A multi-species study on feed-based environmental enrichment at the National Zoological Gardens, Pretoria

by

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This work is dedicated to my mother, Rita Thomas who through love, support and endless patience has fuelled my passion to live my dreams.

Back row (from left to right): Winnie Seremane, Isaac Dlamini, Joanne Osuagwuh, Jimmy Mphela, Kenneth Nengovhela, Keneilwe Mabatja, Thoko Ripinga.

Foreground (from left to right): Meriam Mashiane, Baleseng Maema, Maria Manamela.

I who was given my big brain by mistake
can not deny the foolishness in the chances that I take
but for dumb luck I have survived
and moreover have even thrived
for I was built to laugh.
Anonymous

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ABSTRACT

Environmental enrichment is a commonly used management tool in most captive animal institutions world wide. Enriching environments is aimed at improving the welfare, conservation and 'educational worth' of an animal, with the most commonly employed method being that of feed-based enrichment where the normal food items are presented in a novel way or novel food items are offered. Despite being common practice, few large scale multi-species studies have been conducted to determine the efficacy of such methods. The aim of this research is to assess the effect of feed-based enrichment on a broad range of mammal species (six), to determine any predictable responses and examine the overall effect of enrichment on captive wild animals within the National Zoological Gardens (NZG), Pretoria.

1. INTRODUCTION

1.1. THE HISTORY OF ZOOS

Humans have kept wild animals for thousands of years (Bostock, 1993), with Africa appearing to be where the first zoo was recorded (Mullan and Marvin, 1987). In Egypt, wild animals were kept for religious reasons (Mullan and Marvin, 1987), with species ranging from hippopotamuses (*Hippoptaus amphibious*) to scarab beetles (Smith, 1969). The management and husbandry of such animals was not financially restrained, with most species kept outside in 'semi-liberty' with the best food, for example live prey in the case of the lions (*Panthera leo*) (Bostock, 1993).

Collecting and keeping wild indigenous species was diversified in 1400 BC when the Egyptian Queen Hatshepsut shipped mammals and birds from Somalia (Cary and Warmington, 1963). During this period the first 'acclimatisation garden' known as the 'Garden of Ammon' was formed in which exogenous species could adapt before release as additions to the local fauna (Cary and Warmington, 1963).

Research within zoos started much later in France during 1664 with the opening of Louis XIV's menagerie in Versailles, which combined public viewing with the Academy of Science (Bostock, 1993). However, the studies concentrated on the developing science of comparative anatomy (Loisel, 1912).

The Zoological Society of London founded in 1926 started the London Zoological Gardens as a purely scientific institute (Bostock, 1993). The Institute carried out research on comparative anatomy and, in addition, behavioural observations such as examination of the reaction of monkeys to snakes (Glickman and Sroges, 1966). Despite its role in zoological research, the conditions in which the animals were kept resulted in a greatly reduced life expectancy for many species, causing concern over the ethics of captivity (Altick, 1978).

1.2. THE MODERN ZOO!

An increasing number of zoological gardens worldwide are striving to achieve three main objectives, namely conservation, animal welfare and education. This is highlighted by the umbrella organization of the World Association of Zoos and Aquariums (WAZA) that represents over 1200 institutions and affirms in its mission statement that it seeks "to guide, encourage and support the zoos, aquariums and like-minded organizations of the world in animal care and welfare, environmental education and global conservation". Similar testament is accredited to other organizations such as the British and Irish Association of Zoos and Aquariums (BIAZA) and the African Association of Zoos and Aquaria (PAAZA).

1.2.1. Conservation

Conservation in its most basic form means to 'preserve' - keep in its original state (Hawkins, 1990). Within the auspice of zoological organizations this infers a requirement for successful captive breeding and reintroduction of animals, in order to maintain and replenish natural wild populations (Mathews *et al.*, 2005).

One success story of captive breeding and reintroduction is that of the De Wildt Cheetah Centre in South Africa. Established in 1971 by Ann van Dyk, it was the first to successfully breed cheetahs (*Acinonyx jubatus*) in captivity resulting in the removal of these animals from the threatened species listings (Nel, 2004). Another example is the successful release of captive bred black-footed ferrets (*Mustela nigripes*) by researchers at the University of Wyoming, U.S.A., avoiding possible extinction in their North American range (Russell *et al.*, 1994).

Unfortunately such success is rare (Seddon, 1999) and the reasons for failure often complex, unclear and/or unreported (Mathews *et al.*, 2005). However, population size (Bryant *et al.,* 2002), predator recognition (McLean *et al.*, 1996) and foraging ability (Snyder *et al.,* 1996) are a few of the many proposed causes of failures in conservation objectives. Unfortunately few of these suspected short-falls have been scientifically tested (Mathews *et al.*, 2005).

One example that illustrates the variable success of such ventures is that of the role played by captive breeding and reintroduction of wild dog (*Lycaon pictus*) within Southern Africa, discussed by Woodroffe and Ginberg (1997). Nine national parks within Namibia, South Africa and Zimbabwe were assessed from 1975 to 1995 with almost 80% of wild dog reintroductions ending in failure. The reasons for this ranged from predation by lions, starvation, disease and shooting on nearby farms. However, even a successful release often resulted in high mortalities. For instance, of the twenty-two wild dog introduced to Hluhluwe/Umfolozi Park in 1980-1 only eight remained by 1983 (64% mortality rate) before the pack bred successfully for the first time (Maddock, 1996).

Other more recent examples of reintroduction failures include the inability of released gibbons (Hylobotidae) on the island of Mintin, Thailand to maintain a sustainable wild population due to a lack of suitable habitat availability and poor quality relationships between released adults (Cheyne, 2006). The discovery that the first ever released giant panda (*Ailuropoda melanoleuca*) had died in the bamboo forests of Sichuan Province, China as a result of injuries sustained from fighting with wild panda on June 01, 2007 also highlights the fragility of reintroduction conservation (Carnivore conservation org., 2007).

The first documented reintroduction was of fifteen American bison (*Bovida bison*) from the New York Zoological Society's Bronx Zoo to Wichita National Forest, Oklahoma in 1907, in order to reestablish southern American prairie populations (Beck, 2006). What is most worrying is that in all this time the reintroduction success rates are not improving (Fischer and Lindenmayer, 2000). However, one generally accepted prerequisite for successful conservation programmes is the ability of captive animals to undertake wild-type behaviour (Kinahan, 2005; Mathews *et al.*, 2005; Glick, 2007). This is therefore often used as the benchmark to assess "appropriate behaviour" in captive species, despite being an unrealistic target in many cases (Kinahan, 2005).

1.2.2. Education

'To educate' infers the need to train or instruct intellectually, morally and socially with the development of character or mental powers based on experience (Hawkins, 1990). Zoological institutions afford the opportunity to educate the general public in conservation and welfare issues along with broader topics of the natural world (AZA, 2007).

Some of the elements required to achieve public education within zoos include the creation of interactive exhibits, interpretive tours and education programs that bring people into contact with living animals (AZA, 2007). These requirements can go hand in hand with the conservation and welfare objectives of the institute (Falk *et al.*, 2007). However, caution must be taken to ensure conflicting messages are not conveyed; for example petting an animal while stating verbally it is a wild creature, not a pet. In addition the welfare of the animal should always be taken into account as shows and demonstrations may be enjoyed by the public but may put undue stress on the animal (Shepherdson *et al.*, 2004).

1.2.3. Welfare

Animal welfare was defined by Dawkins (2003) as an animal's ability to take control of the surrounding environment and have individual choice. Ensuring the availability of resources for which an animal was most motivated to interact with was seen as the best way in which to improve welfare (Dawkins, 1990). Examples of enclosure design and enrichment schemes aimed at improving animal welfare in zoos is discussed under the relevant sections below.

The measure of welfare has traditionally been determined by physical health, long life and reproductive success of the animal (BIAZA, 2007). More recently, natural and abnormal behaviour along with the degree of freedom and choice have also been used to measure welfare (Wickins-Drazilova, 2006).

The discussion of abnormal behaviour often leads to the mention of stereotypies. A stereotypic behaviour otherwise known as obsessive-compulsive behaviour, is defined as "normal activities or behaviour for the species, but repetitive or constant, without obvious purpose or function, even to the point of being damaging to the animal" (Blood and Studdert, 2002). Such behaviour can range from gross abnormalities such as nodding and body swaying (Elzanowski & Sergiel, 2006), pacing (Moore, 2004) and self-mutilation (Broom & Johnson, 1993) to more subtle behaviour such as tongue rolling in giraffes (*Giraffa camelopardalis*) (Hummel et al., 2002) and sleeping excessively (Wikipedia, 2007).

The motivation and affects of such 'abnormal' behaviour on the animals are often controversial. Obviously, examples of self-mutilation such as non-human primates exhibiting auto-aggression due to unsatisfactory environmental conditions (Broom & Johnson, 1993) can clearly be defined as detrimental to an animal's wellbeing and therefore raise serious welfare issues. However, Shepherdson (2004) examined 55 polar bears (*Ursus maritimus*) (50% of the North American captive bear population) and determined that the stereotypic behaviour displayed by many of these animals functioned to increase stimulation in a boring environment, decrease arousal to stress, provide a response to frustration and satisfy the motivation to be active. He argued that in these cases the 'abnormal' behaviour was a coping mechanism which had a negligible affect on the animal's welfare.

Other authors such as Hummel *et al.* (2002) go further, stating that certain stereotypic behaviour may actually be beneficial to an animal's welfare. In this study the possible causes of tongue rolling and object licking in captive giraffe was examined. One of the possible explanations was that far from this behaviour being abnormal it could be seen as an adaptive behaviour as the high quality (energy) low roughage diets that are often feed to captive animals result in decreased chewing, decreased salivation and hence decreased buffering of the rumen content. Therefore the tongue roling that is seen as abnormal may actually be increasing saliva production, aiding in ruminal buffering and hence preventing physiological disturbances such as ruminal acidosis.

1.2.4. Conflicting Objectives

The need for conservation, education and welfare in the modern zoo can lead to conflict. For example, what an animal wants to do (welfare) may not indeed be seen as a 'natural wild-type behaviour' (conservation). Furthermore, concentrating on increasing an animal's attractiveness to the public in order to maximise the 'educational worth' of the species, may be seen as detrimental to the animal's welfare.

This is highlighted in the review by Kinahan (2005) which draws attention to wild type behaviour and their conflicting importance to conservation and welfare objectives. One example used was the ability of large cats to hunt, which is imperative for successful reintroduction into the wild (conservation) but it is argued that it may (Leyhousen, 1979) or may not (Lindburg, 1988) be of significance in the overall welfare of such animals within captivity. Kinahan (2005) ultimately concludes that "well defined and realistic goals as well as a thorough understanding of the study species are necessary before we can identify appropriate behavioural patterns for animals in captivity".

However, the ultimate conflict of interest must be the ethical question revolving around the welfare of released animals within conservation programmes (International Academy of Animal Welfare Science, 1992) when the mortality rate of released captive bred species is often far greater than translocated wild-bred counterparts (Ginsberg, 1994).

1.3. FINDING SOLUTIONS

1.3.1. Enclosure Design

In order to try and meet the requirements of the modern zoo many of the old Victorian cage type exhibits are being replaced with new style environmentally naturalistic, often mixed species larger enclosures. Size however, is not everything as "it is not just the amount of space that is important but what can be done with it" (BIAZA, 2007).

Many countries have legislation outlining minimum standards that must be adhered to, such as the Zoo Licensing Act (1981) and Animal Welfare Act (2006) within the U.K. WAZA also has a Code of Ethics and Animal Welfare that was adopted in 2003 for all its members, highlighting the requirements on zoo enclosures and specific points to note in any design such as the materials to be used and proximity to the public.

Recent advances in the design of zoos intended to facilitate the above objectives have been mainly in America, where more and more animals are kept in simulated environmentally wild-type exhibits; for example the Congo Gorilla Forest exhibit at the Bronx Zoo, New York which incorporates a 6.5 acre area of simulated rainforest housing over 400 animals from 55 species including the largest breeding group of lowland gorillas (*Gorrilla beringei graueri*) in North America (Wild conservation society, 2002). Other examples include the Australian Outback Adventure that opened in 2006 at Detroit Zoo, Michigan that incorporates a walking path through a simulated outback habitat that is home to 17 red kangaroos (*Macropus rufus*) (Detroit Zoo, 2006) and in San Francisco Zoo, California the 3 acre mixed species African Savanna exhibit, houses giraffe, antelope species, African Ostrich (*Struthio camelus*) and many endangered African bird species (San Francisco Zoo, 2004).

Elsewhere in the world other innovative designs are being implemented, such as the walk through aviary that was opened to the public at The National Zoological Gardens, South Africa in 2005 which houses indigenous birds from four different habitats. Another example is that of the Taronga Zoo, Australia that has a South East Asian Rainforest Experience exhibiting 200 animals from 40 different species including 4 Asian elephant (*Elephas maximus*) in a simulated rainforest setting with misting around ponds and waterfalls to create a humid environment and sound scapes to reproduce the natural sounds of the forest (Sydney Morning Herald, 2006).

Despite the improvement in enclosure design aimed at recreating more naturalistic surroundings, it is still often unrealistic to elicit wild-type behaviour for all species, especially those with more complex behavioural repertoires (Kinahan, 2005). The question must also be asked, who benefits more from naturalistic enclosures, the animals or the visiting public? (BIAZA, 2007) These problems may go some way to explaining the continued lack of success with reintroduction programmes (Fischer and Lindenmayer, 2000) and the continued problems of stress exhibited by certain species in captivity leading to welfare concerns (Broom & Johnson, 1993).

1.3.2. Environmental Enrichment

There are many definitions of ‘environmental enrichment’ in the literature. To define it in the most basic form: Environment – surroundings, conditions or circumstances of living (Hawkins, 1990); Enrichment – to increase strength, wealth or value (Hawkins, 1990). Taking these two basic definitions in the context of captive zoo animals, environmental enrichment can be seen as the means by which an animal's surroundings can be enhanced. The aim of such enhancement can be to improve an animal's well-being (welfare), promote instinctive or learned wild-type behaviour (conservation), ensure the enclosure is more aesthetically pleasing to the public (education) or a combination of these reasons.

Environmental enrichment has been dominated by two approaches: the naturalistic approach, that relies upon creating the wild environment in captivity to provide stimulation for captive animals (Wormell & Brayshaw, 2000) and behavioural engineering, which relies upon providing devices and machines that animals operate to receive some form of reward usually food (Young, 2003). A more user friendly categorisation was discussed by Bloomsmith *et al.* (1991) that identified five major types of enrichment, each of which can be subdivided:

1 Social
- a) Contact
  - i. Conspecific (pair, group, temporary, permanent).
  - ii. Contraspecific (human, non-human).
- b) Non-contact
  - i. (Visual, auditory, co-operative device).
  - ii. (Human, non-human).

2. Occupational
- a) Psychological (puzzles, control of environment).
- b) Exercise (mechanical devices, run).

3. Physical
- a) Enclosure
  - i. Size (alteration).
  - ii. Complexity (panels for apparatus).
- b) Accessories
  - i. Permanent (furniture, bars).
  - ii. Temporary (toys ropes, substrates).

4. Sensory
- a) Visual (tapes, television, images, windows).
- b) Auditory (music, vocalizations).

c) Other stimuli (olfactory, tactile, taste).

5. Nutritional

a) Delivery (frequency, schedule, presentation, processing).

b) Type (novel, variety, browse, treats).

Such programmes of enrichment range from large projects such as the natural environmental simulations discussed above under 'enclosure design' to much smaller, simplistic strategies. To illustrate the various classes of environmental enrichment, below are examples of current projects being undertaken in zoos around the world.

In addition to the large scale naturalistic enclosures designed to mimic wild habitats other examples of behavioural enrichment include the placement of branches in the elk (*Alces alces*) and reindeer (*Rangifer tarandus*) exhibits at Minnesota Zoo, U.S.A. during rutting to help animals shed the velvet from their antlers, hence encouraging wild-type behaviour (Minnesota Zoo, 2007). In Auckland Zoo, New Zealand the spider monkeys (*Ateles geoffroyi geoffroyi*) have horizontal bamboo poles that move from side to side to stimulate natural swinging and balancing behaviour (Auckland Zoo, 2007). Training is another element of behavioural enrichment that can be utilized in order that animals will cooperate with certain medical procedures that would otherwise require physical or chemical constraint; for example the male western lowland gorillas' (*Gorilla beringei graueri*) at Omaha's Henry Doorly Zoo, Nebraska that have been trained by Dr. Corrine Brown to ejaculate voluntarily in order that electro-ejaculation under anaesthetic is not necessary. This allows semen to be collected that is used for artificial insemination of females such as those at the Barcelona Zoo, Spain (Abello et al., 1999).

With regards to social peers, very few animals in modern zoos are kept in isolation with many of the newer enclosures not only incorporating multiple individuals from the same species but developing mixed exhibits with a variety of species in order to more closely mimic wild-type conditions. In Chester zoo, U.K. the 'Bears of the cloud forest' exhibit that opened in 2004 houses spectacled bears (*Tremaretos ornatus*) in a habitat of trees and rocks that share the enclosure with ring-tailed coatis (*Nasua nasua*) (Chester

Zoo, 2007). This was taken further in Saint Louis Zoo, U.S.A. where in the 'Red Rocks' area the zoo staff plan every year which exhibits will be mixed. For example the banteng (*Bos javanicus*) herd and Reeve's muntjac (*Muntiacus reevesi*) or the bongos (*Tragelaphus euryceros*) and the yellow-backed duikers (*Cephalophus silvicultor*) have been mixed in the past. The idea behind the exercise is to "educate visitors by telling a story about whole bio-communities rather than single featured residents while also providing an interactive and dynamic experience for the animals" (Saint Louis Zoo, 2007).

Artificial appliances, although not necessarily as aesthetically pleasing to the public as naturalistic artifacts, can be extremely useful enrichment tools. Oregon Zoo, U.S.A. uses climbing structures and rope netting in the colobus monkey (*Colobus guereza*) enclosure (Oregon Zoo, 2007) and Monkey World in U.K. uses complex polyvinyl chloride (PVC) jungle gym and rope swings throughout its facilities that houses over 150 primates from 15 different species (Cronin, 2005).

Food based enrichment is the most popularly documented form of environmental stimulation within zoological establishments (Azevedo *et al.*, 2007). In Edinburgh Zoo, U.K. fruit is suspended on a long thin piece of rope from a walkway so that the ringtailed lemurs (*Lemur catta*), red-ruffed lemurs (*Varecia variegata ruba*) and Sclater's black lemurs (*Eulemur macaco flavifrons*) have to adopt an inverted posture to obtain food otherwise out of reach. This mimics the wild behaviour of all three species (McMonagle & MacDonald, 2007). Other simple methods of presenting food items in a novel manner include scattering food over the floor of the enclosure rather than in one position such as for the African savanna elephants (*Loxodonta africana*) of the National Zoological Gardens, South Africa (Ingle-Moller, 2007) or using feeding cubes that release food items when manipulated correctly by the animals such as the bug puzzles (ball with small holes in it) that are given to the meerkats (*Suricata suricatta*) at the Minnesota Zoo, U.S.A. (Minnesota Zoo, 2007). Both these methods are designed to increase foraging and feeding times, as is the presentation of novel food items such as peanut butter, fruit pie filling, raisins and sunflower seeds stuffed into small holes around the Grizzly bear (*Ursus arctos horribillis*) exhibit at Oregon Zoo, U.S.A. (Oregon Zoo, 2007).

Finally, allowing animals choice within their environment is also becoming a more widely practiced form of environmental enrichment (Azevedo *et al.*, 2007). For example, in Blackpool zoo U.K., the four female Asian elephants have access to the house and paddock twenty-four hours a day allowing them choice over their environment (Blackpool Zoo, 2007). In Smithsonian National Zoological Park, U.S.A. the birds within the aviary have areas where they can hide or be seen, bathe in water or dust, eat from a tray or find their own food and move between the sun or shade (Smithsonian, 2007).

Therefore, as illustrated above, environmental enrichment is an integral part of the modern zoological garden, aimed at improving animal conservation, welfare and public education. However such creativity and environmental enrichment must go hand in hand with sound corroborative research, to achieve long term improvements.

1.3.3. The Science of Environmental Enrichment in Zoos

Environmental enrichment is a relatively new area of scientific study; however, since 1999 there has been a noticeable acceleration in the number of articles published (de Azevedo et al., 2007). Despite increasing efforts to determine the efficacy of this field of work it still often lacks theoretically based guidelines to assist animal care staff in establishing effective enrichment programs (Tarou & Bashaw, 2007). Organisations are trying to change this and establish multidisciplinary cooperation, for example the 7th International Conference on Environmental Enrichment held in New York in 2005, was entitled ‘Unifying the Art & Science of Animal Enrichment’. It featured thirty presentations during the symposium with topics ranging from welfare, abnormal behaviour and giving animals’ choice, to non-visual sensory stimuli and methods of assessing enrichment (Wildlife Conservation Society, 2005).

One of the major areas that must be investigated in order to ensure enrichment success is the fundamental source of problems in order that appropriate modifications can be implemented. For instance, Clubb and Mason (2007) noted that certain carnivore species such as the brown bear (*Ursus arctos*), American mink (*Mustela vison*) and snow leopard (*Panthera uncia*) appear to adapt well to captivity where others such as the clouded leopard (*Neofelis nebulosa*) and the polar bear (*Ursus maritimus*) tend to be prone to breeding problems, poor health and repetitive stereotypic behaviour. They determined that understanding the fundamental source of such differences could allow for more pre-emptive rather than reactive enrichment. They collated data on median stereotypic levels and infant mortalities for multiple captive carnivores then regressed these values against median values of relevant natural behavioural biology (e.g. hunts per day, home range size etc.). It was found that instead of stereotypic levels and infant mortality rates relating to foraging as often assumed, it was linked to natural ranging behaviour (i.e. increased home range size and typical daily travel distance in the wild related to increased stereotypies and infant mortalities in captivity).

1.2.3.1. Enclosure design

With the many advances in enclosure design there is a growing need to determine the animals' usage and movements within such environments in order to ensure such spaces forfil their desired purpose. Such analysis is critcal not least because the building and construction of such enclosures is the single most costly form of enrichment afforded zoo animals and once constructed often the most difficult to change or adapt.

Stoinski *et al.* (2000) highlighted the lack of information available in respect to habitat usage, documenting four years of habitat use and structural preferences of western lowland gorillas at Zoo Atlanta, U.S.A.. It was determined that quality rather than quantity of space was important as 50% of the time was spent in less than 15% of the exhibit by the animals observed.

Also in Zoo Atlanta, Chang *et al.* (1999) examined the changes in behaviour between mandrill (*Mandrillus sphinx*) in their traditional all indoor exhibit and the new indoor / outdoor facility. It was found that as hoped, in the new exhibit that represented important features of the mandrills' forest habitat, foraging and locomotion increased, while stationary behaviour decreased. It was concluded that it was the increased environmental complexity and novelty rather than the decreased confinement that improved the primates' well-being.

Vertical space has also been recognized as an important element of enriched environments. In the Fort Wayne Children's Zoo, Indiana, U.S.A. the spatial utilization of three adolescent orangutans (*Pongo pygmaeus*) were examined. The indoor enclosure had a flooded floor and retractable skylight with large moulded trees and interwoven vines covering an area of 1,620m^3 in space. Dividing the vertical space into four zones it was found that the upper canopy was favoured with only 1% of the time being spent on the flooded floor. The animals behaviour was seen as comparable to wild orangutans and it was determined that the design of the habitat provided opportunities for a range of species-typical behaviour that varied depending on vertical hight (Hebert & Bard, 2000).

Not all such enriched enclosures however, are sufficient to achieve their aim. Wood (2002) investigated two groups of zoo chimpanzees (*Pan troglodytes*), one that lived in a small and mostly barren habitat at the Los Angeles Zoo, U.S.A. yet had a successful social history and the other that lived in a larger and more enriched habitat within North Carolina Zoological Park, U.S.A. yet had a turbulent social history. It was determined that Los Angeles chimpanzees had lived with social stability and familial continuity while the North Carolina chimpanzees had been split apart and reconstituted six times and many had been introduced as adults. This highlighted the fact that enriched environments are not sufficient to improve animal well-being without adequate management and husbandry also being practiced.

Other external factors have also been shown to influence habitat utilization. In India, thirty captive lion-tailed macaques (*Macaca silenus*) from eight different zoos were observed ‘on exhibit’ and ‘off exhibit’. Mallapur *et al.* (2005) determined that although space utilization varied among individuals, it was negatively influenced by the presence of visitors. Visitor presence also increased abnormal behaviour by 20%, suggesting that visitors adversely affect the welfare of the macaque (Mallapur *et al.*, 2005).

As indicated by the examples above, much of the published habitat utilization studies have been on non-human primates. However, assessment of space usage in mixed species exhibits has also been studied. Armstrong & Marples (2003) undertook a study to look at the efficacy of mixed species exhibits within Dublin Zoo, Ireland in which five giraffe (*Giraffa camelopardalis*), five plains zebra (*Equus burchelli*), five scimitar horned oryx (*Oryx dammah*) and three Ostrich (*Struthio camelus*) were housed. Hierarchical structures were shown to be stable and correlated to body size between the species. Concentrating on the effect within the zebra population, it was determined that there was a negative correlation between space use and social rank where lower social rank zebra showed higher space use.

1.2.3.2. Environmental enrichment

The assessment of behavioural enrichment overlaps that of enclosure utilization as discussed above. One area not yet discussed is training, that is an important area of behavioural enrichment. Lambeth *et al.* (2006) demonstrated that positive reinforcement training (PRT) techniques reduced stress levels in the management of captive nonhuman primates. 128 chimpanzees were used in the study from various American establishments. PRT was used to train chimps to voluntarily present a leg for an intra-muscular injection with haematology and serum chemistry profiles being collected from healthy chimps of both sexes and various ages during their routine annual physical examination over a seven year period. By examining variables of acute stress such as total white blood cell count and absolute segmented neutrophils it was determined that animals that voluntarily presented for injection compared to involuntary injections showed significantly less indicators of physiological stress.

The study of enrichment with regards social peers can observe behavioural changes in animals either, before and after separation of individuals or before and after introductions. This is an important aspect of zoo environments as animals are often moved between zoos for breeding purposes or to manipulate social group composition. Most attachment relationships between animals have however, only been studied in non-human primates (Hoff et al., 1994).

Tarou *et al.* (2000) observed two female giraffe at Zoo Atlanta, U.S.A. before and after separation of the resident male for breeding purposes. The three had been together for nine years and although it was indicated in this work that previous studies had suggested giraffe do not form lasting attachments both females indicated behavioural and physiological signs of stress after separation. These included increased levels of activity, stereotypical behaviour, contact behaviour and decreased habitat utilization.

In the case of platypus (*Ornithorhynchus anatinus*) lone captive individuals were observed having a predictable nocturnal activity pattern, with long periods of continuous presence in the water, much like that of their wild counterparts. When individuals were paired a 'dominance' relationship developed with the dominant individual's activity pattern remaining largely unchanged. However, the subordinate animal's active period shortened and became fragmented appearing more often during the daylight period. This was suggested to be due to avoidance reactions as a result of competition, forcing the subordinate to be active more often during the day to ensure temporal separation from the dominant animal (Hawkins, 1998).

Artificial appliances such as inedible, manipulable objects are widely used within zoos. Altman (1999) examined the welfare of three types of captive bear: polar bears (*Ursus maritimus*), sloth bears (*Melursus ursinus*) and spectacled bears (*Tremiarctos ornatus*). It was determined that all three groups showed a high level of stereotypic pacing and excessive inactivity. The two polar bears were given plastic floats while the sloth bear and spectacled bear received plastic balls. Within the seven week experiment, the polar bears doubled their activity in the presence of the toy, the spectacled bear halved its pacing in the presence of the toy, yet the sloth bear showed no response to the objects.

Carlstead *et al.* (2005) looked at different food based enrichment methods of reducing stereotypic behaviour in captive sloth bears, American black bears (*Ursus americanus*) and brown bears (*Ursus arctos*). Firstly, honey-filled logs were placed in each enclosure; this significantly increased investigatory activity in place of pacing, with habituation to the manipulatable objects being counteracted by refilling the logs. Secondly, different feeding strategies were employed for the American black bear with once daily feeding in the den, once daily feeding with supplemental food from a mechanical feeder and once daily feeding with food hidden in the exhibit in manipulatable objects, being tested. Only the later form of feeding caused a significant decrease in stereotypic pacing behaviour from a median of 150 minutes per day to 20 minutes per day. Therefore the use of novel food items and novel presentation of food appeared to successfully decrease stereotypic behaviour.

In another successful use of feed based enrichment to increase welfare, Jenny & Schmid (2002) examined the hypothesis that Amur tigers (*Panthera tigris altaica*) in Zurich, Switzerland were showing stereotypic pacing behaviour due to "permanently frustrated appetitive foraging behaviour". Several electrically controlled feeding boxes were installed where access to the food was limited to twice daily for 15 minutes at semi-random times. The boxes had to be actively opened by the tigers. The effect on behaviour was monitored for individuals in both solitary confinement and paired confinement with the female decreasing pacing from 16% to 1% when solitary and from 7% to 0.01% when paired. The male only decreased pacing when the feeding boxes were employed within paired enclosures from 10% to less than 0.01%. This study therefore supports the initial hypothesis.

Many other successful food based enrichment studies have been reported such as Stoinski *et al.* (2000) that determined by substituting an equal dry weight of browse for hay in three African savanna elephants, there was a significant increase in feeding time and species-specific behaviour, or Mcphee (2002) that used intact calf carcasses as enrichment for nine large felids in three different zoos to successfully decrease off-exhibit stereotypic behaviour. While Vargas & Anderson (1999) successfully increased predatory skills of seventy captive juvenile black-footed ferrets (*Mustela nigripes*) by exposing them to live hamsters (*Mesocricetus auratus*) in order to improve reintroduction rates back into the wild. With captive lions often suffering from obesity, inactivity and stereotypies, Altman *et al.* (2005) gradually adapted a captive pride from a conventional feeding program to a random gorge and fast feeding schedule. This significantly improved nutritional status and increased activity levels with pacing being half as frequent on fasting days as feeding days.

However research undertaken by Liu *et al.* (2006) at the Beijing Zoo, China indicated that the feed-based enrichment added as a naturalistic stimuli for four adult pandas (*Ailuropoda melanoleuca*) had no significant effects on stereotypic behaviour or on the associated faecal cortisol levels that were being used to measure physiological stress. This study was carried out by analyzing behavioural observations and faecal cortisol levels before and after environmental enrichment for three female and one male adult panda (*Ailuropoda melanoleuca*) each housed separately. Each enclosure consisted of a small pond and artificial hill. The panda were fed steamed breads daily and one pot of milk morning and evening. Fresh bamboo was fed *ad lib.* and during the enrichment period fresh bamboo segments were stapled firmly into small holes drilled on large logs.

Zoo research on animal control in their environment appears limited. Owen et al. (2005), compared the behavioural and hormonal data for four giant panda in two different management conditions. The first group was confined to an exhibit area while the second was given choice to move freely between exhibit and off-exhibit bedroom areas. Those given a choice displayed significantly fewer signs of behavioural agitation and urinary cortisol suggesting that offering some environmental control can improve well-being. Likewise Ross (2006) also demonstrated an improved well-being in two sibling polar bears when given free access to indoor off-exhibit holding space rather than being confined purely to the outside on-exhibit area.

1.2.3.3. Limitations of zoo research

Mathews *et al.* (2004) attempted to use behavioural assessment to determine the suitability of captive bred animals for reintroduction. This was achieved by using bank voles (*Clethrionomys glareolus*) as a model to compare wild-bred and captive-bred animal behaviour under identical novel environmental conditions. This illustrated that the captive animals did display some wild-type behaviour, but were generally less dominant and unable to utilize certain food resourse. In addition Mathews *et al.* (2004) inferred that such evaluation could be used to determine the impact of environmental enrichment.

Mason *et al.* (1998) discussed using the economic technique of measuring the elasticity of demand i.e. the change in consumption or usage of a particular resource dependant on its' cost. Inference was then made to the ability to rank such resources in order of importance with the purpose of improving welfare for captive animals.

The problem with many captive animal studies however, is the limited sample size. The basic assumption that individual data points are statistically independent is therefore commonly inaccurate in behavioural studies (Martin & Patrick, 1993). Pooling related data (Ings et al., 1997) and pseudo-replication (Williams et al., 1996) have incorrectly been used by some authors in an attempt to overcome this difficulty.

Pooling related data is a common error in behavioural research, with this practice being called the 'pooling fallacy' by Machlis *et.al*. (1985). Machlis *et al.* (1985) showed how this erroneously assumes that the aim of the research is to obtain large samples of measurements, rather than measurements from large samples of subjects (Martin & Patrick, 1993). One example is Patton *et al.* (1999) that monitored the pregnancy and reproductive cycles of thirteen captive white rhinoceros (*Ceratotherium simum simum*) by measuring faecal progesterone and using behavioural observations. Eight females exhibited flat or erratic endocrine profiles while evidence of seventeen reproductive cycles, were found in five females. The cycles fell into two main categories; those that lasted approximately one month duration (n=10) and those that lasted two months duration (n=7). Incorrectly the authors have totaled n=17 instead of correctly stating n=5.

Pseudoreplication can also be a problem (Hurlbert, 1984). In this case, although a large sample of subjects may be examined, the conditions to which they were all exposed may not truly represent the same conditions (Martin & Patrick, 1993). An illustration is that of Parker *et al.* (2006) who examined the effectiveness of feed based environmental enrichment on reducing stereotypic behaviour in two captive vicugna (*Vicugna vicugna*) housed within the same enclosure. They showed that both individuals decreased stereotypies when their normal food was divided into two distinct areas and increase stereotypies when browse was added to the diet. These findings were highly significant in one of the animals but less clear in the second. However, one of the adult females had lived at Marwell Zoological Park since birth, while the second arrived only two weeks prior to the onset of the observations. The effect that this difference may have had on the behaviour of these two animals is unclear.

The ultimate problem with such statistical error, is that it reduces the ability to relate such research to other populations (Kaps and Lamberson, 2004).

1.2.3.4. Unanswered questions

As discussed above, food-based enrichment is the most common form of environmental enrichment reportedly utilized in zoological establishments (Azevedo *et al.*, 2007). The current body of research available in this area determines the principle aim of such enrichment as being a desire to increase an animal's well-being (welfare) or species specific, wild-type behaviour (conservation) by increasing foraging time (Swaisgood, 2007). The subsequent increase in activity levels is also sometimes reported as being beneficial to the attractiveness of the animals to the visiting public (Young, 1997). Many authors also state that increased foraging activity results in increased enclosure utilization (Shepherdson *et al.* (2005); Sommerfield *et al.* (2005)). However, is this approach too simplistic?

Does the presentation of food in a novel manner, such as hiding it throughout the enclosure always result in increased foraging time for every species? If so does this really increase an animals well-being or species specific behaviour? Furthermore, does increased foraging activity always result in increased enclosure utilization? Although the current published research would suggest a YES answer to the above questions in most instances, is it that so-called 'failed' enrichment programmes have largely gone unreported, resulting in a bias within the scientific press? The subsequent study aims to help answer some of these questions.

1.2.3.5. What is required for a good enrichment study?

Any research must first begin with a fundamental question. In this case it is three-fold: Does food-based enrichment 1) increase foraging time, 2) increase welfare and / or species specific behaviour and 3) increase enclosure utilization?

Swaisgood et al. (2005) highlighted four major requirements for a scientific approach to enrichment; these were:

1. Large sample size e.g. through multi-institutional studies.
2. Appropriate repeated measures design e.g. multiple baseline and experimental phases.
3. Provision of full statistical information about behavioural changes observed including standard error.
4. Ultimately develop predictive science for enrichment, stereotypies and well-being.

To expand on the above list there should also be an effort to minimize external variables that could bias results.

1.2.3.6. What key problems are seen for mammalian groups in zoos?

When considering feed based enrichment, it is useful to divide mammals into three major groups according to their evolutionary physiological feeding strategy, defined as: carnivores, omnivores (including insectivores) and herbivores, with herbivorous species being further subdivided into ruminants and hindgut fermenters. Carnivores are defined as those animals that only feed on flesh or other animal products (Hawkins, 1990). Omnivores are animals that feed on both animal and plant products and herbivores are those animals that feed exclusively on plant materials (Hawkings, 1990).

Carnivores include members of the cat family such as leopard (*Panthera pardus*). Omnivores incorporate a broad group of animals such as red panda (*Ailurus fulgens*) and primate species including the lion-tailed macaque (*Macaca silensus*). Ruminants incorporate antelope species such as the steenbuck (*Raphicerus campestris*) and hindgut fermenters include all equine animals as well as African savanna elephant (*Loxodonta africana*).

Each of these groups has its own set of problems commonly encountered in captive situations.

Large carnivores are evolutionarily adapted to capture and consume large vertebrate prey (Biknevicius & Van Valkenburgh, 1996). In captivity the opportunity to undertake such natural behaviour patterns that are necessary to succeed in a natural habitat are denied (McPhee, 2002). Instead, captive felids are often fed primarily a diet of processed meat (Lindburg, 1998) that can result in physiological and behavioural problems (McPhee, 2002). For example, Lindburg (1998) showed that captive-reared tigers (*Panthera tigris*) fed processed meat suffered from gingival health problems, plaque build-up and focal palatine erosions. Additionally, many authors have shown that an environment without appropriate external stimuli can elicit stereotypic behaviour such as pacing, head swinging and excessive licking (McPhee, 2002).

Mallapur & Choudhury (2003) suggested that captive omnivorous primates such as macaques are prone to abnormal behaviour such as stereotypic pacing and self-biting due to the variance in diet and food acquisition techniques used in the wild. Abnormal behaviour was seen in the absence of insects and a variety in the diet. Cognitive abilities and social complexities were also suggested to play a role in the exhibiting of undesirable behaviour. Mallapur & Choudhury (2003) concluded that a reduction in the time spent foraging and undertaking other active species specific behaviour was directly associated with an increase in the proportion of abnormal behaviour seen.

A large portion of, a wild herbivores diet consists of low quality vegetation (Shoshani, 1992), therefore a considerable portion of the time must be spent feeding in order to fulfil nutritional requirements. This is illustrated from data collected by Shannon G. (2005) for a PhD thesis, documenting the quantitative analysis of activity budgets for free ranging African savanna elephants from three South African national parks. This study showed that male and female animals spent a mean of 45% and 42% respectively of their time feeding, with peak feeding bouts occurring between 06:00 to 08:00 and 16:00 to 18:00.

The use of relatively high quality feed (compared to wild co-specifics) and the use of concentrate commercial diet means that captive herbivores consume there required nutrients within a short space of time. Thus in zoos, a large amount of time that would be spent feeding in the wild freed up (Wiedenmayer, 1998). The lack of sufficient stimulation of foraging activity is thought to be one of the main factors underlying the performance of stereotypies in captive herbivores (Oftedal *et al.*, 1996).

In summary, abnormal behaviour is seen in many captive mammals and is often related to decreased activity and foraging behaviour compared to that of wild conspecifics.

1.4. AIM & HYPOTHESIS

1.4.1. What Is The Overall Aim Of The Project?

Modern zoological institutes have three main aims: conservation, education and animal welfare. "It is unarguable that animals being re-released into the wild need to know how to forage or hunt for food" (Kinahan, *personal communication*). The type and presentation of food items to captive animals has also been shown to have a direct effect on the visability of certain species to the public (Young, 1997) along with the degree of stereotypies observed (Oftedal *et al.*, 1996).

Food based enrichment is the most popularly documented form of environmental enrichment within zoological establishments (Azevedo *et al.*, 2007) and yet, as discussed above, the literature scientifically testing the efficacy of feed based enrichment is not extensive, usually only examining a single species and rarely reporting failures.

The aim of this study was therefore to determine the effect of feed-based enrichment on the activity budgets and enclosure utilization of a representative group of mammals from a broad range of taxa within the National Zoological Gardens (NZG), Pretoria. The exact focus of this work is hence to see if feed-based enrichment is as effective a tool for captive animal welfare and conservation as currently thought.

1.4.2. What Were The Expected Findings?

From the literature I would expect that feed-based enrichment would increase foraging time, increase animal welfare by decreasing stereotypies, increase wild-type behaviour and increase enclosure utilization for all individuals in all study species, with very few exceptions. However, from personal experience of seeing the number of enrichment feed-based 'toys' lying around enclosures within various zoos I would expect a much more varied response, between not only different species but also between

2. METHOD

2.1 STUDY SPECIES

Six different mammal species at the National Zoological Gardens, South Africa were chosen for this study. The number of species used was determined by the number of observers that were available to undertake the work. The aim was to incorporate a broad range of species that had a variety of feeding types (e.g. carnivores, herbivores and omnivores) and in which a specific goal for feed-based enrichment could be established. Although most of the chosen animals had been exposed to different enrichment protocols in the past, none had been systematically studied to determine the true success or failure of such ventures. It was believed that by taking such a diverse group, with the inherent problems of each as discussed in the introduction, a true reflection of the efficacy of the enrichment protocol could be tested.

In addition to the above, the following criteria were used to determine the final selection of species used for this study-:

a. Willingness of the keeper to become involved in such a study.

b. No foreseen changes to the composition of the group during the period of observation.

c. No foreseen changes to the animals' routine or environment during the period of study.

d. Animals within a group were individually identifiable.

e. Species in question typically diurnal.

f. The animals were clearly visible at all times from a static viewing point.

g. Wild type behaviour budgets were available from the literature.

Based on these criteria the following animals were selected for this study-:African savanna elephant (*Loxodonta africana*), leopard (*Panthera pardus*), lion-tailed macaques

(*Macaca silensus*), red panda (*Ailurus fulgens*), black and white ruffed lemurs (*Varecia variegate*) and steenbuck (*Raphicerus campestris*).

2.1.1 African Savanna Elephant, *Loxodonta africana* (Blemenbach, 1797), Elephantidae

Four adult elephants, one male and three females were housed at the NZG. The male, Charlie (Elephant 1), and the oldest female, Thandi (Elephant 4), were both wild-caught in Zimbabwe and estimated to be born in 1981. Both arrived in Pretoria in July 2001 on loan from Pietermaritzburg. Landa (Elephant 3), born in 1984, and Pumbi (Elephant 2), born in 1985, were also wild-caught, being donated from Kruger National Park. Landa arrived at the NZG in April 1986, whilst Pumbi joined her in March 1987. Thandi was identified by having one short tusk, while Landa had two long thin tusks and Pumbi had no tusks.

All four elephants were housed together, spending the majority of the day and night in the large enclosure with free access to the two adjoining night rooms (see appendix 7.2a for enclosure design). For one to three hours a day the animals were moved into the smaller enclosure so as to facilitate cleaning and food replenishment in the main area. This started at any time from 08:00 to 11:00.

Under non-enrichment conditions, a diet of fruit, vegetables and fibre were delivered to the elephants. This included ¾ bale (11kg) teff (grass), 1 ½ bales (15kg) lucerne, 1 bucket (10kg) horse cubes, 1 bucket (10kg) antelope cubes, ½ box (8kg) carrots, ½ box (8kg) beetroot, 5 loaves of bread, 12 apples, 12 bananas, ¼ bag (2.5kg) potatoes, ¼ bag (2.5kg) sweet potatoes, ¼ bag (4kg) pumpkins and ¼ bag (2kg) squashes per animal. One wheelbarrow full of mixed, fruit and vegetables were randomly scattered over the floor of the small enclosure. This was the incentive to encourage movement of the elephants into the smaller area.

The teff and lucerne were provided in the large enclosure in four to five piles within twenty metres of the night room entrance. The remaining bulk of the food items were randomly thrown over the floor of the large enclosure within the vicinity of the night room entrance. Once the elephants were released back into the large enclosure the fruit and vegetables were consumed within two hours. The hay was ingested throughout the day, with some still available at dusk. None remained by the next morning.

2.1.2. Leopard, *Panthera pardus* (Linnaeus, 1758), Felidae

The male leopard Ingwe, was housed alone. Born in captivity in February 1995 within a circus environment (Natal Zoological Gardens owned by Boswell Wilkie Circus), he was loaned to the NZG, arriving in January 1999. He was kept in the night room during the evening from 17:00, being released into the open enclosure from 08:00. Throughout the day he had free access to the nightroom.

Ingwe was feed every second day, with an approximately 5kg slab of meat from either horse (equids) or cattle (bovids) carcasses. It was always positioned in the same location on the elevated ledge at the rear of the enclosure (see appendix 7.2b for enclosure design) and was placed in the enclosure before Ingwe was released from the nightroom in the morning.

2.1.3. Lion-tailed Macaques, *Macaca silenus* (Linnaeus, 1758), Cercopithecidae

All four lion-tailed macaques were captive born, and the group comprised two males and two females. Shylah (Macaque 1 - identified as the skinny male) was born in Wuppertal Zoo, Germany on 12 January 1986 and arrived at the NZG on 09 February 1999. Ganeera (Macaque 2 - identified as the fat female), having been born on 17 September 1994 at Zoo de Doue-la-Fontaine, France, arrived at the NZG on 09 February 1999. Mulan (Macaque 3 - identified as the big male) and Yindi (Macaque 4 - identified as the little female) were both born at the NZG on 12 March 1999 and 18 November 2001 respectively.

During the night the macaques had free access to the night room and outside enclosure. On non-enrichment days, from 08:00 the night room was closed so that cleaning could take place. Between 08:30 and 09:30 all the macaques were closed into the night room so that the outside enclosure could be cleaned and one five litre bucket (10kg) of coarsely chopped seasonally variable fruit and vegetables such as lettuce, tomatoes, banana, apple, leche, pawpaw, melon and grapes along with other food items such as eggs and jam sandwiches were scattered over the floor of the outside enclosure. The macaques would then be confined to the outside enclosure for the rest of the day.

2.1.4. Red Panda, *Ailurus rulgeus* (F. Cuvier, 1825), Ailuridae

The two red panda were mother and daughter, both having been born in the NZG. The older female named Tenzing (Red panda 1 - identified by a thinner tail and light face) was born on 06 December 1993 and Mitchell (Red panda 2 - identified by a thicker tail and darker face) the younger female was born on 19 December 2000.

The non-enrichment feeding regime consisted of a flat plastic tray (45cm diameter and 1cm deep) containing approximately 3kg finely chopped seasonally variable mixed fruits such as apple, banana and kiwi. This was placed on the floor of the left side night room (see appendix 7.2d for enclosure design) at about 10:00 every morning. Approximately ten branches of chopped bamboo were placed outside the central kennel situated mid-way up the main tree in the enclosure once daily at between 14:00 and 15:00.

2.1.5. Black And White Ruffed Lemur, *Varecia variagata* (Kerr, 1792), Lemuridae

The ruffed lemurs were housed in a large mixed age and sex ratio group of fourteen animals. The dominant male and female and their daughter were chosen as key individuals that would be directly monitored to assess the impact of the feed based enrichment. All three animals were born in the NZG; Rex (Lemur 2) the dominant male was born on 29 September 1994, Roxanne (Lemur 3) the dominant female was born on

06 October 1995 and Rubie (Lemur 1) their daughter was born on 06 December 2002. In order to facilitate easy identification of the three animals, colour markers were placed on the fur between the shoulder blades of each individual using children's colour paints that were non-toxic and non-irritant to the animals. Rex had a blue spot, Roxanne a red spot and Rubie yellow.

The normal feeding regime consisted of one bucket (approximately 10kg) coarsely chopped seasonally variable fruit and vegetables such as beetroot, lettace, carrots, bananas and apples. The mixture of fruit and vegetables fed to the ruffed lemurs was placed on three feeding platforms in plastic trays that were evenly spread throughout the enclosure at a height of one metre from the ground. Food was provided once daily between 14:00 and 15:00.

2.1.6. Steenbuck, *Raphicerus campestris* (Thunbery, 1811), Bovidae

The steenbuck were housed as a family unit consisting of an adult male called Rocky (Steenbuck 2), an adult female that was un-named (Steenbuck 1) and their daughter called Sophy (Steenbuck 3). Both the adults were wild caught. Rocky was found in the Mpumalanga mountains, donated by a member of the public to the NZG in 2002 and handraised by keepers. The un-named female was confiscated by Gauteng nature conservation from a member of the public and sent to the zoo in April 2003 at which time she was believed to be about three years old. Sophy was born on 09 March 2005.

The Steenbuck were normally fed with a pile of lucerne (2 kg) and a plastic container of 3kg seasonally variable finely chopped fruit and vegetables such as lettuce, beetroot and carrots. The food items were placed directly outside their night room on the concrete hard standing once daily between 08:00 and 09:00.

2.2. BEHAVIOURAL OBSERVATIONS

2.2.1. Preliminary Work

Between four and eight hours were initially spent by Dr. J. C. Osuagwuh observing each of the study species, during which time ad libitum notes on each groups specific behaviour patterns were collected. These observations were then listed to form an ethogram and utilized in the design of a general observational record sheet (see Appendix 2). Although the observers used the same design of record sheet for each species, behaviour that was not relevant to a specific species, for example elephants clinging, was deleted from the species specific behavioural list (see figure 3.1 for ethogram).

Figure 2.1. Ethogram (adapted from Hnath & Yannessa, 2005)

1. Allogroom – One animal picking through the fur / skin of another using fingers, teeth. This does not include self-grooming.
2. Being groomed – Receiving a groom from another animal.
3. Cling – A baby holding tight around its mothers belly. Two or more adults holding each other tightly.
4. Defaecation – Faecal elimination, squatting to defaecate and straining are all included.
5. Drinking – Taking water into the mouth in order to consume it.
6. Escaping aggression – Hiding, running, cowering. Any action intended to remove the animal from the aggression of another.
7. Feeding – Any manipulation of food consisting of chewing, handling, biting and swallowing of food with the purpose of being eaten.
8. Huddle – Sleeping or resting next to another animal. This does not include two animals sleeping within proximity to each other. The bodies of the animals must be closely touching.
9. Interact with observer – This behaviour consists of prolonged attention to the observer, this does not include casual glances.

10. Interact with public – This behaviour consists of prolonged attention to zoo visitors, this does not include casual glances.
11. Interact with zoo staff – This behaviour consists of prolonged attention to zoo staff, this does not include casual glances.
12. Jumping – Vertically up and down or whilst moving in a horizontal direction, without apparent stimulus from other animals in the group.
13. Maintenance – Behaviour consisting of self-grooming, scratching. This activity does not involve any other animal.
14. Non-visible – When an animal is not seen at that moment, whether hiding or obscured by another object.
15. Pacing – Continuing the same pattern of activity repeatedly whether walking, circling etc
16. Physical aggression – Physical fighting using teeth, claws, hooves, tusks etc.
17. Play – A behaviour consisting of friendly chasing, tumbling and grappling between two or more animals in the group.
18. Postural aggression – Aggression without physical fighting. Including chasing, visual and vocal threats.
19. Running / Sprinting – All cases other than escaping aggression (see above).
20. Sexual behaviour – Examining or licking the genitalia of another animal, attempting to mount or performing a mount.
21. Sleeping / Resting – In a stationary position with eyes closed.
22. Stationary – Animal in non-mobile, resting with eyes open. This does not include huddling with another animal but can be within the proximity of another.
23. Urinating – Urine elimination and squatting to urinate area included.
24. Vocalization – Making any type of noise from the mouth in order to communicate with another. Several different vocalizations occur.
25. Walking – Moving forward at a steady pace, with at least one foot on the ground at any one time.
26. Colic signs/Signs of illness – Kicking at own body, restless and uncomfortable or generally listless. Any abnormal behaviour that can be linked to ill health by the vet are placed in this category.

3. RESULTS

3.1. AFRICAN SAVANNA ELEPHANT *(Loxodonta africana)*

3.1.1. Behavioural Observations

3.1.1.1. Descriptive data

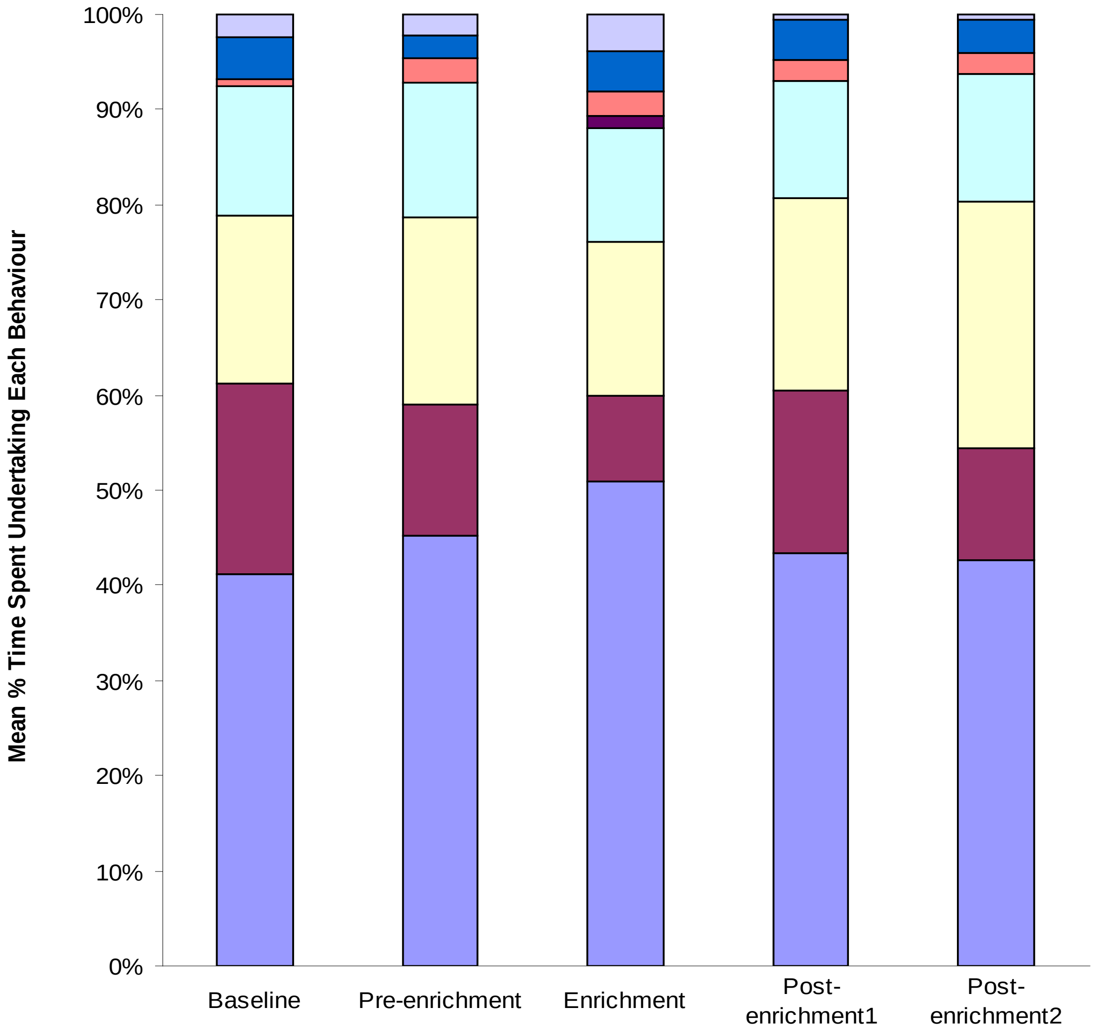
Fig. 3.1. illustrates the proportion of time spent by the elephants performing the various behavioural patterns, by representing the mean time spent expressing each behaviour for the different periods of the study i.e. 'Baseline', 'Pre-Enrichment', 'Enrichment', 'Post-Enrichment Day1' & 'Post-Enrichment Day2'.

All the African savanna elephants spend the majority of the day undertaking feeding related behaviour (Behav A), being stationary (Behav B) and performing active species specific behaviour (Behav D). The male elephant (Elephant 1) also spent a noticeable amount of the day performing abnormal behaviour (Behav C). These observations were true for all periods of the study (see figure 3.1.). See Appendix 6.4 for full descriptive statistics.

Kinahan A.(2007, *personal communication*), suggested that the time of day in which an animal performs specific behaviour may be altered during periods of enrichment even when the overall behavioural repertoire of the animal or the total amount of time spent undertaking each behaviour remains unchanged. Therefore, to determine if this was true for the elephants, fig. 3.2. and 3.3. illustrate the behaviour recorded during the morning period (08:00 to 11:55) and afternoon period (12:00 to 15:55) respectively, for each study period.

Figure 3.1. Representation of behavioural patterns for each study period (African savanna elephant)

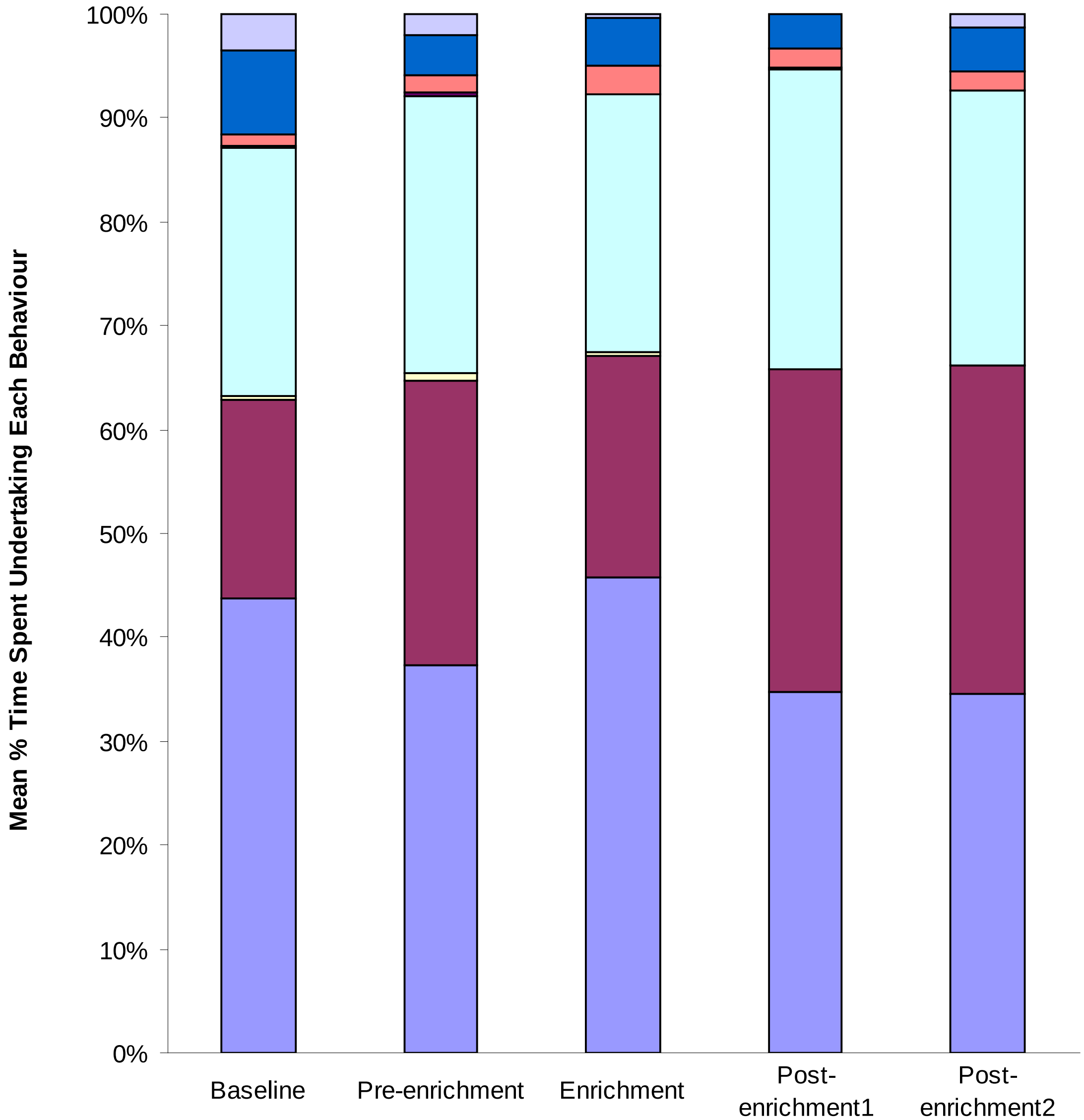
a. African savanna elephant *(Loxodonta africana)* – Elephant 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.02	0.02	0.04	0.01	0.01
BehavG	0.05	0.02	0.04	0.04	0.04
BehavF	0.01	0.02	0.03	0.02	0.02
BehavE	0.00	0.00	0.01	0.00	0.00
BehavD	0.14	0.14	0.12	0.12	0.13
BehavC	0.18	0.20	0.16	0.20	0.26
BehavB	0.20	0.14	0.09	0.17	0.12
BehavA	0.41	0.45	0.51	0.43	0.43

Period Of Study

b. African savanna elephant *(Loxodonta africana)* – Elephant 2

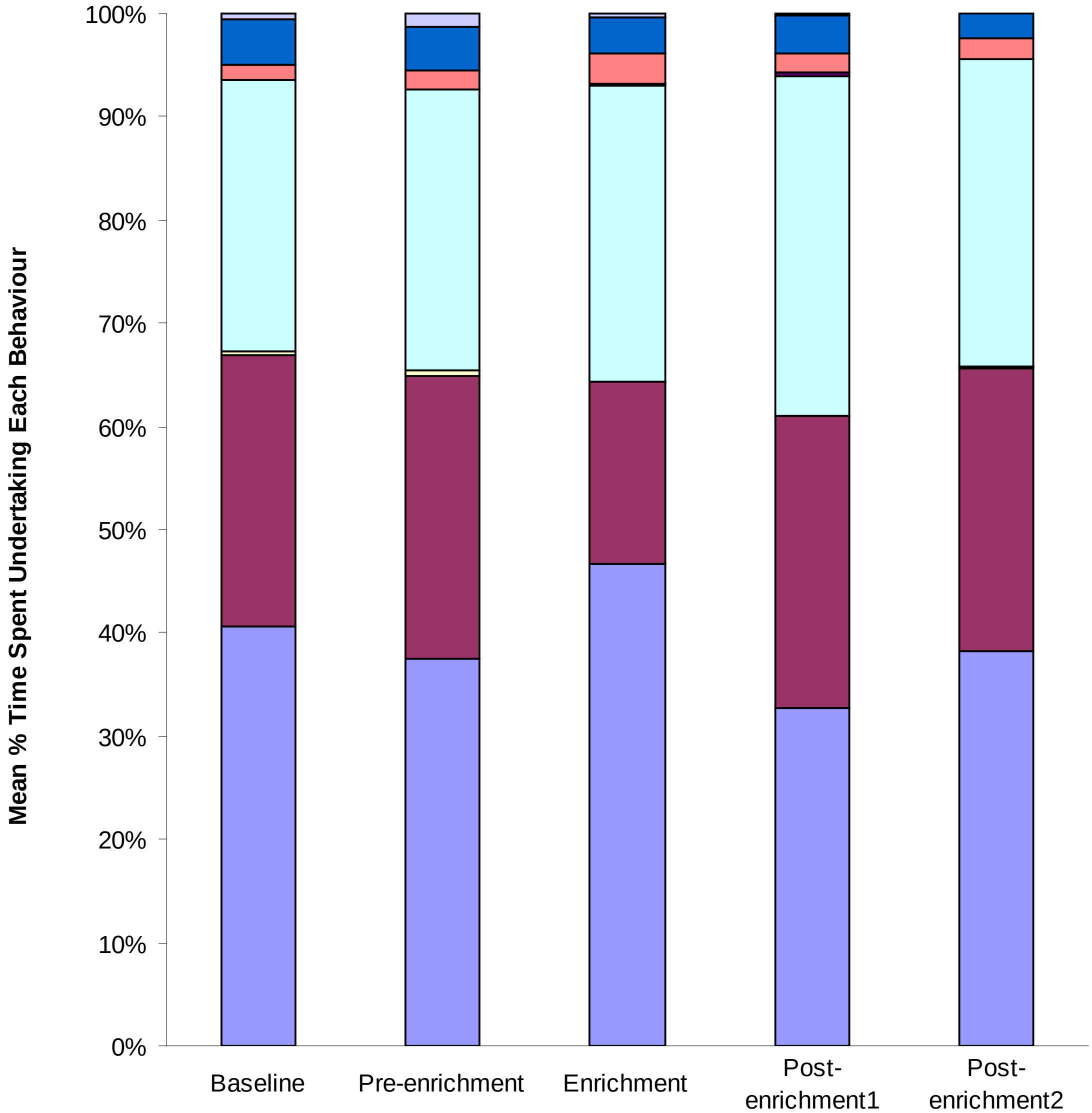


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.03	0.02	0.00	0.00	0.01
BehavG	0.08	0.04	0.05	0.03	0.04
BehavF	0.01	0.02	0.03	0.02	0.02
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.24	0.26	0.25	0.29	0.26
BehavC	0.00	0.01	0.00	0.00	0.00
BehavB	0.19	0.27	0.21	0.31	0.32
BehavA	0.44	0.37	0.46	0.35	0.34

Period Of Study

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

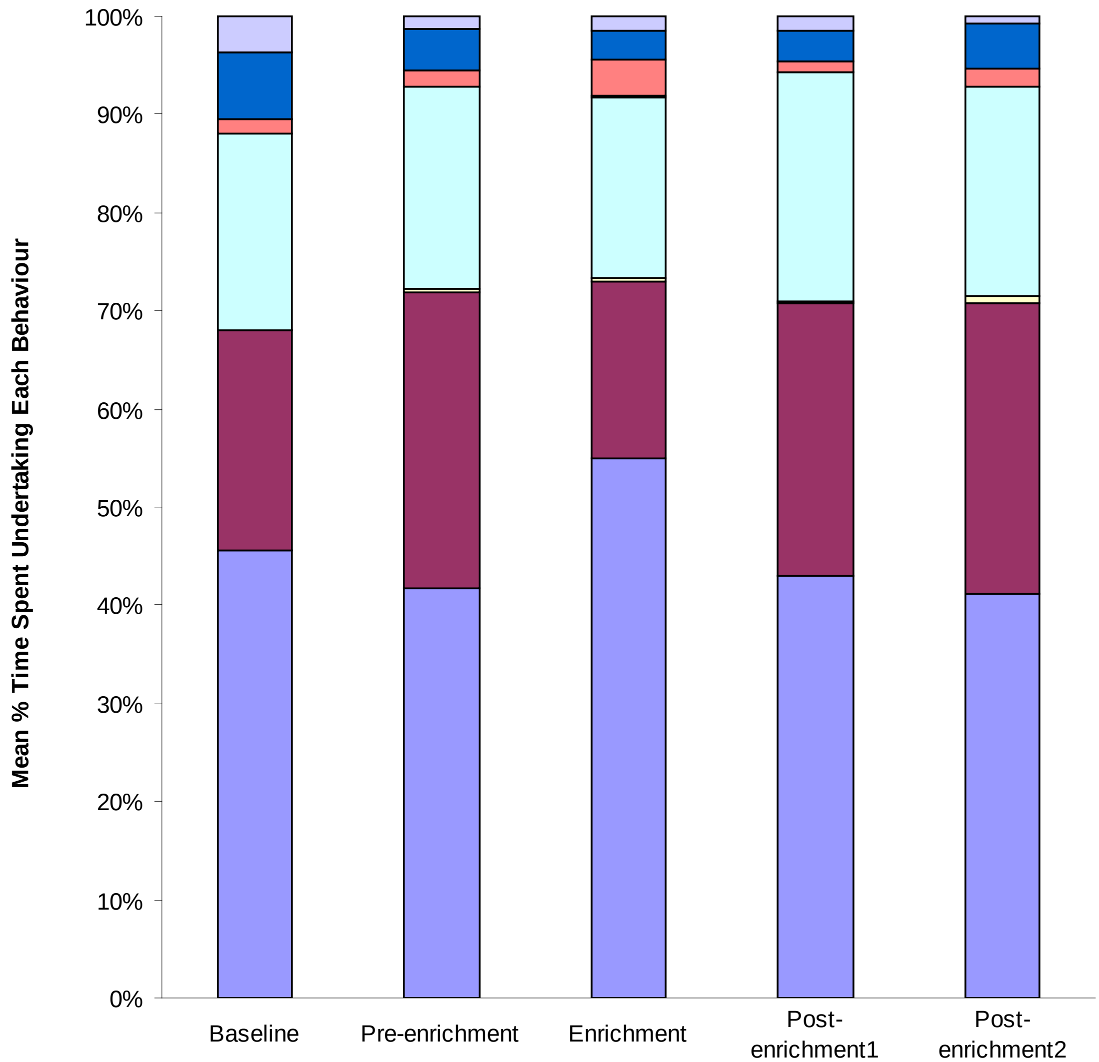
c. African savanna elephant *(Loxodonta africana)* – Elephant 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.01	0.00	0.00	0.00
BehavG	0.04	0.04	0.03	0.04	0.02
BehavF	0.02	0.02	0.03	0.02	0.02
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.26	0.27	0.29	0.33	0.30
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.26	0.27	0.18	0.28	0.27
BehavA	0.41	0.37	0.47	0.33	0.38

Period Of Study

d. African savanna elephant *(Loxodonta africana)* – Elephant 4

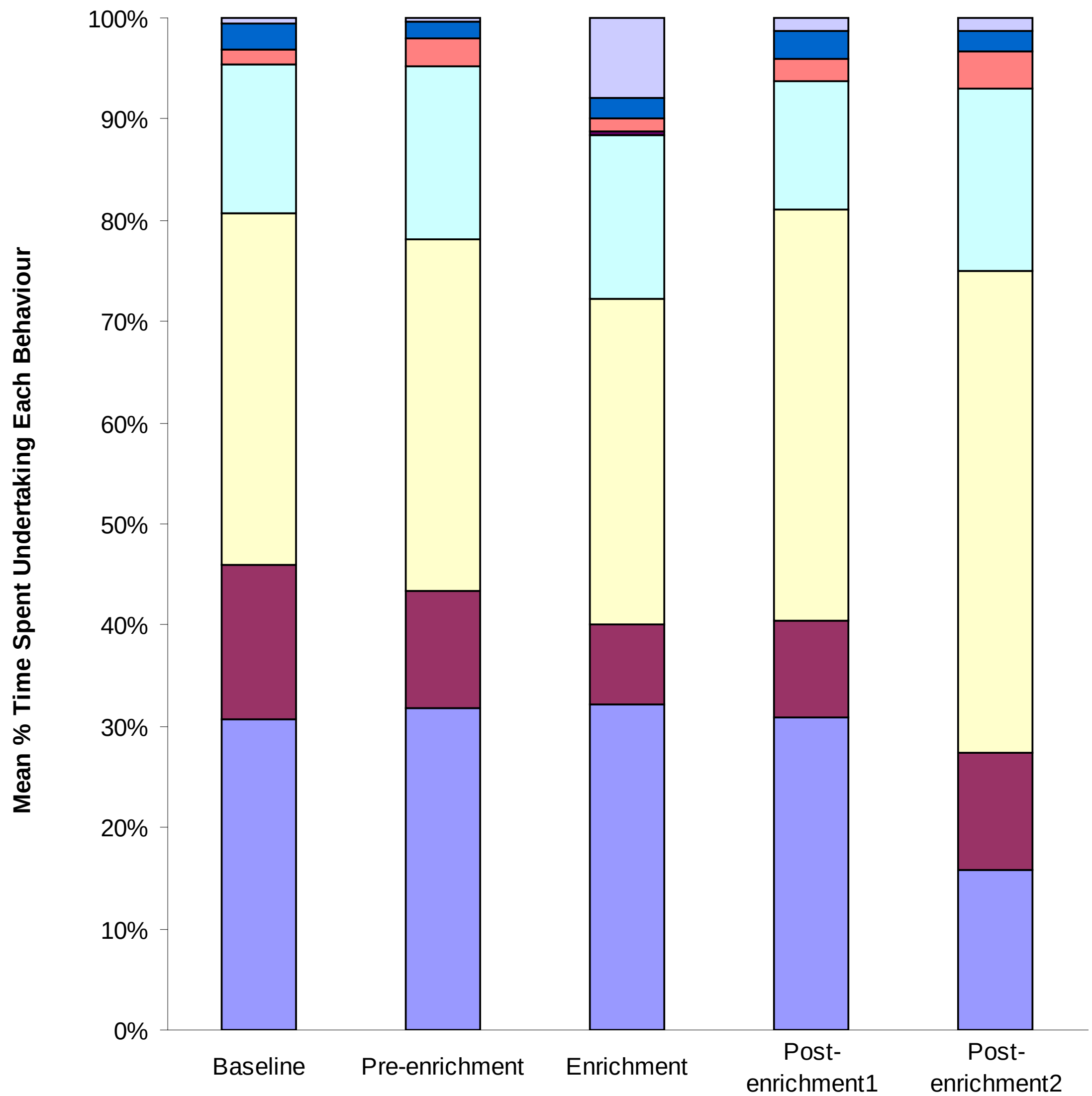


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.04	0.01	0.01	0.01	0.01
BehavG	0.07	0.04	0.03	0.03	0.05
BehavF	0.02	0.02	0.04	0.01	0.02
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.20	0.20	0.18	0.23	0.21
BehavC	0.00	0.00	0.00	0.00	0.01
BehavB	0.22	0.30	0.18	0.28	0.29
BehavA	0.45	0.42	0.55	0.43	0.41

Period Of Study

Figure 3.2. Representation of behavioural patterns for each study period (Morning period only)

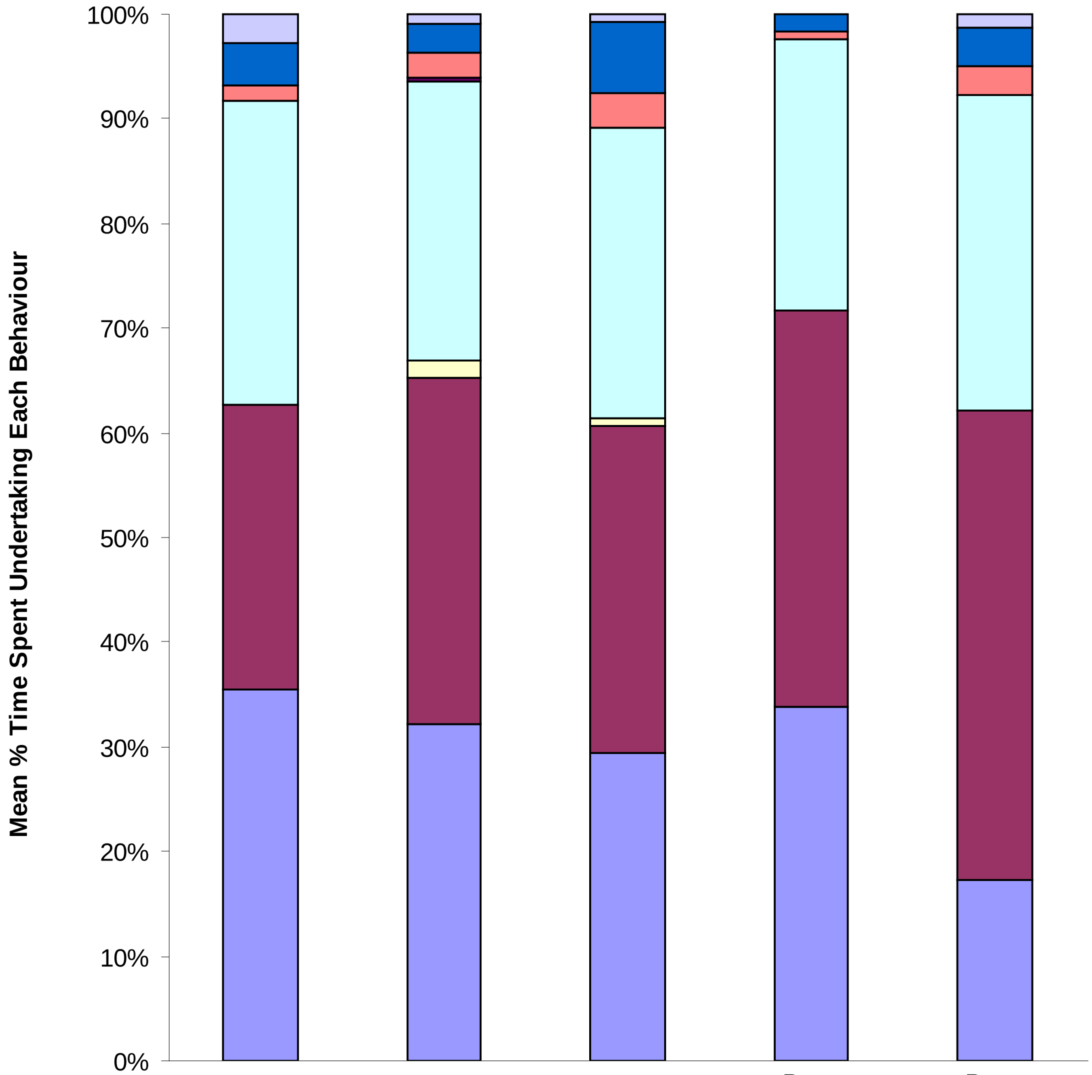
a. African savanna elephant *(Loxodonta africana)* – Elephant 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.00	0.08	0.01	0.01
BehavG	0.03	0.02	0.02	0.03	0.02
BehavF	0.02	0.03	0.01	0.02	0.04
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.15	0.17	0.16	0.13	0.18
BehavC	0.35	0.35	0.32	0.40	0.48
BehavB	0.15	0.12	0.08	0.10	0.12
BehavA	0.31	0.32	0.32	0.31	0.16

Period Of Study

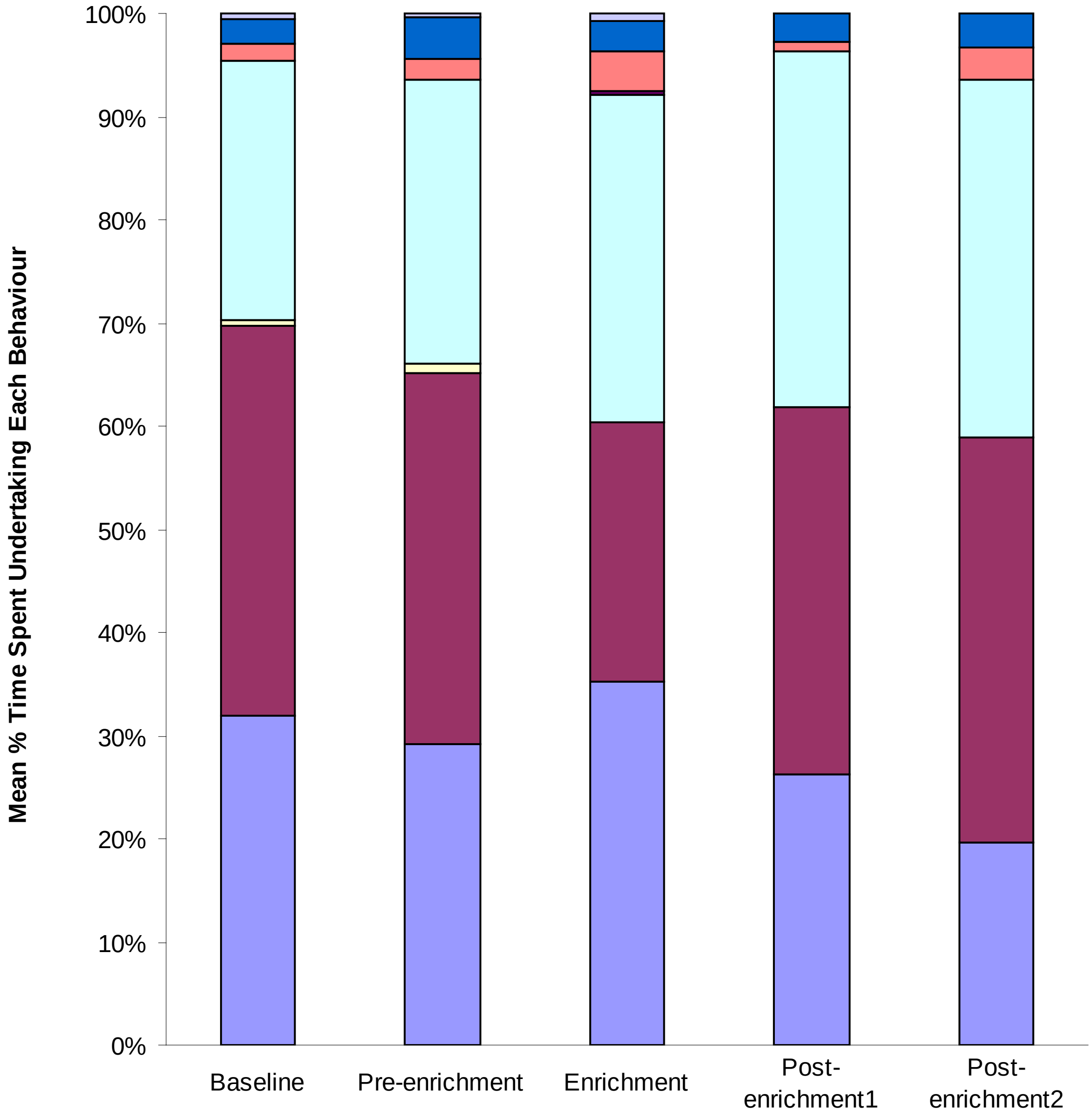
b. African savanna elephant *(Loxodonta africana)* – Elephant 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.03	0.01	0.01	0.00	0.01
BehavG	0.04	0.03	0.07	0.02	0.04
BehavF	0.02	0.02	0.03	0.01	0.03
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.29	0.27	0.28	0.26	0.30
BehavC	0.00	0.02	0.01	0.00	0.00
BehavB	0.27	0.33	0.31	0.38	0.45
BehavA	0.35	0.32	0.29	0.34	0.17

Period Of Study

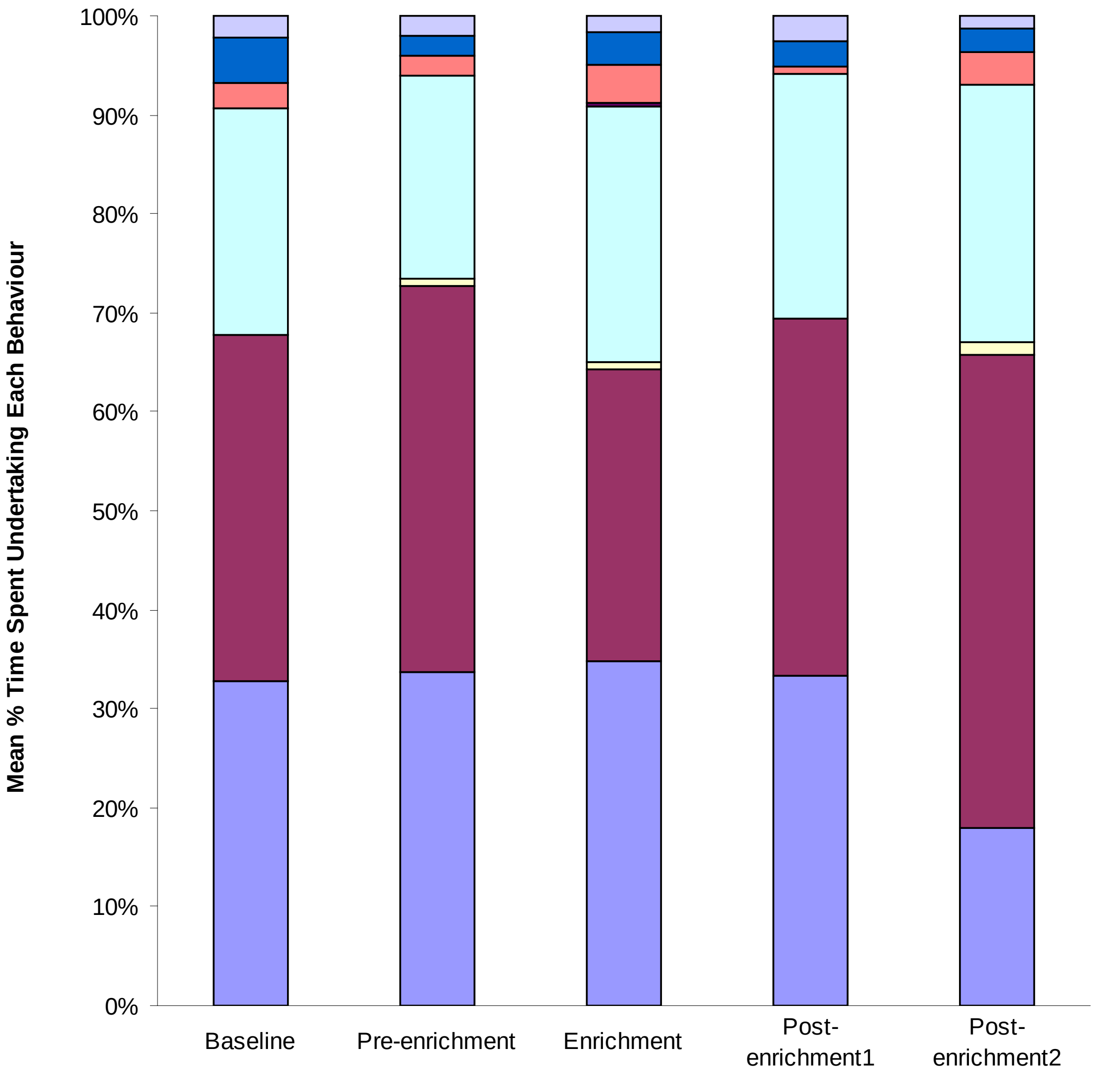
c. African savanna elephant *(Loxodonta africana)* – Elephant 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.00	0.01	0.00	0.00
BehavG	0.03	0.04	0.03	0.03	0.03
BehavF	0.02	0.02	0.04	0.01	0.03
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.25	0.27	0.32	0.35	0.35
BehavC	0.01	0.01	0.00	0.00	0.00
BehavB	0.38	0.36	0.25	0.35	0.39
BehavA	0.32	0.29	0.35	0.26	0.20

Period Of Study

d. African savanna elephant *(Loxodonta africana)* – Elephant 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.02	0.02	0.02	0.03	0.01
BehavG	0.05	0.02	0.03	0.03	0.02
BehavF	0.03	0.02	0.04	0.01	0.03
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.23	0.20	0.26	0.25	0.26
BehavC	0.00	0.01	0.01	0.00	0.01
BehavB	0.35	0.39	0.29	0.36	0.48
BehavA	0.33	0.34	0.35	0.33	0.18

Period Of Study

When comparing the above graph with the afternoon data overleaf, there does appear to be some variation between morning and afternoon activity, but no striking variation presents itself when comparing enrichment and non-enrichment periods.

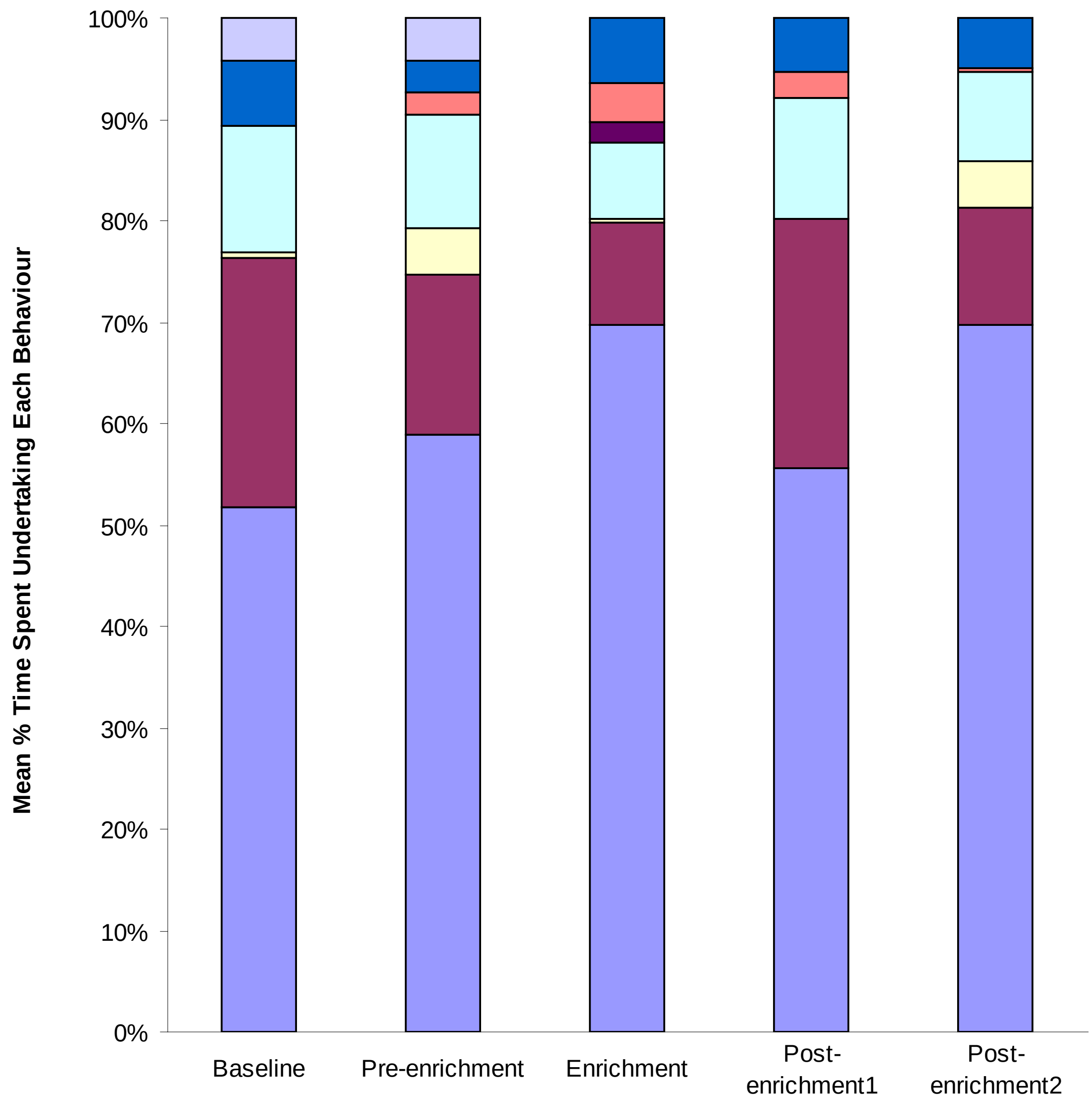
Both feeding behaviour (Behaviour A) and stationary behaviour (Behaviour B) seem to differ across most periods of the study. All the elephants appear to perform more feeding behaviour in the afternoon than in the morning and be stationary more often in the morning than in the afternoon. Whether there are any true significant differences between the data represented, is discussed under the 'statistical analysis' section later.

The morning data for the male elephant (Elephant 1) clearly indicates that the majority of the abnormal behaviour (Behaviour C) was exhibited in the morning, being performed from 32% to 48% of the time during the morning regardless of study period while only being exhibited a maximum of 5% of the time during the afternoon. The abnormal behaviour performed by the male seemed to be at the expense of stationary behaviour and active species specific behaviour (Behaviour D).

Unlike the other species in this research, the elephant resided in two separate enclosures. The majority of the morning period was spent in the small camp (see Appendix 6.2a) while the afternoon was always spent in the large camp. Therefore any behavioural changes may not only reflect the time of day but the elephants' environment and space availability.

Figure 3.3.: Representation of behavioural patterns for each study period (Afternoon period only)

a. African savanna elephant *(Loxodonta africana)* – Elephant 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.04	0.04	0.00	0.00	0.00
BehavG	0.07	0.03	0.06	0.05	0.05
BehavF	0.00	0.02	0.04	0.03	0.00
BehavE	0.00	0.00	0.02	0.00	0.00
BehavD	0.12	0.11	0.08	0.12	0.09
BehavC	0.01	0.05	0.00	0.00	0.05
BehavB	0.25	0.16	0.10	0.25	0.12
BehavA	0.52	0.59	0.70	0.56	0.70

Period Of Study

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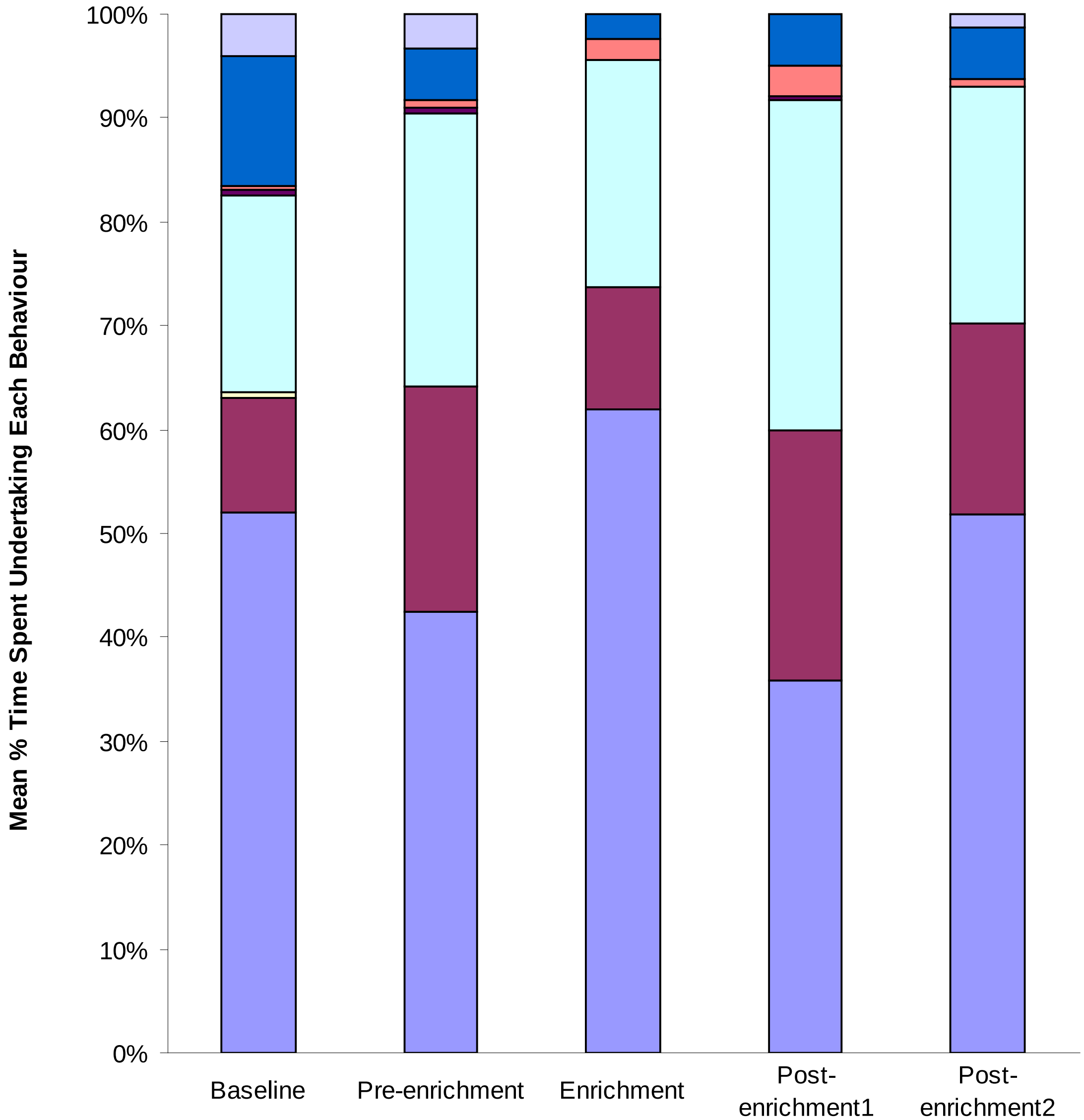
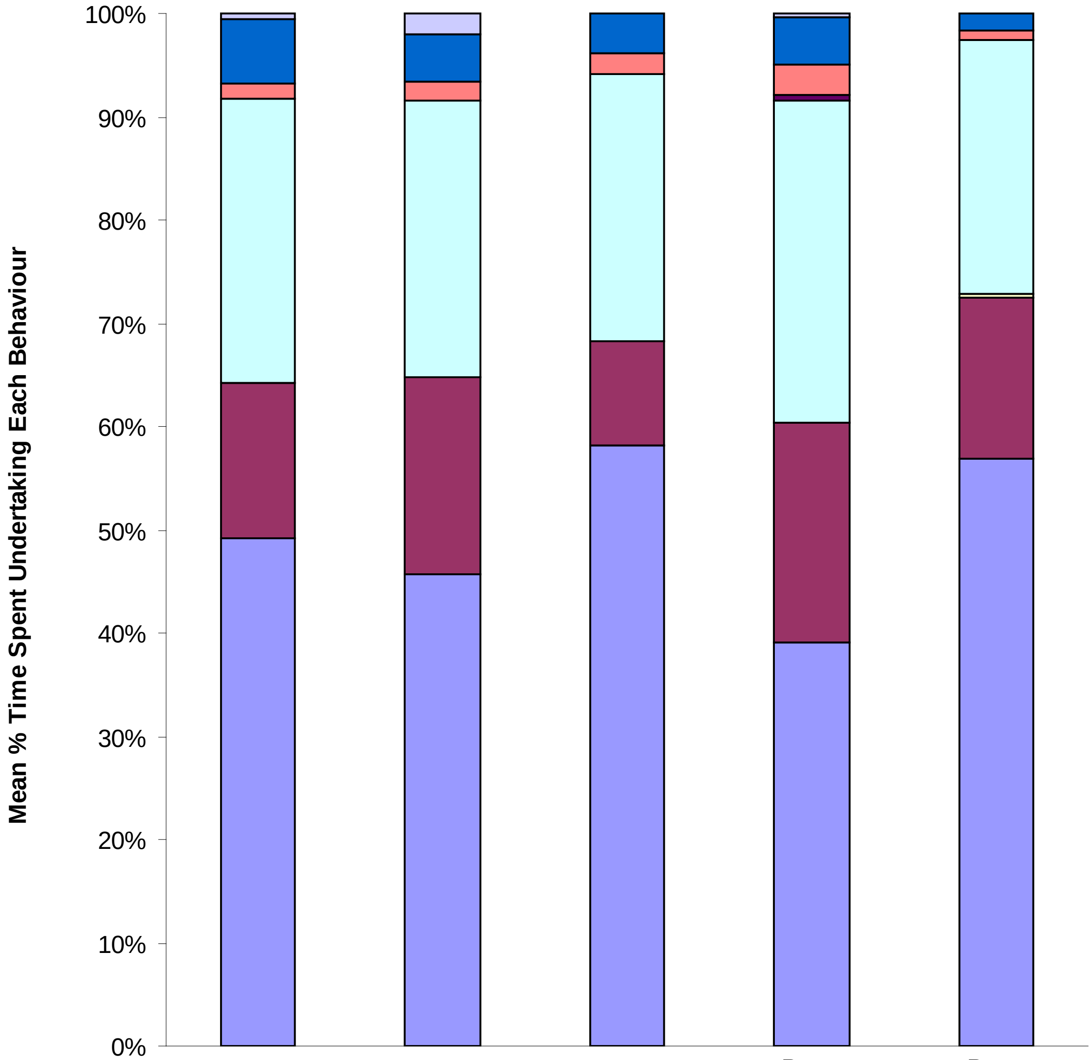
b. African savanna elephant *(Loxodonta africana)* – Elephant 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.04	0.03	0.00	0.00	0.01
BehavG	0.12	0.05	0.02	0.05	0.05
BehavF	0.01	0.01	0.02	0.03	0.01
BehavE	0.01	0.00	0.00	0.00	0.00
BehavD	0.19	0.26	0.22	0.32	0.23
BehavC	0.01	0.00	0.00	0.00	0.00
BehavB	0.11	0.22	0.12	0.24	0.18
BehavA	0.52	0.42	0.62	0.36	0.52

Period Of Study

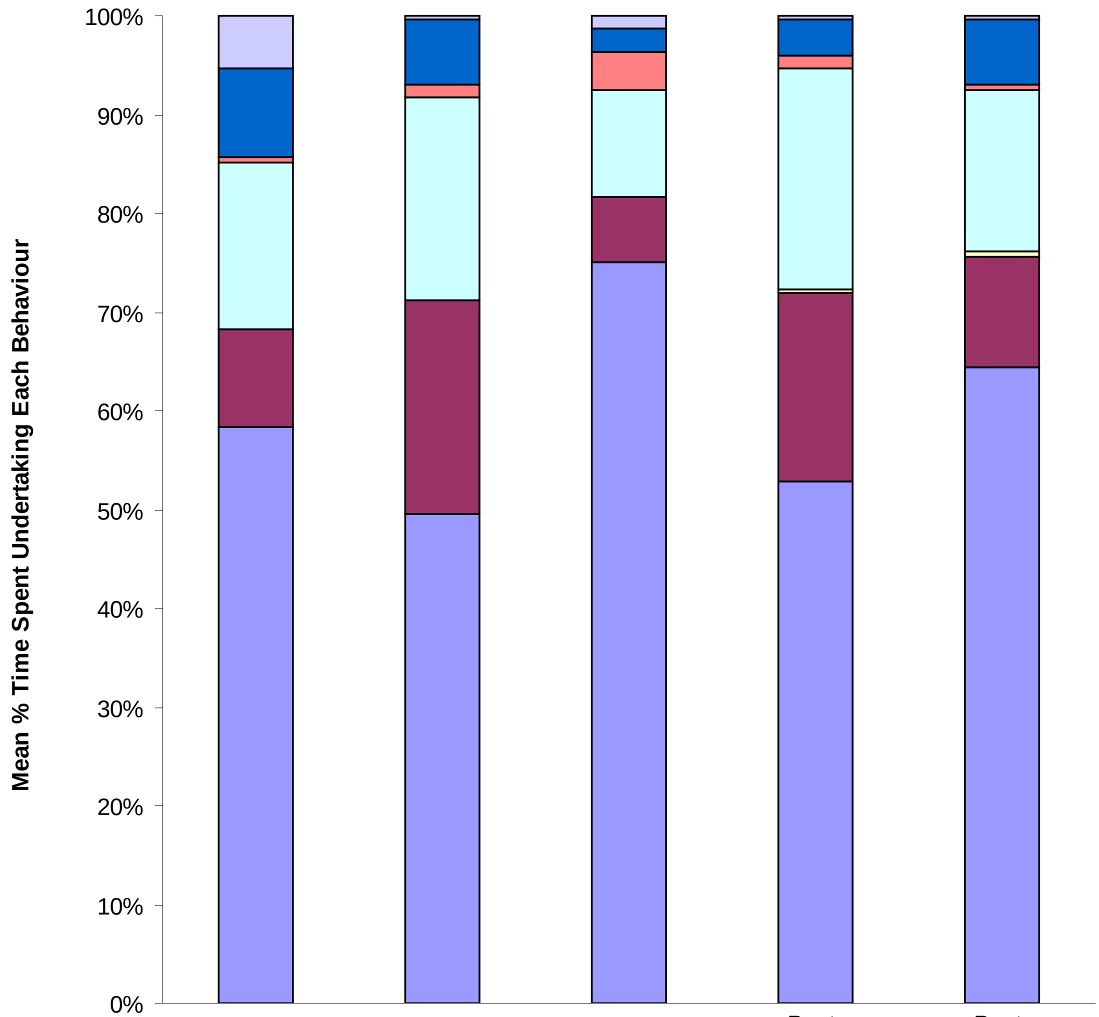
c. African savanna elephant *(Loxodonta africana)* – Elephant 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.02	0.00	0.00	0.00
BehavG	0.06	0.05	0.04	0.05	0.02
BehavF	0.02	0.02	0.02	0.03	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.27	0.27	0.26	0.31	0.25
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.15	0.19	0.10	0.21	0.16
BehavA	0.49	0.46	0.58	0.39	0.57

Period Of Study

d. African savanna elephant *(Loxodonta africana)* – Elephant 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.05	0.00	0.01	0.00	0.00
BehavG	0.09	0.07	0.02	0.04	0.07
BehavF	0.01	0.01	0.04	0.01	0.00
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.17	0.21	0.11	0.22	0.16
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.10	0.22	0.07	0.19	0.11
BehavA	0.58	0.50	0.75	0.53	0.64

Period Of Study

3.1.1.2. Statistical analysis

The data was analysed by Mann-Whitney-U (SPSS) as described in section 2.5.1.

Whole day data analysis

Table 3.1., highlights the significant findings for the proportion of time spent undertaking behaviour between each study period for each individual elephant.

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Behaviour A	-	-	-	-	-	-	-	-	-	-	* (577.0)	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	-	* (586.5)	-	-	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour G	-	** (431.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-	-	* (720.0)	-	-

Table 3.1. Individual comparative results for the various study periods

*-=no significant difference, * = $p \leq 0.05$, **=$p \leq 0.01$, ***=$p \leq 0.001$, Number in ( ) = U value. Elephant 1, Elephant 2, Elephant 3, Elephant 4.*

The majority of the comparative data showed no significant difference between study periods. The table does show that one of the females (elephant 2) significantly decreased non-relevant behaviour (behaviour G) when comparing the baseline and pre-enrichment data and increased the amount of time that was spent non-visible (behaviour H) when comparing post-enrichment 1 and post-enrichment 2 periods. Elephant 3 significantly decreased feeding behaviour (behaviour A) when comparing enrichment and post-enrichment 1 periods and the male (elephant 1) significantly increased stationary behaviour when comparing the same periods.

Morning and afternoon data analysis

When a Mann-Whitney U test was used to compare the morning data only, no significant differences were found for any of the behavioural patterns between the study periods for any of the individual elephants.

In contrast many significant results were identified when comparing the afternoon data only (see table 3.2.). Elephants 1 and 2 both had a significant decrease in non-relevant behaviour (behaviour G) when comparing the baseline and pre-enrichment afternoon data. The same two African savanna elephants were also significantly more visible during enrichment compared to the pre-enrichment period and during the comparison of the same two periods, elephant 2, increased feeding behaviour (behaviour A). Elephant 4 also significantly increased feeding behaviour during the enrichment period compared to pre-enrichment and showed a significant decrease in stationary behaviour (behaviour B), active species specific behaviour (behaviour D) and non-relevant behaviour (behaviour G).

When comparing enrichment to the post-enrichment 1 period, elephants 2, 3 and 4 all showed a significant decrease in feeding behaviour (behaviour A), whilst all four elephants showed a significant increase in stationary behaviour (behaviour B) and elephants 2 and 4 exhibited a significant increase in active species specific behaviour (behaviour D).

Elephants 2 and 3 showed a rebound increase in feeding behaviour when comparing post-enrichment 1 and post-enrichment 2 periods, whilst elephant 1 significantly decreased stationary behaviour (behaviour B) during the same periods.

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Behaviour A	-	-	-	-	-	** (91.5)	-	** (103.5)	-	** (87.5)	** (104.5)	** (97.0)	-	* (120.0)	** (95.0)	-
Behaviour B	-	-	-	-	-	-	-	* (126.5)	** (114.0)	* (119.0)	** (113.0)	* (128.0)	* (127.0)	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	* (125.5)	-	* (123.5)	-	** (107.0)	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour G	* (104.0)	* (88.0)	-	-	-	-	-	* (135.5)	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	** (140.0)	* (160.0)	-	-	-	-	-	-	-	)	-	-

Table 3.2. Individual comparative results for the various study periods (Afternoon only) *-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Elephant 1, Elephant 2, Elephant 3, Elephant 4.*

3.1.2. Spatial Utilisation

3.1.2.1. Descriptive data

As stated above, the African savanna elephants, unlike any other observational group within this study were moved between two separate camps daily. The morning period was spent mainly in the small enclosure while the afternoon was spent mainly in the large enclosure by all individuals. The exact time at which the animals were moved varied, therefore an analysis of whole data for each camp was used as each enclosure was treated as a separate entity when analyzing spatial utilization.

Figure 3.4. and 3.5. represent the spatial utilisation of the individual African savanna elephants for each of the five study periods in the small and large camps respectively. Appendix 6.2a shows the demarcation of zones / quadrants within each enclosure i.e. Position (Pos) 7, 8, 9, 25, 26 and 27. Pos 0 represents every observational recording period in which a particular individual was non-visible.

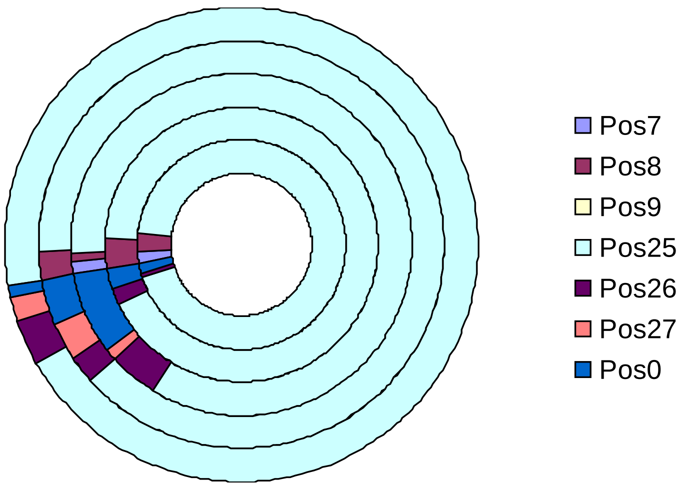
From the figures below, individual animal and study period variation in enclosure utilisation is evident. Elephant 1, the male, spent 84% to 94% of the time within position 25 of the small camp. Utilisation of the other areas of the small camp by elephant 1 appeared to increase during the enrichment period, steadily decreasing again over the subsequent post-enrichment 1 and post-enrichment 2 periods.

The three female elephants all move throughout the small enclosure more extensively than the male, with elephant 2 and 3 having very similar spatial utilisation patterns. As with elephant 1 the majority of time was spent by all the female African savanna elephants in position 25. The exception to this was elephant 2 and 3 during the post-enrichment 1 period, during which a greater proportion of the day was spent in position 27. Unlike the male, all three females appear to increase space usage during the post-enrichment 1 period, with the enrichment and post-enrichment 2 periods indicating reduced movement in comparison.

Figure 3.4. Representation of spatial utilisation (Small camp)

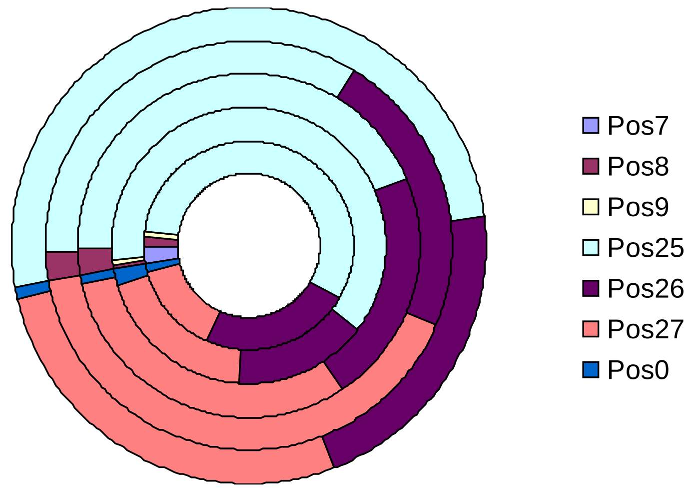
Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.

a. African savanna elephant *(Loxodonta africana)* – Elephant 1



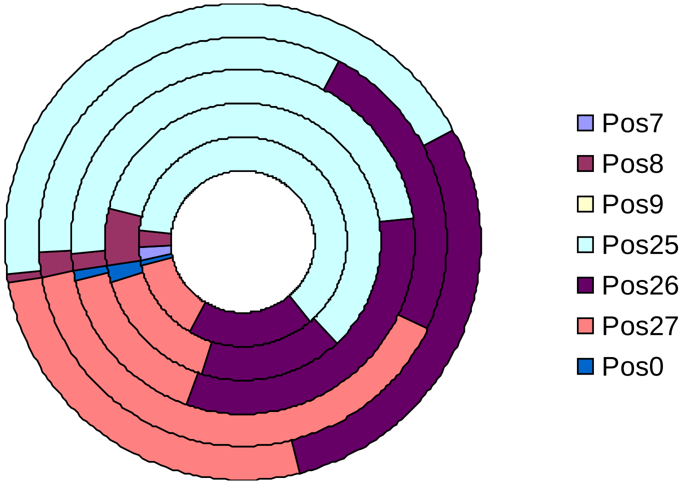
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.02	0.00	0.01	0.00	0.00
Pos 8	0.03	0.04	0.01	0.02	0.00
Pos 9	0.00	0.00	0.00	0.00	0.00
Pos 25	0.92	0.92	0.84	0.89	0.94
Pos 26	0.01	0.02	0.05	0.02	0.03
Pos 27	0.00	0.00	0.01	0.03	0.02
Pos 0	0.02	0.03	0.08	0.04	0.01

b. African savanna elephant *(Loxodonta africana)* – Elephant 2



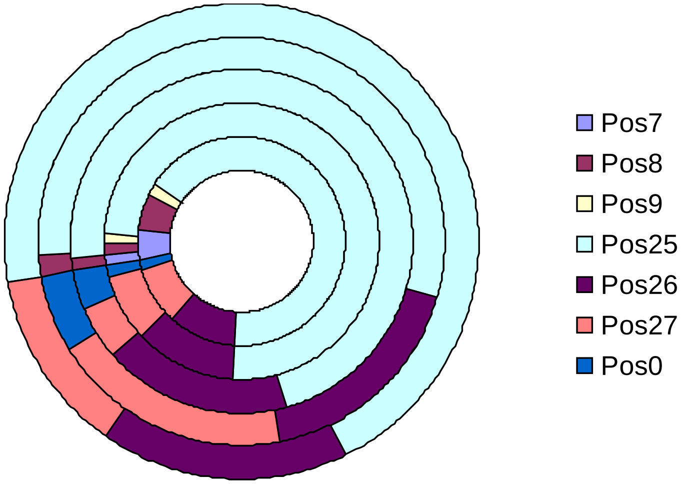
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.03	0.00	0.00	0.00	0.00
Pos 8	0.02	0.01	0.03	0.02	0.00
Pos 9	0.01	0.01	0.00	0.00	0.00
Pos 25	0.55	0.62	0.44	0.34	0.51
Pos 26	0.23	0.15	0.22	0.23	0.21
Pos 27	0.14	0.19	0.31	0.41	0.27
Pos 0	0.02	0.02	0.01	0.00	0.01

c. African savanna elephant *(Loxodonta africana)* – Elephant 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.02	0.00	0.00	0.00	0.00
Pos 8	0.03	0.07	0.02	0.02	0.01
Pos 9	0.00	0.00	0.00	0.00	0.00
Pos 25	0.60	0.59	0.49	0.34	0.44
Pos 26	0.19	0.17	0.33	0.24	0.29
Pos 27	0.13	0.15	0.16	0.41	0.26
Pos 0	0.01	0.02	0.01	0.00	0.00

d. African savanna elephant *(Loxodonta africana)* – Elephant 4

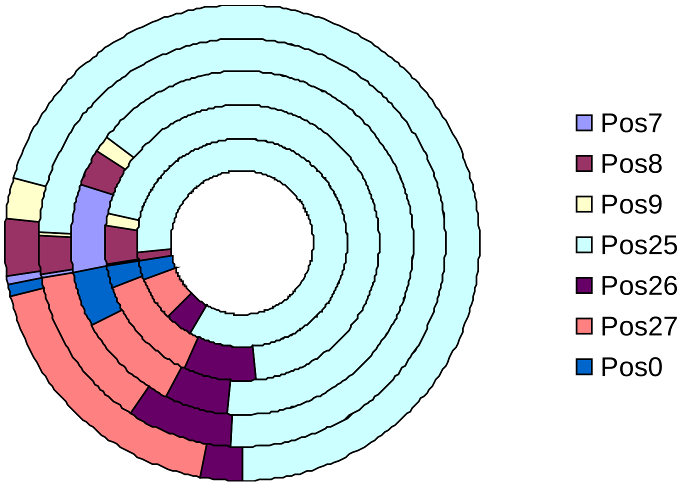


	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.04	0.01	0.00	0.00	0.00
Pos 8	0.06	0.01	0.01	0.02	0.00
Pos 9	0.02	0.01	0.00	0.00	0.00
Pos 25	0.66	0.75	0.73	0.56	0.71
Pos 26	0.10	0.12	0.18	0.17	0.17
Pos 27	0.09	0.08	0.05	0.19	0.12
Pos 0	0.02	0.01	0.04	0.06	0.00

Figure 3.5. Representation of spatial utilisation (Large camp)

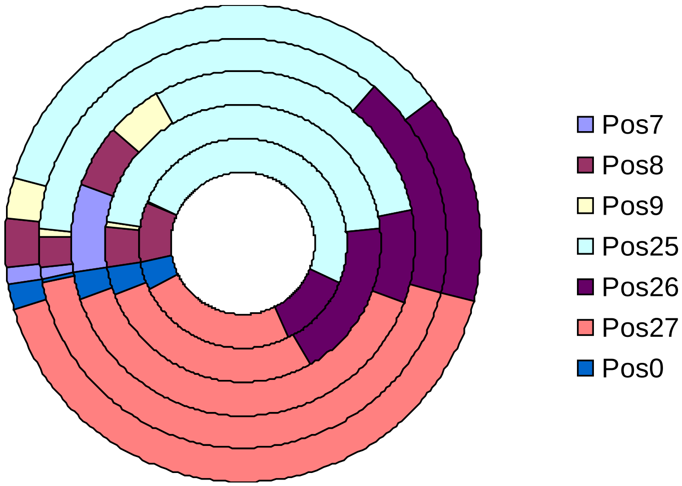
Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.

a. African savanna elephant *(Loxodonta africana)* – Elephant 1



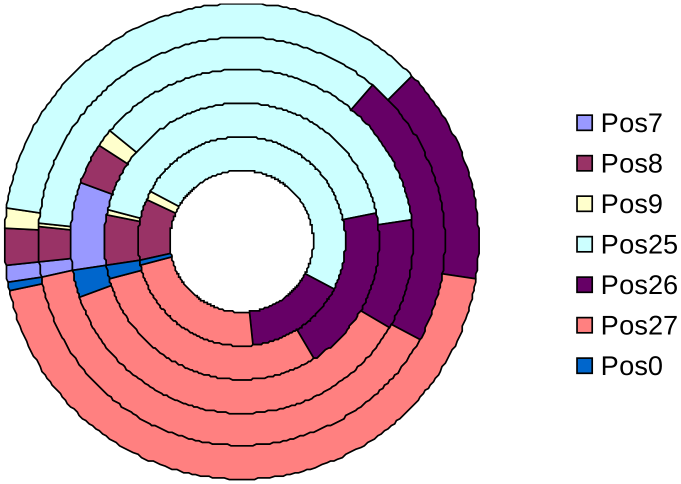
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.00	0.00	0.08	0.00	0.01
Pos 8	0.01	0.05	0.03	0.03	0.04
Pos 9	0.00	0.01	0.02	0.00	0.03
Pos 25	0.84	0.70	0.66	0.75	0.70
Pos 26	0.04	0.09	0.06	0.08	0.03
Pos 27	0.07	0.13	0.10	0.13	0.18
Pos 0	0.03	0.03	0.05	0.00	0.01

b. African savanna elephant *(Loxodonta africana)* – Elephant 2



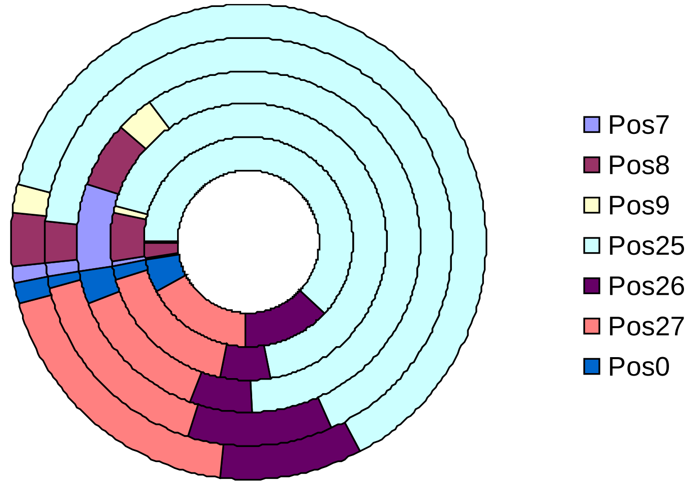
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.00	0.00	0.08	0.01	0.01
Pos 8	0.09	0.05	0.06	0.02	0.03
Pos 9	0.00	0.01	0.05	0.01	0.03
Pos 25	0.49	0.46	0.30	0.35	0.35
Pos 26	0.12	0.19	0.09	0.18	0.14
Pos 27	0.25	0.27	0.39	0.43	0.42
Pos 0	0.05	0.03	0.03	0.00	0.02

c. African savanna elephant *(Loxodonta africana)* – Elephant 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.00	0.00	0.08	0.01	0.01
Pos 8	0.10	0.06	0.04	0.03	0.03
Pos 9	0.01	0.01	0.02	0.00	0.01
Pos 25	0.50	0.43	0.37	0.34	0.35
Pos 26	0.16	0.19	0.10	0.22	0.15
Pos 27	0.23	0.29	0.36	0.39	0.44
Pos 0	0.01	0.02	0.03	0.00	0.01

d. African savanna elephant *(Loxodonta africana)* – Elephant 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.00	0.01	0.08	0.01	0.01
Pos 8	0.02	0.05	0.06	0.03	0.03
Pos 9	0.00	0.01	0.04	0.00	0.02
Pos 25	0.62	0.68	0.59	0.67	0.63
Pos 26	0.14	0.06	0.06	0.11	0.10
Pos 27	0.17	0.17	0.14	0.17	0.19
Pos 0	0.05	0.02	0.03	0.01	0.01

As with the small camp, when elephant 1 was within the large camp he also appeared to utilise space less than the females. However, elephant 4 had a spatial utilisation pattern that appeared to be very similar to elephant 1.

Position 25 and 27 are the two areas most often utilised by elephant 2 and 3. The exact area in which the two individuals spend the most time varied between study periods.

Unlike the small camp, none of the individuals had a clear increase or decrease in enclosure utilisation between study periods, however the specific areas of the enclosure used did appear to vary. For example all individuals appeared to increase the time spent in position 7 during enrichment compared to other study periods.

3.1.2.2. Statistical analysis

The small enclosure was divided into quadrants approximately equal to 10m x 14m. Due to the shape of the large enclosure it was not possible to divide the camp into equal segments. The approximate surface area of each zone within the large enclosure is given in table 3.3.

Zone	***Large Camp***
7	**905m^2**
8	**1013m^2**
9	**553m^2**
25	**1700m^2**
26	**1512m^2**
27	**420m^2**
Total	**6103m^2**

Table 3.3. Approximate square metre area for each zone (Large camp)

Position 9 within the small enclosure was never visited by elephant 1 or 3 during the duration of the observational recording regardless of study period. This represented 16.67% of the area available in the small enclosure. Elephants 2 and 4 were recorded within every zone of the small enclosure during at least one period of the study. All four individuals were also observed utilising all areas of the large enclosure during at least one period of the study. However in the small camp the male (Elephant 1) spent 84% to 92% of the time in 16.67% of the enclosure, whilst the three females spent between 85% and 100% of the time in 50% of the enclosure. This clearly demonstrates that enclosure use was uneven. A similar finding was demonstrated in the large enclosure with the male (Elephant 1) and elephant 3 spending 66% to 84% and 59% to 68% of the time respectively in 24.77% of the available enclosure. Elephants 2 and 3 spent 69% to 79% of the time in 34.74% of the camp.

Individual enclosure use or coefficient of variation (CV) as used by Stoinski et. al. (2001), ranged from 1.44 to 2.71 (see Table 4.1.4.). Elephant 3 utilised the most enclosure space (clumped the least) in the large camp, with a CV of 1.44, during post-enrichment 2 while elephant 1 utilised the least enclosure space (clumped the most) in the small camp, with a CV of 2.71, during the pre-enrichment and post-enrichment 2 periods.

		SMALL CAMP			LARGE CAMP		
		Mean	StDev	CV	Mean	StDev	CV
ELEPHANT 1	Baseline (n=4)	0.11	0.29	2.66	0.11	0.27	2.49
	Pre-Enrichment (n=5)	0.11	0.29	2.71	0.11	0.23	2.16
	Enrichment (n=5)	0.10	0.27	2.61	0.11	0.21	2.04
	Post-Enrichment 1 (n=5)	0.11	0.28	2.63	0.11	0.24	2.18
	Post-Enrichment 2 (n=5)	0.11	0.30	2.71	0.11	0.23	2.05
ELEPHANT 2	Baseline (n=4)	0.11	0.18	1.65	0.11	0.18	1.66
	Pre-Enrichment (n=5)	0.11	0.23	2.12	0.11	0.17	1.63
	Enrichment (n=5)	0.11	0.18	1.67	0.11	0.17	1.53
	Post-Enrichment 1 (n=5)	0.11	0.17	1.53	0.11	0.17	1.53
	Post-Enrichment 2 (n=5)	0.11	0.19	1.72	0.11	0.17	1.58
ELEPHANT 3	Baseline (n=4)	0.11	0.20	1.81	0.11	0.17	1.53
	Pre-Enrichment (n=5)	0.11	0.22	2.04	0.11	0.17	1.59
	Enrichment (n=5)	0.11	0.19	1.68	0.11	0.16	1.52
	Post-Enrichment 1 (n=5)	0.11	0.17	1.50	0.11	0.16	1.44
	Post-Enrichment 2 (n=5)	0.11	0.18	1.63	0.11	0.18	1.60
ELEPHANT 4	Baseline (n=4)	0.11	0.21	1.92	0.11	0.20	1.89
	Pre-Enrichment (n=5)	0.11	0.24	2.23	0.11	0.23	2.14
	Enrichment (n=5)	0.11	0.22	2.09	0.11	0.20	1.87
	Post-Enrichment 1 (n=5)	0.10	0.19	1.80	0.11	0.22	1.98
	Post-Enrichment 2 (n=5)	0.11	0.23	2.11	0.11	0.20	1.85

Table 3.4. Enclosure usage data

When statistical analysis was run using the Mann-Whitney U test several significant changes for specific area usage within enclosures by individual elephants was indicated (See Table 3.5. & 3.6.)

	Baseline (n=32) vs Pre-enrichment (n=40)				**Pre-enrichment (n=40) vs Enrichment (n=40)**				**Enrichment (n=40) vs Post-enrichment 1 (n=40)**				**Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)**			
Pos7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos25	-	-	-	-	-	-	-	-	-	-	-	* (2.0)	-	-	-	-
Pos26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos27	-	-	-	-	-	-	-	-	-	-	** (0.0)	-	-	* (3.0)	-	-
Pos0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.5. Individual comparative results for the various study periods (Small camp only) *-=no significant difference, * = $p \leq 0.05$, **=$p \leq 0.01$, ***=$p \leq 0.001$, Number in ( ) = U value. Elephant 1, Elephant 2, Elephant 3, Elephant 4.*

When analysing the usage of the small camp, elephant 3 significantly increased the time spent in position 27 during post-enrichment 1 compared to the enrichment period. Elephant 2 significantly decreased usage of the same position when comparing post-enrichment 1 to post-enrichment 2. Elephant 4 showed a significant decrease in the use of position 25 during the post-enrichment 1 period compared to enrichment.

Within the large camp, both elephant 1 and elephant 2 significantly decreased usage of position 8 when comparing baseline and pre-enrichment data. Elephant 2 and elephant 3 both decreased the time spent in position 26 during the enrichment period when compared with pre-enrichment, with elephant 3 having a rebound effect during post-enrichment 1 when the time spent in position 26 significantly increased again.

3.2. LEOPARD *(Panthera pardus)*

3.2.1. Behavioural Observations

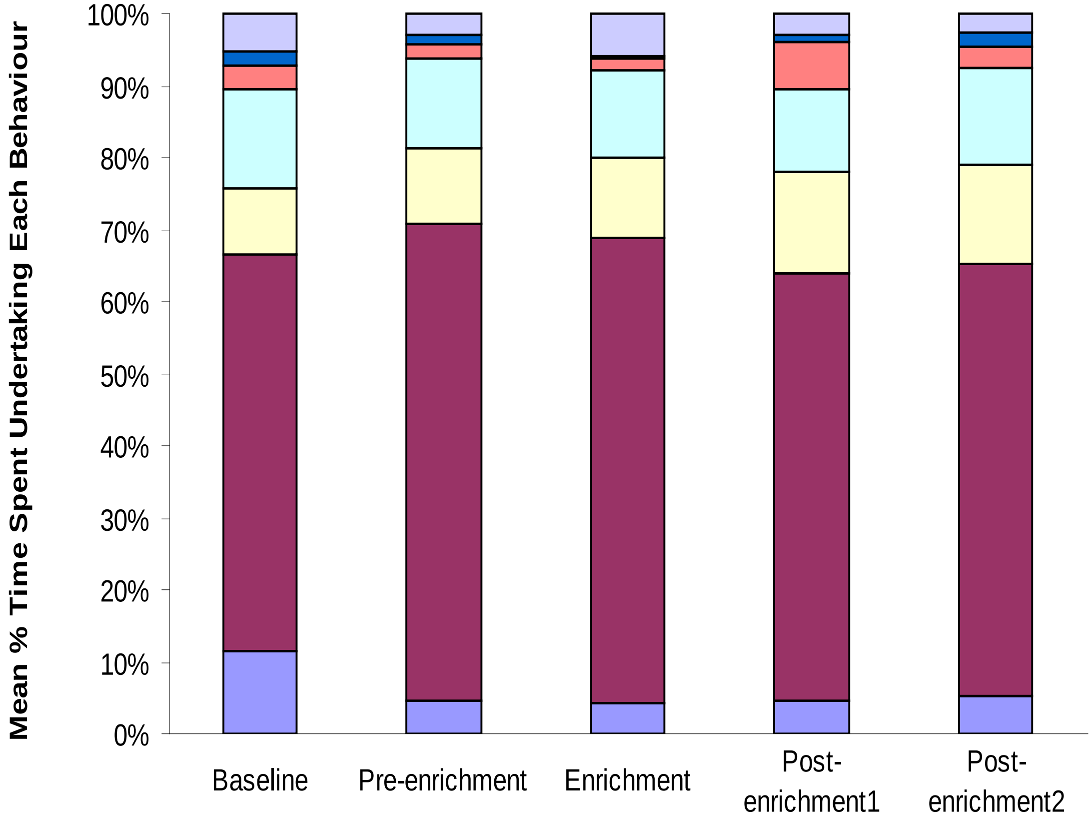
3.2.1.1. Descriptive data

Fig. 3.6. illustrates the proportion of time spent by the leopard performing the various behavioural patterns, by representing the mean time spent expressing each behaviour for the different periods of the study i.e. 'Baseline', 'Pre-Enrichment', 'Enrichment', 'Post-Enrichment Day1' & 'Post-Enrichment Day2'.

Unlike the other species observed in this study, the leopard was only fed every second day. This meant that half the enrichment periods fell on 'feeding days' whilst the other half fell on 'non-feeding' days. Fig 3.7. compares the proportion of time spent expressing each behaviour on enrichment days when food items were also given with enrichment days when food items were not present.

Kinahan A.(2007, *personal communication*), suggested that the time of day in which an animal performs specific behaviour may be altered during periods of enrichment even when the overall behavioural repertoire of the animal or the total amount of time spent undertaking each behaviour remains unchanged. Therefore, to determine if this is true for the leopard, graph 3.8. and graph 3.9. illustrate the behaviour recorded during the morning period (08:00 to 11:55) and afternoon period (12:00 to 15:55) respectively, for each study period.

Figure 3.6. Representation of behavioural patterns for each study period (Leopard)

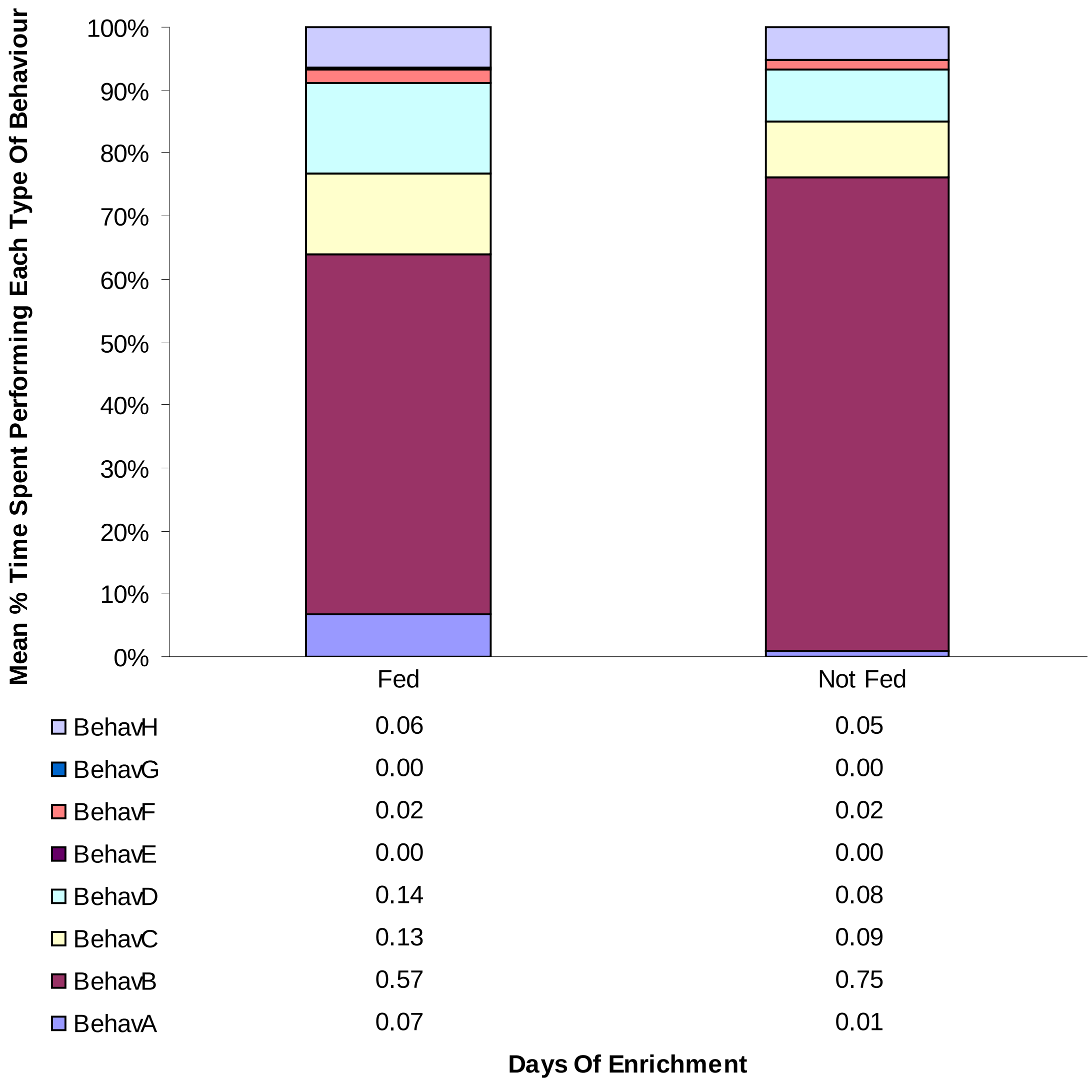


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.05	0.03	0.06	0.03	0.03
BehavG	0.02	0.01	0.00	0.01	0.02
BehavF	0.03	0.02	0.02	0.06	0.03
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.14	0.12	0.12	0.12	0.14
BehavC	0.09	0.11	0.11	0.14	0.14
BehavB	0.55	0.66	0.64	0.59	0.60
BehavA	0.11	0.05	0.04	0.04	0.05

Period Of Study

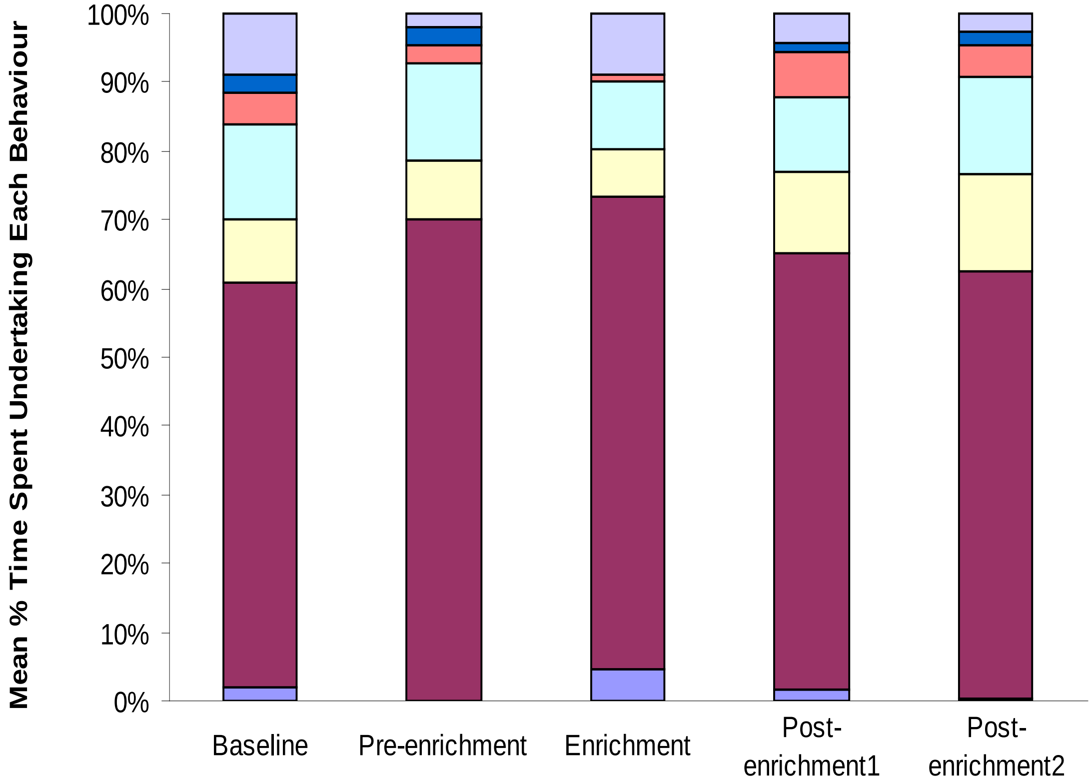
From the graph it is clear that the greatest proportion of the day was spent stationary (Behaviour B) with no visible movement. This appeared to be the case regardless of whether enrichment was present or not. See Appendix 6.4 for full descriptive statistics.

Graph 3.7. Representation of behavioural patterns for enrichment periods ‘with feeding’ and ‘without feeding’



From the graph above it appears that the feeding related behaviour (Behaviour A) increased on enrichment days that also correspond to days on which the leopard was fed. There also appeared to be a corresponding decrease in stationary behaviour (Behaviour B) during feeding day compared to non-feeding day enrichment periods. The statistical analysis of this data is provided below (section 3.2.1.2.)

Graph 3.8. Representation of behavioural patterns for each study period (Morning period only)

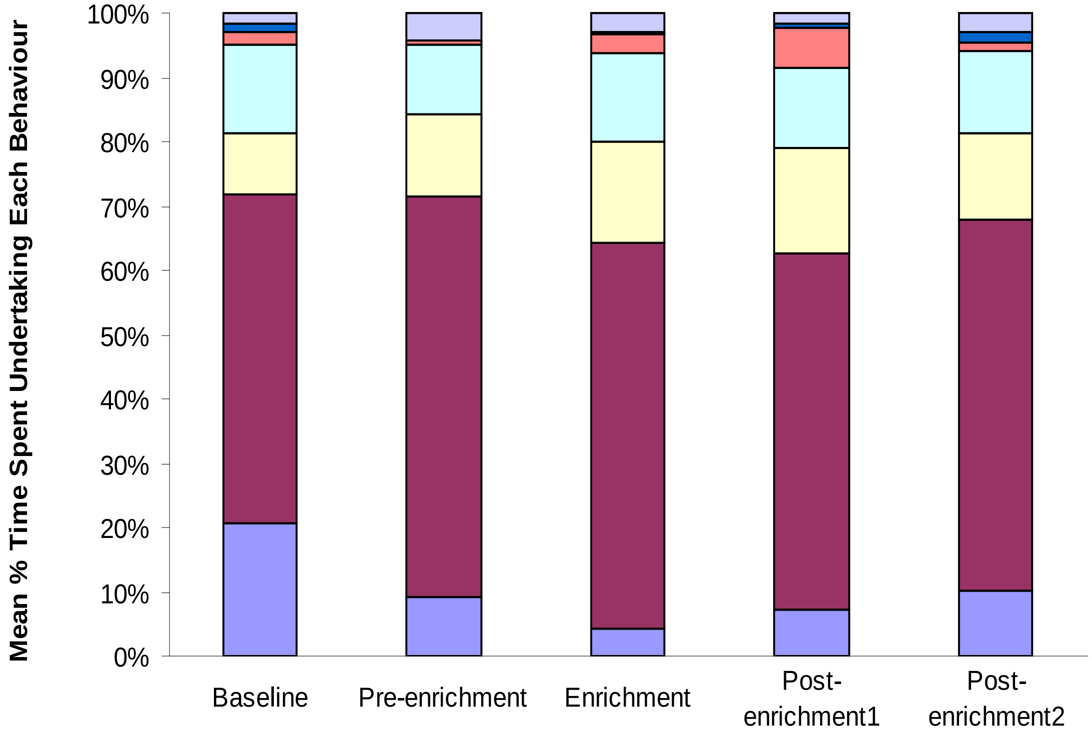


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.09	0.02	0.09	0.04	0.03
BehavG	0.03	0.02	0.00	0.01	0.02
BehavF	0.05	0.03	0.01	0.06	0.05
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.14	0.14	0.10	0.11	0.14
BehavC	0.09	0.08	0.07	0.12	0.14
BehavB	0.59	0.70	0.69	0.63	0.62
BehavA	0.02	0.00	0.05	0.02	0.00

Period Of Study

When comparing the above graph with the afternoon data overleaf, there does appear to be some variation between morning and afternoon activity, but no striking variation presents itself when comparing enrichment and non-enrichment periods. Both feeding behaviour (Behaviour A) and stationary behaviour (Behaviour B) seem to differ across most periods of the study. With the exception of enrichment periods the leopard appears to perform more feeding behaviour in the afternoon than in the morning and is stationary more often in the morning than in the afternoon.

Graph 3.9. Representation of behavioural patterns for each study period (Afternoon period only)



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.02	0.04	0.03	0.02	0.03
BehavG	0.02	0.00	0.00	0.01	0.02
BehavF	0.02	0.01	0.03	0.06	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.14	0.11	0.14	0.12	0.13
BehavC	0.09	0.13	0.16	0.16	0.13
BehavB	0.51	0.62	0.60	0.55	0.58
BehavA	0.21	0.09	0.04	0.07	0.10

3.2.1.2. Statistical analysis

The data was analysed by Mann-Whitney-U test (SPSS).

Whole day data analysis

Table 3.7., highlights the significant findings for the proportion of time spent undertaking behaviour between each study period.

	Baseline (n=32) vs Pre-enrichment (n=40)	Pre-enrichment (n=40) vs Enrichment (n=40)	Enrichment (n=40) vs Post-enrichment 1 (n=40)	Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)
Behaviour A	*** (524.5)**	-	-	-
Behaviour B	-	-	-	-
Behaviour C	-	-	-	-
Behaviour D	-	-	-	-
Behaviour E	-	-	-	-
Behaviour F	-	-	**** (551.0)**	*** (628.5)**
Behaviour G	-	-	-	-
Behaviour H	-	-	-	-

Table 3.7. Individual comparative results for the various study periods

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value.*

The majority of the comparative data showed no significant difference between study periods. The table does show that there was a significant decrease in the time spent performing feeding behaviour when comparing baseline and pre-enrichment data. In addition, a significant increase in human interaction is seen between the enrichment and post-enrichment 1 period with a rebound (defined as a return to pre-enrichment levels) significant decrease between post-enrichment 1 and post-enrichment 2 periods.

Enrichment period analysis

There was no significant difference between enrichment periods that corresponded with days on which the leopard was fed compared to non-feeding days when $p \leq 0.05$. However, there was an increase in feeding related behaviour ($U=141.0$; $p=0.07$) and a corresponding decrease ($U=128.0$; $p=0.07$) in stationary behaviour on days fed compared to non-feeding days when comparing enrichment periods. Although these findings are not highly significant they must be borne in mind when inferences are drawn from the overall study.

Morning and afternoon data analysis

From the table below it is clear that by separating the data into morning and afternoon zones, significant differences were more clearly illustrated. The morning appeared to be the time of day when the majority of differences were seen between the various study periods.

There was a significant decrease in feeding related behaviour (Behaviour A) seen between the baseline and pre-enrichment data during the morning as well as an increase in visibility (Behaviour H) when comparing the same periods.

There was also a significant increase in feeding related behaviour (Behaviour A) during the morning when comparing pre-enrichment and enrichment periods. Abnormal behaviour (Behaviour C) significantly increased in the morning of post-enrichment1 compared to the morning of enrichment.

The significant decrease in non-relevant behaviour (Behaviour G) between the afternoon baseline and pre-enrichment period was followed by a further significant decrease in non-relevant behaviour in the subsequent morning enrichment period compared to pre-enrichment. There was also a significant decrease in human interactions (Behaviour F) seen during the same period. Conversely, there was a significant increase in human interactions between the morning enrichment and post-enrichment 1 period and a significant decrease in human interaction between the afternoon of post-enrichment 1 and post-enrichment 2.

	Baseline (n=16) vs Pre-enrichment (n=20)		Pre-enrichment (n=20) vs Enrichment (n=20)		Enrichment (n=20) vs Post-enrichment 1 (n=20)		Post-enrichment 1 (n=20) vs Post-enrichment 2 (n=20)	
Behaviour A	_* (130.0)_	-	_** (130.0)_	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	-
Behaviour C	-	-	-	-	* (127.0)	-	-	-
Behaviour D	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-
Behaviour F	-	-	_* (152.5)_	-	_** (120.0)_	-	-	__* (129.5)__
Behaviour G	-	__* (130.0)__	_* (150.0)_	-	-	-	-	-
Behaviour H	_* (134.5)_	-	-	-	-	-	-	-

Table 3.8.: Individual comparative results for the various study periods

*Italicised values represent morning data, while those in bold that are not italicised represent the afternoon data. -=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value.*

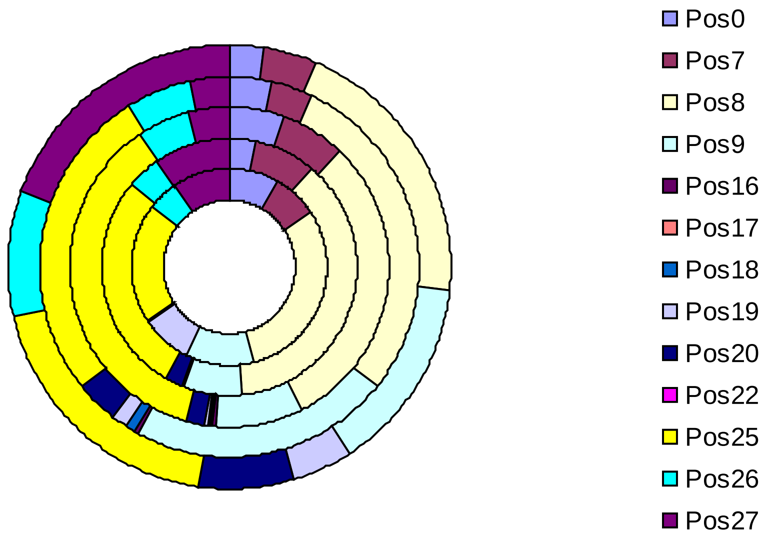
3.2.2. Spatial Utilisation

3.2.2.1. Descriptive data

Figure 3.10. represent the spatial utilisation of the leopard for each of the five study periods. Appendix 6.2b shows the demarcation of zones / quadrants within each enclosure i.e. Position (Pos) 7, 8, 9, 16, 17, 18, 19, 20, 22, 25, 26 and 27. Pos 0 represents every observational recording period in which the leopard was non-visible.

Figure 3.10. Representation of spatial utilisation

Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 7	0.08	0.08	0.06	0.04	0.04
Pos 8	0.30	0.37	0.30	0.28	0.20
Pos 9	0.11	0.07	0.09	0.22	0.14
Pos 16	0.00	0.00	0.00	0.00	0.00
Pos 17	0.00	0.00	0.00	0.00	0.00
Pos 18	0.00	0.00	0.00	0.01	0.00
Pos 19	0.08	0.00	0.00	0.01	0.04
Pos 20	0.00	0.02	0.02	0.04	0.07
Pos 22	0.00	0.00	0.00	0.00	0.00
Pos 25	0.20	0.27	0.36	0.27	0.19
Pos 26	0.05	0.04	0.05	0.06	0.09
Pos 27	0.10	0.10	0.04	0.03	0.19
Pos 0	0.08	0.03	0.06	0.04	0.02

From the figure above, the leopard has a preference for the near and far areas of the enclosure, spending very little time in the intermediate zones. There also does not appear to be any evident study period variation in enclosure utilisation. The only exception to this is an increase in usage of position 27 during post-enrichment 2 compared to the other periods. The leopard spent 53% to 77% of time in 25% of the enclosure (positions 8, 9 & 25) depending on the study period, suggesting a non-random usage of the available space.

3.2.2.2. Statistical analysis

The floor surface of the enclosure was divided into quadrants approximately equal to 3.3m x 6.6m. Position 19, 20 and 22 were all elevated platforms with varied surface areas (as detailed in table 3.9.)

Zone	*Area*
19	**0.6m x 1.0m**
20	**1.2m x 1.0m**
22	**0.6m x 0.6m**

Table 3.9. Approximate square meter area for elevated platforms

Enclosure use or coefficient of variation (CV) as used by Stoinski et al. (2001), ranged from 1.45 to 1.79 (see Table 3.10.). This indicates that there was non-random usage of the enclosure space with preference of specific areas.

	SMALL CAMP		
	Mean	**StDev**	**CV**
Baseline (n=4)	0.08	0.12	1.57
Pre-Enrichment (n=5)	0.08	0.14	1.71
Enrichment (n=5)	0.08	0.14	1.79
Post-Enrichment 1 (n=5)	0.08	0.12	1.45
Post-Enrichment 2 (n=5)	0.08	0.12	1.45

Table 3.10. Enclosure usage data

When statistical analysis was run using Mann-Whitney U two significant changes for specific area usage within the enclosure by the leopard was indicated. When comparing baseline and pre-enrichment data there was a significant decrease in the use of position 19 (p=0.03, U=2.5). There was a significant increase in the use of position 27 (p=0.01, U=0.0) when comparing post-enrichment 1 to post-enrichment 2.

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Pos7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos8	* (2.0)	* (0.5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos26	-	-	-	-	-	* (2.5)	* (3.0)	-	-	-	* (3.0)	-	-	-	-	-
Pos27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.6. Individual comparative results for the various study periods (Large camp only) *-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Elephant 1, Elephant 2, Elephant 3, Elephant 4.*

However, despite these individual changes in spatial utilisation, the majority of enclosure usage appeared to be unaffected by the study period.

3.3. LION-TAILED MACAQUES *(Macaca silenus)*

3.3.1. Behavioural Observations

3.3.1.1. Descriptive data

Fig. 3.11. illustrates the proportion of time spent by the macaques performing the various behavioural patterns, by representing the mean time spent expressing each behaviour for the different periods of the study i.e. 'Baseline', 'Pre-Enrichment', 'Enrichment', 'Post-Enrichment Day1' & 'Post-Enrichment Day2'.

Individual variation was observed between the proportion of the day undertaking different behaviour. The older male (macaque 1) that was almost twenty years old at the time of the study spent the majority of the day performing active species specific behaviour (behaviour D) or being stationary (behaviour B). The majority of the remaining observational time for this animal was spent either feeding (behaviour A) or non-visible (behaviour H).

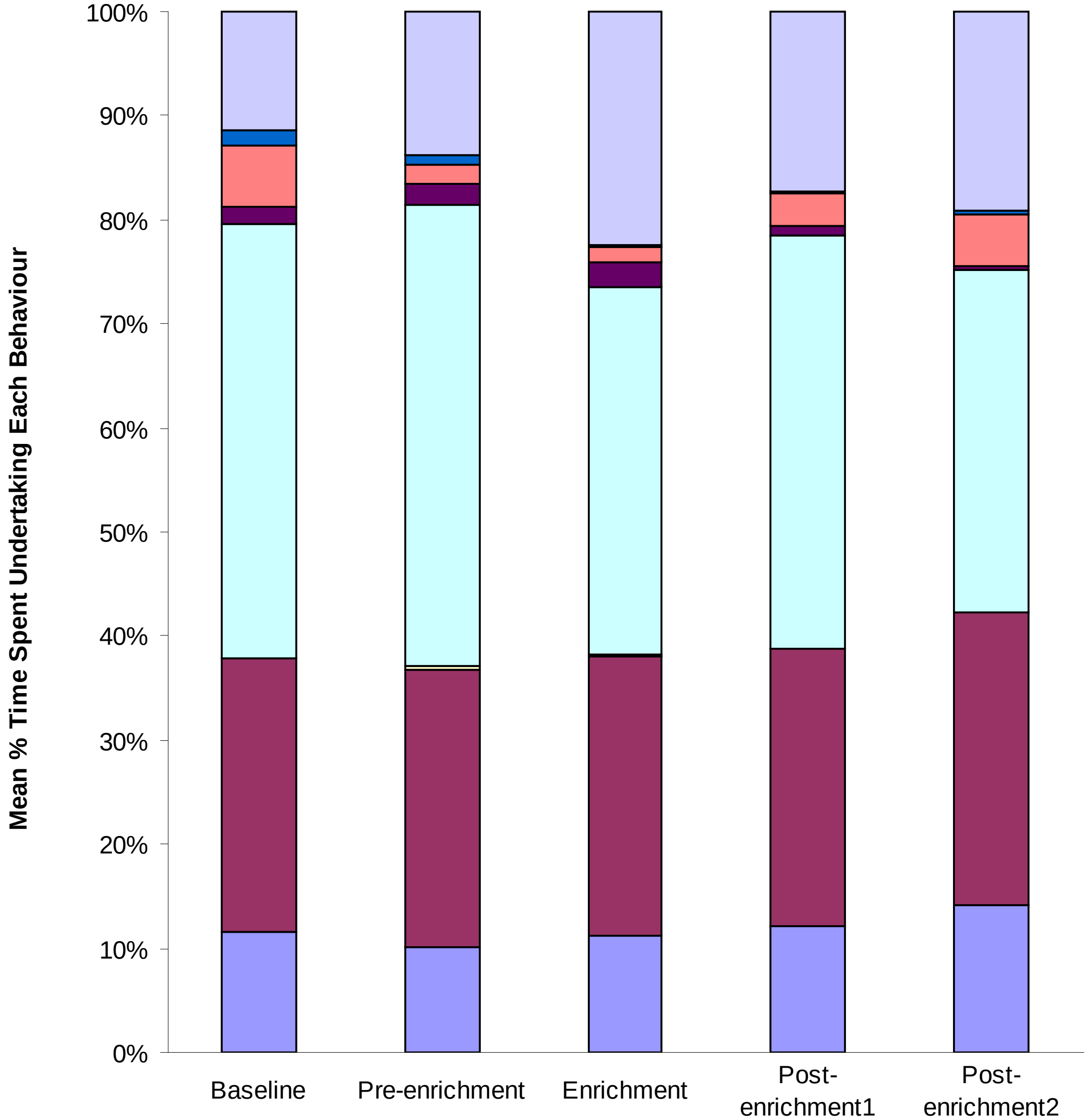
For the larger female (macaque 2) and the other male (macaque 3), a similar pattern of behaviour emerged. Both spent the majority of the day performing active species specific behaviours (behaviour D), while stationary behaviour (behaviour B), feeding (behaviour A) and being non-visible to the observer (behaviour H) appear to occur to a lesser extent in roughly equal proportions.

The youngest female (macaque 4) also spent the majority of the day undertaking active species specific behaviour (behaviour D). Macaque 4 spent less time stationary (behaviour B) and more time feeding (behaviour A) compared to the other three macaques.

The above observations were true for all periods of the study. See Appendix 6.4 for full descriptive statistics.

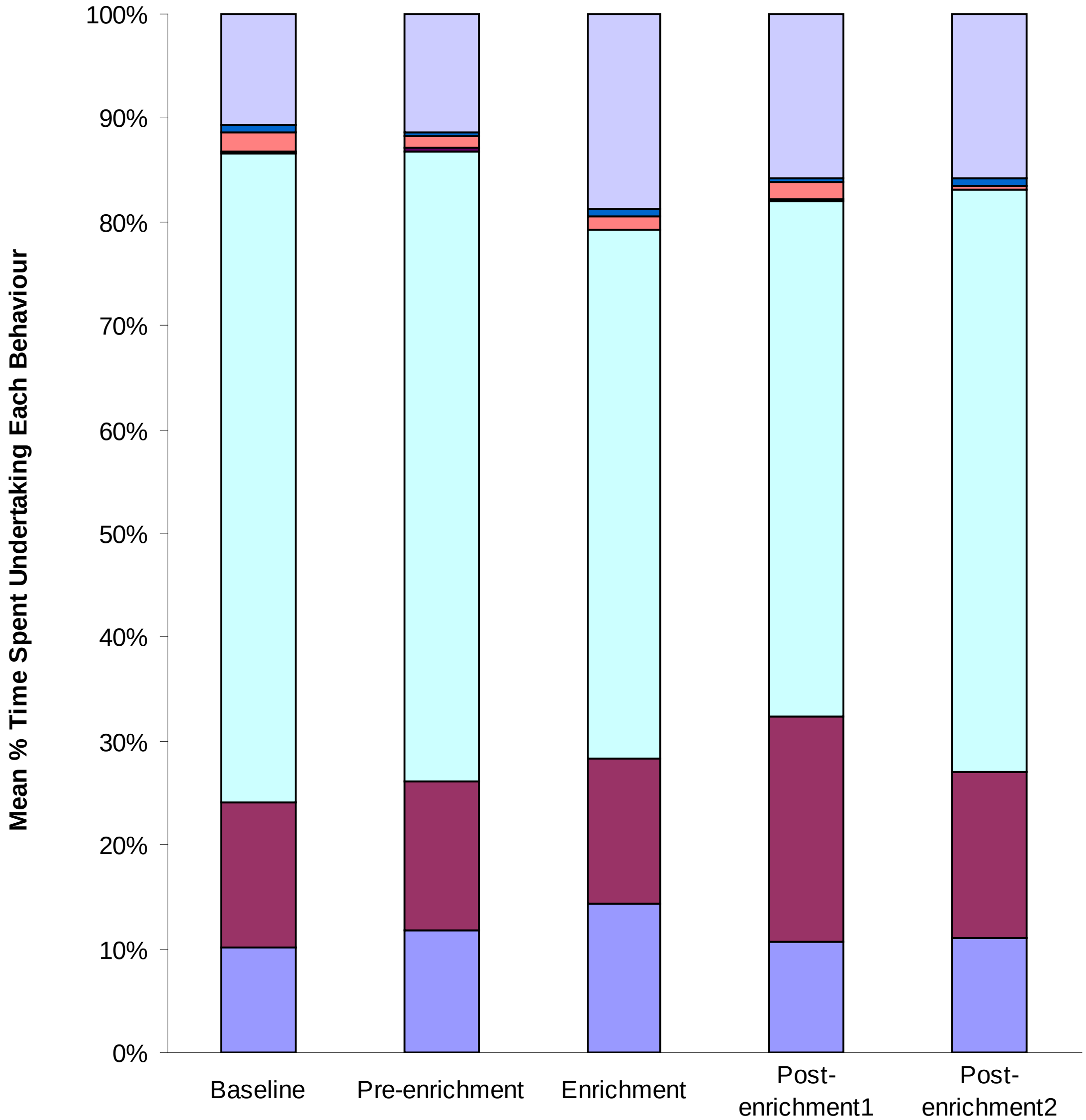
Figure 3.11. Representation of behavioural patterns for each study period

a. Lion-tailed macaques *(Macaca silenus)* - Macaque 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.11	0.14	0.22	0.17	0.19
BehavG	0.01	0.01	0.00	0.00	0.00
BehavF	0.06	0.02	0.02	0.03	0.05
BehavE	0.02	0.02	0.02	0.01	0.00
BehavD	0.42	0.44	0.35	0.40	0.33
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.26	0.27	0.27	0.27	0.28
BehavA	0.12	0.10	0.11	0.12	0.14

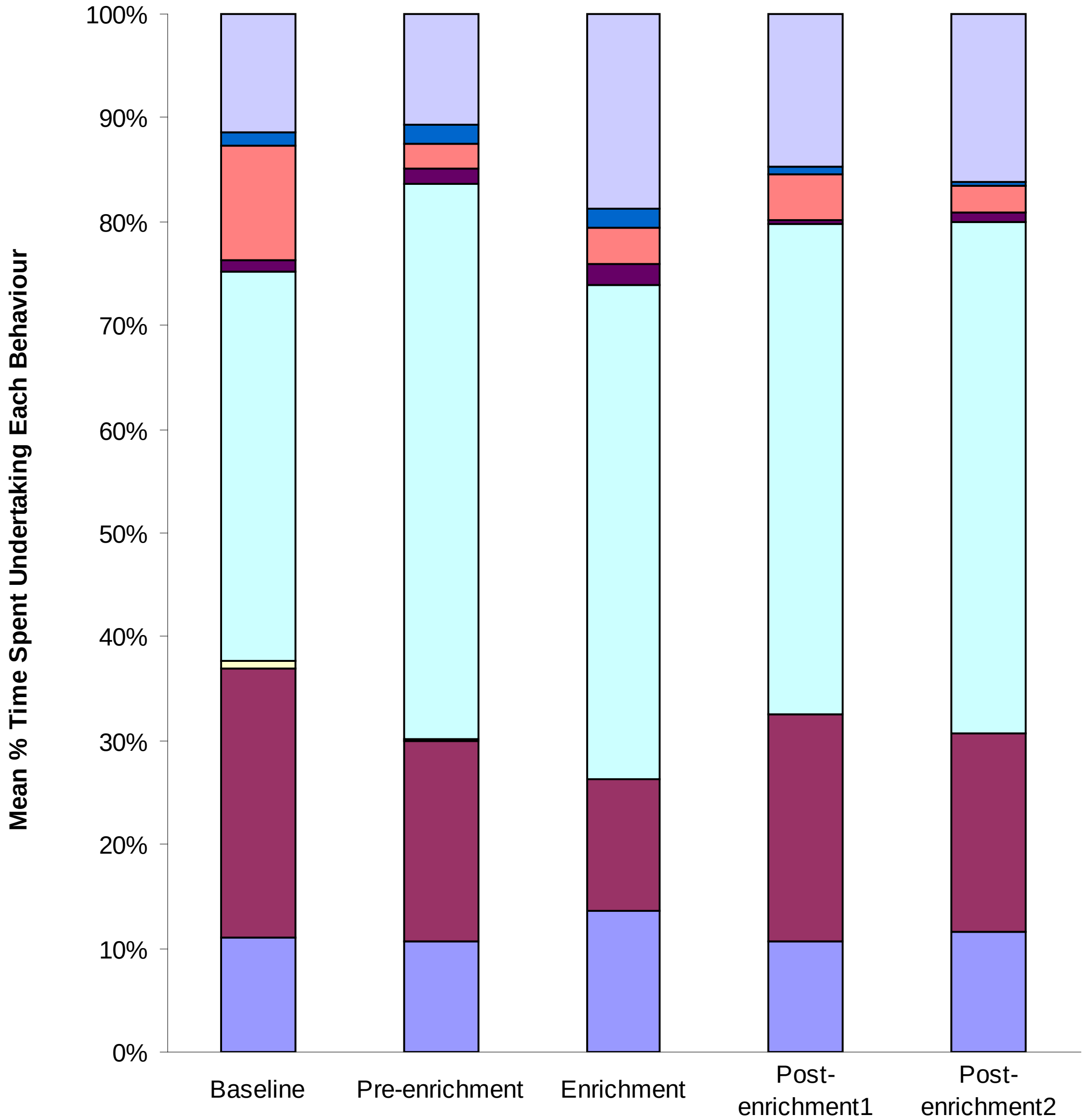
b. Lion-tailed macaques *(Macaca silenus)* - Macaque 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.11	0.11	0.19	0.16	0.16
BehavG	0.01	0.00	0.01	0.00	0.01
BehavF	0.02	0.01	0.01	0.02	0.00
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.62	0.61	0.51	0.50	0.56
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.14	0.14	0.14	0.22	0.16
BehavA	0.10	0.12	0.14	0.11	0.11

Period Of Study

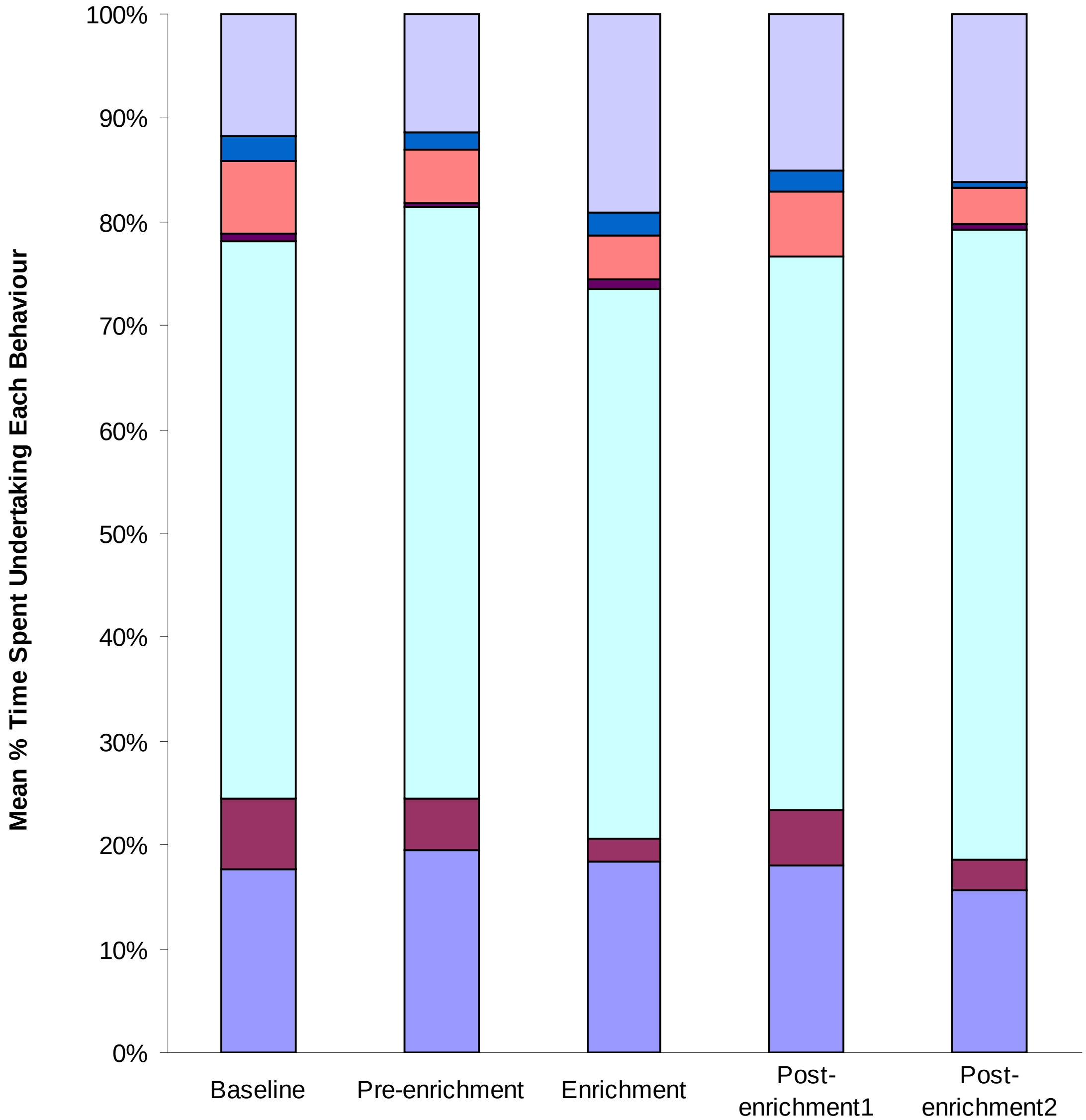
c. Lion-tailed macaques *(Macaca silenus)* - Macaque 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.11	0.11	0.19	0.15	0.16
BehavG	0.01	0.02	0.02	0.01	0.00
BehavF	0.11	0.03	0.04	0.04	0.03
BehavE	0.01	0.01	0.02	0.00	0.01
BehavD	0.37	0.53	0.47	0.47	0.49
BehavC	0.01	0.00	0.00	0.00	0.00
BehavB	0.26	0.19	0.13	0.22	0.19
BehavA	0.11	0.11	0.14	0.11	0.12

Period Of Study

d. Lion-tailed macaques *(Macaca silenus)* - Macaque 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.12	0.11	0.19	0.15	0.16
BehavG	0.02	0.02	0.02	0.02	0.00
BehavF	0.07	0.05	0.04	0.06	0.04
BehavE	0.01	0.00	0.01	0.00	0.01
BehavD	0.54	0.57	0.53	0.53	0.60
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.07	0.05	0.02	0.05	0.03
BehavA	0.18	0.19	0.18	0.18	0.16

Period Of Study

Kinahan A.(2007, *personal communication*), suggested that the time of day in which an animal performs specific behaviour may be altered during periods of enrichment even when the overall behavioural repertoire of the animal or the total amount of time spent undertaking each behaviour remains unchanged. Therefore, to determine if this is true for the macaques, fig. 3.12. and 3.13. illustrate the behaviour recorded during the morning period (08:00 to 11:55) and afternoon period (12:00 to 15:55) respectively, for each study period.

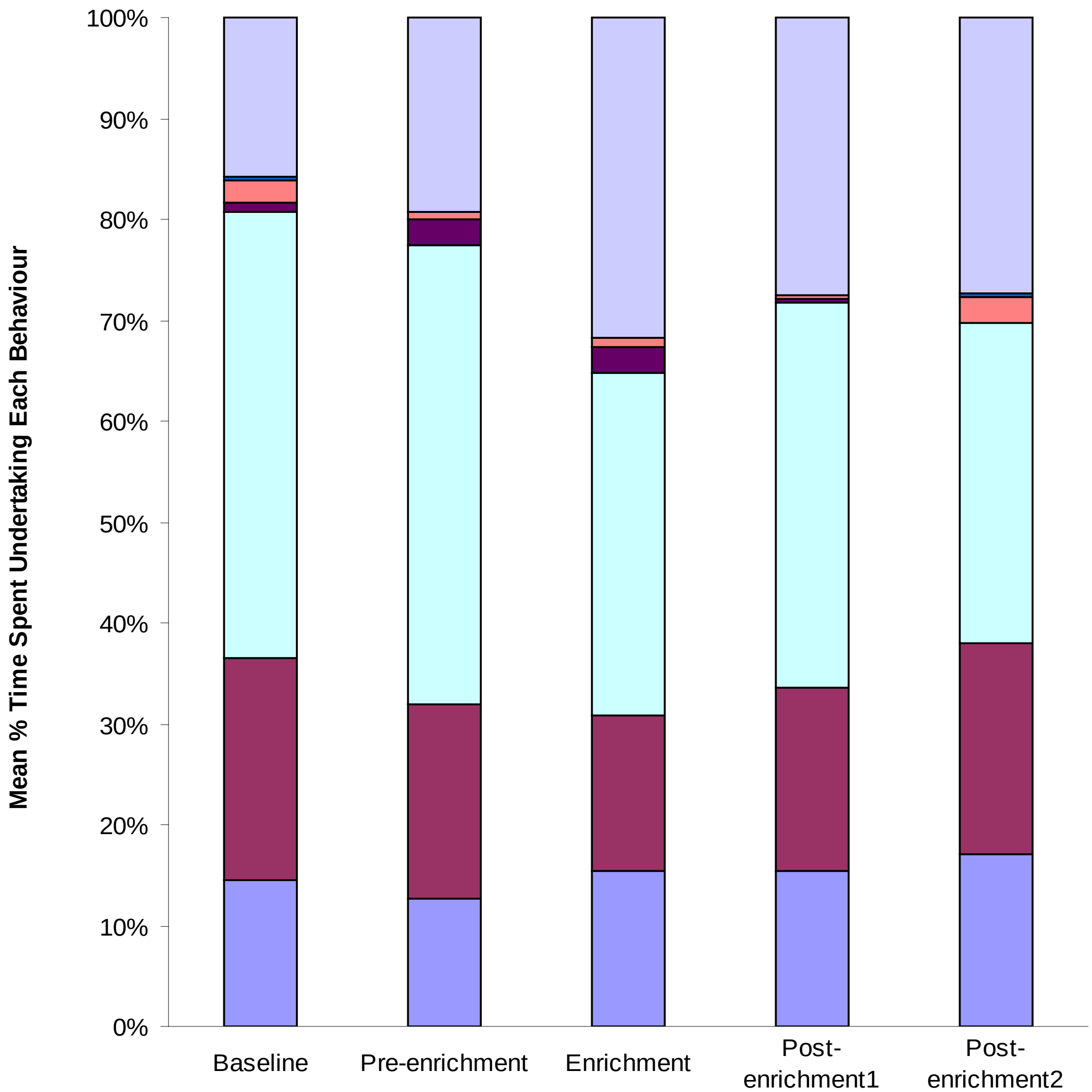
When comparing the morning and afternoon graphs below, there does appear to be some variation between morning and afternoon activity, but no striking variation presents itself when comparing enrichment and non-enrichment periods. For the morning data, there appears to be little individual variation between macaques 1, 2 and 3. All the animals regardless of the period of the study spend the majority of their time undertaking active species specific behaviour (Behaviour D). Feeding (Behaviour A), being stationary (Behaviour B) and non-visable (Behaviour H) were all undertaken to a lesser yet approximately equal extend.

Macaque 4 spent less of the morning stationary and more time feeding compared to the other three animals. However macaque 4 also spent the majority of the morning undertaking active species specific behaviour and the duration of being non-visable to the observer was approximately equal to the other three animals.

When comparing the afternoon graph to the morning, all four animals appear to spend less time eating and less time non-visable to the observer regardless of study period. Macaque 1 appeared to spend more time stationary in the afternoon compared to the morning with approximately equal time devoted to this and active species specific bahaviour. The afternoon graphs for macaques 2, 3 and 4 appear very similar to those of the morning other than for the feeding and non-visable behaviour mentioned above.

Figure 3.12. Representation of behavioural patterns for each study period (Morning period only)

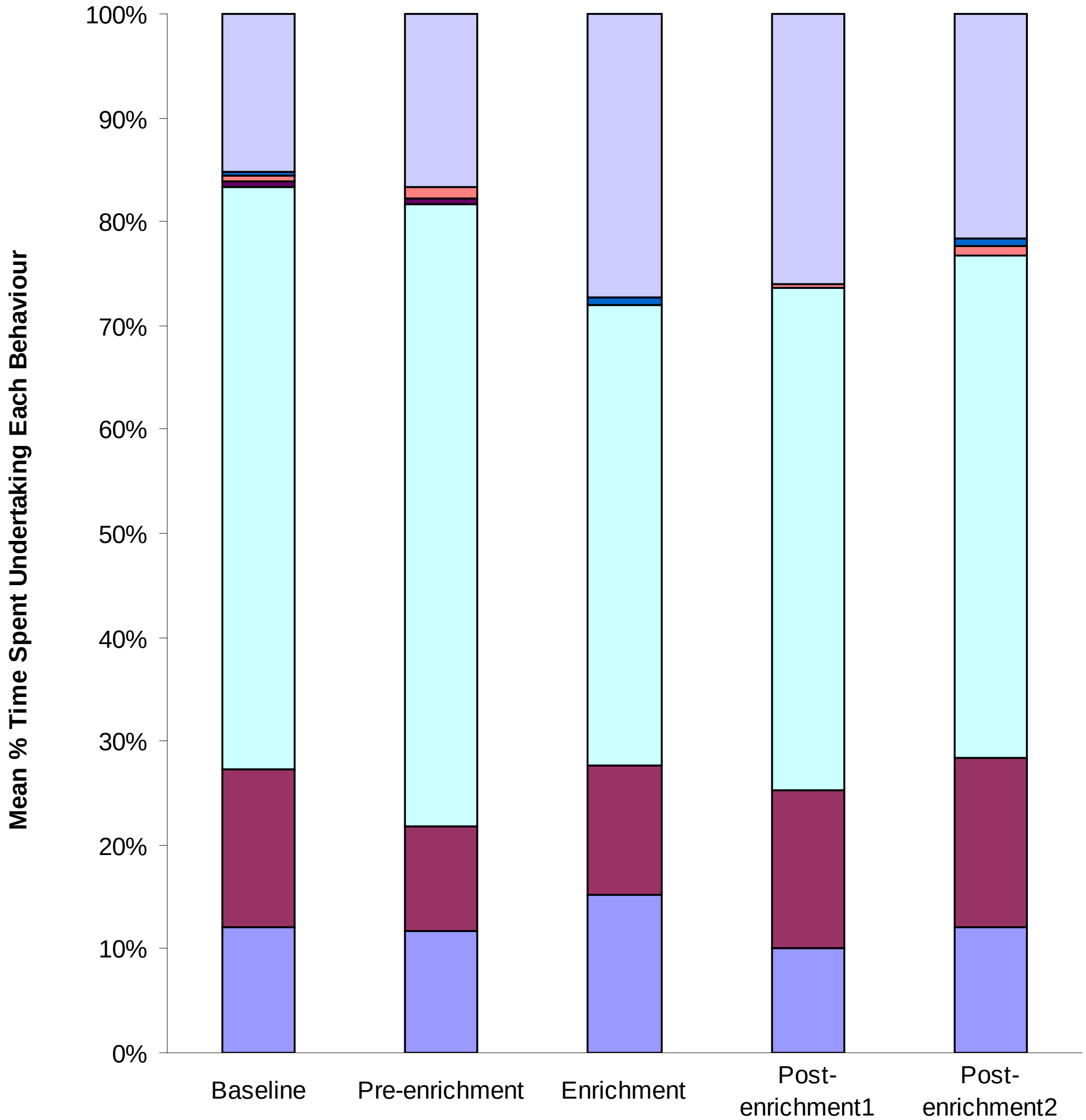
a. Lion-tailed macaques *(Macaca silenus)* - Macaque 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.16	0.19	0.32	0.27	0.27
BehavG	0.01	0.00	0.00	0.00	0.00
BehavF	0.02	0.01	0.01	0.00	0.03
BehavE	0.01	0.02	0.03	0.00	0.00
BehavD	0.44	0.46	0.34	0.38	0.32
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.22	0.19	0.15	0.18	0.21
BehavA	0.15	0.13	0.15	0.15	0.17

Period Of Study

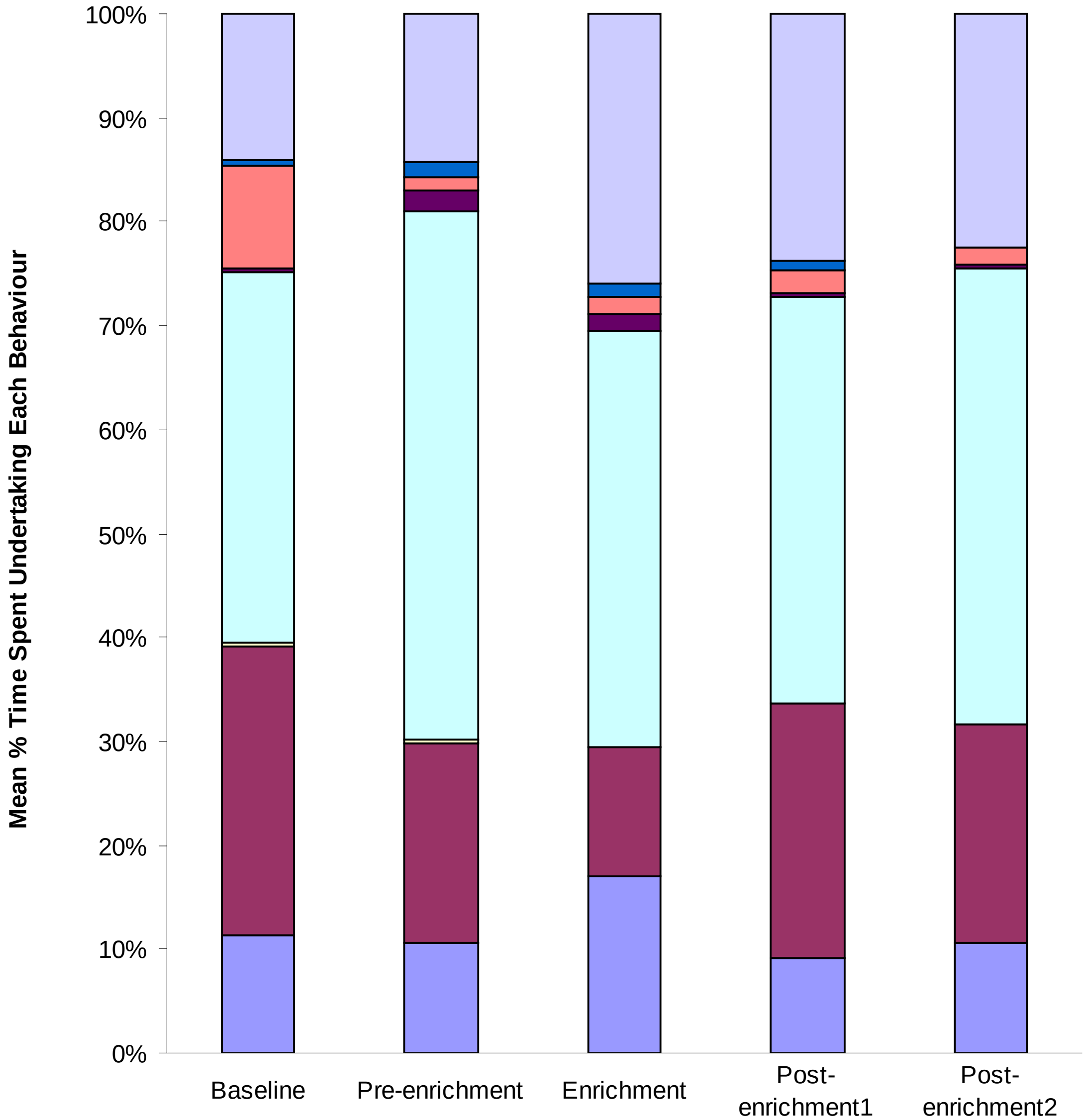
b. Lion-tailed macaques *(Macaca silenus)* - Macaque 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.15	0.17	0.27	0.26	0.22
BehavG	0.01	0.00	0.01	0.00	0.01
BehavF	0.01	0.01	0.00	0.00	0.01
BehavE	0.01	0.00	0.00	0.00	0.00
BehavD	0.56	0.60	0.44	0.48	0.48
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.15	0.10	0.13	0.15	0.16
BehavA	0.12	0.12	0.15	0.10	0.12

Period Of Study

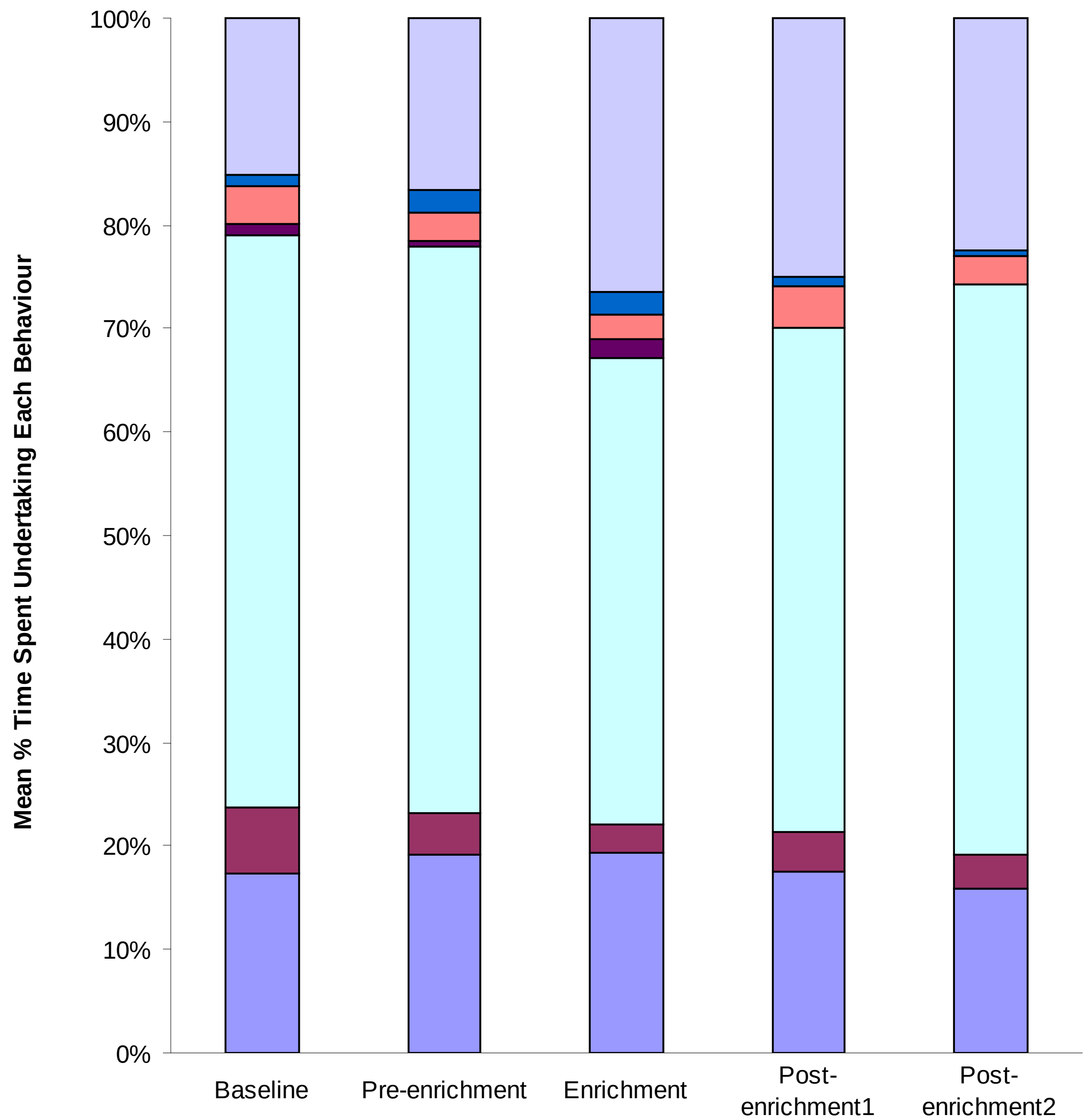
c. Lion-tailed macaques *(Macaca silenus)* - Macaque 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.14	0.14	0.26	0.24	0.23
BehavG	0.01	0.02	0.01	0.01	0.00
BehavF	0.10	0.01	0.02	0.02	0.02
BehavE	0.01	0.02	0.02	0.00	0.00
BehavD	0.35	0.51	0.40	0.39	0.44
BehavC	0.01	0.00	0.00	0.00	0.00
BehavB	0.28	0.19	0.12	0.24	0.21
BehavA	0.11	0.11	0.17	0.09	0.11

Period Of Study

d. Lion-tailed macaques *(Macaca silenus)* - Macaque 4

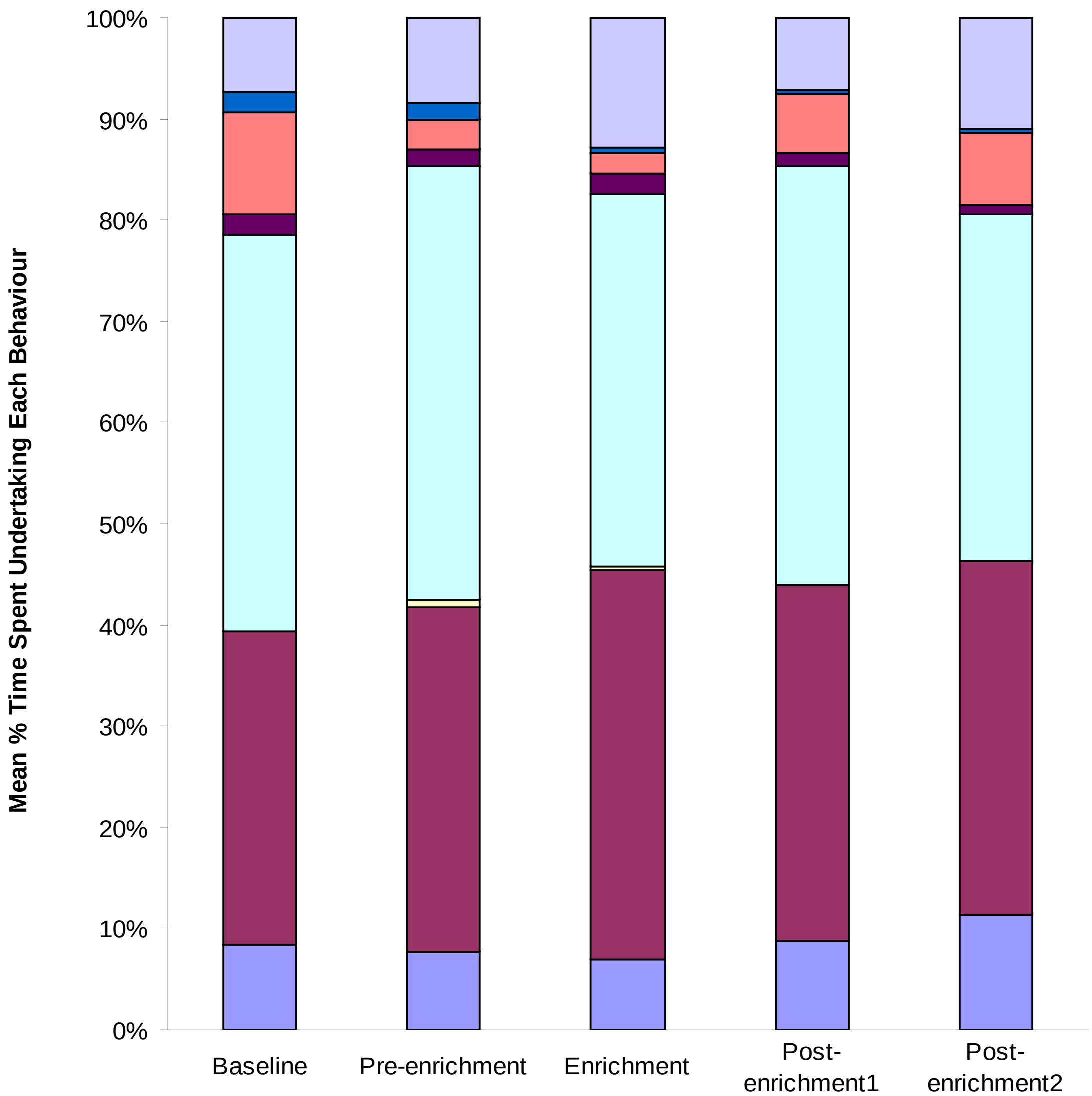


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.15	0.17	0.26	0.25	0.23
BehavG	0.01	0.02	0.02	0.01	0.00
BehavF	0.04	0.03	0.03	0.04	0.03
BehavE	0.01	0.00	0.02	0.00	0.00
BehavD	0.55	0.55	0.45	0.48	0.55
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.06	0.04	0.03	0.04	0.03
BehavA	0.17	0.19	0.19	0.18	0.16

Period Of Study

Figure 3.13. Representation of behavioural patterns for each study period (Afternoon period only)

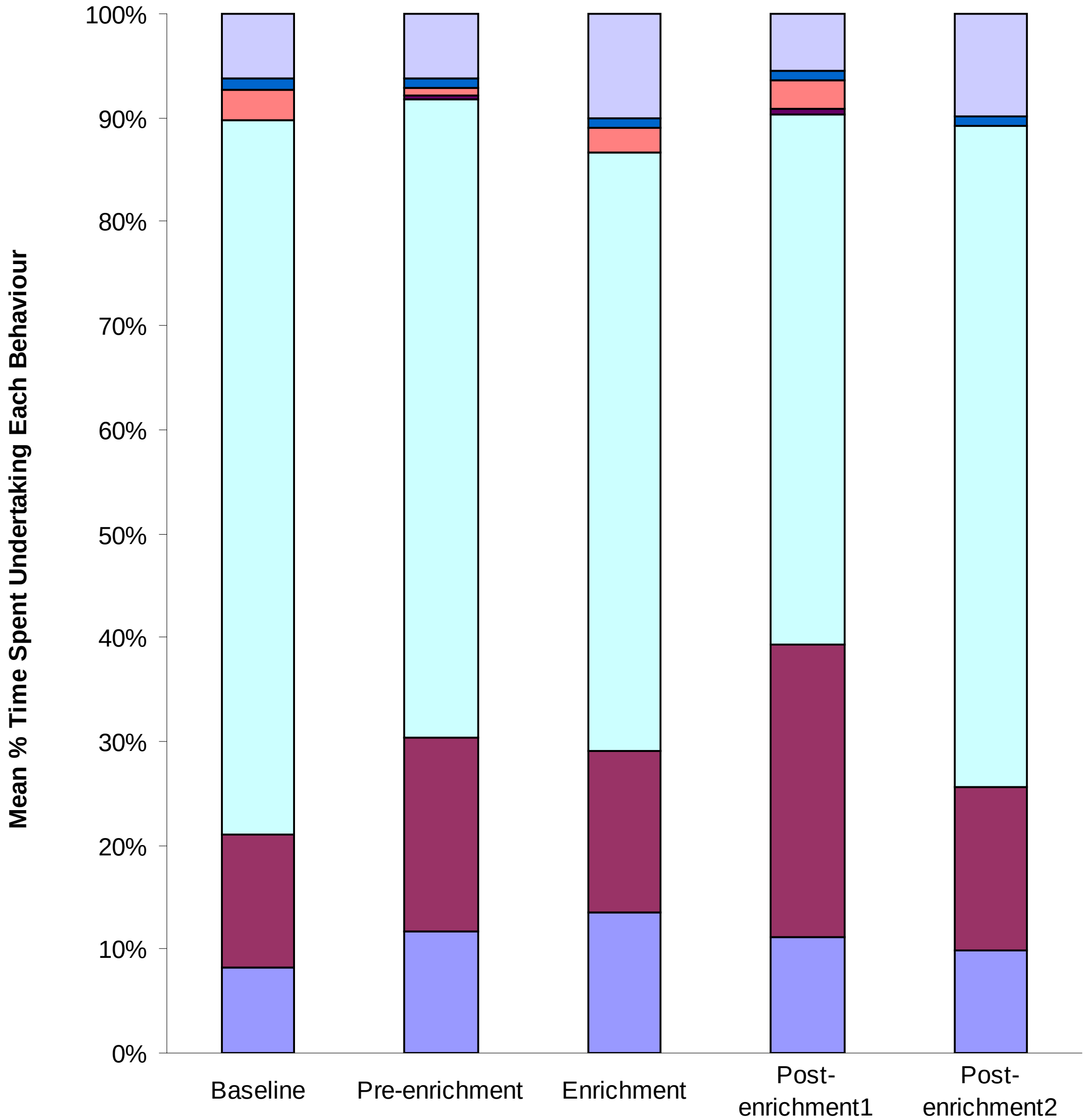
a. Lion-tailed macaques *(Macaca silenus)* - Macaque 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.07	0.09	0.13	0.07	0.11
BehavG	0.02	0.02	0.00	0.00	0.00
BehavF	0.10	0.03	0.02	0.06	0.07
BehavE	0.02	0.02	0.02	0.01	0.01
BehavD	0.39	0.43	0.37	0.41	0.34
BehavC	0.00	0.01	0.00	0.00	0.00
BehavB	0.31	0.34	0.38	0.35	0.35
BehavA	0.08	0.08	0.07	0.09	0.11

Period Of Study

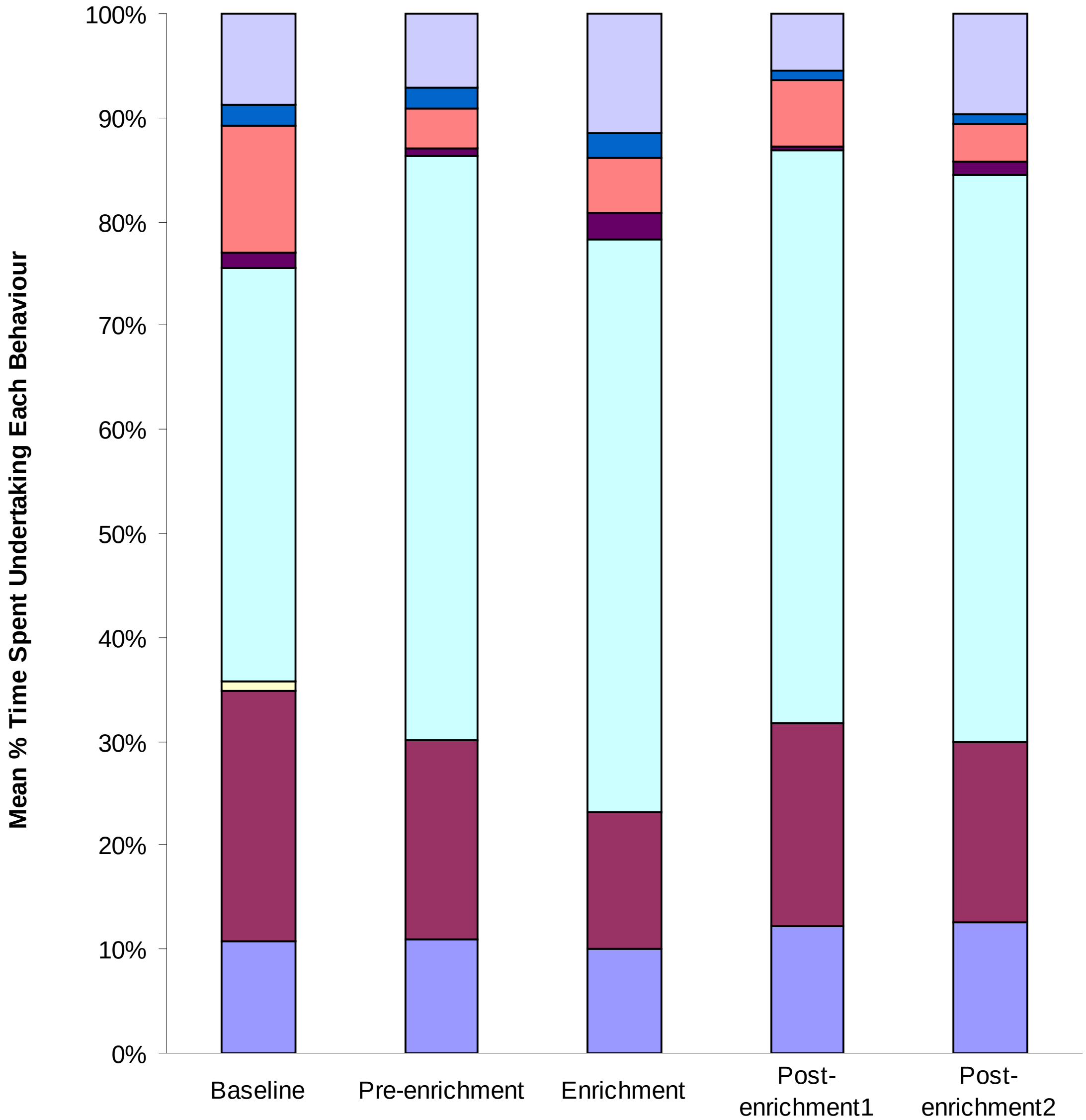
b. Lion-tailed macaques *(Macaca silenus)* - Macaque 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.06	0.06	0.10	0.06	0.10
BehavG	0.01	0.01	0.01	0.01	0.01
BehavF	0.03	0.01	0.02	0.03	0.00
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.69	0.61	0.57	0.51	0.64
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.13	0.19	0.16	0.28	0.16
BehavA	0.08	0.12	0.13	0.11	0.10

Period Of Study

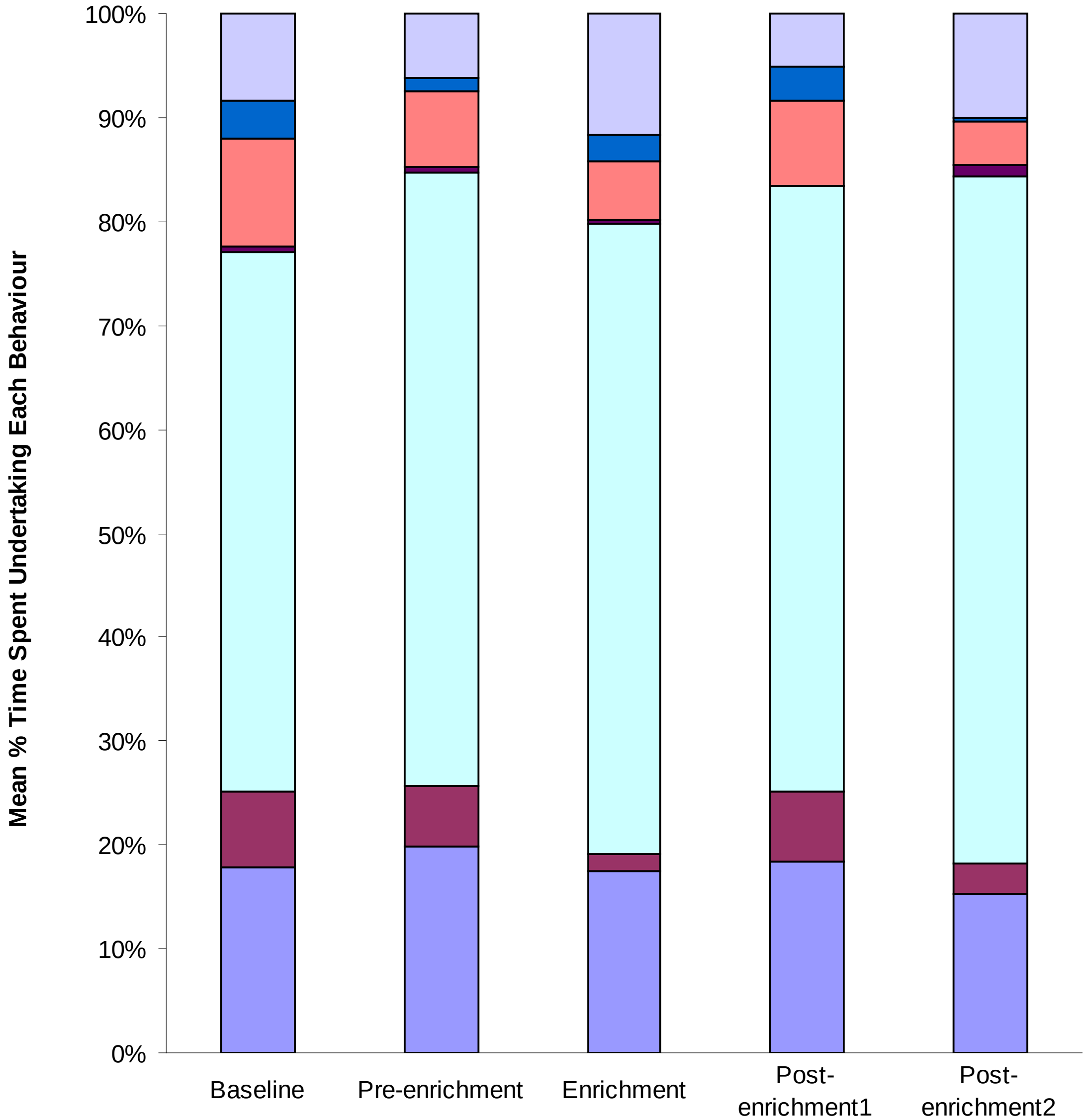
c. Lion-tailed macaques *(Macaca silenus)* - Macaque 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.09	0.07	0.11	0.06	0.10
BehavG	0.02	0.02	0.02	0.01	0.01
BehavF	0.12	0.04	0.05	0.06	0.04
BehavE	0.02	0.01	0.03	0.00	0.01
BehavD	0.40	0.56	0.55	0.55	0.55
BehavC	0.01	0.00	0.00	0.00	0.00
BehavB	0.24	0.19	0.13	0.19	0.17
BehavA	0.11	0.11	0.10	0.12	0.13

Period Of Study

d. Lion-tailed macaques *(Macaca silenus)* - Macaque 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.08	0.06	0.12	0.05	0.10
BehavG	0.04	0.01	0.02	0.03	0.00
BehavF	0.10	0.07	0.06	0.08	0.04
BehavE	0.01	0.00	0.00	0.00	0.01
BehavD	0.52	0.59	0.60	0.58	0.66
BehavC	0.00	0.00	0.00	0.00	0.00
BehavB	0.07	0.06	0.02	0.07	0.03
BehavA	0.18	0.20	0.18	0.18	0.15

Period Of Study

3.3.1.2. Statistical analysis

The data was analysed by Mann-Whitney-U test (SPSS).

Whole day data analysis

Table 3.11., highlights the significant findings for the proportion of time spent undertaking behaviour between each study period for each individual lion-tailed macaque.

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Behaviour A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	-	-)	* (579.5)	*** (443.5)	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	** (401.5)	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	* (658.5)	-	** (637.0)	* (700.0)	-	-	-	-
Behaviour F	* (475.0)	-	*** (359.5)	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour G	-	-)	-	-	-	-	-	-	-	-	-	-	-	-	-	* (659.0)
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-	-	)	-	-

Table 3.11.: Individual comparative results for the various study periods

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Macaque 1, Macaque 2, Macaque 3, Macaque 4.*

The majority of the comparative data showed no significant difference between study periods, with no individual having any significant behavioural variation when comparing pre-enrichment and enrichment periods. Table 3.11. does show that macaque 1 the skinny male, significantly decreased human interaction (Behaviour F) between baseline and pre-enrichment periods, as did macaque 3, the big male. In addition macaque 3 significantly increased active species specific behaviour (Behaviour D) during comparison of the same periods.

For the comparison of the enrichment and post-enrichment 1 period the majority of significant behavioural variation was recorded. Both macaque 2 and 3 significantly increased stationary behaviour (Behaviour B), whilst macaques 1, 3 and 4 all significantly decreased aggressive interactions (Behaviour E).

Macaque 4, the little female, was the only animal to show a behavioural difference between post-enrichment 1 and post-enrichment 2 periods, significantly decreasing non-relevant behaviour (Behaviour G).

Morning and afternoon data analysis

Table 3.12. and 3.12. highlight the significant behavioural changes for each animal for the different study periods during the morning and afternoon respectively. The majority of the significant behavioural variations occurred during the afternoon period. Only four changes were seen during the morning, with macaque 3 significantly decreasing human interaction (Behaviour F) on comparison of baseline and pre-enrichment periods and increasing stationery behaviour (Behaviour B) when comparing enrichment to post-enrichment 1. During the morning macaques 1 and 4 both significantly decreased aggressive behaviour (Behaviour E) when comparing the enrichment and post-enrichment period.

For the afternoon data, macaques 1, 2 and 3 all significantly decreased human interaction (Behaviour F) and macaque 3 increased active species specific behaviour (Behaviour D) when comparing baseline and pre-enrichment periods.

Macaque 4 showed a significant decrease in stationery behaviour (behaviour B) during the enrichment period when compared to pre-enrichment and a rebound significant increase in the same behaviour when comparing enrichment to post-enrichment 1. Macaques 2 and 3 also showed a significant increase in stationery behaviour during the same period. When comparing enrichment to post-enrichment 1, macaque 3 also showed a significant decrease in aggressive interactions (Behaviour E).

Post-enrichment 1 compared to post-enrichment 2 during the afternoon period showed macaque 2 significantly decrease stationery behaviour (Behaviour B) and human interaction (Behaviour F). Macaque 4 significantly decreased non-relevant behaviour (Behaviour G) during the same comparative period.

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Behaviour A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	-	-	-	** (92.0)	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	* (149.0)	-	-	* (160.0)	-	-	-	-
Behaviour F	-	-	** (76.5)	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.12. Individual comparative results for the various study periods (Morning only)

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Macaque 1, Macaque 2, Macaque 3, Macaque 4.*

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Behaviour A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	* (134.0)	-	** (110.0)	* (129.0)	* (124.0)	-	* (111.5)	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	* (89.5)	-	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	* (149.0)	-	-	-	-	-
Behaviour F	* (91.0)	* (115.0)	* (100.5)	-	-	-	-	-	-	-	-	-	-	* (150.0)	-	-
Behaviour G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	* (139.5)
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.13. Individual comparative results for the various study periods (Afternoon only) *-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Macaque 1, Macaque 2, Macaque 3, Macaque 4.*

3.3.2. Spatial Utilisation

3.3.2.1. Descriptive data

Figure 3.14. represent the spatial utilisation of the individual macaque for each of the five study periods. Appendix 6.2c shows the demarcation of zones / quadrants within each enclosure i.e. Position (Pos 1, 2, 3, 7, 8, 9, 19, 20, 21, 25, 26 and 27. Pos 0 represents every observational recording period in which a particular individual was non-visible.

From the figures below, individual animal and study period variation in enclosure utilisation are not clearly evident. All the macaques appear to utilise the majority of the enclosure on a regular basis, showing less clumping than in the case of the African savanna elephants (section 3.1.2.) or leopard (section 3.2.2.).

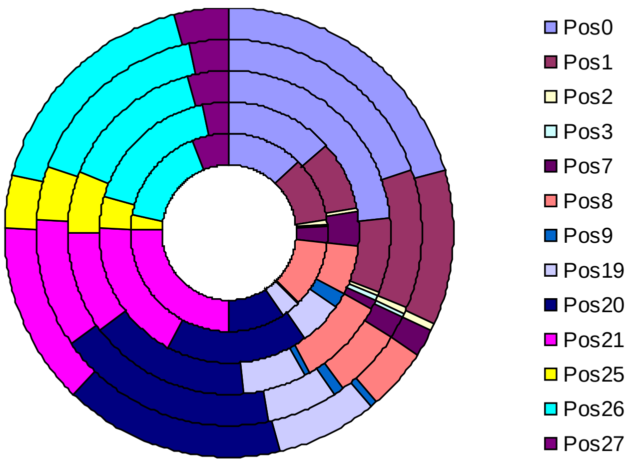
Positions 20, 21 and 26 which account for 25% of the available space appear to be frequented the most by all individuals, with them spending between 41% and 62% of the observed time in these zones. However, it must be borne in mind that 9% to 23% of the time the macaques were non-visible, with the highest percentage of non-visibility being during the enrichment period for each individual.

The least utilised zones were that of position 2 and 3, which were the elevated areas to the centre and right closest to the observational / visitor windows. The above findings were true for all individuals regardless of study period.

Figure 3.14. Representation of spatial utilisation

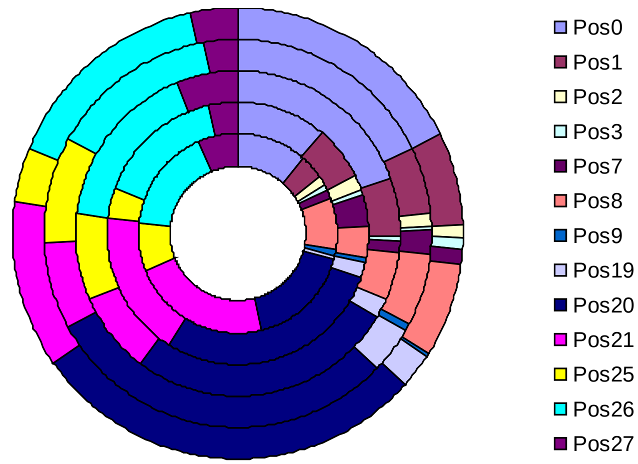
Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.

a. Lion-tailed macaques *(Macaca silenus)* - Macaque 1



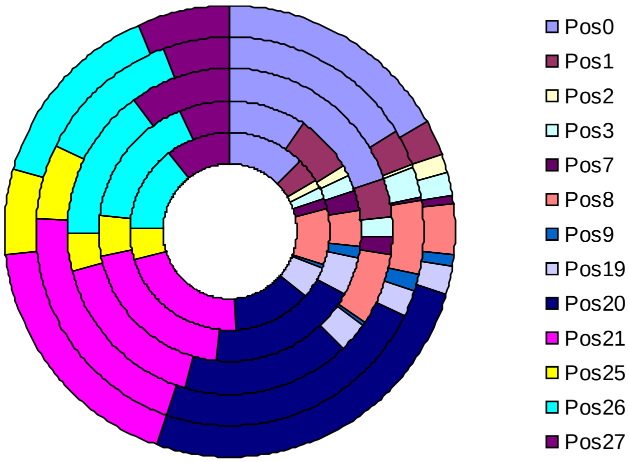
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.12	0.13	0.23	0.20	0.20
Pos 1	0.11	0.09	0.07	0.12	0.11
Pos 2	0.01	0.01	0.00	0.00	0.01
Pos 3	0.00	0.00	0.00	0.00	0.00
Pos 7	0.03	0.04	0.01	0.02	0.02
Pos 8	0.11	0.06	0.09	0.06	0.04
Pos 9	0.00	0.02	0.01	0.01	0.01
Pos 19	0.03	0.05	0.06	0.06	0.07
Pos 20	0.09	0.18	0.16	0.18	0.16
Pos 21	0.26	0.18	0.10	0.11	0.13
Pos 25	0.02	0.04	0.06	0.05	0.04
Pos 26	0.16	0.17	0.15	0.16	0.17
Pos 27	0.06	0.03	0.04	0.03	0.04

b. Lion-tailed macaques *(Macaca silenus)* - Macaque 2



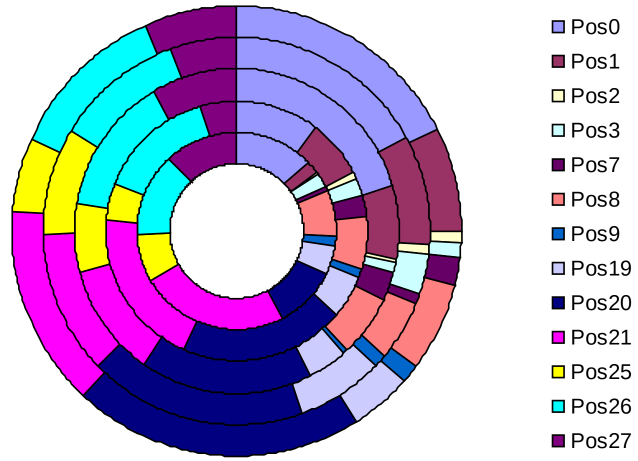
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.11	0.11	0.19	0.17	0.18
Pos 1	0.04	0.07	0.06	0.06	0.07
Pos 2	0.02	0.02	0.00	0.01	0.01
Pos 3	0.01	0.01	0.01	0.00	0.01
Pos 7	0.02	0.04	0.01	0.02	0.01
Pos 8	0.08	0.04	0.05	0.06	0.07
Pos 9	0.01	0.01	0.00	0.01	0.00
Pos 19	0.01	0.02	0.02	0.04	0.02
Pos 20	0.17	0.28	0.26	0.29	0.28
Pos 21	0.23	0.18	0.08	0.07	0.12
Pos 25	0.08	0.04	0.09	0.09	0.04
Pos 26	0.17	0.16	0.17	0.14	0.15
Pos 27	0.06	0.04	0.06	0.03	0.03

c. Lion-tailed macaques *(Macaca silenus)* - Macaque 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.12	0.09	0.20	0.16	0.17
Pos 1	0.04	0.07	0.04	0.03	0.02
Pos 2	0.01	0.02	0.00	0.00	0.01
Pos 3	0.02	0.02	0.02	0.02	0.02
Pos 7	0.02	0.03	0.02	0.00	0.01
Pos 8	0.09	0.04	0.07	0.06	0.04
Pos 9	0.01	0.02	0.00	0.01	0.01
Pos 19	0.05	0.05	0.03	0.02	0.02
Pos 20	0.13	0.18	0.17	0.23	0.26
Pos 21	0.21	0.20	0.16	0.21	0.18
Pos 25	0.05	0.05	0.04	0.06	0.06
Pos 26	0.14	0.17	0.15	0.12	0.14
Pos 27	0.11	0.06	0.10	0.05	0.07

d. Lion-tailed macaques *(Macaca silenus)* - Macaque 4



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.13	0.10	0.20	0.17	0.17
Pos 1	0.02	0.07	0.07	0.09	0.07
Pos 2	0.00	0.01	0.00	0.01	0.01
Pos 3	0.02	0.02	0.01	0.03	0.01
Pos 7	0.01	0.03	0.03	0.01	0.02
Pos 8	0.08	0.06	0.06	0.05	0.06
Pos 9	0.02	0.01	0.00	0.01	0.01
Pos 19	0.05	0.05	0.04	0.07	0.04
Pos 20	0.10	0.20	0.17	0.18	0.20
Pos 21	0.24	0.19	0.11	0.12	0.14
Pos 25	0.08	0.04	0.07	0.09	0.05
Pos 26	0.14	0.15	0.13	0.11	0.12
Pos 27	0.12	0.04	0.09	0.06	0.07

3.3.2.2. Statistical analysis

The enclosure was divided into twelve quadrants of approximately equal size, measuring 5m x 6.6m x 2.25m.

Individual enclosure use or coefficient of variation (CV) as used by Stoinski et al. (2001), ranged from 0.87 to 1.31 (see Table 3.14.). Macaque 3 utilised the most enclosure space (clumped the least) during the baseline period, with a CV of 0.87, however in general macaque 4 tends to utilise the enclosure most effectively. Macaque 2 utilised the least enclosure space (clumped the most) during the enrichment period, with a CV of 1.31 and was generally the individual that had the lowest enclosure usage regardless of study period.

		Mean	StDev	CV
MACAQUE 1	**Baseline (n=4)**	0.07	0.08	1.09
	Pre-Enrichment (n=5)	0.07	0.08	1.06
	Enrichment (n=5)	0.06	0.06	1.00
	Post-Enrichment 1 (n=5)	0.07	0.07	1.01
	Post-Enrichment 2 (n=5)	0.07	0.07	1.07
MACAQUE 2	**Baseline (n=4)**	0.07	0.08	1.10
	Pre-Enrichment (n=5)	0.07	0.09	1.24
	Enrichment (n=5)	0.07	0.09	1.31
	Post-Enrichment 1 (n=5)	0.07	0.08	1.21
	Post-Enrichment 2 (n=5)	0.07	0.09	1.24
MACAQUE 3	**Baseline (n=4)**	0.07	0.06	0.87
	Pre-Enrichment (n=5)	0.08	0.07	0.94
	Enrichment (n=5)	0.07	0.07	0.99
	Post-Enrichment 1 (n=5)	0.07	0.09	1.22
	Post-Enrichment 2 (n=5)	0.07	0.08	1.17
MACAQUE 4	**Baseline (n=4)**	0.07	0.07	1.01
	Pre-Enrichment (n=5)	0.07	0.07	0.96
	Enrichment (n=5)	0.07	0.06	0.93
	Post-Enrichment 1 (n=5)	0.07	0.06	0.92
	Post-Enrichment 2 (n=5)	0.07	0.06	0.93

Table 3.14. Enclosure usage data

When statistical analysis was run using the Mann-Whitney U test, several significant changes for specific area usage by individual macaques was indicated (See Table 3.15.)

	Baseline (n=32) vs Pre-enrichment (n=40)				Pre-enrichment (n=40) vs Enrichment (n=40)				Enrichment (n=40) vs Post-enrichment 1 (n=40)				Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)			
Pos1	-	-	-	-	-	-	* (2.5)	-	-	-	-	-	-	-	-	-
Pos2	-	-	-	-	-	* (5.0)	-	-	-	* (2.5)	-	-	-	-	-	-
Pos3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos20	-	* (1.5)	-	* (1.5)	-	-	-	-	-	-	-	-	-	-	-	-
Pos21	-	-	-	-	-	* (3.0)	-	** (0.0)	-	-	-	-	-	-	-	-
Pos25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pos27	-	-	* (1.5)	-	-	-	* (3.0)	-	-	-	-	-	-	-	-	-
Pos0	-	-	-	-	* (1.5)	* (1.0)	** (0.0)	* (1.0)	-	-	-	-	-	-	-	-

Table 3.15. Individual comparative results for the various study periods *-=no significant difference, * = $p\leq0.05$, **=$p\leq0.01$, ***=$p\leq0.001$, Number in ( ) = U value. Macaque 1, Macaque 2, Macaque 3, Macaque 4.*

As the table above shows, the majority of significant differences in enclosure usage fall within the comparison of pre-enrichment and enrichment. All four individuals significantly increase the time they are non-visible during the enrichment period compared to pre-enrichment, macaque 3 significantly increases the time spent in position 27 and both macaque 2 and 4 significantly decrease the time spent in position 21. Also during the comparison of pre-enrichment and enrichment macaque 2 significantly decreases the time spent in position 2 and macaque 3 decreases the time spent in position 1.

When comparing baseline and pre-enrichment data, macaque 2 and 4 significantly increased the time spent in position 20 and macaque 3 significantly decreased the time spent in position 27. The only other significant enclosure utilisation change was by macaque 2 that showed a rebound effect, significantly increasing time spent in position 2 during post-enrichment 1 when compared to the enrichment period. There were no significant differences seen between post-enrichment 1 and post-enrichment 2 periods.

08112009-1654473.4. RED PANDA *(Ailurus rulgeus)*

3.4.1. Behavioural Observations

3.4.1.1. Descriptive data

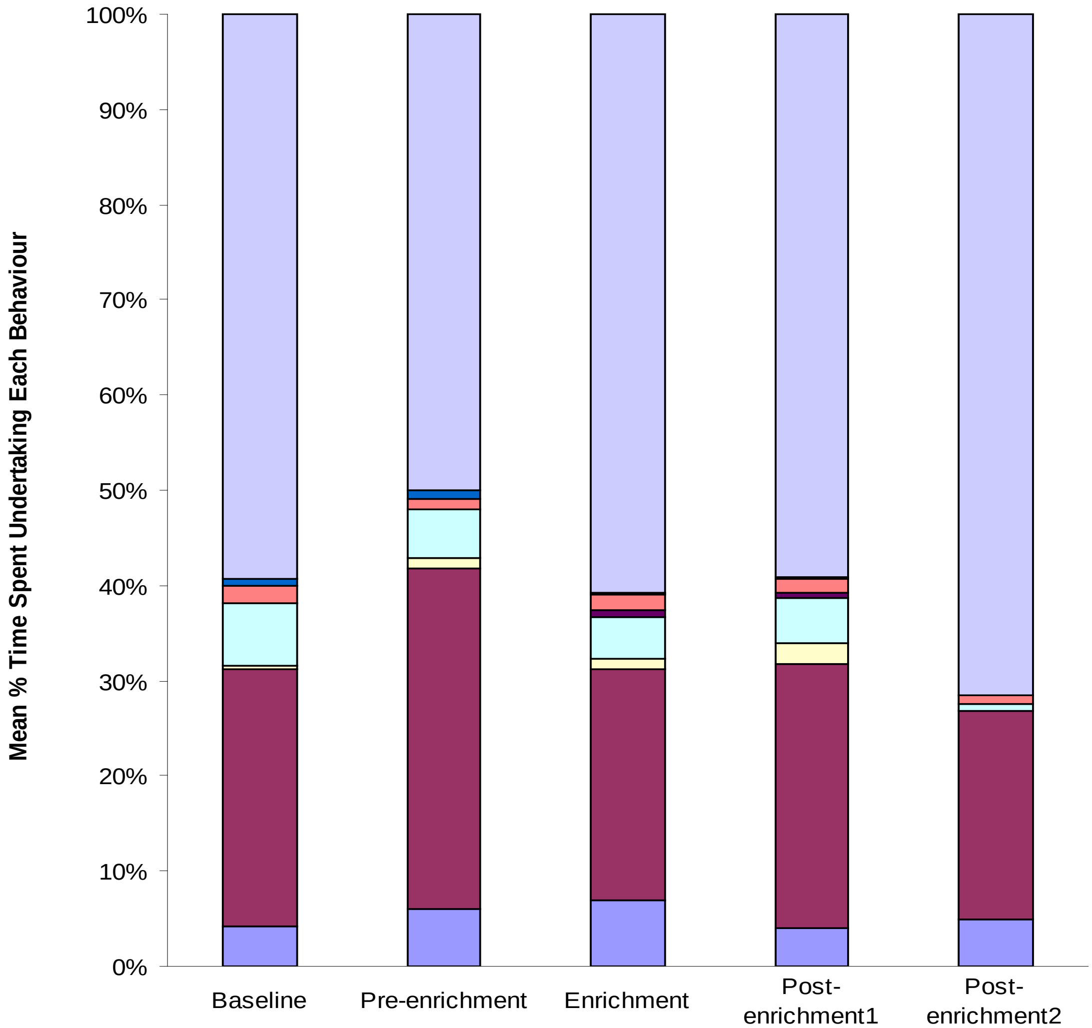
Fig. 3.15.. illustrates the proportion of time spent by the red panda performing the various behavioural patterns, by representing the mean time spent expressing each behaviour for the different periods of the study i.e. 'Baseline', 'Pre-Enrichment', 'Enrichment', 'Post-Enrichment Day1' & 'Post-Enrichment Day2'.

Red panda 1, spent over half of every study period non-visable (Behaviour H) to the observer. When visible, stationery behaviour (Behaviour B) predominated for each study period. Red panda 2, spent a lesser but still substantial percentage of time non-visible (24% to 44% depending on study period) when compared to panda 1, spending the majority of its visible time stationery. The above observations were true for all study periods. No obvious behavioural differences were noted between study period for either animal. See Appendix 5 for full descriptive statistics.

Kinahan A.(2007, *personal communication*), suggested that the time of day in which an animal performs specific behaviour may be altered during periods of enrichment even when the overall behavioural repertoire of the animal or the total amount of time spent undertaking each behaviour remains unchanged. Therefore, to determine if this is true for the red panda, fig. 3.16. and 3.17. illustrate the behaviour recorded during the morning period (08:00 to 11:55) and afternoon period (12:00 to 15:55) respectively, for each study period.

Figure 3.15. Representation of behavioural patterns for each study period (Red Panda)

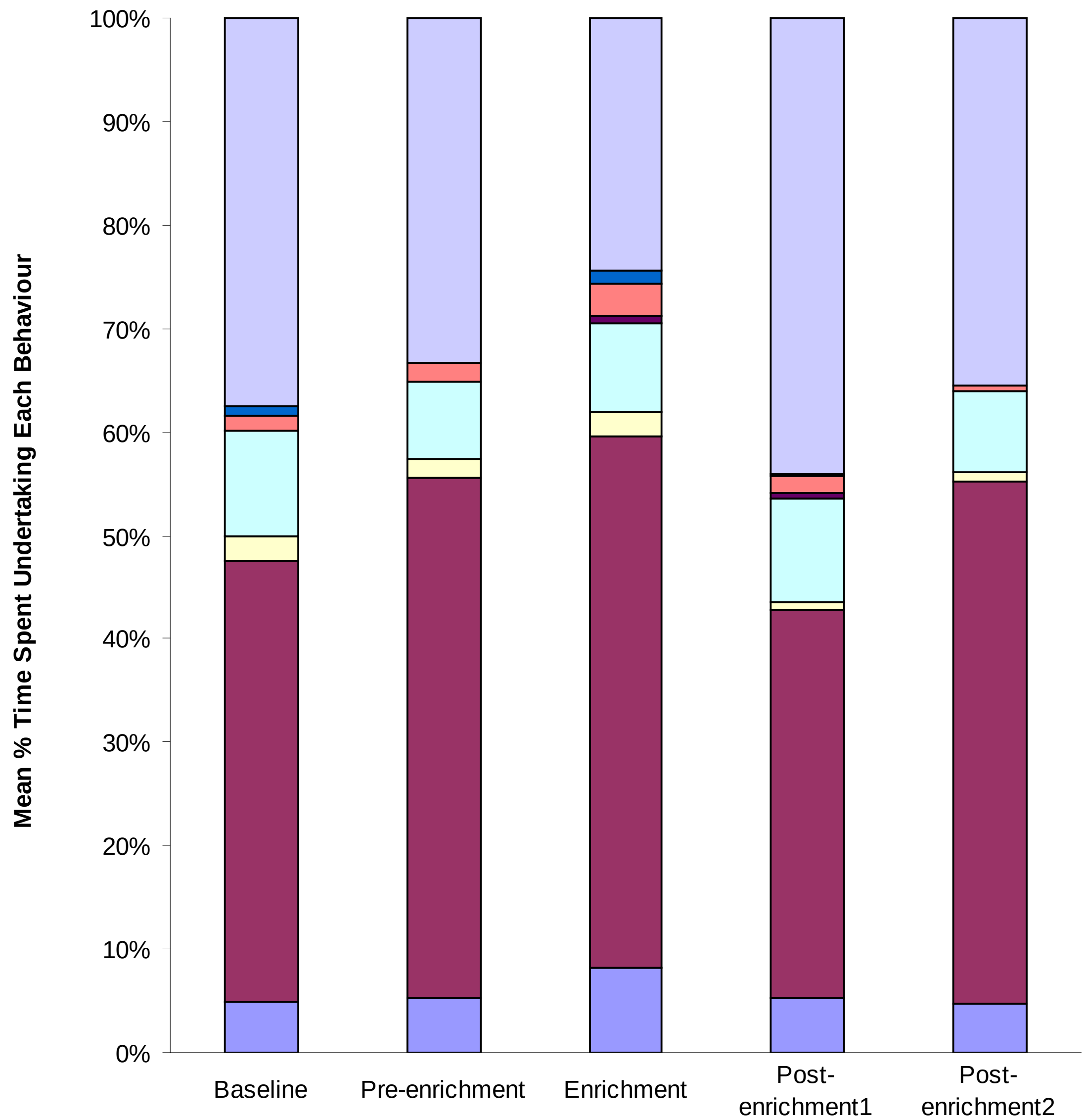
a. Red panda *(Ailurus rulgeus)* - Red Panda 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.59	0.50	0.61	0.59	0.71
BehavG	0.01	0.01	0.00	0.00	0.00
BehavF	0.02	0.01	0.02	0.01	0.01
BehavE	0.00	0.00	0.01	0.00	0.00
BehavD	0.07	0.05	0.04	0.05	0.01
BehavC	0.01	0.01	0.01	0.02	0.00
BehavB	0.27	0.36	0.24	0.28	0.22
BehavA	0.04	0.06	0.07	0.04	0.05

Period Of Study

b. Red panda *(Ailurus rulgeus)* - Red Panda 2

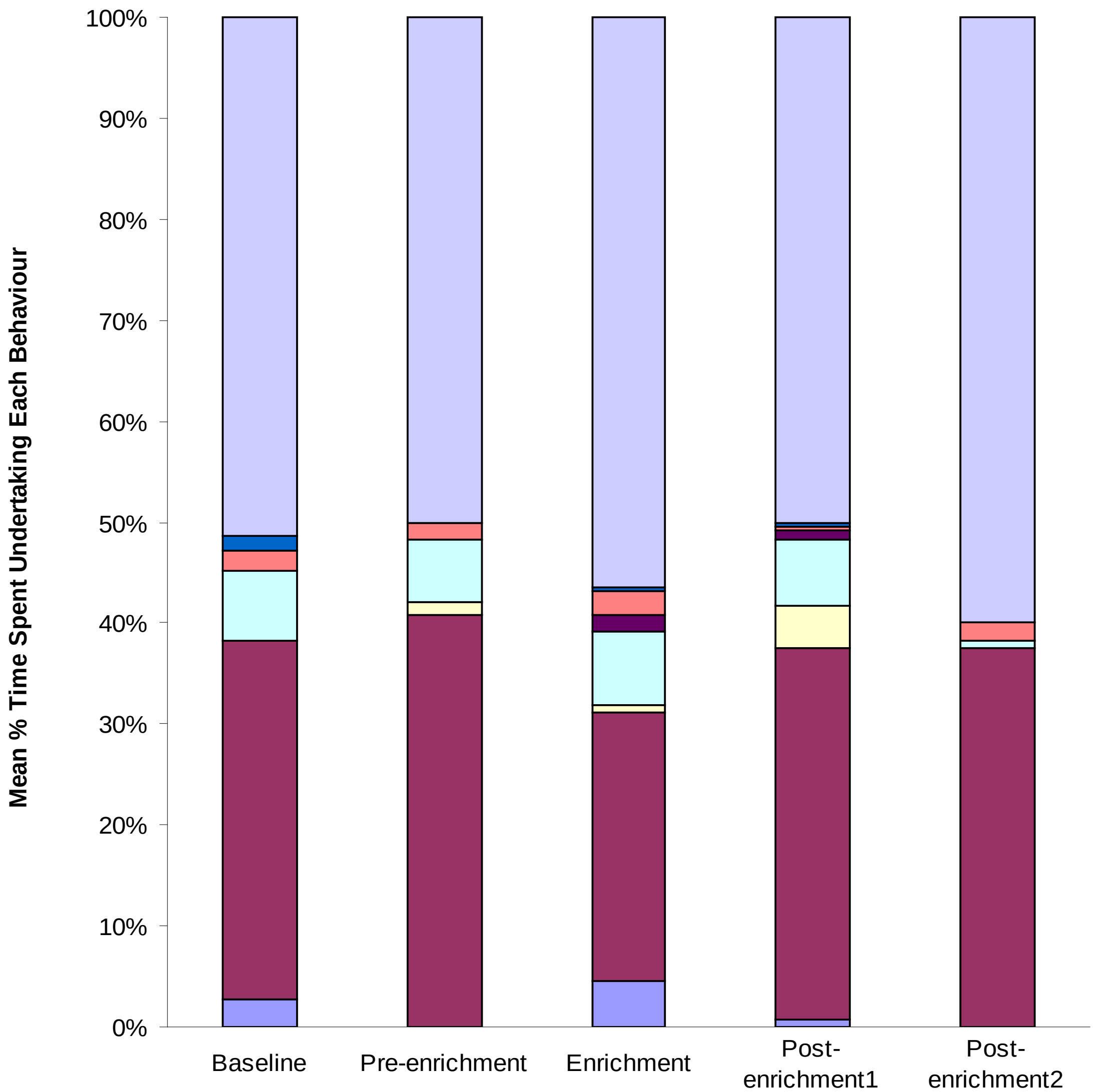


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.38	0.33	0.24	0.44	0.35
BehavG	0.01	0.00	0.01	0.00	0.00
BehavF	0.02	0.02	0.03	0.02	0.01
BehavE	0.00	0.00	0.01	0.01	0.00
BehavD	0.10	0.08	0.09	0.10	0.08
BehavC	0.02	0.02	0.02	0.01	0.01
BehavB	0.43	0.50	0.51	0.38	0.50
BehavA	0.05	0.05	0.08	0.05	0.05

Period Of Study

Figure 3.16. Representation of behavioural patterns for each study period (Morning period only)

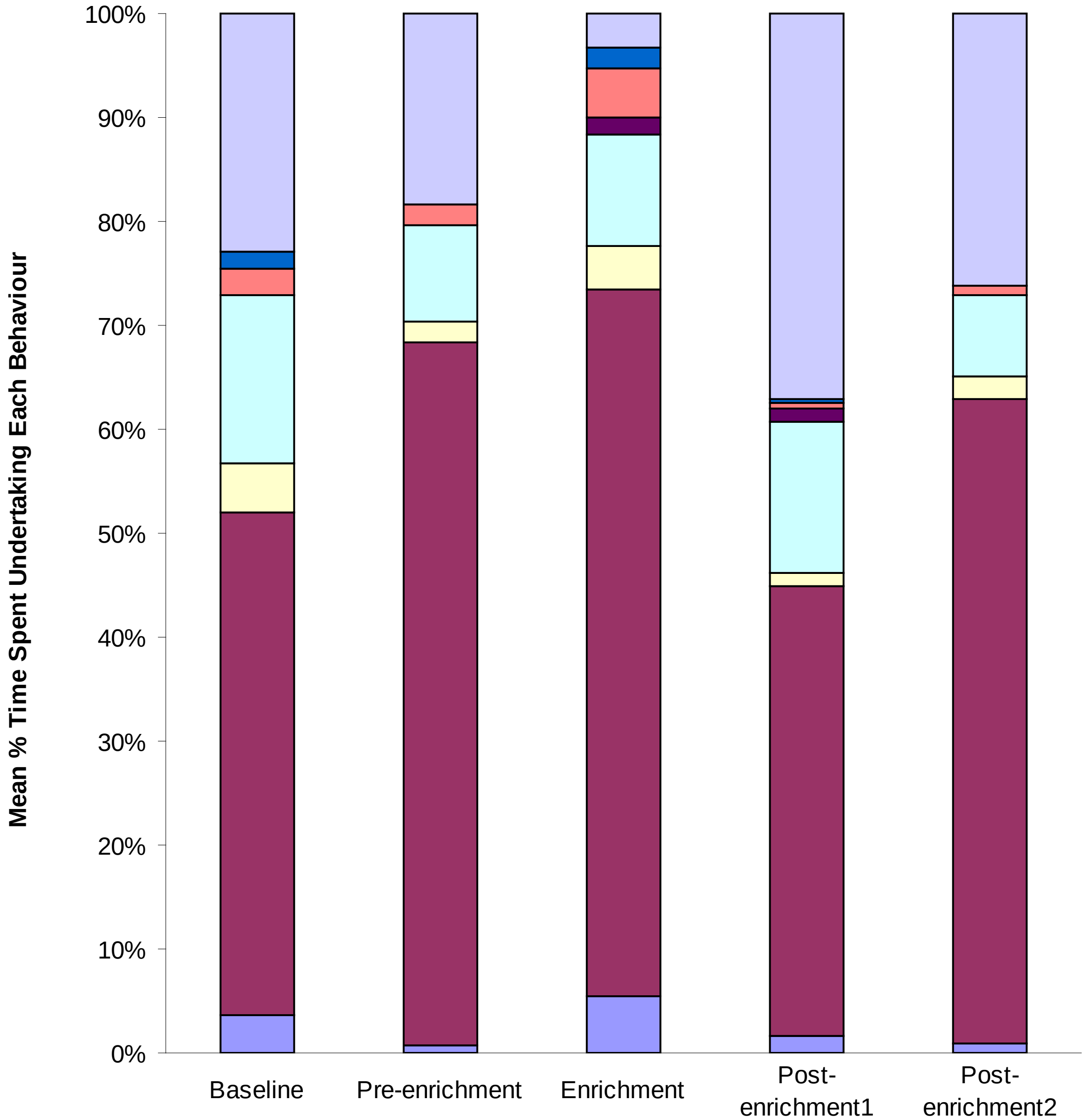
a. Red panda *(Ailurus rulgeus)* - Red Panda 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.51	0.50	0.56	0.50	0.60
BehavG	0.02	0.00	0.00	0.00	0.00
BehavF	0.02	0.02	0.02	0.00	0.02
BehavE	0.00	0.00	0.02	0.01	0.00
BehavD	0.07	0.06	0.07	0.07	0.01
BehavC	0.00	0.01	0.01	0.04	0.00
BehavB	0.36	0.41	0.27	0.37	0.38
BehavA	0.03	0.00	0.05	0.01	0.00

Period Of Study

b. Red panda *(Ailurus rulgeus)* - Red Panda 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.23	0.18	0.03	0.37	0.26
BehavG	0.02	0.00	0.02	0.00	0.00
BehavF	0.03	0.02	0.05	0.00	0.01
BehavE	0.00	0.00	0.02	0.01	0.00
BehavD	0.16	0.09	0.11	0.15	0.08
BehavC	0.05	0.02	0.04	0.01	0.02
BehavB	0.48	0.68	0.68	0.43	0.62
BehavA	0.04	0.01	0.05	0.02	0.01

Period Of Study

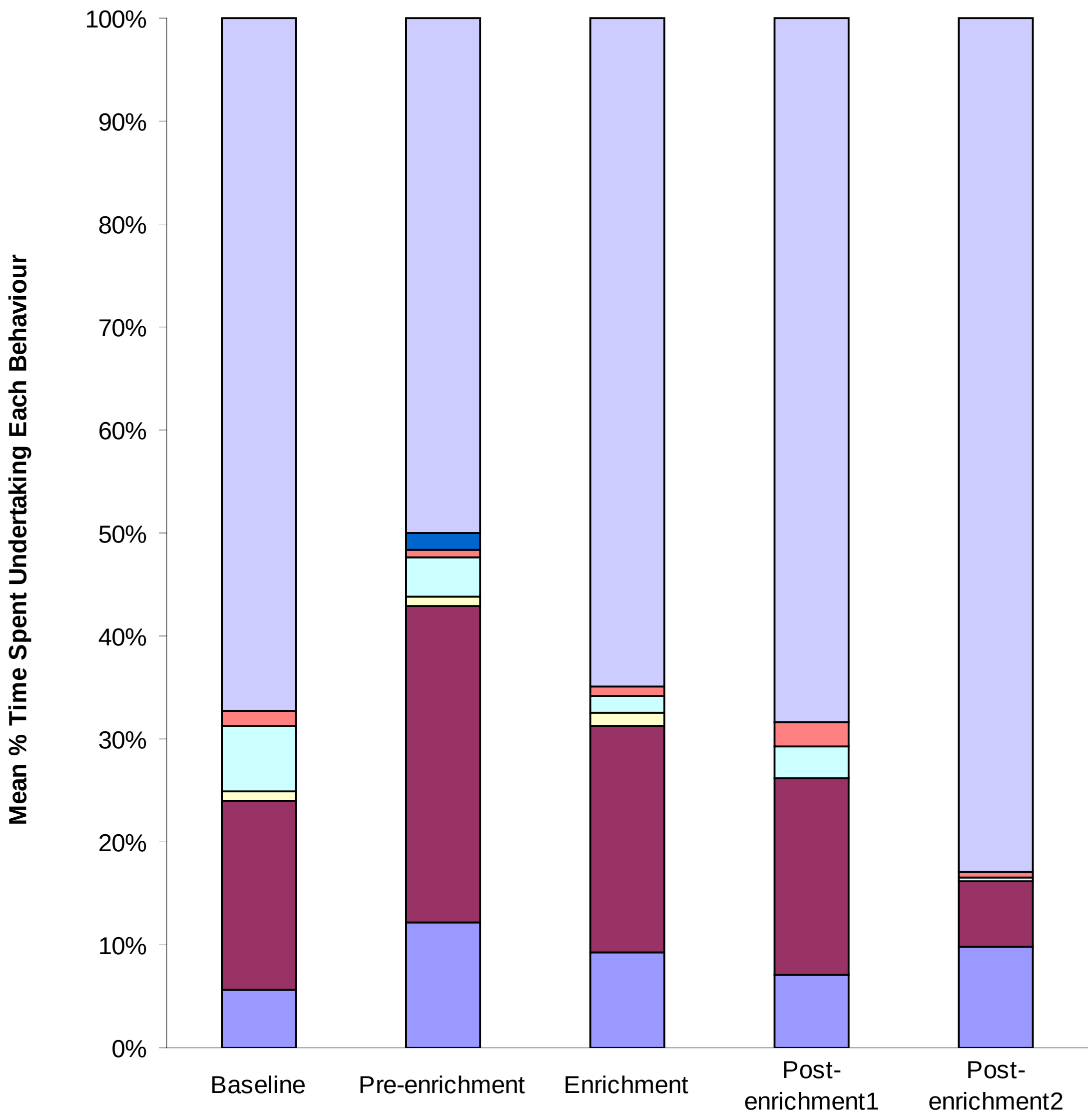
When comparing the morning data (above) to the afternoon data (below), clear individual, time and study period differences were seen. During the morning period panda 1 continued to spend the majority of the observational time non-visible (Behaviour H) with stationery behaviour (Behaviour B) predominating when visible. Red panda 2 was far more visible during the morning period than panda 1.

There was noticeable study period variation, with panda 2 appearing substantially more visible during the morning enrichment period than during non-enrichment periods. Human interactions (Behaviour F) also appeared to be greater for panda 2 during the enrichment period compared to non-enrichment periods when examining the morning data.

During the afternoon, panda 1 spent more time non-visible than in the morning regardless of study period. Similarly panda 2 spent generally more time non-visible in the afternoon when compared to the morning. For both animals stationery behaviour predominated when visible. The exception to this was the post-enrichment 2 period for panda 1, where feeding behaviour (Behaviour A) not stationery behaviour was most commonly recorded during periods of visibility during the afternoon.

Figure 3.17. Representation of behavioural patterns for each study period (Afternoon period only)

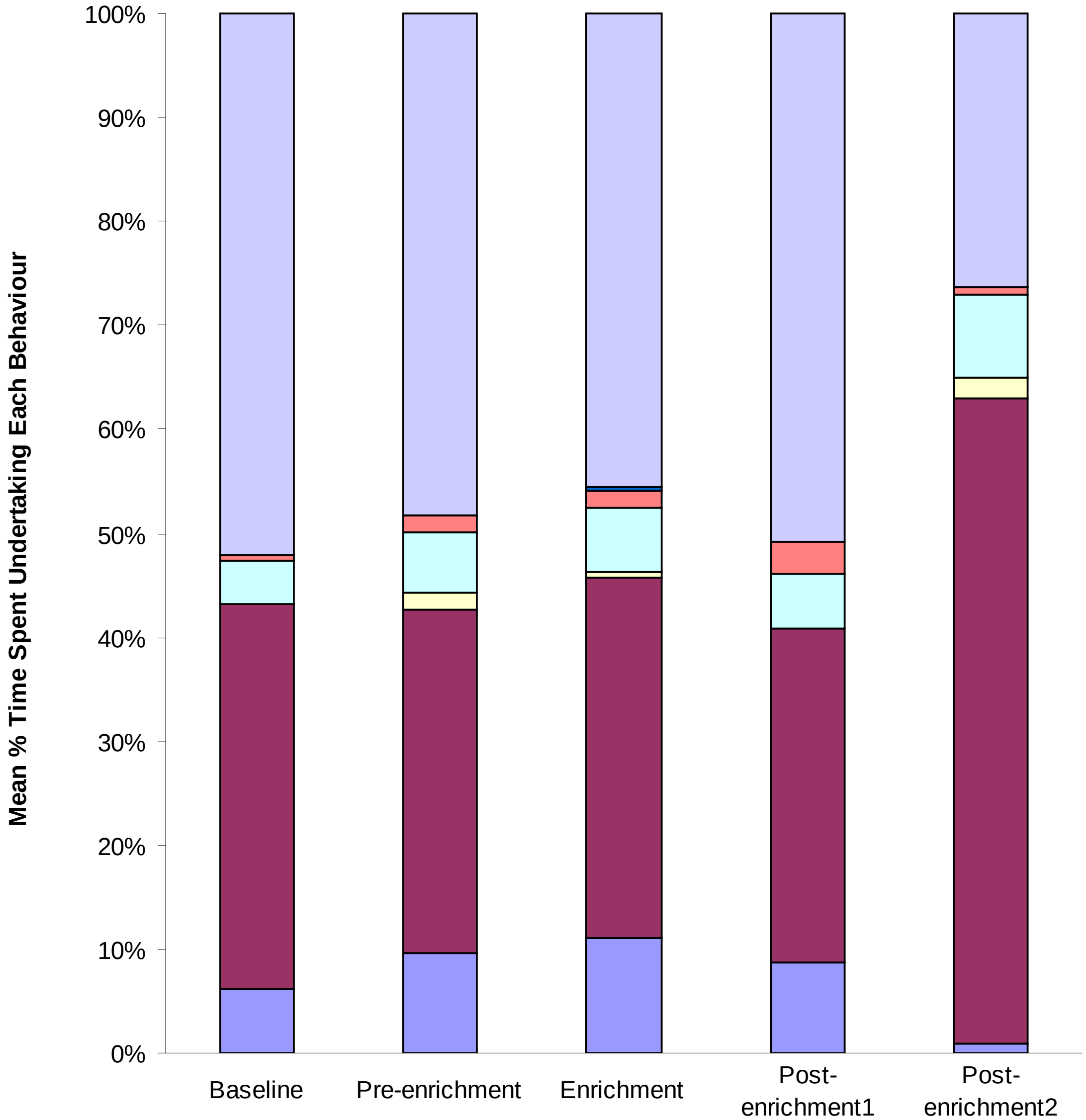
a. Red panda *(Ailurus rulgeus)* - Red Panda 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.67	0.50	0.65	0.68	0.83
BehavG	0.00	0.02	0.00	0.00	0.00
BehavF	0.02	0.01	0.01	0.03	0.00
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.06	0.04	0.02	0.03	0.00
BehavC	0.01	0.01	0.01	0.00	0.00
BehavB	0.18	0.31	0.22	0.19	0.06
BehavA	0.06	0.12	0.09	0.07	0.10

Period Of Study

b. Red panda *(Ailurus rulgeus)* - Red Panda 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.52	0.48	0.45	0.51	0.26
BehavG	0.00	0.00	0.00	0.00	0.00
BehavF	0.01	0.02	0.02	0.03	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.04	0.06	0.06	0.05	0.08
BehavC	0.00	0.02	0.00	0.00	0.02
BehavB	0.37	0.33	0.35	0.32	0.62
BehavA	0.06	0.10	0.11	0.09	0.01

Period Of Study

3.4.1.2. Statistical analysis

The data was analysed by Mann-Whitney-U test (SPSS).

Whole day data analysis

Table 3.16., highlights the significant findings for the proportion of time spent undertaking behaviour between each study period for each individual red panda.

	Baseline (n=32) vs Pre-enrichment (n=40)		Pre-enrichment (n=40) vs Enrichment (n=40)		Enrichment (n=40) vs Post-enrichment 1 (n=40)		Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)	
Behaviour A	-	-	-	-	-	-	-	-
Behaviour B	-	-	-	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	** (628.0)	-
Behaviour E	-	-	-	-	-	-	-	-
Behaviour F	-	-	-	-	-	-	-	-
Behaviour G	-	-	-	* (700.0)	-	-	-	-
Behaviour H	-	-	-	-	-	** (556.5)	-	-

Table 3.16. Individual comparative results for the various study periods (Red Panda)

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Red Panda 1, Red Panda 2.*

The majority of the comparative data showed no significant difference between study periods, with no individual having any significant behavioural variation when comparing baseline and pre-enrichment periods. Table 3.16. does show that red panda 1 significantly decreased active species specific behaviour (Behaviour D) when comparing post-enrichment 1 and post-enrichment 2 periods. Red panda 2, significantly increased non-relevant behaviour

(Behaviour G) during enrichment compared to pre-enrichment and significantly increased the amount of time non-visible during post-enrichment 1 compared to the enrichment period.

Morning and afternoon data analysis

Table 3.18. highlight the significant behavioural changes for each animal during the different study periods for the morning data only. There were no significant behavioural changes between the different study periods in either animal for the afternoon data.

Red panda 1 significantly decreased feeding behaviour (Behaviour A) when comparing baseline and pre-enrichment morning data. There was a subsequent rebound effect with a significant increase in feeding when comparing pre-enrichment with the enrichment period when observing panda 1 during the morning. Red panda 2 significantly increased non-relevant behaviour (Behaviour G) and decreased non-visibility (Behaviour H) when comparing the same periods.

Red panda 2 significantly decreased stationery behaviour (Behaviour B) and significantly increased non-visibility (Behaviour H) from enrichment to the post-enrichment 1 period. When comparing post-enrichment 1 to post-enrichment 2 there was a single significant finding, with a significant decrease in active species specific behaviour (Behaviour D) exhibited by panda 1.

	Baseline (n=32) vs Pre-enrichment (n=40)		Pre-enrichment (n=40) vs Enrichment (n=40)		Enrichment (n=40) vs Post-enrichment 1 (n=40)		Post-enrichment 1 (n=40) vs Post-enrichment 2 (n=40)	
Behaviour A	* (120.0)	-	* (150.0)	-	-	-	-	-
Behaviour B	-	-	-	-	-	* (118.5)	-	-
Behaviour C	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	* (145.0)	-
Behaviour E	-	-	-	-	-	-	-	-
Behaviour F	-	-	-	-	-	-	-	-
Behaviour G	-	-	-	* (160.0)	-	-	-	-
Behaviour H	-	-	-	* (129.0)	-	*** (71.0)	-	-

Table 3.17. Individual comparative results for the various study periods (Morning only)

*-=no significant difference, * = p ≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Red Panda 1, Red Panda 2.*

3.4.2. Spatial Utilisation

3.4.2.1. Descriptive data

Figure 3.18. represents the spatial utilisation of the individual red panda for each of the five study periods. Appendix 6.2d shows the demarcation of zones / quadrants within each enclosure i.e. Position (Pos) 1, 2, 3, 4, 5, 6, 7, 8, 9, 19, 20, 21, 22, 23, 24, 25, 26 and 27. Pos 0 represents every observational recording period in which a particular individual was non-visible.

From the figures below, individual animal and study period variation in enclosure utilisation is evident. Red panda 1 spent between 43% and 74% of the time in position 23 which represented only 5.56% of the available space. The least amount of time spent in this position by red panda 1 was during the pre-enrichment and enrichment periods while the greatest amount of time spent in this position was during post-enrichment 1. The other position regularly visited by red panda 1 was position 5, with 10% to 24% of the time being spent there. The study periods in which position 5 was most and least occupied was inversely proportional to position 23 with the highest frequency being during pre-enrichment while the lowest frequency was during post-enrichment 1. In total these two positions represented 59% to 84% of the observed time during the study, with the lowest combined total being during the enrichment period.

Red panda 2 appeared to disperse more throughout the enclosure than red panda 1, with positions 5, 19, 20 and 23 all being regularly visited. These four positions accounted for 22.22% of the available enclosure space. The extent to which each of these positions were occupied varied between study periods, with the combined time ranging from 42% to 84% of the observations. The enrichment period represented the lowest combined time spent in these areas however it must be borne in mind that during this study period 21% of the time red panda 2 was non-visible.

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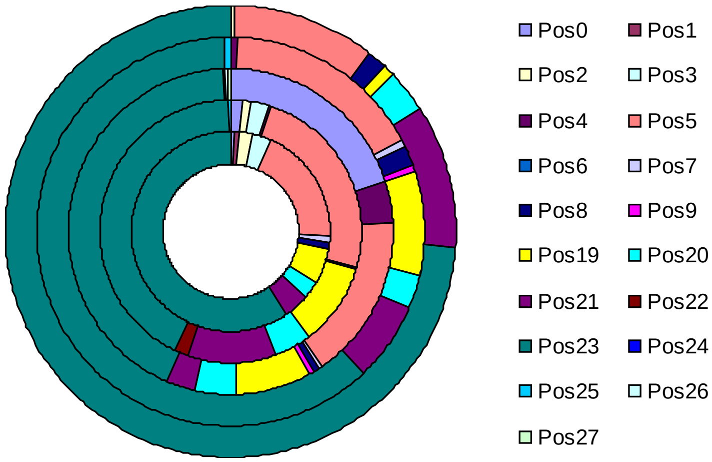
Figure 3.18. Representation of spatial utilisation

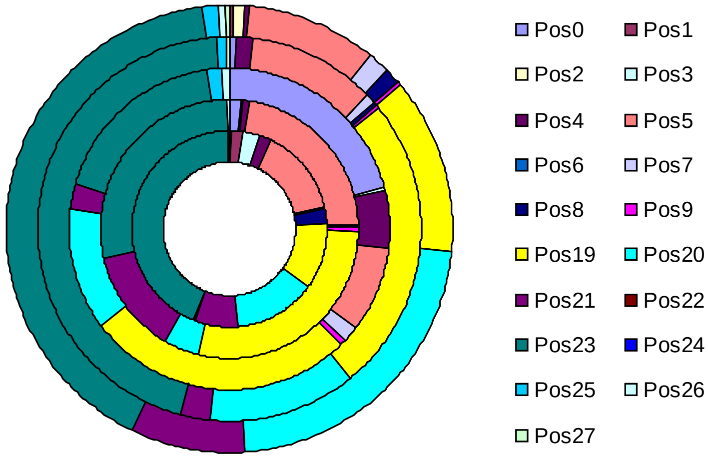
Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.

a. Red panda *(Ailurus rulgeus)* - Red Panda 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos0	0.01	0.01	0.20	0.00	0.00
Pos1	0.01	0.00	0.00	0.00	0.00
Pos2	0.02	0.01	0.00	0.00	0.00
Pos3	0.03	0.02	0.00	0.00	0.00
Pos4	0.00	0.00	0.04	0.01	0.00
Pos5	0.19	0.24	0.16	0.17	0.10
Pos6	0.00	0.00	0.00	0.00	0.00
Pos7	0.01	0.00	0.00	0.00	0.00
Pos8	0.01	0.00	0.01	0.02	0.02
Pos9	0.00	0.00	0.00	0.01	0.00
Pos19	0.06	0.10	0.08	0.08	0.01
Pos20	0.03	0.05	0.04	0.03	0.03
Pos21	0.04	0.11	0.03	0.07	0.10
Pos22	0.00	0.02	0.00	0.00	0.00
Pos23	0.59	0.43	0.43	0.61	0.74
Pos24	0.00	0.00	0.00	0.00	0.00
Pos25	0.00	0.00	0.00	0.01	0.00
Pos26	0.00	0.00	0.00	0.00	0.00
Pos27	0.00	0.00	0.00	0.00	0.00

b. Red panda *(Ailurus rulgeus)* - Red Panda 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos0	0.00	0.01	0.21	0.01	0.00
Pos1	0.02	0.00	0.00	0.00	0.00
Pos2	0.00	0.00	0.00	0.00	0.01
Pos3	0.03	0.00	0.00	0.00	0.00
Pos4	0.02	0.01	0.06	0.01	0.00
Pos5	0.14	0.22	0.09	0.11	0.09
Pos6	0.00	0.00	0.00	0.00	0.00
Pos7	0.00	0.00	0.02	0.01	0.02
Pos8	0.03	0.00	0.00	0.00	0.01
Pos9	0.00	0.00	0.01	0.00	0.00
Pos19	0.11	0.29	0.27	0.25	0.13
Pos20	0.14	0.04	0.12	0.13	0.22
Pos21	0.07	0.13	0.03	0.02	0.08
Pos22	0.00	0.00	0.00	0.00	0.00
Pos23	0.44	0.28	0.18	0.45	0.41
Pos24	0.00	0.00	0.00	0.00	0.00
Pos25	0.00	0.00	0.01	0.01	0.01
Pos26	0.00	0.00	0.01	0.00	0.00
Pos27	0.00	0.00	0.00	0.00	0.00

3.4.2.2. Statistical analysis

The enclosure was divided into approximately equal portions of approximately 5.3m x 8m x 5m. Individual enclosure use or coefficient of variation (CV) as used by Stoinski et al. (2001), ranged from 2.25 to 3.14 (see Table 3.18.). Utilisation of the enclosure space appeared to be similar for both individuals, with red panda 2 showing only marginally less clumping than red panda 1. The extent to which the enclosure was utilised also appeared to be unaffected by enrichment with all study periods showing similar CV results.

		Mean	StDev	CV
Red Panda 1	**Baseline (n=4)**	0.06	0.16	2.83
	Pre-Enrichment (n=5)	0.05	0.13	2.41
	Enrichment (n=5)	0.04	0.12	2.80
	Post-Enrichment 1 (n=5)	0.06	0.16	2.80
	Post-Enrichment 2 (n=5)	0.06	0.17	3.14
Red Panda 2	**Baseline (n=4)**	0.06	0.12	2.25
	Pre-Enrichment (n=5)	0.05	0.13	2.41
	Enrichment (n=5)	0.04	0.10	2.26
	Post-Enrichment 1 (n=5)	0.06	0.13	2.40
	Post-Enrichment 2 (n=5)	0.06	0.13	2.37

Table 3.18. Enclosure usage data

When statistical analysis was re-run using Mann-Whitney U no significant changes were shown for red panda 1 when comparing the various study periods. Red panda 2 showed a significant increase in time spent in position 4 ($p=0.04$, $U=3.5$) when comparing pre-enrichment to enrichment and a significant increase in time spent in position 23 ($p=0.05$, $U=3.0$) when comparing enrichment and post-enrichment 1 periods. In general enrichment did not appear to affect the spatial utilisation of either red panda compared to non-enrichment periods.

3.6. STEENBUCK (*Raphicerus campestris)*

3.6.1. Behavioural Observations

3.6.1.1. Descriptive data

Fig. 3.23. illustrates the proportion of time spent by the lemur performing the various behavioural patterns, by representing the mean time spent expressing each behaviour for the different periods of the study i.e. 'Baseline', 'Pre-Enrichment', 'Enrichment', 'Post-Enrichment Day1' & 'Post-Enrichment Day2'.

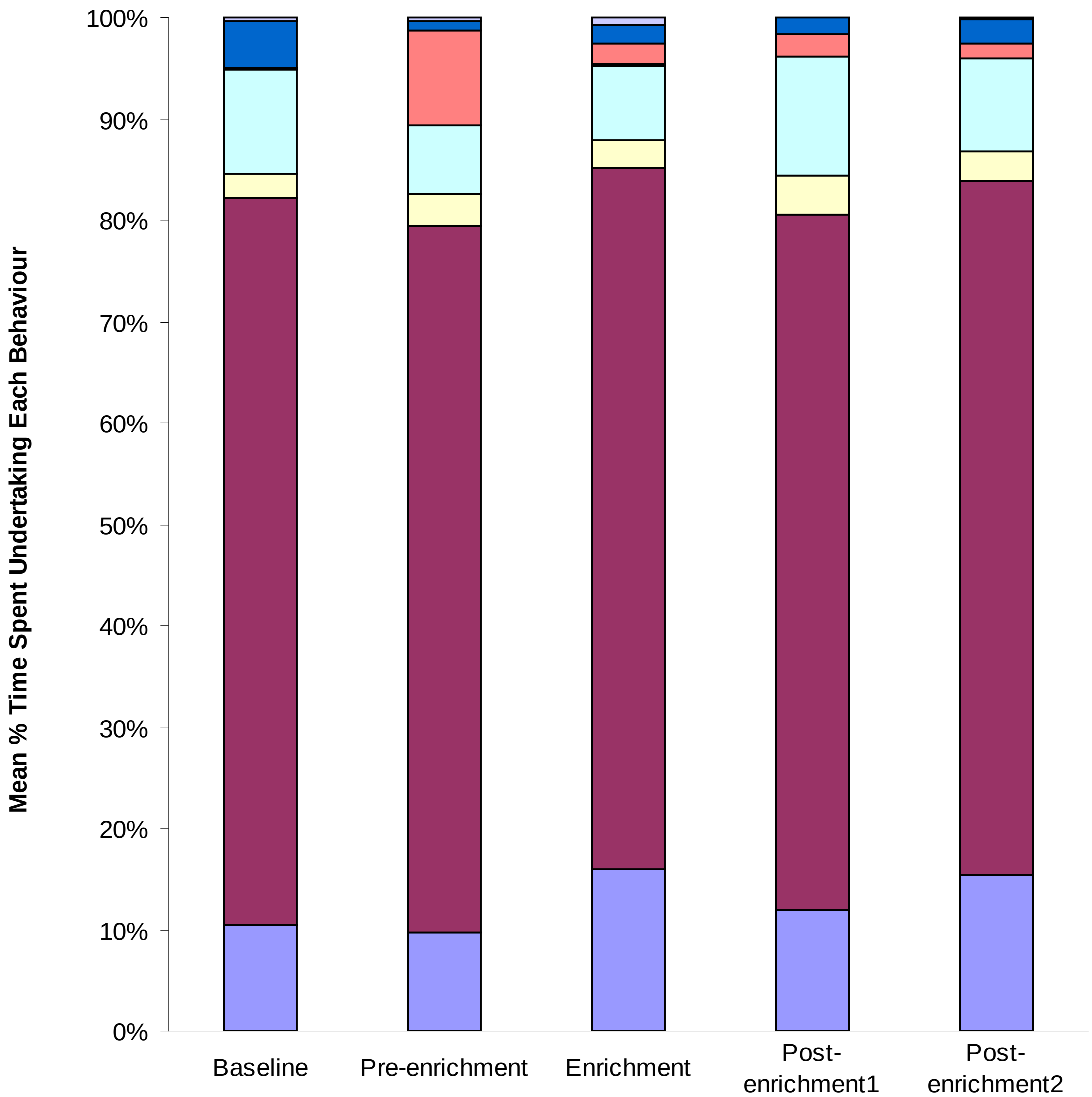
Individual variation was observed between the proportion of the day undertaking different behaviour between the three steenbuck, however the majority of the day for each animal independent of study period was spent stationery (Behaviour B). The adult female (Steenbuck B) appeared to perform the most human interaction (Behaviour F), whilst the youngster (Steenbuck C) undertook the least spending more time non-visible (Behaviour H) than the adult animals. None of the steenbuck undertook human interactions during the baseline period, with the peak period for human interaction being during the pre-enrichment stage for all the individuals.

The female (Steenbuck B) and the youngster (Steenbuck C) appeared to be more visible during enrichment compared to non-enrichment periods, whereas the male (Steenbuck A) displayed the opposite trait.

Feeding behaviour appeared to increase during enrichment compared to non-enrichment periods for both the adults (Steenbuck A and B). The youngster (Steenbuck C) was still suckling, so that Behaviour A refers to suckling rather than eating solids. This behaviour for steenbuck C was greatest during the enrichment and post-enrichment 1 period.

Figure 3.23. Representation of behavioural patterns for each study period (Steenbuck)

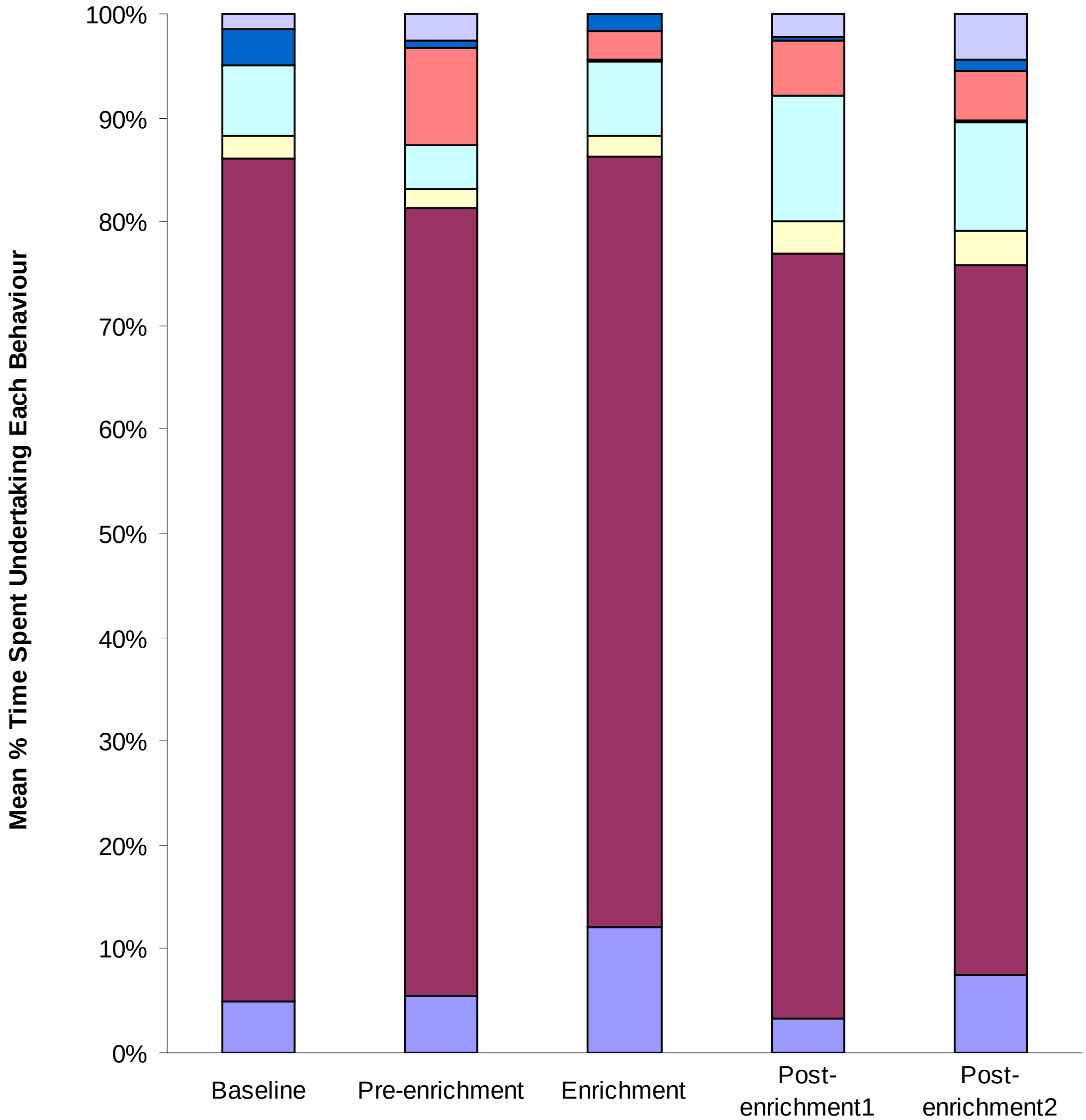
a. Steenbuck (*Raphicerus campestris*) - Steenbuck 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.00	0.00	0.01	0.00	0.00
BehavG	0.05	0.01	0.02	0.02	0.02
BehavF	0.00	0.09	0.02	0.02	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.10	0.07	0.07	0.12	0.09
BehavC	0.02	0.03	0.03	0.04	0.03
BehavB	0.72	0.70	0.69	0.68	0.68
BehavA	0.11	0.10	0.16	0.12	0.15

Period Of Study

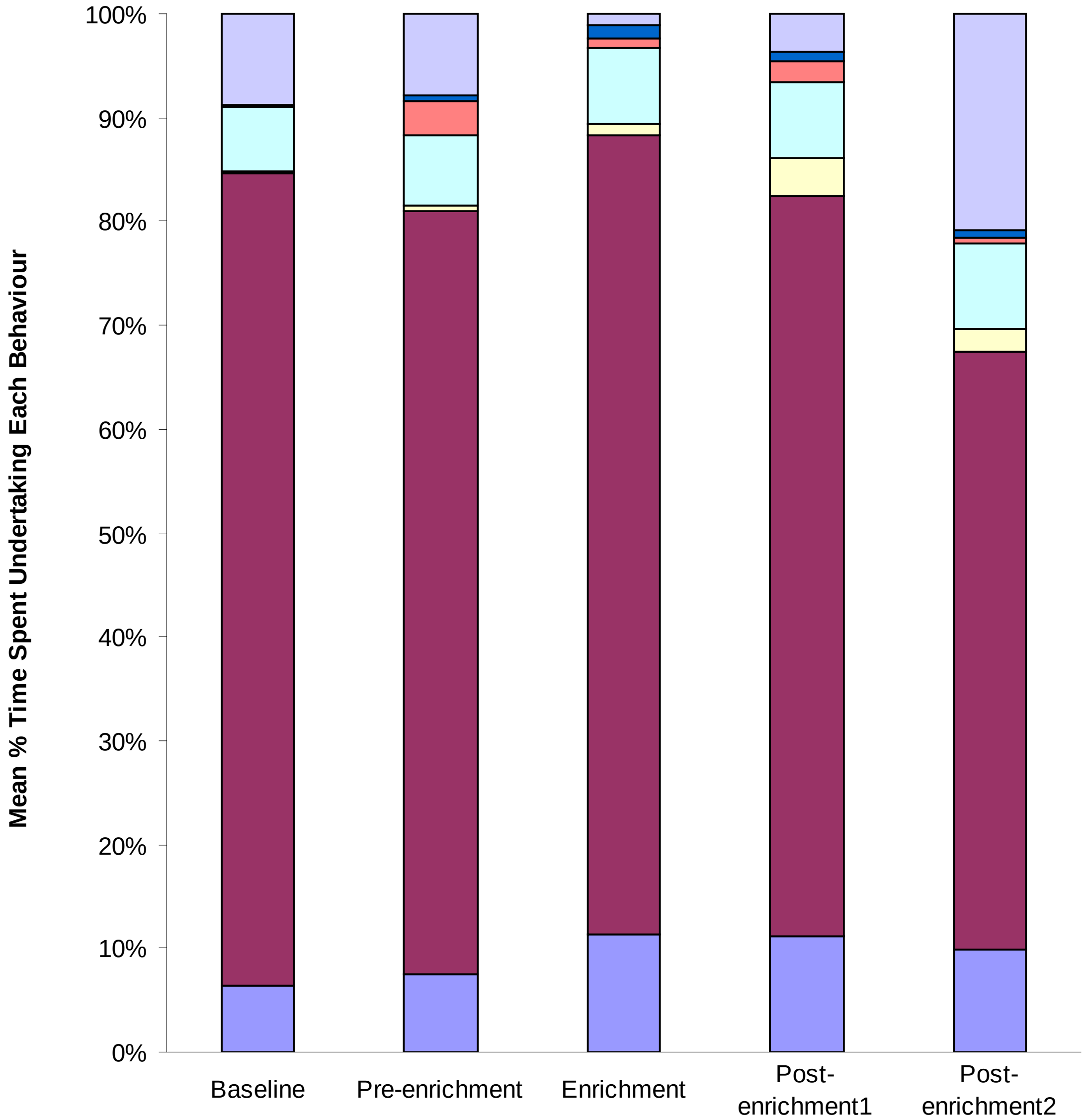
b. Steenbuck (*Raphicerus campestris*) - Steenbuck 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.03	0.00	0.02	0.04
BehavG	0.04	0.01	0.02	0.00	0.01
BehavF	0.00	0.09	0.03	0.05	0.05
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.07	0.04	0.07	0.12	0.10
BehavC	0.02	0.02	0.02	0.03	0.03
BehavB	0.81	0.76	0.74	0.73	0.68
BehavA	0.05	0.05	0.12	0.03	0.08

Period Of Study

c. Steenbuck (*Raphicerus campestris)* - Steenbuck 3

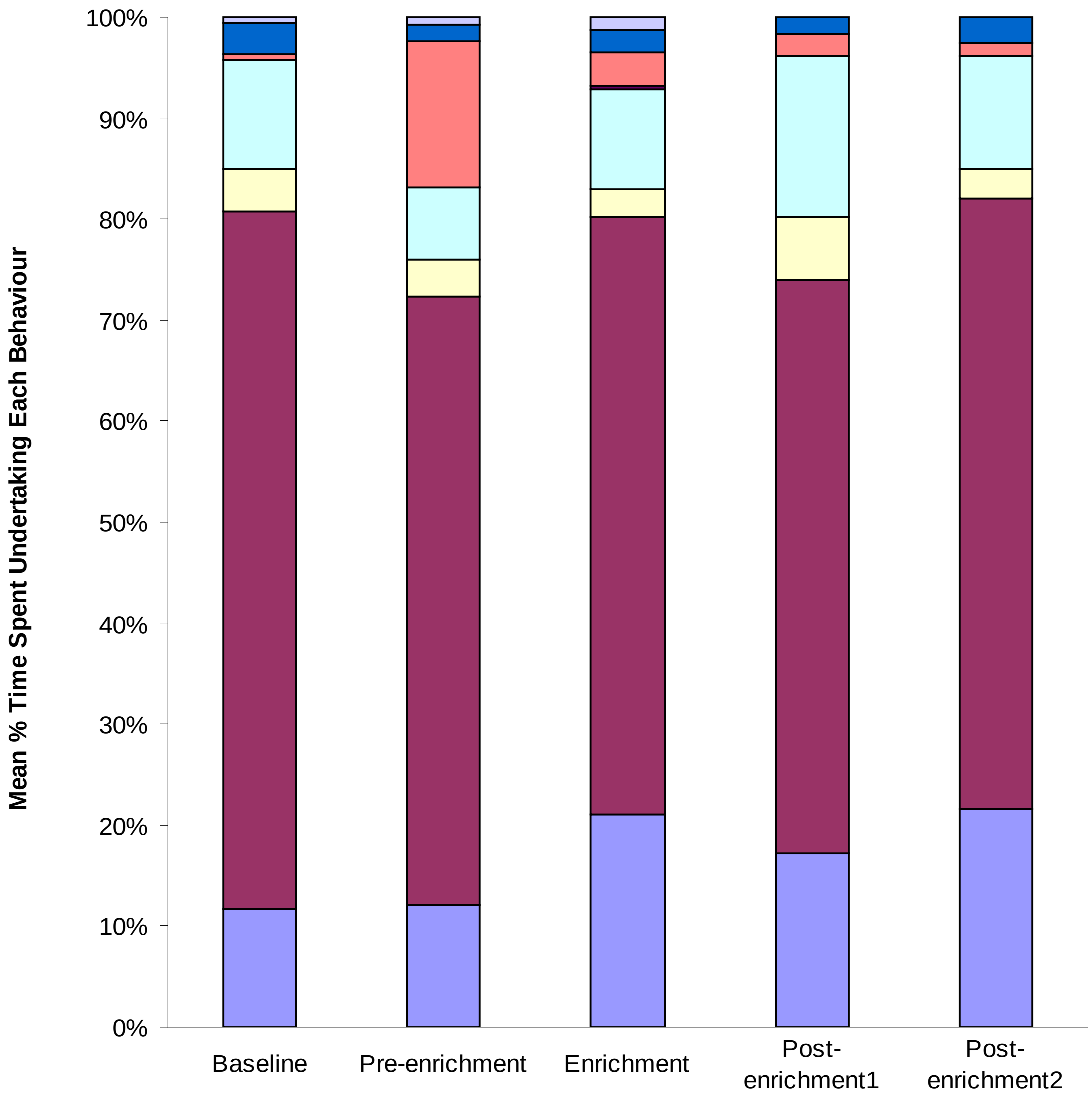


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.09	0.08	0.01	0.04	0.21
BehavG	0.00	0.00	0.01	0.01	0.01
BehavF	0.00	0.03	0.01	0.02	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.06	0.07	0.07	0.07	0.08
BehavC	0.00	0.01	0.01	0.04	0.02
BehavB	0.78	0.74	0.77	0.71	0.58
BehavA	0.06	0.07	0.11	0.11	0.10

Period Of Study

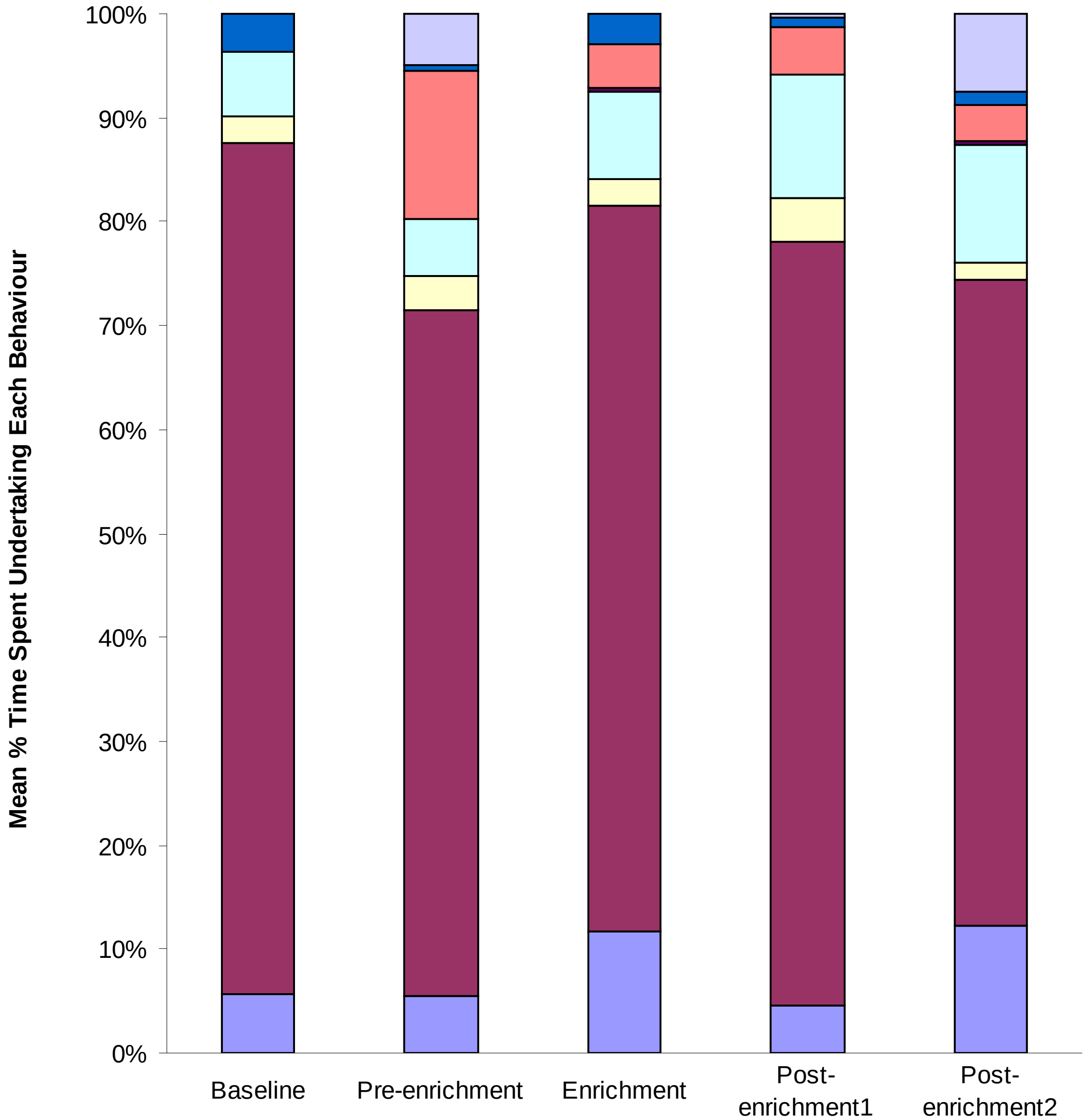
Figure 3.24. Representation of behavioural patterns for each study period (Morning period only)

a. Steenbuck (*Raphicerus campestris)* - Steenbuck 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.01	0.01	0.01	0.00	0.00
BehavG	0.03	0.02	0.02	0.02	0.03
BehavF	0.01	0.14	0.03	0.02	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.11	0.07	0.10	0.16	0.11
BehavC	0.04	0.04	0.03	0.06	0.03
BehavB	0.69	0.60	0.59	0.57	0.60
BehavA	0.12	0.12	0.21	0.17	0.22

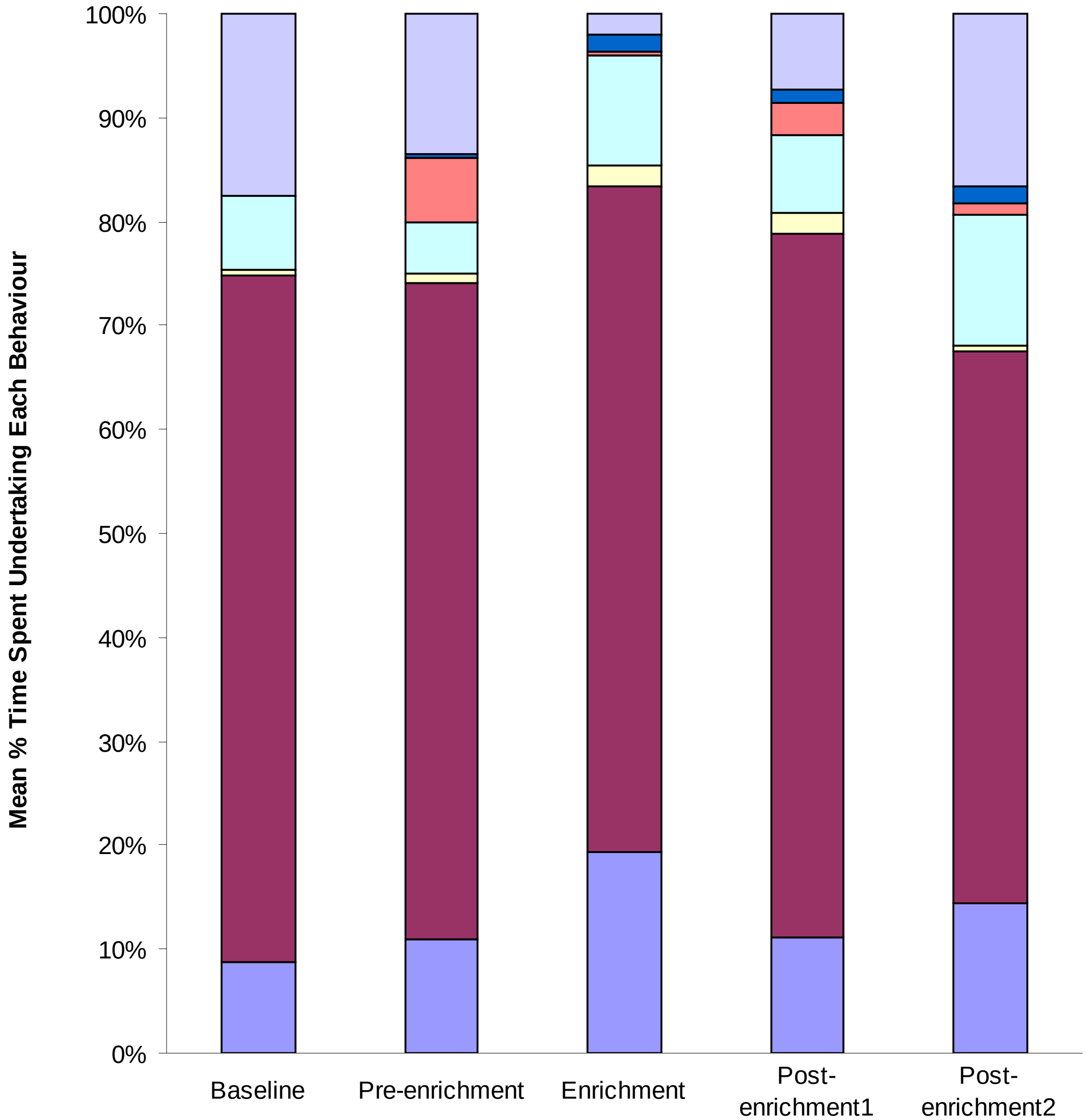
b. Steenbuck (*Raphicerus campestris*) - Steenbuck 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.00	0.05	0.00	0.00	0.08
BehavG	0.04	0.00	0.03	0.01	0.01
BehavF	0.00	0.14	0.04	0.05	0.03
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.06	0.05	0.09	0.12	0.11
BehavC	0.03	0.03	0.02	0.04	0.02
BehavB	0.82	0.66	0.70	0.73	0.62
BehavA	0.06	0.05	0.12	0.05	0.12

Period Of Study

c. Steenbuck (*Raphicerus campestris)* - Steenbuck 3

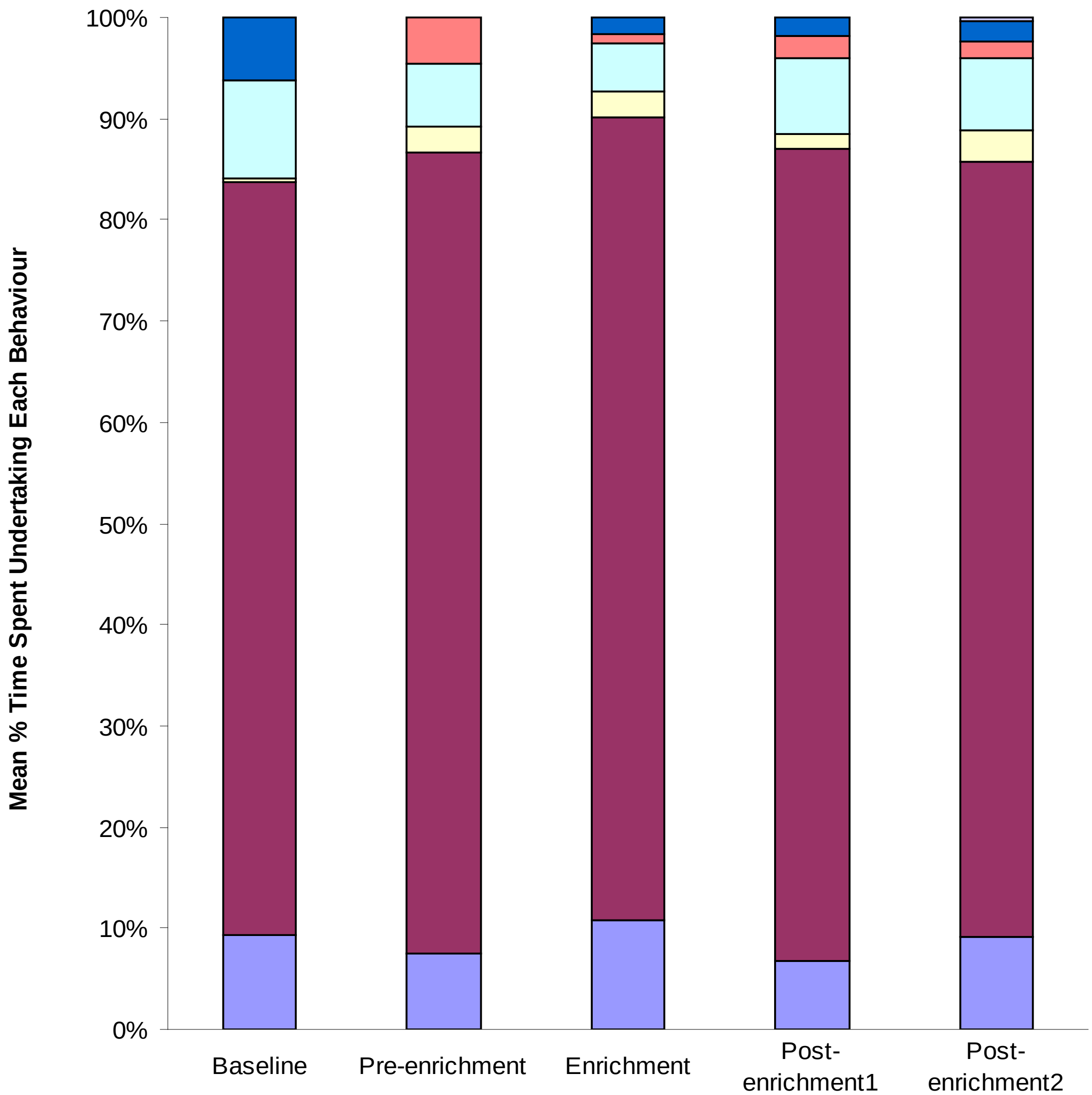


	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.17	0.13	0.02	0.07	0.17
BehavG	0.00	0.00	0.02	0.01	0.02
BehavF	0.00	0.06	0.01	0.03	0.01
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.07	0.05	0.11	0.07	0.13
BehavC	0.01	0.01	0.02	0.02	0.01
BehavB	0.66	0.63	0.64	0.68	0.53
BehavA	0.09	0.11	0.19	0.11	0.14

Period Of Study

Figure 3.25. Representation of behavioural patterns for each study period (Afternoon period only)

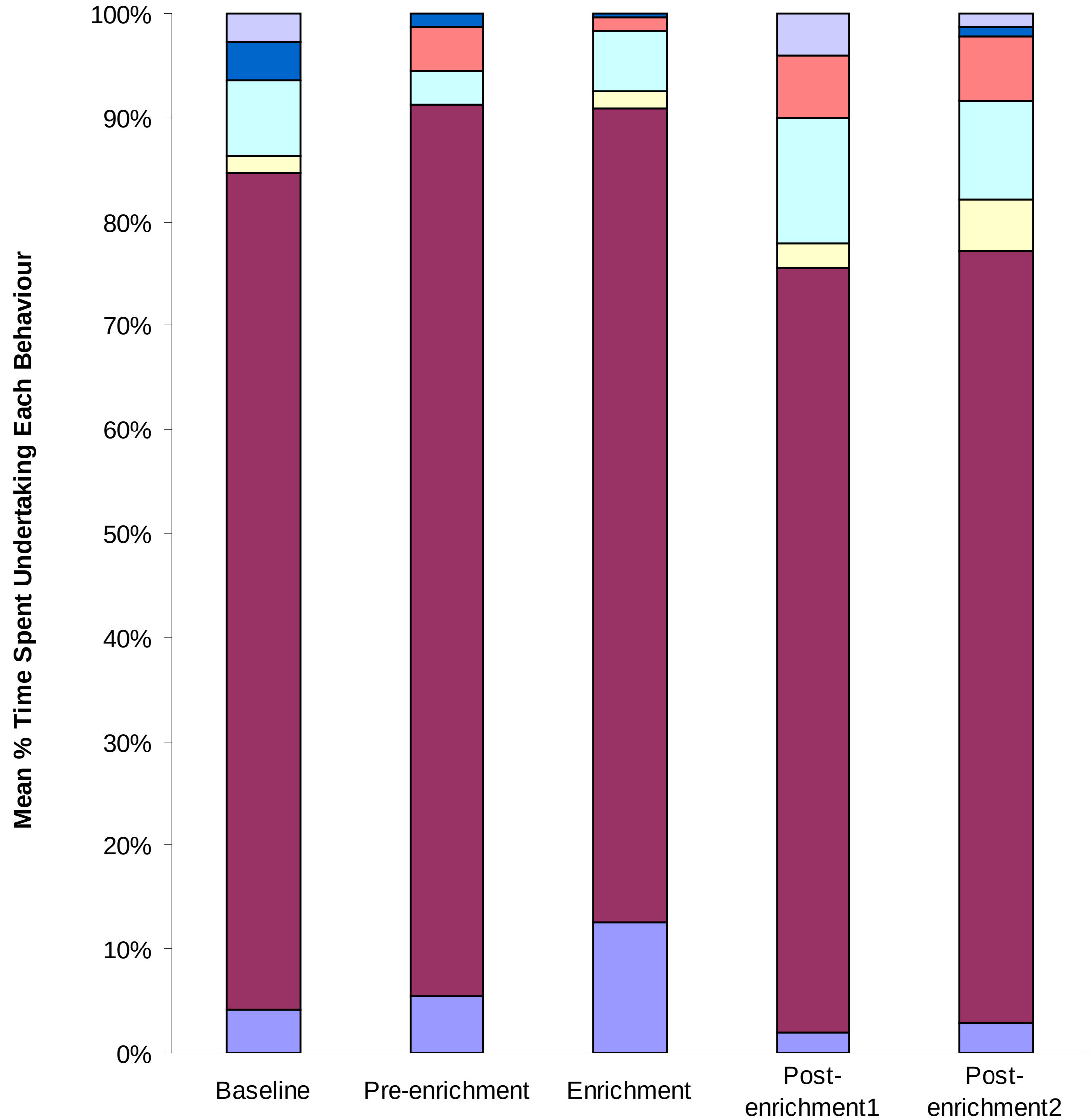
a. Steenbuck (*Raphicerus campestris*) - Steenbuck 1



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.00	0.00	0.00	0.00	0.00
BehavG	0.06	0.00	0.02	0.02	0.02
BehavF	0.00	0.05	0.01	0.02	0.02
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.10	0.06	0.05	0.08	0.07
BehavC	0.01	0.03	0.03	0.02	0.03
BehavB	0.74	0.79	0.79	0.80	0.76
BehavA	0.09	0.08	0.11	0.07	0.09

Period Of Study

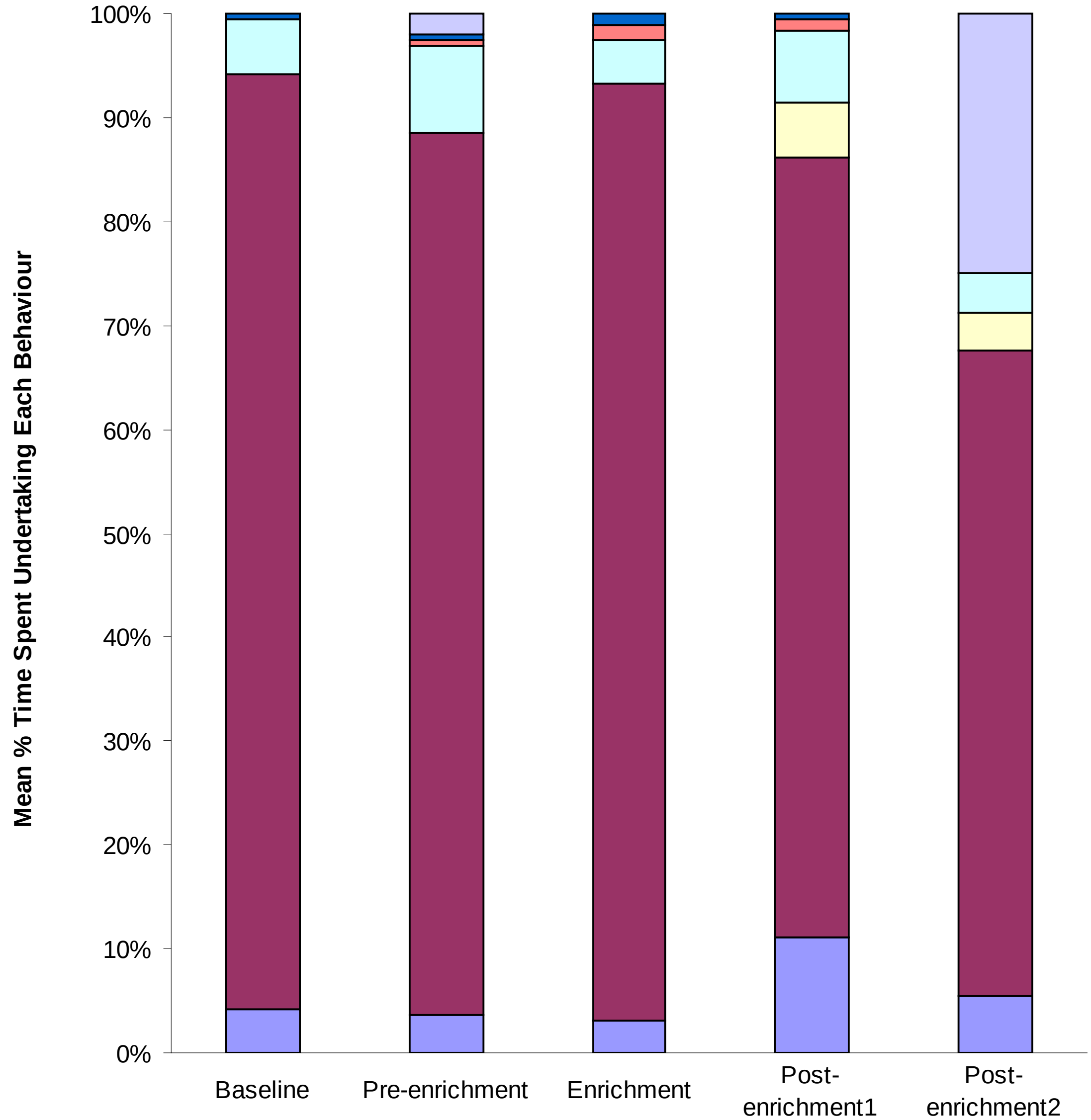
b. Steenbuck (*Raphicerus campestris)* - Steenbuck 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.03	0.00	0.00	0.04	0.01
BehavG	0.04	0.01	0.00	0.00	0.01
BehavF	0.00	0.04	0.01	0.06	0.06
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.07	0.03	0.06	0.12	0.10
BehavC	0.02	0.00	0.02	0.02	0.05
BehavB	0.81	0.86	0.78	0.74	0.74
BehavA	0.04	0.06	0.13	0.02	0.03

Period Of Study

c. Steenbuck (*Raphicerus campestris)* - Steenbuck 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment1	Post-enrichment2
BehavH	0.00	0.02	0.00	0.00	0.25
BehavG	0.01	0.01	0.01	0.01	0.00
BehavF	0.00	0.01	0.02	0.01	0.00
BehavE	0.00	0.00	0.00	0.00	0.00
BehavD	0.05	0.08	0.04	0.07	0.04
BehavC	0.00	0.00	0.00	0.05	0.04
BehavB	0.90	0.85	0.90	0.75	0.62
BehavA	0.04	0.04	0.03	0.11	0.06

Period Of Study

Kinahan A.(2007, *personal communication*), suggested that the time of day in which an animal performs specific behaviour may be altered during periods of enrichment even when the overall behavioural repertoire of the animal or the total amount of time spent undertaking each behaviour remains unchanged. Therefore, to determine if this is true for the steenbuck, fig 3.24. and 3.25.. illustrate the behaviour recorded during the morning period (08:00 to 11:55) and afternoon period (12:00 to 15:55) respectively, for each study period.

The morning and afternoon data when examined separately appears extremely similar to the whole day data. The only notable difference is that feeding appears to be greater during the morning period compared to the afternoon regardless of study period. This trend is most prominent in the male (Steenbuck A) and youngster (Steenbuck C), but less so for steenbuck B.

3.6.1.2. Statistical analysis

The data was analysed by Mann-Whitney-U test (SPSS).

Whole day data analysis

Table 3.20. highlights the significant findings for the proportion of time spent undertaking behaviour between each study period for each individual steenbuck. All three animals show a significant increase in human interaction (Behaviour F) when comparing baseline data to pre-enrichment. For steenbuck 1 and 3 there was also a significant decrease in non-relevant behaviour (Behaviour G) during the same study periods.

The other significant finding all relate to feeding behaviour (Behaviour A). Steenbuck 1 significantly increased this behaviour from pre-enrichment to enrichment periods and steenbuck 2 significantly decreased feeding behaviour between enrichment and post-enrichment 1 period only to have a rebound significant increase in the same behaviour when comparing post-enrichment 1 to post-enrichment 2.

	Baseline (n=32) vs Pre-enrichment (n=40,n=33^)			Pre-enrichment (n=40,n=33^) vs Enrichment (n=40,n=33^)			Enrichment (n=40,n=33^) vs Post-enrichment 1 (n=40,n=33^)			Post-enrichment 1 (n=40,n=33^) vs Post-enrichment 2 (n=40,n=33^)		
Behaviour A	-	-	-	* (577.0)	-	-	-	* (605.0)	-	-	** (565.5)	-
Behaviour B	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour F	** (463.0)	*** (464.0)	* (448..0)	-	-	-	-	-	-	-	-	-
Behaviour G	*** (408.5)	-	* (507.5)	-	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.20. Individual comparative results for the various study periods (Steenbuck)

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Steenbuck 1, Steenbuck 2. Steenbuck 3. ^ = value for steenbuck 3 only (died part way through study)*

Morning and afternoon data analysis

Table 3.21. and 3.22. highlight the significant behavioural changes for each animal for the different study periods during the morning and afternoon respectively. During the morning period all three animals significantly increased human interaction (Behaviour F) when comparing baseline and pre-enrichment data. Steenbuck 2 also significantly decreased non-relevant behaviour (Behaviour G) during the same study periods.

Comparison of pre-enrichment and enrichment periods saw steenbuck 1 significantly increase feeding related behaviour (Behaviour A). Steenbuck 2 significantly increased the same behaviour when comparing post-enrichment 1 to post-enrichment 2.

	Baseline (n=32) vs Pre-enrichment (n=40,n=33^)			Pre-enrichment (n=40,n=33^) vs Enrichment (n=40,n=33^)			Enrichment (n=40,n=33^) vs Post-enrichment 1 (n=40,n=33^)			Post-enrichment 1 (n=40,n=33^) vs Post-enrichment 2 (n=40,n=33^)		
Behaviour A	-	-	-	* (124.5)	-	-	-	-	-	-	** (99.0)	-
Behaviour B	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour F	* (102.5)	** (104.0)	* (104.0)	-	-	-	-	-	-	-	-	-
Behaviour G	-	* (117.0)	-	-	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.21. Individual comparative results for the various study periods (Morning only)

*-=no significant difference, * = p≤0.05, **=p≤0.01, ***=p≤0.001, Number in ( ) = U value. Steenbuck 1, Steenbuck 2. Steenbuck 3. ^ = value for steenbuck 3 only (died part way through study)*

During the afternoon period (table 3.22. below), steenbuck 1 showed a strongly significant decrease in non-relevant behaviour (Behaviour G) when comparing baseline to pre-enrichment. Steenbuck 3 significantly increased feeding related behaviour and decreased stationery behaviour (Behaviour B) during the afternoon enrichment and post-enrichment 1 period. The same animal also showed a significant increase in being non-visible when comparing post-enrichment 1 and post-enrichment 2 periods. No other significant findings were indicated.

It must be borne in mind when examining the data that the young steenbuck (Steenbuck 3) died from a gastro-enteric disease of unknown origin on 21 June 2005. This individual was also, to a greater extent, non-visible during the previous observational period on 17 June 2005 due to being taken ill and confined to the night room from 10:00 that morning.

	Baseline (n=32) vs Pre-enrichment (n=40,n=33^)			Pre-enrichment (n=40,n=33^) vs Enrichment (n=40,n=33^)			Enrichment (n=40,n=33^) vs Post-enrichment 1 (n=40,n=33^)			Post-enrichment 1 (n=40,n=33^) vs Post-enrichment 2 (n=40,n=33^)		
Behaviour A	-	-	-	-	-	-	-	-	** (68.5)	-	-	-
Behaviour B	-	-	-	-	-	-	-	-	* (66.0)	-	-	-
Behaviour C	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour D	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour E	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour F	-	-	-	-	-	-	-	-	-	-	-	-
Behaviour G	*** (80.0)	-	-	-	-	-	-	-	-	-	-	-
Behaviour H	-	-	-	-	-	-	-	-	-	-	-	* (96.0)

Table 3.22. Individual comparative results for the various study periods (Afternoon only) *-=no significant difference, * = $p \leq 0.05$, **=$p \leq 0.01$, ***=$p \leq 0.001$, Number in ( ) = U value. Steenbuck 1, Steenbuck 2. Steenbuck 3. ^ = value for steenbuck 3 only (died part way through study)*

3.6.2. Spatial Utilisation

3.6.2.1. Descriptive data

As stated above, steenbuck 3 died during the latter stages of this study however the data collected before this event is analysed below.

Figure 3.26. represents the spatial utilisation of the individual steenbuck for each of the five study periods. Appendix 6.2f shows the demarcation of zones / quadrants within the enclosure i.e. Position (Pos) 7, 8, 9, 16, 17, 18, 25, 26 and 27. Pos 0 represents every observational recording period in which a particular individual was non-visible.

From the figures below, individual animal and study period variation in enclosure utilisation is evident. Positions 16, 17, 25 and 26 were the four areas where all three steenbuck spent the majority of the time regardless of study period. The percent time in these areas ranging from 88% to 100% depending on the individual and study period.

Each individual varied widely in the extent to which time was spent within these four areas. Steenbuck 1 predominantly stayed in position 25, spending up to 71% of the time observed there depending on study period. Positions 16, 17 and 26 were utilised to a less but approximately equal extent to one another. Steenbuck 2 predominated in position 17 also spending upto 71% in this area depending on study period. Position 25 was also frequented regularly accounting for 53% of the observed time during the pre-enrichment period. Position 16 and 26 were less commonly visited by steenbuck 2. Steenbuck 3 utilised position 25 the most, with upto 81% of the time being spent there. Positions 16, 17 and 26 were therefore not so commonly frequented.

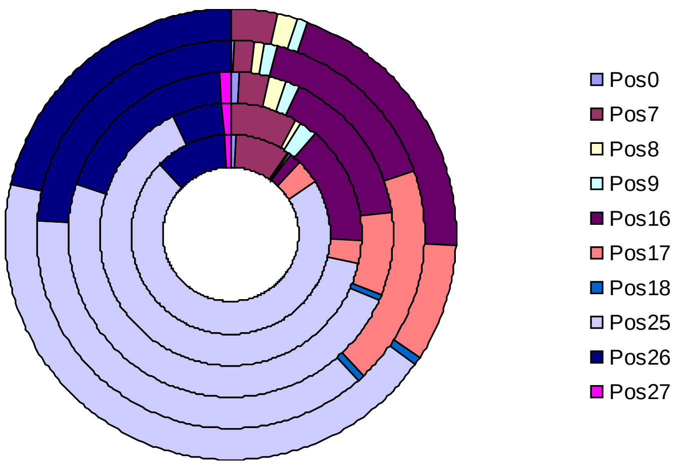
The percentage of time spent in each area did vary noticeably between study periods. For example, steenbuck 1 spent very little time in position 17 during the baseline and pre-enrichment periods (3%) compared to post-enrichment 1 where 18% of the observed time was within this quadrant. Steenbuck 2 also showed a decrease in time spentin position 17 during the pre-enrichment period.

Steenbuck 3 was only observed in position 25 36% of the time during the baseline period. This was far lower than the 56% to 81% of the time recorded for the other study periods.

Figure 3.26. Representation of spatial utilisation

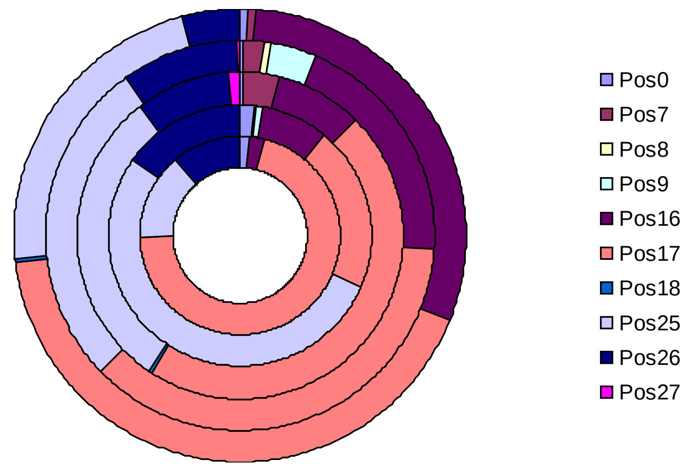
Inner circle depicts baseline data, followed by pre-enrichment, enrichement, post-enrichment 1 to the outermost circle representing the post-enrichment 2 period.

a. Steenbuck (*Raphicerus campestris*) - Steenbuck 1



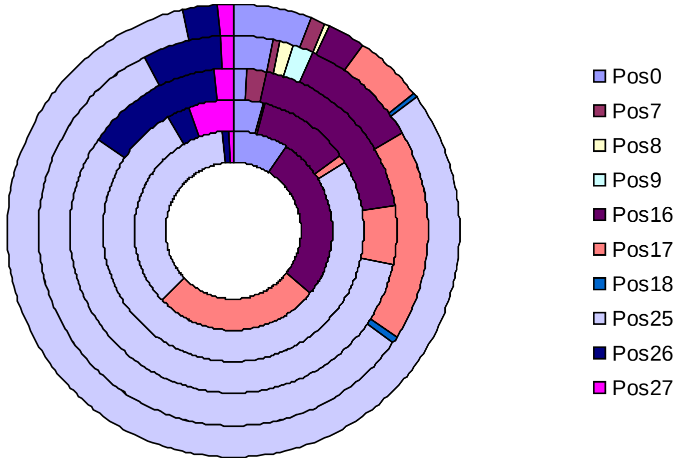
	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.01	0.00	0.01	0.00	0.00
Pos 7	0.09	0.08	0.03	0.02	0.03
Pos 8	0.00	0.00	0.02	0.01	0.01
Pos 9	0.00	0.02	0.01	0.01	0.01
Pos 16	0.02	0.15	0.16	0.16	0.20
Pos 17	0.04	0.03	0.08	0.18	0.08
Pos 18	0.00	0.00	0.01	0.01	0.00
Pos 25	0.71	0.64	0.48	0.37	0.44
Pos 26	0.12	0.06	0.19	0.24	0.21
Pos 27	0.01	0.01	0.01	0.00	0.00

b. Steenbuck (*Raphicerus campestris*) - Steenbuck 2



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.02	0.02	0.00	0.00	0.01
Pos 7	0.00	0.00	0.03	0.02	0.00
Pos 8	0.00	0.00	0.00	0.00	0.00
Pos 9	0.00	0.01	0.00	0.04	0.00
Pos 16	0.03	0.08	0.09	0.20	0.30
Pos 17	0.71	0.20	0.46	0.37	0.42
Pos 18	0.00	0.00	0.00	0.00	0.00
Pos 25	0.14	0.53	0.30	0.27	0.22
Pos 26	0.12	0.15	0.09	0.10	0.04
Pos 27	0.00	0.00	0.01	0.00	0.00

c. Steenbuck (*Raphicerus campestris*) - Steenbuck 3



	Baseline	Pre-enrichment	Enrichment	Post-enrichment 1	Post-enrichment 2
Pos 0	0.09	0.04	0.01	0.03	0.06
Pos 7	0.00	0.01	0.02	0.01	0.01
Pos 8	0.00	0.00	0.00	0.01	0.01
Pos 9	0.00	0.00	0.00	0.02	0.00
Pos 16	0.27	0.11	0.19	0.10	0.03
Pos 17	0.27	0.01	0.06	0.18	0.05
Pos 18	0.00	0.00	0.00	0.01	0.00
Pos 25	0.36	0.75	0.56	0.57	0.81
Pos 26	0.01	0.03	0.14	0.07	0.03
Pos 27	0.01	0.06	0.02	0.01	0.01

3.6.2.2. Statistical analysis

The enclosure was divided into quadrants approximately equal to 6.67m x 13.33m, with each area representing 11.11% of the available area. Steenbuck 2 was never observed within position 8, but the other two steenbuck were seen in every area of the enclosure during at least one study period.

Individual enclosure use or coefficient of variation (CV) as used by Stoinski et. al. (2001), ranged from 1.56 to 2.43 (see Table 3.23.). Steenbuck 1 utilised the most enclosure space (clumped the least), with a CV of 1.56, during post-enrichment 1 while steenbuck 3 utilised the least enclosure space (clumped the most), with a CV of 2.43, during the post-enrichment 2 period.

		Mean (x)	StDev (s)	CV
STEENBUCK 1	Baseline (n=4)	0.11	0.22	2.02
	Pre-Enrichment (n=5)	0.11	0.22	1.96
	Enrichment (n=5)	0.11	0.21	1.89
	Post-Enrichment 1 (n=5)	0.11	0.17	1.56
	Post-Enrichment 2 (n=5)	0.11	0.17	1.57
STEENBUCK 2	Baseline (n=4)	0.11	0.23	2.06
	Pre-Enrichment (n=5)	0.11	0.19	1.73
	Enrichment (n=5)	0.11	0.22	1.98
	Post-Enrichment 1 (n=5)	0.11	0.18	1.60
	Post-Enrichment 2 (n=5)	0.11	0.21	1.92
STEENBUCK 3	Baseline (n=4)	0.10	0.22	2.17
	Pre-Enrichment (n=5)	0.11	0.25	2.29
	Enrichment (n=5)	0.11	0.21	1.90
	Post-Enrichment 1 (n=5)	0.11	0.20	1.88
	Post-Enrichment 2 (n=5)	0.10	0.25	2.43

Table 3.23. Enclosure usage data

When statistical analysis was run using the Mann-Whitney U test, several significant changes for specific area usage within enclosures by individual steenbuck were indicated.

Steenbuck 1 showed no significant changes in area usage between study periods. Steenbuck 2 significantly decreased time spent in position 17 (p=0.01, U=0.0) and significantly increased time spent in position 25 (p=0.03, U=1.0) during the comparison of baseline to pre-enrichment data. Steenbuck 3 significantly increased time spent in position 26 (p=0.04, U=1.0) during enrichment compared to pre-enrichment and also significantly increased time spent in position 25 (p=0.03, U=0.5) when comparing post-enrichment 1 to post-enrichment 2.

4. DISCUSSION

4.1. ACTUAL RESULTS COMPARED TO THE PREDICTION

4.1.1. Activity budgets

The null hypothesis stated that no significant difference in the activity budgets between the enrichment and non-enrichment periods for the species studied within the NZG existed while the alternate hypothesis stated there was a significant difference in the activity budgets between the enrichment and non-enrichment periods for the key mammal groups studied within the NZG. This approach was then extended so that proportional activity budgets, dividing observational time into morning and afternoon were proposed with the null hypothesis stating there was no significant difference in the periods of the day during which activities were observed on enrichment and non-enrichment days for the species studied within the NZG while the alternate hypothesis stated there was a significant difference between the periods of the day during which activities were observed on enrichment and non-enrichment days for the key mammal groups studied with the NZG.

4.1.1.1. African savanna elephant (*Loxodonta africana*)

The majority of the comparative data when analysing whole day data showed no significant difference between study periods. Elephant 2 significantly decreased non-relevant behaviour (behaviour G) when comparing the baseline and pre-enrichment data and increased the amount of time that was spent non-visible (behaviour H) when comparing post-enrichment 1 and post-enrichment 2 periods. These findings are not easily explained; however, the significant finding related to non-visibility, at least, it may be due to insufficient sample size as the findings were not consistent over time or between individual animals. This was further borne out on examination of the descriptive data, with the values for Elephant 2, behaviour H, during the post-enrichment 1 period being:

mean=0.00±0.00 (min.=0.00; max.=0.00)

and during the post-enrichment 2 period being:

mean=0.01±0.04 (min.=0.00; max.=0.17).

However, elephant 3 showed a significant decrease in feeding behaviour (behaviour A) between the enrichment and post-enrichment 1 periods and the male elephant (elephant 1) significantly increased stationary behaviour between the same periods. This suggests that even though there was not a significant increase in feeding and activity levels during the enrichment period, the day following enrichment the animals have a tendency to rest more and eat less.

Therefore, in the case of elephants 2 and 3 the null hypothesis is accepted as no significant difference in the activity budgets between the enrichment and non-enrichment periods for these individuals was found.

For elephants 1 and 3 the picture is less clear, however the null hypothesis must be rejected in favour of the alternate hypothesis as it appears that there was a significant difference in the activity budgets between the enrichment and non-enrichment periods for these individuals due to the negative effect on activity and feeding behaviour during the post-enrichment 1 period. This highlights the importance of the individual differences seen during this study.

The elephants were the only animals within this study to utilize two separate enclosure areas. This made the comparison of morning and afternoon behaviour very important as it indicated the response to the two areas as well as any behavioural changes facilitated by the feed-based enrichment. This is highlighted by the male elephant (elephant 1) as when the behavioural data is taken as a whole it seems that a large proportion of the day is spent undertaking ‘abnormal’ behaviour. However when the data is split between morning and afternoon it is clear that the problem is confined mainly to the morning, indicating a problem within the small camp in which the elephants spend the first part of the day.

The response to enrichment differed between individuals. All the elephants spent the majority of the time undertaking feed-based behaviour regardless of study period. Stationary and active species-specific activities were also undertaken for a large proportion of the day. The male elephant differed from the females during the morning period while in the small camp, by spending a large proportion of the period displaying 'abnormal' behaviour. This may well have been a coping mechanism as all the elephants were seen to be impatient to re-enter the large camp as the small amount of food distributed in the small camp was finished some time before the large camp had been cleaned and prepared.

When looking at the effect of enrichment on the behaviour of the elephants in the small camp (morning period), it appears that no response, either positive or negative was seen. This may well be due to the fact that the size of the camp meant that the elephants soon found the hidden food items and once they had eaten all the food they continued with their normal behaviour. This suggests that either the elephants should spend less time in this small area, or more sophisticated methods are required so as to slow the speed with which the individuals can locate and consume the food. Placing the hay (roughage) within the small camp instead of the fruit and vegetables may also be a means to increase feeding activity and decrease abnormal and stationary behaviour whilst in this area.

Currently Mrs R. Ingle-Moller is investigating the possibility of using feed balls specially constructed for the elephants and these may be of use in this small space. However, caution should be given to possible aggressive behaviour, especially by the male. He exhibited aggression towards the females by chasing them away from food items especially in the large camp, albeit for a very small percent of the time, during this studies enrichment periods.

Therefore the null hypothesis related to the proportional activity budgets is accepted for all the elephants during the morning period.

The effect of enrichment on behaviour within the large camp did show some significant changes. As with the small camp, feed-based behaviour occupied the majority of all the elephant time regardless of study period. Stationary and active species specific behaviour were also undertaken for a significant part of each day and unlike within the small camp, the male elephant did not show the same level of abnormal behaviour.

Elephants 1 and 2 both had significant decreases in non-relevant behaviour (behaviour G) when comparing the baseline and pre-enrichment afternoon data. As with the whole day data this finding is not easily explained. Possibly of more importance is that the same two elephants were also significantly more visible during enrichment compared to the pre-enrichment period and during the comparison of the same two periods, elephant 2, increased feeding behaviour (behaviour A). Increased visibility suggests greater utilisation of the enclosure (which will be discussed under section 5.1.2.) and increased feeding behaviour indicates that the environmental enrichment had a positive effect on this individual increasing foraging time. This was also the case for elephant 4 that significantly increased feeding behaviour during the enrichment period compared to pre-enrichment. In addition elephant 4 showed a significant decrease in stationary behaviour (behaviour B), active species-specific behaviour (behaviour D) and non-relevant behaviour (behaviour G) during the same period suggesting that the increase in feeding behaviour was significant enough to displace other activities normally undertaken. This may or may not be of benefit as decreased stationary behaviour could be related to a decrease in boredom, would be beneficial, however a decrease in active species-specific behaviour may not be as positive.

Elephants 2, 3 and 4 showed a decrease in feeding behaviour on post-enrichment 1 indicating that the behavioural response to the enrichment was of short term duration, lasting only as long as the enrichment was undertaken. Stationary behaviour also significantly increased for all the elephants the day following enrichment. This may indicate a rebound response to enrichment, indicating that the elephants were resting more in order to recover from the increased exertion of the previous day. This can be interpreted in two ways, either in a positive or negative light. The fact that the three females especially seemed to be affected by mild exhaustion the day following enrichment can be seen as a reason to increase such enrichment periods in order to increase fitness levels. However the flip side is that increasing energy expenditure which results in a reduced energy intake the following day can be seen as having negative physiological effects on the animal or even psychological if it is partly in response to increased activity by an aggressive male.

However, the fact that elephants 2 and 3 showed a significant increase in feeding behaviour again when comparing post-enrichment 1 and post-enrichment 2 periods and elephant 1 significantly decreased stationary behaviour (behaviour B) during the same periods shows that any post-enrichment effects are only temporary with reversion to normal levels of behaviour within 48 hours.

For the afternoon period the null hypothesis that stated there was no significant difference in the activity budget between enrichment and non-enrichment periods, related to proportional activity budgets was rejected in favour of the alternate hypothesis for all of the four elephants.

In summary the environmental enrichment appeared to have positive results for all four individuals during the afternoon period, which corresponds to the period they were in the large enclosure. In contrast no effect is seen during the morning period which corresponds to the period in which the elephants are located in the small camp. Although it can not categorically be stated that the space availability within each camp played the pivotal role in the success or failure of this enrichment I would strongly suggest this was the case.

4.1.1.2. Leopard (*Panthera pardus*)

Unlike the other species observed in this study, the leopard was only fed every second day. This meant that half the enrichment periods fell on ‘feeding days’ whilst the other half fell on 'non-feeding' days. There was no significant difference between enrichment periods that corresponded with days on which the leopard was fed compared to non-feeding days at the 0.05 level. However, there was an increase in feeding related behaviour ($U=141.0$; $p=0.07$) and a corresponding decrease ($U=128.0$; $p=0.07$) in stationary behaviour on days fed compared to non-feeding days when comparing enrichment periods. Although these findings are not highly significant they must be borne in mind when inferences are drawn from the overall study. In addition, a point to note is that a proportion of the food given was always wasted as the leopard often allowed wild slender mongoose (*Galerella sanguinea*) to enter the enclosure and steal the meat (see figure 4.1.).

Figure 4.1. Mongoose within the leopard enclosure, thieving the meat.

When examining whole day data, the greater portion of the day was spent stationary with no visible movement, with the majority of the comparative data showing no significant difference between study periods. There was a significant decrease in the time spent performing feeding behaviour between baseline and pre-enrichment data. The reason for this finding is unclear. In addition, a significant increase in human interaction was seen between the enrichment and post-enrichment 1 period with a rebound significant decrease between post-enrichment 1 and post-enrichment 2 periods. This may be related to several factors, not least the fact that on enrichment days keepers and observers spent longer in the enclosure in order to fix the enrichment items and in so doing left their scent on items not usually touched which the leopard may well have related to those sitting watching him on the other side of the glass. The resulting curiosity may explain the increased human interaction. Alternatively the leopard may have associated the individuals directly with the enrichment item placed in his enclosure the day before and was merely examining whether the item was still available. Whatever the reason it seems to be indirectly linked to the enrichment period; however the effect appears transient as within 48 hours the leopard returned to pre-enrichment activity levels.

Whether to accept or reject the null hypothesis is questionable; however, as there is an effect on human interaction that appears to be related to the environmental enrichment the null hypothesis is rejected in favour of the alternate hypothesis, although not apparently due to the stimuli we intended to provide.

When data was separated into morning and afternoon, variation between the two data sets was evident with the morning appearing to be the time of day when the majority of differences were seen between the various study periods.

There was a significant decrease in feeding related behaviour (Behaviour A) seen between the baseline and pre-enrichment data during the morning as well as an increase in visibility (Behaviour H) when comparing the same periods. These findings are not easily explained but make it harder to draw any inference from the fact that the leopard significantly increased feeding related behaviour (Behaviour A) during the morning when comparing pre-enrichment and enrichment periods. Whether this increase was a true effect of the enrichment or merely a resurgence to normal levels after an unknown factor resulted in decreased feeding during the pre-enrichment period is uncertain. The fact that feeding related behaviour did not decrease during either of the post-enrichment phases of this study also appears to imply that rather than the increase in feeding behaviour during the enrichment period being due to the presence of the enrichment items, it may well be nothing more than a return to normal levels after the drop in feeding seen during the pre-enrichment period. The question remains, what caused the initial decrease in feeding related behaviour?

Abnormal behaviour (Behaviour C) significantly increased in the morning of post-enrichment1 compared to the morning of enrichment. The relevance of this finding to the preceeding enrichment period is difficult to judge as there was no significant decrease in abnormal behaviour during the enrichment period or during the post-enrichment 2 period. This suggests that the morning after enrichment, which itself had no direct effect on abnormal behaviour, there was, in fact, an increase in abnormal behaviour which was maintained during the post-enrichment 2 period.

Once again a clear link between enrichment and behavioural changes cannot be made but from the evidence above a tentative rejection of the null hypothesis in place of the alternate hypothesis can be accepted for the morning data.

When examining the afternoon data, a significant decrease in non-relevant behaviour (Behaviour G) between the baseline and pre-enrichment period was followed by a further significant decrease in non-relevant behaviour in the subsequent morning enrichment period compared to pre-enrichment. The reason behind the initial reduction is unclear but may be related to the leopard being fully habituated to the observers only by the time the pre-enrichment component of the study had started. The reduction in non-relevant behaviour during the enrichment period is also difficult to draw inferences from as there appears to be no other behavioural differences other than a significant decrease in human interactions (Behaviour F) seen during the same period which further confuses the interpretation. Conversely, there was a significant increase in human interactions between the morning enrichment and post-enrichment 1 period and a significant decrease in human interaction between the afternoon of post-enrichment 1 and post-enrichment 2. The possible causes of this effect have been discussed above.

Much like that of the morning data a clear link between enrichment and behavioural changes is unable to be made but from the evidence presented a tentative rejection of the null hypothesis in place of the alternate hypothesis can be accepted for the afternoon data.

A general suggestion may be to decrease the frequency and quantity of meat given to this currently overweight individual (determined by assessing the body condition score which was visually determined as 4.5 on a scale of 1 to 5 where 1 is emaciated and 5 is morbidly obese with 3 representing the ideal) not only will potential health problems be prevented but a probable increase in activity and more substantive response to enrichment will most likely be seen. There is also a notable lack of lean muscle mass on this animal which suggests some form of increased exercise is required.

4.1.1.3. Lion-tailed macaque (*Macaca silensus*)

The majority of the day was spent by all macaques performing active species specific behaviour (behaviour D), with the proportion of feeding (Behaviour A), being stationary (Behaviour B), and non-visible (Behaviour H) behaviour varying between individuals. The individuality in behaviour seen highlights the possibility that the effect of enrichment will also be very individualistic. Statistical analysis confirms that this was the case, with most of the significant behavioural changes being seen during the post-enrichment1 period rather than on the day of enrichment itself, with no individual having any significant behavioural variation when comparing pre-enrichment and enrichment periods for the whole day data.

Macaque 1 (the skinny male) significantly decreased human interaction (Behaviour F) between baseline and pre-enrichment periods, as did macaque 3. In addition macaque 3 significantly increased active species specific behaviour (Behaviour D) during comparison of the same periods. This highlights the need for an adequate period of habituation suggesting some individuals take longer than others to accept and ignore human observers.

For the comparison of the enrichment and post-enrichment 1 period the majority of significant behavioural variation was recorded. Both macaque 2 and 3 significantly increased stationary behaviour (Behaviour B), whilst macaques 1, 3 and 4 all significantly decreased aggressive interactions (Behaviour E). This is an important finding as it suggests that the enrichment could have facilitated aggressive interaction. However, a significant increase in stationary behaviour by macaques 2 and 3 during post-enrichment 1 suggests enrichment may have facilitated positive responses.

Macaque 4 was the only animal to show a behavioural difference between post-enrichment 1 and post-enrichment 2 periods, significantly decreasing non-relevant behaviour (Behaviour G). This finding was not easily explained however it may be due to insufficient sample size as the findings were not consistent over time or between individual animals. This was further born out on examination of the descriptive data as for macaque 4, behaviour G, post-enrichment 1 the mean=0.02±0.04 (min.=0.00; max.=0.17) and post-enrichment 2 the mean=0.00±0.02 (min.=0.00; max.=0.08).

Therefore the null hypothesis is rejected for all individuals in favour of the alternate hypothesis when assessing whole day date.

When the data was assessed by splitting it into morning and afternoon sections the above individualistic responses to the enrichment are further confirmed. The majority of the significant behavioural variations occurred during the afternoon period. Only four changes were seen during the morning, with macaque 3 significantly decreasing human interaction (Behaviour F) when comparing baseline and pre-enrichment periods, and showing increased stationary behaviour (Behaviour B) when comparing enrichment to post-enrichment 1. During the morning macaques 1 and 4 both significantly decreased aggressive behaviour (Behaviour E) when comparing the enrichment and post-enrichment period. The probable reasons for the above responses have been discussed above.

The null hypothesis was, therefore rejected in favour of the alternate hypothesis for macaques 1, 3 and 4 but accepted for macaque 2 when assessing the morning proportional activity budget.

For the afternoon data, only macaque 4 showed any significant difference when analysing pre-enrichment to enrichment data, demonstrating a significant decrease in stationary behaviour (behaviour B). However, macaques 2, 3 and 4 showed a significant increase in stationary behaviour between enrichment and post-enrichment 1 data. This suggests that for all three animals, but especially for macaque 4, enrichment had a significant but short-lived positive effect on behaviour. However, when comparing enrichment to post-enrichment 1, macaque 3 also showed a significant decrease in aggressive interactions (Behaviour E) which may indicate a negative effect due to enrichment.

One problem that could also have contributed toward aggression is that occasionally the macaques were able to pull the pvc pipes off their fastenings and carry them around. This precipitated a lot of interest from the other individuals and often resulted in squabbles over who could carry the pipe.

Yet again the importance of a sufficient habituation period was highlighted as macaques 1, 2 and 3 all significantly decreased human interaction (Behaviour F) and macaque 3 increased active species specific behaviour (Behaviour D) from baseline to pre-enrichment period.

The findings of post-enrichment 1 compared to post-enrichment 2 during the afternoon period showed macaque 2 significantly decrease stationary behaviour (Behaviour B) and human interaction (Behaviour F). Macaque 4 significantly decreased non-relevant behaviour (Behaviour G) during the same comparative period. These findings are not easy to explain but may show that a rest day was required subsequent to enrichment and recovery was complete by the post-enrichment 2 day.

Therefore, much like the morning data. the null hypothesis was rejected in favour of the alternate hypothesis, only this time in the case of macaques 2, 3 and 4. In comparison the null hypothesis was accepted for macaque 1 when assessing the afternoon proportional activity budget. once again this highlights the individual differences.

These results highlight the mixed findings that can often be seen between individuals within an enclosure and emphasize the need for careful monitoring of any enrichment program.

4.1.1.4. Red panda (*Ailurus fulgens*)

It could be postulated that the panda would respond the least to any enrichment protocol due to their naturally nocturnal behaviour. But as with many of the animals within this study some changes were seen, however, individual variation was seen and a definitive response to the enrichment was not seen.

Both red pandas spent a substantial period of each study period non-visible (Behaviour H) to the observer. This must be borne in mind when analysing the data as the behaviour could only be reported during periods when the panda were visible. Unfortunately because of the nocturnal habits of these animals the elevated kennel in the centre of the enclosure was the favoured location of both animals during the observational periods.

When comparing whole day data, the majority of the comparative data showed no significant difference between study periods, with no individual having any significant behavioural variation when comparing baseline and pre-enrichment periods and no significant result being consistent for both individuals. Red panda 1 significantly decreased active species-specific behaviour (Behaviour D) when comparing post-enrichment 1 and post-enrichment 2 periods. This may have been a result of the enrichment as the bamboo was often only removed in place of the normal feeding regime during the morning period of post-enrichment 1. However, this is a tentative supposition and as it is only apparent in one of the two panda is far from conclusive.

Red panda 2 significantly increased non-relevant behaviour (Behaviour G) during enrichment compared to pre-enrichment and significantly increased the amount of time non-visible during post-enrichment 1 compared to the enrichment period. This is clearer evidence that enrichment may have had a positive effect on red panda 2, however the lack of corroborative data and the fact that red panda 1 did not show the same response weakens any inferences draw from it although once again this shows individual differences.

These results show the inconsistence in response to enrichment even within the same group of animals. From the data discussed above the null hypothesis is accepted for red panda 1 and rejected in favour of the alternate hypothesis for red panda 2 when analysing whole day data.

When comparing the morning data, much like that of the whole day data, the findings were inconclusive and not consistent for the two individuals. Red panda 1 significantly decreased feeding behaviour (Behaviour A) when comparing baseline and pre-enrichment morning data. There was a subsequent rebound effect with a significant increase in feeding when comparing pre-enrichment with the enrichment period when observing panda 1 during the morning. These results make it difficult to assess the extent to which enrichment effected feeding behaviour as the rise may have been due to the enrichment but equally could have been nothing more than a return to normal after the pre-enrichment drop being unaffected by the enrichment.

Red panda 2 significantly increased non-relevant behaviour (Behaviour G) and decreased non-visibility (Behaviour H) when comparing the pre-enrichment to enrichment. This suggests a mixed responseto enrichment as an increase in non-relevant behaviour suggests a negative effect that was possibly caused by avoidance behaviour on the part of red panda 2 to the observers and staff that climbed the main tree during enrichment days in order to place the bamboo. However, an increase in visibility during the same period indicates increased activity and was of benefit to the viewing public who were more likely to see the red panda within the enclosure. Whether this was beneficial to the animals themselves is uncertain.

Trying to determine if the null hypothesis should be accepted or rejected for these two animals when comparing the morning data is difficult and no final decision can be made from the data given above.

With no significant behavioural changes between the different study periods in either animal for the afternoon data the null hypothesis is clearly accepted over the alternate hypothesis in this case.

4.1.1.5. Black and white ruffed lemur (*Varecia variegate*)

Surprisingly, looking at the lemur data suggests that the environmental enrichment had no effect on the behaviour of the study animals. The reason for this may be two fold. Firstly, feeding behaviour was not the predominant activity for the lemur and secondly they were very quick to identify the food source and locate the individual food items. Therefore the intelligence of these individuals may have resulted in the attempted enrichment program being inconsequential to them.

When whole day data was assessed, only one significant change in the proportion of time spent undertaking behaviour between each study period was found. Lemur 2 significantly increased ($p=0.003$; $U=480.0$) aggressive interaction (Behaviour E) from baseline to the pre-enrichment period. This may well have been an inadvertent result of the method by which the observers identified the key study animals, with non-toxic children's paints as it was difficult to otherwise recognise the three lemur being observed (see figure 4.2.). This change in appearance (albeit only a spot of colour between the shoulder blades), did arouse interest from the other lemur in the enclosure and initially aggressive interactions were observed. Such interactions appeared to subside by the end of the instructional period but the effect described here may have been a residual finding.

Figure 4.2. Markers used to identify the study animals.

When the study periods were divided into morning and afternoon, none of the lemur showed any significant behavioural changes between periods during the mornings.

During examination of the afternoon data two significant values were observed. Lemur 2 significantly increased ($p=0.01$; $U=104.0$) aggressive interaction (Behaviour E) when comparing baseline and pre-enrichment periods. Lemur 3 significantly decreased ($p=0.01$; $U=140.0$) aggressive interaction between pre-enrichment and enrichment periods. The explanation for the aggressive behaviour is discussed above and highlights the care with which any change in animal appearance must be assessed. All other comparison of afternoon data for all individual lemur were not found to be significantly different between study periods.

For this particular group of individuals, although the enrichment appeared to be enjoyed by the members of the public who saw individuals swinging off hammocks and digging in leaf litter, little to no benefit was gained by the lemurs. This highlights the need to fully assess the requirements of each animal species and their mental capacity to problem-solve and tailor any enrichment program accordingly.

As a result the null hypothesis is accepted for all individuals in the case of both whole day data analysis and for the proportional activity budget analysis.

4.1.1.6. Steenbuck (*Raphicerus campestris*)

The steenbuck are naturally shy animals and as such the presence of the observers had a greater impact on their behaviour than other study species. All three animals showed a significant increase in human interaction (Behaviour F) when comparing baseline data to pre-enrichment. For steenbuck 1 and 3 there was also a significant decrease in non-relevant behaviour (Behaviour G) during the same study periods. This indicates that by the pre-enrichment period the steenbuck were no longer fearful of the observers and were instead curious. Yet again this finding highlights the need for an adequate habituation period before experimental observations are commenced and shows that different species take different amounts of time in order to become comfortable with human presence even in a captive environment.

The other significant findings all relate to feeding behaviour (Behaviour A). Steenbuck 1 significantly increased this behaviour from pre-enrichment to enrichment periods and steenbuck 2 significantly decreased feeding behaviour between the enrichment and post-enrichment 1 period only to have a rebound significant increase in the same behaviour when comparing post-enrichment 1 to post-enrichment 2. Therefore on initial examination, the response to the feed based enrichment at least for the adult female (steenbuck 1) and the adult male (steenbuck 2) appeared to be positive, with the two animals increasing feeding during the period of enrichment.

Therefore in the case of whole day data the null hypothesis is accepted for the youngster (steenbuck 3) but rejected in favour of the alternate hypothesis in the case of both the adults (steenbuck 1 and 2).

When analysing the morning data only all three animals significantly increased human interaction (Behaviour F) when comparing baseline and pre-enrichment data. Steenbuck 2 also significantly decreased non-relevant behaviour (Behaviour G) during the same study periods. The reasons for this have already been discussed above.

Comparison of pre-enrichment and enrichment morning periods saw steenbuck 1 significantly increase feeding related behaviour (Behaviour A). Steenbuck 2 significantly decreased feeding behaviour during comparison of enrichment and post-enrichment 1 and subsequently increased the same behaviour when comparing post-enrichment 1 to post-enrichment 2 much as seen for the whole day data.

It is worth emphasising at this point that the youngster, although occasionally attempting to copy the mother in consuming food items, was in fact still suckling so the lack of effect on this animal thus far is not surprising.

Mirroring the results of the whole day data, for the morning only data the null hypothesis is accepted for steenbuck 3 but rejected in favour of the alternate hypothesis in the case of steenbuck 1 and 2.

During comparison of the afternoon data potentially worrying indirect effects of enrichment were seen, with the young un-weaned steenbuck significantly increasing suckling during post-enrichment 1 compared to enrichment with a subsequent decrease in suckling during post-enrichment 2 ($p=0.07$, $U=85.0$). Stationary behaviour was also higher during days of enrichment and decreased again for post-enrichment1 periods. This would indicate that the steenbuck are undertaking natural behaviour as when the adults forage the youngsters are naturally hidden in the wild and hence lay very still waiting for the return of the adults. However, with an increase in foraging by the adults in this case, the enrichment program may well be indirectly putting strain on the youngster by decreasing suckling opportunities, which may explain the change in behaviour seen by steenbuck 3 the day after enrichment with the youngster being much more active and increasing suckling. Whether this was detrimental to the youngster would require further investigation.

These animals are extremely sensitive and easily stressed and so although the adults do appear to benefit from this enrichment, very careful assessment must be made before changing routine for such animals especially if un-weaned individuals are present.

For the afternoon data the reverse findings are determined with the null hypothesis being accepted for the two adult animals, while being rejected in favour of the alternate hypothesis in the case of steenbuck 3.

4.1.2. Enclosure utilisation

4.1.2.1. African savanna elephant

Little change was seen with regard to spatial utilization of each camp between study periods, with usage of both camps obviously not being random. Within the small camp, the area adjoining the night rooms (position 25) which led back to the large enclosure was the area most regularly frequented by all the individuals. Only elephant 4 significantly decreased time spent in this area during the enrichment period.

This reinforces the findings of the behavioural study, showing that other methods of stimulating the elephants during their time in the small camp are required.

Within the large camp, position 25 was the area most frequented by elephants 1 and 4, with elephants 2 and 3 giving equal weighting to areas 25 and 27 regardless of study period. During normal (non-enrichment) periods, the food was predominantly in area 25, however during the enrichment, food items were scattered more evenly over the whole of the enclosure space. The positioning and presentation of the roughage was not altered, with it still being piled primarily in position 25. This may account for the apparent lack of success in increasing space utilization in these animals during the enrichment period.

An adaptation to the enrichment used in this study may be to utilise the roughage to cover the fruit and vegetable food items rather than leaves. This would facilitate spread of the hay throughout the enclosure, reduce the work time required to undertake enrichment (prevent the need for collecting leaves) and avoid the untidy leaf litter that was often an issue during this work.

Although no strong behavioural trends or spatial utilization changes resulting from the feed-based enrichment were seen for all the individuals, the lack of negative response and individual positive responses within the large camp especially were encouraging. Increased foraging and greater interest for the public appears to be possible using this type of enrichment.

4.1.2.2. Leopard

Positions 8 and 25 were most frequented by the leopard, with non-random utilization of the enclosure. Position 8 was at the front of the enclosure behind the wall separating the two viewing windows and may have been preferred by the leopard as it gave some privacy from the public. Position 25 was immediately in front of the door leading to the night room which from speaking to the keepers, if opened during the day would result in the leopard being out of sight for most of the time. Both these positions therefore suggest that the leopard was trying to hide from the viewing public and find an area of solitude that was otherwise not available to him. During the enrichment period there were no significant changes in spatial utilization at the 0.05 level. This adds further doubt to the significant findings of the behavioural observations especially for the increase in feeding behaviour, as the enrichment items were in areas 17 and 27 that were both rarely frequented by the leopard.

Much like the elephants, although conclusive behavioural trends and spatial utilization changes were not seen in this individual as a result of the feed based enrichment, potential benefits were inferred from the data to which should be the basis of further investigation.

4.1.2.3. Lion-tailed macaque

Spatial utilization was not random, but although the macaques had their favoured areas which were mainly zones of elevation they utilized the entire enclosure space far more than some of the other species observed. During enrichment periods there was a significantly decreased usage of specific areas by macaques 2, 3 and 4, with the exception being position 27, that was the location at gound level in the far right of the enclosure, in which macaques 3 and 4 spent significantly more time. Macaque 1 appeared to be unchanged by enrichment. The only observation that was common to all individuals was that the time spent out of sight was significantly increased during periods of enrichment due to the time it took to prepare the enclosure before the animals were released from the night rooms. This is a negative feature of this enrichment as it decreases the amount of time that the visiting public can view the macaques. However, this would not be a major problem once a proper regime could be established.

4.1.2.4. Red panda

Spatial utilization altered slightly between study periods, with panda 1 spending significantly more time in position 4 during the enrichment period compared to pre-enrichment. This reinforces the findings of increased feed behaviour during this period as one of the bamboo stations was within this zone. An increase in time spent in position 23 during the post-enrichment 1 compared to enrichment period also makes sense as this is where the kennel was situated. This also reinforces the findings of the behavioural study that during non-enrichment periods the panda are often less visible.

Overall, the red panda showed a positive response to the enrichment, but as with most of the species individual differences were observed.

4.1.2.5. Ruffed lemur

As they were already roaming around the entire area of the enclosure quite regularly before enrichment it is not surprising that the spatial utilization appeared to be unaffected during the enrichment periods. This reinforces the finding of the behavioural study that the feed-based enrichment offered to these animals was ineffective at affording any significant changes.

4.1.2.6. Steenbuck

It is clear that all three steenbuck preferred to be near some form of protection as the majority of time was either spent beside the solid dividing wall of the enclosure (positions 25, 26 and 27) or the tree stumps in the centre and left of the exhibit (position 16 and 17).

As such the left side of the enclosure is utilized far more than that of the right and the back of the enclosure in preferred to the front, leading to a non-random usage of the space available.

Utilization of the enclosure by the adult male and female were largely unchanged, with steenbuck 1 showing no significant changes in area usage between study periods while steenbuck 2 significantly decreased time spent in position 17 ($p=0.01$, $U=0.0$) and significantly increased time spent in position 25 ($p=0.03$, $U=1.0$) during the comparison of baseline to pre-enrichment data. Position 17 was associated with fallen logs and plenty of hiding places where as position 25 was associated with the more open area immediately in front of the night room. This change may relate to the animal becoming more relaxed with the presence of the observers and so not feeling like there is a requirement to be so close to cover.

Steenbuck 3 significantly increased time spent in position 26 (p=0.04, U=1.0) during enrichment compared to pre-enrichment and also significantly increased time spent in position 25 (p=0.03, U=0.5) when comparing post-enrichment 1 to post-enrichment 2. These two positions are directly next to one another forming a continuum along the back wall. Although the reason for such a change is not clear, it does reinforce the fact that the young steenbuck was indirectly affected by the enrichment.

The predominance observed for the above areas is not overly surprising as steenbuck are naturally shy animals and prefer sheltered areas and do not easily venture into open spaces.

4.2. COMMONALITY OF RESULTS BETWEEN AND WITHIN SPECIES

Generally there was a poor response to the feed-based enrichment used in this study with none of the study animals showing overwhelming conclusive behavioural pattern or spatial utilization changes common to all members of the group. Certain individuals appeared to benefit from the exercise in particular responses, where as others showed no response while others exhibited signs of deleterious effects. Below, the question of whether there are any trends that can be identified between and within species with regards the response to feed-based enrichment are discussed.

4.2.1. Taxon

Very few trends or similarities were present between the species in this study other than to note that individual animal variation in response to enrichment was common throughout. This included the type of behavioural change seen, whether perceived as positive or negative, with certain individuals exhibiting a mixed response. For example, increasing the time undertaking feeding related behaviour in response to enrichment (which was perceived as a positive response), whilst at the same time significantly decreasing active species specific behaviour (which was seen as a negative response).

All the study species other than the black and white ruffed lemur showed some form of response to the enrichment. Whether this total lack of response by the ruffed lemur was a species trait or a result of external factors is questionable as they were a large group and the only individuals in which not all the animals within the enclosure were assessed. The extent to which the other individuals within the group responded to the enrichment is unknown making it difficult to draw conclusions from the negative result in this case, but may be to do with social complexity and associated behaviour (see section 4.2.2.).

One finding that was true for all the species in the study was that any effect resulting from the feed-based enrichment was short lived, with many of the positive responses such as increased feed related behaviour and decreased stationary behaviour only being noted during the time in which the enrichment was present within the enclosure. The day immediately following enrichment revealed a reversion to pre-enrichment behaviour levels in many cases. This is important as it suggests continual enrichment is required to maintain the desired responses.

For all of the elephants, but more notably the females and also for the two female macaques, post-enrichment 1 appeared to be a day of recovery after the preceding enrichment period. This was characterized by a combination of increased stationary behaviour, decreased active species specific behaviour and on occasion a decrease in feeding behaviour. The reason for such an effect is more likely related to the physical health of the animals (those which are unfit rest after periods of increased exertion) rather than any species or sex related factor. This may improve health over time but may need to introduce the enrichment in a staggered way to avoid exhaustion.

One factor that appeared to be present only within the primate species being studied was the occurrence of aggression. With the macaques this was directly associated with the enrichment while the ruffed lemur aggression appeared to be due to an indirect effect of the study from the method of identifying the key observational animals. These findings suggest that when enriching primate enclosures the possibility of facilitating aggressive interactions between individuals must be considered.

Another finding of this study which was not directly related to the enrichment but is important to note for any observational period was the time required for habituation of the animals to the observers. For the macaque, leopard, elephant and steenbuck there was evidence to suggest that certain individuals within these groups required up to two weeks before complete habituation had occurred. This was despite the fact that all the observed animals were on display and were exposed to zoo visitors and staff on a daily basis.

4.2.2. Social complexity

Three categories of social complexity were used to divide the six study groups, based on the natural history of the animals. The first and most socially complex, were those animals that live within an extended family group with complex hierarchies and mixed sex and age ratios. African elephant, macaques and the black and white ruffed lemur all fell within this category. The second category was those animals that lived within a small close knit family unit consisting of mother, father, current offspring and occasionally offspring from the previous season. The steenbuck was the only group within this study which belonged to this category. The least socially complex animals were defined as those which were naturally solitary such as the leopard and the red panda.

No strong correlation between social complexity and effect of feed-based enrichment on behaviour could be found. However, from the data collected during this study there is some evidence to support the suggestion that the greater the social complexity the more prone animals are to exhibiting aggression in response to enrichment. This was clearly seen in the primates as discussed above, but to a lesser extent some aggression was also recorded in the elephant.

It is clear from the above data that the activity budget and spatial utilization response to feed-based enrichment in this case was not only species specific but also differed between individuals of the same species housed in the same enclosure. In conclusion, feed-based enrichment does not elicit a generalized response in all species or even within all individuals within that species and this is one of the most important findings, emphasizing how useful (but maybe frustrating) this is to the zoo community. Therefore, whenever any form of environmental enrichment is undertaken the question should be asked: Is the cost : benefit worth it?

4.3. VALUE TO THE ZOO

As defined in the introduction conservation, welfare and public education are the three facets on which the aims of any enrichment program should be based. Therefore, in this case the success of this feed-based enrichment can be defined in the following ways:

1. Increasing wild-type behaviour (conservation) – increased feeding behaviour, including foraging as well as ingestion of food items.
2. Increasing choice and decreasing stress (welfare) – decreasing abnormal behaviour and increasing species specific and general activity.
3. Increasing attractiveness to the public (public education) – increasing activity and decreasing time spent out of sight.

5.3.1. Conservation

The aim of enrichment with regard to conservation is often defined as the ability to change the behavioural pattern of an animal or group of animals so that it tends more towards that of wild conspecifics as a result of the enrichment. Unfortunately the greatest obstacle to achieving this goal in a large number of species is the limited good quality, complete data available on activity budgets for wild individuals of the same species. This is so often the case for critically endangered animals in which the requirement for conservation is ironically most important.

However, Singh (2000) described in detail the activity budgets of lion-tailed macaques in a rainforest in Anaimalai hills, western Ghats, south India from August 1994 to March 1996. Data was collected using scan sampling with intervals of 10 minutes on one animal per age-sex class with a total of 10,404 scans being documented. Information on the behaviour being undertaken and the height above ground level at which the animal was seen performing such behaviour, was recorded.

The macaques ate a mixture of leaves, fruit and insects with 55% to 68% of the diet consisting of fruit depending on the season. The percentage frequency of activities was recorded as: passive (17.61%), move (43.59%), eat (30.95%), social (5.79%) and self (3.06%). Almost 50% of the feeding behaviour was recorded between 10:00 and 14:00 with the remainder predominating in the afternoon rather than morning period. The macaques also appeared most comfortable staying off the ground, with 54% of observations being between 5 and 15 meters, 39% of observations were above 15 meters and only 7% of observations recorded the macaques below 5 metres.

When these findings were compared to the data collected at the NZG, certain differences between the wild-type data and captive data become evident. Passive behaviour that can be compared directly with stationary behaviour (behav. B), showed that the adult male (macaque 1) ranged from 26 % to 28% of the time and was unaffected by enrichment, indicating that in comparison to the wild counterparts excessive time was spent stationary.

Macaque 2, the adult female, compares favourably to the wild counterparts before and during enrichment with 14% of the time observed stationary. However, during post-enrichment 1 there is a significant increase in stationary behaviour (22%) hence causing a deviation from the wild-type observation the reason for which was discussed in section 4.2.1. For macaque 4, the enrichment appears to significantly decrease the time seen stationary which may initially be considered a positive result. However, before enrichment the percentage time stationary ranged from 5% to 7% and during enrichment this dropped to only 2% so becoming further removed from that of the wild-type activity budget. Macaque 3 was the only individual in which feed-based enrichment improved the time spent stationary from values that were exceeding the wild data (26%) to those more in line with wild counterparts (13%).

Time spent feeding by the captive macaques was less than half that observed for the wild co-specifics. Even in those animals where the environmental enrichment significantly increased the time spent undertaking feed related behaviour the percentage time observed eating was at best 10% lower than the wild macaque observations. In addition, within the NZG there did not appear a significant difference between the percentage time spent feeding comparing morning and afternoon data.

Active species specific behaviour, when compared with the time spent moving by the wild conspecifics compares favourably between the two even without environmental enrichment. In some cases the environmental enrichment actually decreased the percentage time observed undertaking active species specific behaviour. Potentially negative effects of enrichment are vitally important to consider.

From comparison with the wild-type activity budget it appears that the feed-based enrichment undertaken for the macaques did little to improve the conservational objectives of this species except in the specific case of macaque 3 and in some instances was actually detrimental.

Another study that collected detailed observational data for wild animals was work undertaken by Graeme Shannon for his PhD at the University of KwaZulu-Natal, Durban. The study examined the effects of sexual dimorphism on the movements and foraging ecology of African savanna elephants in Pongola Game Reserve; Pilansberg National Park; Phinda Private Game Reserve; Tembe Elephant Park and Hluhluwe-Imfolozi National Park between November 2002 and December 2005.

In this study, the behavioural observations collected between 06:00 and 18:00 using instantaneous scan sampling either to determine the most common behaviour within a female herd or for the individual males were divided into five main behavioural groups - feeding (F), resting (R), walking (W), drinking (D) and other (O). The data was pooled for the three reserves as the analysis of variance (ANOVA) showed there to be no significant reserve effect.

The average time spent feeding ranged from 51% to 56% , resting 5% to 25%, walking 10% to 30% and drinking accounted for an average 6% of the behaviours observed depending on season and sex dimorphism. The analysis of activity budgets showed both sexes reduced feeding and increased time spent resting during the middle of the day. The proportion of time spent walking was relatively consistent throughout the day in winter but rates peaked in the early morning and late afternoon during the summer period. In addition, the hottest periods of the day in summer were associated with the highest incidence of other behaviour, such as mud bathing, dust bathing and interacting.

When comparing this to the data collected for the captive conspecifics at the NZG, there are some noticeable differences. For the NZG data, feeding and drinking were combined, therefore to allow direct comparison the wild-type data above must be combined resulting in an average feeding / drinking period during observations of 56% to 62%. This was higher than the full day data collected at the NZG which ranged from 33% to 55% regardless of individual or study period.

The NZG elephants also appeared to show stationery (resting) behaviour for a greater proportion of the day compared to the wild elephant with pre-enrichment and post-enrichment levels ranging from 14% to 27% and 17% to 31% respectively. However, the feed-based enrichment did appear to improve the situation, reducing levels to between 9% snf 21% depending on the individual.

Walking was not recorded as a separate grouping for the NZG study but was combined within the active species specific behaviour category. This category accounted for 12% to 33% of the time with no effect as a result of study period. When comparing this to the wild data the values are remarkably similar.

When comparing the different periods of the day for the data collected at the NZG, all the elephants appeared to perform more feeding behaviour in the afternoon than in the morning and be stationary more often in the morning than in the afternoon. This differs from the wild conspecifics and is governed by the movement between the small and large enclosures rather than a result of temperature differences as suspected for the elephants studied by Graeme Shannon.

Other general points to note when comparing the wild elephants to those at the NZG are the total home ranges, which varied dramatically between 17.5km² and 71.5km², the various habitat utilisation *(Acacia* & Marula Woodland, Mixed *Acacia* Woodland, River Line Thicket, *Combretum* Woodland, Flood Plain Grassland and *Euclea* & *Acacia* Thicket) and the variety of food items eaten (leaves, branches, bark, roots, flowers and fruits). Recreating this environment within captivity is virtually impossible, with space and habitat diversity being a major problem for conservation efforts within captivity when managing large mammals.

5.3.2. Education

Public education has a pivotal role to play in zoos. In order to capture and maintain peoples' interest in an exhibit the visibility and activity levels of the animal is important. An exhibit that looks empty because the animal is sleeping behind a log obscuring it from view will result in even the most avid observer soon moving on but animals that are easily visible within an exhibit especially those which actively interact with other conspecifics or objects within an enclosure will sustain curiosity and in so doing are of more 'educational worth'. For an environmental enrichment program to be successful when the aim is education, an increase in visibility and active species specific activities is desirable.

As with many of the aspects of this study there was a mixed response from the species within this study when comparing data in light of educational worth. The ruffed lemurs that showed no response to the enrichment being a highly active species anyway and continually visible making them naturally attractive to the public. The lion-tailed macaque that were also naturally active showed a mixed response to enrichment when analyzing the results in light of educational worth, with all animals actually increasing non-visibility on enrichment days due to the increased time that was required to place the enrichment items. There was some indirect evidence that the macaques increased activity levels during enrichment periods as macaque 2 and 3 both significantly increased stationary behaviour when comparing enrichment to the post-enrichment 1 period. However, for macaque 4, enrichment had a clear negative effect, with an increase in stationary behaviour being seen between pre-enrichment and the enrichment period.

The leopard was animal in which enrichment showed no effect on activity levels or the time visible and the steenbuck in general also showed no significant change. The only exception to this was the young suckling animal (steenbuck 3) that significantly decreased stationary behaviour when comparing enrichment and post-enrichment 1, hence suggesting that enrichment produced a negative response when related to education.

For the red panda, only red panda 2 showed any effect from the enrichment decreasing non-visibility on comparison of pre-enrichment to enrichment and decreasing stationary behaviour when comparing enrichment to post-enrichment 1. These finding suggest that although this individual appeared to be more visible to the public during enrichment, red panda 2 did infact show less activity than during non-enrichment periods. This is a mixed result showing the complexity of enrichment and the behavioural changes associated with it.

The African elephants also showed a mixed response. Elephants 1 and 2 both showed an increase in visibility when comparing pre-enrichment to the enrichment period. All four African elephants gave indirect evidence that enrichment increased activity as there was a significant increase in stationary behaviour when comparing enrichment to the post-enrichment 1 period. However, elephant 4 significantly decreased active species specific behaviour during the enrichment period compared to pre-enrichment due to the increase in feed related behaviour.

It must be borne in mind that feeding related behaviour can also be perceived by the public as an interesting activity that can hold their interest. Section 4.1.1 discussed the impact of enrichment on feeding related behaviour in detail.

4.3.3. Welfare

The aims of enrichment when related to animal welfare are not always the same as those for conservation and education. Often the aim is to decrease inactivity which is seen as a sign of boredom and eliminate inappropriate / abnormal behaviour patterns.

The effect of the feed-based enrichment on activity levels has been discussed above in section 4.3.4. There was two animals that showed abnormal stereotypic behaviour, notably the male African elephant (elephant 1) and the leopard. In the case of the leopard there was a significant increase in abnormal behaviour when comparing enrichment to post-enrichment 1. This is a result that, although suggestive that enrichment may have decreased abnormal behaviour, was not conclusive.

Enrichment appeared to have no effect on the stereotypic behaviour of elephant 1 but as discussed under section 4.1.1. this was likely to be as a result of the limited space in which to carry out feed-based enrichment in the small camp.

4.4. PROS & CONS TO THE APPROACH THAT WAS TAKEN

4.4.1. The Animals And Their Environment

The majority of animals appeared to habituate quickly to the observers, although there was some results as discussed above that suggest this process was still ongoing during the baseline period in certain individuals.

The greatest problem with the animals and their environment was the amount of time some species were non-visable. The red panda especially spent a significant amount of time within the raised kennel resulting in large amounts of the behavioural observation period becoming invalid. As stated above this is a problem that must be borne in mind when analyzing the results as significant changes in the inferences draw potential could occur if the animals had have been visible at all times.

There were also several incidents throughout the study period affecting both animals directly or the environment within or surrounding the enclosures. During the period of observation general maintenance was on occassion undertaken within the facinity of the study species. Examples include, removing and sectioning trees immediately adjacent to the steenbuck enclosure in addition to the removal of a drainage area, requiring heavy machinery. Fortunately, after discussion with the relevant parties the majority of the work was completed on days in which no observations were being conducted or at least without the mini-radio and shouting workman in order to try and minimize the impact. After analyzing the data I believe the maintenance work had minimal impact as especially the steenbuck rarely visited the area of the enclosure near which the work was being undertaken.

Two animals, Pumbi (elephant 2) and the young steenbuck (steenbuck 3) had noticeable medical problems during the course of the observations. On 15 June 2005 at 11:40, elephant 2 suddenly started rolling, kicking at her abdomen and sweating. On immediate consultation with the veterinary staff it was determined that she was prone to bouts of colic and with swift intervention appeared to have recovered in less than one hour of the initial abnormal behavioural signs being seen. This was a brief event that had little impact on the final results.

Steenbuck 3 that was still suckling became sick and was confined to the night room for hospital treatment over the weekend of 18 June 2005. On the 21 June 2005 steenbuck 3 died of a gastro-intestinal upset of uncertain origin. This was one week before completion of the study. Previous data collected for this animal before its death was not affected but the fact that there was a complete repetition of data not collect may have had a slight impact on the accuracy of the results.

Although all these problems are out with the control of this project they have the potential to affect the results and final analysis of the observational data.

4.4.2. Study Design

The study can be broken down into an instructional period, baseline work and a five week repetitive set of pre-enrichment, enrichment, post-enrichment 1 and post-enrichment 2 days. The instructional period was not only a necessity in order to train the observers that had previously not participated in any such project, but it also afforded a sufficient period for the study animals to habituate to the observers. In some animals this extended over into the baseline period.

The baseline period was one week of observations and enabled ‘normal’ individual behaviour to be determined which was imperative in order to assess the effect of the enrichment. The four periods within each of the five week rotations enabled the animals to be assessed before, during and after enrichment so that instant behavioural changes as well as residual effects could be determined.

The observational period was from 08:00 to 16:00 which coincided with the visitor hours of the zoo as well as the normal working hours for zoo staff. Although ideally observational data for a twenty four hour period for the duration of the study would be required, restraints due to financial budget, man power and working norms of the zoo meant that the only realistic observational period would be between 08:00 and 16:00. Therefore inferences drawn from this work are limited to the effect on the animals during the normal working hours of the zoo.

The interval between observations was five minutes, this seem to be the accepted norm in many published papers and appeared to have been sufficient to identify trends within enclosure usage and animal behaviour. The ideal would have been to continually film the animals but this was unrealistic due to financial restraints and time limitation with regard to people able to analyse such data.

The overall design of the study in the time available and financial restraints was economical and effective at achieving the goal of assessing the effect of feed based enrichment.

4.4.3. The People

This study allowed individuals that otherwise would not necessarily have the exposure to scientific fieldwork, to gain a cursory understanding of the discipline. Stimulating interest in research and the broader aspects of welfare and management in captive animals can only be of benefit for the future success of the NZG, as well as to the individuals involved. Soft skills such as team work, communication, self-confidence and problem solving were some of the many other qualities also developed in the observers that undertook this work. The approach of employing non-scientists to collect the observational data, as long as adequate training is given, proved both a viable option and highly successful for the collection of large quantities of data over a short time period.

However, this strategy was not without problems as despite explaining the duration, responsibilities and payments in an initial meeting and handing out a written job description, many rumours and misinformation circulated amongst the individuals working on this project. These ranged from the belief of additional financial incentives, to the thought that the study was an "easy option, to avoid real work". Rectification of these misnomers was achieved, but did cause some friction and initial resentment within the team.

In addition, although there were some Learnerships and ZooPartners that showed a pride in their work and took the project very seriously, there were others that lacked punctuality and self-discipline when accurately recording information this placing extra strain on the remainder of the team. The loss of four members during the study as well as the regular absenteeism of several of the remaining individuals shows that some of the observers failed to understand the commitment required in order to sustain scientific continuity during data collection.

With regards staff members, the project affected many individuals, such as Mrs R. Ingle-Moller, curators, conservators, animal attendants and kitchen staff, as well as those working in administrative office based positions. With the changing emphasis towards research within the NZG this exposed many for the first time, to the effect scientific studies may have on their daily routine. During all aspects of the work, members of staff assisted where necessary and many took an active interest in the study. The vast majority of staff members were happy to assist wherever possible during this study. However, certain individuals were reluctant to help, seeing the research as no more than an inconvenience. This often made it difficult to successfully place and remove enrichment items in a timeous manner. Feeding and enclosure cleaning times also varied widely in certain sections, adding another unnecessary variable to the observation findings.

4.5. FURTHER RESEARCH

4.5.1. Internal Zoo Use

1. Behavioural monitoring of all enrichment programs with predetermined specified aims and methods to monitor success or failure in order to ensure successful outcomes, with identification and prevention of any unforeseen detrimental effects.

2. Re-run the elephant enrichment study, utilizing the roughage component of the diet instead of leaves in order to assess if it would be a sustainable means by which to stimulate the animals and the public.

3. Decrease the leopard's food and monitor for changes in behaviour and increased response to enrichment.

4. Place a kennel within the leopard enclosure, keep moving it around the enclosure and if the animal persistently chooses to spend time within it regardless of its position inference can be drawn to the stress the animal is currently under due to the viewing public.

5. Investigate the use of screens to assess if they change spatial utilization of the steenbuck.

6. An in-depth study on 'aggression' and the relationship if any to environmental enrichment particular in primates such as the macaques.

4.2.2. Wider Research Community

1. Continual enrichment presence to assess long term effects. This will mirror more accurately the situation in most captive animal enrichment programs.

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6. APPENDICES

APPENDIX 6.1 Record Sheet

Name of observer _______________ **Date** __ __ / __ __ / 2005 **Time of first observation** __ __ : __ __

Species ____________________________ **Rain / Dry / Sun / Cloud / Windy / Calm**

Animals to be observed	Code

Time(mins) →	08:00	08:05	08:10	08:15	08:20	08:25	08:30	08:35	08:40	08:45	08:50	08:55	09:00	09:05	09:10	09:15	09:20	09:25	09:30
Allogroom																			
Being groomed																			
Cling																			
Huddle																			
Interact with observer																			
Interact with public																			
Interact with zoo staff																			
Physical aggression																			
Play																			
Postural aggression																			
Sexual behaviour																			
Defecating																			
Jumping																			
Escaping aggression																			
Maintenance																			
Pacing																			
Running / Sprinting																			
Sleeping / Resting																			
Stationary																			
Urinating																			
Vocalization																			
Walking																			
Drinking																			
Feeding																			
Non-Visible																			

	Position			
Time				
08:00				
08:05				
08:10				
08:15				
08:20				
08:25				
08:30				
08:35				
08:40				
08:45				
08:50				
08:55				
09:00				
09:05				
09:10				
09:15				
09:20				
09:25				
09:30				

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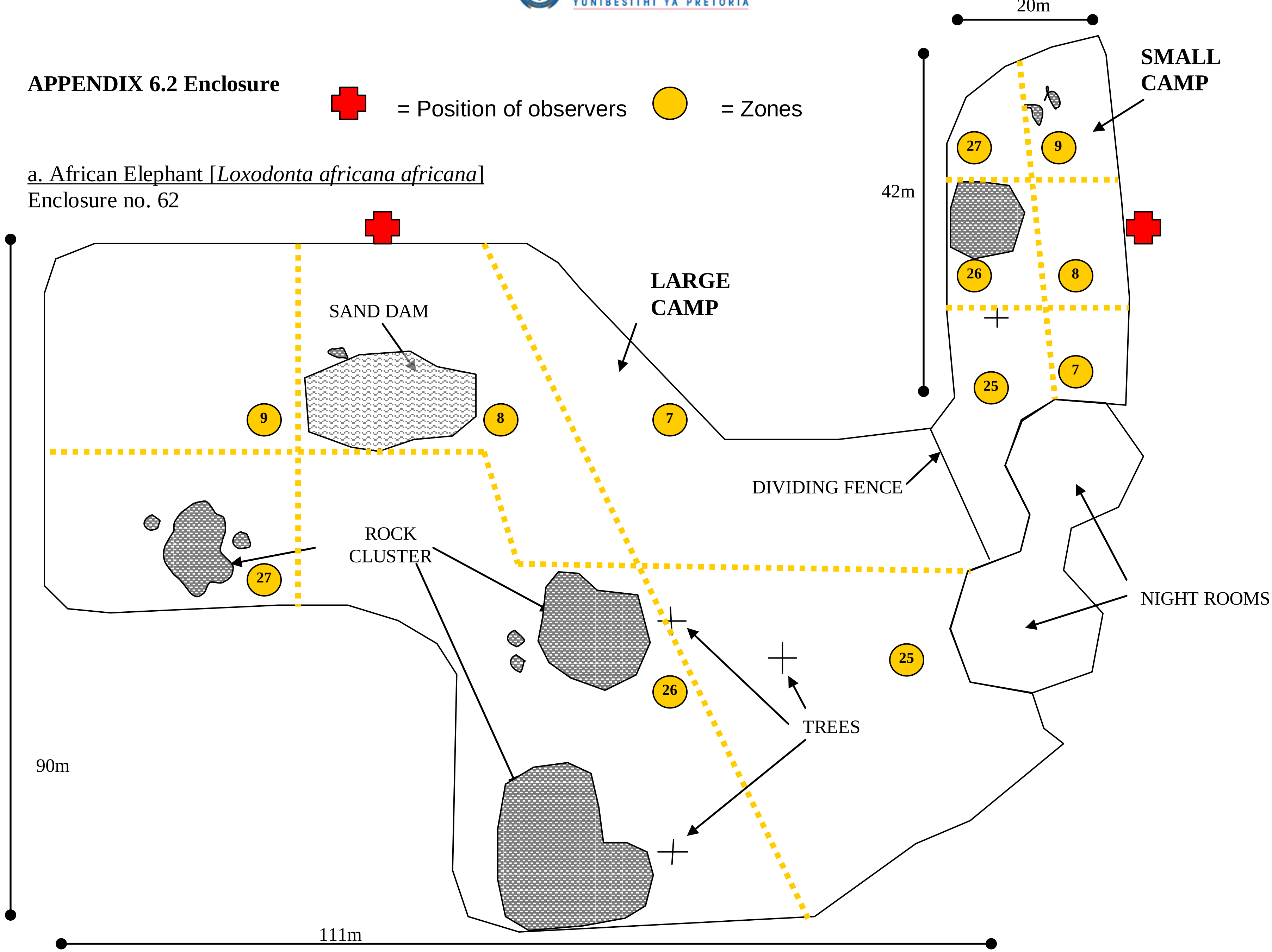
APPENDIX 6.2 Enclosure

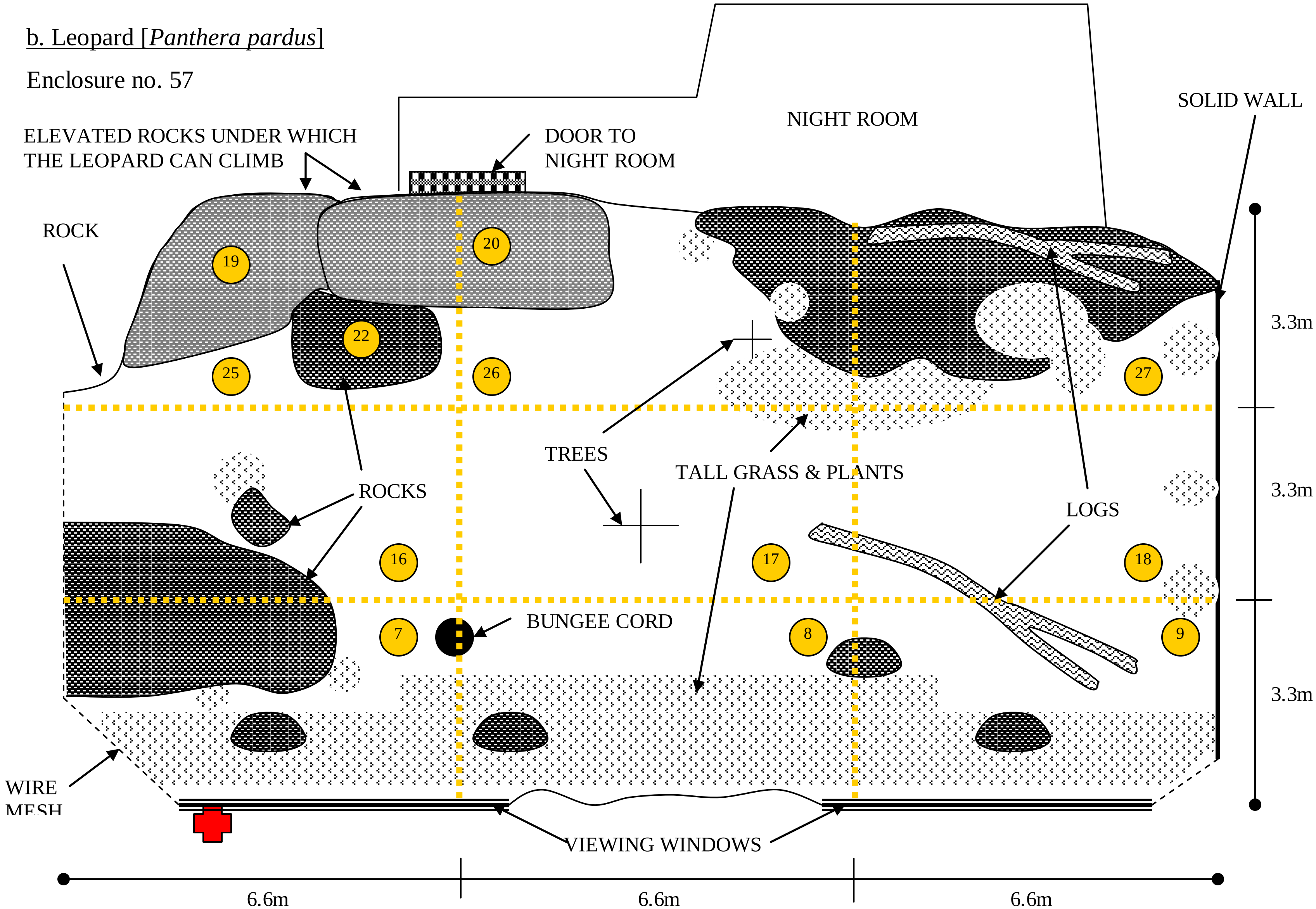
= Position of observers = Zones

a. African Elephant [*Loxodonta africana africana*]
Enclosure no. 62



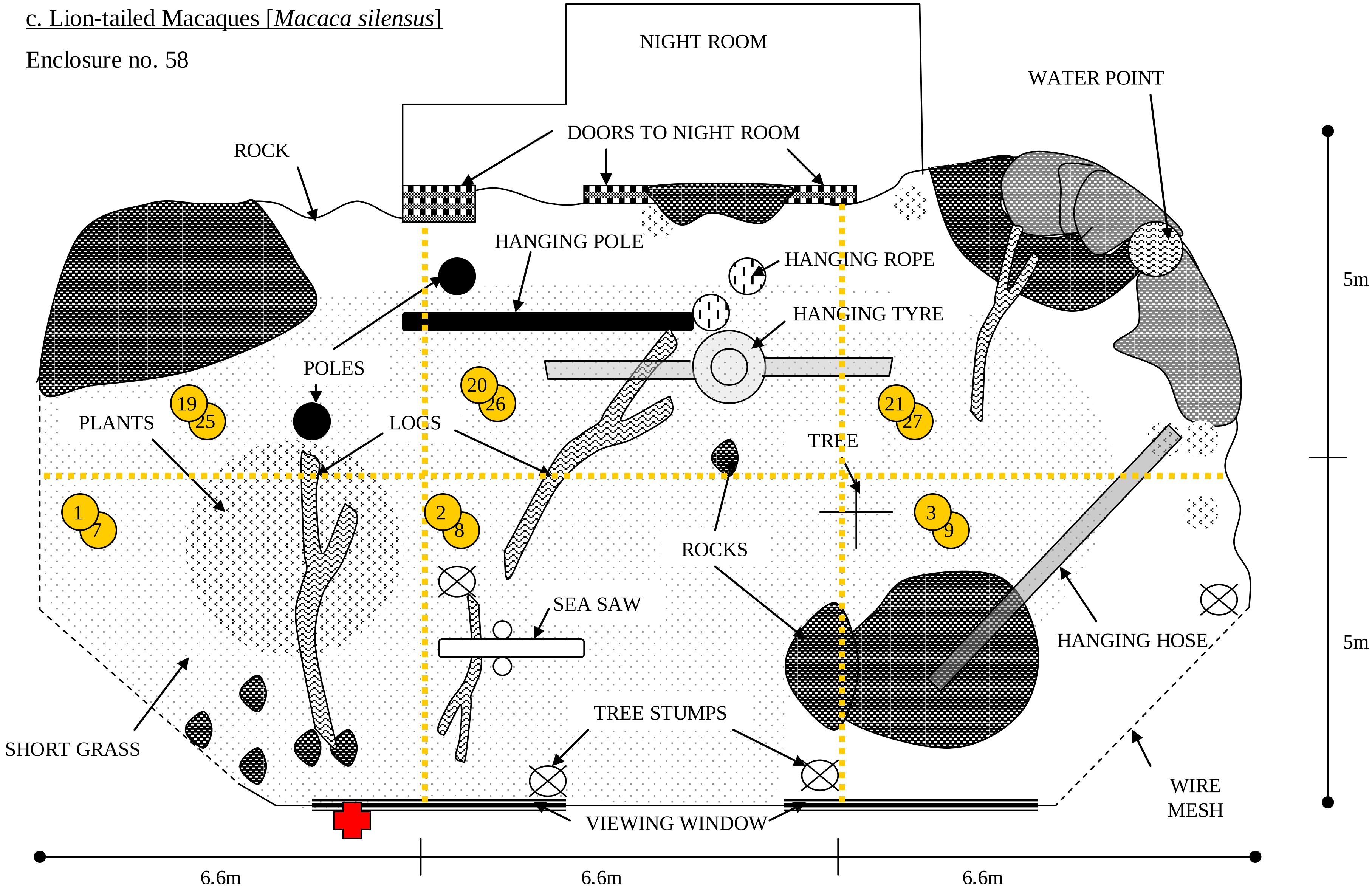
b. Leopard [*Panthera pardus*]

Enclosure no. 57



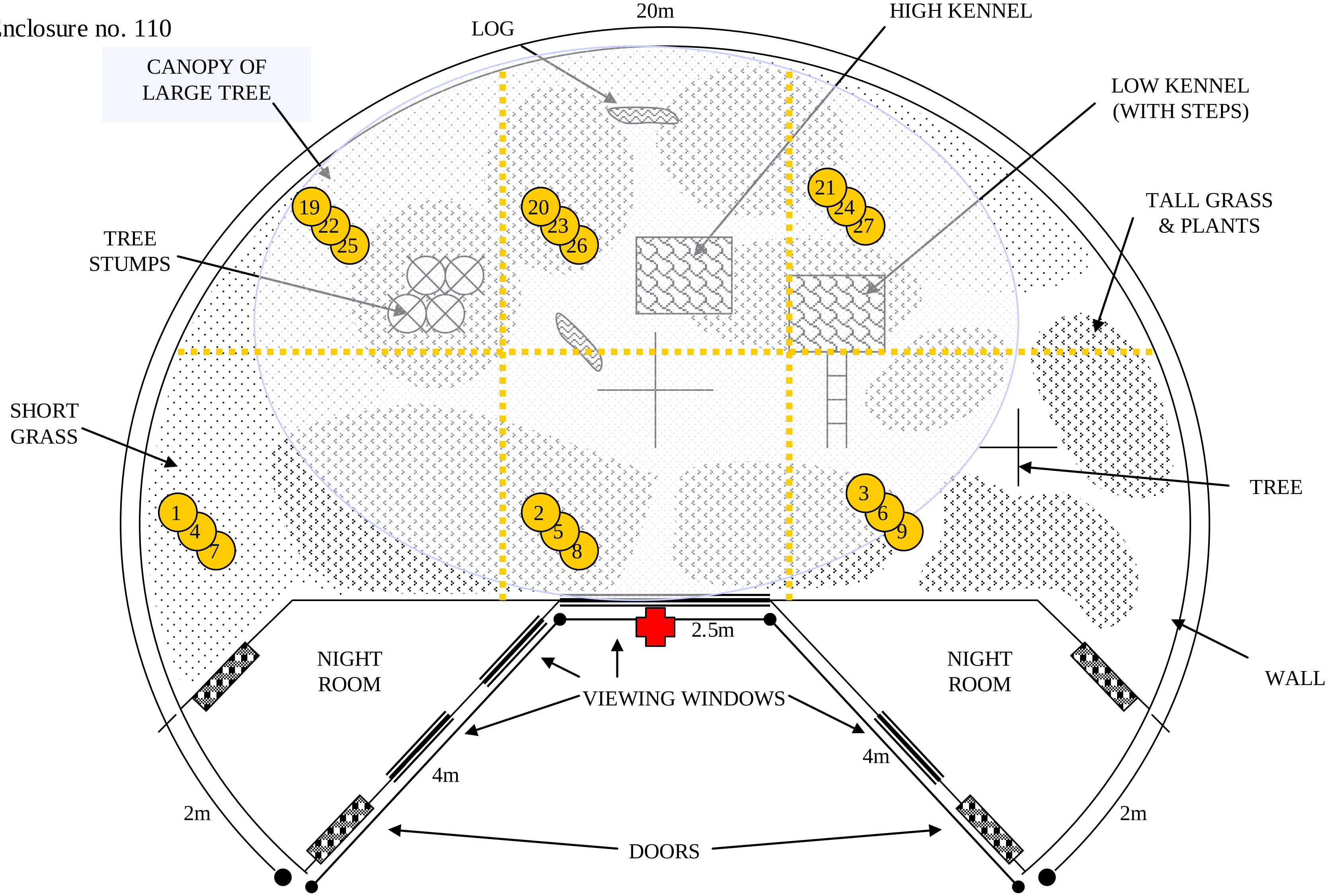
c. Lion-tailed Macaques [*Macaca silensus*]

Enclosure no. 58



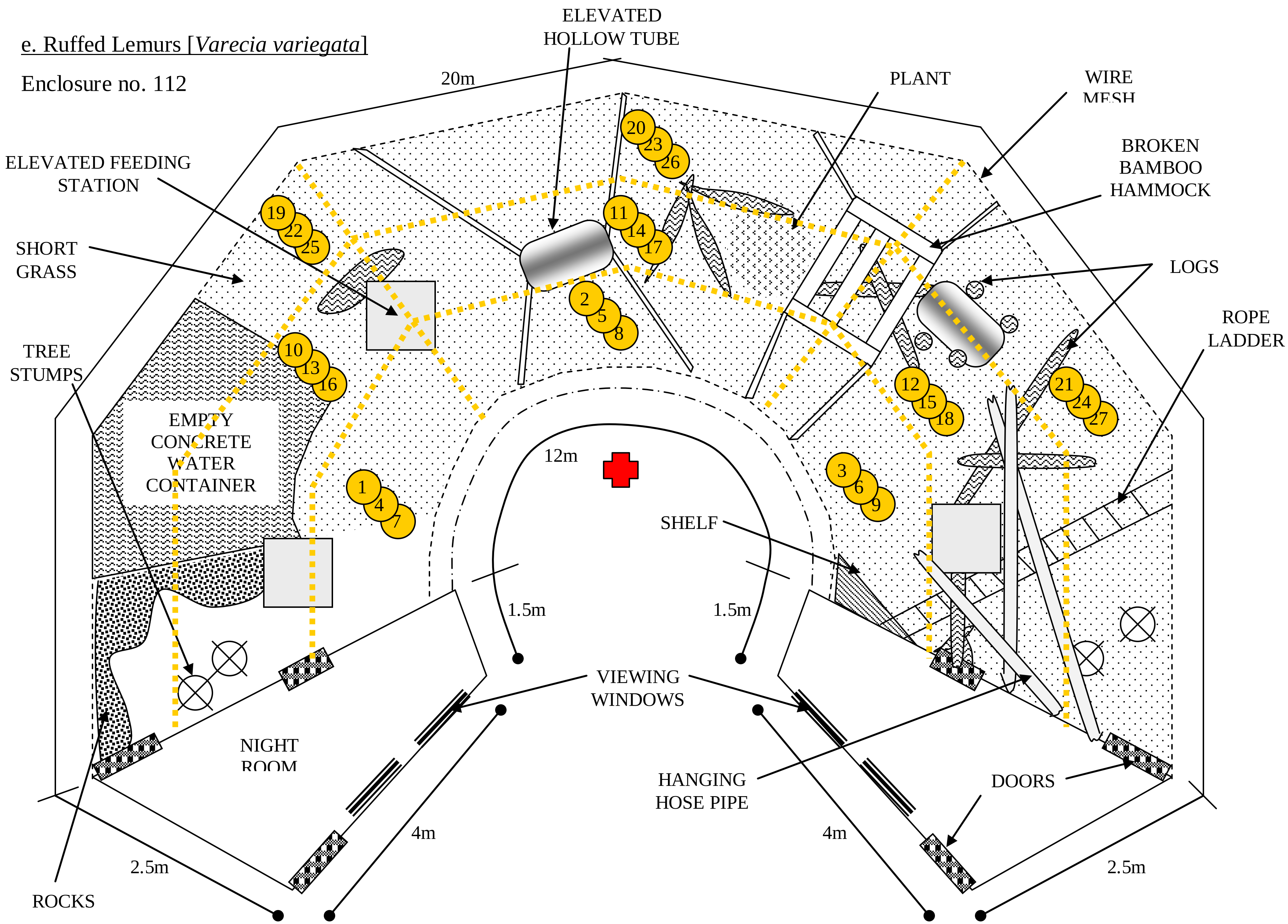
d. Red Panda [*Ailurus fulgens*]

Enclosure no. 110



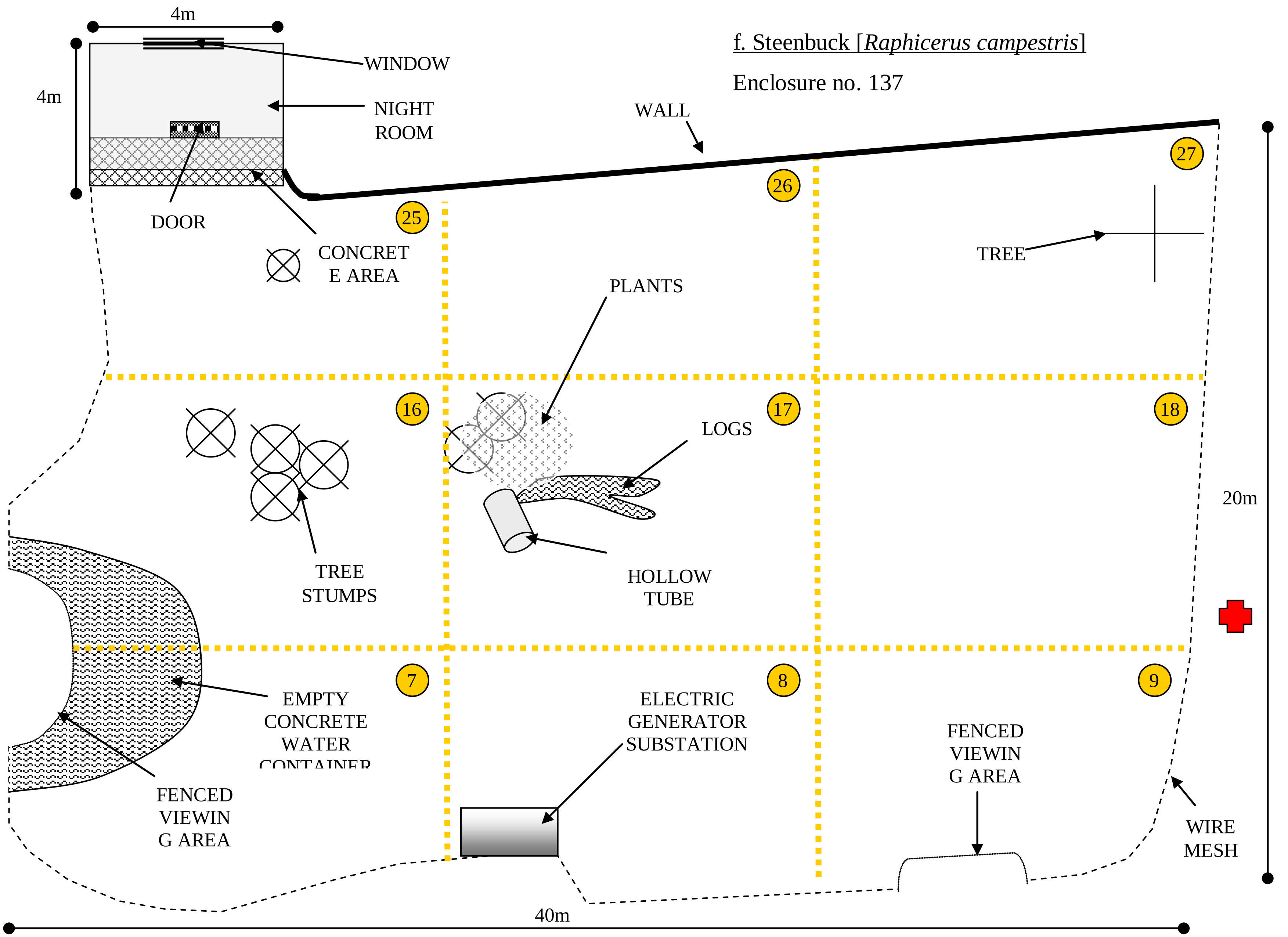
e. Ruffed Lemurs [*Varecia variegata*]

Enclosure no. 112



f. Steenbuck [*Raphicerus campestris*]

Enclosure no. 137

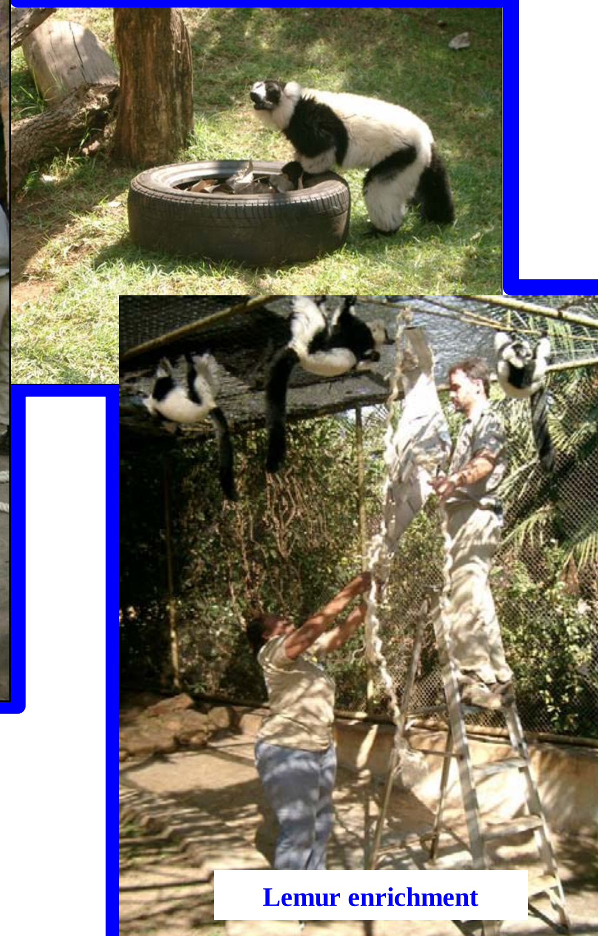


APPENDIX 6.3. Photographic Record Of Enrichment

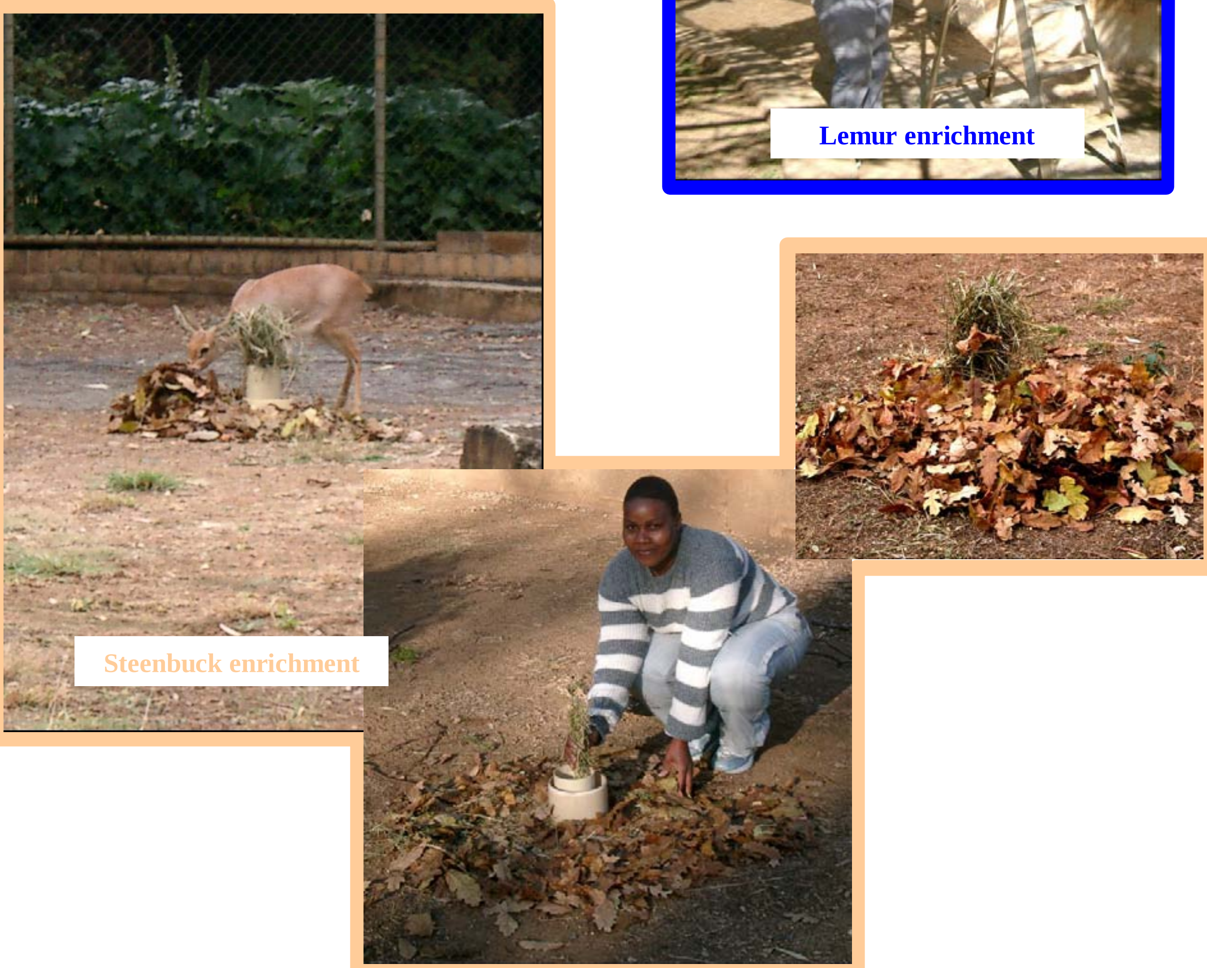
Macaque enrichment

Red Panda enrichment

Preparing before entering the enclosure



Lemur enrichment



Steenbuck enrichment

APPENDIX 6.4. Tabulated Descriptive Statistics

African savanna elephants

Elephant 1

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0.00	0.92	0.41	0.31
BehavB	32	0.00	0.75	0.20	0.22
BehavC	32	0.00	0.75	0.18	0.25
BehavD	32	0.00	0.36	0.14	0.10
BehavE	32	0.00	0.00	0.00	0.00
BehavF	32	0.00	0.08	0.01	0.02
BehavG	32	0.00	0.20	0.05	0.06
BehavH	32	0.00	0.50	0.02	0.09
Valid N (listwise)	32				

Descriptive Statistics Pre-enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.45	0.35
BehavB	40	0.00	0.67	0.14	0.20
BehavC	40	0.00	0.83	0.20	0.26
BehavD	40	0.00	0.50	0.14	0.12
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.08	0.02	0.04
BehavH	40	0.00	0.25	0.02	0.06
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.51	0.37
BehavB	40	0.00	0.55	0.09	0.15
BehavC	40	0.00	0.83	0.16	0.25
BehavD	40	0.00	0.33	0.12	0.11
BehavE	40	0.00	0.42	0.01	0.07
BehavF	40	0.00	0.42	0.03	0.08
BehavG	40	0.00	0.27	0.04	0.07
BehavH	40	0.00	0.83	0.04	0.16
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data1

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.43	0.33
BehavB	40	0.00	0.73	0.17	0.19
BehavC	40	0.00	0.92	0.20	0.29
BehavD	40	0.00	0.42	0.12	0.10
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.42	0.04	0.08
BehavH	40	0.00	0.17	0.01	0.03
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data2

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.43	0.38
BehavB	40	0.00	0.50	0.12	0.14
BehavC	40	0.00	0.83	0.26	0.32
BehavD	40	0.00	0.50	0.13	0.11
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.25	0.04	0.06
BehavH	40	0.00	0.17	0.01	0.03
Valid N (listwise)	40				

Elephant 2

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0	0.92	0.44	0.25
BehavB	32	0	0.58	0.19	0.21
BehavC	32	0	0.10	0.00	0.02
BehavD	32	0	0.50	0.24	0.15
BehavE	32	0	0.08	0.00	0.01
BehavF	32	0	0.08	0.01	0.03
BehavG	32	0	0.42	0.08	0.10
BehavH	32	0	0.42	0.03	0.09
Valid N (listwise)	32				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0	0.92	0.37	0.28
BehavB	40	0	0.83	0.27	0.28
BehavC	40	0	0.17	0.01	0.03
BehavD	40	0	0.50	0.26	0.14
BehavE	40	0	0.08	0.00	0.02
BehavF	40	0	0.09	0.02	0.03
BehavG	40	0	0.25	0.04	0.06
BehavH	40	0	0.33	0.02	0.06
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0	1.00	0.46	0.31
BehavB	40	0	0.67	0.21	0.22
BehavC	40	0	0.08	0.00	0.02
BehavD	40	0	0.75	0.25	0.13
BehavE	40	0	0.00	0.00	0.00
BehavF	40	0	0.25	0.03	0.06
BehavG	40	0	0.50	0.05	0.09
BehavH	40	0	0.08	0.00	0.02
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data1

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0	0.92	0.35	0.28
BehavB	40	0	0.92	0.31	0.27
BehavC	40	0	0.00	0.00	0.00
BehavD	40	0	0.58	0.29	0.15
BehavE	40	0	0.08	0.00	0.01
BehavF	40	0	0.17	0.02	0.04
BehavG	40	0	0.17	0.03	0.05
BehavH	40	0	0.00	0.00	0.00
Valid N (listwise)	40				

Elephant 3

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0.00	0.91	0.41	0.26
BehavB	32	0.00	0.92	0.26	0.27
BehavC	32	0.00	0.09	0.00	0.02
BehavD	32	0.00	0.58	0.26	0.15
BehavE	32	0.00	0.00	0.00	0.00
BehavF	32	0.00	0.08	0.02	0.03
BehavG	32	0.00	0.18	0.04	0.06
BehavH	32	0.00	0.08	0.01	0.02
Valid N (listwise)	32				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.83	0.37	0.28
BehavB	40	0.00	0.92	0.27	0.27
BehavC	40	0.00	0.08	0.00	0.02
BehavD	40	0.00	0.58	0.27	0.13
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.17	0.04	0.05
BehavH	40	0.00	0.17	0.01	0.04
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.08	1.00	0.47	0.29
BehavB	40	0.00	0.58	0.18	0.18
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.58	0.29	0.13
BehavE	40	0.00	0.08	0.00	0.01
BehavF	40	0.00	0.33	0.03	0.07
BehavG	40	0.00	0.17	0.03	0.06
BehavH	40	0.00	0.08	0.00	0.02
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data1

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.92	0.33	0.23
BehavB	40	0.00	0.83	0.28	0.25
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.08	0.58	0.33	0.14
BehavE	40	0.00	0.08	0.00	0.01
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.25	0.04	0.07
BehavH	40	0.00	0.08	0.00	0.01
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data2

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.38	0.31
BehavB	40	0.00	0.83	0.27	0.25
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.67	0.30	0.15
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

<u>Elephant 4</u>

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.92	0.41	0.27
BehavB	72	0.00	0.75	0.17	0.20
BehavC	72	0.00	0.17	0.01	0.04
BehavD	72	0.00	0.50	0.23	0.14
BehavE	72	0.00	0.17	0.01	0.03
BehavF	72	0.00	0.20	0.02	0.04
BehavG	72	0.00	0.33	0.08	0.10
BehavH	72	0.00	0.60	0.05	0.11
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.42	0.34
BehavB	40	0.00	0.83	0.30	0.29
BehavC	40	0.00	0.08	0.00	0.02
BehavD	40	0.00	0.67	0.20	0.15
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.25	0.04	0.06
BehavH	40	0.00	0.25	0.01	0.04
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.08	1.00	0.55	0.31
BehavB	40	0.00	0.92	0.18	0.23
BehavC	40	0.00	0.17	0.00	0.03
BehavD	40	0.00	0.50	0.18	0.13
BehavE	40	0.00	0.08	0.00	0.01
BehavF	40	0.00	0.42	0.04	0.08
BehavG	40	0.00	0.17	0.03	0.04
BehavH	40	0.00	0.25	0.01	0.06
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data1

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.43	0.30
BehavB	40	0.00	0.92	0.28	0.28
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.58	0.23	0.15
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.09	0.01	0.03
BehavG	40	0.00	0.18	0.03	0.05
BehavH	40	0.00	0.25	0.01	0.05
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data2

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.41	0.34
BehavB	40	0.00	0.92	0.29	0.30
BehavC	40	0.00	0.17	0.01	0.03
BehavD	40	0.00	0.58	0.21	0.15
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.18	0.02	0.04
BehavG	40	0.00	0.17	0.05	0.06
BehavH	40	0.00	0.25	0.01	0.04
Valid N (listwise)	40				

Leopard

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.92	0.08	0.22
BehavB	72	0.00	1.00	0.57	0.30
BehavC	72	0.00	0.58	0.11	0.14
BehavD	72	0.00	0.50	0.15	0.14
BehavE	72	0.00	0.00	0.00	0.00
BehavF	72	0.00	0.17	0.03	0.05
BehavG	72	0.00	0.17	0.02	0.04
BehavH	72	0.00	0.58	0.04	0.11
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.05	0.18
BehavB	40	0.00	1.00	0.66	0.33
BehavC	40	0.00	0.67	0.11	0.16
BehavD	40	0.00	0.50	0.12	0.14
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.17	0.01	0.04
BehavH	40	0.00	0.50	0.03	0.10
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.04	0.11
BehavB	40	0.00	1.00	0.64	0.32
BehavC	40	0.00	0.58	0.11	0.15

BehavD	40	0.00	0.50	0.12	0.12
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	0.75	0.06	0.15
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.50	0.04	0.13
BehavB	40	0.08	1.00	0.59	0.29
BehavC	40	0.00	0.58	0.14	0.14
BehavD	40	0.00	0.50	0.12	0.11
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.25	0.06	0.08
BehavG	40	0.00	0.18	0.01	0.03
BehavH	40	0.00	0.36	0.03	0.08
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.05	0.15
BehavB	40	0.00	1.00	0.60	0.29
BehavC	40	0.00	0.50	0.14	0.14
BehavD	40	0.00	0.50	0.14	0.13
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.03	0.05
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.25	0.03	0.07
Valid N (listwise)	40				

Descriptive Statistics Post Enrichment Data2

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0	0.83	0.34	0.28
BehavB	40	0	0.92	0.32	0.29
BehavC	40	0	0.00	0.00	0.00
BehavD	40	0	0.75	0.26	0.16
BehavE	40	0	0.00	0.00	0.00
BehavF	40	0	0.08	0.02	0.03
BehavG	40	0	0.25	0.04	0.06
BehavH	40	0	0.17	0.01	0.04
Valid N (listwise)	40				

Lion-Tailed Macaques

Macaque 1

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.58	0.14	0.13
BehavB	72	0.00	0.67	0.26	0.17
BehavC	72	0.00	0.08	0.00	0.02
BehavD	72	0.00	0.83	0.38	0.20
BehavE	72	0.00	0.17	0.02	0.04
BehavF	72	0.00	0.33	0.08	0.09
BehavG	72	0.00	0.10	0.01	0.03
BehavH	72	0.00	1.00	0.11	0.21
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.33	0.10	0.09
BehavB	40	0.00	0.67	0.27	0.20
BehavC	40	0.00	0.08	0.00	0.02
BehavD	40	0.00	0.83	0.44	0.21
BehavE	40	0.00	0.17	0.02	0.05
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.09	0.01	0.03
BehavH	40	0.00	0.83	0.14	0.25
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation

BehavA	40	0.00	0.67	0.11	0.16
BehavB	40	0.00	0.83	0.27	0.23
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.75	0.35	0.23
BehavE	40	0.00	0.10	0.02	0.04
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	1.00	0.22	0.34
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.33	0.12	0.12
BehavB	40	0.00	0.92	0.27	0.21
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.92	0.40	0.22
BehavE	40	0.00	0.09	0.01	0.03
BehavF	40	0.00	0.25	0.03	0.06
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	1.00	0.17	0.29
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.50	0.14	0.15
BehavB	40	0.00	0.83	0.28	0.22
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.75	0.33	0.22
BehavE	40	0.00	0.08	0.00	0.02
BehavF	40	0.00	0.67	0.05	0.12
BehavG	40	0.00	0.09	0.00	0.02
BehavH	40	0.00	1.00	0.19	0.31
Valid N (listwise)	40				

<u>Macaque 2</u>

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.36	0.08	0.10
BehavB	72	0.00	0.82	0.15	0.14
BehavC	72	0.00	0.36	0.01	0.04
BehavD	72	0.00	1.00	0.64	0.22
BehavE	72	0.00	0.09	0.00	0.01
BehavF	72	0.00	0.09	0.02	0.03
BehavG	72	0.00	0.09	0.01	0.02

BehavH	72	0.00	1.00	0.10	0.20
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.12	0.12
BehavB	40	0.00	0.42	0.14	0.13
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.08	1.00	0.61	0.29
BehavE	40	0.00	0.08	0.00	0.02
BehavF	40	0.00	0.08	0.01	0.03
BehavG	40	0.00	0.08	0.00	0.02
BehavH	40	0.00	0.83	0.11	0.22
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.70	0.14	0.18
BehavB	40	0.00	0.42	0.14	0.11
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.92	0.51	0.27
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	0.08	0.01	0.02
BehavH	40	0.00	0.92	0.19	0.30
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.11	0.11
BehavB	40	0.00	0.58	0.22	0.16
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	1.00	0.50	0.30
BehavE	40	0.00	0.09	0.00	0.01
BehavF	40	0.00	0.25	0.02	0.05
BehavG	40	0.00	0.08	0.00	0.02
BehavH	40	0.00	1.00	0.16	0.28
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.11	0.12
BehavB	40	0.00	0.50	0.16	0.15
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	1.00	0.56	0.26

BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.09	0.00	0.02
BehavG	40	0.00	0.08	0.01	0.02
BehavH	40	0.00	1.00	0.16	0.28
Valid N (listwise)	40				

<u>Macaque 3</u>

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.33	0.12	0.10
BehavB	72	0.00	0.58	0.26	0.15
BehavC	72	0.00	0.08	0.01	0.03
BehavD	72	0.00	0.75	0.36	0.19
BehavE	72	0.00	0.09	0.01	0.03
BehavF	72	0.00	0.55	0.12	0.13
BehavG	72	0.00	0.10	0.01	0.03
BehavH	72	0.00	1.00	0.10	0.20
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.11	0.14
BehavB	40	0.00	0.58	0.19	0.16
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	1.00	0.53	0.24
BehavE	40	0.00	0.09	0.01	0.03
BehavF	40	0.00	0.36	0.03	0.06
BehavG	40	0.00	0.08	0.02	0.03
BehavH	40	0.00	0.83	0.11	0.20
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.70	0.14	0.16
BehavB	40	0.00	0.58	0.13	0.13
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	1.00	0.47	0.24
BehavE	40	0.00	0.10	0.02	0.04
BehavF	40	0.00	0.33	0.04	0.07
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.92	0.19	0.28
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.33	0.11	0.10
BehavB	40	0.00	0.42	0.22	0.13
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.91	0.47	0.24
BehavE	40	0.00	0.08	0.00	0.02
BehavF	40	0.00	0.25	0.04	0.07
BehavG	40	0.00	0.09	0.01	0.03
BehavH	40	0.00	1.00	0.15	0.27
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.12	0.11
BehavB	40	0.00	0.50	0.19	0.15
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.83	0.49	0.25
BehavE	40	0.00	0.08	0.01	0.02
BehavF	40	0.00	0.17	0.03	0.05
BehavG	40	0.00	0.09	0.00	0.02
BehavH	40	0.00	1.00	0.16	0.28
Valid N (listwise)	40				

Macaque 4

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.42	0.16	0.11
BehavB	72	0.00	0.33	0.08	0.09
BehavC	72	0.00	0.09	0.00	0.01
BehavD	72	0.00	0.92	0.57	0.21
BehavE	72	0.00	0.17	0.01	0.03
BehavF	72	0.00	0.42	0.06	0.09
BehavG	72	0.00	0.17	0.02	0.04
BehavH	72	0.00	1.00	0.10	0.20
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.19	0.13
BehavB	40	0.00	0.25	0.05	0.08
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.08	0.92	0.57	0.25
BehavE	40	0.00	0.09	0.00	0.02

BehavF	40	0.00	0.27	0.05	0.08
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.83	0.11	0.23
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.60	0.18	0.15
BehavB	40	0.00	0.17	0.02	0.04
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	1.00	0.53	0.25
BehavE	40	0.00	0.10	0.01	0.03
BehavF	40	0.00	0.25	0.04	0.06
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.92	0.19	0.29
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.18	0.14
BehavB	40	0.00	0.27	0.05	0.07
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.92	0.53	0.26
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.50	0.06	0.09
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	1.00	0.15	0.27
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.16	0.13
BehavB	40	0.00	0.18	0.03	0.05
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	1.00	0.60	0.27
BehavE	40	0.00	0.08	0.01	0.02
BehavF	40	0.00	0.17	0.04	0.05
BehavG	40	0.00	0.08	0.00	0.02
BehavH	40	0.00	1.00	0.16	0.28
Valid N (listwise)	40				

Red Panda 1

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std.

					Deviation
BehavA	72	0.00	0.58	0.06	0.12
BehavB	72	0.00	1.00	0.37	0.35
BehavC	72	0.00	0.33	0.02	0.05
BehavD	72	0.00	0.58	0.10	0.15
BehavE	72	0.00	0.00	0.00	0.00
BehavF	72	0.00	0.42	0.03	0.08
BehavG	72	0.00	0.25	0.00	0.03
BehavH	72	0.00	1.00	0.42	0.40
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.06	0.15
BehavB	40	0.00	1.00	0.36	0.35
BehavC	40	0.00	0.17	0.01	0.03
BehavD	40	0.00	0.25	0.05	0.08
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	0.25	0.01	0.04
BehavH	40	0.00	1.00	0.50	0.38
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.50	0.07	0.13
BehavB	40	0.00	1.00	0.24	0.32
BehavC	40	0.00	0.17	0.01	0.03
BehavD	40	0.00	0.42	0.04	0.10
BehavE	40	0.00	0.25	0.01	0.04
BehavF	40	0.00	0.33	0.02	0.06
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	1.00	0.61	0.37
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.04	0.10
BehavB	40	0.00	1.00	0.28	0.34
BehavC	40	0.00	0.67	0.02	0.11
BehavD	40	0.00	0.33	0.05	0.09
BehavE	40	0.00	0.17	0.00	0.03
BehavF	40	0.00	0.25	0.01	0.05
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	1.00	0.59	0.39

Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.45	0.05	0.12
BehavB	40	0.00	1.00	0.22	0.34
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.08	0.01	0.02
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	0.00	0.00	0.00
BehavH	40	0.00	1.00	0.71	0.36
Valid N (listwise)	40				

Red Panda 2

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.92	0.06	0.13
BehavB	72	0.00	1.00	0.47	0.35
BehavC	72	0.00	0.58	0.02	0.07
BehavD	72	0.00	0.83	0.13	0.17
BehavE	72	0.00	0.08	0.00	0.01
BehavF	72	0.00	0.42	0.02	0.06
BehavG	72	0.00	0.25	0.00	0.03
BehavH	72	0.00	1.00	0.30	0.38
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.05	0.13
BehavB	40	0.00	1.00	0.50	0.39
BehavC	40	0.00	0.25	0.02	0.05
BehavD	40	0.00	0.42	0.08	0.10
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.25	0.02	0.05
BehavG	40	0.00	0.00	0.00	0.00
BehavH	40	0.00	1.00	0.33	0.34
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.82	0.08	0.17
BehavB	40	0.00	1.00	0.51	0.39

BehavC	40	0.00	0.50	0.02	0.08
BehavD	40	0.00	0.50	0.09	0.13
BehavE	40	0.00	0.25	0.01	0.04
BehavF	40	0.00	0.33	0.03	0.07
BehavG	40	0.00	0.17	0.01	0.04
BehavH	40	0.00	1.00	0.24	0.37
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.05	0.15
BehavB	40	0.00	1.00	0.38	0.36
BehavC	40	0.00	0.25	0.01	0.04
BehavD	40	0.00	0.58	0.10	0.16
BehavE	40	0.00	0.17	0.01	0.03
BehavF	40	0.00	0.42	0.02	0.07
BehavG	40	0.00	0.08	0.00	0.01
BehavH	40	0.00	1.00	0.44	0.42
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.05	0.11
BehavB	40	0.00	1.00	0.50	0.38
BehavC	40	0.00	0.33	0.01	0.05
BehavD	40	0.00	0.67	0.08	0.14
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.01	0.03
BehavG	40	0.00	0.00	0.00	0.00
BehavH	40	0.00	1.00	0.35	0.39
Valid N (listwise)	40				

Lemur 1

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.67	0.14	0.13
BehavB	72	0.00	0.83	0.31	0.22
BehavC	72	0.00	0.58	0.02	0.08
BehavD	72	0.00	0.92	0.49	0.23
BehavE	72	0.00	0.17	0.01	0.03
BehavF	72	0.00	0.18	0.01	0.03
BehavG	72	0.00	0.17	0.02	0.04
BehavH	72	0.00	0.00	0.00	0.00
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.15	0.16
BehavB	40	0.00	0.92	0.32	0.23
BehavC	40	0.00	0.09	0.01	0.03
BehavD	40	0.00	0.92	0.45	0.24
BehavE	40	0.00	0.33	0.04	0.07
BehavF	40	0.00	0.08	0.01	0.02
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.15	0.17
BehavB	40	0.00	0.92	0.34	0.22
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.83	0.43	0.24
BehavE	40	0.00	0.17	0.03	0.05
BehavF	40	0.00	0.33	0.02	0.06
BehavG	40	0.00	0.17	0.03	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.15	0.17
BehavB	40	0.00	1.00	0.32	0.23
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.92	0.47	0.24
BehavE	40	0.00	0.17	0.02	0.05
BehavF	40	0.00	0.17	0.02	0.04
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.50	0.16	0.17
BehavB	40	0.00	1.00	0.33	0.26
BehavC	40	0.00	0.08	0.01	0.02
BehavD	40	0.00	0.92	0.44	0.21
BehavE	40	0.00	0.17	0.03	0.06
BehavF	40	0.00	0.17	0.01	0.03

BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Lemur 2

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.75	0.12	0.13
BehavB	72	0.00	0.83	0.39	0.23
BehavC	72	0.00	0.67	0.02	0.09
BehavD	72	0.00	1.00	0.43	0.23
BehavE	72	0.00	0.17	0.01	0.03
BehavF	72	0.00	0.18	0.01	0.03
BehavG	72	0.00	0.17	0.02	0.05
BehavH	72	0.00	0.00	0.00	0.00
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.13	0.16
BehavB	40	0.00	1.00	0.38	0.26
BehavC	40	0.00	0.18	0.01	0.03
BehavD	40	0.00	0.92	0.42	0.24
BehavE	40	0.00	0.33	0.04	0.08
BehavF	40	0.00	0.08	0.00	0.02
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.15	0.17
BehavB	40	0.08	0.92	0.41	0.20
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.08	0.83	0.37	0.21
BehavE	40	0.00	0.17	0.02	0.04
BehavF	40	0.00	0.33	0.02	0.07
BehavG	40	0.00	0.08	0.02	0.04
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment1 Data

	N	Minimum	Maximum	Mean	Std. Deviation

BehavA	40	0.00	0.42	0.11	0.13
BehavB	40	0.00	1.00	0.39	0.26
BehavC	40	0.00	0.17	0.00	0.03
BehavD	40	0.00	1.00	0.41	0.25
BehavE	40	0.00	0.17	0.01	0.04
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	1.00	0.05	0.16
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.12	0.14
BehavB	40	0.00	1.00	0.41	0.25
BehavC	40	0.00	0.08	0.00	0.02
BehavD	40	0.00	0.92	0.42	0.21
BehavE	40	0.00	0.17	0.02	0.04
BehavF	40	0.00	0.08	0.00	0.01
BehavG	40	0.00	0.09	0.01	0.03
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Lemur 3

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.75	0.13	0.15
BehavB	72	0.00	0.83	0.40	0.23
BehavC	72	0.00	0.67	0.02	0.09
BehavD	72	0.00	1.00	0.39	0.22
BehavE	72	0.00	0.08	0.01	0.02
BehavF	72	0.00	0.18	0.01	0.03
BehavG	72	0.00	0.40	0.04	0.08
BehavH	72	0.00	0.00	0.00	0.00
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.11	0.13
BehavB	40	0.00	0.92	0.38	0.24
BehavC	40	0.00	0.09	0.01	0.02
BehavD	40	0.00	1.00	0.43	0.25
BehavE	40	0.00	0.33	0.03	0.07
BehavF	40	0.00	0.08	0.00	0.02
BehavG	40	0.00	0.25	0.04	0.06

BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.75	0.17	0.20
BehavB	40	0.08	0.92	0.38	0.22
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.83	0.40	0.24
BehavE	40	0.00	0.08	0.01	0.02
BehavF	40	0.00	0.25	0.02	0.05
BehavG	40	0.00	0.17	0.03	0.05
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.50	0.13	0.14
BehavB	40	0.00	0.92	0.41	0.24
BehavC	40	0.00	0.00	0.00	0.00
BehavD	40	0.00	0.83	0.41	0.22
BehavE	40	0.00	0.08	0.01	0.02
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	0.17	0.03	0.06
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.83	0.16	0.19
BehavB	40	0.00	1.00	0.40	0.24
BehavC	40	0.00	0.08	0.00	0.01
BehavD	40	0.00	0.82	0.39	0.20
BehavE	40	0.00	0.17	0.02	0.04
BehavF	40	0.00	0.17	0.01	0.03
BehavG	40	0.00	0.08	0.02	0.03
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Steenbuck 1

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.58	0.13	0.15

BehavB	72	0.09	1.00	0.71	0.21
BehavC	72	0.00	0.25	0.02	0.05
BehavD	72	0.00	0.36	0.10	0.10
BehavE	72	0.00	0.00	0.00	0.00
BehavF	72	0.00	0.08	0.00	0.02
BehavG	72	0.00	0.25	0.03	0.06
BehavH	72	0.00	0.09	0.00	0.02
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.67	0.10	0.15
BehavB	40	0.00	1.00	0.70	0.28
BehavC	40	0.00	0.42	0.03	0.08
BehavD	40	0.00	0.42	0.07	0.10
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	1.00	0.09	0.20
BehavG	40	0.00	0.17	0.01	0.03
BehavH	40	0.00	0.08	0.00	0.02
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.16	0.16
BehavB	40	0.00	1.00	0.69	0.28
BehavC	40	0.00	0.25	0.03	0.06
BehavD	40	0.00	0.45	0.07	0.10
BehavE	40	0.00	0.08	0.00	0.01
BehavF	40	0.00	0.33	0.02	0.06
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.17	0.01	0.03
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.58	0.12	0.15
BehavB	40	0.00	1.00	0.68	0.30
BehavC	40	0.00	0.33	0.04	0.08
BehavD	40	0.00	0.64	0.12	0.15
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.02	0.05
BehavG	40	0.00	0.11	0.02	0.03
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.55	0.15	0.15
BehavB	40	0.17	1.00	0.68	0.24
BehavC	40	0.00	0.36	0.03	0.07
BehavD	40	0.00	0.33	0.09	0.11
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.17	0.01	0.04
BehavG	40	0.00	0.17	0.02	0.05
BehavH	40	0.00	0.08	0.00	0.01
Valid N (listwise)	40				

Steenbuck 2

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.36	0.06	0.10
BehavB	72	0.00	1.00	0.78	0.22
BehavC	72	0.00	0.18	0.02	0.05
BehavD	72	0.00	0.50	0.08	0.11
BehavE	72	0.00	0.00	0.00	0.00
BehavF	72	0.00	0.33	0.00	0.04
BehavG	72	0.00	0.25	0.03	0.06
BehavH	72	0.00	1.00	0.03	0.14
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.25	0.05	0.08
BehavB	40	0.00	1.00	0.76	0.28
BehavC	40	0.00	0.18	0.02	0.04
BehavD	40	0.00	0.33	0.04	0.07
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.75	0.09	0.19
BehavG	40	0.00	0.18	0.01	0.03
BehavH	40	0.00	0.58	0.03	0.11
Valid N (listwise)	40				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	1.00	0.12	0.21
BehavB	40	0.00	1.00	0.74	0.25
BehavC	40	0.00	0.17	0.02	0.05
BehavD	40	0.00	0.33	0.07	0.09
BehavE	40	0.00	0.08	0.00	0.01

BehavF	40	0.00	0.58	0.03	0.10
BehavG	40	0.00	0.17	0.02	0.04
BehavH	40	0.00	0.00	0.00	0.00
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.42	0.03	0.08
BehavB	40	0.10	1.00	0.73	0.26
BehavC	40	0.00	0.27	0.03	0.08
BehavD	40	0.00	0.58	0.12	0.14
BehavE	40	0.00	0.00	0.00	0.00
BehavF	40	0.00	0.42	0.05	0.11
BehavG	40	0.00	0.08	0.00	0.02
BehavH	40	0.00	0.70	0.02	0.11
Valid N (listwise)	40				

Descriptive Statistics Post-Enrichment2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	40	0.00	0.33	0.08	0.09
BehavB	40	0.00	1.00	0.68	0.28
BehavC	40	0.00	0.33	0.03	0.08
BehavD	40	0.00	0.42	0.10	0.12
BehavE	40	0.00	0.08	0.00	0.01
BehavF	40	0.00	0.33	0.05	0.10
BehavG	40	0.00	0.17	0.01	0.03
BehavH	40	0.00	1.00	0.04	0.17
Valid N (listwise)	40				

Steenbuck 3

Descriptive Statistics Baseline Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	72	0.00	0.44	0.03	0.09
BehavB	72	0.00	1.00	0.79	0.31
BehavC	72	0.00	0.09	0.00	0.01
BehavD	72	0.00	0.33	0.04	0.09
BehavE	72	0.00	0.00	0.00	0.00
BehavF	72	0.00	0.00	0.00	0.00
BehavG	72	0.00	0.09	0.00	0.01
BehavH	72	0.00	1.00	0.12	0.30
Valid N (listwise)	72				

Descriptive Statistics Pre-Enrichment Data

	N	Minimum	Maximum	Mean	Std.

					Deviation
BehavA	33	0.00	0.50	0.07	0.14
BehavB	33	0.00	1.00	0.74	0.28
BehavC	33	0.00	0.09	0.01	0.02
BehavD	33	0.00	0.33	0.07	0.09
BehavE	33	0.00	0.00	0.00	0.00
BehavF	33	0.00	0.36	0.03	0.09
BehavG	33	0.00	0.08	0.00	0.02
BehavH	33	0.00	1.00	0.08	0.22
Valid N (listwise)	33				

Descriptive Statistics Enrichment Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0.00	0.75	0.11	0.19
BehavB	32	0.08	1.00	0.77	0.27
BehavC	32	0.00	0.17	0.01	0.04
BehavD	32	0.00	0.50	0.07	0.12
BehavE	32	0.00	0.00	0.00	0.00
BehavF	32	0.00	0.25	0.01	0.05
BehavG	32	0.00	0.17	0.01	0.04
BehavH	32	0.00	0.17	0.01	0.04
Valid N (listwise)	32				

Descriptive Statistics Post-Enrichment 1 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0.00	0.45	0.11	0.14
BehavB	32	0.09	1.00	0.71	0.26
BehavC	32	0.00	0.56	0.04	0.11
BehavD	32	0.00	0.27	0.07	0.09
BehavE	32	0.00	0.00	0.00	0.00
BehavF	32	0.00	0.17	0.02	0.05
BehavG	32	0.00	0.18	0.01	0.03
BehavH	32	0.00	0.50	0.04	0.10
Valid N (listwise)	32				

Descriptive Statistics Post-Enrichment 2 Data

	N	Minimum	Maximum	Mean	Std. Deviation
BehavA	32	0.00	0.67	0.10	0.17
BehavB	32	0.00	1.00	0.58	0.39
BehavC	32	0.00	0.27	0.02	0.07
BehavD	32	0.00	0.42	0.08	0.11
BehavE	32	0.00	0.00	0.00	0.00
BehavF	32	0.00	0.09	0.01	0.02
BehavG	32	0.00	0.09	0.01	0.02
BehavH	32	0.00	1.00	0.21	0.39

2. Re-evaluation of feed based enrichment during the evening and at night to assess the effect the time of day has on the impact of enrichment on behaviour especially on nocturnal animals. This could also be tried during different seasons and during periods when there are no visitors in the zoo in order to assess the effects of external factors on the response to enrichment.

3. Detailed analysis of the factors affecting response to enrichment within a species – e.g. sex, age, group composition etc. This could be achieved by re-evaluation of feed based enrichment centreing on the novel presentation of food in an enclosure with a large number of animals of varying ages, sexes and a known social ranking system such as the fourteen black and white lemur at the NZG. This would assist to evaluate any animal specific factors which can help to predict the response expected to environmental enrichment programs.

4. By using the observational and evaluation protocols laid out in this study assess the effect of feed based enrichment on the behaviour of other animal taxa, such as reptiles, amphibians, fish, aquatic mammals and birds.

5. Use different types of enrichment such as social contact (conspecific [pair, group, temporary, permanent]; allospecific [human, non-human]), occupational (psychological [puzzles, control of environmental]; exercise [mechanical devices, run]), physical (Enclosure [size alteration, complexity]. accessories [furniture, bars, toys ropes, substrates]) or sensory (visual, auditory, olfactory, tactile, taste) to assess the effects of the type of enrichment on the predictability of behavioural change in an animal.

27. Eating rotten wood – Specifically and deliberately consuming pieces of rotten wood.
28. Marking – Short squirts of urine or defaecating against a vertical surface. Rubbing scent glands on the ground or other solid object.
29. Sand spraying over the body – (Specific to elephants) Using trunk to collect sand, then blowing it over their own bodies.
30. Smell – Using nose to investigate an area with obvious sniffing.
31. Spraying body with mud and water – (Specific to elephants) Using trunk to collect mud and water, then blowing it over their own bodies.
32. Stereotyping – Normal activities or behaviour for the species, but repetitively or constantly performed, even to the point of exclusion of all other activities.

Utilisation of the various areas of the enclosure by each group of animals being studied was also assessed during this period, in order to determine the best fixed vantage point from which to observe the animals most successfully. Appendix 6.2 indicates the position of the observers from which the records were made. With the exception of the elephants that moved camps during the day necessitating observer relocation, all enclosures could be viewed from a single static location.

2.2.2. Observer Training

Each of the six species to be examined were allocated two people that would observe them for the period of the study. An instructional period consisting of 5 days between 09 May and 13 May 2005 was initially undertaken. During this period observations, without interference to the regular routine of the animals, were conducted. Each of the observers spent four of the five days recording data on their allocated species and one day rotating between the other five species. This afforded the opportunity for observers to master the recording techniques using the observational record sheet and familiarize themselves with the study species. By the end of the week all the observers were able to record the behavioural activity of individual study animals using instantaneous scan sampling at intervals of five minutes.

2.2.3. Repeatability Of Observation (Observer Bias)

Observer bias was recorded at the end of the instructional period by examining data collected by all the observers standing at the same vantage point recording their observations using instantaneous scan sampling at five minute intervals on the same animal at the same time. Nine animals within seven enclosures were observed for seven hours (one hour per enclosure) by all participants recording their findings onto observational record sheets.

The animals chosen for this part of the study were similar to those that would be part of the main body of work: a blesbok (*Damaliscus dorcas phillipsi*), chimpanzees (*Pan troglodytes*), giraffe (*Giraffa giraffa*), nyala (*Tragelaphus angasi*), patas monkeys (*Erythrocebus patas*), white rhino (*Ceratotherium simum*) and three wild dogs (*Lycaon pictus*). The combination of animals was chosen for several reasons: 1) ease with which an individual could be identified to ensure all observers were reporting on the correct animal, 2) an attempt was made to ensure most of the behavioural patterns that could be expected by the main study species would be observed during this period, 3) the enclosures chosen also had to allow clear visualization of animals by all nine observers, 4) the animals in question had to be visible at all times so that unproductive periods were avoided.

The complete data consisted of eight data sets per animal observed, resulting in a total of seventy two data sets per individual observer that could be compared.

2.2.4. Baseline Observation

Baseline behavioural data was obtained using instantaneous scan sampling every five minutes between 08:00 to 16:00 for each study species over a four day period between 17 May 2005 and 23 May 2005. All the species were studied on the same day during the same time period from a static viewing point (with the exception of the elephants that had two viewing points) by the allocated observers. The behaviour for each species was recorded as listed on the ethogram above. An example of the record sheet used to document each animals behaviour is shown in appendix 6.1. For each day of observations fifty six replicates for each animal were collected.

This method of observation and recording was maintained throughout all of the study periods including pre-enrichment, enrichment, post-enrichment 1 and post-enrichment 2.

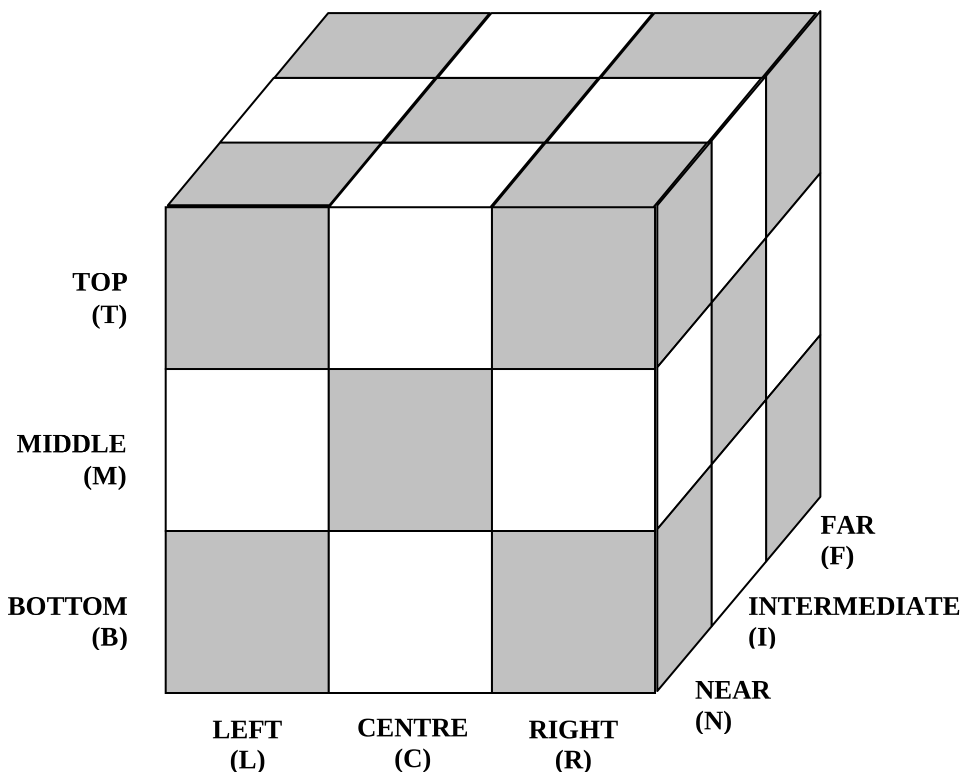
2.3. SPATIAL UTILISATION

In order to determine the position of each animal within its environment, enclosures were divided into quadrants using visual cues as illustrated in appendix 6.2. This allowed easy and rapid determination of which quadrant the study animal was in at any point during observations.

For non-arboreal animals, only the X- and Z-axis were used to describe the position of the animals within their environment, where as vertically mobile animals also required the Y-axis to describe their position in space. For example the steenbuck could be described as “LN” (left, near) if seen at the left hand side of the enclosure nearest to the observer, whereas a lion-tailed macaque in the same location but swinging from a tree, may be described as “LNM” (left, near, middle) or “LNT” (left, near, top) depending on the height of the animal within the environment.

For the ruffed lemur (see appendix 6.2e) and steenbuck (see appendix 6.2f) , the dimensions of each enclosure was measured and coloured cards attached to the wire and wall respectively to give visual identification of where the left, central and right quadrants intersected. The near, intermediate and far zone for the steenbuck was determined to be from the fence to the middle of the empty concrete water container for near, then from there to behind the logs, plants and tree trunks for the intermediate zone and then from there to the wall and night room for the far zone. These zones for the ruffed lemur were determined as anywhere behind the feeding platforms (far), at the same level as the feeding platforms (intermediate) and in front of the feeding platforms (near). As the ruffed lemurs were also vertically mobile top, middle and bottom zones were also divided into three equal heights. The top zone was determined as anywhere on or above the roof sections of the feeding platforms, the middle zone was that from below the feeding platform roof to the top of the bushes that ran throughout the central section of the enclosure and the bottom zone was anywhere below this point.

Figure 2.2: Three dimensional space utilization model



The leopard (see appendix 6.2b) and lion-tailed macaques (see appendix 6.2c) also had their enclosures measured and evenly divided into left, central and right quadrants. The leopard had depth divided into three zones. '***Near***' was determined as being close to the viewing windows, half way between the viewing window and the back wall was defined as '*intermediate*' and on or near the back wall determined as being '***far***'. As the leopard also had three elevated rocks at various vertical heights at the back left of the enclosure these were identified as '***left, far, top***', '***centre, far, top***', and '***left, far, middle***'. The macaques that were also vertically mobile had the height of the enclosure measured and divided into three equal sections using the tubing and trees in the enclosure as visual identification of quadrant divisions.

The red panda (see appendix 6.2d) enclosure was divided into '***left***', '***centre***' and '***right***' with the central area being to the right of the tree stumps and the left of the low kennel. Depth was divided into '***near***' and '***far***', with the back of the main tree trunk acting as the division. The three vertical zones were divided according to the high kennel. Anything below the kennel was '***bottom***', at the level of the kennel was '***middle***' and above the kennel was '***top***'.

The small enclosure of the elephants (see appendix 6.2a) was divided into '***near***' and '***far***', with the front of the rock cluster denoting the division between the two. '***Left***', '***central***' and '***right***' zones were measured equally and coloured cards were attached to the back wall to act as visual cues. The large enclosure due to the size and shape was unable to be divided equally. The '***central***' zone included the dam and the two rock clusters closest to the night room. The '***near***' zone included the dam while the '***far***' zone included all the rock clusters.

The position of each individual within the enclosure was noted concurrently with the behavioural observations at five minute intervals from 08:00 to 16:00 during both the baseline study and enrichment periods, being entered onto the record sheet (see appendix 6.1), as discussed above.

2.4. FEEDING ENRICHMENT

2.4.1. Species Specific Feed-Based Enrichment

For all the study animals the presentation of food not the quantity was the only aspect being changed. Below is a description of the method of feeding enrichment used for each species.

2.4.1.1. African savanna elephants

On 'enrichment days' feeding was separated into three feeds per day instead of two as was the normal practice. For the first feed in the small enclosure at any time from 08:00 to 11:00 the one wheelbarrow full of fruit and vegetables usually fed to the elephants was placed in random locations within the small enclosure and was hidden by leaf litter. Several food items were also hidden amongst the man-made rocky outcrop within the small enclosure.

The remainder of the food that was usually scattered over the floor of the large enclosure filled three wheelbarrows. The food in two of these wheelbarrows was placed into five randomly chosen shallow pits that had been dug by the elephants in the large enclosure. Leaf litter was then used to cover the food as well as fill three other pits in which no food items were present. Several food items were also hidden amongst the three man-made rocky outcrops within the large enclosure. The presentation of the hay component of the diet remained unchanged. These food items were available to the elephants as soon as they were released from the small enclosure back into the large enclosure once the keepers had finished cleaning.

The remaining one wheelbarrow containing fruit and vegetables was retained until approximately 13:00 when the observers would throw the food into the large enclosure, scattering it for the animals and so also dividing the feeding that took place in the large enclosure into two distinct time periods.

Therefore the feeding enrichment for the elephants consisted of hiding and scattering the food items.

2.4.1.2. Leopard

Feeding enrichment for the leopard comprised an equine hide split in two with one part frozen and hanging on bungy rope while the other was unfrozen and wrapped around the tree stump. Due to the alternate day feeding, half the enrichment days fell on the same day as feeding while the other half were on non-feeding days.

2.4.1.3. Lion-tailed macaques

On enrichment days food items were hidden throughout the enclosure. Six tyres were spread evenly on the floor of the enclosure and four out of six of the tyres were randomly selected and had food items placed in them which were subsequently hidden by leaves, the remaining two tyres were filled with leaves only. This meant that during enrichment days the macaques did not know which tyres contained food and which didn't. The macaques were within the night room while the feeding enrichment was being prepared so were unable to see which tyres were filled with food items.

In addition the vertical space was utilized by wiring three pvc pipes to various structures within the outside area. The base of two of the three pipes were then filled with the remaining food items and packed full of leaves. The third pipe was filled with leaves only.

2.4.1.4. Red panda

On environmental enrichment days, two pvc pipes were wired to the branches of the main central tree and one pvc pipe to the smaller tree on the right of the enclosure. These were then equally filled with the bamboo shoots normally fed daily to the pandas. The presentation of the fruit mixture was not altered.

2.4.1.5. Black and white ruffed lemur

During enrichment days six tyres, six pvc pipes, and three hammocks were used to hide and disperse the food. It also ensured the entire space of the enclosure was utilized both horizontal and vertical.

The tyres were spread evenly over the floor of the enclosure and much like the macaques food was placed in four of the six tyres and covered with leaves. The remaining tyres were filled with leaves only. The pvc pipes were spread evenly throughout the enclosure and secured using wire within the mid-level between the floor and mesh ceiling. The base of four of the six pipes, were filled with food items and then the remaining space covered with leaves. The remaining two pipes were filled with leaves only. Finally the hammocks were secured to the mesh roof of the enclosure, with food items being placed on two of the three hammocks and covered with a layer of leaves. The third hammock was covered in leaves only. The initial plan was to hang hammocks on the lion-tailed macaques enclosure as well, however the curator decided the mesh roof of that enclosure would not withstand the weight if several of the macaques were to sit on the hammock at the same time.

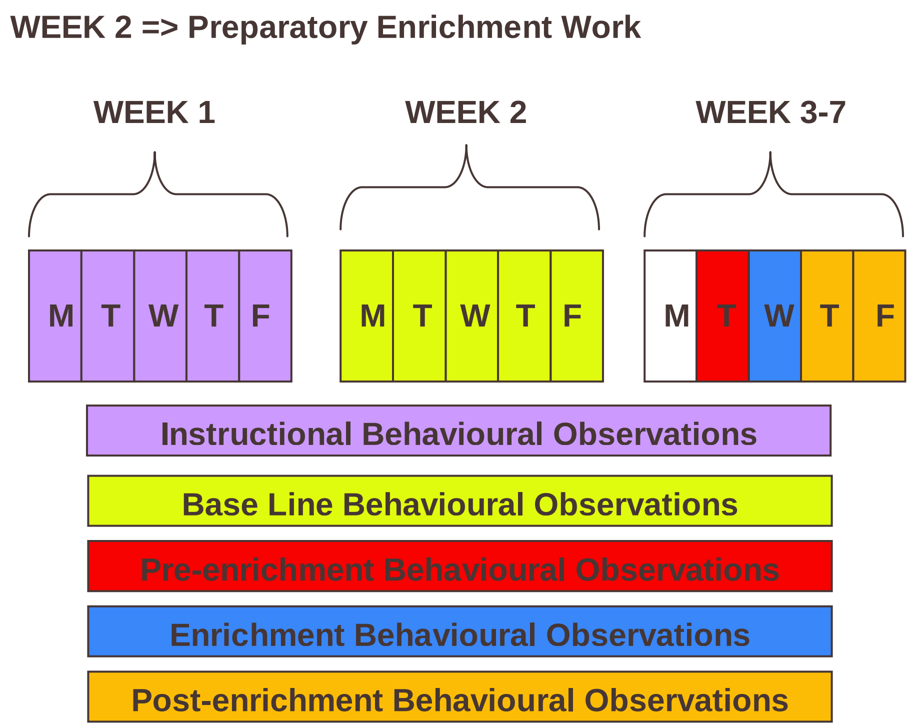
2.4.1.6. Steenbuck

On the enrichment days, six pvc pipes were placed end up throughout the enclosure and filled with the lucerne, forming small bush-like structures. The fruit and vegetables normally fed was then evenly spread around each of the six lucerne tufts and covered in a layer of leaf litter.

3.4.2. Study Period

The main study comprised a pre-enrichment, enrichment, post-enrichment 1 and post-enrichment 2 element (see figure 2.3.) undertaken from Tuesday to Friday with five repetitions on consecutive weeks from 24 May 2005 to 24 June 2005. Behavioural data was obtained using instantaneous scan sampling every five minutes between 08:00 to 16:00 for each species studied as discussed for baseline observations, with data being collected in the same way for each element of the study. The data was recorded on the same record sheets along with positional data for each species as discussed above.

Figure 2.3: Structure of the study



DURATION OF STUDY: Mon 09 May to Fri 24 June 2005

2.5. DATA ANALYSES

2.5.1. Behavioural Data

Following the recoding of the specific behaviour as described in the ethogram, 8 major behavioral categories were decided upon enabling similar broad behavioural categories to be used by each species. (Table 2.1)

It was these broad groupings that were then used to display and analyse the data collected during the project in order to more easily identify trends and / or patterns of behaviour that may vary between enrichment and non-enrichment periods.

	Elephants	Leopard	Macaques	Panda	Lemurs	Steenbuck
A. Feeding Related	**7**	**7**	**7**	**7**	**7**	**7**
B. Stationary Behaviour	**21,22**	**21,22**	**21,22**	**21,22**	**21,22**	**21,22**
C. Abnormal Behaviour	**15,32**	**15,32,27**	**15,32**	**15,32**	**15,32**	**15,32**
D. Active Species Specific Behaviour	**13,17,19,20, 25,29,31**	**13,17,19,23, 24,25,28**	**1,2,3,8,12,13,17 ,19,20,24, 25**	**12,13,19,2 5,30**	**1,2,3,8,12, 13,17, 19,20,24,2 5**	**1,2,8,12,13,17,1 9,20,25**
E. Aggressive Interactions	**6,16,18**	**-**	**6,16,18**	**6,16,18**	**6,16,18**	**6,16,18**
F. Human Interactions	**9,10,11**	**9,10,11**	**9,10,11**	**9,10,11**	**9,10,11**	**9,10,11**
G. Non-Relevant	**1,2,3,4,5,8,12, 23,24,26,28**	**1,2,3,4,5,6,8, 12,16,18,20**	**4,5,23,28**	**1,2,3,4,5,8 ,17,20, 23,24,28**	**4,5,23,28**	**3,4,5,23,24,28**
H. Non-Visible	**14**	**14**	**14**	**14**	**14**	**14**

Table 2.1: Behaviour Categorisation. The numbers used in each box relate directly to the behaviour listed above in the ethogram. E.g. 1 = Allogroom and for the African savanna elephants was placed in category G, for non-relavant behaviour.

In order to visually display the data, the descriptive data collected using the SPSS statistical computer package (see appendix 6.4) was used to create a stacking bar chart. The x-axis representing the study period (baseline, pre-enrichment, enrichment, post-enrichment 1 and post-enrichment 2) while the y-axis was the mean percentage time spent undertaking each behaviour. This was done for each individual animal both for whole day behavioural data and morning and afternoon data separately.

In order to analyse the descriptive data that was not normally distributed, Mann-Whitney U test was chosen. Although a non-parametric test making it less powerful than the equivalent parametric test (t-test) for data analysis, it is more robust as it is less dependent on specific assumptions such as a normal distribution (Martin & Bateson, 1995). It may also be used with as few as four observations in each sample (Fowler & Cohen, 1995).

2.5.2. Spatial data

A pie chart was used to visually represent the percentage mean time spent in each zone for each study period. To give an indication of the amount of dispersal in the enclosures, the coefficient of variation (CV) as used by Stoinski *et al.* (2001) was used with the formula:

$$CV = s/x \text{ (where s = standard deviation and x = mean)}$$

.

The descriptive statistics were then analysed using the Mann-Whitney-U test (SPSS) as discussed above, to determine significant differences in spatial utilisation between the different study periods at probability levels of $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$.

individuals. Habituation to enrichment would also be a concern as a decrease in effect may be seen over time. In addition, the more complex the wild behaviour pattern, the less likely captive animal behaviour would be expected to correlate to those of the wild conspecifics.

1.4.3. Hypotheses

1.4.3.1. Activity budgets

The aim was to determine if feed-based enrichment significantly changed the behaviour of the animals within the study. Two sets of hypotheses were therefore formed:

Overall activity budgets

Null Hypothesis – There was no significant difference in the activity budgets between the enrichment and non-enrichment periods for the key mammal groups studied within the NZG.

Alternate Hypothesis – There was a significant difference in the activity budgets between the enrichment and non-enrichment periods for the key mammal groups studied within the NZG.

Proportional activity budgets

Null Hypothesis - There was no significant difference in the periods of the day during which activities were observed on enrichment and non-enrichment days for the key mammal groups studied within the NZG.

Alternate Hypothesis - There was a significant difference between the periods of the day during which activities were observed on enrichment and non-enrichment days for the key mammal groups studied within the NZG.

1.4.3.2. Enclosure utilisation

The second aim was to assess the utilization of the enclosure by the specific individuals being observed. The hypothesis being:

Null Hypothesis – The utilization of the enclosures was random and did not change between enrichment and non-enrichment days for the key mammal groups studied within the NZG.

Alternate Hypothesis – The utilization of the enclosures was not random and did change between enrichment and non-enrichment days for the key mammal groups studied within the NZG.

1.5. THE STUDY SITE

The National Zoological Garden [NZG], Pretoria was established in 1899 by Dr Jan Willem Boudewyn Gunning, a Dutch medical doctor. Over the century, it evolved from a place of only recreation into a leading institute for conservational research and education (van der Berg and Hopkins *et al.*, 2000). Dr. Rudolph Bigalke, director from 1927 to 1962, developed many of the large naturalistic enclosures and enhanced the zoos role in conservation.

Dr. Frank Brand (1962-1984) continued Bigalke's work, redesigning enclosures to exhibit animals in more natural habitats. Additional areas of land out with the zoo were also acquired, resulting in the formation of the Lichtenburg Game Breeding Centre in 1974 and the Potgietersrus Breeding Centre in 1981 (van der Berg and Hopkins *et al.*, 2000). The De Wildt Cheetah Centre also entered into partnership with the zoo while Dr. Brand was director (Nel, 2004).

Currently under the direction of Mr. Willie Labuschagne, a thirty year master plan to redevelop the zoo, begun in 1990 is underway. In addition many links have been forged between NZG and worldwide conservation, education and zoological organizations with the principles of the zoo held within the NZG mission that states (van der Berg and Hopkins *et al.*, 2000):

"By exhibiting, caring for, acquiring and propagating indigenous and exotic animals, a national and educational service is rendered to the community, thereby fostering understanding, knowledge, research, care of and appreciation for our wildlife."

In 2004, the National Research Foundation [NRF] became the governing body of the zoo, with it's own vision (Venter, 2004):

"To support and promote research through funding, human resources development and the provision of the necessary research facilities in order to facilitate the creation of knowledge, innovation and development in all fields of science and technology, including indigenous knowledge and thereby to contribute to the improvement of the quality of life of all people of the Republic."

Within the NZG to date, only isolated, mainly unpublished behavioural studies have been undertaken. No large scale, long term, behavioural observations or enclosure usage examinations have occurred. The data collected in this study goes a small way towards rectifying this. Having employed Mrs Robynn Ingle-Moller as an Environmental Enrichment Co-ordinator in 2002 and having recently formed a Research Department headed by Prof. Antoinette Kotze in 2005, the NZG is currently in a strong position to integrate enrichment and collaborative research to expand upon this work and so benefit all concerned, especially in light of the current ongoing redevelopment of the enclosures.