS

Study area

The Gandhi Zoological Park, Gwalior was chosen to conduct the captive management study on tiger, lion and leopards. The fieldwork in the present study was conducted during summer (June and August) and winter (November and January) 2004-06. The summer season presents two extra stressors on captive animals high temperatures and high visitation rates that makes it an ideal time to conduct this study. Data on large felids were collected with the help of records available in the zoo and by regular observations. Information regarding staffing pattern of the zoological park with reference to animal keepers, animal attendants and other persons in the captive management of large felids was also recorded.

Study animals

Documentation of data on the origin, age, sex, colour and type of the each tiger, lion and leopard was collected from the records maintained at the zoo.

Exhibit study

Old obsolete cages (Menagerie)

The old obsolete cages (menagerie) of tiger, lion and leopard were studied with their structural dimensions, abiotic and biotic variables. The layout of old cages for tiger, lion and leopard were sketched with internal and surrounding features.

Captive tigers in old obsolete cages

Tigers were kept in very old cages made of stone blocks with the flooring and roofing of stone slabs supported by the huge pillars. The cage measures 8.22m. × 5.66m × 3.36m height with a total covered area of 46.52 m^2, with big six iron bar windows of 1.53m × 2.13m, 1.53m × 1.22m and 1.22m × 1.06m for ventilation and public viewing while two sliding gates of 0.61m × 0.91m were provided for daily activities. A shift cage of 2.59 m × 5.66 m size had a big window and a vertical sliding gate. The visitor's side had a water tank 1.51m × 1.23m with the depth of 0.37m and railing at a distance of 1.21m. The cage was devoid of mud, grass, logs, direct sunlight and open air. The cages were washed daily with broom and water hose. Zoo previously had an open enclosure with iron bars as barrier and housing. The moat was used to exhibit the buffalo kill by the tiger to the royal guests of Gwalior ruler. Later Central Zoo Authority disqualified this enclosure for display on technical grounds and then it was renovated to an open naturalistic enclosure for tiger. The staffing pattern of animal keepers, animal attendants and other persons involved in the captive management of large felids is presented in Table 1.

Table 1: Staff Pattern at Zoo

Sl. No.	Employee's Name	Number of Employees
1	Dy. Commissioner (In-charge)	1
2	Wildlife Veterinary Officer	1
3	Zoo officer (Curator)	1
4	Asstt. Zoo Keeper	1
	For Large Felids	
1	Animal Keeper & Assistant Keeper	For enclosures of Tiger, Lion, Himalayan Black Bear
2	Animal Keeper & Assistant Keeper	For enclosures of Leopard, Rhesus, Macaque, Bonnet, Macaque, Chinkara, Four Horned Antelope, Neel Gai & Hiran Van

Captive lion in old obsolete cages

It was a menagerie 6.57 × 5.66 m^2 fully covered. Flooring and roof of stone slabs at 3.36 m height was supported by 03 huge pillars. It had 02 gates with 0.61 × 0.91m^2 of iron bars for husbandry needs and five big windows of 1.52 × 2.13 m^2 for ventilation, and facilitating the public to view these felids. A small shifting cage of 3.14 × 2.66 m^2 sizes was attached to the main cage at one end by iron sliding gate for day-to-day operations. The other end of the shift cage had a small old capture cage of iron bars measuring 2.61 × 1.06 m^2 for close observations and some restrainment. Partial sunlight was available in the cages by these windows for very few hours. The walls of the cage were irregular, rough and absorbent to urine squirts and floor washings. The floor was of stone slabs with rough, uneven surfaces and improper joints that accumulated dirt, traces of urine, feces and floor washings. The exhibit cage and the shifting cage were cleaned and washed by water in the morning.

Captive leopard in old obsolete cages

These felids were kept in small old exhibit cage with stonewalls on three sides and iron bars grill on the visitor's side. This iron grill had a hinged gate of 0.58 × 0.89 m^2 for day-to-day keepers work and railing at 1.21m from it. The size of the cage was variably 2.43 × 5.66 × 3.36 m^3. A small drinking water trough made of stone was kept at the front of left corner. The roof and flooring was of stone slabs. The rear side of the cage had a vertical sliding gate (0.59 × 0.91m^2) leading to shift cage. A small shifting cage of size 2.20 × 2.59 × 2.18 m^3 was provided to shift the leopards for routine cleaning procedures. A small iron cage or kraal of 1.21 × 1.06 and 1.79 m^3 dimensions with a sliding gate of 0.57 × 0.89 m^2 was attached to the shift cage for providing sunlight to the felids. The exhibit cage was devoid of space, natural substrate and direct sunlight.

Modernistic enclosures

The new modernistic enclosures for tigers, lions and leopards were studied in terms of enclosure designs, standoff barriers, open exhibit area, off exhibit area or night holding with their dimensions. Individual enclosure was studied to collect information on the animal housing, safety, hygiene, animal visibility, access for keepers, furniture used, environmental enrichment, microclimatic control, water supply, space for animal movement, floor, wall, doors of housing, facility for cleaning of animal enclosures and pest control.

Captive tigers in the modernistic enclosures

Exhibit area

In the modern enclosure the variables like exhibit area, off-exhibit area, moat, substrate, pool availability and environment items were recorded. The tigers were exhibited in the open naturalistic enclosure. The elevated platform of tiger enclosure was 29.81 × 28.82 m^2. It had concrete wet moat on two sides, it was 3.59 m wide at the bottom and 8.20 m wide on its upper end, with off-exhibit area or housing on third side and 6.8 m high stone wall on the last side. The floor was constructed with soft mud and grass *Cyanadon dactylon.* It had trees of different sizes which include *Ficus bengalensis*, *Phoenix dactylifera*, *Anthocephallus oxydentale*, *Moringa oleifera*, *Morus alba*, *Azadirachta indica*, *Dalbergia latifolia*, Rangoon creepers and other avenue trees. The green grass was maintained round the year by water sprinklers. A fresh water pond of 2.21 m diameter and 0.5 m depth was in the front and middle of the enclosure. These were the components of structural enrichment of the enclosure.

On the visitor's side the moat had stonewall of 7.49m height and the other side of the moat was sloppy with pitching of spherical stones. Small trees, plants and grasses were grown in between the stones of this pitching for enrichment. A part of enclosure was shaded at noon, the rest of the enclosure was getting intense sunlight. There were two vertical sliding doors of 0.53 × 0.71m^2 to connect the open enclosure with the off-exhibit area or night holding. There was one service entrance of the enclosure 0.81 × 1.49 m^2 from the open kraal, used for routine cleaning and maintenance operations by the animal keeper. There was a 1m high moat wall on the visitors' side with 1m iron pipe standoff barriers running around the enclosure maintaining the visitors' minimum distance of 1m from this wall. Shrubs were planted in this space as visual screen to camouflage the wall for enrichment and the details are depicted in Table 2(a).

Table 2(a): Details of Royal Bengal Tigers (*Panthera tigris*) in Gandhi Zoological Park, Gwalior

Sl. No.	Name	Age	Sex	Colour	Origin
1	Shyam	14 years	Male	Normal	Captive Bred, Madhav National Park, Shivpuri (M.P.)
2	Ganga	14 years	Female	Normal	Captive Bred, Madhav National Park, Shivpuri (M.P.)

Off-exhibit area

The housing area was designed for resting, feeding, restraining and medical management of captive felids. It was with four resting and feeding cubicles, two shift corridors, squeeze cage, semi-open kraal with service gallery in 22.0 × 3.12 m^2 floor area and stone slab roofing at 3.71 m height. Open enclosure was connected to the cubicles, squeeze cage and kraals by two vertical sliding doors, (0.53 × 0.69 m^2) with separate shift corridors (1.38 × 3.20 m^2). The night holding or feeding and resting cubicle was 2.12 × 3.20 with 3.71 m^3 height at 0.24m above the floor level of service gallery. Individual cubicles had glazed tiles in its three walls and wrought iron bars in the front with a hinged gate for attendants work. The upper ends of the cubicles and semi open kraal below the ceiling were covered by a grill of iron bars at a height of 2.52 m. A semi-open kraal (4.57 × 3.20 m^2) on the anterior end of the off-exhibit area had semi natural conditions with partial sunlight, water pool and concrete flooring. Inbuilt sequence cage of 1.30 m height, 1.42 m width and 1.76 m length was between this kraal and night holding cubicles. On the other end of the housing had an attached big open kraal (10.05 × 6.42 m^2) with natural conditions of direct sunlight, water pool and natural substrate. It was 0.30 m above the gallery level and was covered by chain link mesh at its height of 4.27 m. Each kraal had the provision of hinged service gate (0.91 × 1.74 m^2) for husbandry needs. All the cubicles, corridors, kraals and squeeze cage were interconnected by horizontal sliding doors with locking arrangements and operated from a (3.12m wide and 22m) long service gallery. Three air coolers in the summer season and subsequently three heaters in the winters were installed in the service gallery for seasonal climate control. Electric ceiling fans and lights were available in individual cubicles and service gallery. Insects' killer was provided in the gallery. Drinking water was provided in stone troughs. Entry of visitors in this off-exhibit area was strictly prohibited.

Captive lion in the modernistic enclosures

There were five hybrid lions of Afro-asiatic species, two were males and three were females and the details are depicted in Table 2(b).

Table 2(b): Details of Afroasiatic Lions (*Panthera leo*) in Gandhi Zoological Park, Gwalior

Sl. No.	Lion	Age	Sex	Colour	Origin
1	Bhoora	19 years	Male	Normal	Captive Bred. Kamla Nehru Zoological Park, Indore.
2	Pooja	19½ years	Female	Normal	Captive Bred. Kamla Nehru Zoological Park, Indore
3	Raja	16 years	Male	Normal	Captive Bred, Chattabir Zoological Park, Chandigarh, (Punjab)
4	Rani	14 years	Female	Normal	Captive Bred, Chattbir Zoological Park, Chandigarh, (Punjab)
5	Razia	19½ years	Female	Normal	Captive Bred at Gwalior Zoo

Exhibit area

A new naturalistic enclosure was constructed. The enclosure had a total area of 1267 m^2. The dry moat with loose mud was 4.30 m wide at the bottom and 9.08 m wide at the upper end. The moat wall was 6.83 m high at the visitor's side with an area of 245 m^2, a stonewall on the third side was 16.65 m long and 6.44 m high while fourth side of the enclosure had a off-exhibit area. The minimum distance between the animal and at the visitor's level was 9.10 m. The area of the enclosure platform was 1022 m^2. It was raised to visitor's level benefiting both the lions and visitors. The floor substrate of the enclosure was of soft mud having green grass *Cyanadon dactylon* in most parts of the area round the year. This green grass was maintained by watering with water sprinklers. The enclosure was enriched by seventeen trees like *Azadirachta indica*,

Cassia fistula, Bogunvillia *sps*, *Dalbergia latifolia*, *Ficus bengalensis, etc*. These served as shade area, hiding places, for playful activities, squirting and scratch posts for these felids. The dry moat had many small trees. The grass was trimmed every month and trees were lopped as per the requirement after the rainy season in the weed control programme. The enclosure got intense heat in the central part while the rest of the enclosure area was shaded. A small waterfall with a pool was provided in the left corner of the enclosure for enrichment. The moat was accessible to the felids by a long ramp with flooring of spherical non-slippery stones. Sprinkler system was used twice daily for one hour in the summer and as per requirements in other seasons. The enclosure had 1m high concrete wall on the visitor's side, at 1.0 m distance the iron pipe standoff barriers of 1.0 m height were placed at visitors gallery. Additionally, shrubs were planted to camouflage the wall.

Off-exhibit area

The exhibit area was connected to off-exhibit area by two 0.58 × 0.84 m^2 vertical iron sliding gates. The off exhibit had housing or night holding area with three separate feeding cum resting cubicles, two shift corridors, natural and semi natural kraals with an inbuilt squeeze cage. From the open enclosure lions were shifted in a 1.59 × 3.48 m^2 corridor interconnected to the feeding and resting cubicles. These cubicles of 14.02 × 3.27 m^2 and height of 3.08m were also connected to the kraals and inbuilt squeeze cage. The cubicles had concrete wall on three sides and iron bars on front side with a service gallery 14.02 × 3.27 m^2 and 3.08 m height as indicated in the layout plan. Iron bars on the top at the height of 1.98 m also covered these cubicles. The ceiling fans and lights were installed on each cubicle above these bars. The cubicles floor level was 0.36 m above the level of gallery. They had glazed tiles on the three walls for better dirt visibility, easy cleaning and good hygiene. Each cubicle was provided a stone water pot. A semi open kraal of 1.53 × 3.48 m^2 and height of 3.08 m as situated at the anterior end of the housing with semi natural conditions like indirect sunlight and concrete floor. Squeeze cage of size 1.30 m height × 1.42 m width × 1.76 m length was between the semi open kraal and the cubicles. Open kraal was 9.11 × 7.32 m^2 covered by chain link mesh at the height of 4.73m having direct sunlight, natural substrate and a small pond of 0.91 m in diameter and 0.45 m depth. Each kraal had a keeper's gate of 0.76 × 0.91m^2 for cleaning operations.

Captive leopard in the modernistic enclosures

There were four leopards of normal colour, one was male and three were female .The details of these felids regarding age, etc has compiled in Table 2(c).

Table 2(c): Details of Leopards (*Panthera pardus*) in Gandhi Zoological Park, Gwalior

Sl. No.	Leopard	Age	Sex	Colour	Origin
1	Raja	13 years	Male	Normal	Captive bred, Birth – 1992
2	Rani	12 years	Female	Normal	Captive bred, Birth – 1992
3	Ragini	12 years	Female	Normal	Captive bred, Birth – 1993
4	Sonia	18 years	Female	Normal	Captive bred, From Aurangabad Zoo (MS) in 1996 at 9 ½ years age
5	Saraswati	14 years	Female	Normal	Captive bred, Birth – 1991

Exhibit area

A modern naturalistic leopard enclosure had been constructed near the lion and tiger enclosure. Due to behavioral constraints of leopards, moated enclosures were not in practice. A totally covered hemispherical shaped naturalistic chain linked enclosure design was adopted. It was oval shaped enclosure with the total area of 348 m^2. The height of the chain-linked dome was 8.04 m. A concrete elevation was provided at their gate of housing. Wooden logs have been placed elevated on the left side of the enclosure in the form of bench, which served as climbing and scratching posts. On the same side there were many elevated concrete contours where the leopards preferred to climb and rest. The leopards were not permanently at ground level as there were many elevation points in this enclosure. The chain link mesh was secured to a cemented wall at a height of 0.4 m. A standoff barriers and a camouflage hedge runs around the

front of the entire leopard enclosure, keeping the visitors at a minimum distance of 1.0 m.

Off exhibit area

The off-exhibit enclosure was located behind the exhibit enclosure and was not accessible to the public. The off-exhibit enclosure had a shift corridor, squeeze cage, five resting and feeding cubicles and an open kraal. All were adjacent to each another and were interconnected in their sidewall by sliding shutters 0.56 × 0.66 m^2 operated from the service gallery of 2.91 × 16.72 × 2.81m^3 height. Except kraal all had concrete flooring. The shift corridor of 1.81 × 1.82 m^2 was also attached to squeeze cage having 1.59 m width × 1.41 m length × 1.28 m height. The cubicles of 1.82 × 2.13 × 3.12 m height had brick wall on three sides with a smooth plaster while the front faces were made up of wrought iron bars having small-hinged doors for day to day husbandry activities. The open kraal was 5.59 × 5.14 m^2 with 2.92 m height. Clean drinking water was kept in stone water troughs at the anterior left corner of the cubicle.

Husbandry of large felids in modernistic enclosures

Tigers, lion and leopards were checked every day in their respective cubicles with leftover food, water and the excretions like urine and feces. Any aspect deviating from normal was reported to the authorities. Accordingly, they were shifted in open enclosures and kraals vacating the feeding and resting cubicles. Any felid found uneasy was detained in the kraal, or inbuilt squeeze cage for necessary medical examination. Each tiger was taken into the open enclosure rotationally, keeping others in the kraals in the day hours. In these shifting operations of tigers, animal keeper interaction plays an important role by accustomed vocalization and actions. In the cubicles of the housing, the excreta were collected at spot, scrubbed, swept and cleaned with the water hose every day and by the evening the house was completely dried. The stone water troughs were cleaned by scrubbing and filled with clean water. The service gallery and the drains were cleaned and later sanitized by phenol biweekly. The animal needs daily routine of cleaning and disposal of waste started at 8.30 hours at the leopard house. The doors and windows of the housing were kept open for sunlight and cross ventilation, at the same time ceiling fans of the cubicles were also used to completely dry up the cubicles and gallery by the afternoon. The open exhibit enclosure was cleaned and swept immediately, at the same time water pool was cleaned weekly on Fridays. The tiles of the cubicle walls were acid cleaned for crusts and rinsed thoroughly every month. In the summer season, environmental temperature rises more than 45°C. The sprinklers were kept open in the morning and evening for maintaining the green grass of enclosure and improving its humidity, and reducing the surrounding temperature for microclimatic and environmental enrichment. In the housing, bionets were provided on doors and windows to curtail the direct draft of heat waves from outside. During extreme hot hours of the day, lions were shifted in housing for protecting them from heat stroke. At night three coolers were used to control the temperature and humidity. Availability of cool drinking water was ascertained round the clock. The water pool of open enclosure and kraals were cleaned and filled with fresh water regularly. In winter season the temperature drops around 7°C, during the day hours. Tiger exposure to direct sunlight was ascertained. The night holding cubicles were provided with wooden planks for resting and to protect the tiger from extremely cold concrete floor. At night, most of the windows were closed to avoid cold wave. Three electric heaters or heat convectors were used to keep the housing warm and comfortable to the tigers, lion and leopards.

Table 3: Feeding Schedule of Large Felids

Sl. No.	Species	Sex	Beef (Kg)	Chicken (Kg) on Friday
1	*Panthera tigris*	Male	14.0	1.00
		Female	12 .0	1.00
2	*Panthera leo*	Male	14.0	1.00
		Female	12.0	1.00
3	*Panthera pardus*	Male	5.0	0.800
		Female	4.0	0.800

The tigers, lion and leopards were fed around at 17:00-17.30 hours in their respective individual feeding and resting cubicle of the housing. Each was given beef every day, except on Friday, as it was the fast day for zoo carnivores. Tigers were offered chicken as a substitute on Friday. The feeding schedules of these felids have depicted in Table 3. In extreme environmental temperatures of summer and

winter seasons, weekly fasting on Friday were avoided. Tigers were provided full diet on Fridays to protect them from extreme heat and cold stress. Leopards were taken in their individual feeding and resting cubicles at feeding time 17 hours and were kept throughout night upto next morning 8.30 hours. Each leopard was fed whole beef every day except Friday.

RESULTS AND DISCUSSION

This study clearly showed that tigers, lion and leopards in more "natural" and "complex" enclosures performed less stereotypic pacing and more exploratory behaviors than those in "unnatural" enclosures. Environmental enrichment was an important factor in reducing inactivity and aberrant behavior in the study animals. These results suggest that captive large felids should be housed in large enclosures containing natural substrate and vegetation, water pools, ample shade a variety of resting locations and variety of enrichment items by maintaining good practices of husbandry.

Effects of the menageries' environment on felids' behavior

These felids were housed in traditional menagerie as old as 1921. Gwalior zoo had moated enclosures with iron bars as public barriers, for tiger, lion and leopards. Only few animals were kept in them due to managerial problems. These cages were devoid of space, natural substrate with enriched surroundings and sunlight. The felids housed in them were more prone to stress and various ailments. The cages were washed with broom and water in the morning and felids had to remain on wet floor and most part of the day defecating and urinating on the same place. The hair coat of these felids was soiled up frequently with urine and feces especially at hindquarters. These felids sprayed squirts of urine caudally at their height, the old rough walls were good absorbent for this spray of urine, fecal washings etc. The fecal matter, urine and dirt accumulated in the joints, cracks and crevices of stone slabs of the floor, these served as a breeding ground for microbes as well as good media for survival of eggs of internal and external parasites and their subsequent re-infections. A common drain at the front of the exhibit cage on the visitors side appeared unhygienic. A stench of offensive smell emanating from the cages throughout the day distracting the visitors. This conjured up visions of small unhygienic enclosures, stark iron bars, dingy concrete, congestion, bad odour and misery. Feeding was done on the same unhygienic floor. The study felids were more under stress in summers and winters due to direct draft of hot and cold winds and absence of natural surroundings. The restrainment of these animals was very stressful due to lack of accessibility and control on the felids from only front side leading to many difficulties in their medical management. These findings are in accordance with Walker (2000), who indicated that the word "menagerie" is now a 'bad' word in organized or "conservation conscious" zoo community. It is a collection of animals with no purpose beyond education and/or entertainment.

Effects of modern naturalistic enclosure on felids' behavior

The gallery of the enclosure was curved giving a circular appearance. The present study reveals that the enclosures designs of these felids were naturalistic and on the trends of landscape immersion and was in consistent with observations recorded by Plaatsman (1996). Its concept was sequentially placed giving wider view of natural habitats to the visitors as suggested by Pal (2000). The availability of a water pool in tiger enclosure and a water hole in lion and leopard enclosure is also supported by Bush *et al.* (2002). The enclosures had natural substrate of mud, grass and trees making the exhibit complex and the foot ailments were negligible. The enclosure facility of tiger, lion and leopards were available with separate exhibit areas, moats and night holdings or housings. By the use of a dry or wet moat as a barrier, it had been made possible to remove the visible barrier of iron bars or grill and present an unobstructive view of the animals at the eye level of visitors (Desai, 2000). Hediger (1970) suggested that the animals did not need a "Kennel" but a territory- a natural division of space with specific habitat and social organization. Forthman and Quick (1984) identified a modern approach to zoo exhibit design. Natural substrates associated with outdoor exhibits like grass and dirt are essential as felids on concrete enclosure exhibited cracked pads and early symptoms of arthritis (Baker, 2003), sore foot pads, leg injuries and also stereotypic behaviors (Manson, 1991 and Law *et al.,* 1997). Ledges produce elevated resting sites and long distance viewing that promotes security (Baker, 2003). The presence of

vegetation created a more natural environment providing hiding areas away from public and creating areas of shade. Planting also attracts insects and birds into exhibits, which provide more complex environment for the animals (Law *et al.,* 1997). Bush *et al.,* 2002 suggested that pool availability for tigers is important, as they are avid swimmers. Tigers appear to enjoy the water and swimming provides an alternative form of exercise and enrichment.

Effects of the captive environment on behavior of tigers, lion and leopards

In this study, enclosure size significantly influenced exploring and pacing behaviors of the captive tiger, lion and leopards. Animals in larger enclosures explored more and paced less often. This result is in agreement with Caro (1993) who stated that tiger and lions are largely terrestrial and do best when maintained outdoors in open enclosures that are planted with grass, bushes and trees for shade, surfaces to mark, places to hide and other aspects in their enclosure that will change their pathways. Shoemaker *et al.* (1997) also mentioned that leopards are terrestrial but highly arboreal and their enclosures should include climbing structures like live or dead trees and ledges for elevated resting and long distance visibility. Multiple elevated resting spaces have also been remained for exhibits and night enclosures for all terrestrial or arboreal species. A larger enclosure not only provides appropriate space for exercise, but it also allows animal keepers and zoo designers to implement a wider variety of enrichment items such as vegetation, scents, ledges and substrates. The use of natural substrate and vegetation in enclosures also reduced stereotypic pacing and increased exploratory behaviors at these sites.

The modern exhibition of large cats was away from barred enclosures and towards large naturalistic moated enclosures. In the present study, it was found that the pantherids of the zoo were maintained in secured enclosures. The tigers and lion were kept in naturalistic enclosures with wet and dry moat, good vegetation for environmental enrichment. The wet moat was wide with sufficient height. Similarly, the open area was more than sufficient for tiger and lion. This result supports the findings of several other studies addressing the issue (Wooster, 1997). Leopards were kept in open enclosures with an area higher than the recommendations of Shoemaker (2003) and Anon (1992). Wooster (1997) suggested that natural substrates such as grass/hay beds, piles of leaves, large clumps of grass, and wood chips, could stimulate natural behaviors in captive animals. These substrates stimulate olfactory senses when soaked in different scents such as catnip or urine from other animals, and crickets or other insects added to the substrates can stimulate play or hunting behaviors (Wooster, 1997). Vegetation and natural substrates also attract birds and insects into the enclosures, which provides a greater diversity of stimulation. Carnivores, most notably solitary felids, are among the most difficult species for which to develop enrichment plans (Mellen and Sheperdson, 1997). Large home ranges in the wild and natural methods of capturing prey are almost never provided in the captive environment due to a lack of space and negative public reaction in providing live prey. Enrichment for captive felids is also difficult because cats habituate quickly to novel conditions (Mellen *et al.,* 1998).

Concrete was the only type of substrate used in early zoo animal enclosures, as it was considered more hygienic and easier to clean than natural substrates. Law *et al*. (1997) found that concrete floors are actually less hygienic and more odoriferous than floors covered with wood chips. Law *et al*. (1997) showed that cats had a lower incidence of parasites and sore footpads when they were housed with a wood chip substrate. Some tigers in this study that were housed with unnatural or mixed substrate had obvious skin abrasions (mostly on elbow joints) that appeared to be caused by lying on concrete.

Vegetation can also be used as cover from adverse weather and for hiding from stresses such as noisy visitors or other exhibit animals that may appear threatening. Law *et al*. (1997) stated that "plants and substrates that help provide shade and hiding places are extremely important to the psychological and physical welfare of cats planting in the enclosures provides a more complex and sympathetic environment for the animals". These results agree with this statement, as the animals housed with natural substrate and vegetation paced less and did not have abrasions.

Environmental enrichment has been widely recommended for maintenance of the physical and psychological well being of captive animals (Mench, 1998). While many studies have shown that environmental enrichment improves the lives of small felids, this study shows

that large felids (tigers, lion and leopards) benefit from environmental enrichment. A high level of enrichment significantly reduced stereotypic pacing of the captive felids in this study, and was marginally significant in increasing time spent exploring. These results were not surprising given the large body of literature regarding environmental enrichment and stereotypic behaviors. Sheperdson (1997) reported that animals in enriched environments seem to maintain a healthy weight, groom themselves properly, and lack stereotypic behaviors. Three of the animals in this study that were living in sterile enclosures did not appear to be physically or psychologically healthy.

Off exhibit area was very well cross-ventilated with windows and doors on all the four walls along with two big ventilators on the ceiling. For better air circulation in hot and humid climate, ceiling fans and window exhaust fans were also installed and this improved the behaviors of felids. These results are in consistent with Shoemaker *et al.* (1997) who suggested that indoor area should have a negative air pressure 10-15 air changes per hour of non re-circulated air and relative humidity within the limits of 30-70%. Visitor's area must be far away from the night holding area there by reducing the potential of disease transmission from the public as well as complaints of problematic odours. Baker (2003) reported that proper ventilation in the off exhibit area should be considered an integral fact of exhibit design to promote cooling, control odours and reduce the risk of disease transmission among specimens.

In the present study, insects control was found to be satisfactory. It was primarily done by good sanitation and hygiene. Insect population was further reduced by using ISI marked electronic insect killers which was installed in the housing of tiger, lion and leopard. Baker (2003) has also indicated to reduce the insect population by good sanitation, electronic insect killers, growth inhibitors, pest strips and natural or synthetic pyrethrins.

The study animals spent a majority (76%) of their time resting, which is not surprising given that captive felids are often inactive. The tigers predominantly rested in a single location of their enclosures, possibly indicating a lack of desirable resting sites in most enclosures. These findings are consistent with the guidelines of Bush *et al.* (1987) and Shoemaker *et al.* (1997). The feeding and resting cubicles of tiger and lions were of comparable dimensions and those of leopards were of greater size as reported by Shoemaker (2003) and Anon (1992). Providing tigers with "favorite" spots in several locations throughout the enclosure might encourage them to use more of the available space. These encouraged the animal to vary its resting location. This strategy also worked to bring a timid animal closer to visitor viewing locations. A few common characteristics of the preferred resting locations in this study included shade availability, a sheltered space, an elevated platform, a compact dirt substrate (grass appeared to be worn away by overuse), and locations within viewing proximity of other animals.

The animals in this study spent an overwhelming 90% of their time in shaded areas illustrating the importance of providing captive animals with ample areas of shade, especially during summer months. Providing more shaded areas would allow animals to occupy larger proportions of their enclosure spaces. Forthman *et al.* (1995) found that shade alone may be insufficient in reducing thermal load in large mammals. If the shaded area has a heat index higher than in direct sunlight, due to poor air circulation or the thermal performance of certain building materials, the animals may not properly thermoregulate.

Keeper presence did not significantly affect tiger behavior, but many of the animals did become vigilant when a keeper was nearby. Animal keepers who had no contact with the resident animals cared the new animals. They were consistently present during visitor hours to moderate visitor activity and answer questions. Keeper presence was low at all other sites, where keepers were present only during cleaning and feeding times. This study indicated that dressed fresh whole beef of sub adult buffaloes was fed in hygienic conditions to the captive felids that showed physical and psychological well being. This result was in consistent with the findings of Lindburg (1988) who supported psychological well being remains an elusive concept regarding "pleasure" in feeding, the difficulties encountered in its measurement do not render it unimportant, we may be guided by the fact that the behaviors commonly associated with feeding in nature lead to the conclusion that much of their pleasure centre around food.

Effects of animal variables on behavior

Of the three large felids included in this study, tigers

rested less, explored less, and performed more stereotypic behaviors than the lion and leopards. Literature regarding variation in behavior of captive large felids appears to be lacking. A majority of the large felids in this study were housed in larger enclosures did not display any pacing behavior throughout the entire study. For this reason, we cannot rule out the possibility that the behavioral differences were related to felids type. The concept of geographic variation in behavior has been studied in primates, fish and birds (Foster and Endler, 1999). Many studies address geographic variation in large felids, but few if any focus on behavior (Kitchener and Dugmore, 2000). Rather than looking at behavioral differences within the large felids, most researchers are trying to determine whether the large felids actually deserve that distinction, or whether morphological differences simply arise from geographic location. Various investigators found that "most of the geographical variation seen in large felids today is largely cline in response to environmental and ecological gradients throughout their mainland distribution." Felids keepers at these sites had varying opinions on the existence of behavioral differences large felids. These results indicate that there may be behavioral differences among the tigers, lion and leopards; however this question should be re-examined on study animals with more comparable enclosure types and with a larger sample size.

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