CHAPTER 6

FACTORS MODIFYING PROXIMITY IN CAPTIVE LION-TAILED MACAQUES (*Macaca silenus*)

6.1 Introduction

It is important to investigate spatial proximity between animals for both theoretical and applied reasons. Theoretically, measures of spatial proximity are an important tool for understanding the type and intensity of social relationships in primates (Brown, 2001; Hornshaw, 1985; Schaffner et al., 1995). There may be welfare implications of individual proximity in captivity, such as the negative effects of crowding (Baker & Aureli, 1997; De Waal et al., 2000). Furthermore social distances have been shown to significantly modify HPA function (Smith et al., 1998).

Many primate species face serious threats of extinction in the wild, commonly due to the destruction of their habitat (Cowlishaw & Dunbar, 2000; Muroyama & Eudey, 2004). Habitat destruction causes primate populations to become fragmented and in some species prevents natural dispersal and migration of males (Cowlishaw & Dunbar, 2000). Although some species of primates appear to cope satisfactorily with changing habitats, others are seriously affected (Cowlishaw & Dunbar, 2000). Habitat fragmentation may affect inter-individual distances in primates, possibly resulting in negative effects on cortisol levels and therefore health and breeding success (Moberg, 2000; Sapolsky, 2005). The habitat of the lion-tailed macaque is fragmented, forcing the population to divide into small breeding populations in closer proximity than the normal proximity typical to the species (Singh et al., 2001). Since many groups of lion-tailed macaques in the wild now live in small units in isolated forest fragments, the captive situation (typically with small group

size, restricted living space and infrequent male exchange) provides a suitable model for measuring consequences of forced physical and social proximity. Data on wild lion-tailed macaque proximity is sparse and mean inter-individual distances do not appear to have been recorded. Quantitative data has shown that wild lion-tailed macaques are always found to be dispersed from one another (Singh et al., 2000) and that adult males in particular have a low rate of interaction with other group members, often staying on the periphery of the group (Hohmann, 1988).

Proximity between captive individuals may be affected by many different variables for example the institution in which the animal is housed, its age and sex (see below).

6.1.1 Effect of institution on proximity

Spatial proximity has not been measured in wild lion-tailed macaques but spatial distances comparative to the wild can not always be achieved in most captive groups because of enclosure space limitations (Kaumanns & Rohrhuber, 1995). This could potentially lead to increased aggression and unwanted behaviours. In captivity accurate mean inter-individual distances for lion-tailed macaques have been recorded. Tennemann (1992) as cited in Kaumanns and Rohrhuber (1995) studied inter-individual distances in five captive lion-tailed macaque groups. She found inter-individual distances in all groups to be similar, ranging between two and three meters, even though the five indoor enclosures differed in size. Hornshaw (1985) found similar results in captivity recording a mean inter-individual distance of 2.68m for lion-tailed macaques. Similar results have also been found by Irving-Lewis (2004), enclosure size did not significantly influence inter-individual distances in five captive groups of lion-tailed macaques. However Kaumanns et al (1988) as cited in Kaumanns and Rohrhuber (1995) found mean distances of seven meters in a group that was housed in a large enclosure of 30 by 50 meters.

In captivity spatial restrictions are present that vary by institution. Primate social relationships may be affected by the group, in particular the males, not having the ability to disperse widely (Kaumanns & Rohrhuber, 1995). The institution and enclosure in which an animal is housed may modify its levels of proximity to other individuals. It could be expected that distances between individuals will be correlated with enclosure size, with the larger distances between individuals being seen in larger enclosures. In the current study mean inter-individual distances and time spent within "arms-reach" to other individuals were examined in captive lion-tailed macaques housed in three enclosures.

6.1.2 Effect of age on proximity

The age of an animal may modify its time spent in proximity to other individuals. The performance of behaviour is affected by age (as discussed in chapter 4) and the expression of certain behaviours may be linked to proximity due to their very nature. Proximity has been linked with play (Flack et al., 2004), foraging (Rose, 1994), auto-grooming (Manson & Perry, 2000), agonistic behaviour (Bjornsdotter et al., 2000; Pereira et al., 2000) and mating behaviours (Soltis et al., 1997). Research has shown that certain behaviours are more common in certain age groups, for example young animals perform play behaviours more than adults (De Oliveira et al., 2003; Defler, 1995), therefore one would assume this would bring them in close proximity with one another. Similarly adults perform more sexual behaviours thus bringing them close together (see chapter 4). Mother and infant lion-tailed macaques were predictably found to have the lowest mean inter-individual distances in five captive groups (Tennemann, 1992 as cited in Kaumanns & Rohrhuber, 1995). Proximity between individuals may therefore be modified by age. The effect of age on mean distances and time spent within "arms-reach" to other individuals were explored in captive lion-tailed macaques. It was predicted based on the above research that distances between individuals and "arms-reach" proximity will vary depending on age

and that mother and infant lion-tailed macaques would have the lowest inter-individual distances and spend more time within "arms-reach".

6.1.3 Effect of sex on proximity

The sex of an animal may modify its time spent in proximity to other individuals. Female animals may spend more time in proximity to other females in female bonded societies, forming bonds important for the raising of infants. For example, this was observed in closely related female dyads of grey mouse lemurs (*Microcebus murinus*) who lived in significantly closer proximity than closely related male dyads (Radespiel et al., 2001).

Males of a species may spend less time in proximity with each other and have greater inter-individual distances due to competition for females. To support this, adult male woolly monkeys were seldom observed in close proximity to one another (Di Fiore & Fleischer, 2005). As mentioned previously, wild adult male lion-tailed macaques spend more time on the periphery of the group and have a low rate of interaction with group members (Hohmann, 1988; Singh et al., 2000) so one would expect this to be mirrored in captivity. When mean distances between five captive groups of lion-tailed macaques were studied, adult males were in a spatially peripheral position to the rest of the group. However, proximity was modified by reproductive status, since when females were in oestrus, male and female dyads were observed in close proximity (Tenneman, 1992, as cited in Kaumanns & Rohrhuber, 1995). It can be predicted from the above research that the distance between adult males and other individuals will be greater than distances between adult females and other individuals in lion-tailed macaques. The effect of sex on mean inter-individual distances and time spent within "arms-reach" to other individuals were assessed in captive lion-tailed macaques.

6.1.4 Measures of spatial proximity

A variety of methods exist for monitoring social proximity. These methods include detailed scoring of animal locations in relation to physical aspects of their environment (Bercovitch, 1995; Hornshaw, 1985; Plowman, 2003), recording approach and retreat behaviour for development of the Hinde index (Bardi et al., 2001; Brent et al., 2003; Gerson, 2002; Schaffner et al., 1995; Soltis et al., 1997), and recording of instances when animals are or are not within pre-defined distances from one another. This may be in contact (Bentley-Condit, 1999; Brent et al., 2003; Hornshaw, 1985; Schaffner & French, 1997; Schaffner et al., 1995), "arms-reach" (Schaffner & French, 1997; Schaffner et al., 1995) or at various other distances from one another (Bentley-Condit, 1999; Bentley-Condit & Smith, 1998, 1999; Bentley-Condit et al., 1997; Gerson, 2001; Kutsukake, 2003; Seltzer & Wright, 2000). The measurement of distances between individuals and time spent within "arms-reach" of other individuals will be measured in three groups of lion-tailed macaques. Measurement of inter-individual distances as a method of proximity assessment was chosen as previous research on captive lion-tailed macaques has used this method (Hornshaw, 1985; Kaumanns & Rohrhuber, 1995) and therefore a comparison could be made. The measurement of instances when animals were in "arms-reach" with one another was chosen as a method of proximity assessment to examine the frequency when individuals were in close contact to one another.

6.1.5 Aims

This chapter aimed to examine factors modifying proximity in captive lion-tailed macaques (*Macaca silenus*) as it is important to understand social relationships in captivity. The variables examined included institution, age and sex.

6.2 Methods

Proximity data were collected from 29 lion-tailed macaques housed in three institutions (Chester, Bristol and Assiniboine Park Zoo) during 188 hours of behavioural observations. Table 6.1 shows the number of data points collected. Proximity data were collected in the form of "arms-reach" proximity (when individuals were or were not within an arms-reach of each other) and distances between individuals. "Arms-reach" data were collected instantaneously every 30 seconds during each focal observation and distance data were collected before and after each focal observation (every 5 minutes). Distance between individuals was calculated using Pythagoras' Theorem (see chapter 2 section 2.2.2) on a specifically designed spreadsheet (Microsoft Excel 2000), refer to appendix 2. Details on subjects, housing, data collection and sample collection are outlined in chapter 2 sections 2.1-2.3.

Table 6.1 – *The number of data points collected for proximity measures,* ***Note:*** *Table shows the number of scans collected to assess distances between individuals. Each scan calculated between 6 and 16 distances between individuals, depending on the number of individuals in the group.*

	Number of scans per animal		
Proximity measure	**Chester**	**Bristol**	**Assiniboine**
Distance between individuals	672	504	1224
Arms-reach proximity	840	720	720

6.2.1 Data Analysis

Distances between individuals could only be obtained when animals were in the observer's sight, therefore the distance data did not need correcting for time spent out of sight. Distance data were not normally distributed so were log transformed. Mean distances between individuals in different institutions could not be statistically compared because distances at Chester were recorded between animals both inside and outside, whereas in Bristol and

Assiniboine individual distances could only be obtained between individuals inside or outside, due to visual limitations. "Arms-reach" proximity data were corrected for time spent out of sight and arcsine transformed.

A mean was obtained for both males and females for the distance and mean time spent in "arms-reach" to each age/sex class. Age/sex class variables were adult male, adult female, juvenile female, juvenile male and infant female (see chapter 2 section 2.5 for age group classification). A 1-Factor between groups ANOVA was performed to determine whether time spent in "arms-reach" proximity by adult males to all other group members (adult females, juvenile females, juvenile males and infant females) differed by institution. Similarly, a 1-Factor between groups ANOVA was performed to determine whether time spent in "arms-reach" proximity by adult females to all other group members (adult males, juvenile females, juvenile males and infant females) differed by institution. A between group 1-Factor ANOVA was performed to determine whether the mean distances and "arms-reach" proximity between adult males to all other group members (see above) differed by age and sex class. Similarly, a between group 1-Factor ANOVA was performed to determine whether the mean distances and "arms-reach" proximity between adult females to all other group members (see above) differed by age and sex class. An independent sample t-test was performed on adult male and adult female distances to all other group members to examine whether males have a greater mean distance than females to other group members.

6.3 Results

The mean inter-individual distances for each zoo are shown in table 6.2. It should be taken into account, however, that the mean distances at Chester may be larger than the other two groups for the reasons discussed in section 6.2.1. Mean distances between individuals in different institutions were therefore not statistically compared, as mentioned previously. A 1-Factor between groups ANOVA was performed to determine whether time spent in "arms-reach" proximity differed by institution. The time that adult males spent

within "arms-reach" proximity to other group members (adult female, juvenile female, juvenile male and infant female) did not vary between institution (F [2, 9] = 1.02, NS). The time that adult females spent within "arms-reach" proximity to other group members (adult male, juvenile female, juvenile male and infant female) did not vary between institution (F [2, 9] = 1.08, NS).

Table 6.2 – *Mean distances between individuals for each institution and enclosure size. Note: distances between animals located in both inside and outside enclosures at the same time were measured at Chester Zoo.*

Institution	Mean distance	Inside enclosure size	Outside enclosure size	Total enclosure size
Chester	5.19	1092.00 m^3	792.54 m^3	1884.54 m^3
Bristol	2.80	134.20 m^3	457.38 m^3	591.58 m^3
Assiniboine	3.56	19.20 m^3	360.00 m^3	379.20 m^3

A 1-Factor between groups ANOVA was performed to determine whether the mean distance between adult males and all other group members differed by age and sex class. Similarly, a 1-Factor between groups ANOVA was performed to determine whether the mean distance between adult females and all other group members differed by age and sex class. Inter-individual distances did not significantly differ by age or sex class in males (F [3, 6] = 2.80, NS) or females (F [3, 6] = 2.52, NS). An independent samples t-test demonstrated that males did not have greater mean inter-individual distances to other group members than females (t [22] = 0.56, NS). A 1-Factor between groups ANOVA was performed to determine whether the time spent in "arms-reach" proximity by adult males to all other group members differed with age and sex class. Similarly, a 1-Factor between groups ANOVA was performed to determine whether the time spent in "arms-reach" proximity by adult females to all other group members differed by age and sex class. The time spent within "arms-reach" proximity did not significantly differ by age or sex class in males (F [3, 6] = 3.89, NS) or females (F [3, 6] = 2.50, NS).

6.3.1 Results Summary

- The time spent within "arms-reach" proximity by lion-tailed macaque individuals did not differ between the three institutions.
- Mean distances between adult males and adult females to other age and sex classes did not differ.
- Males did not have greater inter-individual distances to other group members than females.
- Time spent within "arms-reach" proximity by adult males and adult females to other age and sex classes did not differ.

6.4 Discussion

The institution in which the individuals were housed did not have a significant effect on time spent within "arms-reach" proximity, despite each institution having a different enclosure size. Although surprising, this result is similar to results of previous research on lion-tailed macaques, exploring mean inter-individual distances ("arms-reach" proximity does not appear to have been studied). Tennemann (1992) as cited in Kaumanns and Rohrhuber (1995), Hornshaw (1985) and Irving-Lewis (2004) found distances between individuals in different enclosure sizes to be similar. Distances of 2-5m found in this study are similar to results by Tennemann (1992) as cited in Kaumanns and Rohrhuber (1995). It could be assumed from this result that enclosure size does not have an effect on proximity between individuals and that individuals will remain at similar distances from one another even in large areas. Although enclosure size would be presumed to be an obvious variable in modifying proximity in lion-tailed macaques, social structure may have also played a part. The social structure for each of the three groups of lion-tailed macaques studied was different, for example some groups had more adult females and juveniles than others. It would therefore be expected that due to differences in social structure there would have been differences in lion-tailed macaque proximity between institutions. The lack of these differences is interesting and requires further research. Although there are difficulties collecting this type of data from wild groups of lion-tailed

macaques it would be interesting to see if similarities were found between proximity of groups in different sizes of fragmented habitats, as this is not thought to be the case.

The mean distances and time spent in "arms-reach" proximity between adult males and adult females to other age and sex classes did not differ. Also males did not have greater inter-individual distances to other group members than females. The latter result is surprising considering results from previous studies. Data on proximity of males to other group members in wild groups of lion-tailed macaques is qualitative, however captive studies have shown similar results, with males being peripheral to other group members Tenneman (1992) as cited in Kaumanns and Rohrhuber (1995). In captivity space restrictions may prevent male lion-tailed macaques being on the periphery of the group. This could be potentially negative, since captivity is not permitting the species-specific proximity patterns and as a result aggression might be increased with potential negative influences on HPA activity and reproduction.

It is interesting that adult females were not in significantly closer proximity to other females or their young as one would have predicted, as other captive studies on lion-tailed macaques have shown this, for example, Tennemann (1992) as cited in Kaumanns and Rohrhuber (1995). The results from the current study may have been due to the individuals being observed at different reproductive phases, which can affect proximity as has been shown in lion-tailed macaques previously by Tennemann (1992) as cited in Kaumanns and Rohrhuber (1995). In the latter study when females were in oestrus, proximity towards males increased.

The results from this chapter on a whole are surprising and further investigation is needed on a larger scale to see how significant the results are to the captive lion-tailed macaque population. Ideally this would be combined with data from wild groups in both non-fragmented and fragmented habitats to examine whether fragmentation affects proximity between individuals and to what extent changes in proximity alone are detrimental to

the species. The lack of difference in proximity patterns assessed by "arms-reach" contact between institutuions has clear implications for lion-tailed macaque enclosure design by zoological institutions. It may be possible, as has been discussed previously that the size of the enclosure does not affect lion-tailed macaque behaviour and subsequent welfare. Instead enclosure layout, furnishings and other areas of lion-tailed macaque management may be more important for the welfare of the species.