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# Social behaviour in captive reticulated giraffes (*Giraffa camelopardalis reticulata*): Analysis of enclosure use and social interactions between giraffes housed at Whipsnade Zoo

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**Abstract**

Wild giraffe (*Giraffa camelopardalis*) herds have been described as random associations of individuals, but recent research has suggested that giraffe do form social bonds and have a complex social structure. The aims of this investigation were to determine whether a group of three captive giraffe associated randomly or patterned their behaviour and proximity in a way that suggests social relationships. Also to analyse how the giraffe use their enclosure in order for the zoo to develop the enrichment program to encourage the giraffe to use the enclosure more equally. Index of association and maintenance of proximity were used to analyse the social interactions. SPI and Chi Squared (goodness of fit) tests were used to determine the enclosure usage. Mother- son pairs and pairs with large age differences between members interacted and associated most often. Areas of the enclosure such as the inside, concrete area, and sand area were used more than expected; on the other hand areas such as grass areas were used less than expected; this is because these areas contain no resources. The social structure of this captive group is influenced by social relationships between individuals, especially mother and son. It is suggested that the social behaviour between wild individuals should be examined more closely in order to improve the welfare of giraffes in captivity.

*Key words:* Giraffe; Social; Association; Relationships; Home range; Bond; Captivity; Enclosure use

# Introduction

## Social behaviour of giraffe

Social preferences among mammals are defined as patterns of interactions or association in which certain individuals are more likely to direct their social behaviour towards some individuals more than others (Bashaw et al, 2007). If social preferences are maintained over a period of time then they are considered relationships (Bashaw et al, 2007).Symmetric relationships are relationships in which the two individuals involved direct similar behaviours to one and another and show mutual attraction. This type of relationship requires both individuals to play a part; therefore, reciprocity can be used to determine the strength of this relationship (Bashaw et al, 2007).

The life history of ungulates can be used to explain the social relationships of adult ungulates. Relationships between mother and her offspring can often be maintained into adulthood. Interactions have been observed between mothers and calves up to the age of 18 months in wild giraffe (Leuthold and Leuthold, 1975). This can be seen in other species such as baboons (*Papio cynocephalus*) where mother-daughter bonds among baboons last into adulthood (Silk et al, 2006). This can also be seen among wild swine (*Sus scrofa*) where bonds particularly in females have been known to last into adulthood (Graves, 1984).

Even though there is strong evidence showing presence of social relationships among species of mammals it is suggested that giraffe (*Giraffa camelopardalis*) form loose bonds between individuals (Dagg and Foster, 1976; Langman, 1977). This implies that they are not very social animals; even relationships between mother and her calves do not seem to be present, because there is often a great distance observed between them (Coe, 1967; Dagg and Foster, 1976). The social bonds have been observed to be temporary and mainly to occur between young animals (Le Pendu et al, 2000) especially in situations of nursery and lying out groups. Calves go through a “lying out” period, during which they spend the first two weeks of their life resting, so that all of their energy is channeled toward growth (Pratt and Anderson, 1979).

Various studies have been conducted on relationships between mothers and calves in giraffes, two opposing conclusions emerge from these studies. Some authors report vast distances between mother and calf, apparent abandonment of calves, and difficulty determining the mother of calves; which leads to the conclusion that giraffe have weak mother- calf bonds (e.g. Innis, 1958; Dagg and Foster, 1976).

However, recent research concludes giraffes form social bonds, suggesting that previous studies may have misunderstood social bonds between giraffes, especially between mother and calf. It has been proved that giraffe can maintain visual contact over long distances, more so than other animals because of their height and the terrain of the grasslands in which they live (Dagg and Foster, 1976). Langman (1977) acknowledged that mothers may remain distant from their calves to prevent the calves from being exposed to extreme heat loads; the mother would do this by leaving her calf in the shade while she forages. Recent studies have also discovered that giraffe can produce low frequency sounds, which are below the level of human hearing and can travel over large distances, which may allow communication between individuals over great distances (e.g. Connell-Rodwell et al, 2001). Similar

studies have also been carried out in other animals (fiddler crabs: Aicher and Tautz, 1990; mole rats: Narins et al, 1992; elephants: Wood et al, 2005). The evidence shows that distance between individuals does not mean that social relationships are not present.

**Enclosure use**

For species housed in captivity, they are constrained by the space and conditions provided; they cannot separate themselves from the group if conditions become undesirable, as they are restricted within the limits of the enclosure. Inadequate physical and social features of the captive environment can result in discomfort and stress that can lead to serious physiological, behavioural and welfare problems (Bashaw et al, 2007; Barnes et al, 2002). Physical features of the captive environment such as the complexity of the environment and the amount of space available can have a huge impact on movement and inter individual distances (Leone and Estevez, 2008). Spatial confinement can inflict behavioural restrictions on animals because of limitations in movement and use of space. Group size variations, high animal densities and social factors may increase these effects. (Estevez et al, 2007). Overcrowded groups in captivity can have negative effects on the animals. Captive primates housed in high density groups show higher levels of aggression and stress (Elton and Anderson, 1977; Price and Stoinski, 2007). Similar results have been found in ungulates; increased density of animals is correlated with increased stereotypic licking in giraffes, okapi, horses (Redbo et al, 1998; Bashaw et al, 2007). Duikers are highly susceptible to stress. In captivity group size has been proved to be critical in the successful management of this species. When duikers were housed at Los Angeles Zoo in groups of five, stress related jaw abscesses were seen in the individuals, but when the duikers were housed in groups of three jaw abscesses were not seen, suggesting that these individuals were not showing signs of stress (Barnes et al, 2002).

Enclosure usage is an important area for all animals, it is important in giraffes as in the wild they have a huge home range: a mean of 282km $^2$ (Toit, 1990).The area that an animal occupies must be large enough to provide an adequate supply of resources. As the body size or metabolic requirements of an animal increase, the home range size of the animal also increases. Carnivorous animals tend to have a larger home range than omnivores or herbivores of a similar size (Makarieva et al, 2005; Grant et al, 1992).

In captivity environmental pressures such as the availability of resources and predation are controlled in captivity; animals experience little to no competition for food or predation risk. As a result, group size is often more flexible in captivity than in the wild (Price and Stoinski, 2007). The giraffes' home range depends on the distribution of food and water resources available and therefore is not a travelling need. This means in captivity enclosures only need to be large enough to have all the resources that the animal requires (Grant et al, 1992). However, exercise is important and so management of animals needs to facilitate an appropriate exercise regime for good health (Harris et al, 2008; The Zoos Forum, 2010).

The aims of this study was to understand the social structure of giraffe, by determining whether they are social or unsocial animals, whether relationships are stronger between related individuals rather than unrelated individuals. This was achieved by observing social interactions between members of the group. The study

was also designed to discover how the captive giraffe at Whipsnade Zoo use their enclosure and suggest ways that the enclosure can be altered to ensure effective use of all zones in the enclosure.

## Methods

### Subjects and housing

The subjects were three captive reticulated giraffes (*Giraffa camelopardalis reticulata*) housed at Whipsnade Zoo, Dunstable. The two females: Ina, born at Prague Zoo in 2002 and Savannah, born at Whipsnade in August 2002 were unrelated. The male, Mtoto was born at Whipsnade Zoo in July 2008, and is the son to Savannah. The outdoor exhibit housed the giraffe from approximately 09:30 to 17:30 hours, and they spent the rest of their time indoors, throughout the day there was still access to the indoor area. Throughout the study, the giraffe were fed alfalfa indoors and outdoors. The giraffe were also fed browse by the keeper on a weekly basis.

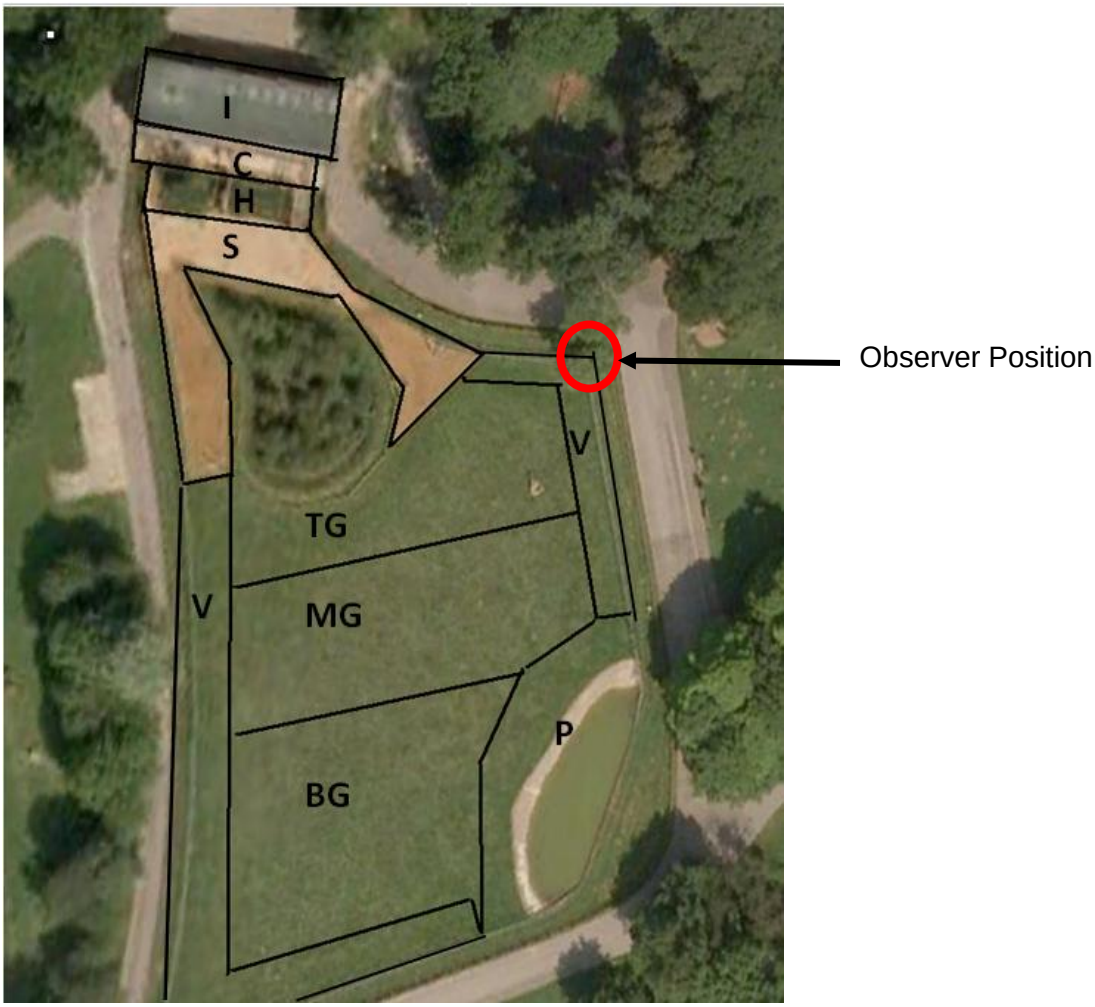


**Figure 1**: Diagram of the giraffe enclosure at Whipsnade zoo.

**Key: I**=Inside, **C**=Concrete area, **H**= Hay area, **S**= Sand area, **V**=Near Visitors, **P**=Near Pool, **TG**= Top grass area, **MG**=Middle grass area, **BG**=Bottom grass area.

## Observation Method

The giraffe were observed on 26 randomly selected days for a period of six weeks. Observations, using focal animal sampling were made during daylight hours (10:00-5:30pm). During this time the behaviour of each subject was recorded for a 15 minute focal sample in random order (Martin and Bateson, 2007). The behaviour the subject was performing and the area of the enclosure in which the subject was located were recorded.

Mtoto was observed for a total of 4.25 hours. Savannah and Ina were observed for a total of 6.75 hours each, on a random schedule. Observations were made from a position to the side of the enclosure so most areas of the enclosure could be seen (see Figure 1).

The exhibit was divided into defined areas (as shown in Fig 1); the location of each giraffe was recorded on each scan. Area (I) was the inside area of the enclosure. Area (C) was the concrete area just outside the inside area. Area (H) contained the hay feeders. Area (S) was the sand area containing the enrichment poles of which sometimes browse was hung. Area (V) was the area closest to the public viewing (around the edge of enclosure). Area (P) was the area surrounding the pool where the giraffe would drink. Area (TG) was the top grass area just below sand area. Area (MG) was the middle grass area, and Area (BG) was the bottom grass area (See Figure 1)

## Behaviour sampling

**Table 1:** Description of behaviours used for collecting data

| Behavioural categories |
|---|
| 1. LD (Lying down): the animal is resting on side with neck low to the ground |
| 2. St (Standing): The animal is standing motionless |
| 3. W (Walking): the animal is walking, with a ‘goal’ (walking towards food) |
| 4. Wn (Wander): the animal is walking, aimlessly (no ‘goal’) |
| 5. F (Feeding): to ingest food such as hay or branches |
| 6. S (Sitting): When giraffe sitting with front legs bent back, neck up right |
| 7. R (Ruminating): when the animal is chewing the cud |
| 8. Sn (Sniffing): the animal is sniffing an item or another individual |
| 9. Li (Licking): a single lick of itself or another individual, or licking of a substance, this may be a stereotypy or lack of nutrients |
| 10. Sc (Scratching): the animal is scratching a part of its body on an object or by scratching with a part of its body |
| 11. Dr (Drinking): To ingest water |
| 12. U (Urinating): the animal is urinating |
| 13. Df (Defecating): the animal is defecating |
| 14. Mt (Mounting/ attempt to mount): the animal is attempting to mount another animal, may be due to dominance or attempting to mate |
| 15. Sp (Sparring): the animal is hitting another animal with its neck |
| 16. G (Grooming): the animal appears to be licking itself or another individual more than once |

17. StO (Standing observing): the animal appears to be standing motionless observing at an object or an individual
18. O (Observing): the animal appears to be focusing on something or another individual
19. Rn (Running): the animal is running, faster pace than walking, usually running away or towards something
20. UT: an animal is tasting another animals urine, this could be to test if the female is in oestrus
21. * (Social interaction): if a behaviour involves another individual then a * is placed next to the behaviour

The above behaviours however were collapsed into three groups of resting behaviour, general behaviour and feeding behaviour in order to carry out the chi-square tests on the association between behaviour and location of the giraffes in their enclosure.

**Table 2:** Affiliative Social Interactions Recorded on an All-Occurrence Basis for Each Focal Animal

| Behaviour | Definition |
|---|---|
| 1. Approach | One animal moves to within proximity of another and stops; actor must appear to be moving directly toward the second animal and have no other apparent reason to enter the area. |
| 2. Necking | One animal rubs or entwines its neck with a second animal's neck. |
| 3. Head rub | One animal rubs its head on a part of a second animal's body other than the neck or head. |
| 4. Bumping | One animal pushes a second animal, usually with the actor's chest. |
| 5. Social exam | One animal sniffs or licks part of a second animal's body other than the genital area or the muzzle. |
| 6. Muzzle/muzzle | Two animals make contact between muzzles or sniff each other's muzzles with less than 15.24 cm (6 inches) separating them. |
| 7. Cofeed | Two animals eat from the same feeder or branch of a plant. As a result of the ratio of feeder or branch size to animal size, animals cofeeding in this study were always proximate to one another. |
| 8. Sentinel | One animal approaches a second animal that is lying down and stands in proximity to that animal; actor may also be performing another behaviour |

Table adapted from Dagg (1970); Pratt and Anderson (1985) and Bashaw et al (2007).

**Statistical analyses**
Data were 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 exact mathematical equivalent of the original SPI if zone sizes are equal, however in a range of realistic situations the modified SPI is more sensitive and more accurately reflects the extent of enclosure utilisation (Plowman 2003).

The modified formula:

$$SPI = \frac{\sum |f_o - f_e|}{2(N - f_{e\min})}$$

Where $f_o$ is the observed frequency of observations in a zone, the expected frequency of observations in a zone, based on zone size assuming even use of the whole enclosure. | $f_o$ - $f_e$ | the absolute difference between $f_o$ and $f_e$, Σ summed for all zones, N the total number of observations in all zones and $f_{e\,\min}$ the expected frequency of observations in the smallest zone.

If the SPI=1.0, this indicates minimum utilisation, i.e. giraffes spend their time in one area. Conversely if SPI=0, there is maximum utilisation, i.e. all areas are used equally.

To determine SPI, the enclosure was divided into zones using the modified Spread of Participation Index method. This allowed for the inclusion of unequal and equal zones to give a more accurate representation of enclosure utilisation.

Secondly data was subjected to goodness of fit, chi-square analysis (Eddison, 2000) to determine if there were associations between the behaviour being performed and the location of the giraffe in the enclosure.

In order to analyse the observed association and interactions between the individuals, association indices were constructed from the formula:

$$\text{Index of association} = N_{\square\square} / (N_A + N_B + N_{AB})$$

Where $N_{AB}$ is the number of occasions A and B are seen together; $N_A$ is the number of occasions A is seen without B; and $N_B$ is the number of time B is seen without A. This index has the merit that all scores fall between 0 (no association) and 1.0 (complete association) ;( Martin and Bateson, 2007).

In order to analyse the individual(s) degree of social interaction among group members, the responsibility for proximity were constructed from this formula:

$$\text{Maintenance of proximity} = U_A / (U_A + U_B) - S_A / (S_A + S_B)$$

Where $U_A$ is the number of occasions when the pair were united by A's movements; $U_B$ is the number of occasions when the pair were united by B's movements; $S_A$ is the number of occasions when the pair were separated by A's movements; and $S_B$ is the number of occasions when the pair were separated by B's movements. The index ranges from -1.0 (B totally responsible for maintaining proximity) to +1.0 (A totally responsible). A zero value indicates that A and B were equally responsible for maintaining proximity (Martin and Bateson, 2007).

# Results

## Spread of Participation Index (SPI)

The SPI is 0.46. The results show that the giraffes do not spend all their time in one area nor do they use the enclosure equally. The SPI results suggest that enclosure usage can be improved to ensure more effective use of the enclosure.

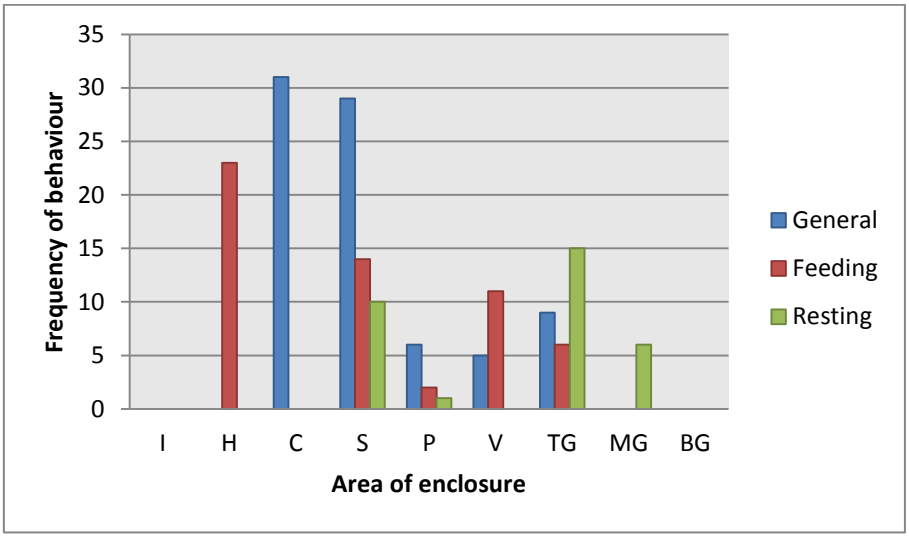


**Figure 2:** The frequency of behaviours exhibited in each area of the enclosure

## Chi Squared (Goodness of fit)

The results from the goodness of fit chi-square test ($X^2$=447.29; D.F. =8; P<0.001) show that the enclosure is not being used evenly by the group of giraffe. Standardised residuals were calculated to identify specific areas used more or less than expected. The values in Table 3 (below) show that in zones I, H, C, S and TG (top part of the enclosure) the giraffes were observed significantly more than expected. The results also show that in areas P, V, MG and BG the giraffes were observed significantly less than expected.

**Table 3:** Results from Chi Squared (Goodness of fit) test

| Zone | Standardised Residuals $\frac{O-E}{\sqrt{E}}$ |
|---|---|
| **I** | 8.5 |
| **H** | 8.1 |
| **C** | 14.3 |
| **S** | 6.6 |
| **P** | -3.7 |
| **V** | -2.5 |
| **TG** | 2.3 |
| **MG** | -3.1 |
| **BG** | -5.1 |

**Key: I**=Inside, **C**=Concrete area, **H**= Hay area, **S**= Sand area, **V**=Near Visitors, **P**=Near Pool, **TG**= Top grass area, **MG**=Middle grass area, **BG**=Bottom grass area.

A standardised residual >| *1.96* | indicates a significant deviation for expected (Eddison, 2000).

## Index of Association

**Table 5:** The index of association between the three captive giraffe housed at Whipsnade Zoo

| | Savannah | Ina | Mtoto |
|---|---|---|---|
| Mtoto | 0.67 | | |
| Savannah | | 0.25 | |
| Ina | | | 0.28 |

A high number means a high association between individuals; where as a low number means a weak association between individuals.

**Table 6:** The index of association between Savannah and Ina; after Mtoto had been removed and sent to Norway Zoo.

| | Savannah | Ina |
|---|---|---|
| Savannah | | |
| Ina | 0.18 | |

This index has the merit that all scores between 0 (no association) and 1.0 (complete association) (Martin and Bateson, 2007).The strength of association between each member of the group is highlighted in Tables 5 and 6. To indicate the varying strength between individuals, green represents a high association (from the range of data collected - see Appendix A), blue represents a medium association; red however represents hardly any association observed between individuals.

The strength of association between the members of the group is also presented diagrammatically as a sociogram. It is an estimated strength of association between members based on observations that were recorded.

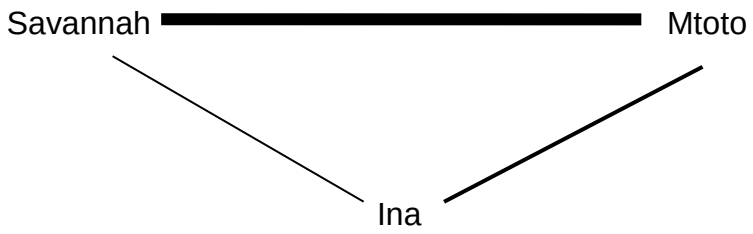


**Figure 4.** Sociogram of strengths of association between members of the giraffe group housed at Whipsnade Zoo. The thickness of line indicates the strength of association. For example Savannah and Mtoto show the strongest association.

### Maintenance of proximity

**Table 7:** The maintenance of proximity between the three captive giraffe housed at Whipsnade Zoo

| | Savannah | Ina | Mtoto |
|---|---|---|---|
| Mtoto | 0.34 | | |
| Savannah | | 0.08 | |
| Ina | | | 0.17 |

A positive number means that 'A' is more responsible than 'B' for maintaining proximity. A negative number means that 'B' is more responsible than 'A' for maintaining proximity. A zero value indicates that A and B were equally responsible for maintaining proximity. The individual responsible for maintaining proximity is highlighted in orange.

**Table 8:** The maintenance of proximity between Savannah and Ina; after Mtoto had been removed and sent to Norway Zoo.

| | Savannah | Ina |
|---|---|---|
| Savannah | | |
| Ina | 0.1 | |

The index ranges from -1.0 (B totally responsible for maintaining proximity) to +1.0 (A totally responsible). A zero value indicates that A and B were equally responsible for maintaining proximity (Martin and Bateson, 2007). To indicate which individual is responsible for maintaining proximity, it has been highlighted orange on the individual that is responsible (see table 7). The results show that Mtoto is more responsible than Savannah for maintaining proximity. Mtoto is also more responsible than Ina for maintaining proximity. Savannah was slightly more responsible than Ina for maintaining proximity, but the value (0.08) is close to zero which means both are almost equal at maintaining proximity. Therefore, Mtoto is the key individual that is maintaining proximity within the group.

## Discussion

The results reveal that social relationships existed within the herd of three captive giraffe housed at Whipsnade Zoo. It has also been discovered that the giraffes did not use their enclosure evenly.

### Enclosure use

A captive environment introduces behavioural and spatial limitations on an animal. A good understanding of an animal's use of space and environmental features permits the design of captive environments that match the animals' biological and behavioural requirements, which maximizes their welfare (Estevez and Christman, 2006; Ross et al, 2009). Although space use is influenced not only by environmental preferences, but also by social and biological factors, studying the way in which

animals use their enclosure is a valuable way to measure the appropriateness of their environment (Ross et al, 2009).

The standardised residual results showed that areas of the enclosure were used significantly more than expected. These areas were; the inside area (I), the area containing the hay feeders (H), the concrete area (C), the sand area (S) and the top grass area (TG). The results also showed that areas of the enclosure were used significantly less than expected. These areas were; the pool area (P), the areas close to visitors (V), the middle grass area (MG) and the bottom grass area (BG). It may be suggested that the giraffes spent more time than expected in the inside area (I), to get privacy from visitors or even other group members. The data showed that in particular Ina spent a lot of time inside (see appendix A). Ina's history is unknown but it is thought that she may have been mistreated this could explain why Ina spent a lot of time inside as she may be wary of humans. In the wild, adult female giraffes forage for a relatively constant proportion of each 24 hours throughout the year (approximately 53%), this is because giraffes reproduce all year and the females need to maximise their energy intake at all times (Pellew, 1984). This evidence may explain why the giraffes were seen more than expected in the feeding area (H). The concrete area (C) and the sand area (S) were used more than expected. The sand area contained two enrichment poles where browse was regularly hung thus containing a food resource which would have encouraged use of this area. The concrete area is just outside the inside area, the giraffes may have been seen here often as they may have been walking towards the inside area or walking out of the inside area towards another area.

Areas of the enclosure such as; Pool area (P), bottom grass area (BG) and the area near to visitors (V) may have been used significantly less than expected as these areas are close to where the visitors are. Most studies on visitor effects on animals have reported to have a negative effect on the animals (Birke 2002; Wells, 2005).Studies to date report audience activity (Hosey and Druck, 1987; Mitchell et al, 1991); height (Chamove et al, 1998) and noise (Birke, 2002) to be aspects influencing the behaviour of animals (Wells, 2005). The only behaviour to be recorded in the middle grass area (MG) was resting; resting behaviour was also recorded frequently in the top grass area (TG). These areas can be classed as the areas furthest from the visitors and suggests these are areas where the giraffes can 'relax'.

The scaling of home range is controlled by spatial distribution of the available resources; the scarcer the resources, the greater the mass scaling exponent of the home range (Makarieva et al, 2005). Therefore, in captivity all the resources are within the enclosure thus the animal's home range is not needed to be as great as it is in the wild. Parts of the enclosure at Whipsnade were not used this is because all the resources that the giraffe need are provided in the other areas. Therefore they do not need to use parts of the enclosure that do not contain any resources. To make more effective use of the enclosure in areas with no or low use such as bottom grass (BG), and middle grass (MG); enrichment feeding poles could be added. The areas where the giraffe are fed could be rotated to different areas of the enclosure. When fed browse from the 'keeper for a day' participants, it could be fed at different areas of the enclosure to encourage the giraffe to use more areas. To encourage more even use of the pool area (P), bottom grass area (BG) and the area near visitors (V) a second barrier could be put around the enclosure to keep visitors at a further

distance from the giraffe. Alternatively some areas of the enclosure could be limited to the visitors to give the giraffe more privacy.

**Social behaviour**

The data revealed that social relationships existed within a herd of three captive giraffe. Social interactions and associations were nonrandomly distributed, which indicates social preferences.

The sample size used was limited to a single group of giraffe, of two females and one male, so confirmation of these results awaits future studies, but these results suggest that observations of other captive and wild groups will reveal similar social dynamics among giraffe. Other studies have shown mother–offspring relationships in giraffe (Pratt and Anderson, 1985; Bercovitch and Berry, 2010) and similar patterns have been observed in other ungulates (Becker and Ginsberg, 1990). Maintenance of mother– offspring bonds to adulthood has been documented in studies of bison (Green et al, 1989), sheep (Guilhem et al, 2000), and cattle (Reinhardt and Reinhardt, 1981).

Peer preferences in ungulates have been thought to develop as a result of age related dominance (Bashaw et al, 2007). In the wild, older females will sometimes remain with a crèche of calves. The female will occasionally let calves other than her own suckle from her and she will also defend against predators in order to protect the young (Langman, 1977; Pratt and Anderson, 1979). A preference for older females could emerge from these allomothering activities and could explain why Mtoto and Ina appear to have a bond.

A wild giraffe herd is made up of subgroups; within these groups individuals have social relationships. These individuals have been known to temporarily separate and reunite. Some authors have reported this as giraffes being unsocial (Coe, 1967; Dagg and Foster, 1976; Langman 1977). But a fission-fusion model can be used to best describe giraffe social structure. A fission-fusion society can be described as the temporary formation and dissolution of sub groups that vary in number and demographic composition within a large, stable community (Bashaw et al, 2007). Within a fission-fusion society of wild chimpanzees (*Pan troglodytes*), mothers with dependent offspring will group together and form nursery groups (Mitani et al, 2002). This can be comparable with the nursery groups that have been observed in wild giraffe (Leuthold and Leuthold, 1975). Other ungulates such as red deer have also been observed to show dynamics of a fission-fusion society (Conradt and Roper, 2000).

The enclosure at Whipsnade Zoo differs from the habitat that giraffes would be in the wild. The captive environment means the food resources are more patchily distributed in space and time, social density increases, and dispersal is regulated by the zoo management team. The increased density at Whipsnade Zoo could have increased the frequency of social interactions, which may give the appearance that the social relationships between individuals are stronger than they perhaps are. This may increase the quantity of social interactions among the herd, but it would not change the quality of the social interaction between individuals. Although the enclosure at Whipsnade could be considered semi-natural, the captive environment

in which this study was conducted may have influenced the social relationships observed.

In conclusion, the studied group of three captive giraffe at Whipsnade Zoo exhibited social preferences that were maintained by both partners, and appeared to be present over the period of time they were observed. Therefore this group of giraffe appear to have formed social relationships. These relationships appear to reflect continuation of mother-son attachment after weaning, as well as possible effects of allomothering. From this study it can be suggested that social relationships among captive giraffe may form the basis of the social structure of giraffe herds and can be identified by examining the index of association and maintenance of proximity. It is suggested that the social behaviour between wild individuals should be examined more closely. A good understanding of giraffe social behaviour in the wild means giraffe can be housed appropriately in captivity, maximising animal welfare (Ross et al, 2009).

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