PRELIMINARY EVALUATION OF ENVIRONMENTAL ENRICHMENT TECHNIQUES FOR AFRICAN LIONS (*Panthera leo*)

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A study was conducted over 24 days to evaluate the effects of three environmental enrichment techniques (frozen balls of ice containing fish, various scents, hanging logs) on four captive African lions (Panthera leo). Behavioural data on activity level and behavioural diversity were collected daily during a baseline and an enriched session. All enrichments produced positive changes in behaviour. Enrichment was also associated with increased use of space by the lions. The enrichment techniques evaluated in this study each produced distinct and positive changes in behaviour thus reinforcing the need for variety to be exercised in captive enrichment programmes. Providing different enrichments allows animals to perform a greater range of behaviours, become more active in captivity, and will decrease the likelihood of habituation to certain enrichment items. Environmental enrichment should be a part of any management protocol for animal welfare and health.

Keywords: *African lion, animal welfare, environmental enrichment*

Introduction

Although popular among zoo visitors, some members of the family Felidae are generally considered to be poor exhibit animals (Shepherdson *et al* 1993). Carnivores and large omnivores, such as bears, tend to be inactive or asleep, out of view or engaged in abnormal and/or stereotypic behaviours while on exhibit. Abnormal maternal care and increased susceptibility to disease and parasites have also been identified as potential results of captive stress in these taxa (Snyder 1975; Hutchins *et al* 1983). Large mammals are often housed in enclosures that do not provide opportunities for the demonstration of natural behaviours (Forthman *et al* 1992; Mellen *et al* 1981); some enclosures may not even provide adequate opportunity to perform basic activities (Hutchins *et al* 1983).

The need for environmental enrichment for captive animals has been well established (Carlstead & Shepherdson 1994 and references therein). The goals of enrichment are varied and include: increasing activity levels, providing opportunities for species-typical behaviours, decreasing or eliminating stereotypic or self-destructive behaviours, improving captive breeding and rearing of offspring, and educating the public. Environmental enrichment has also been found to aid in veterinary monitoring of animal health (Mellen *et al* 1981) and to potentially decrease wear on exhibit features such as large trees and natural foliage (Hutchins *et al* 1983).

Some research has been conducted in the area of feeding enrichment in terms of introducing new food sources and alternative methods of food presentation (Hediger 1966;

Mellen *et al* 1981; Lindburg 1988; Carlstead *et al* 1991; Forthman *et al* 1992; Shepherdson *et al* 1993). These studies have found that this form of enrichment is associated with increased activity and increased behavioural diversity and complexity. Enrichment has also led to increased use of exhibit space and decreased abnormal behaviour.

Environmental enrichment also has been found to educate visitors and to enhance their experience at the zoo. Exhibits that simulate the animal's natural environment and those that contain enrichment for their occupants have proven to be very popular with visitors (Hutchins *et al* 1983; Mellen *et al* 1981). Enrichment also has increased interactions between zoo staff and the public, and visitors seem to appreciate the efforts made in zoos to improve the captive environment of the animals (Mellen *et al* 1981).

African lions (*Panthera leo*) present a challenge to zoo managers in terms of increasing activity. In the wild lions are inactive for an average of 20 to 21 hours per day (Schaller 1972). Two hours of the day may be spent travelling through the pride's territory, and lions may spend 40–50 minutes of the day eating, provided that a successful capture occurred that day. However, hunting success is variable, and several days may elapse between feedings (Schaller 1972). Most zoos do not have facilities to house an entire pride of lions; this in turn limits opportunities for captive lions to demonstrate the complex social behaviours seen among pride members in the wild. Enrichment for lions must not only be interesting to the animals but also durable and safe for them. This further limits the range of environmental enrichment techniques available to animal managers.

This preliminary study evaluated the effectiveness of three environmental enrichment techniques for lions in off-exhibit holding areas. Holding areas tend to be sterile, uninteresting environments that do not provide much stimulation for their occupants. The goal of this study was to determine which techniques were effective in increasing the activity of lions when they do not have access to naturalistic exhibits. No previous research on environmental enrichment for lions seems to have been published, and little data exist for other members of the genus *Panthera*. It is hoped, therefore, that this report will provide enrichment ideas for other large felids as well.

Methods

Subjects

The subjects were four African lions (*Panthera leo*), a pair of adults and a pair of subadult males. The adult male was seven-years-old; the female was six-years-old. The subadult males were brothers and both were three-years-old. The adults were captive-born and reared in the United States; the cubs were captive-born in South Africa and brought to the United States when they were three-years-old.

Housing and caretaking protocol

The adults and the juvenile lions were kept separately and were usually placed on exhibit on alternate days in a naturalistic enclosure designed to simulate the kopjes or rocky outcroppings on the African savannah. When off exhibit, the lions had access to their night cages as well as to two outdoor patios (patio 1 dimensions 3.38x1.95x1.17m; patio 2 2.6x1.95x1.17m). The indoor holding areas had elevated resting platforms, and the outdoor patios contained large logs on the floor. Both areas had sources of freshwater. Outdoor patios and night cages were cleaned prior to data collection each day (1330h) to eliminate

distractions to the lions. All lions were fed at approximately 1700 hours each day. Adults received approximately 3.1kg of chopped horse meat; cubs received approximately 1.4kg of meat. All lions were fasted one day per week.

Enrichments

Zoos commonly provide some of their animals with large blocks of ice that may or may not have food items frozen in them (ie fishcicles and fruitcicles). However, in many cases these objects are not manipulatable due to their size, and the animal can only sit and lick the ice until the frozen items inside become attainable. I thought it might be interesting to give the lions objects that they could manipulate with their paws and move around the enclosure if they wished. The first enrichment involved placing a small, frozen fish into a latex balloon and then filling the balloon with water. A tray filled with sand served as a container that would hold 12–15 balloons. The balloons were packed in sand to maintain their round shape and then frozen. After freezing, the balloons were removed from the frozen ball of ice. Three ice balls were placed in the enclosure for each observation period. Various scents were placed in the enclosures as a second enrichment. These scents included musk cologne (Coty Diversified, New York, NY) peppermint extract, allspice and almond extract (McCormick & Company Inc, Hunt Valley, MD). The musk was chosen as it was an animal-based scent. Peppermint extract was chosen due to its botanical relation to catnip (*Nepeta cataria*) which was not available during the study. Allspice and almond were chosen due to their strong odour and because these had been used before at other zoos. These were used separately and were applied to four randomly selected locations within the enclosure. The third enrichment was hanging logs. These logs are common cage furniture when felids are exhibited in menagerie style cages which provide little spatial heterogeneity. They are part of the permanent cage furniture and thus receive little use after the animal has become accustomed to the enclosure. The Zoo Atlanta lions, however, had never been exposed to hanging logs and so these were chosen as an enrichment. Two 12–18 inch long logs were suspended from the overhead cage mesh with half inch steel cable and hooking clips. Due to time constraints, hanging logs were not given to the juvenile males during this study.

Enrichments were presented in a largely haphazard sequence as certain enrichment items became available at different points throughout the study. The adult lions were kept off exhibit for a period of seven days at the beginning of the study due to the female being in oestrus and resultant difficulty in shifting the adults to the exhibit. Adults also were kept off exhibit on days when the adult male showed signs of stress due to high summer temperatures. In some instances these alterations resulted in repeated presentations of enrichment items on consecutive days.

Data collection

Pairs of lions were observed for two 30 minute intervals on each of 24 days beginning at 1330 hrs and 1530 hrs. These time intervals corresponded to periods of low keeper activity in the area. The first observation period was a baseline period in which no enrichments were provided. Prior to the second observation, enrichment item(s) were placed on patio 1. The observation period began when the lions were given access to the cage containing the enrichments.

During observations the enclosure was scanned every 20 seconds (scan sampling, Altmann 1974) and a behaviour from the ethogram (Table 1) was recorded for each animal to determine an activity budget for the animal during that time of day. On every tenth scan the location of each animal within the enclosure was recorded. The outdoor patios were divided into six approximately equal areas; the night cages were not visible and so were given a separate location score. Simultaneous to scan sampling, one-zero sampling (Altmann 1974) was conducted on the behaviours defined in Table 2 to track the occurrence of rare or species-specific behaviours. For example if lick/gnaw was seen any time within a 20 second interval, it received a score of one regardless of the actual frequency of licks.

Table 1 Ethogram of scan sampled behaviours for African lions.

Behaviour	Definition
Resting	Cat is lying down or sitting with eyes closed, head down
Alert	Cat is lying or sitting with eyes open, head up
Standing/Locomoting	As implied
Not Visible	Out of observer's view

Table 2 Ethogram of one-zero sampled behaviours for African lions.

Behaviour	Definition
Licking/Gnawing	Oral manipulation of object, include mouth carrying
Paw Manipulation	Any manipulation with paws, includes holding an object still
Sniffing/Flehmen	Sniffing ground, enclosure features, or other objects/Flehmen: mouth open, lips drawn back, face wrinkled, tongue out
Face rubbing/Back roll	Cat rubs side of face against another cat or object, wall, cage mesh/animal rolls on to back

Analysis

Scan sampled behaviours were expressed as the mean number of scans the behaviour was recorded per 30 minute observation period. Point sampled behaviours were expressed as mean frequencies per 30 minute observation period. Adults and cubs were analysed separately. Differences between baseline and enriched (ie ice, scents or logs) conditions were tested using Kruskall-Wallace analysis of variance with *post hoc* Dunn's contrasts on the scan sampled and point sampled behaviours (Hollander & Wolfe 1973). The family-wise alpha for Kruskall-Wallace tests for each group (adults or juveniles) was 0.10 (seven behaviours tested thus $P = 0.014$ Bonferroni adjustment for each contrast). For the adults,

post hoc Dunn's tests were conducted with a family-wise alpha of 0.05 (each test $P = 0.016$ Bonferroni adjustment). The same was true for the cubs except that the per test alpha was 0.025.

In order to determine if enrichments had an effect on the lions' use of space, a spread of participation index (SPI) (Dickens 1955) was calculated for baseline and enriched conditions. The spread of participation index was originally developed by educators to determine if students participated equally in class discussions or if certain individuals tended to dominate discussions. This index can be easily applied to studies of use of space by animals if areas of the enclosure are treated statistically as equivalent to students. An SPI of 0 indicates maximum utilization of space or all areas used equally, while an SPI of 1 indicates minimal use of space. The spread of participation index (SPI) has previously been used in studies of use of space by captive felids (Shepherdson *et al* 1993). Results presented below are based on 24 days of observations between 14 June and 26 July 1994.

Results

Lick/Gnaw ($P < 0.014$), Paw manipulate ($P < 0.014$), and Sniff/Flehmen ($P < 0.014$) showed significant differences between baseline and enriched condition in adults (Table 3), although all recorded behaviours changed in mean rate with various enrichments (Table 4). Lick/Gnaw and Paw manipulate increased significantly over baseline when ice was presented. Sniff/Flehmen increased significantly when scents were placed in the enclosure. Paw manipulate also increased significantly when hanging logs were present in the enclosure.

Table 3 **Changes in lion behaviour associated with enrichments.**

Group	Behaviour	Ice	Scents	Logs
Adults	Rest	ns	ns	ns
	Alert	ns	ns	ns
	Stand/Locomote	ns	ns	ns
	Lick/Gnaw	$P < 0.016$	ns	*
	Paw manipulate	$P < 0.016$	*	$P < 0.016$
	Face rub/Back roll	ns	ns	ns
	Sniff/Flehmen	*	$P < 0.016$	ns
Cubs	Rest	ns	ns	See note
	Alert	ns	ns	
	Stand/Locomote	$P < 0.025$	*	
	Lick/Gnaw	$P < 0.025$	ns	
	Paw manipulate	$P < 0.025$	ns	
	Face rub/Back roll	ns	ns	
	Sniff/Flehmen	$P < 0.025$	$P < 0.025$	

Note: All significant changes are increases in behaviour over baseline. Cubs did not receive logs during this study. Asterisks represent values that just missed statistical significance (ie $0.05 > P > 0.025$). ns – not significant

Table 4 **Mean rates of behaviours per 30 minute observation period in adults as a function of enrichment.**

Behaviour	Baseline	Ice	Scents	Logs
Rest	100.20	36.00	67.14	65.50
Alert	59.67	109.30	94.71	85.00
Stand/Locomote	6.33	26.00	13.43	23.00
Lick/Gnaw	0.00	36.67	0.71	4.50
Paw manipulate	0.00	22.30	8.50	10.50
Sniff/Flehmen	1.13	6.33	10.57	2.00
Face rub/Back roll	2.47	2.00	10.71	0.00

In cubs, Stand/Locomote ($P < 0.014$), Lick/Gnaw ($P < 0.014$), Paw manipulate ($P < 0.014$), and Sniff/Flehmen ($P < 0.014$) showed significant differences across treatments (Table 3). All of these behaviours increased significantly when ice containing fish was presented to the lions. Sniff/Flehmen also increased significantly when scents were placed in the enclosure. As in adults, all behaviours showed changes in mean rate across baseline and enriched conditions (Table 5).

Table 5 **Mean rates of behaviours per 30 minute observation period in cubs as a function of enrichment.**

Behaviour	Baseline	Ice	Scents
Rest	43.63	7.25	22.00
Alert	117.63	123.75	146.75
Stand/Locomote	3.25	36.00	9.75
Lick/Gnaw	0.38	35.75	1.00
Paw manipulate	0.00	10.75	0.75
Sniff/Flehmen	0.50	8.25	11.25
Face rub/Back roll	0.88	2.50	5.00

Use of space

The SPI did not change between baseline and enriched conditions for the adults. The SPI of the juveniles was 0.69 during baseline and 0.48 in enriched conditions indicating that enrichment seemed to elicit greater use of space by the juvenile lions. The cubs used almost all of the space available to them when they received enrichment as compared to using less than half of the available space during the baseline observations (Figure 1).

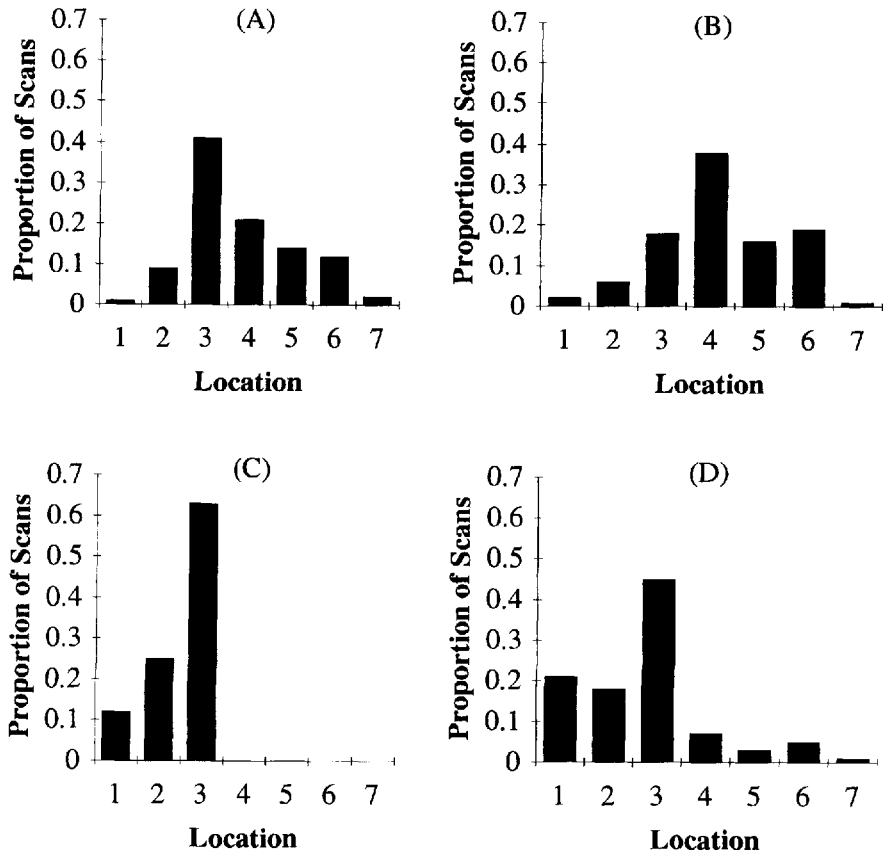

Figure 1 **Use of space by adult lions during baseline (A) and enriched (B) conditions and by cubs during baseline (C) and enriched (D) conditions.**

Discussion

In this study the different enrichment techniques used had a roughly equal effect on the behaviour of the adults and cubs. In both groups all behaviours showed changes in mean rate when enrichments were presented. The fact that more of these changes were not significant may be due in part to the conservative statistical tests used. Several behaviours showed dramatic increases over baseline yet failed to reach statistical significance .

All of the enrichment techniques investigated produced positive changes in the behaviour of the lions. The lions were more active and alert and used more of the space available to them. Frozen balls of ice containing fish elicited most of the changes in the lions' behaviour and could thus be said to be most effective. However, the fish was consumed on only one occasion. The lions typically pushed the ice balls around until they shattered and then licked them. The lions revisited the ice several times during the observation session. Of the scents used, peppermint extract elicited the strongest responses possibly due to the relatedness of peppermint to catnip. Another scent that was used after this study ended was commercially produced deer hunting lure (Buck Stop Lure Company Inc, Stanton, MI). This was a liquid

substance composed of extracts from tarsal glands of male deer during the rut. This proved to be extremely effective in increasing the activity of the adults and also eliciting some rare behaviours such as social play and chasing.

Results from this study suggest that different classes of enrichment produce different changes in behaviour. This finding emphasizes the need for a variety of enrichment techniques to be employed. Other studies have shown that several types of enrichment should be used with captive animals to decrease habituation to enrichment items, and to account for individual differences in interest in enrichment items (Mellen *et al* 1981; Carlstead *et al* 1991).

The findings of this study and those of Carlstead *et al* (1991) also emphasize the need for novel stimuli and manipulatable objects to be provided. The lions' holding area already contained logs on the floor and olfactory cues from the keepers and cagemates; however, these cues were not stimulating to the animals. Animals are likely to be stimulated only by objects and practices that are not part of the daily caretaking routine and may interact more with objects that they can control. Carlstead *et al* (1991) also suggested the positive effect of having several types of enrichment available to bears concurrently. Enrichment should also take advantage of as many of the animal's senses as possible instead of focusing on food items as many current enrichment practices do.

One of the goals of enrichment is to elicit natural behaviours. When the adults were given logs, both responded to them by grabbing the log and biting it for several minutes. This behaviour resembled the techniques of suffocation, strangulation, and spinal cord trauma that lions use in the wild to subdue prey (Kruuk & Turner 1967; Schaller 1972; Lindburg 1988). When scents were placed in the enclosure, the lions engaged in more back rolling behaviour, particularly when peppermint was presented. Lions and other carnivores commonly roll in the dung of other animals. This behaviour may serve to mark the area with the animal's scent, but it is unclear why it is commonly performed on the dung of other animals (Schaller 1972). It is also possible that dung rolling may serve to hide the scent of the carnivore when approaching prey. However, pet owners report that when their dog or cat rolls in ungulate dung, the animal seems to enjoy the experience and appears to be in ecstasy. The same response occurs when cats are presented with catnip. It could be that some plant compound exists which is excreted in the faeces of ungulates and has a similar effect as nepetalactone, the active ingredient in catnip (Budavari 1989).

Animal welfare and conservation considerations

This study and those by others clearly demonstrate that simple, inexpensive alterations in an animal's environment or in the caretaking routine can have significant, positive effects on the behaviour of captive animals. It is also clear that captive animals become more active and perform more functional and species-typical behaviours if given the appropriate opportunities to do so (Hediger 1950, 1966; Morris 1962; Markowitz 1978; Hancocks 1980; Forthman-Quick 1984; Hutchins *et al* 1983; Carlstead *et al* 1991; Forthman *et al* 1992; Shepherdson *et al* 1993; Carlstead & Shepherdson 1994). When animals can be seen in an accurate simulation of their natural habitat demonstrating their species-specific behaviours, the visitor can develop more of an appreciation for the animal and can learn more about its behaviour in the wild and its general biology. This knowledge of animals and appreciation for their existence will hopefully go a long way towards encouraging their conservation.

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