INTRODUCTION

Captivity can have adverse effects on the behaviour of captive wild animals has been known for some time. Confining an animal to a cage or enclosure reduces the complexity, and increases the predictability, of its environment. As a result of this "environmental impoverishment", "undesirable" behaviours increase and "desirable" ones decline. This degradation causes a downward spiral. It therefore becomes necessary to keep animals occupied in captivity. However, concerns to maintain easy management and good hygiene in the traditional zoo enclosure (hard concrete floors and ceramic tiled walls) often override the psychological needs of the animals. The focus and motivation for enrichment are changing as our understanding of the physiological and behavioural needs of captive animals improves as well as of the cause and effect of captive behaviour.

What are undesirable behaviours?

Just because a captive animal behaves differently in captivity it does not necessarily mean that it is suffering, but in the absence of any criteria for judging welfare it can be said that if an animal behaves the same in captivity as in the wild it is probably not suffering. Activities such as coprophagy, regurgitation, hair-pulling, self-injury or stereotyped movements are generally judged as undesirable whilst active exploration, play, affiliation and foraging are judged as desirable. The desirability of a behaviour displayed by a captive animal must be considered at various levels.

Normality: where possible behavioural repertoires and activity patterns should approximate those in the wild. Because there is variation in nature and because sometimes field data are scarce, it may not always be possible to confirm what "wild" behaviour is but the principle still holds. The preservation of a species depends on maintenance of more than just genetic material.

Public acceptability: the zoo visitor wants to *see* neither an inactive animal nor one exhibiting stereotyped or aberrant behaviour. Apart from any obvious benefit to the animals, environmental enrichment makes the exhibition of captive animals more interesting and more acceptable to the public. This is particularly important in the current climate where more and more doubts are being expressed about zoos and their social and ecological value.

Theoretical considerations: *some* enrichment work has a theoretical rationale e.g.

setting goals for calorie expenditure or pre-release training.

Practical considerations: enrichment can often be a way of improving husbandry methods. Successful projects should see reductions of aggression, self-injury, stereotyping and other aberrant behaviours.

Types of Environmental Enrichment.

Much of the pioneering work on behavioural enrichment was initiated in the U.S. Two schools of thought evolved, each emphasizing a different way of enriching captive environments. The first is typified by Hal Markowitz working mainly in Portland Zoo, Oregon, and is referred to as **behavioural engineering** (Markowitz, 1982). Faced with the task of encouraging more activity and more foraging-related behaviour in animals in traditional sterile enclosures, Markowitz developed a number of mechanical devices that would deliver food to animals on completion of a task. Examples:

- a system whereby gibbons *(Hylobates lar)* were able to activate a food dispenser by operating two widely spaced levers.
- a system whereby Diana monkeys *(Cercopithecus diana)* could exchange plastic tokens for food at a food dispenser.
- a display in which pumas *(Felis concolor)* were able to trigger the release of artificial 'prey' animal. Capture of the prey activated the food dispenser.

The alternative school of thought, known as the **naturalistic** approach, was pioneered by Woodland Park Zoo in Washington (Hancock, 1980). It aims to recreate the natural environment as far as possible using natural materials.

Aims of Enrichment

Enrichment must aim at enhancing the social and physical environment of the captive animal.

Improvements to the social environment

Keeping animals with socially compatible individuals:

Even species which in the wild are relatively solitary may benefit from this. Compatible social groupings may be very different from those found in the wild because of changed environmental constraints. The natural sociobiology of the species should be known before changes are made to the grouping policies. The size and the structure of a social group are of great importance to its cohesion and

overall health. Dominance hierarchies and age and sex distribution of a group will determine the levels of stress and competition experienced by its members.

Greater keeper input: The individual, or team, responsible for the care of an animal or group of animals may be responsible for much of the stress which they experience. Movement of animals and feeding must be established as routines in order to reduce this stress to a minimum.

Amelioration of the physical environment

The inclusion of more stimulating substrates: Grass, shavings, peat and woodwool can be used to replace the bare concrete floors of more traditional enclosures: a move from "hard" to "soft" cages.

The introduction of appropriate cage furniture: The provision of appropriate furnishings within the cage facilitates locomotion and allows an animal to make full use of three dimensional space within an enclosure.

The use of screens and panels: Used correctly, they subdivide space and create a series of more complex and partially compartmentalized environments.

The provision of manipulable objects: Manipulable objects such as puzzle boxes provide variability and active stimuli for the captive animals.

Improvements of the psychological environment

Reduction of stress levels: Management techniques and exhibition methods may be adapted to reduce unnecessary stress. Provision for species specific traits, e.g. flight distance and response to the public, is important.

Predictability: The spatial and temporal predictability of a captive environment may be reduced relatively easily by modifying routines. Though the necessity for a basic routine in the captive situation is indisputable, there should always be room for some flexibility.

Foraging: the aim is to increase time spent searching for food in captivity to simulate nature.

Manipulative behaviour: animals are given materials to manipulate.

Learning: new behaviours may be learnt which make use of natural ability and consume time. Some may be used educationally in demonstrations, not to be confused with shows, and others may be related to food acquisition. This approach still holds greatest potential for development as it can be applied to existing

enclosures and does not have to be expensive.

Enrichment and food

Most enrichment programmes involve changes in food presentation both spatially and temporally. Any efforts to slow feeding rates and spread them out over a longer time period are beneficial as they prevent other activities reaching unnaturally high levels. The amount of food offered does not have to be increased since presentation can be adapted instead. In many cases, the increased effort required to obtain food will in fact increase caloric expenditure by the animal.

Planning Environmental Enrichment.

A major factor hindering the definition of simple, effective guidelines for optimising well-being in a wide variety of animals is the fact that environmental needs differ across species: husbandry techniques that promote well-being of one species will not necessarily transfer to another species. The most powerful perspective from which to devise environmental enrichment devices for a specific taxon in captivity, and subsequently to evaluate their implementation is a detailed knowledge of that species' natural history Comparison of the activity profiles of animals in the wild with conspecifics in captivity would be a way of achieving this.

Choice of species

All species require enrichment. However, it is important to identify the animals or species in a collection which will benefit most from a programme of enrichment. These are animals:

- housed in inappropriate social groups.
- with special health care requirements.
- which were hand-raised and need to acquire natural skills.
- exhibiting stereotypies.
- living in unnatural and environmentally impoverished environments.
- in appropriate social groups or naturalistic environments where enrichment would improve behavioural repertoire.

Methodology

The natural behavioural repertoire of the species being taken up for the enrichment programme will be established from a detailed review of literature regarding the behavioural patterns of the species. If information about the behvioural patterns of a species is not available in literature closely related species will be used to acquire the necessary information.

Evaluating Environmental Enrichment.

It is important to assess the benefits an animal is deriving from enrichment. Of course, it is impossible to know whether or not an animal is 'happy' or content with its environment. However, it is possible to use scientific evidence to increase the chance that our decision is correct. This problem can be approached by observing an animal's behaviour. The behaviour of an animal can indicate its emotional disposition by watching how the animal reacts to aversive situations (such as being hurt or attacked). If the same behaviour is observed in another context it can be assumed that situation is also aversive to the animal. Another important observation is the extent to which the captive animal performs different or abnormal behaviours.

A positive evaluation based on this criterion will justify the continuation of the enrichment programme and further work on other exhibits and species. Such an assessment requires the study of the animals' behaviour before (known as the Baseline study) as well as after or during enrichment, if it is ongoing. The following behavioural changes confirm the benefits of enrichment:

- An increase in the behavioural repertoire (other than fearful or aversive behaviours) of the subject.
- A decrease in abnormal or stereotyped behaviours.
- Positive changes in the animals activity patterns; lethargic animals becoming more active, hyperactive ones calmer.
- Better use of cage space and of the environment.
- Improved locomotory activity, climbing, swimming and flying.
- Reduced aggressive or associal behaviour.

The behavioural repertoire of the specie sin captivity will be assessed using scan and focal sampling techniques for behavioural observations. Time lapse video

recording of the individuals being observed will carried out and used for detailed study of behavioural patterns.

Statistical tests as appropriate will be used for analysis of the behavioural data collected. The results of this analysis will be used to test the efficacy of changes in housing and enrichment being made in the enclosures.

Expected Outcomes of the Project

Sl. No.	Expected Outcome	Time frame
1.	Collection of baseline data on behavioural patterns of selected species in captivity	From 6th month onwards
2.	Development of Enrichment material for selected species in captivity	From 6th month onwards
3.	Evaluation of benefits of enrichment on selected species	From 8th month onwards
4.	Development of guidelines for enclosure enrichment in Indian zoos	34th – 36th month

WORK PLAN

It is proposed to conduct the work involved in the project in a two-phased manner. The first phase would involve active visits to zoos holding identified species for collection of baseline data on the behavioural patterns.

Sl. No	Activity	Time Frame in Months											
		0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33	33-36
1.	Recruitment of project personnel	■											
2.	Purchase of Equipment	■											
3.	Identification of Zoos (To be done in Consultation with CZA)	■											
4.	Identification of Species (To be done in Consultation with CZA & Zoos)	■											
5.	Pre-enrichment Data collection and analysis		■	■	■	■	■	■	■	■	■	■	
6.	Designing & implementing of enrichment devices		■	■	■	■	■	■	■	■	■	■	
7.	Post-enrichment Data collection and analysis		■	■	■	■	■	■	■	■	■	■	
8.	Report Writing				■				■				■

1. Species taken up und CZA Programme
2. Zoo – co-ord, partici. + other major zoos holding animals in captivity
3. literature survey
4. field visits – data from field in India 60-70 visits
5. Expert biologists inputs
6. Expert zoo men's inputs
7. Enrichment suggested - descriptive as well as diagramatic
8. Dimensions ~~and~~ of housing and furnishing
9. Assisting zoos in implementation?

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BUDGET

Budget Summary

Sl. No.	Head	Amount in (Rs.)
1.	Equipment	445000.0
2.	Development of Enrichment material	350000.0
3.	Books and periodicals	100000.0
4.	Salary total	2077392.0
5.	TA/DA accommodation of project personnel	600000.0
6.	Stationary	150000.0
7.	Miscellaneous and contingencies	150000.0
Total		**3872392.0**
Rupees Thirty Eight Lakhs, Seventy Two Thousand and Three Hundred and Ninety Two Only		

Detailed budget breakup – year-wise

Head	Details	Year 1	Year 2	Year 3	Amount (Rs,)
Equipment	Computers and peripherals. 2 laptops for field personnel & 1 Desktop with Printer & UPS for Office work, External Hard Disks (500 GB) 3 Nos	200000.0			200000.0
	Digital Cameras (3 Nos.) (Approximate cost Rs. 20000.00 each)	60000.0			60000.0
	Handycams (3 Nos.) (Approximate cost Rs. 35000.00 each)	105000.0			105000.0
	Binoculars	30000.0			30000.0
	Miscelanneous items	20000.0	15000.0	15000.0	50000.0
	Equipment Total	**415000.0**			**445000.0**
Development of Enrichment material		100000.0	150000.0	100000.0	350000.0
Books and periodicals	Purchase of Books and Literature collection	50000.0	25000.0	25000.0	100000.0
Salary	Senior Research Associate (@ of Rs. 32372.00 per month)	388464.0	388464.0	388464.0	1165392.0
	Research Fellows 2 ((@ of Rs. 12,000,00 pm for the first 2 years & @ of Rs. 14,000.00 pm for the Third year)	288000.0	288000.0	336000.0	912000.0
Salary total					**2077392.0**
TA/DA accommodation of project personnel	Travel from WII to Field Sites and Lodging Boarding Expenses	200000.0	200000.0	200000.0	600000.0
Stationary		50000.0	50000.0	50000.0	150000.0
Miscellaneous and contingencies		50000.0	50000.0	50000.0	150000.0
	Total	**1541464.0**	**1151464.0**	**1149464.0**	**3872392.0**
Rupees Thirty Eight Lakhs, Seventy Two Thousand and Three Hundred and Ninety Two Only					

Annexure I

Examples of Environmental Enrichment Devices.

The following set of simple and practical techniques are taken from Shepherdson (1994). Techniques are categorised according to type of behaviour targeted and their increasing complexity.

Device	Description	Source
FORAGING DEVICES		
Smell Trails	Smells placed at different locations in enclosure at different times. Smell trail can lead to a food reward. May include food, other animals, food additives, perfume Philadelphia Zoo etc. Meat trails have been successfully used for black bears in Glasgow Zoo.	Law *et lt.* (1990).
Activity Foods	Best activity food are those that require the most amount of work per reward. Food items include corn on the cob, celery, artichokes, very small seeds. Effectiveness of this activity depends on the substrate and ease of finding and picking up items from it.	Bloomsmith *et al.* (1988).
Browse	Obtained from grounds, tree surgeons, gardeners, foresters etc. Provides a food source, variety, manipulable objects, toys and tools. Has reduced abnormal behaviours in bears, cats etc.	Hutchins (1984), Law *et al. (1986,* 1990).
Meat Sticks	Meat is hung on the end of a wooden meat hook which in turn is hung from the enclosure roof. To get to the meat the animal must leap up and pull down. Provides food in a more naturalistic way because the animal must perform hunting behaviours. Successful with medium to large cats at Glasgow Zoo.	Law *et al. (1990).*
Sand Barrel Feeder	Small barrel or container filled with a mixture of sand and food items (meal-worms, seeds, etc.) with an opening at the bottom at which animals can dig/scratch to encourage flow of sand and food. Suitable for small digging foragers such as	Ewer (1963).

Device	Description	Source
	meerkats.	
Underground Food Pipes	Pipes buried vertically in the ground filled with food items. Animal has to find a pipe containing food and hook the food out. Used for black bears at Glasgow Zoo.	Law *et al. (1990).*
Ice Food Blocks	Food items frozen into ice blocks of varying size. Stimulates investigation, activity and manipulation. Increases time spent and challenge of obtaining food. Useful for polar bears, small felids and primates.	Law *et al. (1990).*
Honey Logs	Drilled out logs with honey and sealed with wooden plug. Animal has to rip log to obtain honey. Used successfully with bears.	*Carlstead et al. (1991)*
Feeding Log	A deep 'V' groove cut into a log or logs provides a location for hiding nuts and other food items.	*Carlstead et al. (1991)*
Artificial Honey Tree	A pump delivers honey from a container through a pipe to a bowl in the top of a dead tree. Bears can climb tree and find honey as they might in the wild.	Used in various zoos (Taronga, Amersterdam, Sydney, National).
Artificial Gum Tree	Several different designs including a length of Dowel cut into sections each one of which has a number of reservoirs drilled into it and a central hole. Reservoirs are filled with a gum arabic solution and the sections are then threaded back together along a steel rod. Animals can obtain the gum by gnawing through the outside to break into a reservoir. An easier alternative is drill holes into a log and fill them with gum using a syringe. This device provides gumivorous animals (e.g. marmosets, lemurs, sugar gliders, bush-babies etc. with a naturalistic food source.	McGrew *et al.* (1986).
Fish Catapult	Catapult fed by conveyer belt ejects into enclosure at unpredictable times.	Markowitz (1982).
PLAY DEVICES		
Display Drum	A drum or sounding board that will reverberate when hit or jumped upon.	Kortlandt (1960).
Up-rooted Trees	Placed in enclosure and replaced at intervals. Provides a climbing structure, foraging areas, manipulable objects etc. Used	Bloomsmith *et at.* (1989).

Device	Description	Source
	successfully for chimpanzees.	
Tug-of-War	A rope running between two cages in such a way that animals in either cage can pull rope from other. Increases interest of animals in rope since it will occasionally become 'alive' when an animal in the other cage pulls on it. Successfully used with primates.	Maple (1979).
ENVIRONMENTAL COMPLEXITY DEVICES		
Visual Barriers	Constructed from vegetation, boards, walls, rock work etc. Sometimes reduces aggression but also increases complexity by increasing psychological space.	Traylor-Holzer and Fritz (1985), Mckenzie *et al.* (1986), Adams and Babladelis (1987).
Cold Rock	Same principle as hot rock except rocks are cooled by refrigeration pipes instead of heated. Animals that may need to cool down during hot weather can be encouraged to use certain parts of the exhibit.	
Artificial Rain	Fogging units or greenhouse spraying kits used to provide artificial rain storm. An extra perhaps unpredictable stimulus. Can be used by animals to cool down or to keep enclosure humidity up. Important for most animals to keep plastic hoses etc. out of animal reach. Should be set up in such a way that exposure to rain is voluntary. Used in London Zoo.	
Pivoting/ Hanging Pipes	Lengths of plastic piping pivoted or hung so that when animal enters pipe and moves through it the pipe tips up or swings.	
Ambush Box	Nest box with brush fringe over opening. Used for cats by allowing the animal to look out from a position of security.	