2012

Analyses of captive behaviour and enclosure use in Rothschild giraffes (Giraffa camelopardalis rothschildi) housed at Paignton Zoo Environmental Park

Garry, S.

Garry, S. (2012) 'Analyses of captive behaviour and enclosure use in Rothschild giraffes (Giraffa camelopardalis rothschildi) housed at Paignton Zoo Environmental Park ', The Plymouth Student Scientist, 5(2), p. 4-30.
http://hdl.handle.net/10026.1/13981

The Plymouth Student Scientist
University of Plymouth

Analyses of captive behaviour and enclosure use in Rothschild giraffes (*Giraffa camelopardalis rothschildi)* housed at Paignton Zoo Environmental Park ®

Sarah Garry

Project Advisor: John Eddison, School of Biomedical and Biological Sciences, Plymouth University, Drake Circus, Plymouth, PL4 8AA

Abstract
It has been suggested that wild herbivorous animals, like the Rothschild Giraffe (*Giraffa camelopardalis rothschildi*), are difficult to house in captivity due to their natural wide home range and specialised diet. The aim of this study was to understand what influence the design of the giraffe enclosure at Paignton Zoo has on the activity budget of the Rothschild Giraffes (*Giraffa camelopardalis rothschildi*) housed in it, in relation to enclosure use and the performance of a natural behavioural repertoire. This was achieved by observing the giraffe's behaviour and location when in the enclosure, both indoors and outdoors. The Spread of Participation Index and Chi Squared (goodness of fit) tests were used to determine the degree of spatial selectivity and to help elucidate the degree to which the giraffes made efficient use of their enclosures; the chi squared (goodness of fit) was additionally used to analyse the exhibition of behaviour. Subsequent analyses and standardised residuals of the data revealed that the subjects did not use their outdoor enclosure evenly, as some areas which provided resources were used significantly more than others: Tonda (X^2=1495.31; D.F. =5, P<0.001); Sangha (X^2=769.975; D.F. =5; P<0.001); Janica (X^2=1737.45; D.F. =5; P<0.001); Yoda (X^2=1660.91; D.F. =5; P<0.001). The data from the indoor enclosure also showed significant individual differences between enclosure section preference: Tonda (X^2=636.853; D.F. =13; P<0.001); Sangha (X^2=1707.11; D.F. =18; P<0.001) Janica (X^2=1531; D.F. 18; P<0.001). Similarly, subsequent analyses and standardised residuals showed that some behaviours were exhibited significantly more or less than others in both the outdoor and indoor enclosures; whereas others were not used to an extent that differed significantly from expected values. Outdoor results: Tonda (X^2 = 3929.62; DF = 18; P<0.001); Sangha (X^2=3961.49; D.F. =19; P<0.001); Janica = (X^2=3860.35; D.F. =18; P<0.001); Yoda (X^2=4332.84; D.F. =19; P<0.001). Indoor results: Tonda (X^2=636.853; D.F. =13; P<0.001); Sangha (X^2=1707.11; D.F. =18; P<0.001); Janica (X^2=1531.42; D.F. =16; P<0.001); Yoda (X^2=1236.64; D.F. =11; P<0.001). The study suggests that enclosure design has a profound influence on the behavioural activity budget and enclosure use of the giraffes housed in it. It is suggested that enclosure use could be improved by provision of more feeding enrichment around the enclosure.

Key Words: Giraffe; Enclosure Use; Behaviour; Stereotypic, Enrichment; Welfare.

Introduction

Animal welfare has been at the forefront of many investigations, particularly in captive species such as zoo housed animals. All captive environments are required to fit the comprehensive framework for analysis of welfare as stated in the Animal Welfare Act (2006). Part of this legislation enforces the assurance of the performance of "most normal" behaviours by the provision of adequate space and resources. This freedom is a focus of this current investigation, (although the other freedoms should not be disregarded as they are equally important in determining the welfare of an animal). Monitoring behaviour to create an activity budget is a beneficial way of detecting anything abnormal in an animal's behavioural repertoire and additionally enables the recording of their location at the time of performance to give a full account of enclosure use. Abnormal behaviours are defined by Boorer (1972) as behaviours which are elicited by wild animals in captivity but not by their free-ranging counterparts; however this definition should be considered with caution as some wild animals may perform behaviours which are not commonly found in their species behavioural repertoire.

Space can be a major limitation for many captive environments; currently twenty-six billion animals incorporating ten-thousand species are housed in captivity (Mason 2010). Whilst the aim of most of these captive environments is research, education, and conservation (Mallapur et al, 2002), the constraints of confinement and poorly enriched environments can cause stress and abnormal behaviour. Examples of such abnormalities include: stereotypies, excessive inactivity, deviant sexual behaviour, and abnormal maternal care (Carlstead 1991; Mason 1991; Wiepkema & Koolhaas 1993). Stereotypies, more commonly referred to as stereotypic behaviour can be defined as: invariant and repetitive with no clear goal or function (Mason 1991, Carlstead 1998). It is therefore important to monitor how effectively animals are using their enclosure and what behaviours these enclosures are causing them to elicit, in order to identify problem areas.

Behavioural observations are useful to record how enclosure design influences the activity budget of animals in captivity (Reinhardt et al. 1996; Monte & Pape 1997; Seidensticker & Forthman 1998). Individuals acclimatize to change in their environment, by amending the amount of time spent performing different behavioural activities (Firol-Jaman & Huffman 2008); but these often vary across age and sex in accordance with physiological and social needs. Few performances of species-specific behaviours suggest that the observed enclosure design and captive habitat are poorly enriched and lacking stimulation, causing animals to express stereotypic behaviours in replace of their natural behaviour. Stereotypic behaviours have diminishing effects on the welfare of animals which perform them (Mason & Latham 2004; Mason et al. 2007), they are caused by variable contributory factors which are partly species dependent. Zoo animals are not bred for adaptation to captive conditions but specifically to avoid this (Carlstead & Shepherdson 2000), weakly enriched enclosures therefore may not be enough to stimulate the appropriate 'normal' behaviours which you would expect from a wild conspecific.

In some species, stereotypic behaviours are performed as a coping technique in suboptimal environments (McBride & Cuddeford 2001); in these instances research suggests that caution must be taken when acting to remove the behaviours as they currently benefit the animal by satisfying a motivation. Stereotypy in this case is claimed to be most successfully reduced by positively changing the animal's environment to encourage appropriate goal directed behaviour which increases the animal's natural behavioural repertoire (Shepherdson 1989; McBride and Cuddeford 2001, Mason et al. 2007).

For herbivores, like giraffes which browse throughout the day, the performance of both ‘normal’ and stereotypic behaviours is related to their natural need to forage for large time periods. Mason (1991) therefore asserts that monitoring standing and feeding behaviours can be propitious of suboptimal health and hence used to detect the progression of unnatural behaviours. However due to the feeding strategies within captive environments this is not always reliable. Veasey et al. (1996) found significant differences between the time periods that wild and captive giraffes spend feeding and standing, with feeding behaviours being “76.9%” versus “26%” respectively. This is due to the feeds used in captive diets, which are modified, thereby reduce the time giraffes spend feeding and digesting, leaving excess free time which giraffes fill by performing oral-stereotypic behaviours (Kiley-Worthington 1987; Houpt & McDonnell 1993; Cooper & Mason 1998; Koene & Visser 1997; Bashaw et al*.* 2001; Bergeron et al*.* 2006).

Bergeron et al. (2006) further supports this, she asserts three hypotheses to explain the occurrence of oral-stereotypic behaviours in ungulates. The first hypothesis suggests that captive ungulates’ diets do not fully satisfy them, because they are deficient in fibre and therefore do not fill the gut. Secondly she hypothesises that captive diets take too little time to find, chew or ruminate, which leaves the animals with unfulfilled feeding motivation. The third and final hypothesis suggests that oral stereotypic behaviour is caused by gut dysfunction due to the substituted low-fibre and carbohydrate rich foods often given to captive ungulates. In such cases oral stereotypy is suggested to benefit gut health by generating saliva which helps to rectify gastrointestinal pH. Monitoring behavioural repertoires are evidently beneficial, they give an indication of the proportion of ‘normal’ behaviours versus stereotypic, and consequently the welfare of the subject animals.

In order to gain a greater understanding of captive settings, research has investigated several aspects of enclosure design, including: size, complexity, shape, and enrichment. It has been proposed that these features influence the proportion of abnormal behaviour exhibited by confined animals (Maple, 1979; Macedonia, 1987; Kirkwood, 1998), as does inappropriate social arrangements (Barnes et al. 2002; Bashaw et al*.* 2007). Evaluating enclosure use can therefore be used to determine both positive and negative features of captive environments; but it must be recognised that both biological and social factors are contributory to this outcome. Past research emphasises the importance of understanding enclosure use. For example, Mason (2010) investigated the effect of spatial limitations on natural hunting/ranging activity in carnivores. She concluded that stereotypic pacing and captive infant mortality for thirty one species was provoked by their restricted ability to travel across wide ranges. Yet even if laterally there is enough space: poorly constructed landscapes, proximity to other conjoining buildings and structural elements all effect spatial use by reducing the overall spatial capacity of that enclosure; Ogden et al*.* (1990) found just this in captive gorillas.

Empty, boring, barren enclosures can also have negative consequences. Zoo enclosure design should be largely based on the biological and behavioural needs of the animal it houses (Mellen & Macphee 2001; Estevez & Christman 2006; Price & Stoinski 2007; Ross et al. 2009). For example Firoj Jaman & Huffman (2008) discovered that the provision of food in naturally vegetated, enriching enclosures is largely responsible for the variations in daily activity budgets.

If enclosures are too restrictive due to group size and density then this can have a negative impact on the animal’s well-being. Such negativity has been found in captive primates by an expression of increased aggression and stress (Elton & Anderson 1977; Price & Stoinski 2007). Likewise, Sloth's (*Ursus ursinus*) enclosure use and behaviour are strongly affected by their physical and social environment as-well as rearing history. Giraffes that naturally have a mean home range size of "282km^2" (Toit 1990) have been found to cope well in restricted captive conditions. This is because their spatial needs are quite flexible. In the wild a giraffe's home range depends on the location of food and water, whereas in captivity these essentials are provided to an ample degree. Consequently this reduces competition between giraffes and depresses their desire to travel; so that they can be housed in relatively sizeable groups (Price & Stoinski, 2007) providing they receive enough resources (Grant et al. 1992). Enclosure design must also be in conjunction with the fact that when an animal's body size or metabolic requirements increase, the home range size also increases (Perry 2011). This is also important for the exercise needs of an animal to maintain a good health status for them (The Zoos Forum 2010).

The aim of this study was to understand what influence the design of the giraffe enclosure at Paignton Zoo Environmental Park ® has on the activity budget of the Rothschild giraffes (*Giraffa camelopardalis rothschildi*) housed in it, in relation to enclosure use and the performance of a natural behavioural repertoire. This was achieved by observing the giraffe's behaviour and location when in the enclosure, both indoors and outdoors. This study was also designed to record whether the parts of the enclosure were used effectively, and to suggest ways that this could be improved to ensure efficient use of all areas.

Methods

Subjects and Housing

The subjects for this study were four captive Rothschild giraffes housed at Paignton Zoo, Devon. The subjects are described below in Table 1. Their outdoor exhibit houses the giraffes from approximately the hours of 08:30-16:30, post 16:30 they are brought inside to be given an evening feed and secured for the night. Throughout the day the giraffes can access part of the indoor enclosure (section 6), for shelter.

Throughout the study the diet of the giraffes consisted of:

- Dry feed: A mixture of browser pellets, pony cubes, and cabbage- Given morning and early evening.
- Lucerne – Available in feed troughs at all times.
- Dengie Hi-fi – given to Giraffes if they finish their daily allowance of lucerne as it is low in nutrients so has little impact on their weight.
- Browser – Varies randomly on a daily basis according to availability: Hawthorne (*Crataegus),* Ash (*Fraxinus),* Hazel (*Corylus)*, Evergreen Oak (*Querus Ilex),* Cotoneaster (*Cotoneum quince),* Sycamore (*Acer pseudoplatanus),* Bamboo (*Poaceae Bambusadeae)*, Beech (*Fagus)*, Field Maple (*Acer campestre),* Blackthorn (*Prunus spinosa*)**.**

Table 1*:* The Giraffe Subjects Involved in this Observational Study.

Rothschild Giraffe (*Giraffa camelopardalis rothschildi*)	**Initial used to identify giraffe on observation sheet.**	**Sex**	**Age (years)**	**Description**
Tonda	T	Male	1.5	Born at Paignton Zoo, the son of Janica.
Janica	J	Female	6	Born at Dvur Kralove Zoo in the Czech Republic. Mother to Tonda, described as a brilliant one by the keepers.
Sangha	S	Female	5	Born at Liberic Zoo in the Czech Republic. A calm and confident character.
Yoda	Y	Male	5.5	Born at Givskud Zoo, Denmark. Often attention seeking with the keepers.

The giraffes (see Table 1) were observed during a two day pilot study which took place from the 8th July-9th July 2011. The purpose of this pilot study was to: learn about the uniqueness of each giraffe, devise a behavioural observation sheet, divide the enclosure as appropriate for use during observation and finally to test the full observation procedure during two observation sessions on the afternoon of the second day. The giraffes were then observed for two ten-day periods for research purposes. The first observation period occurred from the 11th July – 20th July 2011 and the second from the 13th September – 22nd September 2011.

Four behavioural observations were made on each study day during the hours of daylight (10:00-18:00) from various locations around the exhibit (see Figure 1), using scan instantaneous sampling (Martin & Bateson, 2007). Each day, three observations were carried out when the giraffes were outdoors and one once the giraffes were brought indoors. The behaviour the subject was performing (see Table 2), the area of the enclosure that the subject was in (see Figures 1 and 2), and the number of visitors present at the time were recorded at one minute intervals for thirty minutes, for each observation. All giraffes were observed for a total of forty hours.

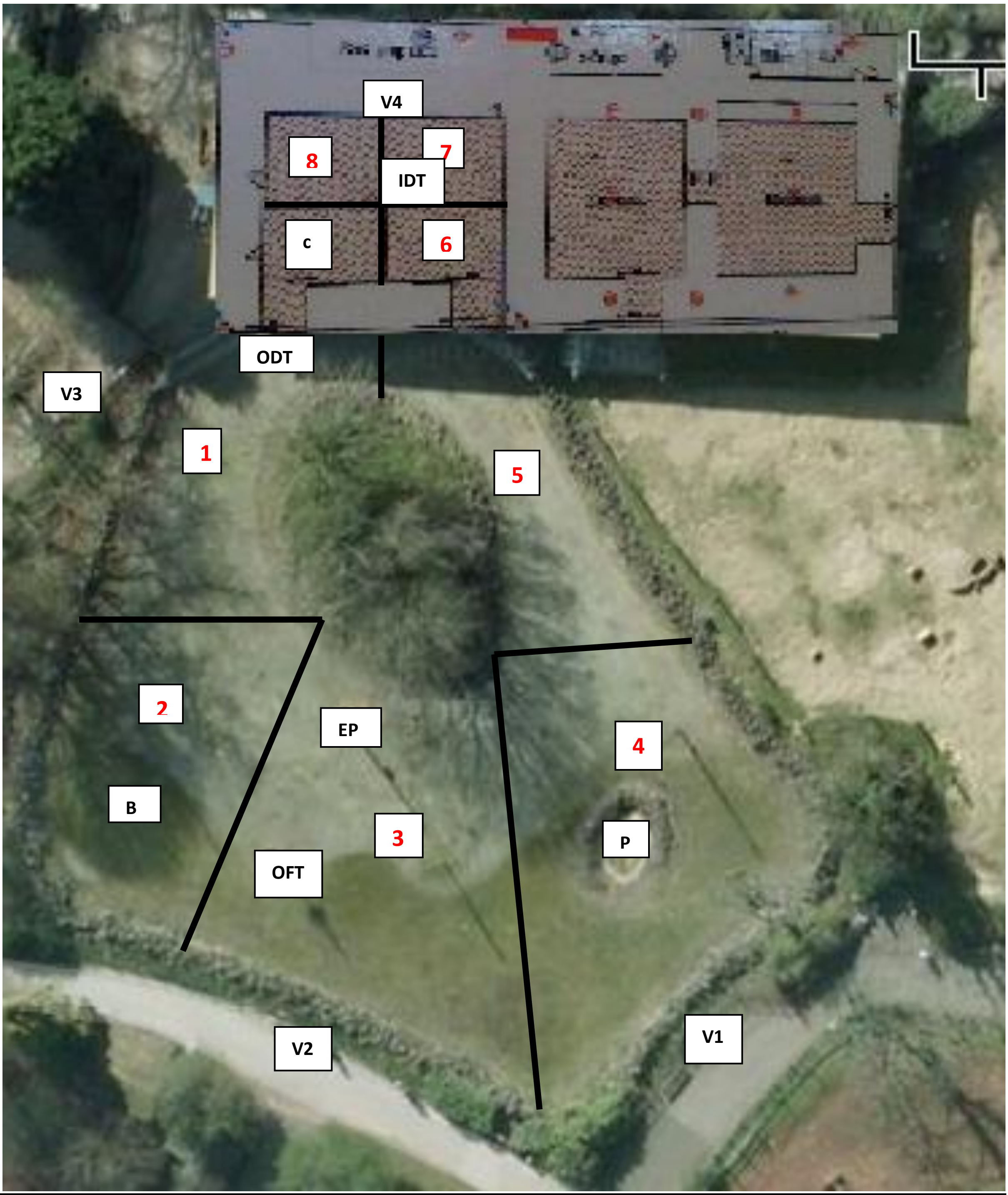

Figure 1: Diagram of the giraffe enclosure at Paignton Zoo showing each enclosure section and viewing stations.

Key: **1**=Enclosure section 1, **2**=Enclosure section 2, **3**=Enclosure section 3, **4**=Enclosure section 4, **5**=Enclosure section 5, **6**=Enclosure section 6, **7**=Enclosure section 7, **8**=Enclosure section 8. **V1**=Viewing area 1, **V2**=Viewing area 2, **V3**= Viewing area 3, **V4**=Indoor viewing platform, **P**=Pond, **B**=Browser location, **OFT**=Outdoor feeding trough, **EP**=Enrichment Post, **C**=Crush, **ODT**=Outdoor drinking trough, **IDT** = Indoor drinking trough.
Note: This image is too small to show all indoor feeding locations.

Enclosure Section 1
- Open outdoor area contains drinking trough
- Gravel floor

Enclosure Section 2:
- Open outdoor area containing browse
- Gravel floor

Enclosure Section 3:
- Open, outdoor area containing feeding trough and enrichment post
- Gravel floor

Enclosure Section 4:
- Open outdoor area containing a pond
- Gravel floor

Enclosure Section 5:
- An open area to the right of the central trees
- Gravel floor

Enclosure Section 6:
- Part of the indoor housing area
- Wooden flooring
- Shelter
- Access to feed on occasion

Figure 2: Description of Outdoor Enclosure Sections as Indicated on figure 1.

Indoor enclosure sections include sections 6 and 7 for Tonda, Sangha and Janica, where they had free roam between the two. Yoda was confined to section 8 so was not able to be analysed for indoor enclosure use.

Table 2: Description of behaviours used for collecting data.

Behaviour	**Description of behaviour**
Sleeping (standing)	The subject is stood stationary whilst in a natural periodic state of rest, their eyes closed and consciousness is completely or partially lost; a decrease in bodily movement and responsiveness to external stimuli.
Sleeping (lying)	Subject is lying on the ground whilst in a natural periodic state of rest, their eyes closed and consciousness is completely or partially lost; a decrease in bodily movement and responsiveness to external stimuli.
Resting (standing)	Subject is stood stationary/motionless but not asleep, they are aware of surrounding stimuli and fully conscious.
Resting (lying)	Subject lying on the ground, but they are aware of surrounding stimuli and fully conscious.
Individual play	Subject responding to stimuli and engaging in activity for enjoyment and recreation rather than a serious or practical purpose.
Social play	Subject responding to each other and engaging in activity for enjoyment and recreation rather than a serious or practical purpose.
Social interaction	Subject interacting with each other, for examples: nudging, rubbing noses, sniffing.
Autogrooming (standing)	Subject self-grooming either by nibbling or licking their fur/mane whilst standing motionless
Autogrooming (lying)	Subject self-grooming either by nibbling or licking their fir/mane whilst lying down.
Allogrooming (standing)	Subject grooming another conspecific whilst standing motionless
Allogrooming (lying)	Subject grooming another conspecific whilst lying down.
Drinking from outdoor trough	Subject consuming water from the water source positioned in section 1.
Drinking from indoor trough	Subject consuming water from the water source positioned in section 7.
Drinking from pond	Subject consuming water from the pond positioned in section four.
Locomotion (walking)	The subject is manoeuvring from one position to another at a normal walking pace.
Locomotion (galloping)	The subject is moving from one position using a three beat gate, faster than a walk, but slower than a canter.
Paying interest in visitors (walking)	The subject is appearing to directly observe the visitors in their view whilst manoeuvring from one position to another.
Paying interest in visitors (lying)	The subject is appearing to directly observe the visitors in their view whilst lying on the floor.
Paying interest in visitors (standing)	The subject is appearing to directly observe the visitors in their view whilst standing motionless
Stereotypic behaviours	Invariant and repetitive behaviours with no clear goal or function (Mason 1991)
Interaction with enrichment	Subject uses their environment in a natural, species-specific manner.
Eating from outdoor feed trough	Subject feeds from the lucerne held in the feed trough in enclosure section 3.

Eating from floor under outdoor feed trough	Subject feeds from the lucerne that has fell out of the feed trough and that is on the floor beneath it in section 3.
Eating from browser	Subject feeds from the browse which is hung from the post in enclosure section 2.
Eating from floor under browser	Subject feeds from the browse that has snapped off and fell beneath the branches in enclosure section 2.
Eating natural vegetation	Subject eats from the natural plants and trees within and around their enclosure.
Chewing cud (standing)	The subject regurgitates their food from the first stomach to the mouth and chews it again whilst standing motionless.
Chewing cud (walking)	The subject regurgitates their food from the first stomach to the mouth and chews it again whilst moving from one position to another.
Other	Any other behaviours that occur which are not listed above.

Statistical Analyses

Spread of Participation Index (SPI)

The data collected on the giraffes enclosure use for both indoors and outdoors was subjected and a modified Spread of Participation Index (SPI) was calculated to determine their use of available space (Plowman 2003). The modified SPI is the same mathematical equivalent of the original SPI, but offers a more accurate and acute analyses of enclosure utilisation (Plowman 2003).

The modified Formula:

$$\textbf{SPI=}\ \frac{\sum|\boldsymbol{fo-fe}|}{\mathbf{2}(\mathbf{N}-\boldsymbol{fe\ min})}$$

> Where f_o is the observed frequency of observations in an enclosure section and f_e is the expected frequency of observations within an enclosure section; this is based on enclosure section size when enclosure use is assumed to be even. The difference between f_o and f_e is termed the absolute value, and represented by the symbol: |*fo-fe*|**,** which is summed for all enclosure sections by ∑. N is used to represent the total number of observations in all enclosure sections; finally fe_{min} is the expected number of observations in the smallest zone.

The SPI value of 0 implies maximum equal use of all enclosure sections; contrastingly an SPI value of 1 suggests that the giraffe spent all its time in just one enclosure section, thereby showing minimal utilisation of the whole enclosure.

Chi-Squared Goodness of Fit

The chi-squared goodness of fit statistical model was used to determine how close the observed values were in conjunction with the values expected under the fitted model (Eddison 2000). The goodness of fit chi-squared was used to analyse both enclosure use and exhibition of behaviour, to determine if particular enclosure sections/behaviours were used/exhibited more or less than would be expected if used/exhibited randomly. Standardised residual was then calculated to determine whether the differences between the observed and expected values (later referred to as the absolute value) were significant, if the value was greater than 1.96 (+1.96), or less than 1.96 (-1.96) then the value was considered significant (Eddison 2000).

The relative proportion of each enclosure section size (see Table 3) for the outdoor enclosure was used to calculate the expected values for enclosure use.

Chi-Squared Goodness of Fit Formula: $\sum \frac{(O-E)^2}{E}$

Standardised Residual: $\sum \frac{(O-E)}{\sqrt{E}}$

Where O = the observed frequency of the behaviour and E = the expected frequency of the behaviour.

Table 3: Table showing the relative outdoor enclosure section sizes, used for chi-squared (goodness of fit) analyses.

Enclosure Section	Relative Proportions of Outdoor Enclosure Section Size
1	0.134
2	0.175
3	0.268
4	0.268
5	0.113
6	0.041

Results

Spread of Participation Index (SPI)

Spread of Participation Index (SPI) for Outdoor Enclosure Use:
The spread of participation indices in the outdoor enclosure for each giraffe are shown in Figure 3.

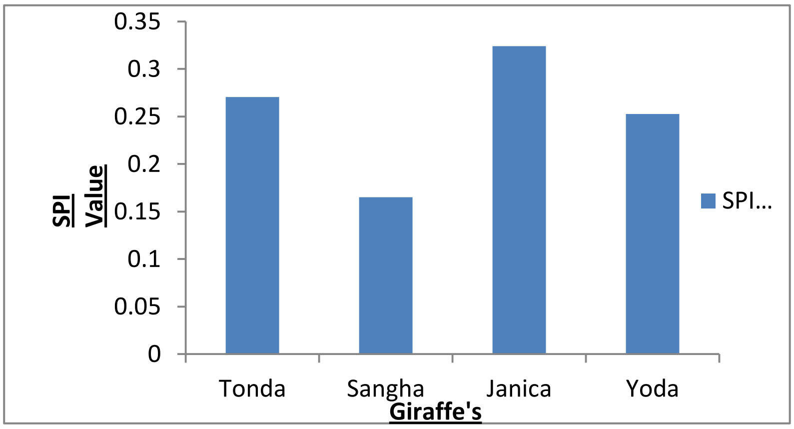

Figure 3: The spread of Participation Index for Outdoor Enclosure Use

The giraffes appear to differ with respect to their preferring particular enclosure sections over others (see Figure 5), thereby showing that the enclosure is not used equally. Sangha had the lowest SPI of 0.164986 suggesting minimal bias for enclosure section use, Yoda and Tonda had a slightly stronger but still minor preference for some sections over others, proven by SPI results of 0.252715 and 0.270424 respectively. Finally Janica had the largest SPI value of 0.323952, implying that she is the most particular about enclosure use. The SPI concludes that although each enclosure section is not used equally by the giraffes, the values are near 0, which indicates only minor preference for some sections over others.

Spread of Participation Index (SPI) for Indoor Enclosure Use:
The spread of participation indices for indoor enclosure use are shown in Figure 4.

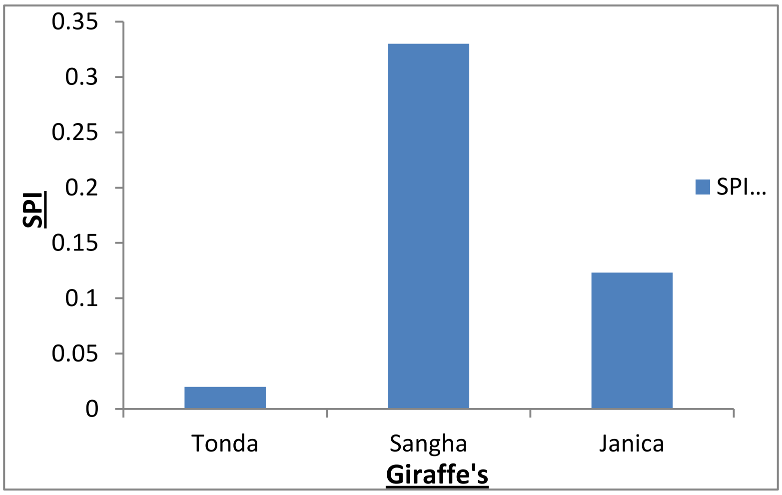

Figure 4: The spread of Participation Index for Indoor Enclosure Use for Tonda, Sangha and Janica.

Similarly to outdoor enclosure use, the giraffes were also statistically proven to have individual preferences for indoor enclosure section (see Figure 6). The SPI values indicate unequal enclosure use (see Figure 4). Tonda shows slight preferences between sections 6 and 7 with an SPI of 0.02. His time was therefore nearly spread evenly between the two indoor sections. Janica on the hand had a slight bias for one section over another with an SPI of 0.123333. Contrastingly to outdoors where Sangha was the most particular, proven by an SPI of 0.33, she is therefore the most selective when using the indoor enclosure.

Chi-Squared Goodness of Fit for Outdoor Enclosure Use:
When used to analyse outdoor enclosure use the chi-square test showed significant differences between the observed enclosure use values and the expected (see Figure 5): Tonda (X^2=1495.31; D.F. =5, P<0.001); Sangha (X^2=769.975; D.F. =5; P<0.001); Janica (X^2=1737.45; D.F. =5; P<0.001); Yoda (X^2=1660.91; D.F. =5; P<0.001). Subsequent analyses and standardised residuals showed that enclosure section 6 was used significantly more than expected by all of the Giraffes; enclosure section 2 by Tonda, Janica and Sangha, section 5 solely by Janica and section 3 by Yoda. Whilst on the other hand enclosure sections used significantly less than expected by all Giraffes included sections 1 and 4. Tonda, Sangha and Janica used enclosure sections 3 significantly less than expected, Tonda, Sangha and Yoda used enclosure section 5 significantly less than expected and Yoda was the only giraffe to use enclosure section 2 significantly less than expected.

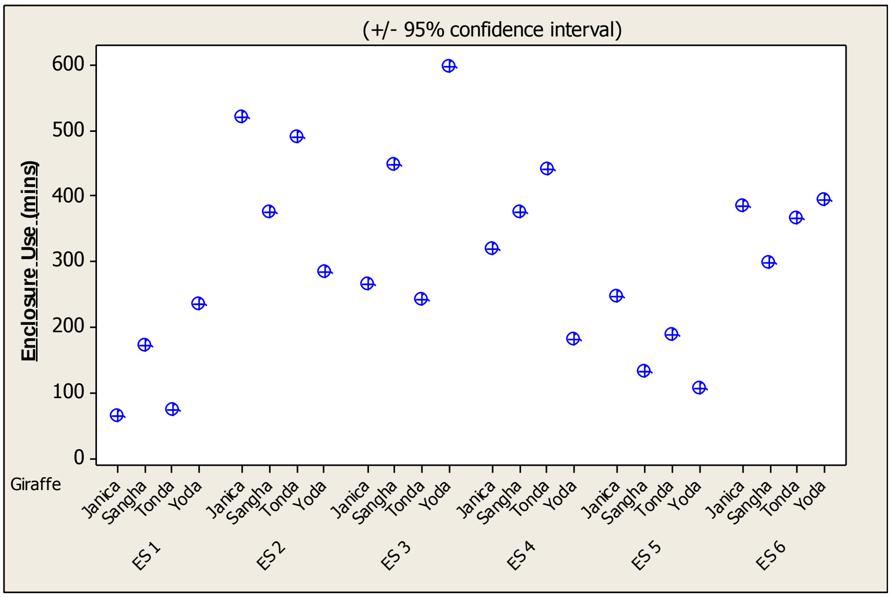

Figure 5: The frequency of behaviours exhibited in each outdoor enclosure section for Tonda, Sangha, Janica and Yoda, shown in alphabetical order.

Key: **ES 1** = Enclosure Section1, **ES 2** = Enclosure Section2, **ES 3 =** Enclosure Section 3, **ES 4** = Enclosure Section 4, **ES 5 =** Enclosure Section 5, **ES 6** = Enclosure Section 6

Chi-Squared Goodness of Fit for Indoor Enclosure Use:

The chi -square test showed significant differences between the indoor enclosure use observed values and the expected (see Figure 7): Tonda (X^2=636.853; D.F. =13; P<0.001); Sangha (X^2=1707.11; D.F. =18; P<0.001) Janica (X^2=1531; D.F. 18; P<0.001). Subsequent analyses and standardised residuals showed that enclosure section 7 was used significantly more than expected by Sangha, whereas enclosure section 6 was used significantly more than expected by Janica; and vice versa. Tonda did not use either section significantly more or less than expected.

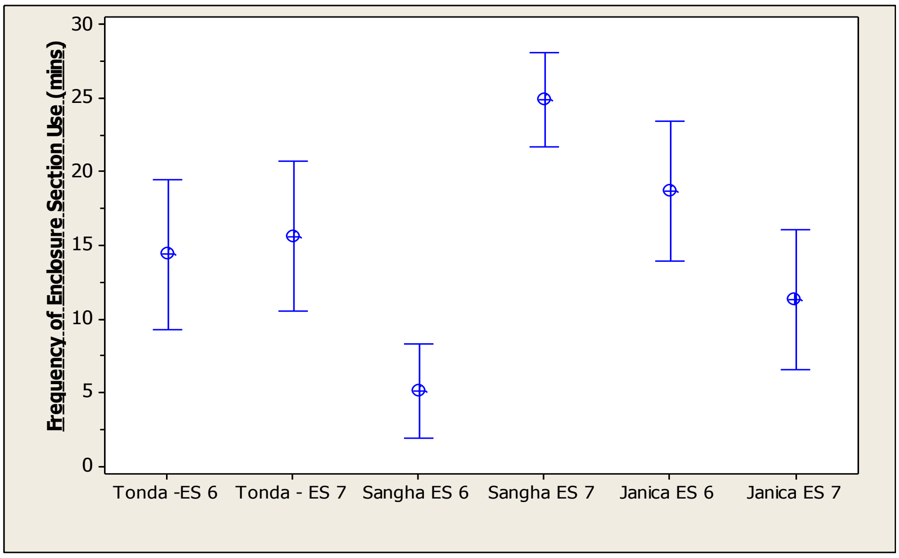

Figure 6: The frequency of behaviours exhibited in each indoor enclosure section for Tonda, Sangha, and Janica.

Key: **ES 6** = Enclosure Section6, **ES 7** = Enclosure Section 7.

Chi-Squared (Goodness of Fit)

Chi-Squared Goodness of Fit for Outdoor behavioural Observations:
The chi-square test showed significant differences in the performance of behaviours from expected values for all four Giraffes: Tonda (X^2 = 3929.62; DF = 18; P<0.001); Sangha (X^2=3961.49; D.F. =19; P<0.001); Janica = (X^2=3860.35; D.F. =18; P<0.001); Yoda (X^2=4332.84; D.F. =19; P<0.001). Subsequent analyses and standardised residuals showed that the following behaviours were exhibited more than expected (p<0.001) by all of the giraffes: Resting (standing) (13.25% of activity budget [a.b]); Eating from browser (20% a.b) and Chewing Cud (Standing) (24% a.b). Tonda additionally ate from the floor under the outdoor feed trough more than expected, whilst Sangha, Janica and Yoda ate from the outdoor feed trough itself more than expected. However there were individual differences in the amount of time spent performing feeding behaviours between the giraffes. Janica and Tonda favoured feeding from the browser, spending 23.56 % and 24.96% of their time doing so respectively; whereas Yoda and Sangha spent a higher percentage of time feeding from the outdoor feed trough, 30.11% and 20.83% respectively. The giraffes chewed cud on average for 24% of their time. There were individual differences between the amount of time the giraffes spent resting: Tonda, 13.56%; Sangha, 15.61%; Janica, 18.39% and Yoda, 5.44% (see Figure 8).

Behaviours performed less than expected for all subjects include: Social Interaction (0.96% a.b); Allogrooming (0.26% a.b); Autogrooming (1.07% a.b); Paying Interest in Visitors (Standing) (1.29% a.b); Eating natural Vegetation (1.92% a.b.); chewing cud (walking) (2.46% a.b); Interaction with enrichment (0.56% a.b), and other (1.92% a.b). Additionally some giraffes performed behaviours others did not (see Figure 8), most of which occurred to a significantly lesser extent than expected; an exception being Sangha who locomoted walking for 6.67% of her activity budget, significantly more than expected; whereas Tonda, Janica and Yoda, locomoted for: 3.72%, 4.5% and 3.56% respectively.

The following behaviours were not exhibited to an extent which differed significantly from expected: Tonda = Resting (standing), Janica = locomotion (walking) and Yoda = Resting (standing).

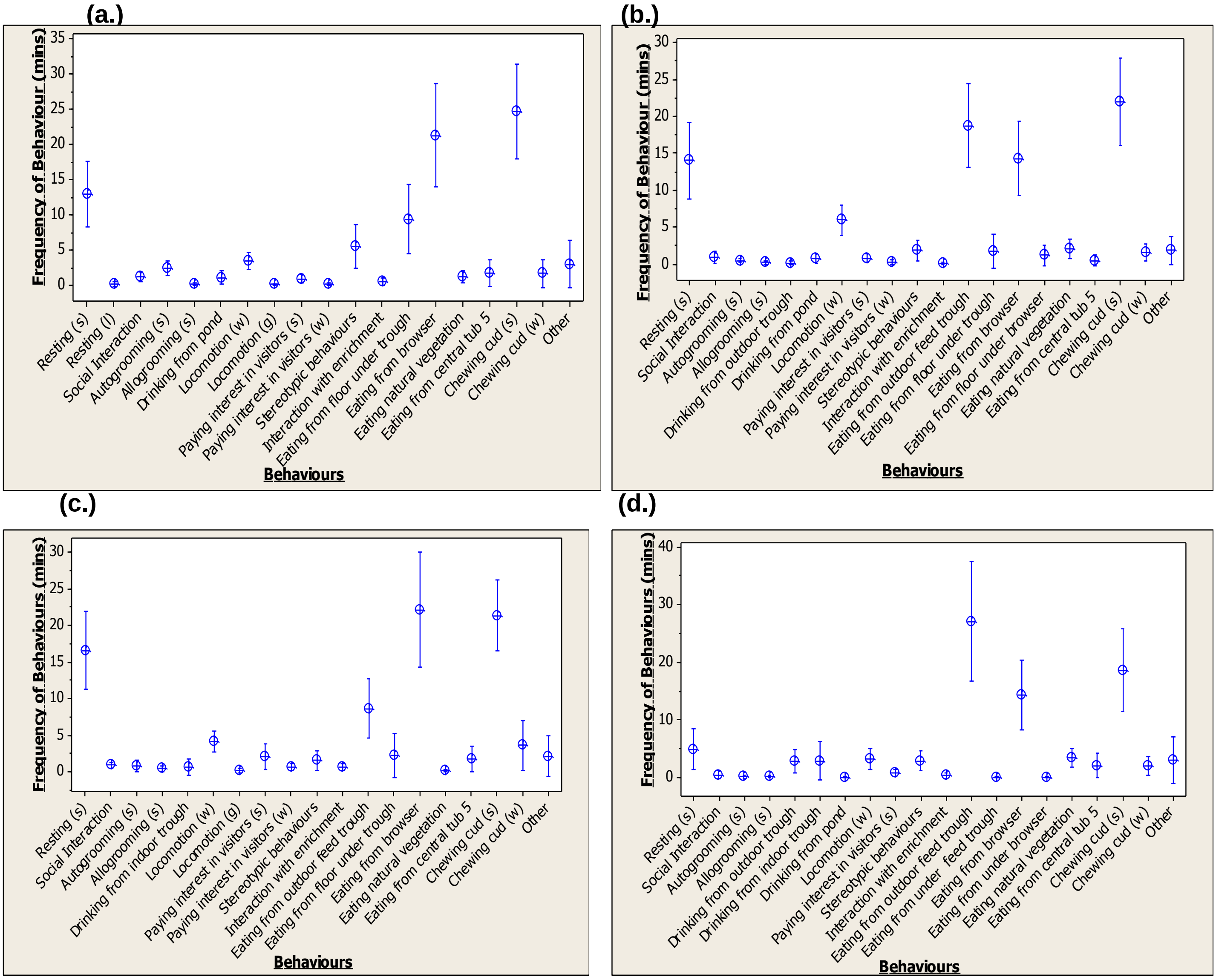

Figure 8: The mean duration (minutes) of outdoor behaviour during 1800 minutes of observation for all four Giraffes, showing ± 95% confidence interval. **(a.)** Tonda **(b.)** Sangha **(c.)** Janica **(d)** Yoda.

Chi-Squared Goodness of Fit for Indoor behavioural Observations:

The results from the chi-square test for exhibition of indoor behaviours showed significant differences in the performance of some indoor behaviours from expected Tonda (X^2=636.853; D.F. =13; P<0.001); Sangha (X^2=1707.11; D.F. =18; P<0.001); Janica (X^2=1531.42; D.F. =16; P<0.001); Yoda (X^2=1236.64; D.F. =11; P<0.001). Subsequent analyses and standardised residuals showed that none of the behaviours were performed significantly more than expected by all of the giraffes, partly due to Yoda's constraint to a separate enclosure section, but also due to individual differences (P<0.001). All giraffes collectively ate from the indoor tubs significantly more than expected as shown in Figure 8, but with individual preferences as to which tub they ate from. Tonda showed the least preference eating significantly more from tubs: 1 (21.5% a.b), 2 (17.67% a.b) and 3 (19% a.b). Tonda, Sangha and Janica ate from the indoor basket (15.17% a.b, 10% ab , 13.83% a.b) significantly more than expected, whereas Yoda was the only giraffe to eat from central tub 5 significantly more than expected (13.33% a.b). Additionally Janica was the only giraffe to exhibit the following behaviours more than expected: Stereotypy (7.83% a.b) and Chewing Cud (standing) (9.33% a.b) whilst Yoda was the only giraffe to eat from a hay net more than expected (35.33% a.b).

All of the giraffes exhibited the following behaviours less than expected: Social Interaction (1% a.b); Locomotion (walking) (1.5% a.b); and other (1.6% a.b). A few behaviours were also exhibited by three of the giraffes to a significantly lesser extent than expected, including: Resting (standing), Autogrooming (Standing), stereotypy and chewing cud (Walking); whilst all other behaviours, excluding those listed as being insignificant below, were exhibited to a significantly lesser degree than expected but by only one or two of the giraffes as shown in Figure 9.

Behaviours which were not exhibited to an extent which differed significantly from expected include: Tonda = Eating from central tub 5; Sangha = Resting (standing), Eating from Indoor Tub 1 and Chewing cud (standing) and Yoda = Chewing cud (standing).

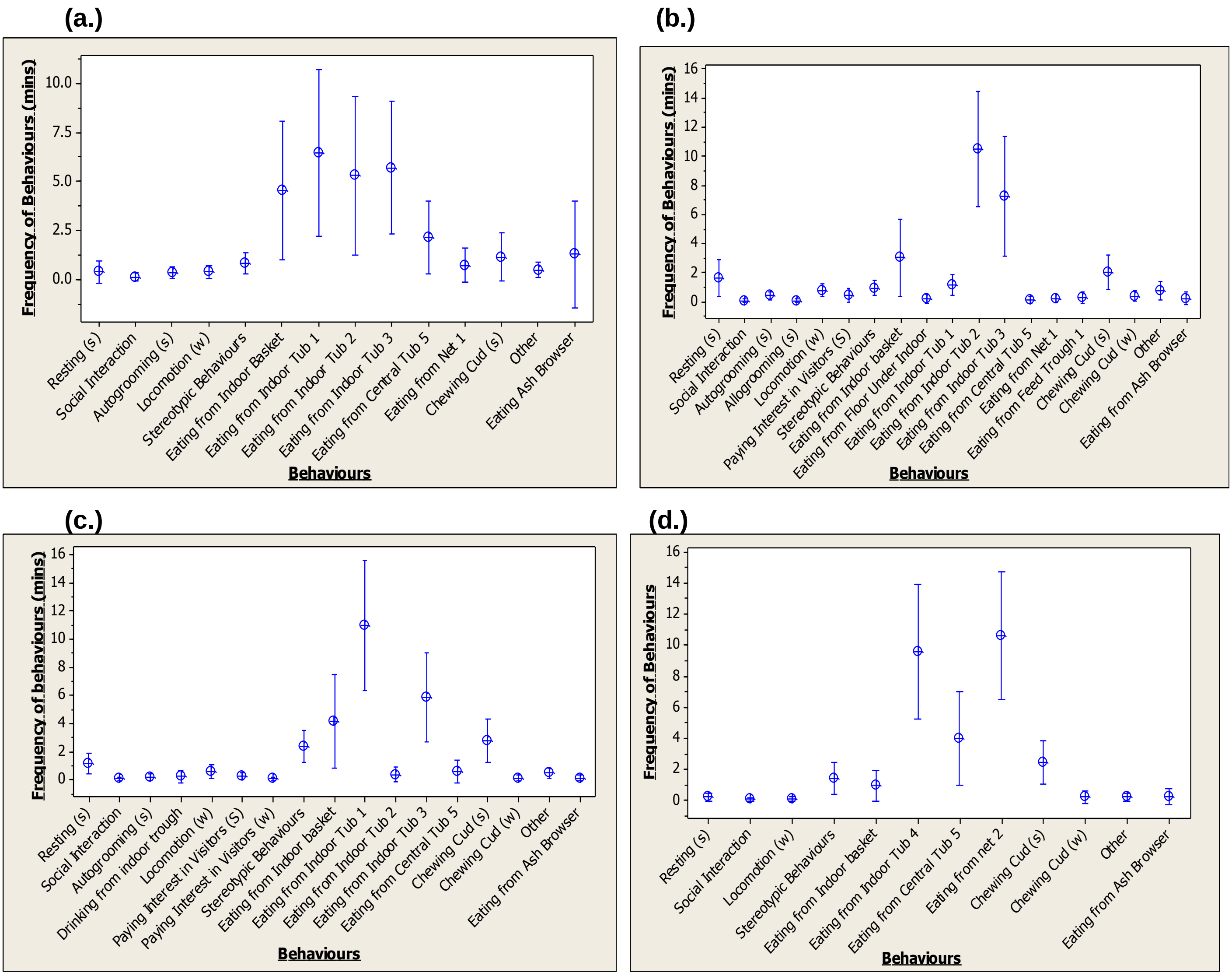

Figure 9: The mean duration (minutes) of outdoor behaviour during 600 minutes of observation for all four Giraffes, showing ± 95% confidence interval. **(a.)** Tonda **(b.)**Sangha **(c.)** Janica **(d)** Yoda.

Discussion

It is suggested that the giraffe's use of their environment at Paignton Zoo is influenced by environmental preferences and resources, biological factors and social factors. The constraints and limitations of their captive enclosures showed minimal behavioural change which implies an appropriate captive environment for the giraffes. The results reveal that the giraffes at did not use their enclosure evenly, as some enclosure sections were used significant more or less than expected; and they exhibited some behaviours significantly more or less than expected. But after extensive research these results can be justified, as discussed below.

Outdoor Enclosure Use

The chi squared and standardised residual results show that some areas of the outdoor enclosure were used significantly more than expected. These areas included: section 6 for all of the giraffes; section 2 for Tonda, Sangha and Janica, and additionally section 5 for Janica, and 3 for Yoda. It may be suggested that the giraffes favoured section 6 due to its sheltering properties. As section 6 is indoors, it offers protection from the wet, cool, weather that occurred during most of the observation period. Rothschild giraffes are native to African Savannahs (Pellew 1984), a much warmer and dryer climate to that of Paignton, England; the tall slender physique of giraffes is therefore designed to dissipate heat, and has a negative effect when weather is poor. Giraffes have a large surface area to body ratio, the dark patches of their skin have many blood vessels beneath them, which vasodilate during hot weather to encourage heat loss (Sathar et al. 2010). Giraffes are therefore limited to protecting themselves from cold weather by seeking shelter. Section 6 also offers refuge from the presence of visitors; although the giraffes showed little reaction to visitor presence, visitors may cause negative physiological reactions not visible by observation alone; the giraffes' movement away from open enclosure areas to indoors may therefore be an escape response (Mallapur et al. 2005). Many studies have demonstrated the negative effect of visitor presence on the behaviour of captive animals (Wells, 2006). Feeding-anticipation, may be another contributory cause for the giraffes to favour section 6. On occasion, if the giraffes finished their outside feed by early afternoon the zoo-keepers supplied dengie hi-fi indoors in central tub 5; they also encourage the giraffes into section 6 at 16.30hours for an evening feed. The giraffes may therefore have associated section 6 with the provision of food, as demonstrated studies on carnivores this motivates them to spend time anticipating the arrival of their next feed (Fernandez 2009).

The results indicate that Section 2 was used significantly more than expected by Sangha, Janica and Tonda; a possible reason being the provision of browse in this enclosure section. Contrastingly, Yoda was the only giraffe to spend significantly more time in section 3 than expected, a probable explanation being the presence of hay which contributes too many large herbivorous captive diets as part of enrichment (Baxter & Plowman, 2001; Clauss & Hatt, 2006; Codron et al. 2011). Reasons for the favoured enclosure sections shall be discussed under the behavioural sector later on in the discussion in association with feeding behaviour. It is strongly proposed that the location of the feeding stations has a strong influence on enclosure section use. Giraffes are estimated to feed hourly (Dagg & Foster 1976), contributing to "53%" of their time in the wild (Pellew 1984) in order to max their energy intake and meet their high nutritional requirements and metabolic demands (Pellew 1984; Baxter & Plowman, 2001; del Castillo et al. 2005; Fernandez et al. 2008).

The results suggest that the confinements of captivity do not negatively affect the giraffes behavioural repertoire; this may be because spatial distribution of the essential resources provides opportunity for the giraffes to use their enclosure adequately to exhibit all behaviours, which are expected to be observed within their natural home range (Makarieva et al. 2005). Janica spent a significant amount of time in section 5, which is where the giraffes were witnessed to often chew cud. The other giraffes, did not use this section as much as expected, nor did any giraffe use sections 1 or 4. This may be because these areas do not offer resources necessary for their survival. To make more effective use of these enclosure sections, the keepers could supply more sources of feeding enrichment such as tongue twisters (Fernandez et al. 2008); this would reduce dominance behaviour by Yoda and encourage the giraffes to spend more time feeding. Sections 1 and 4 are also close to observation zones, so adding an additional barrier to increase the distance between the giraffes and the public may also be effective.

Indoor enclosure use

Tonda had no strong preferences as to which enclosure section he fed in, you would expect two giraffes to feed in section 7 as this had the provision of lucerne (nets) and two feeding tubs, whereas section 6 only has one feeding tub. However, Tonda spent nearly half his time in each enclosure section whilst Sangha predominantly occupied feeding stations in section 7 and Janica in section 6. This occupancy of enclosure sections may be habituated behaviour. Janica and Sangha have been at Paignton Zoo for much longer than Tonda and may therefore have become accustomed to routine, due to the lack of variability in their feeding regime (Poole 1995). Tonda may also choose to share Janica's feeding tub in section 6 due to mother-off spring relationship, as has been demonstrated in previous studies (Pratt & Anderson 1985; Becker & Ginsberg, 1990; Bercovitch & Berry 2010). Tonda may feel more secure sharing Janica's feeding station as she is less likely to exhibit age related dominance than Sangha due to their stronger social bond (Bashaw et al. 2007).

Outdoor and Indoor Behavioural discussion

Data from both the indoor and outdoor behavioural observations suggest that the giraffe's most predominant behaviours were feeding behaviours, with the addition of resting and chewing cud for outdoor observations. However, the limited data on indoor behavioural observations means that the results are subjected to observation bias. Only half an hour's worth of observations was conducted daily when the giraffes were indoors; which specifically occurred during feeding time. The indoor observations were therefore subjected to minimal variability and were not a true reflection on the captive giraffes' indoor behavioural repertoire. All of the observed behaviours shall therefore be discussed regarding the outdoor data as this offers a more reliable guide to captive giraffe behaviour.

Resting is a natural part of wild giraffe behaviour and often occurs when the sun is at its highest (Du Toit & Yetman, 2005). The results show that the captive giraffes rested for significantly more time, or as much time as expected. This resting behaviour was observed to partake in the afternoon once the subjects had consumed most of their food. A potential explanation is given by Caister et al. (2003), who observed giraffes to not forage in the afternoon during excessively hot weather conditions, but to spend most of their time resting in the shade until early evening. Although the weather is unlikely to be a large contributing factor in Paignton, England, it could be a natural response to the giraffe's circadian clock to rest when the sun is at its highest. Alternatively, Siegel (2005) claims that giraffes sleep for as little as "3-4 hours" a night, they could therefore take the opportunity to rest during bouts of feeding.

It is suggested that wild giraffes spend the majority of the day and part of the night feeding, with a higher frequency of feeding behaviour occurring in the early morning and late afternoon (Innis 1958; Pellew 1984). This pattern of feeding was replicated by the subject giraffes, which is expected due to their innate and stimulus-driven (by the presence of their feed) motivation to feed at these times (Veasey et al. 1996). The giraffes spend large proportions of their morning feeding from the outdoor feed trough (or under it, in the case of Tonda) and from the browser; and feed again in the late afternoon when food is provided inside. As browse has slow fermentation properties (Owen-Smith 1979), the keepers combat this by providing the nutritious lucerne in the outdoor feed trough to ensure daily nutritional requirements are met. Tonda, being the youngest giraffe, was too short to feed from the outdoor feed trough, so ate the lucerne which fell to the floor; this could additionally explain Tondas preference for feeding from the browse in section 2. Feeding from the browse also meant that Tonda did not have to compete with Yoda for dominance over the trough (Moxon, 2008). Due to Yoda's sex and dominant status, he is likely to feed more than the females (Pellew 1984) and have first choice of feeding station. Furthermore Yoda often discouraged other Giraffes from feeding at the same station as him, which inevitably increased his time at the outdoor feed trough and reduced the other giraffes. Similar dominance behaviours have been found in rhesus macaques (*Macaca mulatta*) who share feeders in a small enclosure; the crowding was found to increase dominance-related behaviours (Judge & de Waal 1993) and in chimpanzees (*Pan troglodytes*) (Nieuwenhuijsen & de Waal, 1982).

Sangha and Janica's preference for the browse may alternatively be explained by the keepers' suspicion that both giraffes were pregnant. The females may have spent more time feeding from the highly nutritious browse to optimise their energy reserves as they would if feeding in the wild from Acacia spp (Coe 1998; Skinner & Smithers 1990).

Giraffes are considered to be selective browsers (Bredin et al. 2008), but the trimmed back natural vegetation suggests that the giraffes consume the vegetation surrounding their enclosure when it is in reach. This behaviour was not common during this study as the vegetation was already stripped back too far for the giraffes to eat. Additionally food was only sometimes provided in central tub 5, therefore any observations of this feeding behaviour being exhibited were biased, and the option for them to feed at this station was not always available. Naturally giraffe activity budgets are variable throughout seasons (Veasey et al. 1996), as the giraffes adapt to changes in available diet (Baxter & Plowman 2001; Fernandez et al. 2008; Pellew 1984) and metabolic demands (del Castillo et al. 2005). Further studies must therefore be conducted which consider seasonal changes, record times of feeding and eliminate feeding observation bias for a more accurate discussion to be formed.

Giraffes are foregut fermenters (Mertens 2007). This herbivorous adaption allows them to swallow large particles of food and retain it in the rumen, until regurgitating it as cud at a later time. In the wild, this means that giraffes can increase available foraging time whilst bacterial agents begin digesting the tough fibre from plant materials (Mertens 2007). However in captivity, the Giraffes are provided with adequate food and do not have to waste potential foraging time travelling between feeding grounds. But chewing cud still occurs as part of their digestion. Du Toit and Yetman (2005) found chewing cud to take up "13.1%" of the giraffes activity budget; however the subjects in this experiment spent on additional 11% more of their time chewing cud. Reasons for this may include differences in diet composition, such as the subjects receiving a more fibrous diet requiring greater ruminations time, or observation bias, as the giraffes were only observed for 90 minutes a day; observations may have occurred during times of chewing cud when at other times different behaviours may have been exhibited. It must be mentioned that the giraffes often consumed most of their outdoor feed by early afternoon, which naturally leaves them excess time to fill ruminating (Owen-Smith 1998).

Additionally giraffes are the only species to ruminate whilst walking (Du Toit & Yetman 2005), an adaptation to alleviate their passage constraints (Du Toit & Yetman 2005) which is often restricted due to their large height. In the wild, large herbivorous species have to walk long distances between feeding patches (du Toit & Yetman, 2005) which is when this behaviour would occur. However, due to the spatial limitations of captivity, and the eradication of the need to walk between feeding grounds, the giraffes were not observed to: walk, ruminate whilst walking or gallop for any long time periods. Dagg & Foster (1976) describe a giraffes gallop as reaching speeds of up to “55-65 km/h”, this explains why galloping was only observed on a couple of occasions and for only a few yards.

It could be suggested that the presence of the pond in the giraffe enclosure is for enrichment purposes as opposed to provision of water. Three of the giraffes infrequently used the pond for drinking, whilst Janica did not use it at all. Whilst wild giraffes are partially dependent on waterholes to obtain water, the captive subjects are provided with a water trough at head height which eliminates their need to use the pond.

Grooming (auto and allo grooming) is considered by most, as an essential act to maintain the body’s surface. However some research suggests that it is also a mechanism to reduce arousal and relax the animal exhibiting the behaviour (Spruijt et al. 1992), as it is often triggered in contemporary stressful situations as a displacement behaviour (Munksgaard & Simonsen 1996; Herskin et al. 2004a; Herskin et al. 2004b). It may therefore be favourable that none of the giraffes groomed themselves or each other as much as expected. Further evidence to support this comes from Hansen and Berthelsen (2000) who found higher rates of autogrooming in rabbits kept in barren enclosures. Likewise, excessively restrictive enclosures and overcrowding have also been found to increase rates of autogrooming in dairy calves (Kiley-Worthington, 1983; Kerr and Wood-Gush, 1987; Feh & de Mazieres, 1993; Le Neindre, 1993; Jensen, 1995; Ferrante, 1998). One explanation for low rates of allogrooming could be that proposed by Spruijt, et al. (1992) who asserts that higher occurrences of allogrooming are observed when horses fail to conceive than when conceiving is successful. This is a potential explanation as both female giraffes were suspected to be pregnant at the time of observation. An alternative explanation, favours the idea that allogrooming reduces stress. Research suggests that the frequency of allogrooming can be an indirect symbol of mild ‘social stress’ and tension in herds and groups of animals (Spruijt et al. 1992; Sato et al. 1993; Feh & de Mazieres 1993). Allogrooming being exhibited amongst animals in stressful environments has been found to increase β-endorphin levels amongst primates (Keverne et al. 1989) and reduce the heart rates of primates (Boccia et al. 1989; Aureli et al. 1999), cattle (Sato et al. 1993) and horses (Feh & Mazieres, 1992; McBride et al. 2004).

Giraffes are observed to lay down; both in the wild and in captivity (Innis 1958; Leuthold 1979; Tobler & Schwierin 1996). In the wild, during the summer this behaviour is exhibited more often as food is abundant, the Giraffes therefore do not have to dedicate as much time in search of food, so have more time during the day to rest, chew cud and lay down (Innis 1959). However lying down is a difficult procedure for giraffes, due to their long legs and height; getting back on their feet again is equally challenging (Van Niekerk & Pienaar 2009), hence why this behaviour was only observed by Tonda, the smallest/youngest giraffe. A further reason, proposed by the keepers at Paignton Zoo is that the outdoor enclosure substrate is gravel, which would be uncomfortable for the giraffes to lay down on (Personal Communication, 2011).

Giraffes are thought to fit into the fission-fusion model of social relationships; thereby being a society whom consists of sub groups that have a temporary formation and dissolution structure, which varies in number across a large scale community (Bashaw et al. 2007). In the wild the giraffes are likely to reinforce their social relationships by social interaction after periods of time spent apart; whilst in captivity, the giraffes are always within close proximity, so may not feel the need to reinforce these bonds as much. Jarman (1974) supports this view, he proposes that social relationships are innately determined because they are a function of the evolutionary environment and so will always be present to an extent, the extent of which is dependent upon the environment in which the giraffes live. Crook et al.'s (1976) asserts that the few social behaviours still present in captivity occur as sociality is fundamental to mammalian society, Veasey et al. (1996) agrees, he claims that social relationships may be important in the lives of captive giraffes. Although contrastingly, Bashaw (2011) suggests that social behaviours are not strongly dependent on the environment.

Providing enrichment for captive giraffes is difficult unless feed based. According to the keeper at Paignton Zoo, the subject giraffes are not interested in manipulable objects or toys as a form of enrichment, but do enjoy the provision of browse. The Giraffes at Paignton Zoo have a barrel with holes in, hanging from a post in section three of their enclosure but it is unused. As stated by Zaragoza et al. (2011), It is vital to provide wild animals in captivity with environmental enrichment to improve their psychological and physiological well-being and to increase activity and behaviours within their repertoire. The introduction of different feeding enrichment could therefore be beneficial for these giraffes, particularly in unused enclosure sections. It could lengthen the amount of time the giraffes spend feeding and encourage them to elicit more natural behaviours. In the wild the giraffes have to select the edible parts of trees and shrubs, using enrichment such as tongue twisters could therefore enhance this natural behaviour (Fernandez et al. 2008).

There are three potential effects of visitor presence: a negative influence, form of enrichment or a changing variable that has no affect (Kawata 1971; Snyder 1975; Hosey 2000). But the fact that the giraffes show no significant interest in the visitors whilst standing or walking suggests that the visitor's role is the latter. Occasionally the giraffes approached a crowed of visitors, but never cautiously. The Zoo keepers also offered a 'meet the giraffes day', where-on the giraffes would willingly take food from a guest's hand. Yoda was the most confident giraffe as he was regularly trained by zoo staff in the crush. A potential reason for the giraffes' confidence or lack of effect by visitor presence is their size. It is suggested that larger animals, like the giraffe are more likely to be non-responsive to visitors as they do not perceive the visitor to be a risk (Chamove et al. 1988; Hosey 2000; Margulis et al. 2003). A further reason could be that the giraffes have merely become habituated to the presence of strangers around their enclosure after spending years in captivity (Hosey 2005). Only when an exceptionally large and noisy crowed approached the enclosure, would the giraffes respond.

Stereotypy in giraffes is said to be environmental dependent, with higher rates of oral stereotypy often occurring in barren indoor enclosures (Carlstead 1998; Bashaw 2011). The giraffes in this experiment were found to exhibit stereotypical behaviours to a significantly lesser extent than expected or as in the case for Tonda, to a non-significant degree. The stereotypical behaviours which were exhibited often occurred indoors and were specifically oral stereotypies. The presence of bars in particular offer targets for oral stereotypies to be exhibited and are not natural to the giraffe, this suggests that the presence of oral stereotypies are stimulated by an abnormal organism–environment interaction (Carlstead 1998).

Limitations of the Study and Ideas for further research:

Due to the study being conducted in a zoo environment, the researcher only had permission to observe the giraffes during diurnal hours 10.00-18.00. Indoor observations were therefore limited to giraffe feeding times. The giraffes are encouraged to move inside at 16:30 hours and the indoor observations began when the giraffes were provided with an evening feed; this is natural for them as in the wild late evening is an optimal time period for foraging (Georgii 1981; Owen-Smith 1998). As the indoor behavioural data suggests, feeding was the paramount behaviour during this observation period; particularly from the indoor tubs which contained browser pellets, pony cubes, and cabbage. However all of the indoor observations are subject to observer bias; as previously mentioned, giraffes are thought to have an innate and stimulus drive to feed, they therefore unlikely to exhibit any other behaviour during the thirty minutes when food is abundant. The data extracted from these observations are therefore inaccurate records of the giraffe's indoor behaviour and should not be relied upon for any other purpose than feeding preferences. Additionally, browser material was only inserted into the indoor basket once the giraffes had consumed most of their pelleted feeds, records of giraffes feeding from the indoor basket are therefore also subject to bias due to time and application of the browse, and when observations were being conducted. For an improved analysis of indoor enclosure use and behavioural observations with the elimination of observation, one therefore proposes increased observations throughout the night of the captive giraffes.

The overall data analyses does not highlight what enclosure sections individual behaviours occurred in, to get a better, fuller and more detailed understanding of enclosure use a cross tabulation is recommended.

Conclusion

In conclusion, the studied group of four captive giraffes at Paignton Zoo exhibited a variety of behaviours, which after analysing previous research on wild counterparts, can be suggested to have occurred in their relative proportions as expected from a natural behavioural repertoire. This suggests that the giraffes are currently experiencing good welfare standards and adequate living conditions for a large captive herbivorous species. Due to the constraints of captive environments some behaviours which are found more abundantly in the wild are reduced in the captive environments as individuals have acclimatized to changes in diet, space and metabolic demand. The study suggests that the captive enclosure design influences the giraffe's behavioural repertoire, particularly in relation to feeding. But overall the giraffes cope well in a captive environment and do not elicit any behaviours of concern; total enclosure use however could be improved by the provision of more enrichment.

Acknowledgements
I would like to thank the staff at Paignton Zoo for providing me with the opportunity to conduct my study on their Rothschild Giraffes and for providing me with background information on the giraffes upon request. I would also like to thank Dr. John Eddison for his helpful advice, time and support throughout this project.

References

Animal Welfare Act. 2006. Chapter 45. United Kingdom. Her Majestys Stationary Office. HMSO.
Aureli, F., Preston, S. D. & De Waal, F. B. M. 1999. Heart rate responses to social interactions in free moving rhesus macaques (*Macaca mulatta*): a pilot study. Journal of Comparative Psychology, **113**, 59–65.
Barnes, R., Greene, K., Holland, J. & Lamm, M. 2002. Management and Husbandry of duikers at the Los Angeles Zoo. *Zoo Biology*, **21**, 107-121.
Bashaw, M. J. 2011. Consistency of captive giraffe behaviour under two different management regimes. *Zoo Biology,* **30,** 371-378.
Bashaw, M. J., Bloomsmith, M.A., Terry, L.M., & Bercovitch, F.B. 2007. The structure of social relationships among captive female giraffe (*Giraffa camelopardalis*). *Journal of Comparative Psychology,* **121**, 46-53,
Bashaw, M., Tarou, L., Maki, T. & Maple, T. 2001. A survey assessment of variables related to stereotypy in captive giraffe and Okapi. *Applied Animal Behaviour Science*, **73**, 235-247.
Baxter, E. & Plowman, A. B. 2001. The effect of increasing dietary fibre on feeding, rumination and oral stereotypies in captive Giraffes (*Giraffa camelopardalis*). *Animal Welfare*, **10**, 281-290.,
Becker, C. D. & Ginsberg, J. R. 1990. Mother-infant behaviour of wild Grevy's zebra: adaptations for survival in semi desert East Africa. *Animal Behaviour*, **40,** 1111-1118.
Bercovitch, F. B. & Berry, P. S. M. 2010. Reproductive life history of Thornicroft's giraffe in Zambia. *African Journal of Ecology, **48,** 535-538.*
Bergeron, R., Badnell-Waters, A. J., Lambton, S. & Mason, G. 2006. Stereotypic Oral Behaviour in Captive Ungulates: Foraging, Diet and Gastrointestinal Function. Second Edition. In: Stereotypic Animal Behaviour.(Ed. by G. Mason. & J. Rushen) Fundamentals and Applications to Welfare. Wallingford. CABI.
Boccia, M. L., Reite, M. & Laudenslager, M. 1989. On the physiology of grooming in a pigtail macaque. *Physiology and Behaviour*, **45,** 667–70.
Boorer, M. K. 1972. Some aspects of stereotyped patterns of movement exhibited by zoo animals. *International Zoo Yearbook*, **12**, 164–168.
Bredin, I. P. Skinner, J. D. & Mitchell, G. 2008. Can osteophagia provide giraffes with phosphorus and calcium? *Onderstepoort Journal of Veterinary Research,* **75,** 1-9.
Caister, L. E., Shields, W. M. & Gosser, A. 2003. Female tannin avoidance: a possible explanation for habitat and dietary segregation of giraffes (*Giraffa camelopardalis peralta)* in Niger. African *Journal of Ecology,* **41,** 201-210.
Carlstead, K. 1991. Husbandry of the fennec fox (*Fennecus zerda*): Environmental conditions influencing stereotypic behaviour**.** *International Zoo Yearbook,* **30**, 202–20.
Carlstead, K. 1998. Determining the causes of stereotypic behaviours in zoo carnivores: toward appropriate enrichment strategies. In: *Second nature: Environmental Enrichment for Captive Animals* (Ed. By D.J. Shepherdson., J.D. Mellen., M. Hutchins), pp. 172-183. Washington DC: Smithsonian Institution Press.

Carlstead, K. & Shepherdson, D. 2000. Alleviating Stress in Zoo Animals with Environmental Enrichment. Chapter 16. In: *The Biology of Animal Stress. Basic Principles and Implications for Animal Welfare.* (Ed. G.P. Moberg., & J. A. Mench) Washington D.C: Smithsonian Institution Press.
Chamove, A., Hosey, G., & Schaetzel, P. 1988. Visitors excite primates in zoos. *Zoo Biology,* **7,** 359-369.
Clauss, M. & Hatt, J. M. 2006. Review: Rhinoceros feeding in captivity. *International Zoo Yearbook*, **40**, 197-209.
Codron, D., Codron, J., Sponheimer, M., Bernasconi, S. F., & Clauss, M. 2011. When animals are not quite what they eat: diet digestibility influences ^{13}C- incorporation rates and apparent discrimination in a mixed feeding herbivore. *Journal of Zoology*, **89**, 453-465.
Coe, M. 1998. Some aspects of the interaction between mammalian herbivores and Acacia Eriobola E. Mey. *Transactions of the Royal Society of South Africa*, **53**, 141-147.
Cooper, J. J & Mason, G. J. 1998. The identification of abnormal behaviour and behavioural problems in stabled horses and their relationship to horse welfare: a comparative review. *Equine Veterinary Journal*, **30**, 5-9.
Crook, J. H., Ellis, J. E. & Goss-Custard, J, D. 1976. Mammalian social systems: structure and function. *Animal Behaviour*, **24,** 261–27.
Dagg, A. I. & Foster, J. B. 1976. The Giraffe: Its Biology, Behaviour, and Ecology. New York, Van Nostrand Reinhold.
del Castillo, S. M., Bashaw, M. J., Patton, M. L., Rieches, R. R., & Bercovitch, F. B. 2005. Fecal steroid analysis of female giraffe (*Giraffa camelopardalis*) reproductive condition and the impact of endocrine status on daily time budgets. *General and Comparative Endocrinology,* **141**, 271–281.
Du Toit, J. T. & Yetman, C. A. 2005. Effects of body size on the diurnal activity budgets of African browsing ruminants. *Behavioural Ecology*, **2,** 317-325.
Eddison, J. C. 2000. Quantitative Investigations in the Biosciences using Minitab. London: Chapman and Hall/CRC.
Elton, R. H. & Anderson, B. V. 1977. The Social Behaviour of a group of Baboons (*Papio anubis*) under artificial*. Journal of Primatology*, **18,** 225-234.
Estevez, I. & Christman, M. C. 2006. Analyses of the movement and use of space of animals in confinement: The effect of sampling effort. *Applied Animal Behaviour Science*, **97**, 221-240.
Feh, C. & de Mazieres, J. 1993. Grooming at a preferred site reduces heart rate in horses. *Animal Behaviour*. **46,** 1191–1194.
Fernandez, E. J. 2009. Appetitive Search Behaviours and Stereotypies in Captive Animals. Ph.D. thesis. Indiana University.
Fernandez, L. T., Bashaw, M. J., Sartor, R. L., Bouwens, N. R. & Maki, T. S. 2008. Tongue twisters: feeding enrichment to reduce oral stereotypy in giraffe (*Giraffa camelopardalis*). *Zoo Biology, **27**, 200-212.*
Ferrante, V., Canali, E., Mattiello, S., Verga, M., Sacerdote, P., and Manfredi B., & Panerai, A. E. 1998. Preliminary study on the effect of size of individual stall on the behavioural and immune reactions of dairy calves. *Journal of Animal and Feed Science,* **7,** 29–36.
Firoj Jaman, M. & Huffman, M. A. 2008. Enclosure Environment Affects the Activity Budgets of Captive Japanese Macaques (*Macaca fuscata*). *American Journal of Primatology*, **70**, 1133–1144.
Georgii, B. 1981. Activity patterns of female red deer in the Alps. *Oecologia,* **49,** 127–136.

Grant, J. W. A., Chapman, C. A. & Richardson, K. S. 1992. Defended versus undefended home range size of carnivores, ungulates, and primates. *Behavioural Ecology and Sociobiology*, **31**, 149-161.
Hansen, L. T. & Berthelsen, H. 2000. The effect of environmental enrichment on the behavior of caged rabbits (Oryctolagus cuniculus). *Applied Animal Behaviour Science***, 68**, 163–167.
have got it right? *In Proceedings of the 5th International Zoo Design Conference*. Paignton, England
Herskin, M. S., Kristensen, A. M. & Munksgaard, L. 2004a. Behavioral responses of dairy cows toward novel stimuli presented in the home environment. *Applied Animal Behaviour Science*, **89,** 27–40.
Herskin, M. S., Munksgaard, L. & Ladewig, J. 2004b. Effects of surgical catherization and degree of isolation on the behavior and endocrine pancreatic secretion of newly weaned pigs. *Physiology & Behaviour*, **83**, 411–420.
Hosey, G. 2000. Zoo animals and their audiences: what is the visitor effect? *Animal Welfare*, **9**, 343-357.
Hosey, G. 2005. How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science,* **90**, 107-129.
Houpt, K.A. & McDonnell, S.M. 1993. Equine stereotypies. *Compendium on Continuing Education for the Practising Veterinarian,* **15,** 1265- 1271.
Innis, A. C. 1958. The Behaviour of the giraffe, Giraffa Camelopardalis, in the Eastern Transvaal. *Proceedings of the Zoological Society of London, **131,** 245-278.*
Jarman, P. J. 1974. Social organization of antelope in relation to their ecology. *Behaviour,* **48,** 215–266.
Jensen, M. B. 1995. The effect of age at tethering on behavior of heifer calves. *Applied Animal Behaviour Science,* **43**, 227–238.
Judge, P.G. & de Waal, F. B. M. 1993. Conflict avoidance among rhesus monkeys: coping with short-term crowding. *Animal Behaviour,* **46**, 221–232.
Kawata, K. 1971. Observations on cotton-headed tamarins at Topeka Zoo. *International Zoo Yearbook*, **12,** 45-47.
Kerr, S. G. C. & Wood-Gush, D. G. M. 1987. A comparison of the early behaviour of intensively and extensively reared calves. *Journal of Animal Production,* **45,** 181–189
Kiley-Worthington, M. 1983. The behavior of confined calves raised for veal: are these animals distressed? *International Journal for the study of Animal Problems*, **4,** 198–213.
Kiley-Worthington, M. 1987. *The Behaviour of Horses in Relation to Management and Training.* London: J. A. Allen.
Kirkwood, J. K. 1998. Design for the accommodation for wild animals: How do we know when we
Koene, P. & Visser, E. K. 1997. Tongue playing behaviour in captive Giraffes. *International Journal of Mammalian Biology*, **62**, 106-101.
Le Neindre, P. 1993. Evaluating housing systems for veal calves. *Journal of Animal Science*, **71**, 1345–1354.
Leuthold, B. M. 1979. Social organization and behaviour of giraffe in Tsavo East National Park. *African Journal of Ecology*, **17,** 19–34**.**
Macedonia, J. M. 1987. Effects of housing differences upon activity budgets in captive sifakas (*Propithecus verreauxi)*. *Zoo Biology,* **6,** 55-67.
Makarieva, A.M. Gorshkov, V.G. and Bai-Lian, L. 2005. Why do population density and inverse home range scale differently with body size? Implications for ecosystem stability. *Ecological Complexity*, **2**, 259–271.

Mallapur, A., Qureshi, Q., & Chellam, R. 2002. Enclosure Design and Space Utilization by Indian Leopards (*Panthera pardus*) in Four Zoos in Southern India. *Journal of Applied Animal Welfare Science*, **5**, 111-124.
Mallapur, A. Sinha, A. & Waran. N. 2005**.** Influence of visitor presence on the behaviour of captive lion-tailed macaques (*Macca silenus*) housed in Indian Zoos. *Applied Animal Behaviour Science*, **94**, 341-352.
Maple, T. L. 1979. Great apes in captivity: The good, the bad and the ugly. In: *Captivity and behavior: Primates in breeding colonies, laboratories and zoos*. (Ed: T. L. Maple, J. Erwin, & G. Mitchell) pp. 239–273. New York: Van Nostrand Reinhold.
Margulis, S., Hoyos, C., & Anderson, M. 2003. Effect of felid activity on zoo visitor interest. *Zoo Biology,* **22,** 587-599.
Martin, P. & Bateson, P. 2007. *Measuring Behaviour: An Introductory Guide*. Cambridge, Cambridge, U.K: University Press.
Mason, G. 1991. Stereotypies: A critical review. *Animal Behaviour*, **41**, 1015–103.
Mason, G. 2010. Species differences in responses to captivity: stress, welfare and the comparative method. *Trends in Ecology and Evolution,* **25**, 713-721.
Mason, G., Clubb, R., Latham, N. & Vickery, S. 2007. Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Applied Animal Behaviour Science,* **102,** 163-188.
Mason, G.J. & Latham, N. 2004. Can't stop, won't stop: is stereotypy a reliable animal welfare indicator. *Animal Welfare,* **13**, 57-69.
McBride, S. D., & Cuddeford, D. 2001. The Putative Welfare-Reducing Effects of Preventing Equine Stereotypic Behaviour. *Animal Welfare*, **10**, 173-189.
McBride, S. D., Hemmings, A. and Robinson, K. 2004. A preliminary study on the effect of massage to reduce stress in the horse. *Journal of Equine Veterinary Science*, **24,** 76–81.
Mellen, J. & Macphee, M. S. 2001. Philosophy of environmental enrichment: past, present and future. *Zoo Biology*, **20**, 211-226.
Mertens, D. R. 2007. Digestibility and intake. In: *Forages Volume 2. The Science of Grassland Agriculture*. 6th ed, chapter: 32. (Ed: R. F. Barnes., C. J. Nelson., K. J. Moore., and M. Collins), U.K. Blackwell Publishing.
Monte, M. & Pape, G. 1997. Behavioural effects of cage enrichment in single-caged adult cats. *Animal Welfare*, **6,** 53–66.
Moxon, S. 2008. Dominance hierarchy as integral to reproductive suppression; an adaptation consequent to the evolution of the male. In: XIX Biennial Conference of the International Society for human ethology. Italy: Almar Matr Studiorum.
Munksgaard, L. & Simonsen, H. B. 1996. Behavioral and pituitary adrenal-axis responses of dairy cows to social isolation and deprivation of lying down. *Journal of Animal Science*, **74,** 769–78.
Nieuwenhuijsen, K. and de Waal, F. B. M. 1982. Effects of spatial crowding on social behavior in a chimpanzee colony. *Zoo Biology*, **1**, 5–28.
Ogden, J. J., Lindburg, D.G. & Maple, T.L., 1990. Gorilla adaptations to naturalistic environments. *Zoo Biology*, **9**, 107–121.
Owen-Smith, N. 1979 Assessing the forage efficiency of a large herbivore, the kudu. *South African Journal of Wildlife Research,* **9,** 102–110.
Owen-Smith, N. 1998 How high ambient temperature affects the daily activity and foraging time of a subtropical ungulate, the greater kudu. *Journal of Zoology,* **246,** 183–192.
Pellew, R. A. 1984. The feeding ecology of a selective browser, the giraffe (*Giraffa camelopardalis tippelskirchi*). *Journal of Zoology*, **202**, 57–81.

Perry, S. 2011. Social Behaviour in captive reticulated Giraffes (Giraffa camelopardalis reticulata): Analyses of enclosure use and social interactions between Giraffes housed at Whipsnade Zoo. *The Plymouth Student Scientist,* **4**, 50-65.
Plowman, A. B. 2003. A note on a modification of the spread of participation index allowing for unequal zones. *Applied Animal Behaviour Science*, **83**, 331-336.
Poole. T. 1995 Behavioural Problems in Captivity in General and their Management. In: *Proceedings of Zoo The Second International Conference Environmental Enrichment*. Copenhagen, Denmark, 118-130.
Pratt, D.M. & Anderson, V. H. 1979. Giraffe cow-calf relationships and social development of the calf in Serengeti. *Zeitschrift fur Tierpsychologie*, **51,** 233-251.
Price, E. E. & Stoinski, T. S. 2007. Group size: Determinants in the wild and implications for the captive housing of wild mammals in zoos. *Applied Animal Behaviour Science*, **103**, 255-264.
Reinhardt, V., Liss, C., & Stevens, C. 1996. Space requirement stipulations for caged non-human primates in the United States: A critical review. *Animal Welfare*, **5**, 361–372.
Ross, S. R., Schapiro, S .J., Hau, J. & Lukas, K. E. 2009. Space use as an indicator of enclosure appropriateness: A novel measure of captive animal welfare. *Applied Animal Behaviour Science,* **121**, 42-50.
Sather, F., Ludo Badlangana, N. & Manger, P. R. 2010. Variations in the Thickness and Composition of the Skin of the Giraffe. *The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology,* **293,** 1615-1627.
Sato, S., Hata, K. & Tarumizu. K. 1993. The influence of social factors on allogrooming in cows. *Applied Animal Behaviour Science*, **38,** 235–244.
Seidensticker, J. & Forthman, D. L. 1998. Evolution, ecology and enrichment: Basic considerations for wild animals in zoos. In: *Second nature, environmental enrichment for captive animals*. (Ed. by: D. J. Shepherdson, J. D. Mellen, & M. Hutchins) pp. 15–30. Washington, DC: Smithsonian Institution Press.
Shepherdson, D. 1989. Stereotypic behaviour. What is it and how can it be eliminated or prevented? *Ratel*, **16**, 100-105.
Siegel, J. M. 2005. Clues to the functions of mammalian sleep. *Nature*, **437**, 1264-1271.
Skinner, J. D. & Smithers, R. H. N. 1990. *The mammals of the Southern African Sub Region.* Pretori: The University of Pretoria.
Snyder, R. 1975. Behavioural stress in captive animals. In: *Research in zoos and aquariums* (Ed. by G. Rabb) pp.41-76. Washington DC: National Academy of Sciences.
Spruijt, B. M., Van Hooff, J. A. & Gispen, W. H. 1992. Ethology and neurobiology of grooming behavior. *Physiological Reviews*, **72,** 825–52.
The Zoos Forum, 2010. *Elephants in UK Zoos. Zoos Forum review of issues in elephant husbandry in UK zoos in the light of the report by Harris et al (2008*). [on-line] Available at: http://www.defra.gov.uk/wildlife-pets/zoos/documents/elephants/elephant-forum-1007.pdf [date accessed: 8th February 2012].
Tobler, I. & Schwierin, B. 1996. Behavioural sleep in the giraffe (*Giraffa camelopardalis*) in a zoological garden. *Journal of Sleep Research*, **5,** 21-32.
Toit, J. T. 1990. Home range-body mass relations: a field study on African Browsing ruminants, *Oecologia*, **85**, 301-303.
Valeix, M., Fritz, H., Loveridge, A. J., Davidson, Z., Hunt, J. E., Murindagomo, F. & Macdonald, D. W. 2009. Does the risk of encountering lions influence African herbivore behaviour at waterholes? *Behavioural Ecology and Sociobiology*, **10,** 1483-1494.
Van Nierkerk, B. V. & Pienaar, U. D. V. 2009. A report on some immobilizing drugs used in the capture of wild animals in the Kruger National Park, *Koedoe,* **6,** 126-123.

Veasey, J. S., Waran, N. K. & Young, R. J. 1996. On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator, using the giraffe (*Giraffa camelopardalis*) as a model. *Animal Welfare*, **5**, 139-153.
Wells, D. L. Coleman, D. & Challis, M. G. 2006. A note on the effect of auditory stimulation on the behaviour and welfare of zoo-housed gorillas. *Applied Animal Behaviour Science,* **100,** 327-332.
Wiepkema, P. R., & Koolhaas, J. M. 1993. Stress and animal welfare. *Animal Welfare*, **2**, 195–218.
Zaragoza, F., Ibanez, M., Mas, B, M., Laiglesia, S. & Anzola, B. 2011. Influence of environmental enrichment in captive chimpanzees (*Pan troglodytes spp.*) and Gorillas (*Gorilla gorilla gorilla*): Behaviour and faecal cortisol levels. *Revista Cientifica*, **21,** 447-456.