The Effect of Zoo Visitors on the Behaviour and Welfare of Zoo Mammals

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Abstract

There is evidence that the presence of the visiting public affects the behaviour of zoo-housed mammals. Understanding the effect of visitors is important in improving animal welfare, achieving zoo conservation goals, increasing visitor education/entertainment, and facilitating interpretation of data on zoo animal biology. A series of studies and experiments focusing on the effect of zoo visitors on captive mammal behaviour is presented. The influence of visitor density on a range of primates and large carnivores is examined. Methodological concerns regarding the operational definition of visitor density in the literature are expressed and a clarification of terms which may be helpful when comparing previous research is provided. Visitor noise data, using an objective measure of the variable, and its relationship to visitor density are also presented.

External and internal visual barriers between visitors and zoo animals were hypothesised to moderate the visitor effect and enrich the environment of the study groups. Camouflage nets mounted on the outside of enclosure viewing windows had little impact on primate or felid behaviour, with the exception of the Sumatran orangutan group, who showed a trend toward decreased social play in the presence of the external barrier. Polar bear behaviour showed evidence of an enriched environment, with trends toward increased levels of swimming and decreased levels of resting. An internal visual barrier, which prevented visitors from having visual contact with the golden lion tamarins when the nonhuman primates were behind it, was also tested and elicited more extensive trends toward behavioural change than did the nets.

Both Sumatran orangutans and zoo visitors were provided with a similar puzzle feeder in an effort to enrich the orangutan enclosure, and improve the visitor experience. It was hypothesised that the orangutans might be stimulated by watching visitors manipulate the device, but this did not occur. Orangutan use of the puzzle feeder within their enclosure was also unaffected.

Olfactory stimuli were introduced into primate and felid enclosures and visitor viewing areas to investigate the role olfaction may play in the visitor effect. Although olfactory stimuli had an extensive significant effect on the behaviour of the study groups when it was introduced into the enclosure, there was little change when visitors were associated with the olfactory stimuli which suggest there may not be an olfactory visitor effect in primates or felids.

The effect of visitors on petting zoo-housed mixed-breed goats, llama, and Vietnamese pot-bellied pigs was studied and compared to their behaviour without the presence of visitors. The goats were unaffected and the llama showed only a trend toward decreased levels of sitting in the presence of visitors. The Vietnamese pot-bellied pigs were significantly affected by the presence of visitors, exhibiting decreased inactivity and social behaviour. The hypothesis that a sustained absence of visitors would result in a more intense visitor effect was tested and was not supported by the data. An additional experiment investigating the effect of visitor grooming on the petting zoo study species showed that, while visitors spent more time interacting with the animals in the grooming condition, the behaviour of the study animals indicated that they did not find visitor grooming rewarding.

Data on the interaction between visitor density and the various experimental techniques tested here indicate that visitor density may impact animal response to environmental enrichment, supporting previous findings in the literature. In the presence of visual barriers, foraging devices, and olfactory stimuli, the relationship between animal behaviour and visitor density changed significantly, both qualitatively and quantitatively. These results suggest that collecting visitor density data when testing environmental enrichment techniques could be helpful when assessing their effectiveness, ultimately improving the welfare of zoo-housed mammals. Based on the data presented here, in conjunction with the literature, a closing discussion outlines proposed refinements to the visitor effect research guidelines published by the British and Irish Association of Zoos and Aquariums (2005).

Chapter 1: Introduction

The following chapter serves as an introduction to the concept of the visitor effect, provides a rationale for investigating the hypothesis, and discusses the nature of the visitor effect and its potential to impact captive animal welfare. The theoretical framework used to evaluate environmental enrichment and assess animal welfare within the context of visitor effect research is outlined. The zoo environment and the methodological limitations it imposes on behavioural research in general, and visitor effect research in particular, is also considered. The statistical technique employed to test hypotheses within this thesis, randomisation tests, is summarised and its usefulness in experimental designs with small sample size is discussed. Finally, the behavioural studies and experiments in this thesis are introduced, highlighting their potential contributions to the visitor effect literature.

1.1 Why Study the Visitor Effect?

The visitor effect hypothesis predicts that zoo visitors affect animal biology, and there are three persuasive reasons, as proposed by Hosey (2000), to investigate this phenomenon. The welfare of animals in zoos is presumably affected by visitors and the mission statements of zoos compel institutions to address welfare concerns in order to fulfil their conservation goals. Zoos are, in part, repositories for endangered species and their preservation in the zoo environment and eventual reintroduction to their wild habitats may be vital to the survival of many commonly held species. Zoos also have an interest in understanding the visitor effect so that they may improve the visitor experience.

Knowledge of the visitor effect has the potential to lead to improved animal management, zoo design, and welfare which will provide a more entertaining and educational experience for the public. Finally, the visitor effect most likely influences any research utilising the zoo population, including behavioural, physiological, veterinary, or cognitive studies and consideration of the visitor effect is important for accurate assessment of data collected on zoo animals.

1.1.1 Why *Not* Study the Visitor Attraction Hypothesis?

In many visitor effect studies, the cause of the behavioural change has not been sufficiently demonstrated. The visitor attraction hypothesis, as discussed in Hosey (2000) and Mitchell et al (1992b), states that increased visitor crowds are not the cause of changes in zoo animal behaviour, but rather the result. Changes in animal behaviour are proposed to be a source of attraction to visitors, resulting in increased visitor density. While there are no data to support a causal link in the visitor attraction hypothesis, Margulis et al (2003) reported that visitor interest and density were associated with active felids, a finding which supports the visitor attraction hypothesis. Unfortunately, like those investigating the visitor effect hypothesis, the authors could only identify a correlation between visitor density and interest and active felid behaviour but did not show that active felids caused increased visitor density or interest.

Kuhar (2007) makes an interesting point about the role enclosure and zoo design may play in the visitor effect-visitor attraction debate. Like the group enclosures in Kuhar’s study, some zoo exhibits (or the animals in them) are not visible from walking paths and visitors may only view the animals from specific viewing areas. The relative isolation of some zoo animal enclosures suggests that the visitor attraction hypothesis is less applicable in these situations, and that the visitor effect is a better explanation for behavioural change. Kuhar's point refers explicitly to animal behaviours that visually attract visitors, but it is likely that the auditory behaviour of many zoo animals also attracts zoo visitors to enclosures. For example, the roar of lions or the call of gibbons seems just as likely to draw visitors to an exhibit as behaviours that are visually interesting. Despite over-looking the importance of auditory contact between visitors and display animals, Kuhar has addressed an important methodological concern that can be addressed in future visitor effect research. Selecting study zoo groups that are housed in visual and auditory isolation from zoo visitors not present in the designated viewing areas (or experimentally manipulating the environment so that this is achieved) may help resolve the visitor effect-visitor attraction debate.

There is no reason to assume that the visitor effect hypothesis and the visitor attraction hypothesis are mutually exclusive (Hosey 2000, Margulis et al 2003). Despite the work of Margulis et al, the visitor effect hypothesis is the more dominant explanation in the literature for the association between animal behaviour and visitor-related variables. The reason for the acceptance of the visitor effect hypothesis over the visitor attraction hypothesis may be that the visitor attraction hypothesis cannot account for many of the behavioural changes documented in the literature. For example, researchers have shown that the presence or absence of zoo visitors, independent of visitor density, has an effect on the behaviour of zoo animals (*Gorilla gorilla graueri*: Vrancken et al 1990, *Chlorocebus aethiops sabaeus*: Fa 1989, *Macaca silenus*: Mallapur et al 2005, *Saguinus oedipus*: Glatston et al 1984, ungulates: Thompson 1989, *Panthera pardus fusca*: Mallapur and Chellam 2002); the visitor attraction hypothesis cannot explain these effects. The visitor attraction hypothesis also does not address the observed differences in the way zoo primates react to male or female audience members or those carrying objects (golden-bellied mangabeys: Mitchell et al 1991b, 1992a, chimpanzees: Cook and Hosey 1995), standing or crouching audiences (Chamove et al 1988), or the experimental manipulations of visitor crowds and noise (Birke 2002). While a greater understanding of the visitor attraction hypothesis will add to the understanding of the role visitors play in the zoo environment, further exploration of this phenomenon may be best left in the hands of zoo professionals charged with the responsibility of educating and entertaining the public.

1.2 How Do Zoo Visitors Affect Captive Animals?

Hosey (2000) suggests that zoo visitors can have either a negative, neutral, or positive effect on captive animals. For the purposes of this discussion, a more explicit definition of these potential outcomes of visitor influence is necessary. A negative effect of visitors is herein defined as one that ultimately decreases animal welfare. A neutral visitor effect may be thought of as either the lack of significant change or statistically significant change in behaviour that is likely to have little impact on animal welfare. A positive visitor effect is one in which captive animals find zoo visitors enriching and promotes animal welfare. The three qualitative differences in the visitor effect are simple to delineate in theory, but can be more difficult to apply when interpreting data. This is primarily due to the difficulties in evaluating environmental enrichment and assessing animal welfare.

1.3 Defining and Evaluating Environmental Enrichment

In addition to investigating the conditions in which zoo animals are affected negatively, neutrally, or positively by visitors, this thesis explores whether visitors can be integrated into successful environmental enrichment programmes; therefore, it is necessary to define what is meant by enrichment. Environmental enrichment of captive animals has been defined as "an animal husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being" (Shepherdson 1998). Environmental enrichment acknowledges that animals have behavioural needs such as hiding from predators, foraging, hunting prey, and interacting with or avoiding other conspecifics. However, the captive environment often thwarts the expression of behavioural needs due to a lack of stimuli, resulting in the need for intervention through environmental enrichment. Shepherdson notes that identifying the behavioural needs of species is still in process, but the effectiveness of environmental enrichment suggests the support of the concept of behavioural needs within the field of environmental enrichment is warranted.

It should be made clear that the inclusion of visitors in environmental enrichment programmes, as was done in several of the experiments presented here, is not meant to imply that zoo animals have a behavioural need to interact with humans. Rather, it is simply an acknowledgement that visitors are a permanent feature of the zoo environment (Hosey 2005) and, given their generally stressful effect on primates (Hosey 2000), attempts to moderate their negative effect and create or accentuate any positive effect on zoo animals is consistent with animal welfare practices and the mission statements of most zoological institutions.

The research carried out by Markowitz at the Portland Zoo (U.S.A.) in the 1970's may be the first use of environmental enrichment techniques that included zoo visitors. Markowitz devised enrichment that allowed participation by both animals and human visitors. While animals were initially "shaped" to learn how to use the enrichment devices, they used the devices "if they wished to." (1982). Markowitz developed a computerised speed game in which visitors and mandrills competed, and this enrichment improved use of the enclosure by the females and allowed the male to earn most of his food through play (1982). Markowitz also tested a similar game at the Panaewa Rain Forest Zoo (Hawaii, U.S.A.) with black spider monkeys (*Ateles ater*). Overall, Markowitz was successful in creating behavioural opportunities for zoo animals and increasing the educational value of the exhibits by increasing visitor understanding of the abilities of primates.

In addition to the use of visitors as elements of enrichment programmes, there are similarities between Markowitz's approach, which balances the dictums of theory and the realities of applied research, and the philosophy behind some of the experiments presented in this thesis. His approach to zoo environmental enrichment, which he called "behavioural engineering," focused on the use of "environmental components" in the engineering of devices that "provide increased behavioural opportunities for animals" (Markowitz and Aday 1998 pp. 47). Markowitz expressed concern that the behavioural engineering he practiced, despite the interest it generated in the public, did not provide more "naturalistic opportunities" for zoo animals (1982). He acknowledged budgetary restraints that constrained his ability to "design entirely new environments" that would provide more naturalistic stimuli and elicit species-specific responses resembling the behaviour of wild populations (Markowitz and Aday 1998). Accordingly, he developed a more pragmatic approach to adapting the available environments to provide the zoo animals with more responsive habitats over which the animals had some control. Markowitz made clear that the techniques he developed were meant to be only temporary, stopgap measures to address immediate welfare concerns.

The approach to visitor effect research in this thesis is, in part, inspired by Markowitz's juggling of theory and applied research. The inclusion of visitors in environmental enrichment was not undertaken because visitors were deemed to be the most effective or appropriate method of introducing stimuli and improving welfare. Rather, visitors were utilised to 1) gather more information on the relationship between zoo animals and visitors 2) utilise an already available source of responsive stimuli 3) attempt to lessen the negative effect of visitors while effective methods of reducing the visitor effect are developed and tested.

Defining environmental enrichment and understanding the need for such intervention in the captive environment, although not without its difficulties, is often relatively straightforward, as is measuring behavioural change as a result of environmental enrichment. However, evaluating the effectiveness of enrichment in improving animal well-being can be more complicated, in part because of the complexities of assessing captive animal welfare.

1.4 Assessing Animal Welfare

Genetic fitness, physiology, and psychology have been used to measure animal welfare and are reviewed in Veasey et al (1996b), but as such measures were beyond the scope of this project, a detailed discussion of non-behavioural measures is not warranted. Instead, behavioural measures pertinent to appraising captive animal welfare are outlined. There are advantages to using behavioural measures of animal welfare. Behavioural measures are non-invasive, they offer an immediate measure, require little equipment, are relatively easy to collect in the captive environment, and may be the first sign of a coping response (Veasey et al 1996b). Given these advantages, it is not surprising that researchers often rely on behavioural measures when assessing animal welfare. However, there is a clear need for physiological data on the visitor effect in zoo animals to support the interpretation of behavioural data (Davey 2007).

Measures used to evaluate welfare do not always agree (Mason and Mendl 1993), and in the case of behavioural measures, this problem may be more likely to arise when collecting a broad range of behaviours as in the studies and experiments presented here. Quantitative data on a wide range of behaviours were considered helpful for this project for several reasons: 1) For many of the species studied, such as polar bears and western lowland gorillas, there was little or no visitor effect data in the literature when observations commenced that indicated which behaviours were most likely to be affected by visitors. 2) Data available on the visitor effect in species more frequently studied, such as chimpanzees and orangutans, were lumped together in behavioural categories that did not often identify the effect of visitors on species-specific behaviour. Although collecting a large number of behavioural categories can lead to difficulties in statistical analysis and interpretation of conflicting measures, the information gained about how visitors affect the behaviour and welfare of zoo-housed species is valuable.

Captive animal well-being is often assessed by comparing it with the behaviour of its wild counterparts. This approach has several drawbacks and Veasey et al (1996a, 1996b) suggest a number of concerns with this method of evaluating welfare, including: 1) The activity budgets of wild animals may be biased due to observational difficulties. 2) Generalising wild animal behaviour recorded in one geographic or temporal location to all members of a species is problematic. 3) Obtaining adequate sample sizes for rare species is difficult in both the wild and captivity. 4) Captive and wild populations are often significantly different genetically. 5) Observations of captive and wild populations are often made by different researchers, which may introduce questions of validity. 6) The approach assumes that wild animals have sufficient welfare. Shepherdson (1998) adds additional concerns about comparing the behaviour of wild and captive when assessing zoo animal welfare, suggesting the data on wild populations are often not available and that captive animals adapt to their environment but this behavioural change is not necessarily indicative of decreased welfare.

Rather than directly compare the behaviour of captive animals to those in the wild, the behaviour and welfare of the study animals were, when data were available, compared to other zoo or laboratory conspecifics. Direct comparisons between zoo-housed and wild populations are unlikely to yield much insight when considering the particular variables of the visitor effect. For instance, visitor-directed behaviour such as begging for food or threatening visitors may increase behavioural diversity, often considered to be an important element when assessing captive welfare, but is not considered to be an improvement in animal welfare. The science of animal welfare in the zoo environment is progressing, but suffers from a lack of consensus on welfare standards and best practices for most zoo-housed species (Maple 2007). Therefore, although comparison of the behaviour of the study animals in this research to other captive groups may be helpful, it should be acknowledged that general welfare concepts in both the zoo and laboratory settings are drawn mainly from what has been observed (or not observed) in the behaviour of wild animals.

The commonly used indicators of impoverished welfare in captive animals, self-directed behaviour and stereotypy, were not observed or observed infrequently in the study groups. It is unclear which abnormal behaviours are characteristic of the stressful presence of visitors for many species, particularly non-primates; this may be due partly to the general lack of agreement on the measurement and assessment of stress in zoo animals (Davey 2007, Maple 2007). Stereotypies are believed to be associated with certain conditions of the captive environment which 1) engender frustration at the inability to perform certain behaviours 2) present inescapable stress or fear or 3) lack stimulation (Mason 1991). Zoo visitors, as a factor in the captive environment, are likely contributors to the development and persistence of stereotypies and data are available linking visitor-related variables to increased stereotypical behaviour in captive primates and felids. Chamove et al (1988) identified a positive correlation between visitor density and stereotyped masturbation in a male mandrill and stereotyped locomotion in two female mandrills in a mixed-species group (*Mandrillus sphinx* and *Mandrillus leucopaeus*). Mallapur and Chellam (2002) observed increased stereotypical pacing in Indian leopards when exposed to unusually high visitor density. Higher levels of stereotypic pacing have been reported in lion-tailed macaques when on display to the public (Mallapur et al 2005). Western lowland gorillas show increased stereotypic body rocking and teeth clenching when visitor density is high (Wells 2005). The effectiveness of environmental enrichment in reducing stereotypies (Shyne 2006, Swaisgood and Shepherdon 2006) suggests that the captive environment, which includes zoo visitors, contributes to the performance of stereotypies by zoo-housed mammals.

Self-directed behaviour is also often interpreted as a sign of diminished welfare in captive animals. Like stereotypies, increased self-directed behaviour has been reported in association with visitor-related variables, although the rate of self-injurious behaviour is apparently low in zoo callitrichids, cebids, cercopithecoids, and apes (Hosey and Skyner 2007). A male pileated gibbon was observed to increase self-biting in relationship to increased visitor density (Skyner et al 2004), while Cooke and Schillaci (2007) reported increased visitor noise was associated with increased self-directed scratching in white-handed gibbons (*Hylobates lar*). Increased self-biting in lion-tailed macaques when visitors were present has also been observed (Mallapur et al 2005). Gorillas have been reported to increase the level of autogrooming as a response to visitors (Wells 2005).

While the infrequency of stereotypies and self-directed behaviour in the studies and experiments presented here bodes well for the general health and well-being of the animals studied, it makes interpretation of the data more difficult. It is possible that some of the observed behavioural changes identified in the study animals will be shown to have an impact on animal welfare once studies with larger sample sizes and multiple measures of welfare have been conducted. Many of the behavioural changes identified in the study animals have yet to be observed in association with changes in other non-behavioural measures of welfare, such as cortisol, mortality rates, or reproductive health, which would support interpretation of results.

Increasing the amount of useable space accessible to captive primates increases the level of “natural behaviors” and reduces the frequency of abnormal and stereotypic behaviour in laboratory primates and this practice is recommended to improve animal welfare (IPS 2007). This recommendation has implications for zoo-housed primates as well, for there are data which indicate that use of enclosure space can be dependent on visitor-related variables such as density. Primates have been shown to use the front or edge areas of their enclosures more when visitors are present (Hosey and Druck 1987, Fa 1989, Vrancken 1990, Mallapur 2005) or in times of high visitor density (Chamove et al 1988, Mitchell et al 1992b). Felids have also exhibited an association between enclosure position and high visitor density (Cunningham 2004). A reduction in the amount of space that is considered to be useable, from an animal perspective, may have a similar detrimental effect on zoo-housed primates as that observed in laboratory-housed primates. Given the potential for visitor-influenced enclosure use to decrease animal welfare, the studies and experiments presented here address enclosure position in relation to visitor-related variables and between experimental conditions.

Given that the most commonly used indicators of poor welfare were observed infrequently or not at all, some of the behavioural changes reported here are assumed to have few direct welfare consequences for the study animals and, therefore, can be said to be of academic interest. Davey (2007) also addresses behavioural change without welfare implications, noting changes in behaviours such as locomotory activity, mother-infant interactions, and vigilance may not have an obvious or direct impact on animal welfare. Although some of the behavioural changes observed in relation to zoo visitors may not impact welfare, these changes are important to identify as visitor-related to facilitate interpretation of zoo research in general.

1.5 Visitor Effect Research and the Zoo Environment

The zoo environment is multi-dimensional and distinctive from other captive environments, such as laboratories, research centres, and sanctuaries, in which animals are housed. Hosey (2005) defined the dimensions which distinguish zoo environments from other captive environments and outlined their demonstrated or hypothesised effects on non-human primates. Although Hosey's review was restricted to the effect of the zoo environment on primates, the distinctive elements of the zoo environment which he defined remain consistent and, therefore, relevant to research that includes non-primate mammalian species. Hosey suggests the following three elements are typical of zoos: 1) the chronic presence of unfamiliar humans 2) restricted space 3) being managed. As Hosey noted, it is likely that all three factors work in combination to affect the behaviour and welfare of zoo animals but there is little available data regarding the interaction between the three dimensions. Even the relationship between visitors and either spatial restriction or animal management has essentially been ignored.

There are many hypotheses about why this lack of data has persisted, but perhaps the most obvious answer to that question is that visitor effects research is still in its infancy. The best evidence of the juvenility of this research topic is that a review article wasn't deemed necessary until the year 2000. However, this does not adequately explain the lack of research on a topic that has wide-reaching behavioural and welfare implications. Why have psychologists, anthropologists, and biologists avoided this avenue of research? Conceivably, the answer lies in the nature of the research topic itself. As Hosey (2000, 2005) illustrated, the zoo environment is complex. There are innumerable factors in the zoo environment indirectly related to visitors which scientists cannot often control: group composition, group size, cage location, enclosure design, zoo design (where other animal enclosures, foot paths, food stalls, educational signs/speakers, entertainment features such as playgrounds, and restrooms are located in relation to the study enclosures), husbandry routines, high/low visitor seasons, and training programs. All these factors can potentially pollute a visitor effect study and reduce the likelihood of obtaining publishable results.

In addition to the obstacles encountered by most zoo researchers, visitor-related variables are difficult to control for or manipulate. Visitor density and visitor noise have been manipulated successfully (Birke 2002), but one can question the validity of manipulating these variables (Jones and Wehnelt 2003). Ideally, what a researcher needs to measure are stimuli that are representative of real visitor density and noise levels and their fluctuations for the results to have any welfare benefit.

Certainly, the implementation of a multi-institutional research visitor effect project would reduce the impact of many of the factors mentioned above by providing an adequate sample size which allows the results to be generalised to the zoo population as a whole. Unfortunately, projects on this scale require additional resources a single institution project does not. While a simple study of the effects of visitor density requires nothing more than behaviour recording paraphernalia, other aspects of visitor effects research can require data-logging sound level meters for visitor noise and multiple video cameras to record human-animal interactions; this adds up quickly when budgeting for a multi-zoo project. Visitor effects research can also be labour intensive (BIAZA 2005). It is difficult for one observer to adequately record the behaviour of both the animals and the visitors simultaneously and at least a two person team should be allocated for some visitor effects research projects. While this resource intensity certainly does not distinguish it from other scientific endeavours, zoological institutions may feel that their money and time are better spent elsewhere.

Zoological institutions may be reticent to spend their scarce resources on visitor effects research. Visitors are, after all, the main source of their revenues and the results of visitor effects research may lead to practices which encroach upon the visitor experience. Additionally, the results of visitor effects research have primarily shown decreased animal welfare due to the presence or behaviour of visitors, which is not in accordance with the mission statements of zoos. Ultimately, the lack of initiation or cooperation by zoos to carry out multi-institutional studies may lead to visitor effects projects not being supported by funding bodies. Although the aforementioned complications surrounding visitor effects research are difficult to surmount, acknowledging the problems inherent in this type of research is helpful in interpreting the literature and is a necessary step in improving the quality of future research.

In 2005, the British and Irish Association of Zoos and Aquariums published a set of guidelines to facilitate visitor effect research. The guidelines are an important resource for researchers beginning visitor effect experiments. In addition to information on basic zoo research methodology, the visitor effect guidelines provide recommendations for studying many behavioural aspects of the visitor effect. The guidelines provide excellent instruction on the following factors that may influence the visitor effect: 1) different audience types 2) how to achieve a “no visitor” condition 3) behaviours that are indicative of good welfare and possibly a positive visitor effect 4) investigating chronic or acute visitor effects 5) enclosure-related variables worthy of study. The data presented in this thesis suggest some additions to the guidelines may be helpful in advancing the science of visitor effect research. One of the purposes for this thesis is to not only provide basic behavioural data on the visitor effect in a range of species, but also inform the practice of visitor effect research by contributing to the refinement of its methodology. Therefore, the final chapter will propose additions to the BIAZA visitor effect guidelines based upon the methodological techniques tested here.

1.6 A Note on Research Design and Statistical Techniques

Designing research that can be appropriately analysed using inferential statistics is recognised as particularly difficult in the zoo environment (Kuhar 2006, BIAZA 2006). Animals housed in groups present a statistical challenge because their behaviour is often related, and this dependency violates the assumptions of most inferential statistics. Most of the study groups in the experiments presented here have more than one member, but they are considered to be a single entity statistically because their behaviour is not independent (Martin and Bateson 1986). For example, in these studies based on data gathered using instantaneous scan samples, the proportion of animals in a group performing a given behaviour were used as the unit of measure to avoid social dependence confounds. While this treatment makes examining individual variation impossible, results on intra-group variation were sacrificed to obtain more reliable information on the group as a whole; additionally, given that there were not adequate sample sizes to test hypotheses regarding sex, age, or life history factors, understanding the effect of visitors on the study groups rather than individuals seemed a more appropriate endeavour. Several of the study groups contain at least one animal that was hand-reared. This is hypothesised to affect the intensity of the visitor effect in these animals, although there is no data in the literature to support this idea. Unfortunately, due to the limitations of the small sample size, the studies and experiments presented here cannot address this issue.

Single-case experiments, while prevalent in the field of zoo animal behaviour (Kuhar 2006), have particular methodological and statistical drawbacks that must be acknowledged. Small sample size makes it difficult to determine if the data meet the assumptions of parametric statistics, and violating these assumptions will affect the power of the tests; these issues can extend to non-parametric statistics, which are often not suitable for more complex research designs (BIAZA 2006). Researchers have tried to increase their sample size through pseudoreplication, a technique in which a study individual contributes more than one measurement to an analysis that does not utilise a repeated measures statistic (Kuhar 2006). Pseudoreplication, as defined by Kuhar, violates the assumption of independence in statistics tests requiring random sampling and inflates the degrees of freedom, making it more likely that the null hypothesis will be rejected when it should not.

Zoo research methods often violate the assumption of random sampling in inferential statistics (Kuhar 2006). In many cases, for obvious reasons, it is not possible for researchers to randomly sample study animals for their experiments. Random sampling is integral to both parametric and non-parametric statistics, however, and violating this assumption invalidates results that were obtained without random sampling (Todman and Dugard 2001). Fortunately, statistical techniques that are free from the assumptions of random sampling and normal distributions are available and one of them, the randomisation test, is used in this thesis to test hypotheses. Because randomisation tests do not make assumptions about the population the sample is derived from, external validity is compromised and the results of experiments using randomisation tests cannot be generalised to other zoo animals (Kuhar 2006). While this may initially appear to be a drawback when one considers the claims of external validity made by zoo researchers who use parametric or non-parametric statistics to analyse data from small-*n* experiments, it is worth pointing out that research based on a small sample size is unlikely to have a high degree of external validity no matter what statistic is used.

Randomisation tests are also suitable to conditions in which multiple measures of the same individual are used, as is the case in the experiments presented here. As previously noted, pseudoreplication is common in zoo research because of logistical constraints which do not allow for data collection on multiple groups of the same species. Kuhar (2006) presents evidence that 24% of *Zoo Biology* papers from the years 2000-2004 included data which was pseudoreplicated. Todman and Dugard (2001) note that repeated measurements of a single individual over time leads to autocorrelation and increased likelihood of Type I errors. Autocorrelation may be less likely to occur in alternating designs, where participants are assigned to treatment conditions, than it is in phase designs (Barlow and Hersen 1984 cited in Todman and Dugard 2001). While several of the experiments presented here use alternating designs and are probably less likely to have Type I errors due to serial dependency, phase experimental designs were also used because it was not possible to assign some enclosure modifications to random treatment occasions.

As previously noted, the relatively large number of behaviours collected on the study groups was an attempt to determine which species-specific behaviours are affected by zoo visitors. Analysing multiple behavioural measures, however, can create issues of multiple testing. BIAZA (2006) recommends when using multiple behavioural measures, such as assessing changes in activity budgets where behaviours are related, that categorical tests such as chi-square or G-tests are used instead of randomisation tests. These tests could not be used in the experiments conducted here for four reasons: 1) behavioural categories were not mutually exclusive, which is a requirement of the categorical tests 2) every data point must be independent, and as noted, there were instances of pseudoreplication in the data 3) durational scores cannot be used 4) there are minimum frequency requirements for all categories which could not be satisfied for some behaviours collected in the experiments presented here.

The randomisation test designs used for the data presented here required multiple tests to address all the behaviours collected for each group. BIAZA (2006) cautions against carrying out multiple tests because the probability of rejecting the null hypothesis increases as the number of tests increases. Although this possibility should not be ignored, correcting for multiple tests (e.g. Bonferroni correction, sequential Bonferroni correction) has its drawbacks as well, including increased risk of committing Type II errors. As the BIAZA statistical guidelines (2006) point out, there is no intrinsic reason why there should be preference for committing Type II errors over Type I errors, and that researchers should consider which error would do the most harm given their particular research question. Given the necessity of carrying out multiple tests, a conservative alpha was employed; trends approaching significance ($p < 0.05$ but > 0.01) are also discussed in an effort to recognise behaviours that might be important to collect in future visitor effect research.

The mathematical theory underlying the randomisation process and the steps in calculating the statistics are thoroughly described in the BIAZA statistical guidelines for zoo data sets (2006) and in Todman and Dugard (2001). It should be noted that because data were collected before the BIAZA recommendations for analysing zoo data sets were published in 2006, the randomisation process described by Todman and Dugard was not part of the original research design. Although a random assignment procedure ensures internal validity, Todman and Dugard suggest there are occasions in which "relaxation" of the random assignment procedure may still yield useful results. The authors indicate that using randomisation tests on existing data, as was done in this case, may be preferable to the "alternatives" (e.g. using other statistics that are more unsuitable). All data from phase design experiments were analysed using randomisation tests that did not have a pre-determined random assignment procedure. However, the intervention point at which the treatment was applied (which should, ideally, be randomised before data collection begins) was predetermined and was not dependent on the response of the study groups to the experimental manipulation, a method which threatens the internal validity of phase experiments. The intervention point for all phase designs was decided before observations began and was based on the number of total samples that were to be collected, resulting in roughly equal numbers of samples from the baseline and experimental phases. It is argued that because the intervention point of each experiment was essentially random with concern to the study animals and their behaviour, the random assignment requirement has been met. Consultation with a zoo animal behaviour researcher with expertise in analysing zoo data sets using randomisation tests yielded support for this method (A. Plowman, *pers. comm.* 2004). Several experiments (Chapters 5 and 6), or parts thereof, were designed with randomised treatments applied to observation times before data collection began, in keeping with the under-riding principle of randomisation tests.

All the randomisation tests used in the experiments presented here were designed by Todman and Dugard (2001) and are available on the compact disc that accompanies their book. Although the authors provide macros for use with the software programs Excel and Minitab, all the randomisation test results were obtained using SPSS. Three of Todman and Dugard’s randomisation test designs were used in this thesis, Design 1 (for single-case phase experiments), Design 5 (for single-case random treatments with two or more treatments), and Design 5a (for experiments with single-case random assignment of two treatments). Design 1 requires inputting the minimum and maximum number of samples from the intervention point, but because the tests were run on existing data, these numbers were not determined before data collection began. Therefore, the minimum and maximum number of samples from the intervention point data were substituted during data analysis with conservative estimates. The conservative estimates limited the number of possible arrangements of the data and, arguably, decreased the probability of making a Type I error. The test statistic for Design 1 is the difference in condition means; the test statistic for Design 5 and Design 5a is the residual sum of squares, which is the equivalent of the *F* statistic (Todman and Dugard 2001).

All statistical tests have a critical level of significance of 0.01 and are two-tailed; this deviation from the more common level of significance of 0.05 was adopted in an effort to prevent Type 1 errors arising from the use of multiple statistical tests, as previously discussed. Trends are discussed if they are equal to or smaller than an alpha of 0.05. Because the data were not normally distributed, medians are used as the measure of central tendency when possible; the use of the data collection software *The Observer* (Noldus) for collecting samples and basic statistical analysis prohibited the use of medians in several circumstances, and these exceptions are outlined in the **Methods** sections where relevant. Medians equal to zero were not infrequent; therefore, means are also included when appropriate to facilitate interpretation.

Box plots were used to graphically present behavioural change between experimental conditions. All box plots use circles to represent outlying data points (1.5 box-lengths from the edge of the box) and asterisks to represent extreme outlying data points (3 box-lengths from the edge of the box). Scatter plots are used to graphically present correlation data. Scatter plot data points, represented by diamonds in the graphs, may not appear visually to equal the sample size listed for each analysis because data points with the same coordinates may be represented by a single diamond.

For many behaviours, both frequency and duration data are presented because it is argued that these measures provide different perspectives which may be useful in interpreting the data and assessing animal welfare. This view is supported by Martin and Bateson (1986), who suggest that rates are helpful for understanding the "initiation" of behaviour while durations provide information on the "continuation" of behaviour. They also state that both the frequency and duration of behaviour should be reported because studies suggest that the two measures are not highly correlated.

1.7 Introduction to Chapters

Chapter 2 examines the effect of two of the most often studied visitor related variables, visitor density and visitor noise, on six species of primate and three species of large carnivore. Chapter 3 investigates enclosure modifications that were hypothesised to moderate the visitor effect by creating visual barriers between visitors and primates or large carnivores. Chapter 4 tests the effectiveness of providing puzzle foraging devices to both zoo visitors and Sumatran orangutans in contributing to a positive visitor effect. Chapter 5 explores the role olfactory stimuli may play in the visitor effect in primates and a large felid. Chapter 6 assesses the visitor effect in petting zoo goats, llama, and

Vietnamese pot-bellied pigs; it also tests the effectiveness of visitors grooming petting zoo animals in facilitating a positive visitor effect.

CHAPTER 2: The Effect of Two Visitor-related Variables on Zoo-housed Mammals.

2.1 Introduction

The effect of zoo visitors and their impact on animal behaviour are discussed in this chapter. The results of studies investigating the influence of two particular variables, visitor density and visitor noise, on the behaviour and welfare of 11 mammalian species groups are presented. Several of the methods used in visitor effects research to gather data on visitor density, the most frequently studied visitor-related variable, will be assessed using the same datasets to determine if there is a preferred method that should be employed in future visitor effects research.

The zoo environment is characterised by three conditions: 1) zoo visitors 2) limited space 3) animal management (Hosey 2005). As Hosey states, it is probable that all three elements have both discrete and synergistic effects on the behaviour of captive primates (and, presumably, other zoo animals). The combined effect of these environmental factors probably has an impact on the behaviour and welfare of zoo animals but there are currently no data available describing the interaction between the three dimensions. The relationship between zoo visitors and either spatial restriction or animal management has also essentially been ignored, with a few notable exceptions, such as Mitchell et al’s (1990a, 1990b, 1991c) work on the effect of cage location and visitor effects in golden-bellied mangabeys (*Cercocebus galeritus chrysogaster*), Wood’s examination of the effects of environmental enrichment and viewing crowds on chimpanzee behaviour (1998), the assessment of an enclosure modification technique intended to reduce the effect of visitors on gorilla behaviour (Blaney and Wells 2004), and the decline in animal-initiated interactions with the public as the result of training in a group of Abyssinian colobus monkeys (*Colobus guereza*) identified by Melfi and Thomas (2005).

Researchers in visitor effects have focused on a few visitor-related variables such as visitor density and visitor behaviour. Despite the limited focus, few visitor-related variables have been examined in a thorough and systematic fashion using an adequate number of groups of the same species. Additionally, the lack of replication of published results by independent researchers hampers our ability to draw firm conclusions about the effect of most visitor-related variables, the relative profundity of data on the effects of visitor density being a possible exception. Upon consideration of the visitor effects literature, it is clear that more data on the discrete as well as the interactive effects of visitor-related variables and the captive environment need to be collected.

2.2 Visitor Density

Visitor density is the most studied visitor-related variable, although the definition of the term and the techniques used to measure density vary enough to warrant further clarification. There is little doubt that these different definitions and measures add breadth to the literature on this topic; however, this lack of preciseness in defining visitor density somewhat hampers attempts to compare the published data on visitor density effects. A review of the visitor density literature reveals three distinct factors concerning visitor density which should be clarified before any meaningful comparison of the results can be made; recent additions to the literature have made these distinctions necessary since the publication of Hosey's review of the visitor effects literature in 2000. The three factors which should be considered in any discussion of visitor density are: 1) scale of measure 2) latency of effect 3) experimental manipulation. Surprisingly, these factors have never been explicitly addressed in a comparative fashion in the literature, although Kuhar (2007) has addressed the methodological concerns for the first two. (All three factors were used to create Tables 2.1 and 2.2, which breakdown the main presence and density findings in the literature). The lack of explicit consideration of these three factors, aside from the lack of sample size, study species diversity, and replication that plagues the visitor effect literature in general, has exacerbated the incompleteness of the visitor density literature.

2.2.1 Scale

"Scale," in this context, refers to the breadth of the measure of the variable visitor density. Some visitor effect researchers have been satisfied with the definition of visitor density as the number of people present. In laboratory or research centre settings, where the visitors are within a demarcated space such as a room within a building or an outdoor run, this definition would be sufficient; however, it's virtually meaningless in the context of many zoos. Many zoo enclosures do not have viewing areas with such clear demarcations for each exhibit. Visitors often spill over from one exhibit to another, forming articulated masses of people, particularly in the case of indoor exhibits which may have several animal enclosures within a hall or pavilion.

The research literature can be subdivided into three operational definitions of visitor density based on the proximity of the visitors to the study exhibits: exhibit density, vicinity density, and institutional density. "Exhibit density" restricts the measure of visitor density to visitors who are within the visitor viewing area(s) designated for the study exhibit during the time of visitor density measurement. Arguably, for this distinction of density scale to be scientifically valid, we assume that the majority of the visitors' attention and behaviour was directed towards the study animals and that the study animals were aware of the direction of human attention and behaviour. Emery's (2000) review of social gaze in vertebrates cites a number of species that appear to be capable of determining whether a human is looking at them, including black iguanas (*Ctenosaura similis*), plovers (*Charadrius sp.*), and hognose snakes. Emery also notes that chimpanzees and orangutans followed the gaze of humans, while brown lemurs (*Eulemur fulvus*), black lemurs (*Eulemur macaco*), squirrel monkeys (*Saimiri sciureus*), brown capuchins (*Cebus apella*), white-faced capuchins (*Cebus capucinus*), stump-tailed macaques (*Macaca arctoides*), pig-tailed macaques (*Macaca nemestrina*), rhesus macaques (*Macaca mulatta*) and tonkean macaques (*Macaca tonkeana*) did not follow a human experimenter's gaze. Emery's review suggests that social gaze may be a factor in the visitor effect for vertebrates and that the scale of visitor density most likely to elicit a behavioural response may depend in part upon a species' capacity for social gaze.

"Vicinity density" is defined as the number of visitors the focal animal could observe, regardless of the visitors' location, at the moment the measurement was being recorded. In other words, the focal animal's visual perspective from its particular position in the enclosure was adopted when assessing visitor density, as is recommended by the BIAZA visitor effect research guidelines (2005). This requires a certain level of conjecture by the researcher, particularly in cases where enclosure design allows the animals to position themselves higher within their enclosure than the observer who is vertically restricted to the ground. The potential benefit of using this scale of visitor density is that it does not make assumptions about the attention, behaviour, or grouping of the visitors. Hypothetically, using this scale of visitor density may be more appropriate in visitor density studies of species that are reliant on auditory or olfactory modes of sensory perception. This scale of visitor density has not been previously collected and the data presented in this chapter will help fill in the gaps between results using the other two scales of visitor density.

"Institutional density" is a simple method of measuring visitor density. It involves counting the number of paying zoo visitors who pass through the entrance gates. Since daily numbers are kept automatically by the zoo staff as part of their financial record keeping, it is the most efficient method to ascertain visitor density for the researcher, freeing her from tracking the dynamic variable and allowing her to focus on animal and visitor behaviour.

Collecting institutional density may have similar benefits to vicinity density data because it places less emphasis on the visual mode of sensory perception, which may be particularly useful for studies involving species that rely on more sense modalities when interacting with their environment.

Institutional density may also be useful to gauge the general ambience of a zoo, although Kuhar (2007) suggests this is one of the method's drawbacks, arguing that it may not be the visitor-related variables causing the behavioural change. Days of high visitor numbers may involve greater zoo employee activity throughout the zoo, making personnel such as security, administration, animal care, and cleaning staff more visible and audible to the display animals. For example, Lambeth et al (1997) documented chimpanzee wounding increased on days with increased human activity in a laboratory setting. The influence of zoo staff on animal behaviour should not be confused with visitor effect variables, but until further research is done on human activity, it will be difficult to tease out the different effects of each variable when density data are collected on such a broad scale.

Despite the ease of collecting institutional density data, there are several potential drawbacks to this method of measuring visitor density. Firstly, it ignores the non-paying visitor. Some zoos may not keep track of the number of zoo members or school groups who enter the zoo each day and this has the potential to underestimate the visitor density numbers. This method also assumes that each exhibit within the zoo has an equal probability of being visited by all the zoo visitors, which does not appear to be the case. Mitchell et al (1990a, 1990b) have shown that exhibit location can affect the number of people who visit an exhibit and the subsequent visitor pressure that is placed on animals housed in high traffic locations. It is also likely that particular species are more popular with visitors, thereby increasing the visitor density for some species and decreasing it for others. Davey and Henzi (2004) reported circulation patterns in zoos similar to that in museums, in which visitors had a direction bias and turned right 84% of the time when entering a primate house. Ward (1998) reported that larger display animals are more popular with visitors than smaller animals.

2.2.2 Latency of Effect

The second factor which should be made more explicit in visitor density studies or experiments is the "latency of effect" of visitor density on the behaviour of the study animals. The literature is divided into two approaches to calculating visitor density, depending on the type of effect one is examining: immediate and cumulative. The immediate effect visitor density research focuses on the effects of high or low density on the behaviour of the animals at the time (or shortly after) each visitor density measurement is taken. In the immediate effects approach, researchers are concerned with the number of visitors present at a particular instance and the effect this has on the animals; therefore, visitor density is determined by summing the number of individual visitors present at the time of measurement. Kuhar (2007) suggests this type of "instantaneous evaluation" of visitor density is problematic because visitor density at one moment is not independent from visitor density measures taken subsequently.

Other researchers have taken a different course from the more prevalent immediate effect approach and attempted to understand the effects of the total number of visitors who visited the study enclosure or the zoo. The essential aspect of the cumulative approach is that it addresses how the total number of visitors who have visited the study enclosure over a particular period of time influences the study animals. Calculation of visitor density in this method is done by summing the number of visitors over a period of time. Both the immediate and the cumulative effects of visitor density can be used in conjunction with the three scales of visitor density, depending on the question the researcher is endeavouring to answer. The density data in Study 1 have been collected using vicinity density to determine if this scale yields different results from the exhibit and institutional methods used by other visitor effects researchers. Additionally, Study 3 will compare these methods and assess whether using an institutional scale identifies similar results as a vicinity scale density. If the results of the two methods are similar, this will suggest that they essentially measure the same variable and can be used interchangeably in visitor density studies and when comparing results from different studies.

Some researchers have stated their objective in calculating visitor density was to estimate the size of groups, while others have not addressed the issue of groups; this ambiguousness makes it difficult to determine if the visitor density effect is due to the tendency of large numbers of people, whether due to space limitations or previous association, to cluster or if it’s merely the presence of a large number of people who are not grouped that is associated with a change in behaviour. Fortunately, the issue of grouping may be addressed in part by characterizing the type of scale employed by the researchers when defining visitor density and a reasonable conclusion regarding the detail of grouping can be attempted. Clearly, both immediate and cumulative calculation approaches have the potential to answer different questions regarding the effects of zoo visitor numbers on zoo animal behaviour and welfare but they should not be confused when comparing study results.

2.2.3 Experimental Manipulation

The final factor that has not been given satisfactory consideration in the visitor effect literature is the decision to manipulate visitor density experimentally. Manipulating visitor density is usually only possible when the researcher is collecting density data on the scale of exhibit density and looking at the effects of visitor density in terms of its immediate effect. Any other scale of visitor density projects would require shutting down parts of the zoo or even the entire institution; indoor exhibits may be the exception because there are controllable entrances and exits, making it easier to restrict visitor access. While this lack of control of the visitor density condition does not make experiments impossible or the results of such work unimportant, it is useful to recognise that having truly independent variability is going to be impractical and perhaps even inappropriate for some visitor effects research projects.

It may also be useful to understand that in welfare terms, the natural fluctuation of visitors is the most realistic reflection of the visitor pressure each study group is under and may be the preferred method of obtaining low and high visitor density conditions. Jones and Wehnelt (2003) raise the issue of whether experimentally manipulating visitor density presents appropriate visitor density stimuli. Although the non-experimental approach may turn out to be the recommended research design for visitor density studies, using natural patterns of visitor density makes this sort of research time intensive and introduces many uncontrolled variables into the project. For most zoos in Europe and North America, the summer months of June, July, and August are the high visitor density months and the rest of the year has patchy periods of high density, but has mainly low visitor density. Because of the seasonality of visitor density, weather, reproductive cycles, and seasonal activity patterns are now introduced into the data, which requires either decent literature on these effects so that their influence on animal behaviour can be teased apart from the visitor density effects or, ideally, the ability to collect samples during several seasons. Kuhar (2007) has noted the difficulty of obtaining differing levels of visitor density over a period of time short enough to avoid confounding variables such as weather, changes in study group composition, and zoo personnel changes.

Deciding whether to manipulate the number of visitors present experimentally brings up the question of how one achieves a no visitor condition. The absence of zoo visitors is a condition which has not been adequately investigated, but can be achieved by two methods. The researcher can exploit the daily fluctuations of visitor density and collect samples when there happens to be no visitors viewing her study group (BIAZA 2005). Alternatively, one can experimentally achieve a no visitor condition by collecting data on days when the zoo is closed; it can be argued, however, that this method is more accurately classified as pseudo-experimentation rather than true experimentation because the experimental conditions are not randomised. Most zoos in North America and Europe are open almost every day of the year, making it challenging to achieve a no visitor condition for any continuous length of time on those continents. It is also possible to achieve a no visitor condition by collecting data before the zoo opens for the day or after it closes; this method is not advisable due to circadian patterns of behaviour that have been documented in some animals, such as jaguars (Sellinger and Ha 2005). Moving study animals into an enclosure which is not on display to visitors is another way of achieving a no visitor condition. However, this is not ideal because the change in the captive environment would be predicted to alter the animals' behaviour (Hosey 2005). Tables 2.1 and 2.2 label visitor presence and density studies as experimentally manipulated if the natural fluctuation of visitor absence/presence or density is *not* used.

Some of the research investigating the interactive effects of visitor behaviour and density has documented a change in animal behaviour due to experimentally elicited human behaviours which are probably not representative of natural visitor behaviour (Chamove et al 1988, Birke 2002, Buchanan-Smith 2004). In some cases, the behaviours could be classified as natural if performed by a few visitors at one time; however, when simultaneously performed by a group of people, they are no longer reflective of visitor behaviour. Certainly, one would predict some habituation by zoo animals to strange visitor behaviour, but it remains difficult to establish what role the abnormal visitor behaviour in the experimental conditions played in eliciting the documented changes in behaviour. This should not be taken to mean that the studies are not useful, for they were important in determining which aspects of visitor behaviour affect display animals and gave valuable indications of possible ways to moderate the visitor effect.

The distinctions made herein regarding the three visitor density factors of scale, latency of effect, and experimental manipulation by visitor effects researchers will be applied in the following literature review and Tables 2.1 and 2.2 to make more specific conclusions about the visitor density research to date. By distinguishing these elements of visitor density research, the need for the studies presented in this chapter will become apparent, as will potential future avenues of research that should be undertaken to gain a full understanding of the impact of visitor density on zoo animals. Because of the number of studies that touch on either visitor presence or density, the main findings of the visitor presence and density literature are summarised in Table 2.1 (primate) and Table 2.2 (non-primate); only studies that address methodological issues or present original concepts or measures are discussed at length here. The tables show that visitor presence or density studies have focused on primates (n= 19), with Old World (n= 9) and lesser or great apes (n= 8) being the most commonly studied primate species; visitor presence or density effect data on prosimians is most scarce in the primate literature (n= 4). Felids are the most frequently studied non-primates used in this type of research (n= 4), but Table 2.2 highlights the general paucity of non-primate visitor density data.

2.2.4 Visitor Presence Studies: Primates

Some researchers have compared the behaviour of their study animals in conditions where visitors are not present to those when visitors are present, rather than focusing on the relative effects of the number of visitors present. These studies must be considered within the context of possible changes in temporal behavioural patterns and/or the captive environment of the study animals that may be associated with achieving the no visitor condition. Despite these methodological drawbacks, the results of such studies can provide an interesting source of comparison with visitor density studies.

In addition to the short-term (immediate) effects reported in Table 2.1, Mallapur et al (2005) examined the “long term effects” of visitors on seven singly-housed lion-tailed macaques in Indian zoos. The six males and one female were permanently singly-housed in on-exhibit enclosures before the study began, and once the visitors present data collection was completed, they were moved to off-exhibit enclosures that were of a similar size and complexity and observations without the presence of zoo visitors were made. The macaques displayed lower levels of abnormal behaviour such as stereotypic pacing while off display to the public. The monkeys also performed less frequent aggressive behaviours and yawning when not in the presence of visitors. Use of enclosure space was also influenced by the removal of zoo visitor stimuli, and the authors found that the macaques used the edges of their cages less when off-exhibit; they also utilised the area of their cages with trees, sleeping platforms, sheds, logs, or elevated bars more when they were off exhibit, suggesting that increasing the amount of useable space, and potentially animal welfare, may be achieved in zoo primates by decreasing the long term exposure to visitors. While their methodology may have introduced environmental change as a confound, their results contribute to the data on how behaviour changes once primates are removed from visitor stimuli for an extended period of time (i.e. over months rather than days).

Visitor Presence and Density Effect: Primate

Author(s)	Species	Scale	Latency	Manipulation of Presence/Density	Results
Birke (2002)	Orangutan	Exhibit	Immediate	No	Increased holding on to adults, sitting, and foraging in infants when density is high; increased foraging and paper sack use to block out stimuli are also seen in adults
Chamove et al (1988): Study 1, 2	Cotton-top tamarin, Diana monkey, ring-tailed lemur	Exhibit	Immediate	Study 1: No Study 2: Yes Visitors asked to crouch or stand up to their full height	Study 1: Increased agonism, decreased grooming, affiliation, and inactivity in the presence of at least six visitors; size of effect dependent on body size/arboreality Study 2: Crouching visitors moderate effects in Study 1
Chamove et al (1988): Study 3	Mandrill	Exhibit	Immediate	Unclear	Increased watching, threatening, and stereotyped masturbation as density increases, decreased affiliate/inactive behaviour
Chamove et al (1988): Study 4	Study groups from Hosey and Druck (1987)	NA	NA	No	No significant correlation between audience-directed behaviour and body weight, arboreality, group size, or length of residence at Chester Zoo
Cooke and Schillaci (2007)	White-handed gibbon	Exhibit	Immediate	No	Looking at the public and looking at mate increased in the presence of larger groups of visitors; higher rates of looking at the public when visitor crowds included children. Individual and sex differences in response to visitor density also reported
Davis et al (2005)	Spider monkey	Institutional	Cumulative	No visitors condition achieved during foot and mouth outbreak of 2001	Increased density correlated with increased cortisol
Fa (1989)	Green monkey	Exhibit	Cumulative	No visitors condition achieved on days when zoo was closed to the public	Increased resting/affiliation when visitors are present; decreased feeding Positive correlation between density and feeding on food obtained from visitors

Visitor Presence and Density Effect: Primate

Author(s)	Species	Scale	Latency	Manipulation of Presence/Density	Results
Glatston et al (1984)	Cotton-top tamarin	Exhibit	Cumulative	On- and off-display groups compared; on- and off-display groups exchanged	Decreased affiliation and agonism in on-display tamarins; parents engaged in less social behaviour with their offspring, and juveniles approached their parents more when on display Negative correlation between density and affiliative behaviour; positive correlation between agonism between mother and young
Hosey and Druck (1987)	Ring-tailed/mayotte lemur, white-fronted capuchin, de Brazza's/Syke's/ black spider/patas monkey, talapoin, barbary/lion-tailed/Sulawesi macaque, hamadryas baboon	Exhibit	Immediate	No	Visitor behaviour more influential than visitor density; increased locomotory activity, increased use of front of enclosure in the presence of large active groups
Kuhar (2007)	Western lowland gorilla	Exhibit	Cumulative	No	Increased out of sight when density is high. Bachelor group was more aggressive and family group was unaffected by high density
Mallapur et al (2005)	Lion-tailed macaque	NA	NA	Short-term: no visitor condition achieved on days when zoo was closed to the public Long-term: on-display animals moved off-display	Short-term effect: increased self-biting, begging, bouncing when visitors are present; decreased social and reproductive behaviour; increased use of front of enclosures Long-term effect: Subset moved to off-exhibit enclosures where less abnormal and stereotypic behaviour is exhibited
Mitchell et al (1992b)	Red-ruffed/ mongoose lemur, squirrel/Francois/ spot-nosed/de Brazza's monkey, golden-bellied	Exhibit	Immediate	No	Replication of Hosey and Druck (1987) but with different species. Visitor-directed behaviour increased when audience is large and active. Visitor presence increased

Visitor Presence and Density Effect: Primate

Author(s)	Species	Scale	Latency	Manipulation of Presence/Density	Results
	mangabey, white-handed gibbon, orangutan, chimpanzee				locomotory activity. Primates more likely to be in the front of their enclosures when visitors are present. Present visitor attraction hypothesis as an alternative explanation for the link between visitors and primate behaviour.
Mitchell et al 1991c	Golden-bellied mangabey	Exhibit	Cumulative	Mangabeys moved to enclosures with different visitor density levels	Decreased visitor density resulted in decreased intragroup aggression and increased grooming, sexual, and play behaviour. Increased density resulted in increased aggression towards visitors/group members and play; decreased aggression towards neighbouring conspecifics
Skyner et al (2004)	Pileated gibbon	Exhibit	Cumulative	No	Positive correlation between self-biting and visitor density
Todd et al (2006)	Diana monkey	Exhibit	Immediate	No	Increased feeding, chewing, playing and decreased grooming, resting, and sleeping when density increased
Vrancken et al (1990)	Eastern lowland gorilla	NA	NA	No	Hand-reared adult female spent more time near visitor viewing windows when visitors were present
Wells (2005)	Western lowland gorilla	Institutional	Cumulative	No	Low density associated with increased resting; high visitor density associated with increased aggression, abnormal behaviour (teeth clenching, body rocking), autogrooming
Wood (1998)	Chimpanzee	Exhibit	Immediate	No	Foraging, object use, grooming and playing decreased when more visitors are present

Table 2.1 The main findings on visitor presence and density in nonhuman primates.

Visitor Presence and Density Effect: Non-primate

Author(s)	Species	Scale	Latency	Manipulation of Presence/Density	Behavioural Change
Carlstead and Brown (2005)	Black/white rhinoceros	Exhibit	Cumulative	No	Positive correlation between the percentage of enclosure perimeter accessible to visitors and corticoid levels in black rhinoceros
Carlstead et al (1999)	Black rhinoceros	Exhibit	Cumulative	No	Positive correlation between mortality and the percentage of enclosure perimeter accessible to visitors
Mallapur and Chellam (2002)	Indian leopard	NA	NA	No visitor condition achieved on days when zoo was closed to the public	Increased resting when visitors are present; increased running, climbing, jumping, standing, walking, rubbing on objects, and rolling on ground when no visitors are present Sharp increase in stereotypies when density extremely high (anecdotal obs.)
Margulis et al (2003)	African lion, Amur/snow/clouded leopard, Amur tiger, fishing cat	NA	NA	No	No difference in behaviour between visitor and no visitor conditions
O’Donovan et al (1993)	Cheetah	Exhibit	Immediate	No	No visitor density effect
Sellinger and Ha (2005)	Jaguar	Exhibit	Immediate	No	Increased time spent out of sight when density is low
Thompson (1989)	Zulu sini, slenderhorn/Dorcas/Mhorr’s gazelle, impala, yellow-backed duiker, lowland nyala, Nile lechwe, Arabian oryx, bongo/sable antelope, greater kudu	NA	NA	Data collected after zoo closed for the day	More vigilance directed towards keeper when no visitors are present

Table 2.2 The main findings on the visitor presence and density effect in non-primate species.

2.2.5 Visitor Presence Studies: Non-primates

The non-primate visitor presence literature consists mostly of felid studies, but also includes a study of ungulates. Thompson (1989) investigated the interaction between keeper presence, the presence of zoo visitors, and the behaviour of twelve separately housed ungulate species. A no visitor condition was achieved experimentally by collecting data for an hour after the zoo had closed for the day, which as stated previously, may have biased the data; the after-hours data were then compared to the data collected during the last open hour per day while visitors were still in the zoo. During the no visitors condition, significantly more vigilance was directed towards the keeper. This study highlights the need for researchers interested in the keeper-animal relationship to record the presence of visitors when collecting data because there is potential for the visitor effect to influence keeper-directed behaviours.

2.2.6 Immediate Effect of Exhibit Density Studies: Primates

Exhibit density is the commonly collected scale of visitor density, with 14 out of the 16 primate density studies presented in Table 2.1 using this method of defining visitor density. Exhibit density is most often used in combination with the immediate effect method of calculating visitor density, as shown in Table 2.1 by the nine studies using these methods together to investigate density effects. Hosey and Druck (1987) indicate audience directed behaviours were more frequent in the presence of large active groups than small active groups, while a significant visitor density effect did not hold up in a comparison between passive visitor groups of differing size. When small passive groups were compared with small active groups and large passive groups were compared with large active groups, there was a significant increase for both comparisons, suggesting that visitor behaviour had more influence on the study primates' behaviour than visitor density. This claim was further supported by the data presented on locomotory activity and spatial dispersion, noting that there were significant increases in locomotory activity across the no visitor, small group, and large group conditions when the visitors were active; the study animals also increased use of the front half of the enclosure when large active groups were present. Overall, Hosey and Druck's results suggest that visitor attempts to interact with the animals had greater influence on the behaviour of the animals than visitor density alone. Their conclusions are important from a welfare perspective and suggest that one avenue for improved zoo primate welfare involves changing visitor behaviour not reducing visitor numbers.

Chamove et al (1988) presented a series of visitor effect studies on a number of primate species, and several of these use innovative methodological techniques to explore the visitor effect in primates. Their first study used three species chosen for their socio-ecological disparateness. The cotton-top tamarin (*Saguinus oedipus*) was selected for its small size and arboreality, Diana monkeys (*Cercopithecus diana*) for their medium body size and arboreality, and the ring-tailed lemur (*Lemur catta*) species for its medium body size and terrestrial nature. The presence of zoo visitors resulted in a significant increase in agonism and a significant decrease in grooming, affiliation, and inactivity in all three species groups. As hypothesized, the size of the effect varied according to species/ecological niche for two of the behaviour categories. Reduction in inactivity was less for the Diana monkey group while a reduction in affiliative behaviour was not significant for the lemur group.

The species differences documented above were explored further in Chamove et al’s (1988) second study using the same study groups and conditions, In an attempt to explore the species differences in response to the presence of visitors, Chamove et al experimentally manipulated the appearance of the body size of visitors and the angle at which animals viewed the public by asking them to alternatively crouch until only their heads were visible to the study animals or stand up to their full height. Species differences in size of effect indicate that the differences in behaviour during the crouching condition were largest for the small arboreal species, middling for the medium-sized arboreal species, and smallest for the medium terrestrial species between the two visitor conditions. When the crouching condition was compared to the no visitor condition, the effects were still present but to a lesser degree. The frequency of glancing at visitors also supports the differential effect of crouching on the study groups, with the tamarins looking at visitors most frequently and the lemurs performing that behaviour least frequently. While the method of moderating visitor behaviour tested is obviously not a practical one, they do make several pragmatic suggestions for reducing the apparent size of visitors that would be useful when designing or remodelling zoo enclosures to increase primate welfare.

Mitchell et al (1992b) replicated the study of visitor density carried out by Hosey and Druck (1987) using a different range of primate species and obtained similar results. The authors concluded that, while their data (and Hosey and Druck's) show that primate behaviour is related to visitor density and behaviour, the direction of causality has not been demonstrated. In addition to their findings on the relationship between visitor and animal behaviour, Mitchell et al's introduction of the visitor attraction hypothesis was a thought-provoking interpretation of the data.

Wood (1998) investigated the interactive effects of visitor density and enrichment on the behaviour of zoo chimpanzee and is one of the few studies investigating the interaction between environmental enrichment, behaviour, and visitor-related variables. Wood documented a strong interaction between visitor density levels and new or one-day old environmental enrichment (including browse, video tapes of wild chimpanzees, foods encased in ice blocks, objects to use as tools, filled burlap sacks, and a mirror), but no significant main effects for either visitor density or enrichment on overall activity patterns were identified. However, when the type of enrichment was held constant, the following significant results were revealed. Foraging, object-using, grooming, and playing by the chimpanzees were more likely to occur during times of low density and new or one-day old enrichment than periods of enrichment and high visitor density. Wood clearly demonstrated the influence visitor density and environmental enrichment had on animal behaviour and the experiment suggests that further notice should be paid to potential visitor effects when assessing environmental enrichment.

2.2.7 Cumulative Effect of Exhibit Density Studies: Primates

The primary objective of the visitor effect studies and experiments discussed thus far has been to determine the immediate effect of groups of visitors on zoo animal behaviour. However, a handful of studies and experiments have looked at the cumulative effect of visitors by measuring the number of visitors who pass through the visitor gates or visit the exhibits over a given period of time. Although there is currently a clear need to distinguish these differences in methodology, it is unclear whether the differences in scale and latency are true biological distinctions and can be linked with particular effects on animal behaviour.

Glatston et al (1984) identified behavioural differences between on and off-display cotton-top tamarin groups, as well as changes in tamarin social behaviour due to visitor density. An on-display group was exchanged with an off-display group, and the new on-display group exhibited less social behaviour towards each other and their young. Agonism, however, increased in both transfer groups and the females in both groups avoided the male significantly more than before the transfers. The authors also noticed a significant difference between the first sampling period of the day and sampling periods later in the day after more visitors had observed the on-display group. After breaking the data down into exhibit density to determine the total number of visitors who had viewed the exhibit per daily sampling period, the authors identified a significant negative correlation between visitor density and the amount of time the tamarins engaged in affiliative behaviour. There was also a significant positive correlation between visitor density and the frequency of agonistic interactions between mother and young. Although there are a number of confounding variables such as cage design, group size, visual/auditory/olfactory contact with conspecifics, and group composition that have the potential to influence the results of the study, the data suggest a visitor effect contributed to the behavioural changes seen in the tamarin group. Additionally, Glatston et al's multi-scale approach to their visitor condition data supports the claim made herein suggesting scale and immediacy of effect distinctions in visitor effect methodology can be useful for collecting, analyzing, and interpreting visitor effect data.

Mitchell et al (1991c) measured exhibit density cumulatively to determine the effect of visitor density on three groups of golden-bellied mangabeys. Two of the groups were moved from their original cages to a similar cage with either a higher or lower visitor density than the original cage. The group that moved from the medium visitor density cage to the lower visitor density cage exhibited significantly decreased intragroup aggression and increased grooming, sexual and play behaviour. The second study group, which moved from the lower visitor density cage to the medium visitor density cage, exhibited significantly increased aggression towards visitors and other group members, increased play behaviour, and decreased aggression towards neighbouring primate groups. Differences in the behaviour exhibited in each cage was identified, regardless of the group occupying them, suggesting the behaviour of the groups was dependent on the levels of visitor density to which they were exposed.

Aggression towards visitors was greater in the cages with high and medium levels of visitor density than the cage with low density levels. Aggression towards neighbouring primates was most frequent in the low density cage. Intragroup aggressive displays were more frequent in the medium density cage, second highest in the high density cage, and the least frequent in the lower density cage. Grooming and sexual behaviour were more frequent in the low and medium density cages than in the high density cage. The highest frequency of play behaviour was exhibited in the medium density cage and the high density cage occupants exhibited no play behaviour. Mitchell et al documented that the behaviour of three groups of mangabeys were affected by the number of visitors who visited their cage as well a change in their enclosure, noting the patterns of change were distinct and the behavioural changes due to one of the variables were not predictive of changes due to the other.

Kuhar (2007) identified a visitor density effect in western lowland gorillas (*Gorilla gorilla gorilla*) housed at Disney's Animal Kingdom (USA). In addition to providing visitor density data, he makes a much needed methodological dissection of the vague term "visitor density," which is useful in interpreting the visitor effect literature. Kuhar makes the distinction between "instantaneous" (equivalent to the term "immediate" used here) or "cumulative" effects, in much the same manner as has been described here. The instantaneous latency of effect method employed in most density studies weights all measures equally, which may not make much sense if an animal has experienced a morning with no visitors followed by a brief period of exposure to people in the afternoon. In addition, he points out that the instantaneous method does not address the visitor attraction-effect conundrum. Kuhar also notes the paucity of data on individuals in the visitor effect literature, and suggests that data on groups may be obscuring significant differences in the effect of visitors on age- and sex- classes. Kuhar's methodological points are well-made and he goes farther than other researchers to define visitor effect terms; it also suggests that visitor effect research is unlikely to contribute to a science of zoo animal welfare until more rigorous empirical methods, such as those outlined by Kuhar, are used to collect and interpret data.

2.2.8 Cumulative Effect of Exhibit Density Studies: Non-primates

Carlstead et al (1999) examined the behaviour, mortality, and breeding success of black rhinoceros (*Diceros bicornis*) housed at 23 zoos within the context of their housing conditions. They used a unique method of estimating visitor density, finding that mortality was significantly positively correlated with the percentage of enclosure perimeter to which zoo visitors had access. Male rhinoceros fear behaviour also increased as the percentage of perimeter open to the public increased.

Virtually nothing is known about the effect of visitors on the physiology of zoo animals. Carlstead and Brown (2005) looked at the relationship between faecal corticoid secretion, behaviour, reproduction, and environmental factors of zoo-housed black rhinoceros and white rhinoceros (*Ceratotherium simum*). The authors state that stress, which can include environmental factors such as visitor pressure, results in increased secretion of glucocorticoids by the hypothalamic-pituitary-adrenal axis. The level of these hormones in the black rhinoceros faecal samples were compared to the percentage of enclosure perimeter (n= 15) which allowed visitor access to determine the immediate effect of visitors on the study rhinoceros. The authors identified a significant positive relationship between corticoid levels and the percentage of the enclosure perimeter with visitor access in the black rhinoceros groups. These results, taken in conjunction with Carlstead et al (1999), indicate that visitor density pressure in black rhinoceros affects behaviour, physiology, and mortality and is a welfare concern. It also suggests that the impact of visitor density should be addressed during the zoo enclosure design process.

2.2.9 Cumulative Effect of Institutional Density Studies: Primates

Only two primate studies have used an institutional scale of visitor density (Wells 2005, Davis et al 2005), but only one uses a physiological measure of animal welfare. Davis et al (2005) suggest that visitor density affects levels of urinary cortisol, a measure of chronic stress, in captive spider monkeys (*Ateles geoffroyii rufiventris*). The authors compared the data from a no visitor condition achieved during the U.K. foot and mouth disease outbreak of 2001 to a visitor presence condition when the zoo was open to visitors. A positive relationship between the daily total number of visitors who visited the zoo and the following morning’s urinary cortisol levels of the study animals was identified. This study highlights the need for more non-behavioural measures of visitor-related stress in visitor effect research.

2.3 Visitor Noise

Visitor noise is a condition of the zoo environment that has been alluded to in the visitor effects literature, but has rarely been examined as a discrete variable. All visitor density studies would appear to be, in essence, also visitor noise studies for it seems common sensical that there is a positive correlation between visitor noise and visitor density. This hypothesis is tested in Study 1 and the results suggest that visitor noise and visitor density can be discrete variables. Some visitor effect studies (Hosey and Druck 1987, Chamove et al 1988, Mitchell et al 1992a, Mitchell et al 1992b, Nimon and Dalziel 1992, Cook and Hosey 1995,) included aspects of visitor behaviour that have an auditory element, such as vocal threats, visitor simulations of animal vocalisations, and attempts to gain animal attention. The distinction between active audiences (who attempt to gain the attention of or interact with the animals) and passive audiences (who do not) suggests that passive audiences are quieter, but data have not been presented to support this, other than the fact that animals are less influenced by passive audiences. Without data on noise levels, it is not possible to separate the effects of visitor noise and non-auditory visitor activity on zoo animals.

The distinction between visitor noise and active audiences is necessary for several reasons. There is a potential for passive visitors, who are not attempting to interact with display animals, to create sufficient noise to influence animal behaviour and impact animal welfare. While passive behaviour is not directed towards the display animals, the animals may perceive this change in noise levels as anthropogenic noise, regardless of its intended audience. By investigating visitor noise discretely, it will be possible to understand if visitor noise influences animal behaviour only when it is perceived by the animals to be interactive and accompanied by other non-auditory behavioural cues, as in the case of the passive/active audience and animal-visitor interaction research, or if general visitor noise also influences the behaviour of zoo animals.

Visitor behaviour and noise should be looked at separately from visitor behaviour because there is evidence (Heffner 1998) suggesting that when animals encounter two simultaneous stimuli, they may only attend to one stimulus and ignore the other. Different sense modalities may be predominant in different species or in response to different situations; unfortunately, the literature on sense sensibilities is geared towards species housed in laboratories, agricultural institutions, or companion animal shelters, which makes extrapolating appropriate methodology for studies of commonly-held zoo species difficult. Species differences in attendance to stimuli suggests that certain species may attend more to visitor behaviour that is visual while others may attend more to visitor noise, suggesting that further research on discrete visitor-related variables may be needed.

Several of the visitor noise studies rely on the researchers’ subjective categorisations of noise, but an objective method of measuring visitor noise is argued to be the preferred method of measuring visitor noise and is recommended by BIAZA (2005) when studying this variable. Defining visitor noise as “soft” or “loud” is essentially meaningless; it is difficult to understand what a researcher means by either of those terms and any attempt to define them is difficult without an objective measure to which one can refer. Issues of consistency of visitor noise stimuli between trials (i.e. observer consistency) also arise without an objective measurement. The ability of each researcher to attend to auditory stimuli is also likely to be different, which could lead to different interpretations of the same stimuli and ultimately lead to a lack of inter-observer reliability. Another problem which arises without an objective measure of sound pressure level is the difference in auditory sensory perception between human and non-human animals. The variation in animal auditory sensitivity (Fay 1988, Heffner 1998) suggests that using noise levels deemed loud or soft by humans could be inaccurate for species other than perhaps the great apes.

2.3.1 Visitor Noise Studies: Primates

There are only two studies of visitor noise on zoo primates. Birke's (2002) experiments investigating the visitor effect on a group of orangutans presented data on the responses of the study group to quiet and noisy visitor groups. Groups of school children or university students observed the orangutans and were asked to be either silent or talk and sing loudly, depending on which condition was being tested, while moving slowly through the gallery. There was little difference in orangutan behaviour between the quiet visitor condition and the group's behaviour prior to the arrival of the visitors. The arrival of the noisy groups, however, brought significant increases in looking behaviour by both the adults and infants, sitting by adults, and approaching and holding behaviours by the infants. The author had predicted an increase in sack use during the noisy visitor condition but it actually declined slightly, suggesting that the orangutans either did not find the noise stressful enough to place the sacks over their heads or that their interest in the noisy visitors outweighed the stressful aspects of the experimental condition. Birke's experiment demonstrated a behavioural change as a result of visitor noise and not visitor density or activity in orangutans, a result that had not been previously described in the visitor effect literature. However, the method by which the noisy condition was obtained is not ideal. A group of people singing loudly is probably not an everyday occurrence for most zoo animals. It would have been preferable if the groups had talked loudly or shouted as these are very common visitor behaviours; as claimed previously, it is probably more appropriate for research with a welfare component to devise experimental manipulations representative of actual zoo conditions.

Cooke and Schillaci (2007) discussed the effect of visitor noise in white-handed gibbons (*Hylobates lar*). While visitor noise affected twelve behaviours significantly for at least one of the study animals, only the rate of look at the public was affected for all the animals in the study. Rates of autogroom, brachiation, hang, climb, bipedal walking, look at mate, open mouth and teeth displays, and self-directed scratching affected at least one male, while the rates of brachiation, hang, climb, social grooming, look at mate, and self-directed scratching were significantly affected by visitor noise in at least one female gibbon. The authors concluded that the level of self-directed scratching reached the level of stereotypy in one male and appeared to commence with periods of increased visitor noise.

2.3.2 Visitor Noise Studies: Non-primates

O'Donovan et al's (1993) study of the visitor effect on cheetahs looked at the influence of visitor noise on adult females and their cubs. Noise was ranked in three categories of no noise (a single visitor or a group observing the animals quietly), low noise (visitors talking normally in front of the enclosure), and medium noise (visitors with raised voices or shouting). The frequency of cheetah reactions (ground slaps, hisses) was measured in relation to the visitor noise categories. Only one reaction was directed towards a quiet audience, 17 towards a low noise audience, and five were directed towards a medium noise audience. The authors concluded that the cheetahs did not exhibit any visitor effect and their behaviour indicated that they were not suffering any visitor-related stress.

Owen et al (2004) was the first study to focus on the discrete effect of visitor noise and use an objective method of measuring visitor noise. Owen et al looked at behavioural and hormonal responses to ambient noise in two zoo-housed giant pandas (*Ailuropoda melanoleuca*). The female exhibited significantly increased concentrations of urinary corticoids as well as increased locomotion and hold-door scratching during noisy days (AvdB[1] 72.0 ± 0.2 dB) as compared to quiet days (AvdB 64.6 ± 0.6 dB) during periods defined as "moderately loud, persistent ambient noise." In the same noise condition, the male did not have elevated corticoid levels but locomotion and honking vocalisations increased in the noisy condition when compared to the quiet condition. In a condition defined as "exposure to very loud, short-term ambient

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[1] AvdB= Average daily levels of ambient noise

noise," the female's corticoid levels were not affected but she did locomote and scratch the hold-door more in the noisy condition (AvdB 80.8 ± 0.3) than in the quiet condition (AvdB 70.7 ± 0.1); the male corticoid levels were also not affected, but behavioural changes included increased honking vocalisations, locomoting, and hold-door scratching in the noisy condition when compared to quiet conditions.

Sellinger and Ha (2005), in the same study that also looked at the effect of visitor density, used a subjective method of measuring "visitor intensity" (visitor noise) in their visitor effect study of two captive jaguars. The authors documented a significant effect of visitor noise on the pacing behaviour of the female jaguar, with longer bouts of pacing when visitors were quieter. The cats also spent more time not visible to visitors when visitors were less noisy.

2.4 Study Objectives

The four studies in this chapter are presented with the aim of addressing particular aspects of the visitor effect hypothesis:

Study 1 and Study 2:

- Determine the immediate effect of zoo visitor density on the behaviour of primates and large carnivore species.

Study 3:

- Compare the data collected on vicinity and institutional scale and determine if there is a preferred method of measuring visitor density.

Study 4:

- Identify the effect of visitor noise on the species used in Study 1.

2.5 A Note on Visitor Behaviour

It should be noted that attention-seeking visitor behaviours such as mimic vocalisations, hitting viewing windows, and vocal threats, occurred infrequently in these studies[2] and an overall analysis of the interactive effect of visitor behaviour and visitor density on animal behaviour was not possible with the data. The lack of frequent overt attempts by the visitors to interact with the animals may be due, in part, to the absence of visitors feeding display animals. Feeding of animals by visitors has been documented (Fa 1989, Cook and Hosey 1995, Hosey 2000) to be a mode of interaction between visitors and zoo animals and the lack of it at the study institutions may have contributed to the infrequency of interactions between the visitors and the study groups. Feeding of the animals by visitors was never observed at the Toronto Zoo and only occurred once, outwith a sampling period, at the Oakland Zoo. This suggests that one of the potential motivating factors for animals to interact with visitors was absent at the study institutions and may have contributed to the generally passive nature of the zoo visitors observed in these studies.

The lack of frequent interactions between visitors and the study animals may also be related to the temperament of the species chosen for the studies. Out of the selected species used in visitor effect research, the primate species which appear to be most interactive with humans are those such as the golden mangabeys (Mitchell et al 1990a, 1990b, 1991a, 1991b, 1991c, 1992a, 1992b) and mandrills (Chamove et al 1988). Cook and Hosey (1995) have reported that chimpanzees appear to be motivated to interact with visitors in exchange for food, but the Oakland Zoo chimpanzees did not beg for food from visitors. Interaction patterns between siamangs (*Hylobates syndactylus*) and zoo visitors have also

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[2] Frequency of attention-seeking behaviour by visitors and other active behaviours were only collected on the Toronto Zoo groups.

been observed (Nimon and Dalziel 1992). Interactions initiated by the siamangs with behaviours such as staring, watching, and gesturing towards humans resulted in humans engaging in similar behaviours such as attempting to touch the siamangs and giving them objects. Initial threatening behaviours directed towards visitors were responded to with threats. Visitor mimicking of siamang vocalisations were responded to with “hostile” behaviours such as yawning and excited movements.

STUDY 1: The Immediate Effect of Zoo Visitor Density on the Behaviour of Primates, Felids, and Ursids at the Toronto Zoo

2.6 Methods

Observations were made in October-November, 2003 on six groups at the Toronto Zoo in Ontario, Canada. The study groups consisted of one group of each of the following species: African lion (*Panthera leo*), Amur tiger (*Panthera tigris altaica*), polar bear (*Ursus maritimus*), Sumatran orangutan, western lowland gorilla, and golden lion tamarin (*Leontopithecus rosalia*). Appendix A provides details on group composition as well as age, rearing history, and origination information for all of the study animals housed at the Toronto Zoo; Appendix B shows the behaviours and their definitions collected on the Toronto Zoo study groups for this study. Appendix C provides descriptions of the study enclosures and salient husbandry practices.

The choice of study species was based on several criteria. Six study groups were determined to be the maximum number of study groups practical for one researcher to accurately and reliably collect the data on for studies 1, 3, and 4. Three primate species were chosen, despite the visitor effect literature consisting mainly of primate studies, because there are many aspects of visitor influence that are not well-understood. The two great ape species were selected for this project to provide a better understanding of how great apes other than chimpanzees react to visitors. The golden lion tamarin group was selected as a study species based on the results of Chamove et al (1988), which demonstrated the need for visitor effect data on small arboreal primates.

Three non-primate species were included in this project because of the lack of visitor effect data on non-primate species. Additionally, the Amur tiger, African lion, and polar bear were selected because they are widely held species within North America (where data collection took place) and further information about the visitor effect in these species could contribute to the body of knowledge which informs good husbandry and welfare practices for these animals.

The sampling method used was continuous focal animal samples (Martin and Bateson 1986); each focal sample was ten minutes long. Systematic ordering of observations resulted in at least a ten-minute interval between samples on the same animal. This rule was relaxed on the tiger group, which consisted of one individual. At least five hours of data per species group were collected over the two week study period.

Data were collected on a Psion Workabout using the behavioural software program *The Observer* (Noldus). Frequencies and durations were calculated using the Elementary Statistics and Lag Sequential Analysis features and then exported to SPSS for further statistical analyses.

2.7 Procedures

Although visitor density is treated as an independent variable, it was not appropriate to manipulate this aspect of the captive condition for the reasons discussed in the introduction to this chapter. Instead, the natural fluctuations in visitor numbers were used to obtain different visitor densities. Visitor density was measured categorically rather than absolutely because it is difficult to calculate quickly an exact number for a large group of people. During the focal samples collected on the Toronto Zoo study groups, visitor density was recorded every minute from the visitor viewing areas. The scale of visitor density utilised in Study 1 was vicinity density. Because of the lack of experimental manipulation of the density conditions, the frequency of density categories are not equally represented in the statistical analyses. The lower density categories are generally over-represented in the Toronto Zoo samples while the categories of higher visitor density are under-represented. Figure 2.1 provides the total frequencies of the visitor density categories for the study groups housed at the Toronto Zoo.

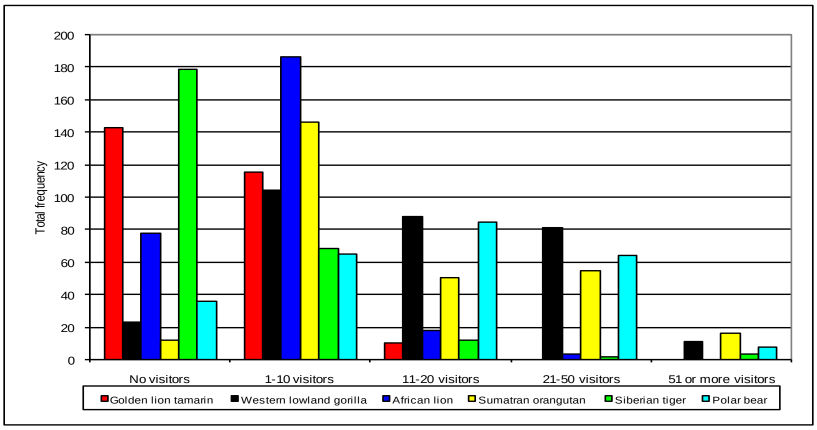

Figure 2.1 The total frequency of the visitor density categories for the six study groups at the Toronto Zoo.

The visitor density categories used in this study were created to facilitate data collection. For the reasons previously stated, it is not usually possible to calculate absolute numbers for visitor density during periods of high visitor density. Therefore, the following categories were used in Study 1 when recording visitor density: no visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51 or more visitors. A density category legend is provided with the first graph for each set of results. Previous studies on the immediate effect of exhibit scale visitor density have also used predetermined density categories rather than absolute numbers (Hosey and Druck 1987, O'Donovan et al 1993, Birke 2002, Sellinger and Ha 2005, Todd et al 2006). One researcher used the percentage of visitor area filled with visitors (Wood 1998). Although these density categories are not intrinsically biologically relevant, the influence of visitor density on animal behaviour and physiology documented in the literature indicates that many approaches used to collect visitor density information are valid.

It is reasonable to question the methodological appropriateness of treating visitor density and visitor noise as discrete variables, for common sense would assert that these two variables are linked and should be addressed in a single study using partial correlation. However, it will be shown that for five of the six animal exhibits in these studies, the level of visitor noise was not dependent on the level of visitor density. The data for the single exhibit for which density and noise are linked could not be subjected to parametric statistics because the data could not be transformed to resemble a normal distribution, a requirement for all parametric statistics, including partial correlation.

2.8 Statistical Analysis

The density data have been analysed with the objective of determining the immediate effect of visitor density on animal behaviour, therefore it was important to examine the influence of visitor density on animal behaviour occurring within a short time period following exposure. To determine the effect of visitor density on subsequent rates of behaviour, a lag analysis was performed by instituting a sixty second interval between each criterion event (a visitor density measurement) and behaviours. Two or more bouts of the same behaviour were counted as separate events within each lag period. Visitor density categories that occurred more than once per sample were aggregated to minimise dependence concerns. The frequency of behaviours per sample was then divided by the frequency of each density category per sample to achieve a mean[3] frequency of behaviour per unique density category for each sample. This step was taken to reduce the statistical impact of autocorrelation of the visitor density categories, a step recommended by the guidelines for handling zoo datasets (BIAZA 2006). Behaviours were included in the analysis if they occurred at least ten times during the baseline data collection period.

The duration of states was also thought to be affected by the number of visitors visible to display animals. Focal animal samples were divided into one-minute intervals associated with a visitor density measurement. Visitor density categories that occurred more than once per sample were aggregated and the associated durations were summed for each sample. The total duration per sample

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[3] Due to the limitations of *The Observer* software, it was not possible to calculate a median frequency per density category, which would have been the preferred measure of central tendency for data that are not normally distributed.

was then divided by the frequency of the unique density categories per sample, providing a mean duration per sample for each density category.

Kolmogorov-Smirnov statistics were calculated and the results suggested that both the rate and duration datasets violated the assumption of normal distribution made by parametric tests, making a non-parametric statistic more appropriate for the visitor density analysis. The ordinal nature of the visitor density categories supported the choice of a non-parametric statistic to analyse the Study 1 data. Therefore, Spearman rank order correlation was used to determine the relationship between visitor density and the frequency and duration of study group behaviour. Caution should be used when interpreting the results because significant correlations between visitor-related variables and animal behaviour do not imply causation. Although there is more evidence in the literature that visitors influence animal behaviour than there is evidence that animal behaviour influences visitor behaviour, as stated in Chapter 1, the data should not be interpreted as supportive of only the visitor effect hypothesis.

2.9 Results

2.9.1 Are Visitor Density and Visitor Noise Discrete Variables?

There was no correlation between median density category per sample and median decibel per sample in the golden lion tamarin, western lowland gorilla, Sumatran orangutan, African lion, or Amur tiger groups. There was a relationship between median density category per sample and median decibel per sample in the polar bear group (Figure 2.2). Table 2.3 lists the results of the Spearman correlations between visitor density and visitor noise.

SPECIES	r	*p* (two-tailed)	n
Golden lion tamarin	.141	.457	30
Western lowland gorilla	.053	.761	35
Sumatran orangutan	.031	.863	34
African lion	-.159	.383	32
Amur tiger	.212	.260	30
Polar bear	**.624**	**.001**	**30**

Table 2.3 The results of the Spearman correlations between visitor density and visitor noise for the six study groups. Significant results are in bold text. n= number of 10-minute samples.

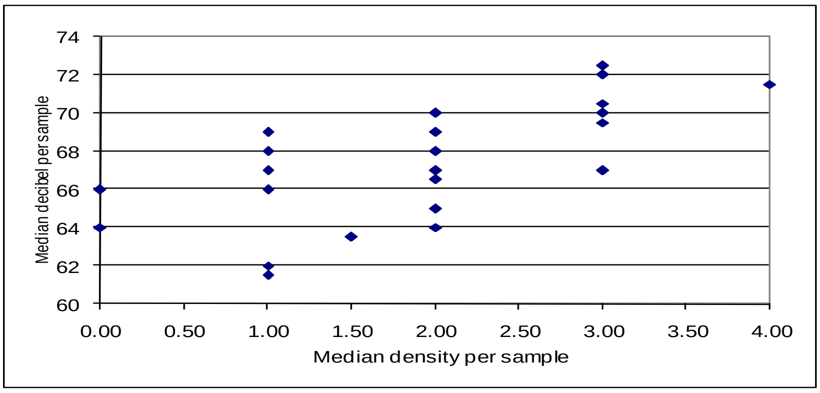

Figure 2.2 The relationship between visitor density and visitor noise in the polar bear group.

2.9.2 The Relationship Between Visitor Density and Behaviour

Spearman's rank order correlations were calculated to determine if there was a relationship between visitor density and the frequency or duration of behaviour for all six groups. There was no correlation between visitor density and the frequency or duration of the behaviours collected in the western lowland gorilla or African lion groups. Tables 2.4 and 2.5 list the results of the Spearman correlations between visitor density and frequency of behaviour in the African lion and western lowland gorilla.

African lion BEHAVIOUR	r	*p* (two-tailed)
> *three meters* (d)	-.073	.586
> *three meters* (f)	-.016	.904
contact (d)	.049	.712
locomote (d)	.016	.903
locomote (f)	.009	.944

African lion BEHAVIOUR	r	*p* (two-tailed)
monitor visitor area (d)	.173	.194
monitor visitor area (f)	.131	.333
proximity (d)	-.052	.696
proximity (f)	-.006	.963
rest (d)	-.090	.501
rest (f)	-.032	.816
sniff air (f)	-.029	.832

Table 2.4 The results of the Spearman correlations between visitor density and the rate and duration of African lion behaviours. (f)= frequency, n= 57; (d) duration, n= 58.

Western lowland gorilla BEAVIOUR	r	*p* (two-tailed)
< *three meters* (d)	.071	.582
> *three meters* (d)	-.004	.972
> *three meters* (f)	-.082	.524
contact (f)	.119	.359
feed/forage (d)	.109	.400
feed/forage (f)	.100	.441
locomote (d)	.007	.955
locomote (f)	.042	.744
monitor visitor area (d)	.100	.439
monitor visitor area (f)	-.001	.992
proximity (d)	-.172	.182
proximity (f)	.037	.773
regurgitation/reingestion (f)	.144	.266
rest (d)	-.001	.996
rest (f)	.083	.522
scratch self (f)	-.043	.737
social play (d)	-.079	.542
social play (f)	-.058	.654
solitary groom (d)	.030	.820
solitary groom (f)	.110	.397
solitary play (d)	.220	.086
solitary play (f)	.162	.208

Table 2.5 The results of the Spearman correlations between visitor density and the rate of western lowland gorilla behaviours. (f)= frequency, n= 62; (d)= duration, n= 62.

The Sumatran orangutan group spent more time engaged in the behavioural state *monitor visitor area* when more visitors were visible, but this relationship was not statistically significant (Figure 2.3). Table 2.6 lists the results of the Spearman correlations between visitor density and Sumatran orangutan behaviour.

Sumatran orangutan BEHAVIOUR	r	*p* (two-tailed)
< *one meter* (d)	-.090	.463
< *three meters* (d)	.139	.254
> *three meters* (d)	-.123	.316
> *three meters* (f)	.155	.209
contact (d)	-.031	.803
contact (f)	.028	.819
feed/forage (d)	.075	.538
feed/forage (f)	.061	.621
head cover (f)	.040	.746
headcover (d)	.067	.582
locomote (d)	-.185	.128
locomote (f)	.012	.922
monitor visitor area (d)	.244	.043
monitor visitor area (f)	.132	.280
proximity (d)	-.019	.876
proximity (f)	.025	.836
rest (d)	-.042	.732
rest (d)	.116	.342
social play (d)	-.189	.119

Table 2.6 The results of the Spearman correlations between visitor density and the frequency and duration of Sumatran orangutan behaviours. Trends are shaded. (f)= frequency, n= 69; (d)= duration, n= 69.

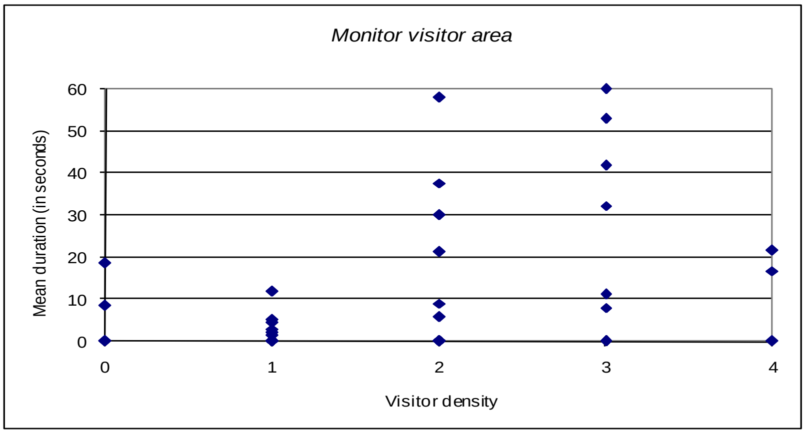

Figure 2.3 The relationship between visitor density and the duration of *monitor visitor area* in the Sumatran orangutan group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

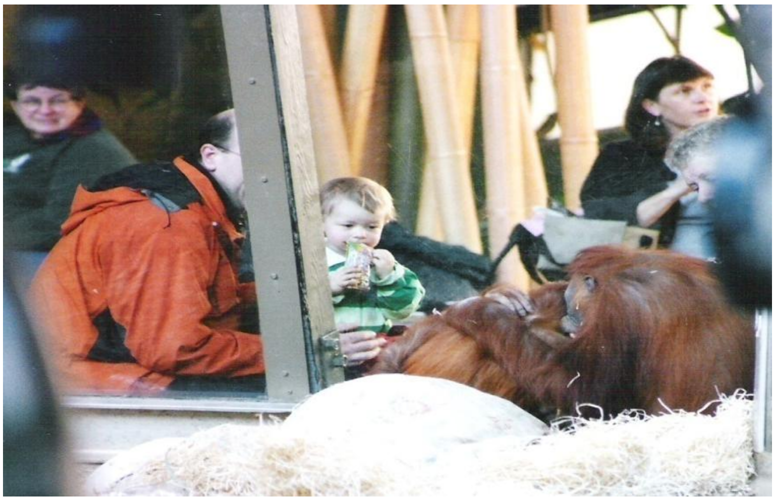

Figure 2.4 The Sumatran orangutans monitoring visitors. Toronto Zoo. Photo by author.

A negative correlation between visitor density and the frequency of the behaviour *solitary groom* was identified in the golden lion tamarin group. The monkeys also engaged in less *rest* when visitor numbers were high, although this relationship was not statistically significant. Table 2.7 lists the results of the Spearman correlations between visitor density and golden lion tamarin behaviour. Figures 2.5-2.7 show the relationship between visitor density and behaviour in the golden lion tamarin group.

Golden lion tamarin BEHAVIOUR	r	*p* (two-tailed)
contact (d)	.005	.975
contact (f)	.088	.541
feed/forage (d)	.132	.356
feed/forage (f)	-.103	.472
locomote (d)	.142	.320
locomote (f)	.086	.550
monitor visitor area (d)	.201	.158
monitor visitor area (f)	.026	.857
nestbox (d)	-.016	.910
proximity (d)	.105	.465
proximity (f)	.229	.106
rest (d)	-.314	.025
rest (f)	-.297	.034
scent mark (f)	-.077	.589

Golden lion tamarin BEHAVIOUR	r	*p* (two-tailed)
scratch self (f)	-.258	.068
social groom (d)	.012	.931
social groom (f)	-.044	.762
solitary groom (d)	-.274	.052
***solitary groom* (f)**	**-.392**	**.004**

Table 2.7 The results of the Spearman correlations between visitor density and the frequency and duration of golden lion tamarin behaviour. Significant results are in bold; trends are shaded. (f)= frequency, n= 51; (d)= duration, n= 51.

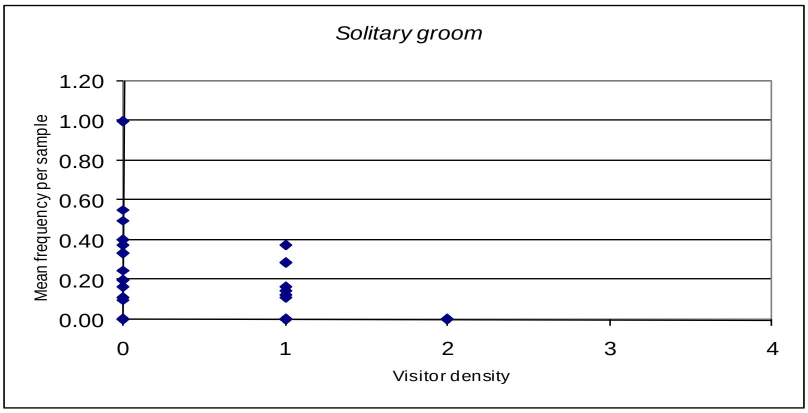

Figure 2.5 The relationship between visitor density and the frequency of *solitary groom* in the golden lion tamarin group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

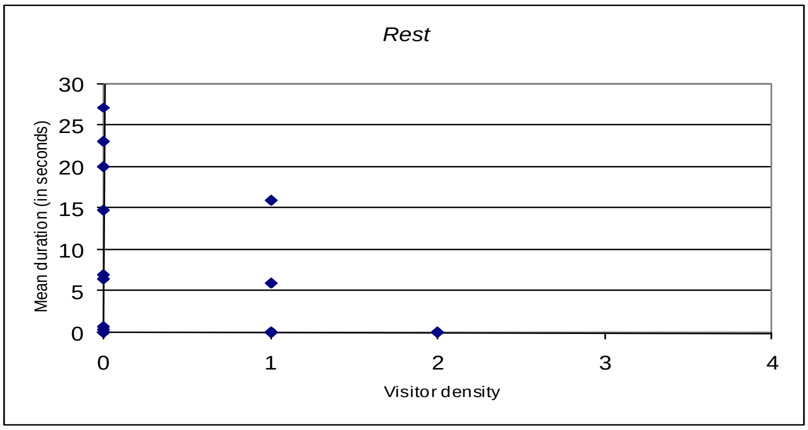

Figure 2.6 The relationship between visitor density and the duration of *rest* in the golden lion tamarin group.

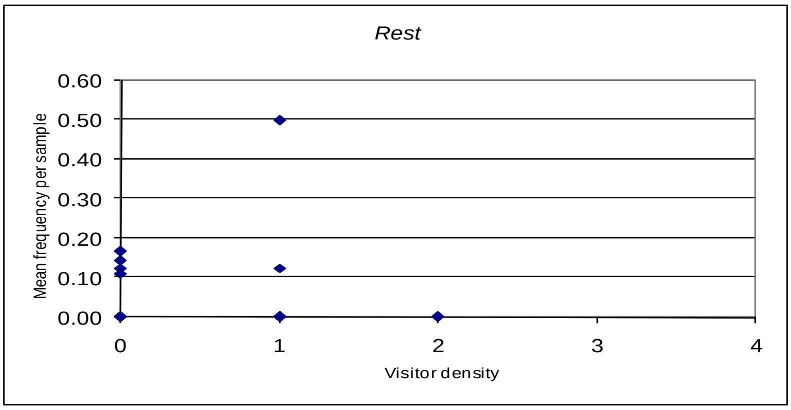

Figure 2.7 The relationship between visitor density and the frequency of *rest* in the golden lion tamarin group.

Proximity to the visitor viewing area decreased significantly when more visitors were present in the tiger group, as evidenced by the increase in > *three meters* when visitor density was higher. There was also a decrease in the frequency and duration of *rest* as visitor density increased, but this relationship was not statistically significant. Table 2.8 lists the results of the Spearman correlation between visitor density and behaviour in the Amur tiger group. Figures 2.8-2.11 show the relationship between visitor density and behaviour in the Amur tiger group.

Amur tiger BEHAVIOUR	r	*p* (two-tailed)
> *three meters* (d)	**.536**	**.001**
> *three meters* (f)	**.631**	**.001**
monitor visitor area (d)	.005	.971
monitor visitor area (f)	-.189	.151
rest (d)	-.262	.045
rest (f)	-.297	.022
sniff air (f)	-.080	.549
sniff object (f)	.018	.895
solitary groom (d)	-.008	.952
solitary groom (f)	-.031	.817
vigilance patrol (d)	.113	.395
vigilance patrol (f)	-.020	.880

Table 2.8 The results of the Spearman correlations between visitor density and the frequency and duration of Amur tiger behaviour. Significant results are in bold text; trends are shaded. (f)= frequency, n= 59; (d)= duration, n= 59.

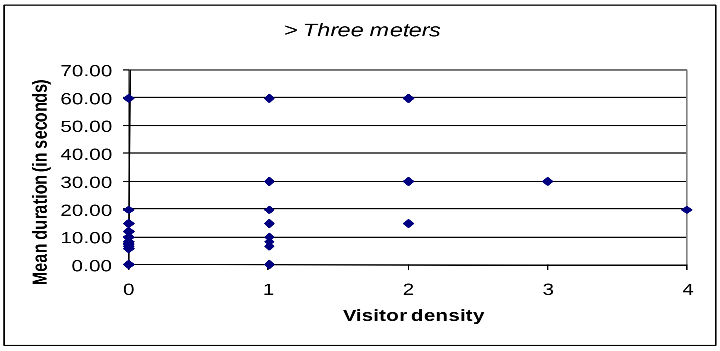

Figure 2.8 The relationship between visitor density and the duration per sample of > *three meters* in the Amur tiger group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

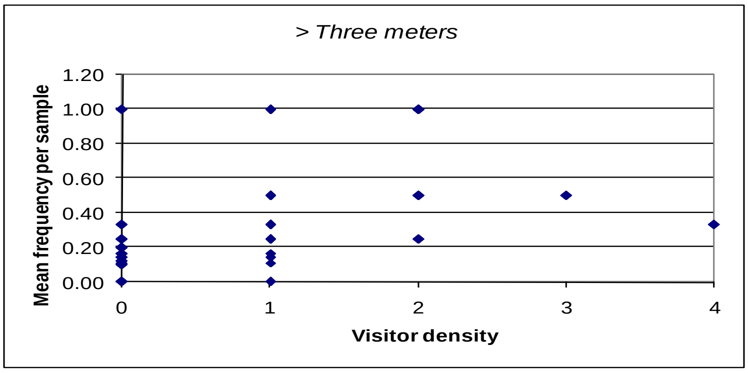

Figure 2.9 The relationship between visitor density and the frequency per sample of > *three meters* in the Amur tiger group.

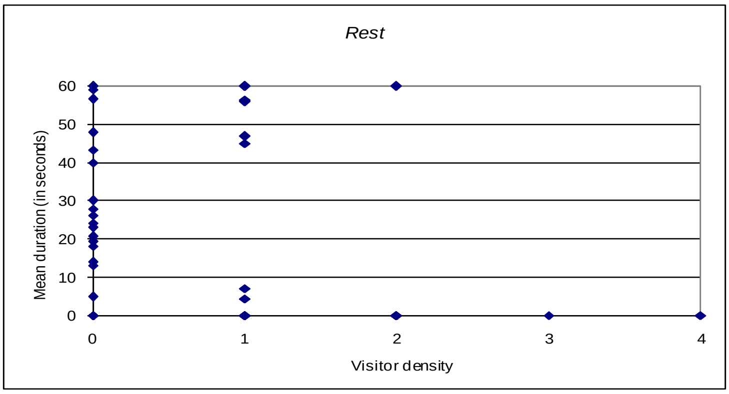

Figure 2.10 The relationship between visitor density and the duration of *rest* in the Amur tiger group.

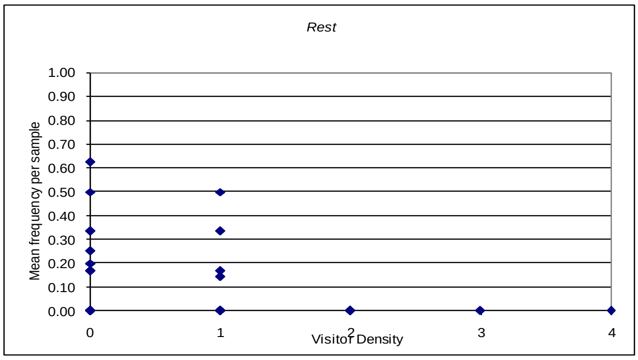

Figure 2.11 The relationship between visitor density and the frequency of *rest* in the Amur tiger group.

Polar bear behaviour was not significantly associated with visitor density, but the frequency of the *monitor visitor area* showed a trend toward significance (Figure 2.12). Table 2.9 lists the results of the Spearman correlations between visitor density and polar bear behaviour.

Polar bear BEHAVIOUR	r	*p* (two-tailed)
locomote (d)	.042	.722
locomote (f)	.044	.709
monitor visitor area (d)	.188	.112
monitor visitor area (f)	.254	.030
proximity (d)	.064	.592
rest (d)	-.200	.090
rest (f)	.041	.729
sniff air (f)	.127	.284
sniff object (f)	-.116	.327

Table 2.9 The results of the Spearman correlations between visitor density and the frequency and duration of polar bear behaviour. Trends are shaded. (f)= frequency, n= 73; (d)= duration, n= 73.

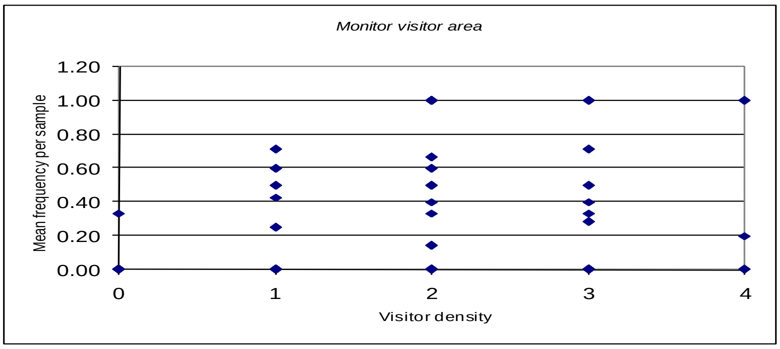

Figure 2.12 The relationship between visitor density and the frequency of *monitor visitor area* in the polar bear group.

2.10 Discussion

2.10.1 Visitor Density and Visitor Noise are Discrete Variables

The lack of relationship between visitor density and visitor noise for all but the polar bear enclosure is a surprising result, but it supports the hypothesis that visitor density and visitor noise are not always associated and can be treated as distinct visitor-related variables in this study. It is unclear why visitor density and noise were associated at the polar bear exhibit and not the other five, but there are numerous environmental differences between the enclosures which may have influenced the results. It is also possible that visitor behaviour differs depending on the species that they are observing, although there are no published data to support this hypothesis.

2.10.2 The Effect of Vicinity Density

The visitor density lag analysis of the Toronto Zoo data identified a statistically significant visitor effect in two of the six study groups, while two additional groups showed evidence of trends in the data. The golden lion tamarin results are supported by Chamove et al’s (1988) hypothesis that the behaviour of small arboreal primates is affected by zoo visitors. Captive primates can exhibit over-grooming or other forms of self-directed behaviour when their welfare is compromised, but high visitor density may be a condition which does moderates this behaviour in some golden lion tamarins. Self-directed behaviour in relation to visitors has been reported in white-handed gibbons (Cooke and Schillaci 2007) as has self-injurious behaviour in pileated gibbons (Skyner et al 2004).

The trend toward decreased rest in association with increased visitor density in the golden lion tamarins is supported by the 55 percent decrease in primate inactivity in the presence of zoo visitors observed by Chamove et al (1988). Bassett et al (2003) also identified decreased inactivity in laboratory-housed common marmosets (*Callithrix jacchus*) as a behavioural indicator of stress from routine husbandry procedures; these findings suggest that reduced resting in the golden lion tamarin study group may be indicative of visitor-related stress. Until data on inactivity in tamarins in the zoo environment are available, the temperament of golden lion tamarins should be taken into account when interpreting this result. For zoo animals for which inactivity is a welfare concern, such as felids, ursids, or some great apes, decreased inactivity might be interpreted as a positive visitor influence; however, for active primates such as golden lion tamarins, the decrease in rest bouts might be considered to be a negative impact in this species.

It is possible that the results for the tamarin group were influenced by group composition. The study group, consisting of a mother and her adult male son, is not typical group composition for this species (Goldizen 1990) and may have affected the results of the study. Given the unusual grouping, it is unknown if the behavioural changes reported in this study are representative of visitor density effects on other captive golden lion tamarin groups.

The trend toward decreased resting associated with increased visitor density in the tiger group contradicts the results reported by Mallapur and Chellam (2002) that identified increased resting in Indian leopards in the presence of zoo visitors. A decrease in inactivity for zoo felids is a positive change in animal welfare and may also contribute to visitor interest and education. Active felids are reported to be of more interest to visitors (Margulis et al 2003), and they provide educational opportunities for the public to view felids performing species-typical behaviour.

The behaviour of the Sumatran orangutan and polar bear groups was not significantly affected by visitor density, but several noteworthy trends were identified. The orangutans spent more time monitoring visitor areas when more visitors were present, suggesting the orangutans may have been either been interested in watching the crowds of people or they increased vigilance in the presence of large crowds. Increased monitoring of visitors was also observed in white-handed gibbons in response to visitor density (Cooke and Schillaci 2007) and was interpreted as species-typical territoriality. Chamove et al 1988 also documented increased monitoring of visitors in a group of mandrills as visitor density increased.

The lack of an extensive visitor effect in captive orangutans contradicts the behavioural change documented in Birke (2002). The adult orangutans in Birke's study used sacks to cover their heads when in the presence of large numbers of visitors, and while this behaviour was observed in the Toronto Zoo orangutans, the behaviour was not correlated with visitor density. Birke also observed a decrease in foraging behaviour when visitor crowds were large, but no such decrease was observed in this study. Several of the behavioural changes that were associated with visitor density in Birke's study were identified in infants, indicating that the lack of youngsters in the Toronto Zoo study group may have contributed to the lack of an extensive visitor effect in this study. The level of visitor effect in orangutans may be related to group composition, with orangutan groups including infants experiencing more visitor density pressure than those with no infants.

The behavioural trend associated with visitor density in the polar bear group was limited to one behaviour, an increase in the frequency of *monitor visitor area*, indicating that either large numbers of people were of visual interest to them or the polar bears felt increased pressure to visually monitor the viewing crowds. *Monitor visitor area* is a behaviour that can be considered contributory, neutral, or detrimental to zoo animal welfare, depending on the behavioural context in which it is exhibited. The presence of visitors for both the polar bear group and the orangutan group can be interpreted as neutral because, while the animals spent more time monitoring large visitor groups, these associations were not statistically significant and behaviours indicative of stress or enrichment were also unaffected.

2.10.3 Gorillas and Lions Are Not Affected By Visitor Density

The lack of an effect on the gorilla group is unexpected given the well-documented visitor density effect in primates and the visitor effect observed in captive gorilla groups (Blaney and Wells 2004, Wells 2005, Kuhar 2007). Possible reasons for the lack of response to visitor density include the size or composition of this particular group, or some unidentified aspect of the enclosure design. The lack of visitor density effect in the gorilla group is not likely to be associated with the general low visitor density of the Toronto Zoo during observations because the gorilla exhibit had the greatest frequency of the second highest visitor density category (21-50 visitors) of all the study groups.

The lack of a visitor density effect on the African lion group is consistent with the conclusion made by Margulis et al (2005) that there was no relationship between visitor density and behaviour in their study felids. The lack of visitor effect in felids argued by Margulis et al and supported by the Toronto Zoo lion data, however, is contradicted by the Toronto Zoo Amur tiger data, the Indian leopard results reported by Mallapur and Chellam (2002), and the Sellinger and Ha (2005) data on jaguars. It is possible that other factors, such as enclosure design, environmental enrichment, group size, and group composition, which were not addressed by Margulis or this study, may play a role in determining the visitor density effect in zoo-housed felids.

STUDY 2: The Immediate Effect of Zoo Visitor Density on the Behaviour of Primates and Felids at the Oakland Zoo

2.11 Methods

Data for this study were collected at the Oakland Zoo (California, USA) during March and April of 2004. The Oakland Zoo data are drawn from observations of one group of each of the following species: African lion, Bengal tiger, squirrel monkey, hamadryas baboon, and chimpanzee. Appendix A provides details on group composition as well as age, rearing history, and origination information for all of the study animals housed at the Oakland Zoo. Appendix B shows the behaviours and their definitions collected on the Oakland

Zoo study groups. Appendix C provides descriptions of the study enclosures and salient husbandry practices.

Rationale for the selection of species in this study is similar to that of studies 1, 3, and 4. Five study groups were determined to be the maximum number of groups for which data could accurately and reliably be collected. Three primate groups were selected because it was hypothesised that primates would be more reactive to visitors than less closely-related mammals. The chimpanzee was chosen for study because, although there is visitor effect data on this primate, its reaction to visitors in the zoo setting is still somewhat unclear. The great apes also represented a unique opportunity to explore further Hosey's (2000) conclusion that chimpanzees "regard human visitors as a source of mild interest" (p. 349) because generally visitor effect research has focused on the potentially negative impact of zoo visitors. The hamadryas baboon and squirrel monkey were included in the study because of their ecological niche and body size, representing larger terrestrial primates and small arboreal primates respectively, and providing a similar comparison of the visitor effect as achieved in Chamove et al (1988). The two large felid species are included in the study to add to the data on non-primates in the visitor effect literature and to collect information which may be helpful in improving the welfare practices for zoo animals that are held by a large number of zoos.

The sampling method used at the Oakland Zoo was instantaneous scan sampling (Martin and Bateson 1986). Although Study 1 and this study both examine visitor density using vicinity density, the data are not considered in the same study because of the different sampling methods employed. The sampling methods differ because the data in both studies served as the baseline for different experiments that required different sampling methods. Presentation of the data sets as two different studies is necessitated by the difference in methodology, and is not meant to imply distinctions between the scale of density collected. The Oakland observation sessions were ten minutes in length with a one minute interval between sample points. Six hours of data per species group were collected on the Oakland groups. Data were collected on a Psion Workabout using *The Observer*. Proportions were calculated using the Elementary Statistics features and then exported to SPSS for further statistical analyses.

2.12 Procedures

Once again, visitor density was treated as the independent variable, although it was not experimentally manipulated. The everyday fluctuations in visitor numbers were used to achieve different visitor densities. As in Study 1, the frequency of density categories are not equally represented in the statistical analyses. The higher visitor density categories are well-represented in the Oakland sample, in comparison to the Toronto Zoo data, while the lower visitor density categories are not as frequent. The difference in visitor density distributions between institutions in Study 1 and Study 2 are most likely due to the time of year that the data were collected at each institution. Figure 2.13 provides the total frequency of each visitor density category for the study groups housed at the Oakland Zoo.

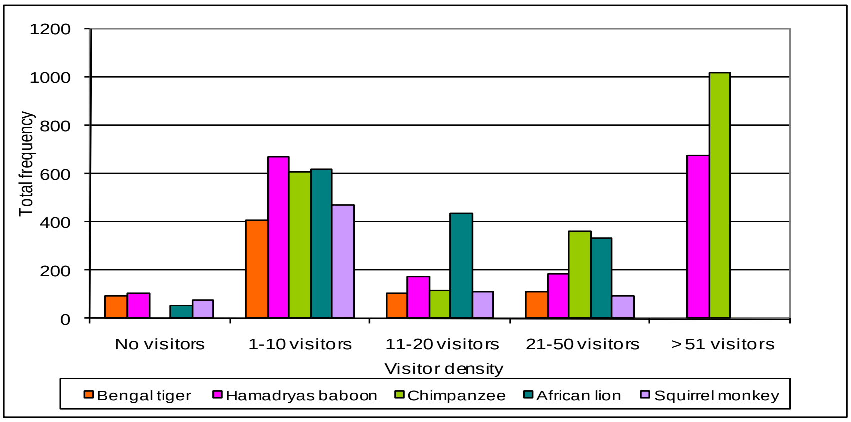

Figure 2.13 The total frequency of visitor density categories in Study 2.

As in Study 1, visitor density was measured categorically rather than absolutely and was recorded every minute. Like Study 1, the scale of visitor density utilised in Study 2 was vicinity density. The visitor density categories and rationale for this study are the same as for Study 1. A density category legend is provided in the first graph for each set of results.

2.13 Statistical Analysis

The visitor density analysis for the data collected at the Oakland Zoo was calculated in a manner suitable for instantaneous scan sampling. The proportion of behaviours for each associated unique density category per sample was calculated (the sum of sample intervals in which each behaviour was observed divided by the number of unique visitor density categories per sample). The mean proportion of behaviours per unique decibel reading per sample became the unit of analysis for the instantaneous scans collected at the Oakland Zoo. Following the calculation of Kolmogorov-Smirnov statistics, a non-parametric statistic was selected for the Oakland Zoo visitor density datasets because of their non-normal distribution and the ordinal level of the visitor density categories. Spearman rank order correlation was used to determine the relationship between visitor density and the proportion of behaviour.

2.14 Results

2.14.1 The Relationship Between Visitor Density and Behaviour

Spearman rank order correlations were calculated to determine if there was a relationship between visitor density and behaviour in the Oakland Zoo groups. The Bengal tiger group was not significantly affected by visitor density. Table 2.10 lists the results of the Spearman correlations between visitor density and Bengal tiger behaviour.

Bengal tiger BEHAVIOUR	r	*p* (two-tailed)
< three meters	-.045	.709
locomote	-.108	.369
out of sight	.228	.056
proximity	-.009	.940
rest	.034	.781
survey	-.039	.746
watch	-.090	.456

Table 2.10 The results of the Spearman correlations between visitor density and the proportion of Bengal tiger behaviour. n= 71.

A statistically significant visitor density effect was identified in two of the three primate groups. There was a significant positive correlation between visitor density and two squirrel monkey behaviours, *survey*, and *locomote*, while the behaviour *out of sight* significantly decreased as visitor density increased. Table 2.11 lists the results of the Spearman correlations between visitor density and squirrel monkey behaviour. Figures 2.14-2.16 show the relationship between visitor density and behaviour in the squirrel monkey group.

Squirrel monkey BEHAVIOUR	r	*p* (two-tailed)
< one meter	.161	.275
chirp	-.150	.307
feed/forage	.207	.157
locomote	**.479**	**.001**
out of sight	**-.690**	**.001**
proximity	-.005	.973
survey	**.383**	**.007**
scratch self	.083	.577

Table 2.11 The results of the Spearman correlations between visitor density and the proportion of squirrel monkey behaviour. Significant results are in bold text. n= 48.

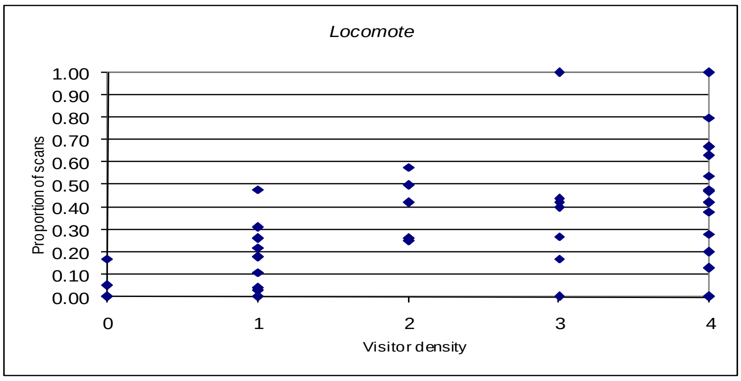

Figure 2.14 The relationship between visitor density and *locomote* in the squirrel monkey group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

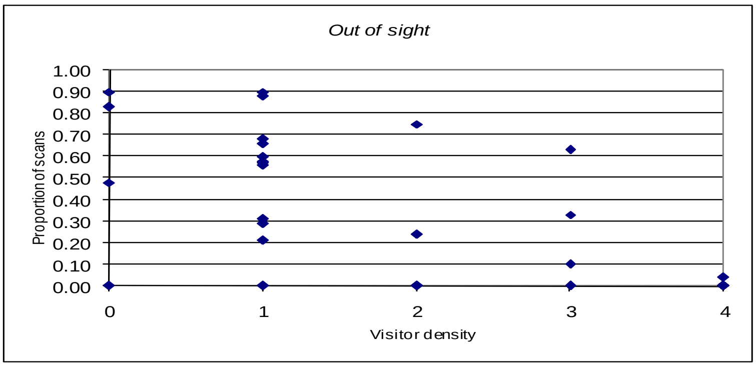

Figure 2.15 The relationship between visitor density and *out of sight* in the squirrel monkey group.

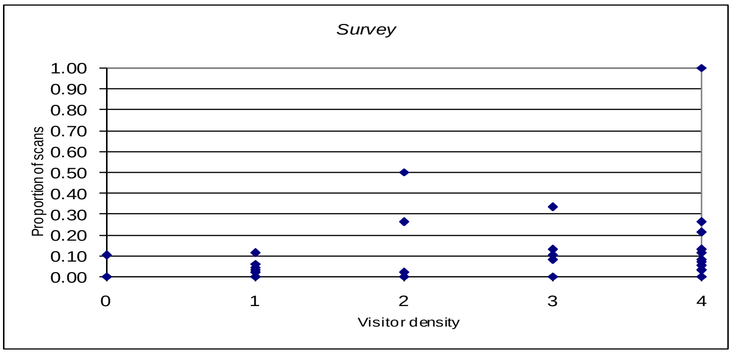

Figure 2.16 The relationship between visitor density and *survey* in the squirrel monkey group.

Two behaviours in the hamadryas baboon group were significantly associated with visitor density. *Feed/forage* was positively correlated with visitor density, while the baboons performed the behaviour *social groom* less frequently when in the presence of more visitors. The baboons also showed a trend toward increased levels of *out of sight* when density was higher. Table 2.12 lists the results of the Spearman correlations between visitor density and baboon behaviour. Figures 2.17-2.19 show the relationship between visitor density and behaviour in the hamadryas baboon group.

Hamadryas baboon BEHAVIOUR	r	*p* (two-tailed)
< one meter	.209	.150
bob	-.216	.137
feed/forage	**.417**	**.003**
grunt	.198	.172
locomote	.149	.308
out of sight	.340	.017
proximity	.095	.516
rest	-.119	.416
scratch self	.156	.285
social groom	**-.416**	**.003**
solitary groom	-.152	.298
solitary play	.138	.346
survey	.018	.901
vigilance patrol	-.083	.571
watch	.023	.874

Table 2.12 The results of the Spearman correlations between visitor density and the proportion of hamadryas baboon behaviour. Significant results are in bold text. n= 49.

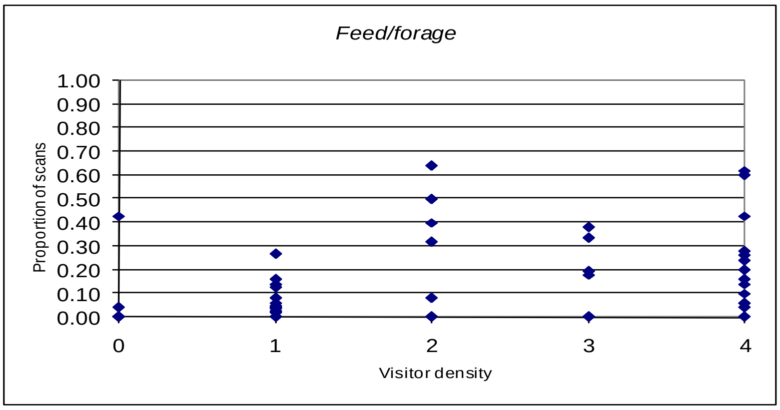

Figure 2.17 The relationship between visitor density and *feed/forage* in the hamadryas baboon group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

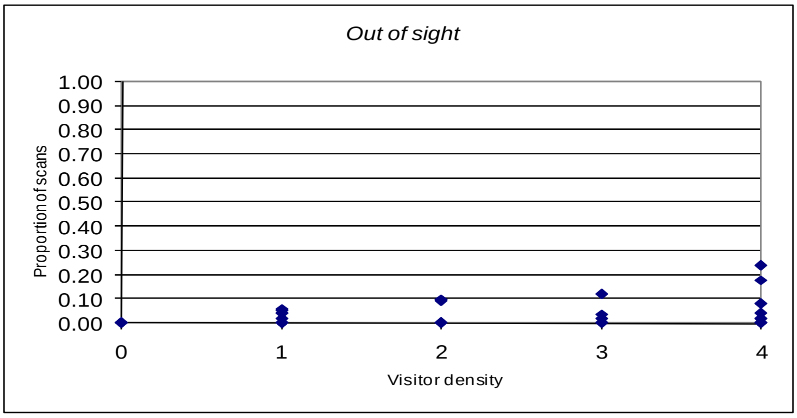

Figure 2.18 The relationship between visitor density and *out of sight* in the hamadryas baboon group.

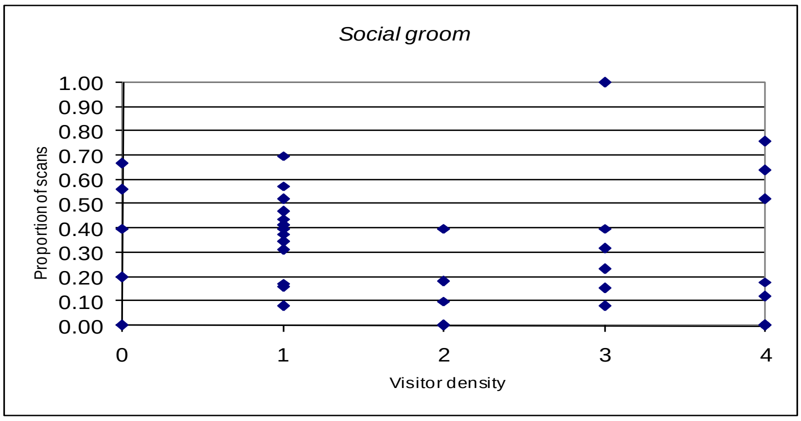

Figure 2.19 The relationship between visitor density and *social groom* in the hamadryas baboon group.

There was a positive correlation between visitor density and location of the chimpanzees in their enclosure, although it was not statistically significant. The chimpanzees were more often located < *one meter* of the perimeter of the enclosure near a visitor area when more zoo visitors were visible to them (Figure 2.20). Table 2.13 lists the results of Spearman correlations between visitor density and chimpanzee behaviour.

Chimpanzee BEHAVIOUR	r	*p* (two-tailed)
< *one meter*	**.385**	**.019**
display	-.055	.748
feed/forage	.229	.174
locomote	.139	.412
out of sight	-.003	.984
proximity	.155	.359
rest	.020	.907
scratch self	-.029	.866
social groom	-007	.966
solitary groom	.083	.624
solitary play	.063	.712
survey	-035	.838
watch	.078	.648

Table 2.13 The results of the Spearman correlations between visitor density and the proportion of chimpanzee behaviour. Trends are shaded. n= 37.

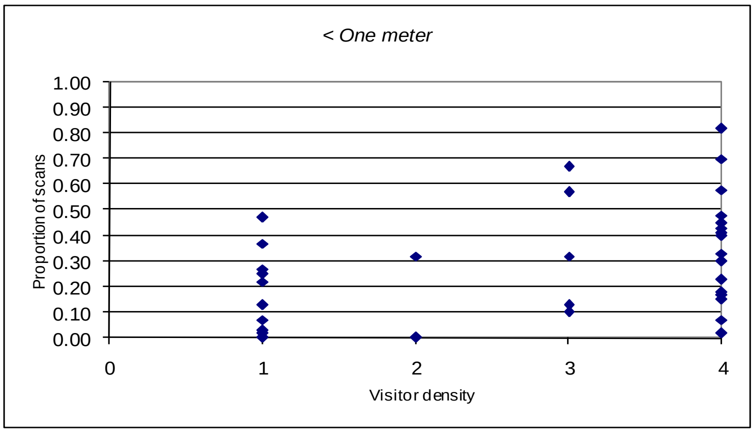

Figure 2.20 The relationship between visitor density and < *one meter* in the chimpanzee group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

There was an association between visitor density and behaviour in one of the felid groups at the Oakland Zoo. *Contact* occurred significantly less frequently in the lion group when high numbers of visitors were present. There was also a trend for levels of *survey* to be negatively associated with visitor density, although this relationship was not statistically significant. Table 2.14 lists the results of the Spearman correlations between visitor density and Oakland Zoo lion behaviour. Figures 2.21 and 2.22 show the relationship between visitor density and behaviour in the Oakland Zoo African lion group.

African lion BEHAVIOUR	r	*p* (two-tailed)
contact	**-.361**	**.002**
locomote	-.181	.136
proximity	.036	.771
rest	.166	.174
survey	**-.296**	**.013**
watch	-.197	.105
sniff air	.028	.819

Table 2.14 The results of the Spearman correlations between visitor density and the proportion of Oakland Zoo African lion behaviour. Significant results are in bold text; trends are shaded. n= 69.

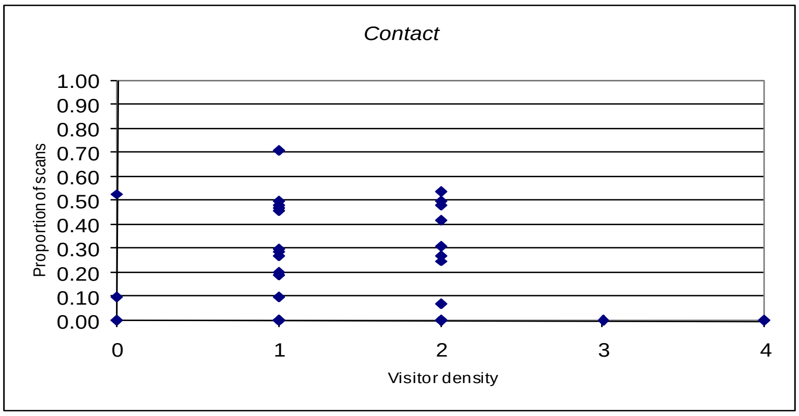

Figure 2.21 The relationship between visitor density and *contact* in the African lion group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

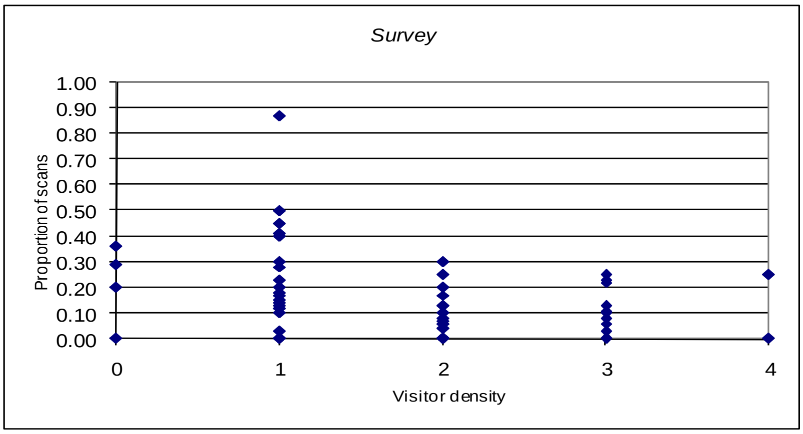

Figure 2.22 The relationship between visitor density and *survey* in the African lion group.

2.15 Discussion

2.15.1 The Effect of Visitor Density on Behaviour

The behaviour of three of the five study groups at the Oakland Zoo was significantly affected by visitor density. The significant increase in the frequency of locomoting and surveying in the squirrel monkey group is consistent with previous reports of increased activity in primates in the presence of visitors (Hosey and Druck 1987, Mitchell 1992a, 1992b) and increased monitoring of the public (Chamove et al 1988, Cooke and Schillaci 2007). Affiliative, aggressive, or abnormal behaviours were not associated with increased visitor density in the squirrel monkey group, but increased surveying suggests the monkeys were more alert to their surroundings when visitor crowds were large. The negative correlation between out of sight and visitor density suggests that the squirrel monkeys may have regarded visitors as a source of interest or a reason for vigilance.

Visitor density significantly affected a range of hamadryas baboon behaviours, and may have had a negative impact on their welfare. The change in baboon behaviour associated with visitor density that is perhaps the most suggestive of the stressful effect visitors was the decrease in social grooming. Decreased social grooming in relation to visitor density has been reported in other primates (Chamove et al 1988, Wood 1998, Todd et al 2006, Cooke and Schillaci 2007).

The increased frequency of feeding and foraging behaviour in the presence of large crowds by the Oakland Zoo baboon group contradicts the lowered frequency of feeding and foraging during high visitor density periods observed in captive chimpanzees (Wood 1998). Feeding and foraging behaviour is both educational and entertaining for zoo visitors, but interpreting this result within the context of the other behavioural changes suggests that these behaviours may have been a symptom of visitor pressure rather than an enriched environment.

The trend toward a positive correlation between visitor density and the baboons' being out of the sight of visitors supports the claim that there was a negative visitor influence on the baboon troop. Like the squirrel monkey and chimpanzee groups housed at Oakland Zoo, the baboons had visual barriers within their enclosure (although their rocky enclosure gave less cover than the verdant squirrel monkey enclosure). They also had access to their indoor holding area during times when the visitors were present, which provided the animals with the opportunity to escape the view of the public. Unlike the squirrel monkeys and the chimpanzees, however, the baboons preferred to be out of sight more often as visitor density increased, suggesting that the baboon group experienced more intense visitor pressure than the smaller arboreal squirrel monkeys or the larger great apes. The increased visitor pressure experienced by the hamadryas baboon group is not consistent with the hypothesis proposed in Chamove et al (1988) that small arboreal primates are influenced by visitors more than terrestrial primates of greater body weight.

Of the three Oakland Zoo primate groups, visitor density appeared to have the least effect on the chimpanzee group, which is not altogether surprising given Hosey's (2000) discussion of the literature on the response of captive chimpanzees to humans. Hosey concludes that humans can be viewed as objects of moderate interest or food resources to zoo-housed chimpanzees, and that zoo chimpanzees generally find humans less stressful than captive chimpanzees in laboratories or primate facilities. The only change in behaviour associated with visitor density in the Oakland Zoo chimpanzee group was the increased use of a one meter zone surrounding the perimeter of the enclosure, and this association was not statistically significant; such a change in behaviour and use of the enclosure suggest visitor numbers were of visual interest to the chimpanzee group, but further data are needed. Potential contributing factors to the negligible visitor effect in chimpanzees are species temperament, enclosure design (Rumbaugh 1988), group composition, group size, and the Oakland Zoo's extensive chimpanzee enrichment program, which included many objects within the enclosure as well as daily grooming and play interactions with the keepers. The distribution of density categories at the Oakland Zoo chimpanzee enclosure was not skewed towards smaller visitor numbers, as was the case for some exhibits at the Toronto Zoo, thus low visitor numbers could not have played a role in the minimal visitor effect in the chimpanzee group.

Contrary to a previous report on the lack of visitor effect on felids (Margulis et al 2003), visitor density had a significant effect on lion behaviour. The decrease in contact as visitor density increased implies a change in the overall qualitative behaviour pattern of social interaction within the group, which is a potential welfare issue. Contact with group members is an important indicator of group cohesion and affiliation and visitor pressures which affect affiliative behaviour indicate an undesirable level of visitor influence. The trend toward decreased surveying suggests the African lion group either visually habituated to large numbers of visitors or that large groups of people are not stimulating.

The lack of a visitor effect in the Bengal tiger group, and the felid data from both Study 1 and Study 2, add to the conflicting reports of felid behaviour and its relationship to zoo visitors. While Margulis et al (2003) found no visitor effect in the six species they studied, Mallapur and Chellam (2002) reported that Indian leopard behaviour depended in part on the presence of zoo visitors and Sellinger and Ha (2005) reported that time spent out of sight of the public was dependent on visitor density. Due to the small number of felid visitor effect studies, it is impossible to make more than an educated guess as to whether, generally, zoo felids experience a visitor effect, but the conflicting data warrant more visitor effect studies of large cats that also take into account husbandry, group size, group composition, and environmental factors.

STUDY 3: Comparing Vicinity and Institutional Scale to Determine if there is a Preferred Method of Measuring Visitor Density

2.16 Methods

The same data set from Study 1, gathered from the six Toronto Zoo study groups, is utilised again in this study. The study methods are essentially the same as in Study 1. Data were collected on a Psion Workabout using *The Observer* (Noldus). Frequencies and durations were calculated using the Elementary Statistics and Lag Sequential Analysis features and then exported to SPSS for further statistical analysis.

2.17 Procedures

The study procedures are similar to those in Study 1. The data on the number of visitors to the Toronto Zoo per observation day were provided courtesy of the Toronto Zoo.

2.18 Statistical Analysis

Study 3 used the daily number of visitors at the Toronto Zoo, previously defined as institutional density, as the scale of visitor density measurement. This study relates the visitor density data collected during the focal animal samples to the daily visitor totals collected by the Toronto Zoo entrance staff to determine if the daily visitor totals are representative of the median number of visitors at the study exhibits. According to the Kolmogorov-Smirnov statistic, the data were not normally distributed, therefore medians are used as the measure of central tendency, with the exception of the daily vicinity density of the tiger group; daily mean density was used for the tiger group because the median was constant and zero for all observation days Daily medians for the frequency of behaviours and the duration of states, as well as the visitor density categories, for each species group were calculated and then Spearman correlations carried out on each species group dataset.

2.19 Results

2.19.1 The Relationship Between Institutional Density and Vicinity Density

There was no correlation between the number of visitors per day to the Toronto Zoo and the daily median, or mean for the Amur tigers, of vicinity density data collected for Study 1. Table 2.15 lists the results of Spearman correlations between the daily number of visitors attending the Toronto Zoo and the median daily visitor density for the orangutan, gorilla, tamarin, lion, and polar bear groups; Table 2.15 also lists the results of the Spearman correlations between the daily number of visitors attending the Toronto Zoo and the mean daily visitor density for the tiger group.

STUDY GROUPS	r	*p* (two-tailed)	n
Sumatran orangutan	.401	.373	7
Western lowland gorilla	.458	.301	7
Golden lion tamarin	.866	.058	5
African lion	-.224	.718	5
Amur tiger	-.058	.913	6
Polar bear	.671	.215	5

Table 2.15 The results of the Spearman correlations between the daily total number of visitors to the Toronto Zoo and the median/mean daily visitor density category for the six study groups. n= number of observation days.

2.19.2 The Relationship Between Institutional Density and Behaviour

There was no correlation between institutional density and the daily median frequency or duration of behaviour for the Amur tiger group. Table 2.16 list the results of the Spearman correlations between institutional density and behaviour for the Amur tiger group.

Amur tiger BEHAVIOUR	r	*p* (two-tailed)
> three meters (d)	-.664	.150
> three meters (f)	.664	.150
monitor visitor area (d)	.154	.771
monitor visitor area (f)	.154	.771
moan (f)	.133	.802
rest (d)	-.221	.674
rest (f)	-.221	.674
sniff air (f)	-.664	.150
sniff object (f)	-.266	.611
vigilance patrol (d)	.029	.957
vigilance patrol (f)	-.171	.745

Table 2.16 The results of the Spearman correlations between institutional density and behaviour (median frequency and median duration of behaviour per observation day) in the Amur tiger group. (f)= frequency, n= 6; (d)= duration, n= 7.

There was a trend showing an association between the median daily duration of behaviour and institutional density in the golden lion tamarin group. The tamarins spent more time performing *monitor visitor area* when institutional density was high (Figure 2.23), but this relationship was not statistically significant. Table 2.17 lists the results of the Spearman correlations between institutional density and behaviour for the golden lion tamarins.

Golden lion tamarin BEHAVIOUR	r	*p* (two-tailed)
contact (d)	-.154	.805
contact (f)	-.154	.805
feed/forage (d)	.100	.873
feed/forage (f)	.264	.668
locomote (d)	.100	.873
locomote (f)	.051	.935
monitor visitor area (d)	.900	.037
monitor visitor area (f)	.564	.322
nestbox (d)	-.671	.215
nestbox (f)	-.577	.308
proximity (d)	.410	.493
proximity (f)	.577	.308
rest (f)	-.866	.058
scent mark (f)	-.224	.718
scratch self (f)	.200	.747
social groom (f)	-.527	.361
social play (d)	-.667	.219
solitary groom (d)	-.300	.624

Golden lion tamarin BEHAVIOUR	r	*p* (two-tailed)
solitary groom (f)	-.316	.604

Table 2.17 The results of the Spearman correlations between institutional density and behaviour (median frequency and median duration of behaviour per observation day) in the golden lion tamarin group. Trends are shaded. (f)= frequency, n= 5; (d)= duration, n= 5.

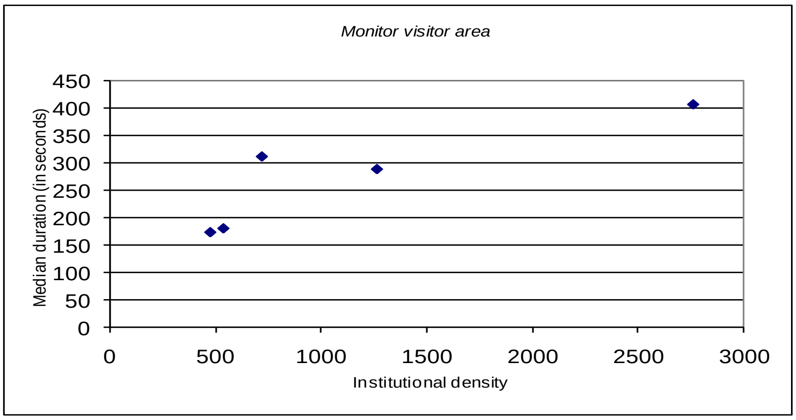

Figure 2.23 The relationship between institutional density and duration of *monitor visitor area* in the golden lion tamarin group.

The lions spent less time engaged in *monitor visitor area* when institutional density was high (Figure 2.24), but this association was not statistically significant. Table 2.18 lists the results of the Spearman correlations between institutional density and behaviour for the African lions.

African lion BEHAVIOUR	r	*p* (two-tailed)
> *three meters* (d)	.359	.553
contact (d)	-.354	.559
contact (f)	-.354	.559
locomote (d)	-.447	.450
locomote (f)	-.447	.450
monitor visitor area (d)	-.900	.037
monitor visitor area (f)	-.369	.541
out of sight (d)	-.051	.935
out of sight (f)	-.474	.420
proximity (d)	-.671	.215
proximity (f)	-.671	.215
rest (d)	.300	.624
rest (f)	.000	1.000
sniff air (f)	.000	1.000

Table 2.18 The results of the Spearman correlations between institutional density and behaviour (median frequency and median duration of behaviour per observation day) in the African lion group. Trends are shaded. (f)= frequency, n= 5; (d)= duration, n= 5.

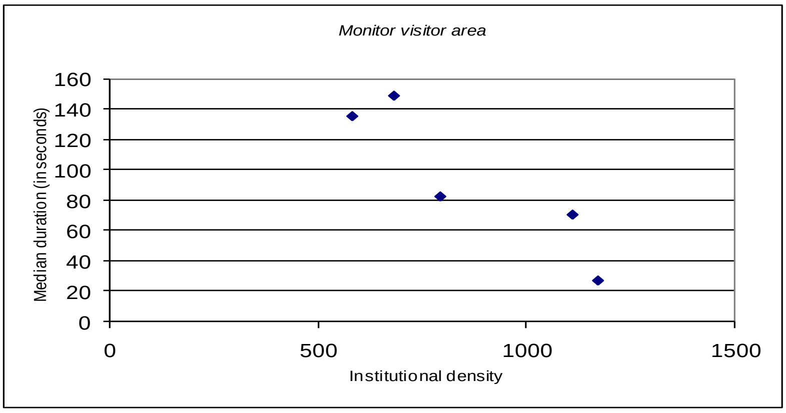

Figure 2.24 The relationship between institutional density and the duration of *monitor visitor area* in the African lion group.

There was a trend for the median daily frequency of *proximity* in the gorilla group to be positively correlated with institutional density (Figure 2.25), but this relationship was not statistically significant. Table 2.19 lists the results of the Spearman correlations between institutional density and gorilla behaviour.

Western lowland gorilla BEHAVIOUR	r	*p* (two-tailed)
< *three meters* (d)	-.612	.144
< *three meters* (f)	-.612	.144
> *three meters* (d)	.612	.144
feed/forage (d)	.214	.645
feed/forage (f)	-.408	.363
locomote (d)	.036	.939
locomote (f)	.036	.939
monitor visitor area (d)	-.429	.337
monitor visitor area (f)	-.055	.908
proximity (d)	.487	.268
proximity (f)	.767	.044
regurgitation/reingestion (f)	.000	1.000
rest (d)	-.286	.535
rest (f)	-.703	.078
scratch self (f)	.262	.570
social play (d)	-.401	.373
social play (f)	-.401	.373
solitary groom (d)	.579	.173
solitary groom (f)	.632	.127
solitary play (d)	.134	.775
solitary play (f)	.134	.775

Table 2.19 The results of the Spearman correlations between institutional density and behaviour (median frequency and median duration of behaviour per observation day) in the western lowland gorilla group. Trends are shaded. (f)= frequency, n= 7; (d)= duration, n= 7.

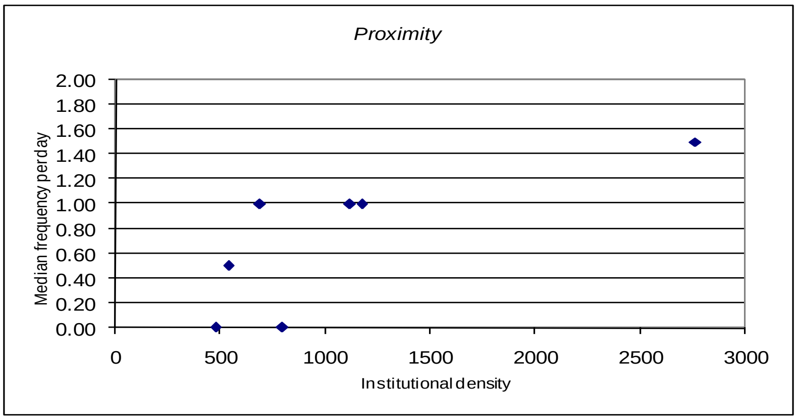

Figure 2.25 The relationship between institutional density and the frequency of *proximity* in the western lowland gorilla group.

The orangutans were less frequently > *three meters* from a viewing window when institutional density was high (Figure 2.26), although this relationship was not statistically significant. The data also show a trend for the orangutans to rest less frequently when institutional density was high (Figure 2.27), but this result was not statistically significant. Table 2.20 lists the results of the Spearman correlations between institutional density and Sumatran orangutan behaviour.

Sumatran orangutan BEHAVIOUR	r	*p* (two-tailed)
< *one meter* (f)	.378	.403
< *three meters* (d)	.464	.294
< *three meters* (f)	.393	.383
> *one meter* (d)	.450	.310
> *three meters* (d)	-.464	.294
> *three meters* (f)	-.791	.034
contact (d)	-.445	.317
contact (f)	-.624	.135
feed/forage (d)	-.071	.879
feed/forage (f)	.000	1.000
headcover (f)	-.408	.363
locomote (d)	.613	.144
locomote (f)	.606	.149
monitor visitor area (d)	.286	.535
monitor visitor area (f)	.168	.718
proximity (d)	.393	.383
proximity (f)	-.134	.775
rest (d)	.036	.939
rest (f)	-.823	.023
scratch self (f)	.204	.661

Sumatran orangutan BEHAVIOUR	r	*p* (two-tailed)
social play (f)	-.204	.661
solitary groom (d)	-.045	.924
solitary groom (f)	-.158	.735

Table 2.20 The results of the Spearman correlations between institutional density and vicinity density (median frequency and median duration of behaviour per observation day) in the Sumatran orangutan group. Trends are shaded. (f)= frequency, n= 7; (d)= duration, n= 7.

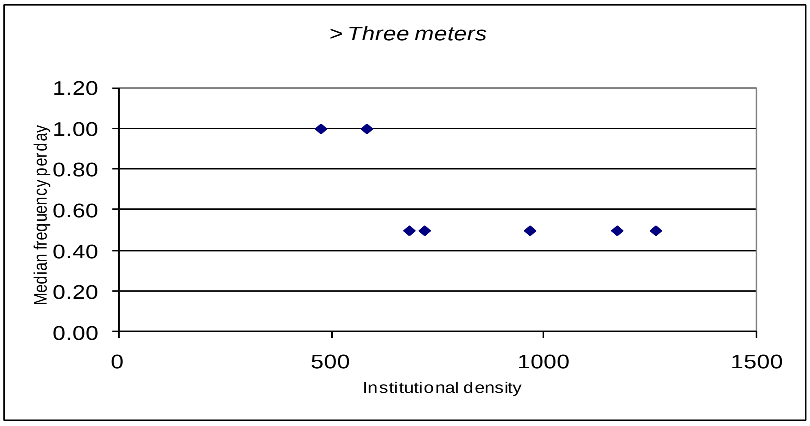

Figure 2.26 The relationship between institutional density and the frequency of > *three meters* in the Sumatran orangutan group.

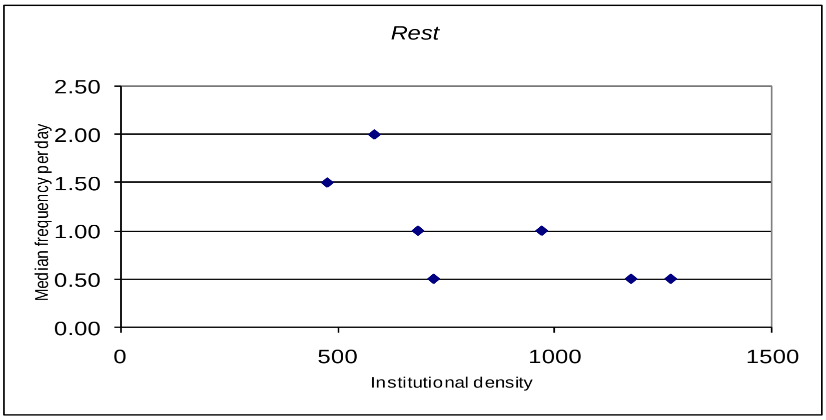

Figure 2.27 The relationship between institutional density and the frequency of *rest* in the Sumatran orangutan group.

The polar bears' *proximity* to a group member was more frequent and longer in duration when institutional density was high (Figures 2.28 and 2.29), although these associations were not statistically significant. Table 2.21 lists the results of the Spearman correlations between institutional density and polar bear behaviour.

Polar bear BEHAVIOUR	r	*p* (two-tailed)
locomote (d)	-.112	.858
locomote (f)	-.112	.858
monitor visitor area (d)	.300	.624
monitor visitor area (f)	.462	.434
proximity (d)	.894	.041
proximity (f)	.894	.041
rest (d)	.100	.873
rest (f)	-.154	.805
sniff air (f)	-.300	.624
sniff object (f)	.354	.559

Table 2.21 The results of the Spearman correlations between institutional density and vicinity density (median frequency and median duration of behaviour per observation day) in the polar bear group. Trends are shaded. (f)= frequency, n= 5; (d)= duration, n= 5.

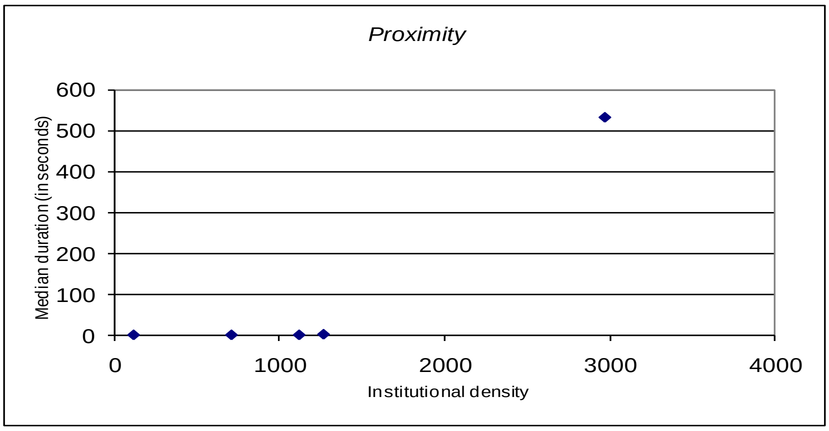

Figure 2.28 The relationship between institutional density and the duration of *proximity* in the polar bear group.

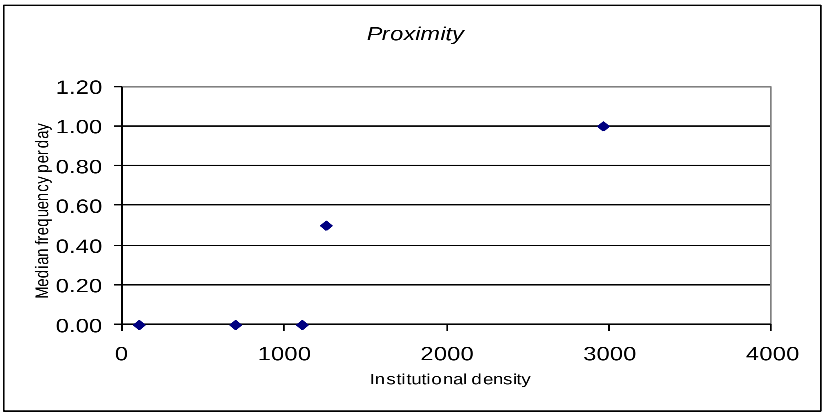

Figure 2.29 The relationship between institutional density and the frequency of *proximity* in the polar bear group.

2.20 Discussion

The results of this study support the claim made in the introduction that institutional density data measures a different scale of visitor density than vicinity density when investigating the immediate effects of visitor density on animal behaviour. The lack of correlation between the daily total number of visitors to the Toronto Zoo and the daily mean of the vicinity data collected at the Toronto exhibits suggests that institutional data are not necessarily reflective of the daily median number of visitors visible to display animals at any given moment.

The institutional visitor density study did not identify a visitor effect in the six Toronto groups, while the visitor density analysis in Study 1 documented a visitor effect in several of the Toronto groups. When comparing the results of Study 1 with Study 3, it becomes apparent that institutional data and vicinity data may measure different aspects of the visitor effect on animal behaviour. This finding indicates that different methodologies within the visitor effect literature may make relating data and conclusions to previous research results problematic.

From the Study 3 results, it would initially appear that vicinity scale is sensitive to weak associations when assessing the visitor effect in terms of the immediate effect on animal behaviour. Contrastingly, institutional density would appear to highlight trends in strong correlations, as evidenced by the high correlation coefficients. However, the difference in sample sizes between these studies necessitates a conservative interpretation of the results. The high correlation coefficients seen in the results of Study 3, in conjunction with a small sample size, suggest that if more data had been collected, one would expect, based on the statistical principle of reversion toward the mean, that the correlation coefficient would be less extreme. However, the results of Study 3 in comparison to Study 1 indicate there is a need for more data on the different visitor density scales and consideration of this issue when comparing results based on different methodologies.

STUDY 4: The Effect of Visitor Noise

2.21 Methods

The study groups for this study are the same as in Study 1, and again, the same data set gathered from the six study groups housed at the Toronto Zoo are used. Data were collected on a Psion Workabout using *The Observer* (Noldus). Frequencies and durations were calculated using the Elementary Statistics and Lag Sequential Analysis features and then exported to SPSS for further statistical analyses.

2.22 Procedures

Visitor noise was measured using a Velleman DVM1326 digital sound level meter and testing from inside the enclosures was done with an Extech Instruments 407727 digital sound level meter; Table 2.22 provides specifications for the sound level meters. Sound pressure levels, essentially loudness expressed in decibels, were measured using a C weighting which filters out less of the low and high frequencies than the A weighting typically used when measuring the effect of noise on humans.

Noise levels were recorded every minute from the visitor viewing areas during focal sampling; all decibels reported were measured in the visitor area.

Ideally, the noise level would have been measured inside the animals' enclosures for this study. Unfortunately, measuring visitor noise levels from inside the enclosures was impractical for several reasons: it would have required expensive sound levels meters capable of logging data, as well as secured locations inaccessible to the animals while still allowing the researcher daily access to the meters. To determine how much of the visitor noise study groups could hear from inside their exhibit, the following test was performed for each enclosure. The researcher positioned a keeper with a sound level meter inside the enclosure (at least three meters from a viewing window for all groups except the golden lion tamarins) when the study animals were off exhibit and then the researcher, while standing in the visitor area, made a loud noise which was simultaneously measured by both sound level meters. The difference in sound level readings between the visitor area and the animal enclosures were generally small (Table 2.23 and most were within the accuracy levels of the two sound levels meters (Table 2.23), suggesting that measuring sound levels from the visitor areas was an acceptable method of noise measurement for this study. An additional supporting point regarding the appropriateness of measuring noise levels from the visitor areas instead of from within the enclosures is the fact that noise levels were taken for the purpose of providing an objective but relative (i.e. low visitor noise when compared to high visitor noise) measurement of visitor noise and were not intended for use in determining the absolute effects of high sound levels on the behaviour or physiology of the study animals.

Meter Type	Range	Accuracy	Microphone Type
Velleman DVM 1326	35-130dB	±3.5dB at 94dB, 1KHz sine wave	1” built-in electret condenser
Extech 407727	40-130dB	± 2 dB at 94dB, 1000 Hz	1” built-in electret condenser

Table 2.22 The specifications of the the two sound level meters used in the Study 2.

STUDY GROUP	NOISE LEVELS
Golden lion tamarins	no difference
Western lowland gorilla	-4dB
Sumatran orangutan	no difference
Polar bear	-3dB
African lion	+2dB
Amur tiger	-1dB

Table 2.23 The difference between noise levels in the enclosures when compared to the visitor areas.

2.23 Statistical Analysis

Before statistical analyses were performed on the visitor noise datasets, instances of sound level readings higher than 80 decibels were removed from the analysis for the animals housed in outdoor enclosures (polar bear, Amur tiger, and African lion groups) to reduce the effect of inaccurate readings due to wind interference. To determine the relationship between visitor noise and the frequency of animal behaviour, a lag analysis with a sixty second lag time between criterion event (sound level measurement) and the occurrence of target behaviours was carried out. Two or more bouts of the same behaviour were counted as separate events within each lag period. Behaviours were included in the analysis if they occurred ten or more times during the baseline data collection period. Decibel readings that occurred more than once per sample were aggregated and the frequency of associated behaviours was averaged to achieve a mean[4] frequency of behaviour per unique decibel reading for each sample (i.e. the frequency of behaviour was divided by the frequency of unique decibel readings per sample). This step reduced the impact of autocorrelation of the visitor noise measurements.

The relationship between visitor noise and the duration of states was also important to understand. Focal samples were divided into ten one-minute intervals, associating the duration of behavioural states with the noise measurement for that interval. Decibels that occurred more than once per sample were aggregated and the associated durations were summed for each sample. The total duration per sample was then divided by the frequency of the unique decibels per sample, providing a mean duration per sample for each decibel. The mean duration of states per unique decibel reading was used as the unit of analysis to reduce autocorrelation of the decibels.

Kolmogorov-Smirnov statistics were calculated for both the rate and duration datasets and the results suggested the data violated the assumption of normality made by parametric tests, making a non-parametric statistic more appropriate for the visitor noise analysis. Spearman rank order correlations were computed to identify statistically significant relationships between visitor noise and animal behaviour.

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[4] Due to the limitations of *The Observer* software, it was not possible to calculate a median frequency per unique decibel.

2.24 Results

There was no correlation between behaviour and visitor noise in the golden lion tamarin group. Table 2.24 lists the results of the Spearman correlations between visitor noise and golden lion tamarin behaviour.

Golden lion tamarin BEHAVIOUR	r	*p* (two-tailed)
contact (d)	-.188	.100
contact (f)	.137	.189
feed/forage (d)	-.068	.551
feed/forage (f)	-.063	.549
locomote (d)	.052	.652
locomote (f)	.061	.563
monitor visitor area (d)	.209	.067
monitor visitor area (f)	.020	.849
nest box (d)	-.187	.102
proximity (d)	.071	.535
proximity (f)	-.070	.507
rest (d)	-.133	.244
rest (f)	-.039	.709
scent mark (f)	-.034	.748
scratch self (f)	-.061	.562
social groom (d)	-.094	.413
social groom (f)	-.016	.875
solitary groom (d)	-.037	.749
solitary groom (f)	-.040	.706

Table 2.24 The results of the Spearman correlations between visitor noise and golden lion tamarin behaviour. (f)= frequency, n= 93; (d)= duration, n= 78.

A significant positive relationship between the duration of *monitor visitor area* and visitor noise was identified in the African lion group (Figure 2.30). Table 2.25 lists the results of the Spearman correlations between visitor noise and lion behaviour.

African lion BEHAVIOUR	r	*p* (two-tailed)
> *three meters* (d)	.063	.423
> *three meters* (f)	-.009	.911
contact (d)	-.066	.401
locomote (d)	-.018	.818
locomote (f)	-.019	.810
***monitor visitor area* (d)**	**.207**	**.008**
monitor visitor area (f)	.059	.452
out of sight (d)	.014	.862

African lion BEHAVIOUR	r	*p* (two-tailed)
proximity (d)	.001	.998
proximity (f)	.052	.502
rest (d)	-.150	.054
rest (f)	.097	.211
sniff air (f)	.056	.476

Table 2.25 The results of the Spearman correlations between visitor noise and African lion behaviour. Significant results are in bold text. (f)= frequency, n= 167; (d)= duration, n= 166.

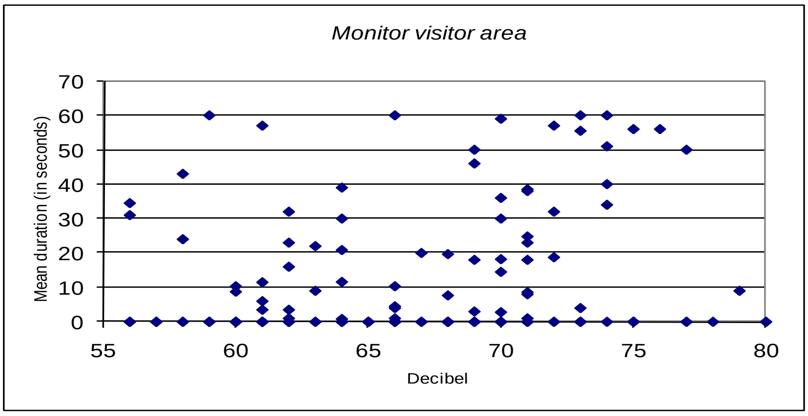

Figure 2.30 The relationship between visitor noise and the duration of *monitor visitor area* in the African lion group.

There was a significant positive relationship between visitor noise and the frequency of > *three meters* in the Amur tiger group, while a trend showing a positive association between noise and *solitary groom* was not statistically significant. Table 2.26 lists the results of the Spearman correlations between visitor noise and tiger behaviour. Figures 2.31-2.33 show the relationship between visitor noise and tiger behaviour.

Amur tiger BEHAVIOUR	r	*p* (two-tailed)
> *three meters* (d)	.206	.021
> *three meters* (f)	**.238**	**.008**
monitor visitor area (d)	.044	.627
monitor visitor area (f)	-.005	.958
rest (d)	-.110	.224
rest (f)	-.101	.260
sniff air (f)	.137	.129
solitary groom (d)	.182	.042

Amur tiger BEHAVIOUR	r	*p* (two-tailed)
solitary groom (f)	.162	.070
vigilance patrol (d)	.009	.918
vigilance patrol (f)	.090	.316

Table 2.26 The results of the Spearman correlations between visitor noise and Amur tiger behaviour. Significant results are in bold text; trends are shaded. (f)= frequency, n=125; (d)= duration, n=125.

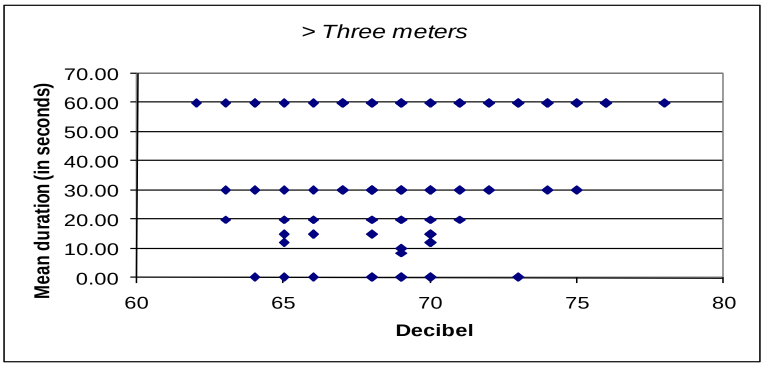

Figure 2.31 The relationship between visitor noise and the duration of > *three meters* in the Amur tiger group.

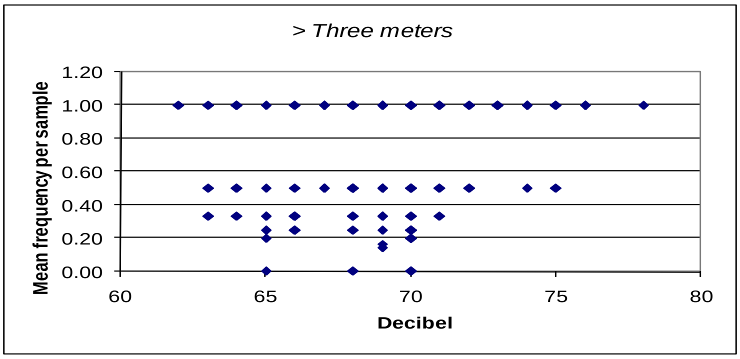

Figure 2.32 The relationship between visitor noise and the frequency per sample of > *three meters* in the Amur tiger group.

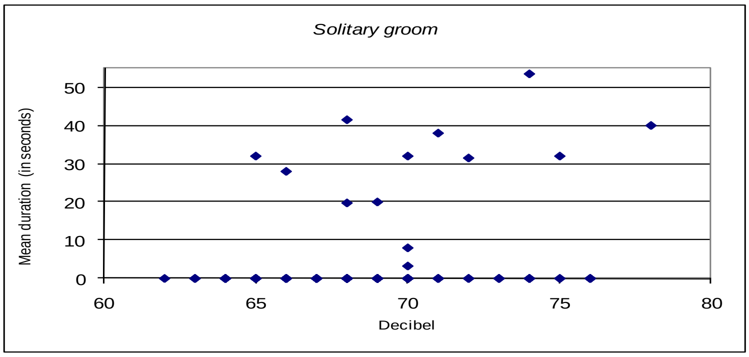

Figure 2.33 The relationship between visitor noise and the duration of *solitary groom* in the Amur tiger group.

The duration of two behaviours performed by the Sumatran orangutan group was significantly associated with visitor noise. The duration of the behaviour *social groom* increased as noise increased (Figure 2.35), while > *three meters* from a viewing window decreased as visitor noise increased (Figure 2.34). Table 2.27 lists the results of Spearman correlations between visitor noise and behaviour in the orangutan group.

Sumatran orangutan BEHAVIOUR	r	*p* (two-tailed)
< *one meter* (d)	.004	.963
< *three meters* (d)	.176	.057
< *three meters* (f)	-.045	.627
> *three meters* (d)	**-.311**	**.001**
contact (d)	.067	.475
contact (f)	.134	.150
feed/forage (d)	-.045	.632
feed/forage (f)	-.071	.449
head cover (d)	.091	.330
locomote (d)	-.099	.290
locomote (f)	.004	.965
monitor visitor area (d)	-.025	.786
monitor visitor area (f)	.075	.421
proximity (d)	-.016	.816
proximity (f)	.087	.350
rest (d)	-.167	.072
rest (f)	.028	.766
***social groom* (d)**	**.284**	**.002**
social play (d)	-.085	.364
solitary groom (d)	-.044	.635

Table 2.27 The results of the Spearman correlations between visitor noise and Sumatran orangutan behaviour. Significant results are in bold text. (f)= frequency, n= 117; (d)= duration, n= 117.

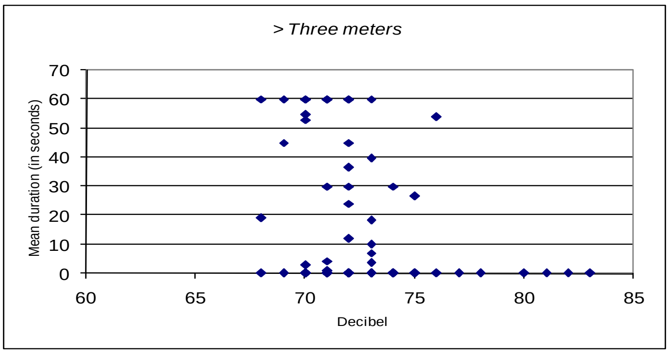

Figure 2.34 The relationship between visitor noise and the duration of > *three meters* in the Sumatran orangutan group.

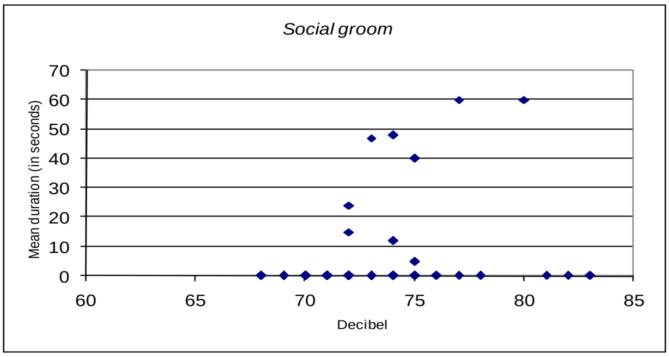

Figure 2.35 The relationship between visitor noise and the duration of *social groom* in the Sumatran orangutan group.

The rate and duration of *social play* decreased significantly as visitor noise increased in the gorilla group (Figure 2.36 and 2.37). Table 2.28 lists the results of the Spearman correlations between visitor noise and gorilla behaviour.

Western lowland gorilla BEHAVIOUR	r	*p* (two-tailed)
< *three meters* (d)	-.013	.884
> *three meters* (d)	.012	.892
contact (f)	.018	.835
feed/forage (d)	.160	.061
feed/forage (f)	-.061	.478
locomote (d)	-.049	.569
locomote (f)	-.106	.215
monitor visitor area (d)	.074	.389
monitor visitor area (f)	-.031	.715
proximity (d)	.051	.554
proximity (f)	.060	.483
regurgitation/reingestion (f)	-.008	.927
rest (d)	.065	.446

Western lowland gorilla BEHAVIOUR	r	*p* (two-tailed)
rest (f)	.055	.523
scratch self (f)	-.101	.239
***social play* (d)**	**-.283**	**.001**
***social play* (f)**	**-.228**	**.007**
solitary groom (d)	-.090	.294
solitary groom (f)	.023	.793
solitary play (d)	-.128	.135
solitary play (f)	-.131	.125

Table 2.28 The results of the Spearman correlations between visitor noise and western lowland gorilla behaviour. Significant results are in bold text. (f)= frequency, n= 138; (d)= duration, n= 138.

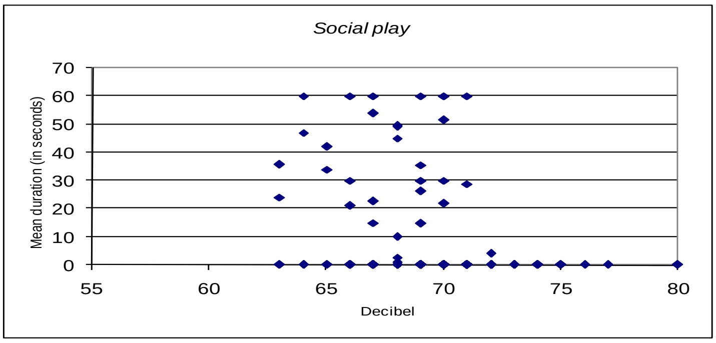

Figure 2.36 The relationship between visitor noise and the duration of *social play* in the western lowland gorilla group.

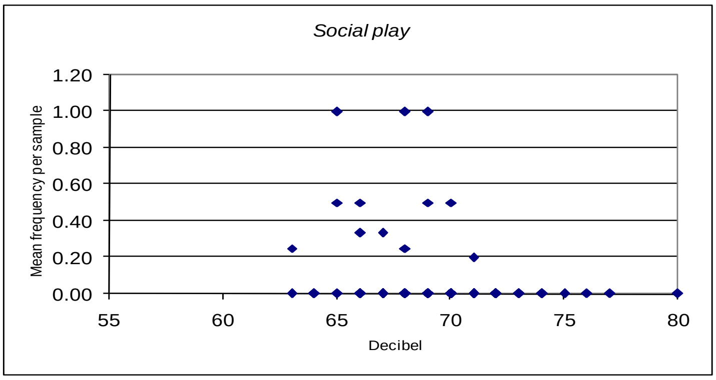

Figure 2.37 The relationship between visitor noise and the frequency of *social play* in the western lowland gorilla group.

There was a significant negative relationship between visitor noise and the frequency of *sniff object* in the polar bear group (Figure 2.38). Table 2.29 lists the results of Spearman correlations between visitor noise and polar bear behaviour.

Polar bear BEHAVIOUR	r	*p* (two-tailed)
locomote (d)	-.076	.352
locomote (f)	-.032	.692
monitor visitor area (d)	.090	.268
monitor visitor area (f)	.029	.721
proximity (d)	-.137	.093
rest (d)	.029	.720
rest (f)	-.049	.551
sniff air (f)	.116	.155
***sniff object* (f)**	**-.243**	**.003**

Table 2.29 The results of the Spearman correlations between visitor noise and polar bear behaviour. Significant results are in bold text. (f)= frequency, n= 152; (d)= duration, n= 117.

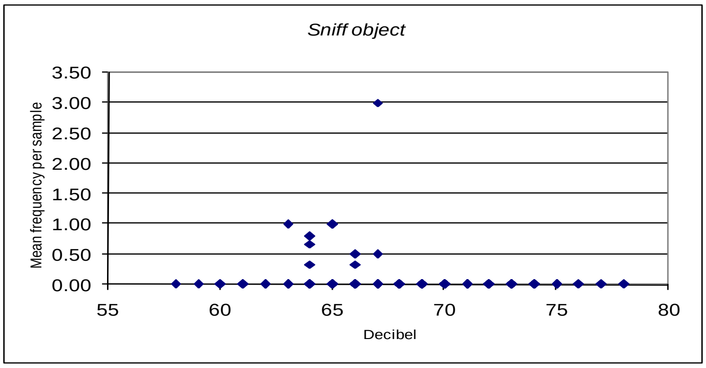

Figure 2.38 The relationship between visitor noise and the frequency of *sniff object* in the polar bear group.

2.25 Discussion

Behaviour following a decibel measurement was dependent on visitor noise in five of the six study groups, with only golden lion tamarin behaviour unrelated to the noise produced by visitors. It is possible that the data on the golden lion tamarin group were confounded by the presence of a large heating system that produced continuous noise and may have drowned out some visitor noise.

Because the youngest two members of the western lowland gorilla group were the only members to engage in social play behaviour, visitor noise influenced only juvenile behaviour. The decreased frequency and duration of play in the Toronto Zoo gorillas is consistent with the sensitivity to noise of juvenile orangutans as described by Birke (2002), although play behaviour was not affected by visitor noise in her study. The decrease in social play behaviour for juveniles could have significant behavioural and developmental implications for captive gorillas but needs to be observed in other groups before firm conclusions are drawn.

The significant decrease in sniffing objects associated with increased visitor noise in the polar bear group is indicative of a reduction in exploratory behaviour due to visitor pressure. Unfortunately, few studies of captive polar behaviour have been published and there are no visitor effect data on zoo polar bears to support this finding. Exploratory behaviour is recognised to be a mode of information gathering in animals and it is considered an important result of effective environmental enrichment (Mench 1998). A decrease in exploratory behaviour may be indicative of an impoverished environment, or in this case, one associated with visitor pressure. Although the link between exploratory behaviour and visitor noise is unclear, given that the polar bears were unlikely to gather any olfactory information about visitors by sniffing objects, it is an intriguing result that warrants further investigation.

The apparent enriching effect of visitor noise on orangutan behaviour was not predicted, given the results of Birke (2002). The significantly increased duration of social grooming suggests that the orangutans may have found visitor noise stimulating, as does the significantly decreased use of areas more than three meters from a visitor viewing window. The enriching effect of visitor noise on the Toronto Zoo orangutans conflicts with the results described by Birke which included increased sitting and looking at visitors in adult orangutans and increased sitting, looking at visitors, and approaching/holding of adults by infants in her study group. The increased clinging of the two study infants, who were two years old, to adult group members during and following noisy conditions in Birke's study was not exhibited by the youngest female member of this group (who was six years old at the time of data collection). The disparity in results between this study and Birke's suggests that the influence of visitor noise may depend on individual temperament and group composition. Orangutan groups with several infants or young juveniles may find visitor noise disturbing, while groups with older juveniles such as the Toronto study group may find visitor noise less stressful or possibly even enriching.

The trend toward increased duration of grooming bouts associated with visitor noise in the Amur tiger group is ambiguous. An increase in self-directed behaviours, particularly in a singly-housed animal (albeit a natural state for a solitary species such as the Amur tiger), can be cause for concern; however, this tiger showed no physical signs of over-grooming, so it is doubtful that this behaviour was indicative of visitor noise-related stress. Sellinger and Ha (2005) observed increased pacing associated with low levels of visitor noise in jaguars, and their results combined with the data on the Toronto Zoo tiger suggest that noisy visitors may be helpful in reducing stereotypies and self-directed behaviour. The Toronto Zoo Amur tiger result, like the polar bear reaction to visitor noise, and its implications for large carnivore welfare are difficult to interpret until the results are replicated in other groups.

The behaviour of the African lion group housed at the Toronto Zoo was not extensively affected by visitor density and only monitoring of the visitor areas was influenced by visitor noise. Sellinger and Ha (2005) identified that jaguars increased the time they spent nonvisible to visitors when crowds were less noisy, a result which suggests that noisy visitors may be positive for zoo felids. While the Toronto Zoo African lion group did not appear to find visitor noise stimulating, the lack of change in behaviours that are not visitor-related and the data from Sellinger and Ha indicate that visitor noise is most likely not a welfare concern for some felid species.

2.26 Conclusion

The effect of visitor density on animal behaviour is difficult to generalise for several reasons. The lack of consistent or well-defined methodology, small sample size, and replication of experiments has prevented firm conclusions regarding visitor density on zoo-housed mammals, particularly non-primate species. A lack of data on the influence of enclosure design, species temperament, personality, group size, group composition, keeper-animal interactions, training, animal control and choice, predictability, and rearing style on zoo animals impedes progress in identifying visitor effects. Despite the lack of fundamental data on these factors, behavioural changes can be described and gradually synthesised as data are accumulated.

The methodological distinctions of scale and latency of effect were introduced in these studies to aid in deciphering the visitor effect literature and the data presented herein suggest that these distinctions may be scientifically valid and, in conjunction with the visitor effect literature, provide a framework with which researchers can understand the visitor effect literature. The lack of relationship between vicinity density and institutional density indicates that visitor pressure is experienced on different levels and over different periods of time by zoo animals and that measuring different scales and the latency of effect of visitor density may provide researchers with a broader understanding of how this variable affects behaviour. The Toronto Zoo data and previous visitor effect studies show that animal behaviour can be dependent on the number of visitors present at an exhibit, the number of people visible to an animal, and the number of visitors it has seen over a given period of time, and that these categories may not be mutually exclusive in their effect on animal behaviour.

The Toronto Zoo data suggest that visitor density and visitor noise are usually discrete variables and groups of visitors should not be subjectively categorised as active or passive, intense or moderate, noisy or quiet based simply on their number. The studies presented the first visitor effect data on captive polar bears and golden lion tamarins, and also demonstrated a visitor effect in both these species. The studies also contributed much needed visitor effect data on captive felids which suggest, in the context of previously published studies, that there is indeed a visitor density effect and large cats may be highly variable in their experience of visitor density pressure. Visitor noise also affected both lions and tigers, and adds more support for the visitor effect hypothesis in felids.

The visitor density and visitor noise data highlighted the need to consider the role group composition plays in the phenomenon of the visitor effect, especially in the case of orangutans and gorillas. Previous research suggests that infants or juveniles may be particularly susceptible to the effect of visitor noise and the Toronto Zoo gorilla data supports this conclusion. Due to the generally small sample size of most visitor effect studies, controlling for group composition has not been possible, but the gaps in the visitor effect literature, and the obvious potential scientific benefit, warrant carrying out visitor effect research on a multi-institutional scale. The data presented in this chapter bolster the claim that zoo animal welfare would benefit from a greater understanding of the visitor effect and the importance of visitor-related studies will become more apparent as zoos develop a science of welfare.

Chapter 3: Can Visual Barriers Moderate the Visitor Effect in Zoo Mammals?

3.1 Introduction

Zoo visitors introduce auditory, olfactory, and visual stimuli into the environment of zoo animals and these stimuli have the potential to influence animal behaviour. The visitor effect literature documents the negative influence of zoo visitors on animal behaviour and welfare, primarily by identifying the negative impact of visitor presence and density on zoo-housed primates. The data presented in Chapter 2 also identified negative effects of visitors, with study groups exhibiting decreased contact and social grooming and increased levels of monitoring visitor areas when visitor density was high. Although data supporting a negative effect of the presence and density of visitors on animal behaviour is sufficient to warrant attempts to moderate this effect, there are few published empirical assessments of visual barriers intended to moderate the visual impact of the public on display animals. This chapter presents data on two techniques that have the potential to moderate the visual presence and density of zoo visitors. The first method of reducing the visual presence of zoo visitors tested was the installation of camouflage nets over viewing windows of primate and large carnivore exhibits and the second method tested was the installation of a privacy screen inside an enclosure housing a species of small arboreal primate.

Despite the growing literature on the effect visitors have on display animals, there have been few attempts to moderate them. Providing visual barriers between visitors and display animals is the only method that attempts to reduce the visitor effect on display animals that has been subject to empirical testing and peer-reviewed publication. The general effect of visitors on zoo primates includes decreased inactivity, increased stereotypies, and increased intragroup aggression (Hosey 2000). These behaviours are indicative of stress in captive animals and have serious implications for zoo animal welfare. The visitor effect demonstrated in Chapter 2 also supports the testing of methods that may moderate the visitor effect. The need to develop techniques or enclosure modifications that reduce the negative effects of zoo visitors on animal behaviour and welfare in general is compelling.

3.2 Part I. Are Camouflage Nets an Effective Method of Moderating the Visitor Effect?

Techniques that attempt to moderate the visual impact of zoo visitors can either be installed externally, such as camouflage nets, or they can be installed inside the enclosure, such as privacy screens. Both techniques have potential drawbacks and benefits, hence the need to test both an external and an internal method of reducing the visibility of visitors. External devices can be less structurally robust than internal visual barriers because the display animals do not have physical access to them, thereby eliminating the animal health and safety concerns associated with an internal visual barrier. The lack of structural robustness in external visual barriers also allows for some flexibility in their use. For instance, external visual barriers such as camouflage nets can be installed and removed more easily, allowing keepers to use them during times of potential animal stress, such as high visitor density or the birth of infants, and remove them as conditions change. In the case of large enclosures, external visual barriers may require covering a large area in order to be effective, making this sort of visual barrier impractical.

Expansive external visual barriers may also have the unintended negative consequence of removing too much external stimuli. Although there is little documented positive visitor effect in the zoo environment, there is evidence to suggest that human activity can have both stressful (Maki et al 1987, Lambeth et al 1997) and enriching (Waitt and Buchanan-Smith 1999) effects on laboratory-housed primates. The general environment outwith the enclosure (Schapiro et al 1993) has also been shown to contribute to lower activations of hypothalamic-pituitary-adrenal system in laboratory rhesus macaques. In addition to the negative consequences of external barriers for zoo animals, they also reduce the visitors' view of the animals, although Norcup (2000) and Blaney and Wells (2004) suggest that visitors enjoyed viewing gorillas through camouflage nets, making the experience more analogous to viewing gorillas in the wild.

3.2.1 Previous Research on the Effectiveness of External Visual Barriers

The need for cover from visitors is a truism known to many of those concerned with animal behaviour and welfare in a zoological setting. Despite the general acknowledgement of the need to lessen visitor pressure on display animals, there is only one empirical investigation of a method of moderating the visual presence of visitors on zoo animals. The lack of research on this topic may be partly due to the sparseness of empirical visitor effect research until the 1980's and partly due to the pragmatic issues implicit in installing visual barriers. Another reason for the lack of data on using visual barriers to reduce the impact of visitors may be that in order for zoos to fulfil their mission of educating (and entertaining) the public, animals must be visible to visitors. Therefore, zoos may be reticent to accept proposals for research that impinge upon the visitor experience.

Blaney and Wells (2004) carried out the only published quantitative investigation of using camouflage nets to cover the viewing windows of a group of six western lowland gorillas (*Gorilla gorilla gorilla*). In a two month-long experiment, divided into a baseline and barrier conditions, the authors collected data on 11 behavioural categories using a scan-sampling technique. The study group spent significantly less time engaged in intra-group aggression and abnormal behaviour in the barrier condition than in the baseline condition and this did not change over the four week period while the barrier was in place The authors also conducted a survey of visitor perception of the gorillas and the gorilla enclosure during the experiment and the results indicate that zoo visitors found the gorillas more exciting and less aggressive and the enclosure “more appropriate for visitors[1]” in the barrier condition. Blaney and Wells also make anecdotal claims that the presence of the barrier altered visitor behaviour. They claim visitors were generally more relaxed and quieter when the camouflage nets were in place and they spent less time banging on the viewing window glass.

Cunningham (2004), in an unpublished Master’s thesis, tested the camouflage nets on small singly-housed felids at the Edinburgh Zoo. The study animals were two Persian leopards (*Panthera pardus saxicolor*), one jaguar

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[1] The authors do not elaborate on this phrase, but it appears visitors interpreted it to mean how successful the enclosure was at replicating wild gorilla habitat.

(*Panthera onca*), and two snow leopards (*Uncia uncia*). In the barrier condition, the enclosure windows were partially covered with camouflage nets, leaving half of the viewing windows uncovered so that visitors had access to a clear viewing area. The installation of the barriers was followed by two days in which no data were collected to allow the felids to adjust to the enclosure modification. Cunningham documented a significant decrease in stereotypical pacing in one Persian leopard, but the pacing of the other study animals remained unaffected by the camouflage nets. The visual barrier influenced the resting behaviour of three of the study animals, with a significant reduction in the frequency of resting in one of the Persian leopards and a significant increase in resting in the jaguar and one of the snow leopards. The camouflage nets also altered the frequency of alert behaviour in one of the study animals, with one snow leopard showing a significant decrease in alert behaviour when the barrier was in place.

Cunningham examined the effect of the camouflage net barrier on the position of the felids within their enclosure and found there was no significant difference between use of the enclosure space between the baseline and barrier conditions. She also looked at the felids’ responses to visitor density and visitor noise in the camouflage net condition. The felid response to visitor density was not influenced by the installation of the camouflage nets, but the response to visitor noise was significantly affected by the camouflage nets in one of the study animals. Only one animal, a snow leopard, responded to visitor noise differently in the net condition, showing no preference for a particular area of the enclosure when the nets were in place but a significant effect for enclosure position at the back of the enclosure without the nets.

Anecdotally, camouflage nets have been reported by Norcup (2000) to be effective in reducing visitor-directed displays, such as banging on the viewing window glass, in the gorillas housed at the Jersey Zoo. Norcup also reports a reduction in intra-group aggression following the installation of the visual barrier, but does not provide any quantitative data to support this. Changes in visitor behaviour were noted by Norcup, including decreased attempts to interact with the gorillas by banging on the glass, decreased visitor noise, and increased visitor interest in the behaviour of the gorillas. Camouflage nets have also been used or tested at several other zoos in the United Kingdom including Paignton Zoo, Chester Zoo, and Edinburgh Zoo, but the results of these trials have not been published. The decision of these zoos not to publish their experiences with the nets may not necessarily be indicative of their ineffectiveness, but rather a reflection of the tendency of students and keepers not to publish the results of their research projects.

3.2.2 Visitor Density: A Potential Confounding Variable Affecting Visual Barrier Experiments

Visitor density is a variable that has been shown to influence the behaviour of zoo animals (Hosey 2000) and it is an important factor to monitor during any visitor effect study, including visual barrier studies. By noting significant changes in visitor density between experimental conditions, researchers can support their assertions that the behavioural changes they observe are due to their experimental manipulation and not an increase or decrease in visitor density. Unfortunately, neither Blaney and Wells (2004) nor Cunningham (2004) presented data on the level of visitor density between baseline and camouflage net conditions in their experiments. Disregarding possible fluctuations in the number of people visiting zoo exhibits between conditions introduces visitor density as a potential confounding variable. Given the documented positive relationship between visitor density and stereotypies or aggression in primates (Maki et al 1987, Chamove et al 1988, Mitchell et al 1991c), the conclusion made by Blaney and Wells that the observed behavioural changes in the gorillas were related to the installation of the camouflage nets would have been bolstered had they also tested whether visitor density decreased significantly between the control and experimental condition. Their research highlights the need to collect and present visitor density data in visual barrier research as part of an effort to make visitor effect research more scientifically rigorous.

Ruling out changes in visitor density between treatment conditions is also important when making claims about visitor behaviour. Although there are not any published data on the correlation between visitor behaviour and visitor density, it is possible that there are significant associations between behaviours such as visitor vocal threats, hitting viewing glass windows, feeding display animals, and visitor density; however, the data in Chapter 2 suggest that often there is no correlation between visitor density and visitor noise. The significant positive relationship between visitor density and visitor noise for the polar bear group supports the notion that assertions of significant changes in visitor behaviour as a result of an experimental manipulation should be supported by visitor density data showing consistency in density between conditions. For instance, the anecdotal claim made by Blaney and Wells (2004) and Norcup (2000) that visitor noise and visitor behaviour such as banging on the viewing windows decreased in the presence of camouflage nets is less convincing without supporting data indicating that these visitor behaviours either: 1) did not correlate with visitor density in the baseline condition OR there was no significant change in visitor density between the experimental conditions.

3.3 Research Objectives

The camouflage net experiment had several objectives:

1. Determine if there was significant change in visitor density and visitor noise between conditions which might confound the results of the camouflage net experiment. Also, assess the potential for the installation of the camouflage nets to affect the amount of light entering the study enclosures.
2. Determine if the installation of camouflage nets over viewing windows reduces the visitor effect in the Sumatran orangutan, western lowland gorilla, golden lion tamarin, polar bear, Amur tiger, and African lion study groups.
3. Determine if camouflage nets affect the relationship between visitor density/noise and animal behaviour identified in the study groups in Chapter 2.
4. Determine if camouflage nets alter visitor behaviours such as hitting viewing windows or mimicking animal vocalisations.

5. Evaluate the welfare implications of installing an external visual barrier in the study groups.

3.4 Methods

The camouflage net experiment was conducted on all six of the Toronto Zoo study groups (Appendix A). The behavioural categories used were the same as Chapter 2 (see Appendix B). The baseline data in this experiment are the same data set used for the Toronto Zoo studies in Chapter 2. The sampling method employed was continuous focal animal samples (Martin and Bateson 1986); each sample was ten minutes in length. Observation order was determined systematically, resulting in at least a ten-minute interval between samples on the same animal. The number of samples per group member was equal for each group, with the exception of the orangutan group. The young female orangutan Sekali was over-represented in the sample because she was the only orangutan who was on display daily. Table 3.1 lists the number of samples collected per condition and the total number of hours of data per condition for each study group.

Study group	Baseline Condition		Net Condition	
	# of samples	# of hours	# of samples	# of hours
African lion	32	5.33	28	4.66
Amur tiger	30	5	23	3.83
Golden lion tamarin	30	5	28	4.66
Polar bear	30	5	30	5
Sumatran orangutan	34	5.67	30	5
Western lowland gorilla	35	5.83	30	5

Table 3.1 The number of 10-minute samples and hours per condition collected for the camouflage net experiment.

Visitor density and visitor noise data were collected in the same manner described in Chapter 2. A density category legend is provided in the first graph for each set of significant results. Data were collected on a Psion Workabout using the behavioural software program *The Observer* (Noldus). Frequencies and durations were calculated using *The Observer*'s Elementary Statistics feature and then exported to SPSS for further statistical analysis.

3.5 Procedures

Two weeks of baseline data were collected in October and November 2003, then camouflage nets were placed over the viewing windows of the six exhibits and another two weeks of data were collected in November and December 2003. Four of the small windows in the African lion cavern were not covered by nets as they were too high for either the lions or people to look through and their bareness was necessary to provide adequate light inside the cavern.

The nets were held in place by adhesive hooks, suction cup hooks, and Velcro tape. Every attempt was made to secure the nets firmly on all sides to prevent zoo visitors lifting up or pushing aside the nets to view the animals, but visitors occasionally ripped the nets or lifted them to get a better view of the animals. In addition, informational signs were placed on the windows describing the experiment and asking visitors to cooperate with the experiment by leaving the nets undisturbed. The weave of the camouflage nets was loose enough to permit visitors to look through or take photographs through the holes while still maintaining its usefulness as camouflage. Table 3.2 lists the number and size of the windows covered with camouflage nets for each study enclosure. Figures 3.1

and 3.2 show the camouflage nets installed on the viewing windows of the tamarin and polar bear enclosures.

ENCLOSURE	NUMBER OF WINDOWS	WINDOW SIZE (centimeters)	CAN ANIMALS TOUCH WINDOWS?	CAN VISITORS TOUCH WINDOWS?
African lion	8	71 x 163 102 x 163 (7)	Yes	Yes
Amur tiger	4	160 x 142 175 x 135 180 x 137 175 x 134	Yes	Yes
Golden lion tamarin	1	330 x 207	No	Yes
Polar bear	29	132 x109 each	No	Yes
Sumatran orangutan	18	142 x 211 112 x 274 (6) 109 x 211 (11)	Yes	Yes
Western lowland gorilla	4	147 x 348 226 x 343 229 x 338 (2)	Yes	Yes

Table 3.2 The width and height of the six exhibits' windows covered in the camouflage net experiment.

Figure 3.1 The golden lion tamarin enclosure in the camouflage net condition. Toronto Zoo. Photo by author.

Figure 3.2 The polar bear enclosure in the camouflage net condition. Toronto Zoo. Photo by author.

It was hypothesised that installing camouflage nets over visitor viewing windows could reduce the amount of light entering the study enclosures. The African lion, Amur tiger, and polar bear enclosures were outdoor habitats that were naturally lit on both the visitor and animal sides; therefore, it was unlikely that the installation of the nets affected the amount of light within those enclosures. The western lowland gorilla and Sumatran orangutan enclosures were in large pavilions that were lit from overhead both by skylights and fluorescent lights, which ensured that amount of light reaching the enclosure was not altered by the presence of the camouflage nets. The smaller glass-fronted golden lion tamarin enclosure was lit by fluorescent light and there was a possibility that the amount of light entering the enclosure was reduced following the installation of the camouflage. To rule out the reduction of light within the golden lion tamarin enclosure as a confounding variable, the amount of light inside the enclosure was measured, without the camouflage nets and again once they had been installed, using a reflected-light exposure meter (Capital TK-79). Light was measured in exposure value (EV), with an American Standards Association (ASA) setting of 400 and a Deutsche Industrie Norm (DIN) of 27.

3.6 Statistical Analysis

Randomisation tests, as described by Todman and Dugard (2001), were the chosen statistical technique employed to identify significant differences in the behaviour of the study groups between the baseline and camouflage net conditions. As recommended by Martin and Bateson (1986), each study group was treated as a single unit because the behaviour of animals within a group is not independent. Todman and Dugard's Design 1 was utilised for analysis of all of the study groups because it is suitable for a repeated measures phase design experiment for a single subject. The test statistic for Design 1 is the difference between condition means.

The statistical procedure for computing the Spearman correlations to identify relationship between the visitor density/noise and animal behaviour section of this chapter was similar to the visitor density/noise analysis in Chapter 2. Randomisation tests were used to analyse the visitor noise and visitor density levels between the experimental conditions. The median of the visitor density categories per sample and the median decibel per sample were calculated and then used to calculate the randomisation tests. The significance level was set at $p < .01$ for analyses and all statistics were two-tailed.

3.7 Results

3.7.1 Baseline Activity Budgets

The baseline condition activity budgets for the study groups outline the behaviours that constituted the majority of the species groups' time on display. The two ape groups spent the most time engaged in *rest* and *feed/forage* behaviours, while the golden lion tamarin group spent more than half their time on exhibit engaged in *monitor visitor area*. Two of the carnivore groups spent most of their time engaged in the inactive behaviour *rest*, while the Amur tiger spent most of its time performing the behaviour *vigilance patrol*. The polar bear group spent more than three quarters of their time on display performing the behaviour *rest* and the African lion group spent almost half their time engaged in *rest*. The activity budgets of the six study group are graphically presented in Figures 3.3-3.8.

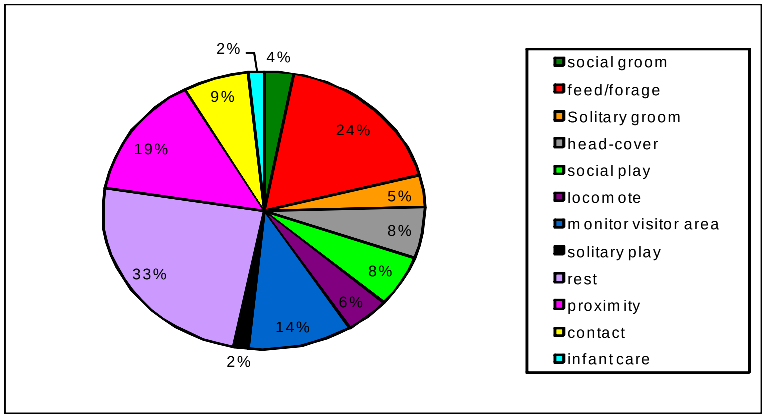

Figure 3.3 The percentage of total sample time the Sumatran orangutan group engaged in durational behaviour.

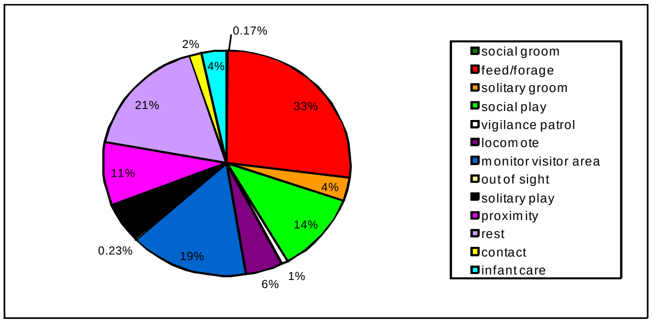

Figure 3.4 The percentage of total sample time the western lowland gorilla group engaged in durational behaviour.

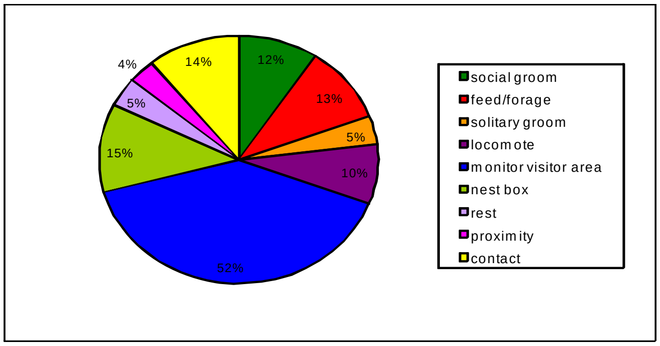

Figure 3.5 The percentage of total sample time the golden lion tamarin group engaged in durational behaviour.

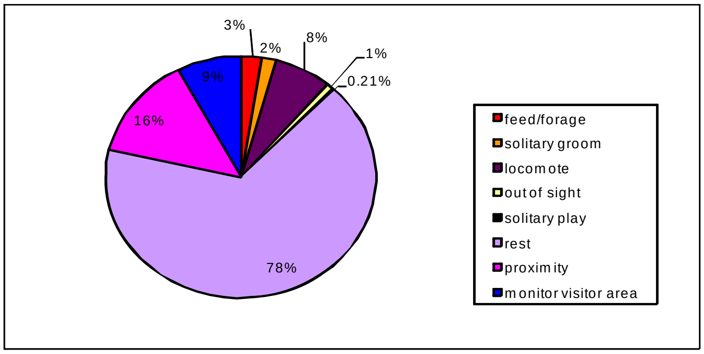

Figure 3.6 The percentage of total sample time the polar bear group engaged in durational behaviour.

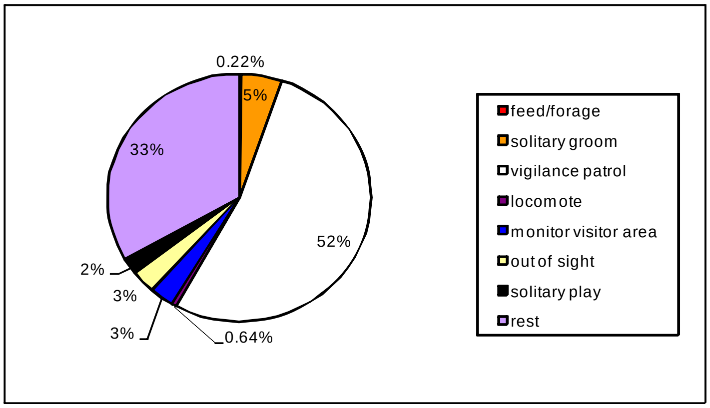

Figure 3.7 The percentage of total sample time the Amur tiger group engaged in durational behaviour.

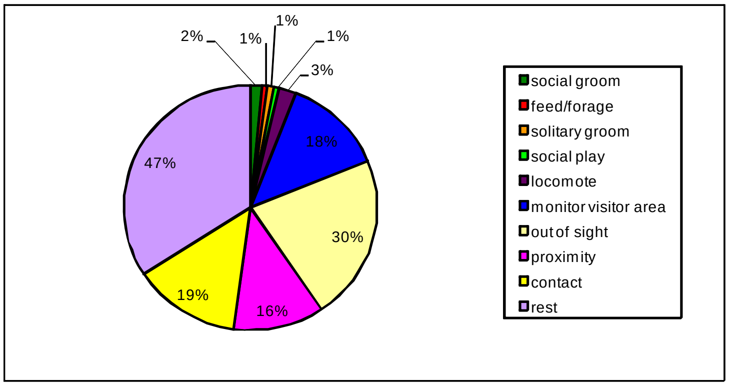

Figure 3.8 The percentage of total sample time the African lion group engaged in durational behaviour.

The proximity of the orangutan, gorilla, lion, and tiger study groups[2] to the exhibit viewing windows was recorded in the baseline condition and the percentage of total sample time they spent < *one meter*, < *three meters*, or > *three meters* of the windows were calculated. Three of the four groups for which this measure was taken spent most of their display time more than three meters from the viewing windows, while the Sumatran orangutan group spent most of their

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[2] Data on proximity to viewing windows was not collected on the polar bear and golden lion tamarin groups because of enclosure designs which either didn't allow for the animals to approach the windows (polar bear) or because the enclosure was small enough that subdividing it was not useful (golden lion tamarins).

time in the middle proximity category, < *three meters* of a viewing window. Figure 3.9 shows the percentage of total sample time each study group spent in proximity of viewing windows in the baseline condition.

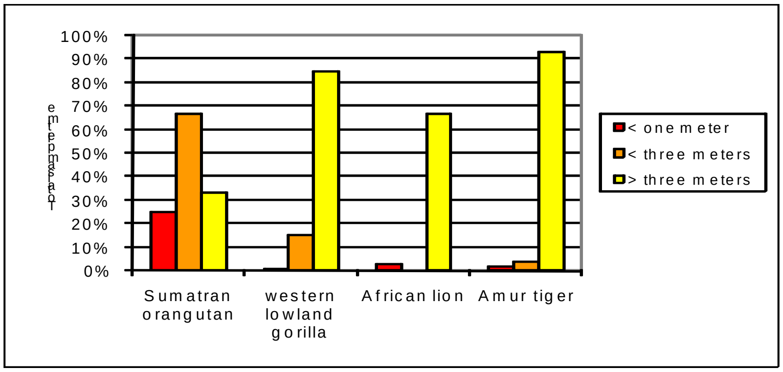

Figure 3.9 The percentage of total sample time that each study group spent in proximity to the visitor viewing windows.

3.7.2 Potential Confounding Variables

Visitor density and visitor noise were hypothesised to be confounding variables in the camouflage net experiment. Randomisation tests were computed to detect changes in the level of visitor density between the baseline and camouflage net conditions for all six study groups. There were no significant changes in the median visitor density level per sample in the camouflage net condition when compared to the baseline condition for any of the study groups, suggesting that visitor density was unlikely to be a contributing factor to the changes observed in animal behaviour in this experiment. Table 3.3 lists the results of the randomisation tests calculated to determine the consistency of visitor density levels between the experimental conditions.

Study Group	Test Statistic	*p* (two-tailed)	n
Sumatran orangutan	-.563	.554	48
Western lowland gorilla	-.376	.555	65
Golden lion tamarin	-.036	1.000	58
Polar bear	.817	.831	60
Amur tiger	.004	.960	53
African lion	-.134	.486	60

Table 3.3 The results of the randomisation tests comparing visitor density between the baseline and the camouflage net conditions.

Randomisation tests were also used to determine if there were significant changes in the levels of visitor noise, measured in decibels, between the baseline and net conditions for the study groups. There was no difference between the median decibel per sample in the baseline when compared to the camouflage net condition. Table 3.4 presents the results of the randomisation test comparing visitor noise levels in the baseline and camouflage net conditions.

Study Group	Test Statistic	*p* (two-tailed)	n
Sumatran orangutan	-4.688	.136	48
Western lowland gorilla	-.052	.950	65
Golden lion tamarin	-1.068	.298	58
Polar bear	.704	.517	46
Amur tiger	-2.539	.771	53
African lion	-5.115	.951	50

Table 3.4 The results of the randomisation tests comparing visitor noise levels between the baseline and net conditions.

The amount of light, in EV, in the golden lion tamarin enclosure in both the baseline and nets condition was 10, suggesting there was little change in the amount of light inside the enclosure following the installation of the camouflage nets.

3.7.3 Camouflage Nets: Changes in Animal Behaviour

Randomisation tests were calculated to compare the frequency and duration of behaviours for the six study species. Animal behaviour was not significantly affected by the installation of the camouflage nets over exhibit viewing windows in any of the study groups. The Sumatran orangutan group spent less time engaged in *social play* following the installation of the camouflage net, but this trend was not statistically significant. Table 3.5 lists the behaviours for which randomisation tests were computed and presents the tests statistics. Figure 3.10 presents the behavioural change observed in the presence of camouflage nets in the Sumatran orangutan group.

Sumatran orangutan BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
< *one meter* (d)	-52.681	.674	34
< *one meter* (f)	-.137	.822	34
< *three meters* (d)	-404.059	.094	49
< *three meters* (f)	-1.441	.091	49
> *three meters* (d)	185.156	.592	24
> *three meters* (f)	.262	.510	24
contact (d)	4.086	.141	31
contact (f)	-.410	.538	31
feed/forage (d)	86.313	.180	69
feed/forage (f)	-.201	.690	69
head-cover (d)	-38.322	.135	17
head-cover (f)	-.342	.499	17
infant care (d)	-4.202	.947	24
infant care (f)	-.112	.951	24
locomote (d)	14.553	.313	54
locomote (f)	-.147	.637	54
monitor visitor area (d)	-6.598	.901	49
monitor visitor area (f)	-.035	.953	49
nest build (f)	-.109	.592	10
proximity (d)	-32.853	.141	50
proximity (f)	-.649	.577	50
rest (d)	43.785	.636	56
rest (f)	-.238	.520	56
scratch (f)	.004	1.001	16
social groom (d)	-26.235	.581	6
social groom (f)	-.235	.592	6
social play (d)	-34.386	.046	16
social play (f)	-.213	.362	16
solitary groom (d)	-5.074	.875	16
solitary groom (f)	-.030	.725	16
solitary play (f)	2.653	.671	11
solitary play (d)	-.042	.583	11

Table 3.5 The results of the randomisation tests for the Sumatran orangutan group in the camouflage net experiment. Trends are shaded. (d)= duration, (f)= frequency.

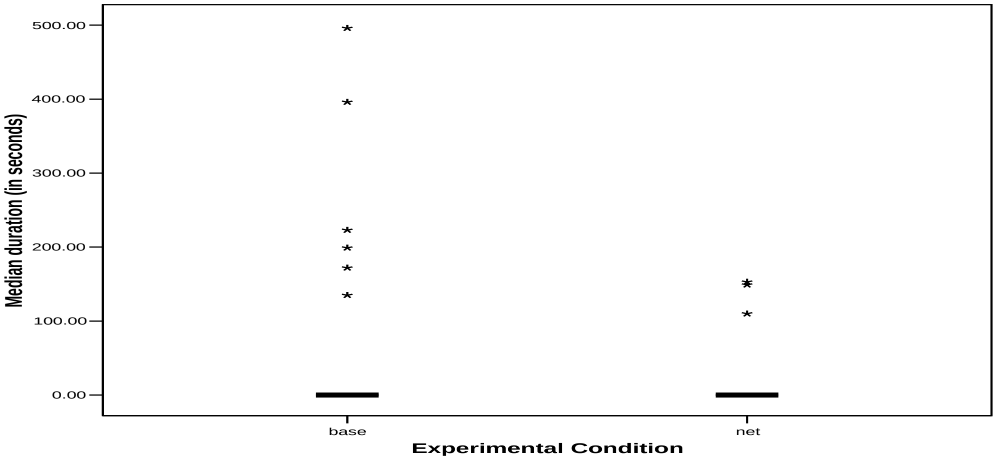

Figure 3.10 The decrease in the median duration of *social play* following the installation of the camouflage nets in the Sumatran orangutan group. Baseline mean proportion: 48, Camouflage net mean proportion: 13.

The behaviour of the western lowland gorilla group did not change significantly from the baseline to the net condition. Table 3.6 lists the randomisation test statistics on the western lowland gorilla group.

Western lowland gorilla BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
< *one meter* (d)	20.176	.137	11
< *one meter* (f)	.305	.141	11
< *three meters* (d)	62.229	.360	45
< *three meters* (f)	.633	.180	45
> *three meters* (d)	-.63.362	.375	74
> *three meters* (f)	.176	.405	74
contact (d)	1.548	.951	18
contact (f)	-.019	.951	18
feed/forage (d)	81.714	.542	128
feed/forage (f)	.305	.280	128
infant care (d)	-11.076	.634	9
infant care (f)	-.071	.452	9
locomote (d)	.086	1.000	69
locomote (f)	-.300	.688	69
monitor visitor area (d)	5.867	.637	124
monitor visitor area (f)	-.262	507	124
proximity (d)	-17.629	.223	64
proximity (f)	-.090	.680	64
regurgitation/reingestion (f)	.467	.368	66
rest (d)	-18.367	.392	90
rest (f)	-.467	.559	90
scratch (f)	-.133	.674	35
social play (d)	-13.538	.488	49

Western lowland gorilla BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
social play (f)	-.024	.873	49
solitary groom (d)	-17.990	.230	20
solitary groom (f)	-.262	.305	20
solitary play (d)	14.776	.126	62
solitary play (f)	.086	.813	62

Table 3.6 The results of the randomisation tests for the western lowland gorilla group in the camouflage net experiment. (d)= duration, (f)= frequency.

There was an increase in the frequency and duration of *feed/forage* in the golden lion tamarin group, but the change was not statistically significant. Table 3.7 presents the results of the randomisation tests in the tamarin group. Figures 3.11 and 3.12 illustrate the behavioural change resulting from the installation of the camouflage nets over the viewing windows of the golden lion tamarin exhibit.

Golden lion tamarin BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
contact (d)	-81.412	.357	38
contact (f)	-.921	.525	38
feed/forage (d)	19.871	.044	115
feed/forage (f)	.517	.044	115
locomote (d)	.350	1.000	233
locomote (f)	-.379	.701	233
monitor visitor area (d)	10.971	.865	328
monitor visitor area (f)	-.645	.512	328
nestbox (d)	-77.548	.287	25
nestbox (f)	-.212	.498	25
proximity (d)	-16.181	.599	32
proximity (f)	-.514	.701	32
rest (d)	-12.500	.445	27
rest (f)	.067	.655	27
scent mark (f)	.102	.790	57
scratch (f)	-.595	.567	167
sniff object (f)	.298	.811	18
social groom (d)	-68.450	.504	43
social groom (f)	-1.226	.302	43
solitary groom (d)	10.621	.136	80
solitary groom (f)	-.181	.656	80
startle (f)	-.012	.859	18

Table 3.7 The results of the randomisation tests for the golden lion tamarin group in the camouflage net experiment. Trends are shaded. (d)= duration, (f)= frequency.

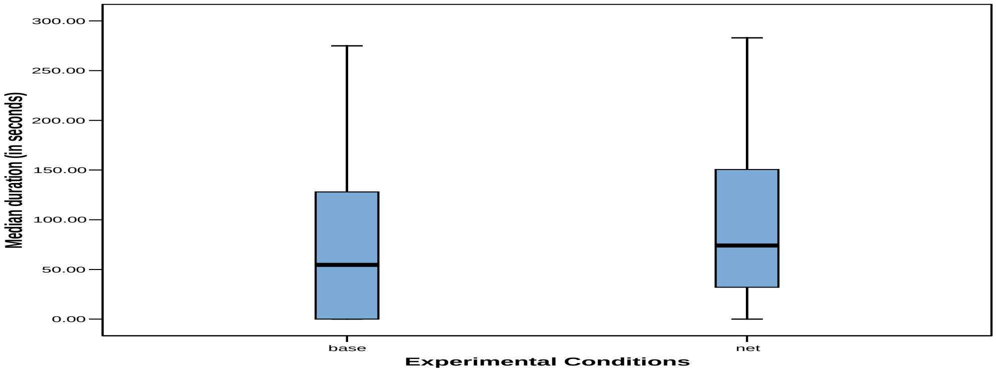

Figure 3.11 The increase in the median duration of *feed/forage* following the installation of the camouflage nets in the golden lion tamarin group.

Figure 3.12 The increase in the median frequency of *feed/forage* following the installation of the camouflage nets in the golden lion tamarin group.

The installation of the camouflage nets over the viewing windows of the polar bear exhibit resulted in an increase in the frequency and duration of the behaviour *swim*, but the change was not significant. The polar bears also spent less time resting following the installation of the nets, but the change did not achieve statistical significance. Table 3.8 lists the behaviours for which randomisation tests were computed and presents the test statistics for the polar bear group. Figures 3.13 and 3.14 show the influence of the camouflage nets on the behaviour of the polar bear group.

Polar bear BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
locomote (d)	54.267	.523	61

Polar bear BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
locomote (f)	.500	.478	61
monitor visitor area (d)	28.667	.301	143
monitor visitor area (f)	-.100	.769	143
proximity (d)	-40.233	.481	26
proximity (f)	.133	.244	26
rest (d)	-130.767	.046	117
rest (f)	-2.033	.535	117
rub (f)	.233	.157	11
sniff air (f)	-1.833	.461	295
sniff object (f)	.267	.748	62
swim (d)	20.133	.049	7
swim (f)	.233	.042	7

Table 3.8 The results of the randomisation tests for the polar bear group in the camouflage net experiment. Trends are shaded. (d)= duration, (f)= frequency.

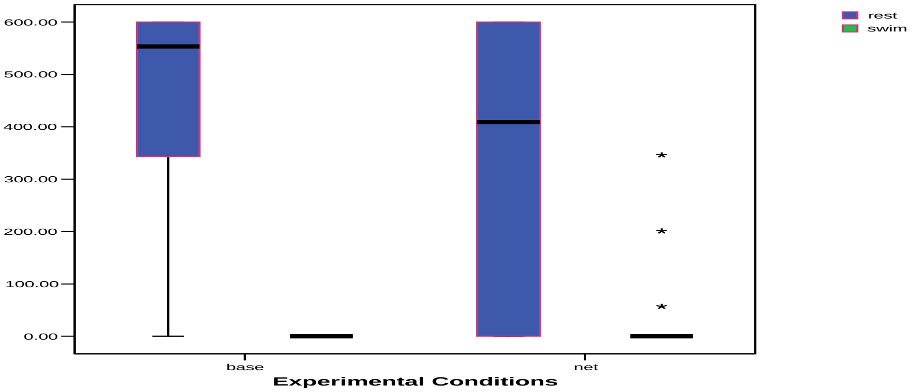

Figure 3.13 The decrease in the median duration (in seconds) of *rest* and the increase in the median duration (in seconds) of *swim* following the installation of the camouflage nets in the polar bear group.

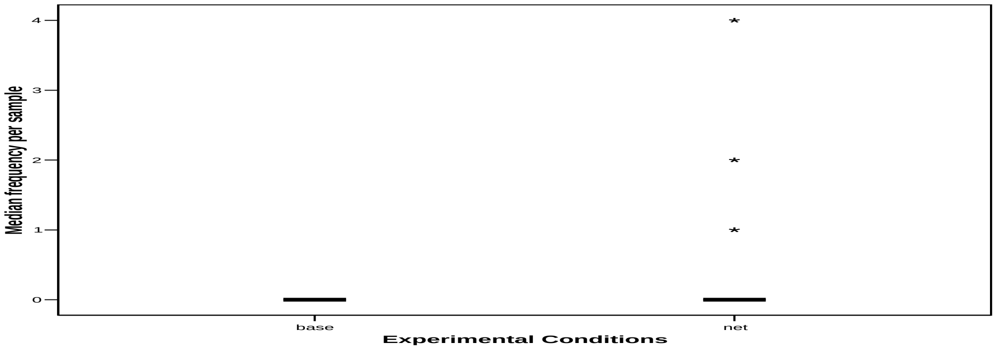

Figure 3.14 The increase in the median frequency per sample of *swim* following the installation of the camouflage nets in the polar bear group. baseline mean proportion= 0, camouflage nets mean proportion= .23.

The behaviour of the Amur tiger was not altered by the presence of the camouflage nets. Table 3.9 lists the behaviours and test statistics for the Amur tiger.

Amur tiger BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
< *one meter* (d)	-7.822	.415	9
< *one meter* (f)	.084	.650	9
< *three meters* (d)	-23.900	.083	20
< *three meters* (f)	.723	.183	29
> *three meters* (d)	-80.397	.470	7
> *three meters* (f)	.439	.091	7
locomote (d)	-2.399	.181	8
locomote (f)	-.036	.905	8
monitor visitor area (d)	-13.242	.333	57
monitor visitor area (f)	-.517	.578	57
moan (f)	.277	.732	47
out of sight (d)	54.210	.375	11
out of sight (f)	.171	.357	11
rest (d)	-84.046	.789	49
rest (f)	-.788	.277	49
sniff air (f)	-.313	.672	14
sniff object (f)	.001	1.000	23
solitary play (d)	-6.036	.638	7
solitary play (f)	-.080	.661	7
solitary groom (d)	-32.596	.421	17
solitary groom (f)	-.413	.453	17
urine mark (f)	.004	1.000	16
vigilance patrol (d)	84.893	.646	84
vigilance patrol (f)	-.188	.265	84

Table 3.9 The results of the randomisation tests for the Amur tiger group in the camouflage net experiment. (d)= duration, (f)= frequency.

The African lion group behaviour was not significantly affected by the installation of camouflage nets over the exhibit viewing windows. Table 3.10 lists the behaviours for which randomisation tests were computed and presents the tests statistics for the African lions.

African Lion BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
contact (d)	57.964	.956	30
contact (f)	.067	.963	30
locomote (d)	15.424	.411	44
locomote (f)	.165	.374	44
monitor visitor area (d)	-13.482	.270	107

African Lion BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
monitor visitor area (f)	-.598	.373	107
out of sight (d)	-102.714	.620	27
out of sight (f)	-.241	.594	27
proximity (d)	-37.254	.776	38
proximity (f)	-.116	.653	38
rest (d)	145.540	.556	104
rest (f)	-.438	.450	104
sniff air (f)	-.152	.629	22
sniff object (f)	.156	.735	10
social groom (d)	-6.116	.277	9
social groom (f)	-.147	.097	9
social play (d)	-1.420	.621	7
social play (f)	-.085	.616	7
solitary groom (d)	-.143	.963	8
solitary groom (f)	-.049	.478	8

Table 3.10 The results of the randomisation tests for African lion group in the camouflage nets experiment. (d)= duration, (f)= frequency.

3.7.4 The Relationship Between Visitor Density and Animal Behaviour in the Camouflage Net Condition

The association between visitor density and animal behaviour in the camouflage net condition was determined using Spearman correlations. The frequency of *locomote* and *monitor visitor area* showed a tendency to be positively associated with visitor density following the installation of the camouflage nets in the orangutans, but was not statistically significant. The duration of < *three meters* and *monitor visitor area* was significantly correlated with visitor density, while other behavioural states that showed trends in their relationship to visitor density, but were not statistically significant, included < *one meter* and *contact*. Table 3.11 lists the behaviours for which Spearman correlations were carried out to determine the relationship between visitor density and behaviour in the Sumatran orangutan group. Figures 3.15-3.22 show the relationship between visitor density and behaviour in the camouflage net condition in the Sumatran orangutan group.

Sumatran orangutan BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *one meter* (d)	.302	.025	-.090	.463
< *three meters* (d)	**.362**	**.007**	.139	.254
< *three meters* (f)	.091	.509	NA	NA
> *three meters* (d)	-.317	.018	.202	.095
> *three meters* (f)	-.141	.305	.155	.203
contact (d)	.294	.029	-.031	.803
feed/forage (d)	.024	.863	.075	.538
feed/forage (f)	.061	.656	.061	.621
locomote (d)	.164	.232	-.185	.128
locomote (f)	.269	.047	.012	.922
***monitor visitor area* (d)**	**.435**	**.001**	.244	.043
monitor visitor area (f)	.289	.032	.132	.280
proximity (d)	.105	.447	-.019	.876
rest (d)	-.038	.783	-.042	.732
rest (f)	.262	.054	.116	.342

Table 3.11 The relationship between visitor density and behaviour in the Sumatran orangutan group. Significant results are in bold; trends are shaded. Net condition: n= 55; Baseline condition: n= 69. (d)= duration, (f)= frequency.

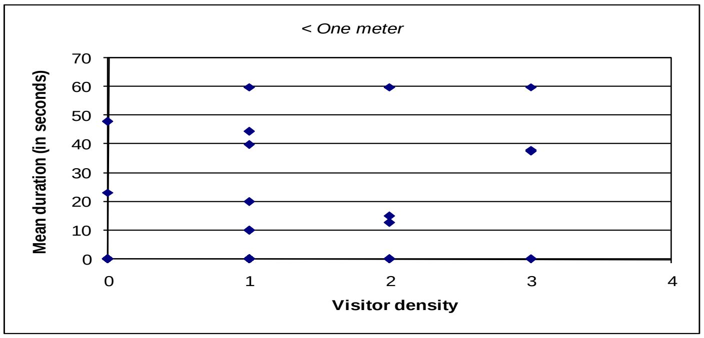

Figure 3.15 The relationship between visitor density and the duration of < *one meter* in the camouflage net condition in the Sumatran orangutan group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

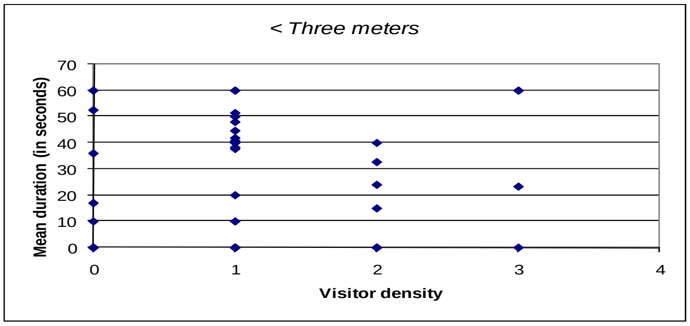

Figure 3.16 The relationship between visitor density and the duration of < *three meters* in the camouflage net condition in the Sumatran orangutan group.

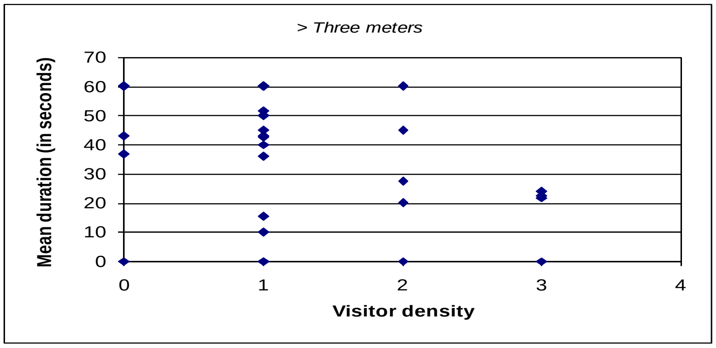

Figure 3.17 The relationship between visitor density and the frequency of > *three meters* in the camouflage net condition in the Sumatran orangutan group.

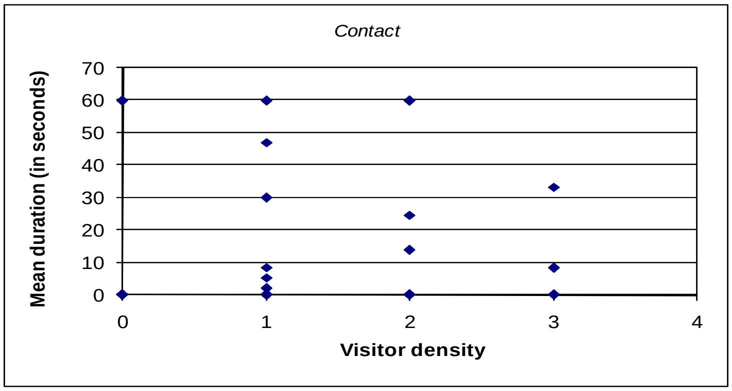

Figure 3.18 The relationship between visitor density and the duration of *contact* in the camouflage net condition in the Sumatran orangutan group.

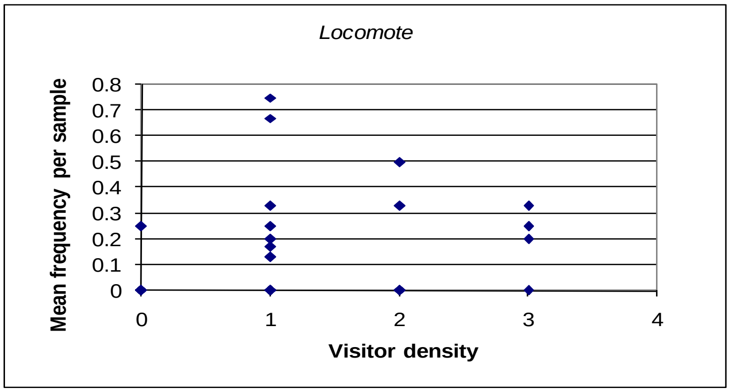

Figure 3.19 The relationship between visitor density and the frequency of *locomote* in the camouflage net condition in the Sumatran orangutan group.

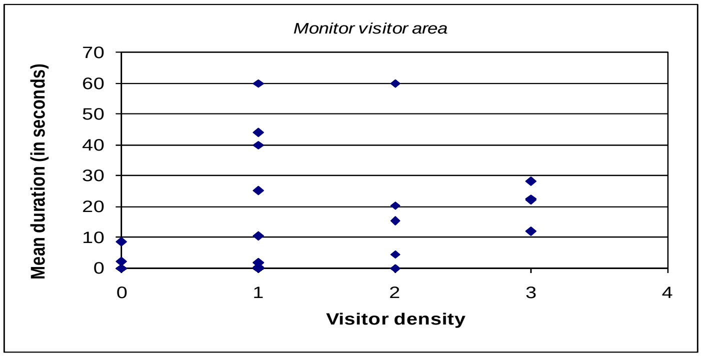

Figure 3.20 The relationship between visitor density and the duration of *monitor visitor area* in the camouflage net condition in the Sumatran orangutan group.

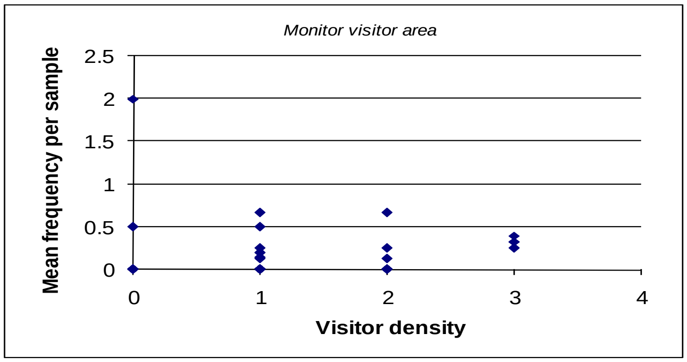

Figure 3.21 The relationship between visitor density and the frequency of *monitor visitor area* in the camouflage net condition in the Sumatran orangutan group.

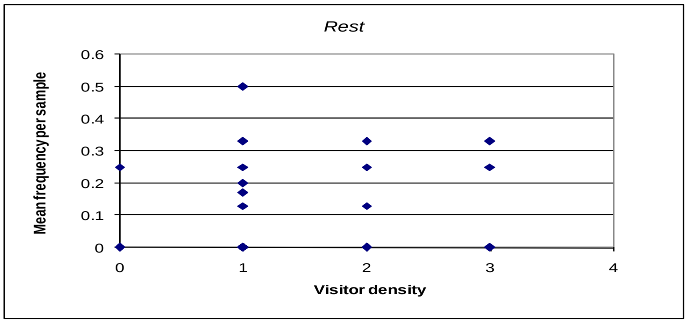

Figure 3.22 The relationship between visitor density and the frequency of *rest* in the camouflage net condition in the Sumatran orangutan group.

The behaviour of the western lowland gorilla group was associated with visitor density in the camouflage net condition. There was a trend toward increased frequency of *regurgitation/reingestion* as visitor density increased, while *locomote* decreased as visitor density increased; neither of these relationships was statistically significant. The duration of *locomote* and < *three meters* decreased significantly as visitor density increased, while the negative association between *proximity* and density was not significant. Table 3.12 lists the behaviours for which Spearman correlations were computed and highlights the significant associations between visitor density and western lowland gorilla behaviour. Figures 3.23-3.27 present the relationship between visitor density and the duration of behaviour in the western lowland gorilla group in the camouflage net condition.

Western lowland gorilla BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *three meters* (d)	**-.348**	**.008**	.155	.230
< *three meters* (f)	-.248	.063	NA	NA
> *three meters* (d)	.198	.134	-.004	.972
> *three meters* (f)	.175	.193	-.082	.524
feed/forage (d)	.176	.191	.109	.400
feed/forage (f)	.086	.526	.100	.441
***locomote* (d)**	**-.378**	**.004**	.007	.955
locomote (f)	-.241	.041	.042	.744
monitor visitor area (d)	.185	.168	.100	.439
monitor visitor area (f)	.129	.340	-.001	.992
proximity (d)	-.320	.015	-.172	.182
proximity (f)	-.231	.084	.037	.773
regurgitation/reingestion (f)	.296	.025	.144	.266
rest (d)	.014	.918	-.001	.996
rest (f)	-.110	.417	.083	.522
scratch self (f)	.027	.841	-.043	.737
social play (d)	-.180	.181	-.079	.542
social play (f)	-.124	.359	-.058	.654
solitary play (d)	-.110	.414	.220	.086
solitary play (f)	-.168	.211	.162	.208

Table 3.12 The relationship between visitor density and behaviour in the western lowland gorilla group. Significant results are in bold; trends are shaded. Net condition: n= 57; Baseline condition: n= 62. (d)= duration, (f)= frequency.

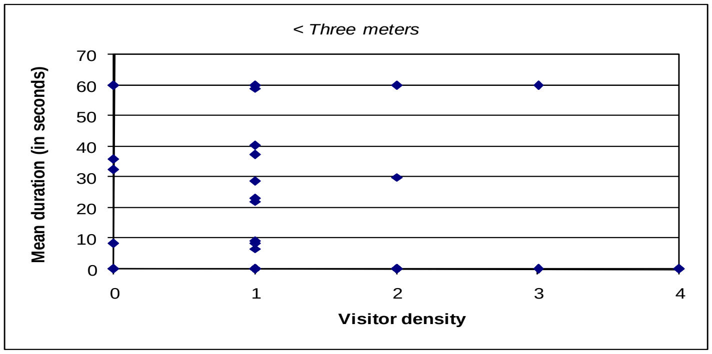

Figure 3.23 The relationship between visitor density and the duration of < *three meters* in the camouflage net condition in the western lowland gorilla group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

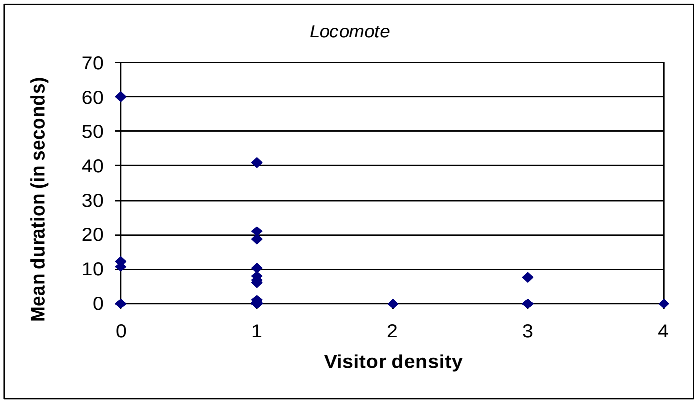

Figure 3.24 The relationship between visitor density and the duration of *locomote* in the camouflage net condition in the western lowland gorilla group.

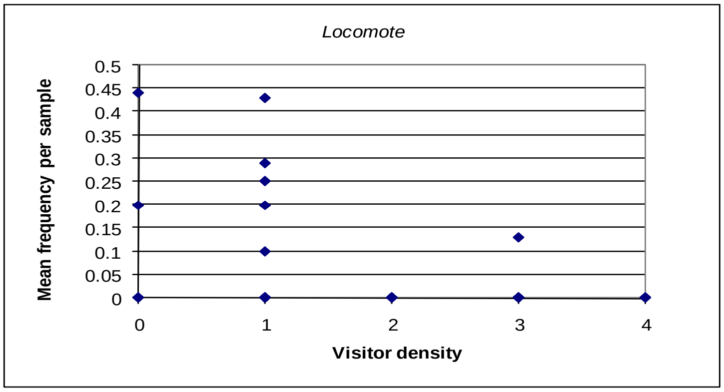

Figure 3.25 The relationship between visitor density and the frequency of *locomote* in the camouflage net condition in the western lowland gorilla group.

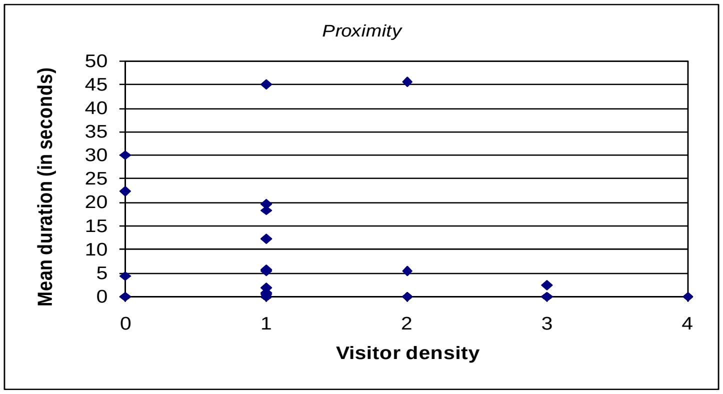

Figure 3.26 The relationship between visitor density and the duration of *proximity* in the camouflage net condition in the western lowland gorilla group.

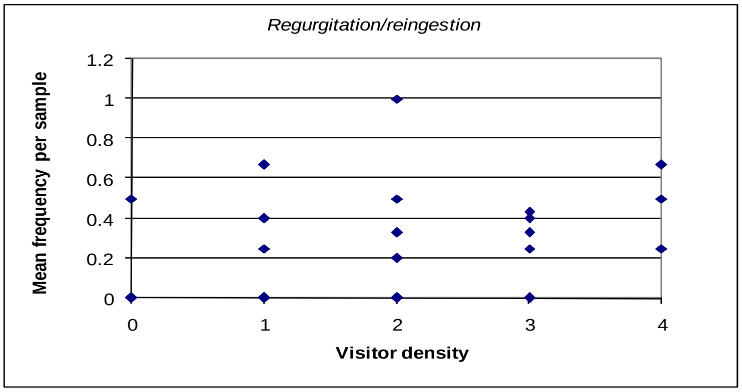

Figure 3.27 The relationship between visitor density and the frequency of *regurgitation/reingestion* in the camouflage net condition in the western lowland gorilla group.

The behaviour of the polar group was not significantly affected by visitor density in the camouflage net condition, but there was a trend for *rest* to decrease as visitor density increased. Table 3.13 lists the behaviours for which Spearman correlations were calculated and presents the results. Figure 3.28 shows the relationship between visitor density and behaviour in the polar bear group in the camouflage net condition.

Polar bear BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
locomote (d)	.111	.440	.042	.722
locomote (f)	-.141	.294	.044	.709

Polar bear BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
monitor visitor area (d)	.040	.783	.188	.112
monitor visitor area (f)	-.068	.614	.254	.030
proximity (d)	.043	.762	.064	.592
rest (d)	-.279	.048	-.200	.090
sniff air (f)	-.082	.542	.127	.284
sniff object (f)	.051	.708	-.116	.327

Table 3.13 The relationship between visitor density and polar bear behaviour. Trends are shaded. Net condition: n= 73; Baseline condition: n= 73. (d)=duration, (f)= frequency.

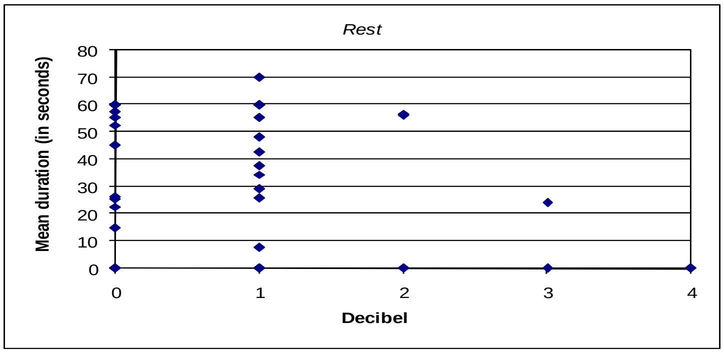

Figure 3.28 The relationship between visitor density and the duration of *rest* in the camouflage net condition in the polar bear group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

The Amur tiger's location within his enclosure was related to visitor density in the camouflage net condition. There was a significant positive correlation between density and > *three meters* proximity to the visitor viewing window. Table 3.14 lists the behaviours for which Spearman correlations were calculated and highlights the significant associations between visitor density and tiger behaviour. Figure 3.29 shows the relationship between visitor density and behaviour in the Amur tiger group in the camouflage net condition.

Amur tiger BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *three meters* (d)	.004	.983	NA	NA
< *three meters* (f)	-.016	.928	NA	NA
> *three meters* (d)	-.027	.875	**.536**	**.001**
> *three meters* (f)	**.471**	**.004**	**.631**	**.001**

Amur tiger BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
monitor visitor area (d)	NA	NA	.005	.971
monitor visitor area (f)	-.070	.687	-.189	.151
moan (f)	.032	.855	-.035	.794
vigilance patrol (d)	-.008	.962	.113	.395
vigilance patrol (f)	.037	.829	-.020	.880

Table 3.14 The relationship between visitor density and Amur tiger behaviour. Significant results are in bold text. Net condition: n= 36; Baseline condition: n= 59 . NA: not occurring frequently enough to run statistical analysis. (d)= duration, (f)= frequency.

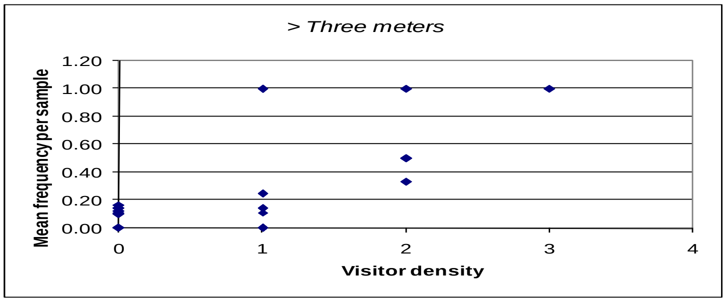

Figure 3.29 The relationship between visitor density and the frequency of > *three* meters in the camouflage net condition in the Amur tiger group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors

The behaviour of the golden lion tamarin and the African lion groups was not affected by visitor density in the camouflage net condition. Tables 3.15 and 3.16 present the results of the Spearman correlations in the golden lion tamarin group and the African lion group.

Golden lion tamarin BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
contact (d)	NA	NA	.005	.975
contact (f)	NA	NA	.088	.541
feed/forage (d)	.067	.687	.132	.356
feed/forage (f)	.054	.703	-.103	.472
locomote (d)	-.098	.551	.142	.320
locomote (f)	.106	.449	.086	.550
monitor visitor area (d)	.264	.105	.201	.158
monitor visitor area (f)	.264	.105	.201	.158
proximity (d)	NA	NA	.105	.465
proximity (f)	NA	NA	.229	.106
rest (d)	-.162	.337	-.314	.025
rest (f)	NA	NA	-.297	.034

Golden lion tamarin BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
scent mark (f)	-.037	.795	-.077	.068
scratch self (f)	-.077	.586	-.258	.068
sniff object (f)	.078	.579	NA	NA
solitary groom (d)	-.203	.216	-.274	.052
***solitary groom* (f)**	-.028	.844	**-.392**	**.004**

Table 3.15 The relationship between visitor density and golden lion tamarin behaviour. Significant results in bold text; trends are shaded. Net condition: n= 53; Baseline condition: n= 51. (d)= duration, (f)= frequency.

African lion BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
> three meters (d)	-.005	.975	-.073	.586
> three meters (f)	-.077	.601	-.016	.904
contact (d)	.022	.882	.049	.712
locomote (d)	.076	.602	.016	.903
locomote (f)	.050	.734	.009	.944
monitor visitor area (d)	.240	.097	.173	.194
monitor visitor area (f)	.166	.254	.131	.333
proximity (d)	.046	.756	-.052	.696
proximity (f)	.175	.229	-.006	.963
rest (d)	.048	.743	-.090	.501
rest (f)	.152	.297	-.032	.816
sniff air (f)	NA	NA	-.029	.832

Table 3.16 The relationship between visitor density and African lion behaviour. Net condition: n= 49; Baseline condition: n= 57. (d)= duration, (f)= frequency.

3.7.5 The Relationship Between Visitor Noise and Animal Behaviour in the Camouflage Net Condition

The relationship between visitor noise and the mean frequency per sample and the mean duration of behaviour was determined by calculating Spearman correlations. The frequency and duration of *locomote* was significantly negatively associated with visitor noise, while there was a significant positive relationship between noise and the frequency of > *three meters*. The data also showed a tendency for *monitor visitor area* to increase as visitor noise increased and a tendency for *rest* to decrease as noise increased, but these relationships were not statistically significant. Table 3.17 lists the behaviours for which Spearman correlations were calculated and highlights the significant relationship between visitor noise and western lowland gorilla behaviour. Figures 3.30-3.34 present the association between visitor noise and the duration of western lowland gorilla behaviour in the camouflage net condition.

Western lowland gorilla BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *one meter* (d)	-.002	.985	NA	NA
< *three meters* (d)	.066	.439	-.013	.884
< *three meters* (f)	-.110	.197	NA	NA
> *three meters* (d)	-.039	.651	.012	.892
> *three meters* (f)	**.352**	**.001**	.076	.374
feed/forage (d)	.152	.072	.160	.061
feed/forage (f)	-.038	.656	-.061	.478
***locomote* (d)**	**-.351**	**.001**	-.049	.569
***locomote* (f)**	**-.287**	**.001**	-.106	.215
monitor visitor area (d)	.192	.023	.074	.389
monitor visitor area (f)	.127	.134	-.031	.715
proximity (d)	-.145	.088	.051	.554
proximity (f)	-.088	.304	.060	.483
regurgitation/reingestion (f)	.137	.107	-.008	.927
rest (d)	-.045	.597	.065	.446
rest (f)	-.212	.012	.055	.523
scratch self (f)	-.053	.538	-.101	.239
***social play* (d)**	-.083	.327	**-.283**	**.001**
***social play* (f)**	.019	.826	**-.228**	**.007**
solitary play (d)	-.053	.530	-.128	.135
solitary play (f)	-.060	.479	-.131	.125

Table 3.17 The relationship between visitor noise and western lowland gorilla behaviour. Significant results in bold text; trends are shaded. Net condition: n= 140; Baseline condition n= 138. (d)= duration, (f)= frequency.

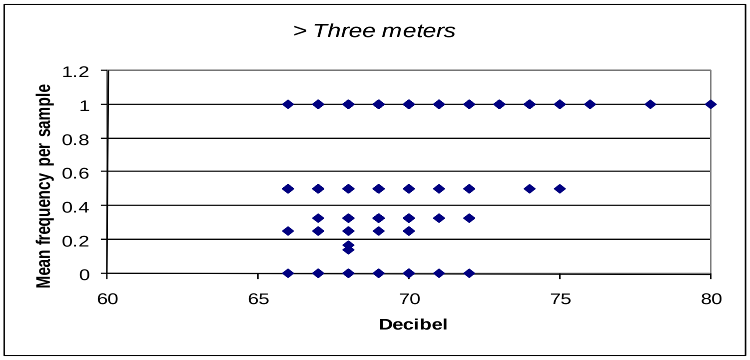

Figure 3.30 The relationship between visitor noise and the frequency of > *three meters* in the camouflage net condition in the western lowland gorilla group.

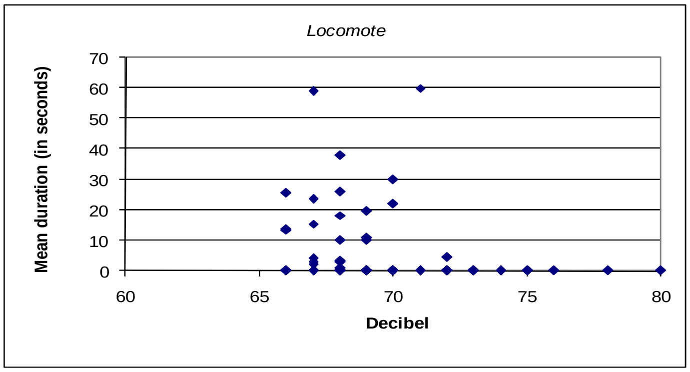

Figure 3.31 The relationship between visitor noise and the duration of *locomote* in the camouflage net condition in the western lowland gorilla group.

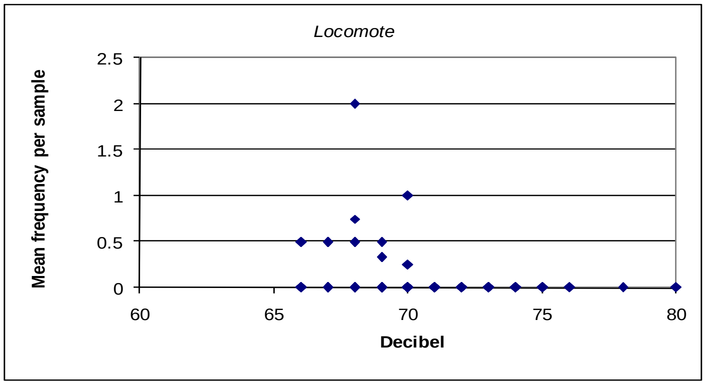

Figure 3.32 The relationship between visitor noise and the frequency of *locomote* in the camouflage net condition in the western lowland gorilla group.

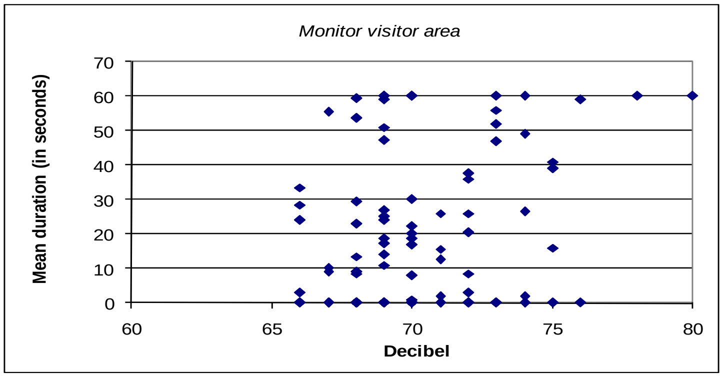

Figure 3.33 The relationship between visitor noise and the duration of *monitor visitor area* in the camouflage net condition in the western lowland gorilla group.

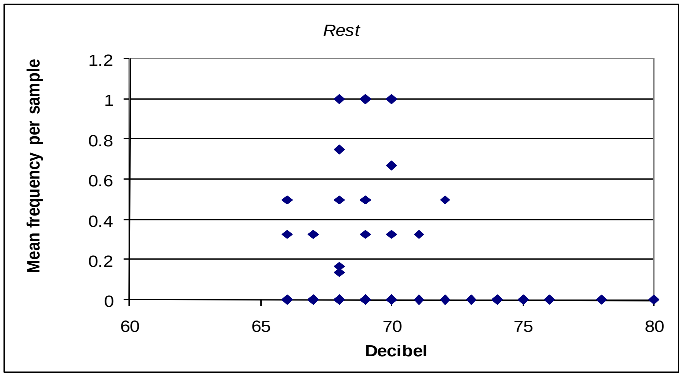

Figure 3.34 The relationship between visitor noise and the frequency of *rest* in the camouflage net condition in the western lowland gorilla group.

The behaviour of the polar bear group was associated with visitor noise in the camouflage net condition. The duration of the behaviour *rest* decreased significantly as visitor noise increased in the camouflage net condition. Table 3.18 lists the behaviours for which Spearman correlations were calculated and highlights the significant relationship between visitor noise and polar bear behaviour. Figure 3.35 shows the relationship between visitor noise and polar bear behaviour.

Polar bear BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
locomote (d)	.167	.223	-.076	.352
monitor visitor area (d)	-.026	.852	.090	.268
monitor visitor area (f)	-.134	.269	.029	.721
***rest* (d)**	**-.358**	**.007**	.029	.720
sniff air (f)	-.036	.766	.116	.155
***sniff object* (f)**	NA	NA	**-.243**	**.002**

Table 3.18 The relationship between visitor noise and polar bear behaviour. Significant results in bold text. Net condition (f): n= 70, (d) n= 55; Baseline: n= 152. NA= not occurring frequently enough to run statistical analysis. (d)= duration, (f)= frequency.

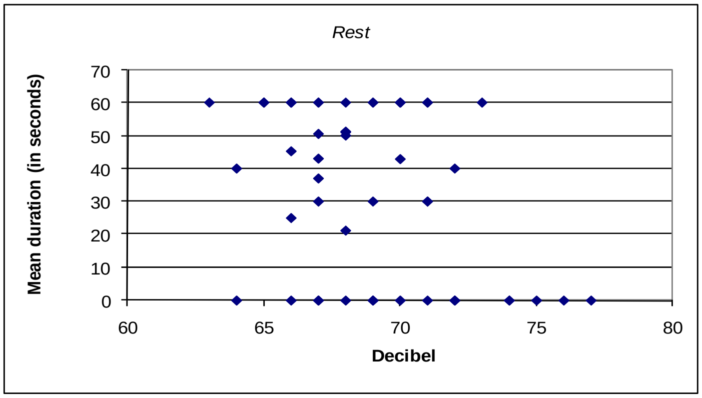

Figure 3.35 The relationship between visitor noise and the duration of *rest* in the camouflage net condition in the polar bear group.

The duration of > *three meters* proximity to a viewing window and *vigilance patrol* decreased significantly as visitor noise increased in the tiger group. Table 3.19 lists the behaviours for which Spearman correlations were calculated and highlights the significant associations between visitor noise and Amur tiger behaviour. Figures 3.36 and 3.37 illustrate the relationship between visitor noise and Amur tiger behaviour.

Amur tiger BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *three meters* (d)	.070	.521	NA	NA
< *three meters* (f)	.090	.405	NA	NA
> *three meters* (d)	**-.346**	**.001**	.206	.021
> *three meters* (f)	.081	.456	**.238**	**.008**
monitor visitor area (d)	.037	.735	.044	.627
monitor visitor area (f)	.049	.653	-.005	.958
moan vocalisation (f)	.123	.257	NA	NA
solitary groom (d)	NA	NA	.182	.042
***vigilance patrol* (d)**	**-.429**	**.001**	.009	.918
vigilance patrol (f)	.198	.065	.090	.316

Table 3.19 The relationship between visitor noise and Amur tiger behaviour. Significant results are in bold text; trends are shaded. Net condition: n= 87; Baseline condition: n= 125. NA: not occurring frequently enough to run statistical analysis. (d)= duration, (f)= frequency.

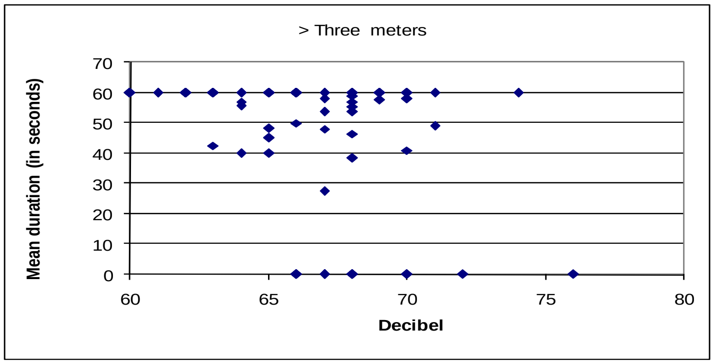

Figure 3.36 The relationship between visitor noise and the duration of > *three meters* in camouflage net condition in the Amur tiger group.

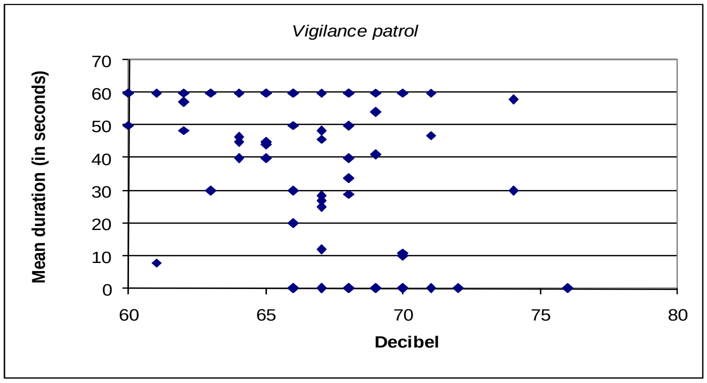

Figure 3.37 The relationship between visitor noise and the duration of *vigilance patrol* in the camouflage net condition in the Amur tiger group.

There was a significant correlation between visitor noise and the location of the orangutans within the enclosure. The orangutans were more frequently > *three meters* from the viewing windows when visitors were noisy. Table 3.20 lists the behaviours for which Spearman correlations were calculated and highlights the significant associations between visitor noise and orangutan behaviour. Figure 3.38 illustrates the relationship between visitor noise and orangutan behaviour.

Sumatran orangutan BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
< *one meter* (d)	.017	.868	.004	.963
< *three meters* (d)	.002	.985	.176	.057
< *three meters* (f)	NA	NA	-.045	.627
> *three meters* (d)	.017	.872	.206	.021
> *three meters* (f)	**.267**	**.010**	**.238**	**.008**
contact (d)	.068	.515	.067	.475
contact (f)	NA	NA	.134	.150
feed/forage (d)	-.003	.976	-.045	.632
feed/forage (f)	-.053	.616	-.071	.449
locomote (d)	-.135	.197	-.099	.290
locomote (f)	-.158	.131	.004	.965
monitor visitor area (d)	.185	.076	-025	.786
monitor visitor area (f)	.174	.095	.075	.421
proximity (d)	.087	.407	-.016	.816
proximity (f)	NA	NA	.087	.350
rest (d)	.005	.960	-.167	.072
rest (f)	.027	.798	.028	.766
***social groom* (d)**	NA	NA	**.284**	**.002**

Table 3.20 The relationship between visitor noise and behaviour in the Sumatran orangutan group. Significant results are in bold text; trends are shaded. Net condition: n= 93; Baseline condition: n= 117. (d)= duration, (f)= frequency.

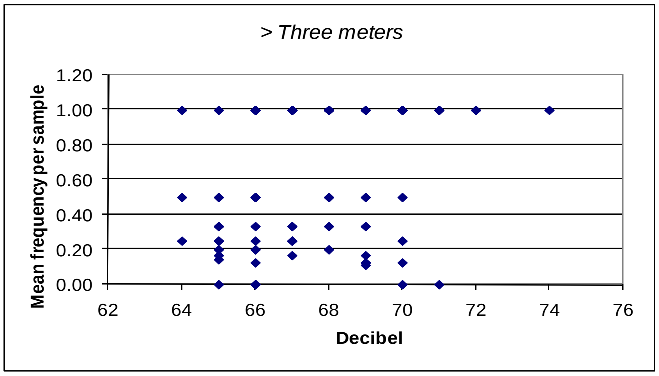

Figure 3.38 The relationship between visitor noise and the frequency of > *three meters* in the Sumatran orangutan group.

African lion behaviour was not significantly affected by visitor noise in the camouflage net condition, but there was a trend toward the the lions to be more frequently located > *three meters* from a visitor viewing window when the public was noisy. Table 3.21 lists the results of the correlations between visitor noise and lion behaviour. Figure 3.39 shows the relationship between noise and > *three meters* in the African lion group.

African lion BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
> *three meters* (d)	.254	.113	.063	.423
> *three meters* (f)	.229	.027	-.009	.911
contact (d)	-.272	.090	-.066	.401
locomote (d)	-.130	.423	-.018	.818
locomote (f)	-.055	.604	-.019	.810
***monitor visitor area* (d)**	.143	.380	**.207**	**.008**
monitor visitor area (f)	.089	.394	.059	.452
out of sight (d)	NA	NA	.014	.862
proximity (d)	.288	.072	.001	.998
proximity (f)	NA	NA	.052	.502
rest (d)	.272	.089	-.150	.054
rest (f)	NA	NA	.097	.211
sniff air (f)	NA	NA	.056	.476

Table 3.21 The relationship between visitor noise and African lion behaviour. Significant results are in bold text; trends are shaded. Net condition: (f) n= 93, (d) n= 40; Baseline condition: n= 166. (d)= duration, (f)= frequency.

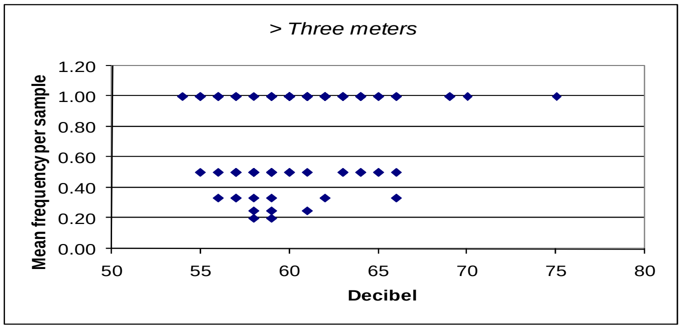

Figure 3.39 The relationship between visitor noise and the frequency of > *three meters* in the camouflage net condition in the African lion group.

There was no significant relationship between visitor noise and the frequency per sample or the duration of the behaviours listed in Table 3.22 for the tamarin group in the camouflage net condition.

Golden lion tamarin BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
contact (d)	NA	NA	-.188	.100
contact (f)	NA	NA	.137	.189
feed/forage (d)	.179	.147	-.068	.551

Golden lion tamarin BEHAVIOUR	Camouflage Net Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
feed/forage (f)	.103	.326	-.063	.549
locomote (d)	.193	.118	.052	.652
locomote (f)	.103	.324	.061	.563
monitor visitor area (d)	-.143	.248	.209	.067
monitor visitor area (f)	.094	.371	.020	.849
nestbox (d)	NA	NA	-.187	.102
proximity (d)	NA	NA	.071	.535
proximity (f)	NA	NA	-.039	.709
rest (d)	.130	.295	-.133	.244
rest (f)	.003	.977	-.039	.709
scent mark (f)	.006	.954	-.034	.748
scratch self (f)	.184	.078	-.061	.562
sniff object (f)	-.068	.518	NA	NA
solitary groom (d)	-.044	.723	-.037	.749
solitary groom (f)	-.012	.912	-.040	.706

Table 3.22 The relationship between visitor noise and golden lion tamarin behaviour. Net condition: (f) n= 93, (d) n= 67; Baseline condition: n= 78 . (d)= duration, (f)= frequency.

3.7.6 Changes in Visitor Behaviour

The hypothesis that visitor behaviours such as vocalisations and banging on the viewing windows of the study group exhibits would decrease following the installation of camouflage nets was tested using randomisation tests. Of the five exhibits where visitors hitting windows occurred frequently enough to warrant a statistical test, the frequency per sample of the behaviour *visitors hit window* was not significantly affected by the presence of the camouflage nets. The frequency of the behaviour *visitors mimic vocalisation* was also not significantly different in the net condition for the study groups. Table 3.23 lists the visitor behaviours analysed and the results of the randomisation tests comparing visitor behaviour between baseline and camouflage net conditions.

Species	Visitor Behaviour	Test Statistic	*p* (two-tailed)	n
Sumatran orangutan	*visitors mimic vocalisation* (f)	-.294	.338	10
	visitors hit window (f)	-.200	.774	7
Western lowland gorilla	*visitors mimic vocalisation* (f)	-.448	.534	8
	visitors hit window (f)	-.043	.630	20

Species	Visitor Behaviour	Test Statistic	*p* (two-tailed)	n
Polar bear	*visitors hit window* (f)	-.267	.293	8
Amur tiger	*visitors mimic vocalisation* (f)	.281	.051	10
African lion	*visitors mimic vocalisation* (f)	-.121	.654	36

Table 3.23 The results of randomisations tests comparing visitor behaviour between the baseline and net conditions at five of the study group exhibits.

3.8 Discussion

3.8.1 Visitor Density/Noise and Light Are Not Confounding Variables

The data suggest that visitor density and noise did not change significantly between the baseline and experimental condition and reduces the likelihood of fluctuations in these variables contributing to the observed changes in animal behaviour. As previously stated, providing data on the levels of visitor-related variables between experimental conditions is helpful when making claims about moderating the visitor effect with visual barriers and should become routine among visitor effect researchers. The camouflage nets did not reduce the amount of light entering the golden lion tamarin enclosure, suggesting decreased light levels were not an issue in this experiment.

3.8.2 Behavioural Changes Following the Introduction of the Camouflage Nets

The lack of influence of the camouflage nets on the rate and duration of behaviour in the primate groups was not predicted. Based on the visitor effect literature, one would predict that reducing the visual stimuli of visitors would be beneficial to primates, but this did not appear to be the case. The effect of the camouflage nets was not extensive in terms of the number of behaviours affected, and these results were unexpected given the enriching effect of the nets on gorillas observed by Blaney and Wells (2004).

The trend toward decreased social grooming following the installation of the camouflage net in the Sumatran orangutan group was not predicted by previous visitor effect research on orangutans which identified negative effects of visitor density and noise, such as increased use of sacks to block out stimuli and increased approaching and holding of adults by infants (Birke 2002). Decreased social grooming is detrimental to social cohesion, an important ingredient in successfully housing a species that is often solitary in the wild but socially-housed in captivity. It was particularly important to encourage affiliative interaction in the Toronto Zoo group of orangutans because composition of the display group varied daily depending on which male was scheduled to be on exhibit.

The lack of influence of the camouflage nets on the behaviour of the western lowland gorilla group in this study was not consistent with the results obtained by Blaney and Wells (2004) in which they identified a positive effect of the camouflage net on stereotypical behaviour and intragroup aggression. The Toronto Zoo gorilla group did not exhibit any aggression during data collection; only one female engaged in an abnormal behaviour, regurgitation and reingestion of food, the absolute rate of which was not affected by the presence of the camouflage nets. Based on these two study groups, it appears that camouflage nets may be helpful in reducing aggression and stereotypies that are visitor-related, but may not have benefits for gorillas whose welfare is not extensively compromised by visitor pressure.

Like the orangutan group, the golden lion tamarin group's behaviour was not affected extensively by the installation of the camouflage nets. The trend toward increased feeding and foraging and its implications for the Toronto Zoo group's welfare, in the absence of other behavioural changes, is open to interpretation, but the result contradicts previous research. Waitt and Buchanan-Smith (1999) identified decreased feeding and foraging in laboratory-housed stumped-tailed macaques when their view of human activity within the laboratory was blocked with a wooden screen. Wood (1998) reported lower frequencies of foraging in chimpanzees in the presence of high density visitor crowds, which indicates increased foraging could be a sign of visitor influence.

The behavioural changes observed in the polar bear group following the installation of the camouflage nets over the visitor viewing windows, although not statistically significant, were indicative of an enriched environment and suggest that external visual barriers such as camouflage nets may be helpful in moderating the visitor effect in zoo polar bears. The tendency toward increased in swimming and decreased resting are particularly promising results in light of the high level of polar bear inactivity which, while not reflective of wild polar bear behaviour, is typical of the zoo population. Wide-ranging carnivores, such as polar bears, are particularly difficult to maintain to an acceptable standard of welfare in captive environments (Clubb and Mason 2003) and, therefore, enclosure modifications that encourage active non-stereotypic behaviours may be helpful in reducing the stress of captivity and preventing behavioural problems.

Although the result of the camouflage net experiment was positive for the polar bear group, it should be noted that the trend toward increased swimming following the installation of the camouflage nets may be related to the design of the exhibit. The study groups' swimming pool ran the length of the front of the enclosure and was overlooked by a wall of waist-high concrete topped with viewing glass and this proximity of the pool to visitors may have contributed to the polar bears' disinterest in swimming. It is conceivable that camouflage nets installed on an enclosure with a swimming pool located on the side or the back of an enclosure may not increase swimming behaviour. However, it is also worth pointing out that several polar bear enclosures in the United States, such as San Diego Zoo, have a similar design (viewing windows above or level with swimming pools), so even if the camouflage nets are only successful in moderating the visitor effect in these types of enclosures, there are a number of polar bears that could potentially benefit from this technique. The results of the camouflage net experiment on polar bears also indicate that the degree of exposure of swimming pools to visitor viewing areas should be considered during the design phase of zoo enclosures.

The two felid groups were unaffected by the installation of the camouflage nets, a result that was predicted by the lack of a visitor effect in the lion (*Panthera leo*), Amur tiger (*Panthera tigris altaica*), Amur leopard (*Panthera pardus orientalis*), snow leopard (*Panthera unica*), clouded leopard (*Neofelis nebulosa*) and the fishing cat (*Felis viverrinus*) studied by Margulis (2003). Other researchers have documented a visitor effect in zoo felids, and found increased inactivity in Indian leopards (*Panthera pardus*) in the presence of zoo visitors (Mallapur and Chellam 2002) while jaguars increased the time spent out of sight of the public when visitor density was high (Sellinger and Ha 2005). Cunningham

(2004) identified behavioural changes in several of her study cats following the installation of a visual barrier, including changes in resting and decreased alertness, which suggests that body size may be a factor in the visitor effect in zoo felids.

3.8.3 The Effect of Visitor Density in the Camouflage Net Condition

Unlike Cunningham's camouflage net experiment on felids (2004), the camouflage nets affected the relationship between visitor density and animal behaviour in several of the primate study groups. The influence of the camouflage net on the relationship between visitor density and Sumatran orangutan behaviour was more extensive than in the baseline condition, although most of the associations were not statistically significant, and these trends may have both negative and positive welfare implications for the group. The behaviour of the Toronto Zoo orangutans after the installation of the nets shows that the group tended to be located differently within the enclosure when visitor numbers were high, spending more time closer to the windows in times of high visitor density than they did without the net barrier in place. The orangutans also spent more time in physical contact with other group members, an indication that the orangutans may have experienced the pressure of high visitor density less with the nets in place.

While the orangutans showed behavioural trends that were consistent with improved welfare during the net condition, the camouflage nets also had an undesirable effect on their behaviour. The nets were not successful in moderating the trend in the relationship between density and the amount of time the apes spent monitoring visitor areas, a sign of visitor density influence (Chamove et al 1988, Birke 2002, Cooke and Schillaci 2007). The orangutans also tended to locomote more following the net installation, a result of active visitors' influence reported by Hosey and Druck (1987) and Mitchell et al (1992b).

The camouflage nets moderated the visitor density effect in the golden lion tamarin group, with a more positive impact on study group welfare than was observed in the Sumatran orangutan group. The trend toward a negative relationship between resting and the number of visitors reported in the baseline condition was moderated once the nets had been installed. Routine husbandry practices have been linked to decreased inactivity post-stressor in laboratory-housed common marmosets (*Callithrix jacchus*) by Bassett et al (2003), which suggests that a decrease in inactivity in callitrichids may be a sign of stress. The negative relationship between visitor density and solitary grooming in the baseline was also no longer significant in the net condition. Decreased grooming in primates in the presence of the public have been reported by Chamove et al (1988), Wood (1998), and Cooke and Schillaci (2007).

The camouflage net barrier had a moderating effect on the relationship between visitor density and polar bear behaviour. The trend toward a positive relationship between visitor density and monitoring visitor areas identified in the baseline condition was eradicated in the net condition, suggesting the bears were less alert to high numbers of visitors. The polar bears also tended to rest for shorter durations when in the presence of a number of visitors in the camouflage net condition, which, as stated previously, may have positive welfare implications for wide-ranging carnivores in captivity.

The nets moderated the visitor effect in the Amur tiger, but the association between the tiger's increased tendency to be at least three meters from the viewing window when visitor numbers were high was still significant, although the effect was smaller after the nets were installed. Differential use of enclosure space has been associated with a visitor effect in primates, including an eastern lowland gorilla (*Gorilla gorilla graueri*: Vrancken et al 1990) and in lion-tailed macaques (*Macaca silenus*: Mallapur et al 2005).

The influence of the camouflage nets on the relationship between visitor density and western lowland gorilla behaviour suggests the barrier introduced a visitor effect in the group when high numbers of visitors were present. While there was no significant correlation between visitor density and gorilla behaviour in the baseline condition, following the introduction of the nets, the gorillas showed a trend toward increased regurgitation and reingestion of food when visitor density increased. Locomotion decreased significantly and there was a trend toward decreased proximity to the viewing windows and other group members. While increased locomotory behaviour in primates has been identified in the presence of active zoo visitors (Hosey and Druck 1987, Mitchell et al 1992b), decreased locomotory behaviour may not be a positive outcome of reducing the visitor effect for some apes. Western lowland gorillas tend to be more sedentary in captivity than is optimal for their health and well-being, and environmental modifications, such as the camouflage nets, that reduce the visitor effect but decrease activity may simply be exchanging one animal welfare problem for another. The overall pattern of behaviour in association with visitor density suggests that visual barriers may increase visitor pressure on some gorillas in times of high visitor numbers.

3.8.4 The Effect of Visitor Noise in the Camouflage Net Condition

The impact of the camouflage nets on the relationship between visitor noise and animal behaviour was also a mix of negative, neutral, and positive visitor effects across the species groups. The influence of the camouflage nets on the association between visitor noise and the rate of Sumatran orangutan behaviour had both positive and negative implications for the welfare of the group. While the nets contributed to a moderation in the trend toward increased time spent more than three meters from a viewing window when visitors were noisy, the nets did not affect the significant relationship between noise and the frequency of being more than three meters from the windows. Although the presence of the nets made orangutan location less dependent on the levels of visitor noise, the nets also moderated the enriching association between high levels of noise and social grooming. Decreased grooming in primates is associated with visitor pressure (Hosey and Druck 1987, Wood 1998, Cooke and Schillaci 2007) and the presence of the nets resulted in a more typical negative visitor effect in the orangutans.

The effect of the camouflage nets on the relationship between visitor noise and gorilla behaviour is a mix of positive and negative changes that could impact the welfare of the group. The installation of the nets removed the significant negative correlation between noisy visitors and social play, a sign that suggests the two youngest members of the group felt less visitor pressure with the nets in place. Visitor noise has been shown to affect the behaviour of young orangutans by increasing the approach and holding behaviours they exhibit towards adult group members (Birke 2002). Like the orangutans in Birke's study, the Toronto Zoo gorillas also spent more time monitoring visitor areas when people were noisier, although this association was not statistically significant. The trend toward a negative correlation between visitor noise and resting suggests that visitor noise can have a stimulating effect on gorillas, while the significant decrease in locomotory behaviour and significant increase in the distance between the gorillas and the viewing windows when the public was noisy indicate the group moved less freely around the enclosure in the presence of loud visitors.

Following the installation of the nets, the Amur tiger spent less time patrolling his enclosure and was less frequently > *three meters* away from the viewing window when visitors were noisy. These behavioural changes suggest the camouflage nets may have helped the tiger cope with visitor noise. The tiger spent more than half his time engaged in vigilance patrols, in part monitoring the activities of zoo staff on the access road that abutted his enclosure, but these results suggest visitor noise also affected his level of attentiveness to his environment.

The camouflage nets moderated the influence of visitor noise on the African lion group monitoring of visitors in the baseline condition, although a trend for the lions to be more frequently distant from the viewing windows when visitors were noisy following the installation of the nets was identified. While the lions may have been less alert to visitors making noise when the visual stimuli was buffered, the tendency toward decreased proximity to viewing windows when visitors were noisy in the net condition suggests visitor noise still impacted lion use of the enclosure space.

The influence of the camouflage nets on the association between visitor noise and polar bear behaviour resulted in a positive change in the group. Following the installation of the camouflage nets, the bears spent less time resting when visitors were noisy. As previously stated, an enclosure modification that fosters increased activity in large carnivores that tend to be sedentary in captivity suggests the technique could be useful in improving the welfare of the species and should be tested with a larger sample size.

3.8.5 Visitor Behaviour in the Camouflage Net Condition

The anecdotal claims by Norcup (2000) and Blaney and Wells (2004) that visitor noise decreased in the camouflage net condition are not supported by the results of this study. The median decibel level did not decrease between the baseline and barrier condition for the six study groups, suggesting the camouflage net does not encourage visitors to behave more quietly. The other visitor behaviours analysed, visitors making animal-like vocalisations and visitors hitting or kicking viewing windows, were unaffected by the installation of the camouflage nets.

Visitor comments regarding the camouflage nets generally reflected their frustration with not having a clear view of the animals, but quantitative data on visitor perception was not collected. Further evidence of visitor dislike of the nets was shown on several occasions in which visitors lifted the camouflage nets or ripped them to get a better view of the animals. Contrastingly, visitors' perceptions of the camouflage nets in the Blaney and Wells study were positive, which perhaps may be related to some unknown visitor variable such as age, enclosure design (ratio of viewing windows to moat viewing), cultural difference (Canadians versus Northern Irish), their personal opinion of zoo animal welfare, or the presence of the researcher conducting the survey.

3.9 **Part II.** Privacy Screens: Can Internal Visual Barriers Moderate the Visitor Effect?

The second visual barrier experiment was conducted on the golden lion tamarins, but this time using an internal visual barrier between the display animals and the visitors. Internal visual barriers have been used in laboratories and research colonies to provide a social buffer between animals or animals and humans, but their effectiveness as a visual buffer between visitors and animals has not been tested in the zoo environment. This experiment tests the use of an internal visual barrier as a technique to moderate the visitor effect and assesses the results with reference to zoo primate welfare.

3.10 Introduction

The need to provide cover to display animals is acknowledged by contemporary zoo architects and zoo management. Many naturalistic enclosures were designed to provide areas of cover from visitors and conspecifics through horticultural plantings but, over time, animal use or plant decay thins vegetation until it no longer provides a visual barrier. More substantial internal visual barriers such as caves, large boulders, and walls are common in zoos, but require explicit design consideration for new enclosures or structural modifications to add these features to existing enclosures. The paucity of visual barrier research in the context of visitor effect studies may explain the lack of cover for some zoo animals, for without the research to back up the hypothesis that cover from visitors is effective, visual barriers may not be high on the list of priorities for zoo management and keepers. Clearly, there is a need to test the effectiveness of internal visual barriers so that zoos can make informed decisions when installing or maintaining vegetation, boulders, wood/textile screens, or architectural structures.

Like external visual barriers, internal visual barriers are not without their own set of potential drawbacks and benefits. Internal visual barriers are probably more practical for large enclosures with expansive viewing areas because they 1) do not block out all external stimuli 2) require less barrier material because only a small area needs to restricted from view 3) do not block all visitor viewing opportunities. However, internal barriers may be more difficult to install securely enough to withstand the use and abuse by large mammals such as the great apes, elephants, and large felids. For these strong animals, or animals who have a sufficient degree of manual dexterity to manipulate the “furniture” of their enclosures, particular care needs to be taken in testing potential cover techniques. However, for smaller or less dexterous animals, the selection of potential cover material is wider. These sorts of practical concerns influenced the selection of the study group for this experiment; a small species of monkey was hypothesised to be less likely to disassemble an easily installed textile screen and would, based on the previous visitor effect literature suggesting that small arboreal primates exhibited a greater visitor effect than large terrestrial primates (Chamove et al 1988), be one of the species most likely to benefit from a visual barrier from viewers. As identified in Chapter 2, the Toronto Zoo golden lion tamarin group exhibited a visitor density effect that potentially could be moderated by an internal visual barrier between the monkeys and visitors.

Internal visual barriers reduce the degree of keeper control that external barriers such as camouflage nets can provide because they usually cannot be installed and removed easily. However, in exchange, internal visual barriers may provide animals with the ability to manage their exposure to zoo visitors that is not possible with external barriers. Internal barriers potentially provide individuals within a group an opportunity to express their preference for when and how long they are visible to visitors, allowing individual members of a group to moderate their exposure to zoo visitors. Although control, choice, and the behaviour of the individual animals are not the focus of this experiment, they are important factors worth consideration in assessments of internal visual barriers between zoo visitors and display animals. For instance, choice and control in use of an indoor off-exhibit den has been shown to decrease stereotypies and increase social play in zoo-housed polar bears (Ross 2006).

3.10.1 Previous Uses of Internal Visual Barriers

As previously stated, the effect of visual barriers on the visitor effect has not been tested. However, their use in the laboratory to provide cover from conspecifics has been tested in several primate species. Decreased aggression between neighbouring cage inhabitants following the installation of a privacy panel between cages has been observed in rhesus macaques (*Macaca mulatta*) (Reinhardt 2000). Estep and Baker (1991) identified a reduction in contact aggression, proximity, and the ability of the alpha male to monopolise copulations in a group of 26 stumptailed macaques (*Macaca arctoides*) during times when temporary walls were erected in a compound at the Yerkes Regional Primate

Centre Field Station. McKenzie et al (1986) documented decreases in inactivity, locomotion, and active affiliation as well as an increase in inactive affiliation in common marmosets and cotton-top tamarins when hanging screens were installed in family rooms in the Stirling University Psychology Primate Unit. Given these data, internal barriers clearly affect primate behaviour and may be useful in reducing exposure to stimuli outwith the enclosure.

The only internal barriers tested for their efficacy in reducing animal reactions to humans was a study carried out on singly-caged juvenile male blue foxes (*Alopex lagopus*) housed at the Juankoski research station at the University of Kuopio (Mononen et al 2001). The influence of concealment screens and elevated platforms on fox behaviour suggests the foxes preferred the cages with elevated platforms, from which they had the best view of human activity, and avoided the floor behind the screens. During experimental human approaches to the cages, some of the foxes used the screens for concealment, suggesting the screens were effective in providing a hiding space from humans. The results of internal barrier experiments are difficult to generalise to the zoo environment, but they suggest that internal visual barriers may be helpful in screening animals from humans.

3.11 Research Objectives

The privacy screen experiment has several aims:

1. Determine if there were changes in visitor density or visitor noise between experimental conditions.

2. Determine if the installation of the privacy screen reduced the visitor effect identified in the golden lion tamarin group in Chapter 2.
3. Determine if the privacy screen affected the relationship between visitor density/noise and golden lion tamarin behaviour identified in Chapter 2.
4. Evaluate the welfare implications of installing an internal visual barrier in golden lion tamarin enclosures.

3.12 Methods

The baseline data for this experiment were collected in October and November 2003 at the Toronto Zoo. The privacy screen was installed in the golden lion tamarin exhibit in January 2004 and another two weeks of observations were made. Focal animal samples (Martin and Bateson 1986), each ten minutes in length, were collected on the study group. Five hours of data (30 samples) were collected without the privacy screen and 7.67 hours of data (46 samples) were collected with the privacy screen in the exhibit. Data were collected using the software program *The Observer* (Noldus) on a hand-held computer (Psion Workabout). The behaviours collected for this experiment are defined in Appendix B.

3.13 Procedures

Following the baseline data collection period, zoo keepers installed a sheet of camouflage-patterned burlap material in the tamarin exhibit using metal links to suspend the fabric from tree branches that were a permanent feature of the exhibit. The screen was approximately two meters wide and 1.5 meters long and hung at mid-canopy level (approximately 1.5 meters from the ceiling and 1.75

meters from the floor.) The screen allowed visitors to see the silhouettes of the monkeys through the screen while providing a reasonable visual buffer between visitors and the golden lion tamarins. The screen did not block the tamarins' view of their marmoset, saki, or sloth neighbours.

3.14 Statistical Analysis

Frequencies and durations were calculated using *The Observer*'s Elementary Statistics feature and then exported to SPSS for further statistical analysis. Randomisation tests, as described by Todman and Dugard (2001), were the chosen statistical technique employed to identify behavioural change. Design 1 was utilised for the privacy screen experiment because it is suitable for a phase design experiment with a single subject. The test statistic for this design is the difference between condition means.

The statistical procedure for computing the Spearman correlations in the visitor density and noise section of this chapter was similar to the visitor density and visitor noise analysis in Chapter 2. A density category legend is provided in the first graph for each set of significant results. The analysis of changes in visitor noise and density between experimental conditions was also similar to those carried out in Chapter 2. The significance level was set at $p < .01$ and all statistics were two-tailed.

3.15 Results

3.15.1 Potential Confounding Variables: Visitor Density and Visitor Noise

The consistency of visitor density levels between the baseline and the privacy screen condition was tested using a randomisation test. There was no significant difference between the median density per sample between the baseline and screen condition (test statistic= -.103, n= 76, *p*= .916). The consistency of visitor noise levels between the baseline and the privacy screen condition was tested using a randomisation test. There was a trend toward a reduction in the median decibel per sample between the baseline and screen condition (test statistic= -1.322, n= 76, *p*= .043). Figure 3.40 shows the difference in the median decibel per sample between the baseline and camouflage net conditions.

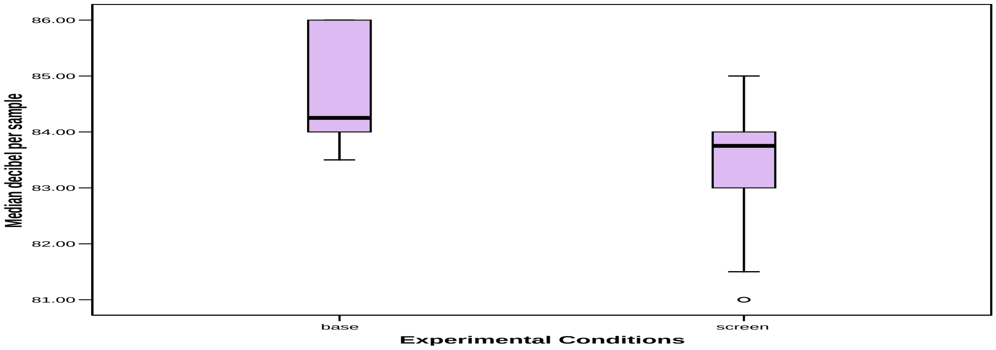

Figure 3.40 The change in the median decibel per sample from the baseline condition to the privacy screen condition in the golden lion tamarin group.

3.15.2 Golden Lion Tamarin Use of the Privacy Screen

The golden lion tamarin group used three methods of reducing their visibility to zoo visitors, including the privacy screen that was installed for the experiment. The tamarins spent 1.91% of their time in the screen condition hidden by the permanent foliage of the exhibit (i.e. performing the behaviour *out of sight*), 12.68% of their time was spent behind the privacy screen, and 25.19% of their time was spent in their nest box. The remaining 60.22% of their time was spent visible to zoo visitors. Figure 3.41 presents the amount of time the golden lion tamarin group spent reducing their visibility to visitors in the privacy screen condition.

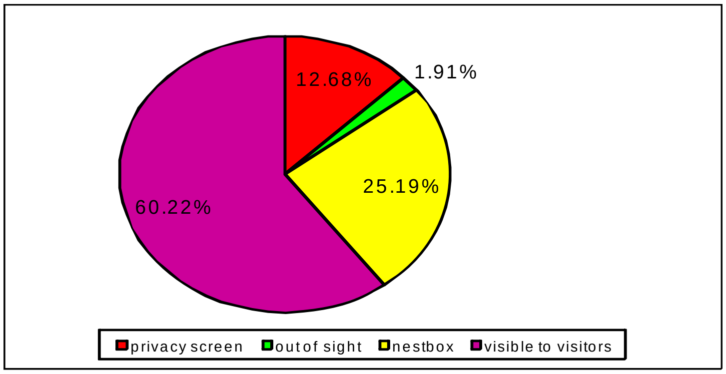

Figure 3.41 The percentage of time the golden lion tamarin group spent not visible or visible to visitors in the privacy screen condition.

3.15.3 Behavioural Changes Following the Installation of the Privacy Screen

The hypothesis that installing a privacy screen inside the golden lion tamarin enclosure would affect behaviour was tested using randomisation tests. Behaviour was not significantly changed by the installation of the screen. However, the frequency of the behaviours *monitor visitor area, scratch self,* and *solitary groom* showed a trend toward decrease in these behaviours in the screen condition. Table 3.24 presents the results of the randomisation tests comparing baseline and privacy screen behaviour in the tamarin group. Figure 3.42 illustrates the behavioural trends in the golden tamarin group following the installation of the privacy screen.

Golden lion tamarind BEHAVIOURS	Test Statistic	*p* (two-tailed)	n
contact (d)	68.310	.160	85
contact (f)	.030	.910	85
feed/forage (d)	-37.635	.740	86
feed/forage (f)	-.994	.137	86
locomote (d)	-39.074	.213	203
locomote (f)	-2.526	.092	203
monitor visitor area (d)	21.074	.383	347
monitor visitor area (f)	-2.314	.045	347
nestbox (d)	62.797	.261	51
nestbox (f)	.228	.176	51
out of sight (d)	11.457	.494	10
out of sight (f)	.217	.172	10
proximity (d)	-16.749	.511	43
proximity (f)	-.387	.924	43
rest (d)	81.957	.867	40
rest (f)	.153	.287	40
scent mark (f)	.045	.913	73
scratch self (f)	-1.558	.045	73
sniff object (f)	-.014	.800	12
social groom (d)	-4.917	.871	78
social groom (f)	-.994	.137	78
solitary groom (d)	-2.983	.565	83
solitary groom (f)	-.619	.046	83
startle (f)	-.138	.592	19

Table 3.24 The randomisation test results for the privacy screen experiment. Trends are shaded. (d)= duration, (f)= frequency.

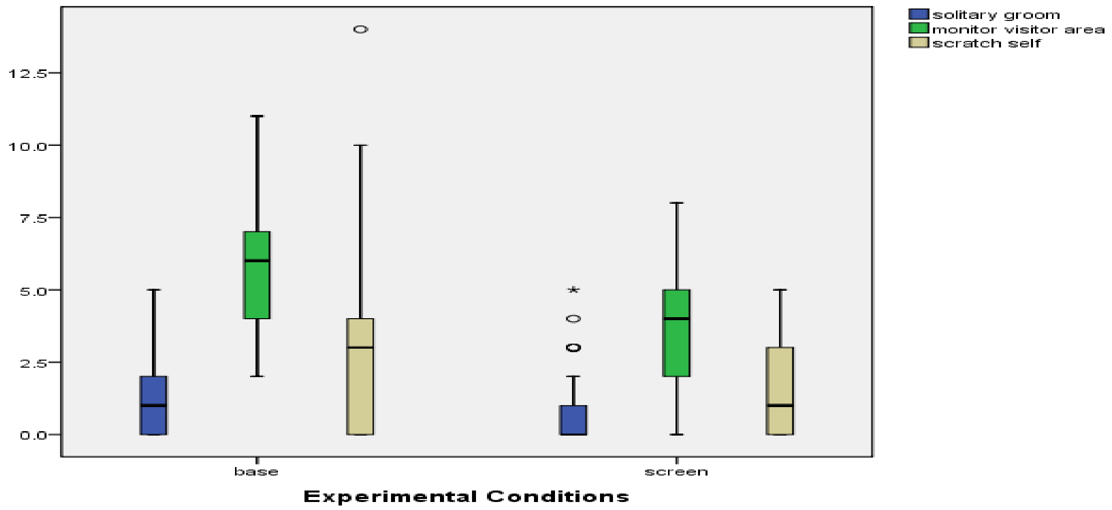

Figure 3.42 The change in the median frequency per sample of *solitary groom*, *monitor visitor area*, and *scratch self* from the baseline condition to the privacy screen condition in the golden lion tamarin group.

3.15.4 The Relationship Between Golden Lion Tamarin Behaviour and Visitor Density Following the Installation of the Privacy Screen

The relationship between visitor density and golden lion tamarin behaviour in the privacy screen condition was determined by calculating Spearman correlations. There were trends toward a positive association between visitor density and the mean frequency per sample of the behaviour *feed/forage* and a negative association between visitor density and the mean frequency of the behaviour *rest*, but neither of these relationships was statistically significant. There was also a trend toward increased duration of *monitor visitor area*, but the association was not significant. Table 3.25 lists the golden lion tamarin behaviours for which Spearman correlations were calculated to determine the relationship between visitor density and behaviour. Figures 3.43-3.45 show the relationship between visitor density and behaviour in the golden lion tamarin group in the screen condition.

Golden lion tamarin BEHAVIOUR	Privacy Screen Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
behind screen (d)	-.142	.231	NA	NA
behind screen (f)	-.045	.703	NA	NA
contact (d)	.139	.240	.005	.975
contact (f)	-.099	.405	.088	.541
feed/forage (d)	.035	.769	.132	.356
feed/forage (f)	.259	.027	-.103	.472
locomote (d)	-.053	.656	.142	.320
locomote (f)	-.146	.218	.086	.550
monitor visitor area (d)	.249	.034	.201	.158
monitor visitor area (f)	-.100	.399	.026	.857
nestbox (d)	.173	.144	-.016	.910
proximity (d)	.016	.895	.105	.465
proximity (f)	-.050	.673	.229	.106
rest (d)	-.005	.965	-.314	.025
rest (f)	-.248	.035	-.297	.034
scent mark (f)	-.137	.249	-.077	.589
scratch self (f)	-.102	.393	-.258	.068
social groom (d)	-.164	.165	.012	.931

Golden lion tamarin BEHAVIOUR	Privacy Screen Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
social groom (f)	-.027	.820	-.044	.762
solitary groom (d)	-.078	.510	-.274	.052
***solitary groom* (f)**	-.049	.680	**-.392**	**.004**

Table 3.26 The relationship between visitor density and golden lion tamarin behaviour. Significant associations are in bold script. Privacy screen condition: n= 73; Baseline condition: n= 51. (f)= frequency, (d)= duration.

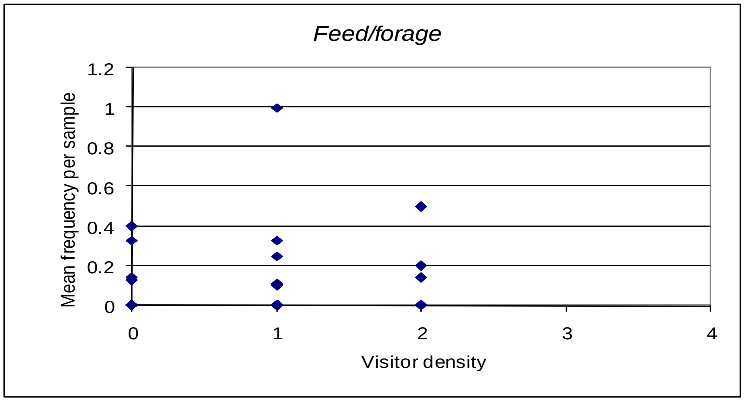

Figure 3.43 The relationship between visitor density and the frequency of *feed/forage* in the privacy screen condition in the golden lion tamarin group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51 or more visitors.

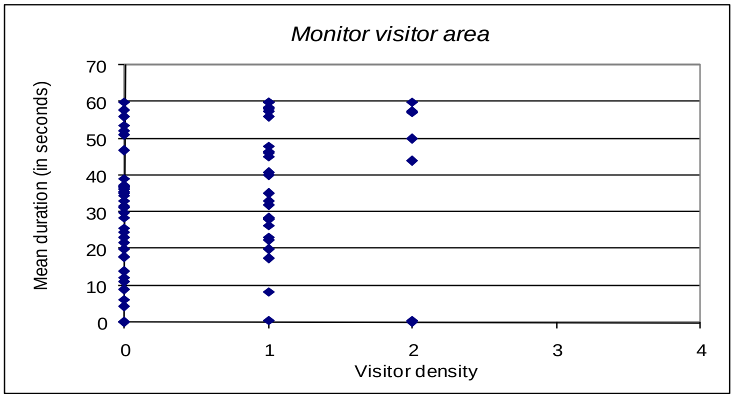

Figure 3.44 The relationship between visitor density and the duration of *monitor visitor area* in the privacy screen condition in the golden lion tamarind group.

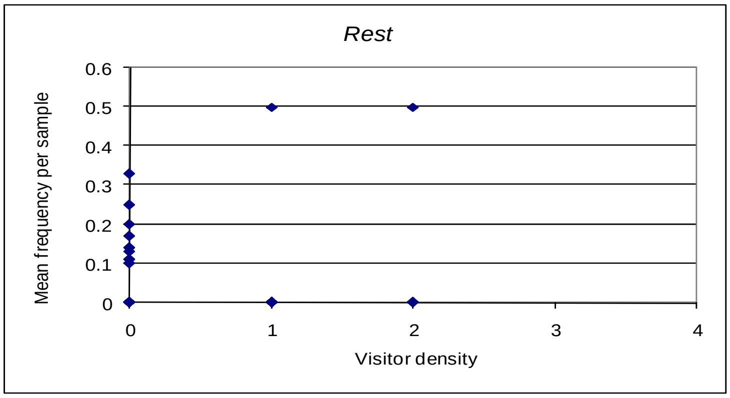

Figure 3.45 The relationship between visitor density and the frequency of *rest* in the privacy screen condition in the golden lion tamarin group.

3.15.5 The Relationship Between Golden Lion Tamarin Behaviour and Visitor Noise Following the Installation of the Privacy Screen

Spearman correlations were calculated to determine the relationship between visitor noise and the mean frequency per sample and mean duration of golden lion tamarin behaviour, but none of the behaviours reached the level of statistical significance. The duration of *feed/forage* showed a trend toward a positive correlation with visitor noise (Figure 3.46). Table 3.26 lists the results of Spearman correlations for all behaviours.

Golden lion tamarin BEHAVIOUR	Privacy Screen Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
behind screen (d)	-.035	.682	NA	NA
behind screen (f)	-.050	.561	NA	NA
contact (d)	-.007	.936	-.188	.100
contact (f)	.055	.522	.137	.189
feed/forage (d)	.173	.045	-.068	.551
feed/forage (f)	.137	.111	-.063	.549
locomote (d)	.110	.202	.052	.652
locomote (f)	.016	.857	.061	.563
monitor visitor area (d)	.062	.476	.209	.067
monitor visitor area (f)	.065	.453	.020	.849
nestbox (d)	-.030	.733	-.187	.102
nest-box (f)	.051	.552	NA	NA
proximity (d)	.167	.052	.071	.535
rest (d)	.003	.976	-.133	.244
rest (f)	-.015	.867	-.039	.709
scent mark (f)	-.165	.055	-.034	.748

Golden lion tamarin BEHAVIOUR	Privacy Screen Condition		Baseline Condition	
	r	*p* (two-tailed)	r	*p* (two-tailed)
scratch self (f)	.086	.321	-.061	.562
social groom (d)	-.074	.392	-.094	.413
social groom (f)	.020	.821	-.016	.875
solitary groom (d)	-.022	.802	-.037	.749
solitary groom (f)	-.042	.624	-.040	.706

Table 3.26 The relationship between visitor noise and golden lion tamarin behaviour. Trends are shaded. Privacy screen condition: n= 136; Baseline condition: n= 78. (f)= frequency, (d)= duration.

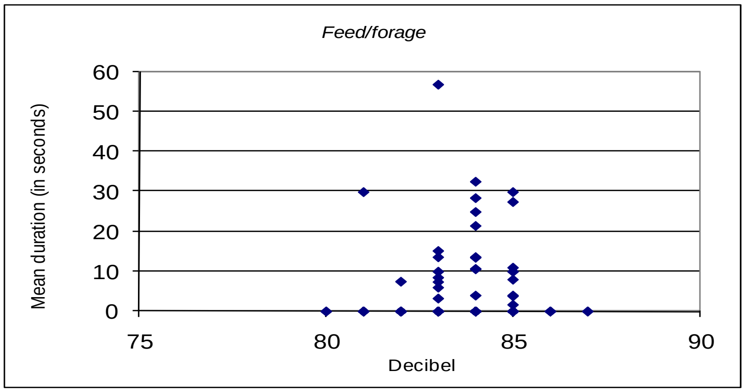

Figure 3.46 The relationship between visitor noise and the duration of *feed/forage* in the privacy screen condition in the golden lion tamarin group.

3.15.6 Visitor Behaviour

Visitor behaviours such as hitting the glass front of the enclosure and vocal threats such as mimic vocalisations were rarely directed at the golden lion tamarins. Consequently, a statistical analysis of overt visitor behaviour was not necessary.

3.16 Discussion

3.16.1 Visitor Noise: A Confounding Variable

The level of visitor density remained consistent between the baseline and privacy screen conditions, which is helpful in establishing that the observed behavioural changes are related to the experimental manipulation and not a coincidental change in visitor density. The trend toward decreased noise suggests that quieter visitors may have contributed to the behavioural changes identified following the installation of the internal barrier. Although there are anecdotal claims that external visual barriers reduce visitor noise (Norcup 2000, Blaney and Wells 2004), there are no published data which indicate that internal barriers might have a similar effect. The internal installation of a visual barrier makes the device relatively inconspicuous to visitors, compared to external barriers, and would be unlikely to alter visitor behaviour. It does not prevent visitors from banging on viewing windows, nor does it require visitors to make an effort to view the animals on display—the animals are simply visible or not in view because they are behind the screen. For these reasons, it is probably unlikely that the internal barrier was the cause of reduced visitor noise between the baseline and screen condition, although it cannot be ruled out.

3.16.2 Behavioural Changes Following the Installation of the Privacy Screen

The privacy screen did not significantly affect the behaviour of the golden lion tamarins, but the identified behavioural trends suggest that privacy screens have the potential to impact golden lion tamarin behaviour. The trend toward decreased monitoring of visitor areas suggests the tamarins were under less visitor pressure. As the group surveyed the visitor viewing area almost six times per ten-minute sample in the baseline condition, a decrease to 3.5 bouts per sample with the screen is desirable. However, the dominance of this behaviour in their activity budget is also a clear indication that the tamarins were alert to presence of visitors in the baseline condition; the lack of significant change in the amount of time the group spent monitoring visitor areas after the screen was installed indicates that the tamarins still exhibited a high level of visitor monitoring despite the internal barrier.

The trend toward decreased in self-directed scratching and solitary grooming may also be the result of reduced visitor influence. Bassett et al (2003) report an increase in self-scratching in both trained and untrained laboratory-housed common marmosets following routine husbandry procedures, and they note that the increase was most pronounced in the observations that were more closely temporally related to the husbandry stressor. In conjunction, these results indicate that self-directed behaviours such as scratching may be reliable indicators of an immediate stressor, such as zoo visitors or husbandry procedures, in callitrichids.

3.16.3 The Relationship Between Visitor Density and Behaviour in the Privacy Screen Condition

The privacy screen did not moderate the visitor density effect in the golden lion tamarin group. The persistence of the trend toward a negative correlation between the frequency of resting and visitor density suggests that the tamarins remained more active in relation to density in spite of the installation of the screen. Decreased inactivity has been linked to stress in laboratory-housed common marmosets (Bassett 2003), and decreased inactivity appears to be a sign of visitor-related pressure in zoo-housed golden lion tamarins. Decreased inactivity is a documented visitor effect in ring-tailed lemurs, cotton-top tamarins, and Diana monkeys (Chamove et al 1988). Given that internal visual barriers have been shown to decrease inactivity in cotton-top tamarins and common marmosets (Chamove et al 1986) in a laboratory setting, the use of internal barriers may not be effective in moderating inactivity associated with the visitor effect in callitrichids.

Several different behaviours trended toward significant correlation with density once the privacy screen was installed inside the tamarin cage, indicating a qualitative difference in the visitor density effect between the baseline and screen conditions. The trend toward increased foraging and feeding associated with visitor density in the privacy screen condition is not supported by all previous research on visitor density or visual barriers. Zoo-housed chimpanzees showed lower frequencies of foraging in the presence of larger visitor crowds (Wood 1998) and a decrease in foraging and feeding in stump-tailed macaques was exhibited when laboratory windows were covered with wooden screens (Waitt and Buchanan-Smith 1999). However, Todd et al (2006) identified increased levels of feeding and chewing in Diana monkeys when visitor density was high. In light of these mixed findings, the increase in feeding and foraging in the Toronto Zoo golden lion tamarin group is difficult to categorise as negative or positive in welfare terms.

The screen eliminated the negative relationship between visitor density and solitary grooming in the baseline condition; solitary grooming can be a self-directed behaviour that is a sign of psychological stress in captive primates. While this finding might be useful for other groups of tamarins in which self-directed grooming is a welfare concern, the Toronto Zoo tamarins spent only five percent of their time grooming themselves in the baseline condition, which is not a significant portion of their activity budget. The monkeys did not exhibit any sign of over-grooming, such as bald patches or skin lesions, which suggests decreased solitary grooming in times of high density did not improve the group's welfare. Given that self-directed behaviour in laboratory primates is used as an indicator of decreased welfare, it is unfortunate that the visitor effect literature does not always make a distinction between self-directed grooming and social grooming. Decreased levels of grooming, in which solitary and social grooming levels are combined into one behavioural measure, have been reported in primates in relation to visitors (Chamove et al 1988, Wood 1998, Todd et al 2006).

While the absolute frequency of *monitor visitor area* trended toward decreased levels with the privacy screen in place, this behaviour trended toward a positive correlation with visitor density. Although monitoring visitor areas doesn't have a direct impact on zoo animal welfare unless it represents an extreme percentage of an animal's activity budget, the trend suggests that even with the visual barrier, the tamarins experienced visitor pressure. Visual attention directed towards visitors has been observed in chimpanzees (Cook and Hosey 1995, Wood 1998), orangutans (Birke 2002), eastern lowland gorillas (Vrancken et al 1990), white-handed gibbons (Cooke and Schillaci 2007), and mandrills (Chamove et al 1988); however, statistical comparisons between different visitor conditions are not as prevalent. Chamove et al (1988) identified a positive linear relationship between the density of visitors and the time a male mandrill spent looking at visitors.

3.16.4 The Relationship Between Visitor Noise and Behaviour in the Privacy Screen Condition

Although there was no relationship between visitor noise and golden lion tamarin behaviour in the baseline condition, the installation of the privacy screen in the enclosure resulted in a trend toward a positive association between feeding and foraging and visitor noise. The increase in feeding and foraging as both visitor density and visitor noise increased suggests that visitor-related variables affect feeding and foraging in tamarins, although whether this change has welfare implications is not possible to determine without more data.

It is interesting to note that neither higher levels of visitor density or noise were associated with the use of the privacy screen, indicating the tamarins did not use the screen to hide behind when visitor numbers or noise increased. Given these results, it is reasonable to assume that the tamarins did not associate the area behind the privacy screen as a refuge from increased visitor density or visitor noise.

3.17 Conclusion

The camouflage nets had no effect on the overall frequency and duration of behaviour in the study groups. The lack of significant behavioural change in the study groups suggests that obstructing the visual stimuli associated with zoo visitors may not improve the welfare of zoo animals. However, particular species, such as the polar bear, may benefit from reduced visitor stimuli. It is unclear why the barrier had no significant effect for most of the primate and large carnivore species, but it is possible the lack of views outwith the enclosure may play a role. While the camouflage nets reduce the visual stimuli of visitors, their presence may also reduce animals' views of surrounding animal enclosures and zoo staff, which previous researchers have shown to influence animal behaviour. Obscured views of the environment outside their enclosure might affect zoo animals' predictability of routine husbandry events and visual contact with other zoo animals. Further research, such as that conducted by Waitt and Buchanan-Smith (1999) in which the primates have control of their view outwith the enclosure, should be carried out in the zoo environment.

The camouflage nets were more influential on animal behaviour during times of visitor density and noise fluctuations than on the absolute frequency and duration of their behaviour. There were no consistent patterns of change across the primates and large carnivores, suggesting the ability of the nets to moderate the relationship between behaviour and visitor density and visitor noise may be related to other variables within the captive environment, such as group size, composition, species temperament, or enclosure design. While the presence of the nets influenced the visitor density and noise effect in most of the species studied, the quality of the behavioural changes varied depending on species. In particular, covering visitor viewing windows in polar bear enclosures seems to have positive welfare outcomes which may be helpful in improving the well-being of zoo ursids, while the nets increased abnormal behaviour in times of high visitor density in the western lowland gorilla group.

The external visual barrier had no effect on the overt behaviour of the visitors at the study enclosures. Visitor noise did not decrease between conditions, nor did the rate of visitor vocalisations directed at the animals or hitting and kicking of the viewing windows. Visitors expressed displeasure at a reduced view of the display animals and attempted to better their view by lifting the nets or ripping them to create larger viewing holes.

Overall, the results of this experiment do not recommend wide-spread use of camouflage nets until the long-term effects of these barriers have been determined. The negative effects identified here indicate a need for periodic monitoring of the welfare of the display animals housed in enclosures where nets have been installed, paying particular attention to changes in behaviour across seasons of low and high visitor density which might be helpful in determining whether the nets block out too much activity outside the enclosure. Future research on the interaction between enclosure design and the presence of external visual barriers should also be undertaken.

Unlike camouflage nets, internal barriers may contribute to reduced visitor noise but further study with a larger sample size is necessary. Although there is some anecdotal evidence that external barriers may affect visitor noise and behaviour (Norcup 2000, Blaney and Wells 2004), a link between internal barriers and visitor-related variables is not clear. The privacy screen used in this experiment was probably not even perceived by many of the visitors. The camouflage print of the screen made it disappear into the canopy and visitors might not have even realised it was there until a monkey disappeared behind it. In fact, the ability to design privacy screens that look like organic objects in a naturalistic enclosure might even be preferable because visitors would not realise the barrier was intentionally there to hide the animals and they might experience less frustration when the display animals were not visible to them.

The decreased level of self-directed behaviours, such as solitary grooming and self-scratching, suggests that the visual barrier may be useful in moderating the visitor effect. The privacy screen was successful in moderating the relationship between visitor density and solitary grooming, but new behaviours trended toward correlation with visitor density in the screen phase of the experiment. Despite the inability of the privacy screen to eradicate all influences of high visitor numbers or noisy visitors, not all the behavioural trends associated with the two visitor variables were necessarily detrimental to the welfare of the golden lion tamarin group. For instance, increased feeding in relation to increased visitor density and visitor noise can be interpreted as a positive visitor effect brought on by the installation of the privacy screen.

Comparing the ability of the two visual buffers to moderate the visitor effect, the privacy screen appeared to be more effective at reducing self-directed grooming and scratching, often signs of stress in captive primates. The nets, however, moderated the visitor density effect more effectively than the privacy screen. The potential for negative visitor perception of the camouflage net barrier suggests that the internal barrier appeared to be the more preferred barrier technique when attempting to moderate the visitor effect in golden lion tamarins, if it can be shown to significantly reduce the negative visitor effect in other golden lion tamarins. Currently, neither of the methods tested can be recommend for general use in reducing the visitor effect in zoo-housed golden lion tamarins, but further study of the visitor effect in small arboreal primates under different housing conditions would greatly inform the understanding of the visitor effect in zoo primates.

Chapter 4: Can a Positive Visitor Effect be Achieved by Providing Puzzle Feeders to Zoo Visitors and Sumatran Orangutans?

4.1 Introduction

The visitor effect on zoo animals can be negative, neutral, or positive (Hosey 2000), but there have been few published attempts to encourage a positive visitor effect in display animals. The experiment presented in this chapter investigates the potential of visitors to have a positive visitor effect on captive Sumatran orangutans by presenting both the study orangutans and zoo visitors with a puzzle feeder foraging device, following a baseline condition in which no feeders were present and another in which only the orangutans were given access to a puzzle feeder. Providing a device designed to enrich the environment of the study nonhuman and human primates is hypothesised to increase feeding and foraging behaviour and orangutan proximity to visitor viewing-windows while reducing negative visitor behaviour such as hitting viewing windows and vocalisations. It is also hypothesised that presenting identical foraging devices to the orangutans and the visitors simultaneously might increase the manipulation of the puzzle feeders by the orangutans.

The visitor effect literature indicates the general effect of zoo visitors is negative, with decreased inactivity, increased aggression, and increased stereotypies in primates. Although the conclusion that visitors have a negative influence on animal behaviour is well-supported in the literature, the results of the visitor density and visitor noise study in Chapter 2 were not all negative and they indicate that visitor stimuli can elicit positive responses in some zoo animals. For example, increased visitor density resulted in significantly increased visibility of the squirrel monkey group, while significantly increased exploratory behaviour in the polar bear group and significantly increased social grooming in the Sumatran orangutan group were associated with increased levels of visitor noise.

4.1.1 Previous Positive Visitor Effect Research

The positive effects of visitor-related stimuli identified in the visitor density and visitor noise studies suggest that it may be possible to increase positive animal responses to zoo visitors, rather than just attempt to moderate the existing negative influence of visitor stimuli. While attempts to moderate the negative visitor effect have been successful in captive felids (Cunningham 2004), western lowland gorillas (Norcup 2000, Blaney and Wells 2004), and petting zoo-housed Romanov sheep and African pygmy goats (Anderson et al 2002), there are few published data on alterations to the zoo environment, animal care, or enrichment programs resulting in a positive visitor effect on animal behaviour. The behavioural engineering research carried out by Markowitz (1982) on a group of zoo-housed mandrills (*Papio sphinx*) is one of the few experiments using visitors to try to improve the welfare of display animals. Although Markowitz’s project was not designed to explicitly address the visitor effect phenomenon, the enrichment program he designed exploited visitor interest in interacting with display animals to enrich the environment of the mandrills. Markowitz installed game consoles, for both the mandrills and visitors, which allowed the mandrills to invite a visitor to play a game. When a visitor responded, a contest to see who could touch a series of lighted panels first began and the mandrills were rewarded with a food reward following the game. The game was used so frequently by the mandrills that zoo staff had to shut down the game in the afternoons so that the male mandrill that monopolised the game did not become overfed. Presumably, the visitors also found the game interesting to play and watch because they spent more than twice as much time at the mandrill exhibit as they did at comparable exhibits in the zoo. An overall enriching effect of the game was reported, including a significant decrease in pacing and a significant increase in activity. Markowitz also noted a decrease in the rate the male mandrill chased the female from rest positions. Interestingly, although the enrichment program was successful, the male mandrill’s reaction to visitors was not affiliative. The male directed shoulder shrugs and gape threats towards visitors after games, suggesting that a positive visitor effect may not always include affiliative interactions between animals and visitors.

The Baltimore Zoo (USA) runs an informal program involving zoo visitors in their chimpanzee (*Pan troglodytes*) enrichment program (B. Penn, *pers. comm.* 2003). The enrichment activity is carried out once or twice per week by several members of staff who are assisted by zoo visitors. The staff and visitors locate themselves in front of the viewing window of the indoor enclosure and show the chimpanzees various enrichment items such as puzzles, dolls, balls, books, and toys. The visitors and staff manipulate the enrichment items and engage the chimpanzees in playful interactions through the glass. While this enrichment program has not produced any empirical evidence to suggest that these activities affect overall chimpanzee behaviour or welfare, the program has the potential to affect chimpanzee and visitor behaviour and result in a positive visitor effect.

In addition to attempting to change animal behaviour, altering visitor behaviour may also contribute to reducing the negative visitor effect and facilitate a positive visitor effect. The presence of zoo visitors is a condition unique to zoos (Hosey 2005) that has been demonstrated to have a detrimental effect on display animals; unfortunately, it is not one that can be manipulated easily by researchers studying the visitor effect. Therefore, reducing active visitor behaviours, such as visitor vocalisations, physical threats, throwing objects, feeding display animals, and hitting or kicking parts of enclosures such as viewing windows, is a more pragmatic way of moderating the negative visitor effect and perhaps encouraging a positive visitor effect. The effect of visitor behaviour is well-documented (Hosey and Druck 1986, Chamove et al 1988, Mitchell et al 1992b, Cook and Hosey 1995) but little effort has been made to alter the visitor environment or experience to proactively influence visitor behaviour. Although reducing the visitor behaviours that result in a negative visitor effect may be recommended by visitor effect research, it may also be helpful to identify visitor behaviour to which zoo animals respond positively. Cook and Hosey (1995) documented interactions between chimpanzees and zoo visitors and identified a tendency for these exchanges to result in food being given to the apes, a proximately positive result for the apes, but one that ultimately negatively impacts their health and welfare.

Regrettably, the data collected thus far on the visitor effect have been overwhelmingly negative, making it difficult to identify visitor behaviours that may influence display animal behaviour in a positive manner and then design enrichment programs to exploit the knowledge gained. The lack of data suggests that creating potentially enriching programs for animals and visitors, such as the one attempted in this experiment, may be a more productive course to identify the context in which the visitors are enriching to animals.

4.1.2 Selection of Study Species

Orangutans were selected for study because of several factors. A great ape species was hypothesised to be more likely than other nonhuman primates to experience a positive visitor effect because of their genetic and cognitive similarity to humans. The temperament of captive orangutans, who are generally more docile than captive chimpanzees but more easily stimulated than captive gorillas, lent itself more readily to the objectives of the experiment. It was also hypothesised that the manual dexterity of orangutans was more similar to humans than is gorillas, increasing the likelihood of the experimental device being successfully operated by the study animals and still challenging the abilities of the human participants.

Although the experiment does not make claims regarding the cognitive abilities of Sumatran orangutans, the ability of the species to attend to the actions of humans was hypothesised to be a necessary component if a positive visitor effect was to be achieved in the experiment. Orangutans have been shown to exhibit social learning by observing human demonstrators. Russon (1996) documented instances of true imitative learning in rehabilitant Bornean orangutans, while Call and Tomasello (1994) reported primate research centre-housed orangutans used emulative social learning to accomplish a problem solving task. While the objective of the experiment is to increase orangutan use of the puzzle feeder (presumably through stimulus enhancement), the mechanism by which this is achieved is irrelevant; the more complex forms of social learning observed in orangutans by Russon and Call and Tomasello, while indicative of a cognitively advanced species which may also be more likely to experience a positive visitor effect, are not tested in this experiment.

4.2 Research Objectives

The research objectives of the puzzle feeder experiment were:

1) Determine if any behavioural changes between experimental conditions might be due to changes in visitor density or visitor noise.
2) Determine if the installation of the puzzle feeder in the orangutan enclosure altered behaviour, in particular, increased foraging behaviour or other behaviours that indicate an enriched environment, such as increased affiliation, activity, or exploratory behaviour.
3) Determine if the installation of the visitor puzzle feeder resulted in the orangutans watching visitors use the visitor puzzle feeder and/or an increase in orangutan use of the puzzle feeder within their enclosure.
4) Determine if the installation of the puzzle feeders affected the relationship between both visitor density/noise and orangutan behaviour reported in Chapter 2.
5) Determine if the installation of the visitor puzzle feeder reduced visitor behaviour such as hitting viewing windows and primate-like vocalisations.

4.3 Methods

The Sumatran orangutan group observed in this experiment was housed at the Toronto Zoo; the composition and background of the group is detailed in Appendix A. The baseline Toronto Zoo data collected on the orangutan group and presented in Chapters 2 and 3 served as the control condition for this experiment; these data were collected in October-November of 2003. The visitor and ape feeders data for the two experimental conditions were collected in December-January of 2004. Focal animal samples (Martin and Bateson 1986), each ten minutes in length, were collected on the study group. Baseline data were collected for 5 hours 40 minutes (34 samples), 7 hours 10 minutes of data (43 samples) were collected with just the orangutan feeder in place, and eight hours of data (48 samples) were gathered with both the orangutan and visitor feeders available for use by the study animals and zoo visitors. The behavioural categories collected are defined in Appendix B.

The puzzle feeders used in this experiment were commercially available laboratory enrichment devices purchased from Lomir Biomedical Inc; the model used was Lomir Primate Enrichment Technologies (P.E.T.) #2029 (Figure 4.1). The devices were designed for use by laboratory chimpanzees, but were also deemed to be suitable for use by the orangutans and humans for this experiment. The feeders measured 45 cm in height x 30 cm wide. The polypropylene feeders were composed of a vertical board with 148 angled cavities (both 5/8” and 1” holes); these cavities were covered by a disc with three holes which presented a reasonable obstacle to extracting the reward out of the cavities for both the orangutans and the zoo visitors.

Figure 4.1 The puzzle feeder foraging device used in the experiment.

The orangutan enclosure had several different foraging devices installed as part of the routine enrichment program. These foraging devices included metal baskets, recessed holes in faux logs, and a transparent puzzle feeder that required the orangutans to push the food reward through a maze. Data on the use of non-experimental puzzle feeders were recorded in addition to the data collected on the experimental feeders.

4.4 Procedures

The dataset used in Chapter 2 constituted the baseline condition in this experiment. The orangutans were then presented with a feeder for one week and behavioural data were collected for the orangutan feeder condition. The orangutan feeder was mounted in the enclosure in full view of visitors standing at the viewing window, but not within three meters of a viewing window. The feeder was filled every morning with peanut rewards. Following the installation of an identical feeder for zoo visitors (orangutan-visitor feeders condition), another week of data were collected on the use of both feeders by the apes and humans respectively. The visitor puzzle feeder was mounted approximately one meter from a viewing window and visible to the orangutans from most locations within the enclosure. The cavities of the zoo visitor feeder were filled with small star-shaped sticker rewards to avoid the health and safety issues associated with providing the visitors with a food reward.

4.5 Statistical Analysis

Randomisation tests were the primary statistical technique used to identify behavioural change. Todman and Dugard's Design 1 for single-case phase designs (2001) was used to determine if there was any significant change in animal or visitor behaviour in the experimental conditions. The test statistic for Design 1 is the difference between condition means. The statistical procedure used to determine the relationship between visitor density/noise and orangutan behaviour was similar to that described in Chapter 2.

4.6 Results

4.6.1 Potential Confounding Variables: Changes in Visitor Density and Visitor Noise between Experimental Conditions

There was no significant change in the median visitor density per sample between the baseline and orangutan feeder condition, but there was a trend toward a decrease in the median visitor density per sample between the orangutan feeder condition and the orangutan-visitor feeders condition (test statistic= -1.470, n= 91, *p*= .040). Figure 4.2 shows the change in the median visitor density per sample between the orangutan feeder condition and the orangutan-visitor feeders condition.

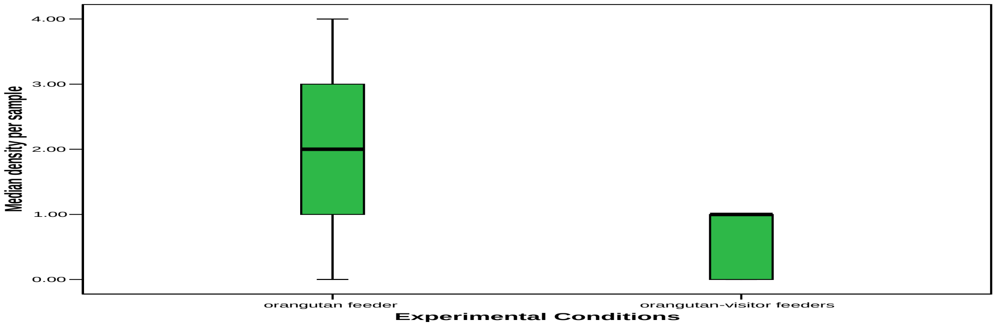

Figure 4.2 The decrease in median visitor density between the orangutan feeder condition and the orangutan-visitor feeders condition.

There was no change in the median visitor decibel per sample between the baseline and the orangutan feeder condition, but there was a trend toward a decrease in the median decibel per sample between the orangutan feeder condition and the orangutan-visitor feeder condition (test statistic= -1.144, n= 91, *p*= .040). Figure 4.3 shows the change in the median decibel per sample between the orangutan feeder condition and the orangutan-visitor feeders condition.

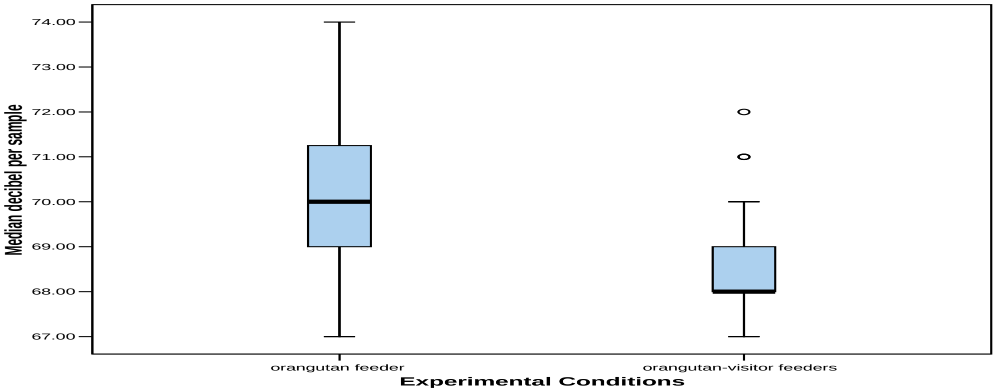

Figure 4.3 The decrease in the median decibel per sample between the orangutan feeder condition and the orangutan-visitor feeders condition.

4.6.2 The Orangutan Feeder Condition

The group used the experimental puzzle feeder for 7% of the total sample time in the orangutan puzzle feeder condition and used non-experimental foraging devices for 3% of total sample time in the orangutan feeder condition. To test the effect of the experimental puzzle feeder on orangutan behaviour, randomisation tests were calculated. There were no significant changes in orangutan behaviour, but the duration of *social play* showed a trend to decrease from baseline levels in the orangutan feeder condition (Figure 4.4). Table 4.1 lists the results comparing orangutan behaviour between the baseline and orangutan feeder conditions.

Sumatran orangutan BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
< *one meter* (d)	-65.620	.241	17
< *one meter* (f)	-.123	.503	17
< *three meters* (d)	-144.291	.402	22
< *three meters* (f)	-.255	.390	22
> *three meters* (d)	144.291	.417	22
> *three meters* (f)	.503	.641	22
contact (d)	14.661	.812	25
contact (f)	.282	.772	25
feed/forage (d)	67.834	.704	44
feed/forage (f)	.226	.683	44
head-cover (d)	-20.653	.145	7
head-cover (f)	-.331	.213	7
infant care (d)	-6.377	.315	7
infant care (f)	-.107	.299	7
locomote (d)	18.966	.403	50
locomote (f)	.644	.362	50
monitor visitor area (d)	35.990	.182	47
monitor visitor area (f)	.495	.137	47
proximity (d)	-27.644	.137	40
proximity (f)	-.178	.419	40
rest (d)	30.469	.223	44
rest (f)	-.229	.692	44
scratch self (f)	.222	.224	19
social groom (d)	-26.235	.322	3
social groom (f)	-.235	.314	3
social play (d)	-29.002	.045	7
social play (f)	-.145	.156	7
solitary groom (d)	-16.888	.811	15
solitary groom (f)	-.120	.627	15
solitary play (d)	-2.575	.471	7

Sumatran orangutan BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
solitary play (f)	.021	.855	7

Table 4.1 The results of the randomisation tests comparing the behaviour of the orangutan in the baseline and orangutan feeder conditions. Trends are shaded. n= 77. (d)= duration, (f)= frequency.

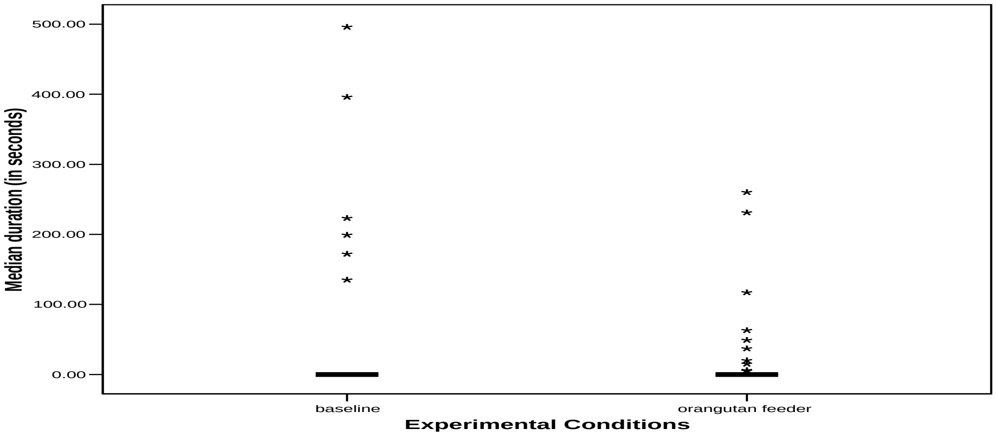

Figure 4.4 The decrease in the median duration of *social play* in the orangutan feeder condition. Baseline mean= 48. Orangutan feeder mean= 19.

Figure 4.5 A Sumatran orangutan uses the puzzle feeder. Toronto Zoo. Photo by author.

4.6.3 Orangutan-visitor Puzzle Feeders Condition

To identify any changes in Sumatran orangutan behaviour following the installation of the visitor puzzle feeder, randomisation tests were carried out. There were no significant changes in orangutan behaviour between the orangutan feeder condition and the orangutan-visitor feeders condition, but there was a trend toward decreased time spent using the experimental feeder with a tool-like object following the installation of the visitor feeder (Figure 4.6).

The study group spent 5% of total sample time in the orangutan-visitor feeder condition using the puzzle feeder, and they used non-experimental foraging devices for 6% of sample time. They did not watch the visitors use the visitor puzzle feeder, nor did the orangutans use the puzzle feeder within one minute following visitor use of the visitor puzzle feeder. Visitors used the visitor puzzle feeder for 2% of total sample time in the orangutan-visitor feeders condition. Visitors did not use the visitor puzzle feeder within one minute following an orangutan use of the orangutan puzzle feeder. Table 4.2 lists the results of the randomisation tests used to identify behavioural changes between the orangutan feeder condition and the orangutan-visitor feeders condition.

Sumatran orangutan BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
< *one meter* (d)	11.950	.773	15
< *one meter* (f)	.056	.910	15
< *three meters* (d)	-86.788	.225	20
< *three meters* (f)	-.040	.829	20
> *three meters* (d)	81.642	.236	37
> *three meters* (f)	-.022	.867	37
contact (d)	7.478	1.000	32
contact (f)	.037	1.000	32
feed/forage (d)	83.888	.630	66
feed/forage (f)	.499	.097	66
locomote (d)	1.297	.761	60
locomote (f)	.126	.280	60

Sumatran orangutan BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
monitor visitor area (d)	-47.897	.126	39
monitor visitor area (f)	-.507	.746	39
proximity (d)	22.645	.134	40
proximity (f)	.425	.076	40
rest (d)	-77.761	.533	25
rest (f)	-.284	.453	25
scratch self (f)	-.355	.311	18
social play (d)	-15.508	.364	7
social play (f)	-.263	.156	7
solitary groom (d)	-10.442	.442	7
solitary groom (f)	-.128	.477	7
solitary play (d)	23.121	.180	9
solitary play (f)	.203	.186	9
use experimental puzzle feeder (d)	-27.441	.140	23
use experimental puzzle feeder (f)	.037	.725	23
use experimental puzzle feeder with tool-like object (d)	-8.711	.043	53
use experimental puzzle feeder with tool-like object (f)	.009	.858	53
use non-experimental foraging devices (d)	23.968	.134	14
use non-experimental foraging devices (f)	-.059	.592	14

Table 4.2 The results of the randomisation tests comparing the behaviour of the orangutans in the orangutan feeder condition and orangutan-visitor feeders condition. Trends are shaded. n= 91. (d)= duration, (f)= frequency.

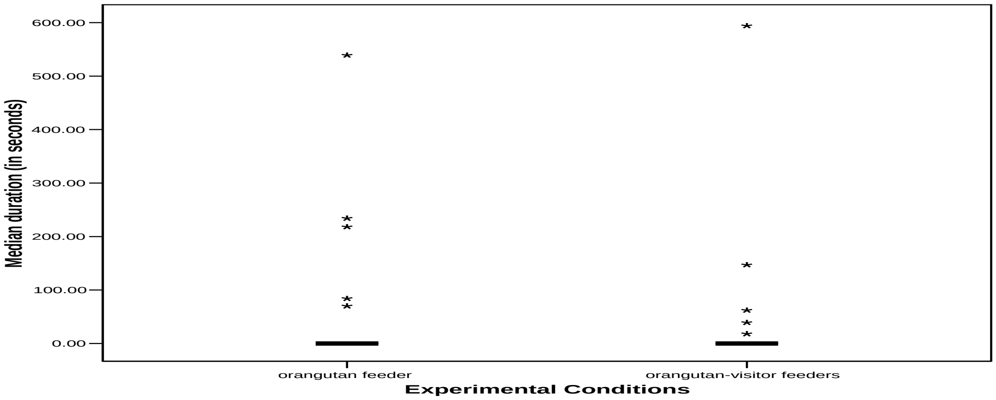

Figure 4.6 The decrease in the median duration of *use experimental feeder with tool-like object* following the installation of the visitor puzzle feeder. Orangutan feeder mean= 27. Orangutan-visitor feeder mean= 18.

Figure 4.7 A zoo visitor manipulates the puzzle feeder. Toronto Zoo. Photo by author.

4.6.4 The Relationship Between Visitor Density and Orangutan Behaviour in the Experimental Conditions

The relationship between visitor density and Sumatran orangutan behaviour in the orangutan feeder and orangutan-visitor feeders conditions was calculated using Spearman correlations. The mean rate or mean duration per sample of behaviour (Table 4.3) was not dependent on visitor density in either the orangutan feeder condition or the orangutan-visitor feeder condition.

Sumatran orangutan BEHAVIOUR	Experimental Conditions					
	Orangutan Feeder		Orangutan-Visitor Feeders		Baseline	
	r	*p*	r	*p*	r	*p*
< *one meter* (d)	.105	.381	.136	.291	-.090	.463
< *one meter* (f)	NA	NA	-.035	.787	NA	NA
< *three meters* (d)	.099	.409	-.048	.712	.139	.254
< *three meters* (f)	.139	.236	-.029	.821	NA	NA
> *three meters* (d)	-.040	.736	.050	.699	-.123	.316
> *three meters* (f)	.690	.554	-.083	.516	NA	NA
contact (d)	.093	.437	.031	.811	-.031	.803
contact (f)	.194	.889	-.024	.850	.028	.819
feed/forage (d)	.203	.087	-076	.556	.075	.538
feed/forage (f)	.137	.241	-.179	.157	.061	.621
head cover (d)	NA	NA	NA	NA	.067	.582
head cover (f)	NA	NA	NA	NA	.040	.746
locomote (d)	-.022	.856	.078	.549	-.185	.128
locomote (f)	-.120	.304	.112	.378	.012	.922

Sumatran orangutan BEHAVIOUR	Experimental Conditions					
	Orangutan Feeder		Orangutan-Visitor Feeders		Baseline	
	r	*p*	r	*p*	r	*p*
monitor visitor area (d)	-.085	.478	.212	.098	.244	.043
monitor visitor area (f)	.016	.889	.131	.300	.132	.280
proximity (d)	-.022	.852	.030	.814	-.019	.876
proximity (f)	-.004	.974	.037	.772	.025	.836
rest (d)	-.057	.631	.046	.724	-.042	.723
rest (f)	-.060	.610	.217	.085	.116	.342
scratch self (f)	-.193	.098	.245	.051	NA	NA
social play (d)	NA	NA	NA	NA	-.189	.119
solitary play (d)	NA	NA	-.023	.861	NA	NA
solitary play (f)	NA	NA	.041	.747	NA	NA
use experimental feeder (d)	.026	.832	.049	.703	NA	NA
use experimental feeder (f)	NA	NA	-.032	.804	NA	NA
use non-experimental feeder (d)	-.075	.531	.056	.664	NA	NA
use non-experimental feeder (f)	-.023	.843	NA	NA	NA	NA

Table 4.3 The relationship between visitor density and Sumatran orangutan behaviour in the experimental conditions. Trends are shaded. (f)= frequency, (d)= duration. NA= behaviour did not occur frequently to warrant statistical analysis. Orangutan feeder condition: (f)= 75, (d) n= 72; Orangutan-visitor feeders: (f) n= 64, (d) n= 62; Baseline: (f) n= 69; (d) n= 69.

4.6.5 The Relationship Between Visitor Noise and Orangutan Behaviour in the Experimental Conditions

The relationship between visitor noise and Sumatran behaviour in the experimental conditions was also determined by calculating Spearman correlations. The behaviour *use of experimental puzzle feeder* was significantly positively correlated with the median decibel per sample in the orangutan feeder condition, while *locomote* was significantly negatively correlated with visitor noise in this condition. Several other behaviours showed trends toward association with decibel levels, including *head cover*, *proximity*, and *rest*, but these relationships did not achieve statistical significance.

A significant relationship between visitor noise and orangutan behaviour in the orangutan-visitor feeders condition was also identified. The duration of *feed/forage* and *use experimental feeder* were significantly negatively correlated with decibel levels in the orangutan-visitor feeders condition. The duration of < *one meter* and *rest* showed a trend toward positive correlation with decibels levels, but these relationships were not statistically significant. Table 4.4 presents the results of the Spearman correlations in the orangutan feeder and orangutan-visitor feeders conditions. Figures 4.8-4.16 show the relationship between visitor noise and orangutan behaviour in the orangutan feeder condition and the orangutan-visitor feeders condition.

Sumatran orangutan BEHAVIOUR	Experimental Conditions					
	Orangutan Feeder		Orangutan-Visitor Feeders		Baseline	
	r	*p*	r	*p*	r	*p*
< *one meter* (d)	-.510	.062	.206	.014	.004	.963
< *one meter* (f)	NA	NA	-.129	.113	NA	NA
< *three meters* (d)	.108	.181	.108	.181	.176	.057
< *three meters* (f)	-.034	.666	-.034	.666	-.045	.627
> *three meters* (d)	-.064	.432	-.116	.169	**-.311**	**.001**
> *three meters* (f)	-.064	.424	-.048	.558	NA	NA
contact (d)	-.078	.334	.081	.338	.067	.475
contact (f)	-.008	.918	-.052	.526	.134	.150
***feed/forage* (d)**	.045	.582	**-.277**	**.001**	-.045	.632
feed/forage (f)	.027	.732	-.149	.066	-.071	.449
head cover (d)	.176	.029	NA	NA	.091	.330
locomote (d)	-.105	.197	.037	.660	-.099	.290
***locomote* (f)**	**-.209**	**.008**	-.066	.415	.004	.965
monitor visitor area (d)	-.147	.069	.148	.078	-.025	.786
monitor visitor area (f)	-.069	.383	-.045	.584	.075	.421
proximity (d)	-.011	.890	-.075	.374	-.016	.861
proximity (f)	-.156	.049	-.083	.306	.087	.350
rest (d)	-.019	.819	.194	.021	-.167	.072
rest (f)	-.178	.025	.078	.337	.028	.766
scratch (f)	-.121	.128	-.014	.868	NA	NA
***social groom* (d)**	NA	NA	NA	NA	**.284**	**.002**
social play (d)	-.060	.458	NA	NA	-.085	.364
solitary groom (d)	NA	N	NA	NA	-.044	.635
solitary play (d)	NA	NA	.002	.978	NA	NA
solitary play (f)	NA	NA	-.022	.791	NA	NA
***use experimental feeder* (d)**	**.221**	**.006**	**-.238**	**.004**	NA	NA
use experimental feeder (f)	.012	.877	-.116	.152	NA	NA
use non-experimental feeder (d)	-.152	.059	-.038	.651	NA	NA
use non-experimental feeder (f)	-.094	.237	NA	NA	NA	NA

Table 4.4 The relationship between visitor noise and Sumatran orangutan behaviour in the experimental conditions. Significant results in bold text; trends are shaded. NA= behaviour did not occur frequently to warrant statistical analysis. Orangutan feeder condition: (f) n= 160, (d) n= 154; Orangutan-visitor feeders condition: (f) n= 153, (d) n= 142; Baseline: n= 117.

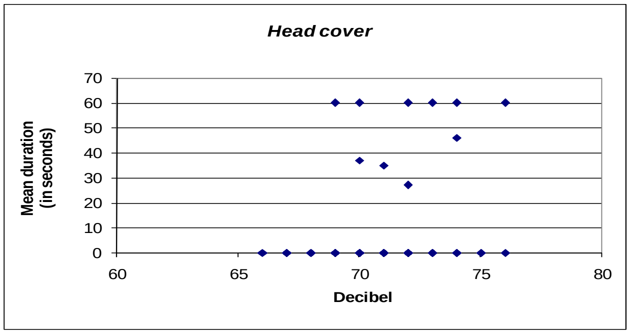

Figure 4.8 The positive relationship between visitor noise and the duration of *head cover* in the orangutan feeder condition.

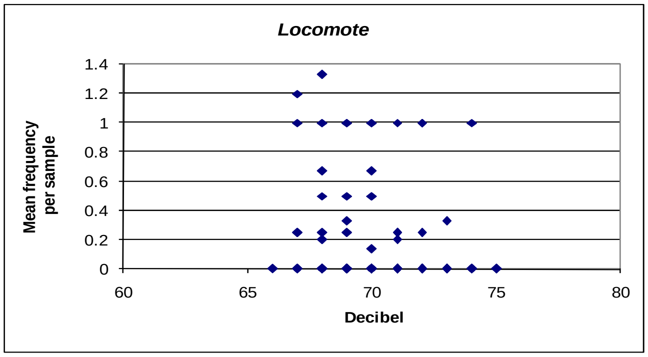

Figure 4.9 The negative relationship between visitor noise and the frequency of *locomote* in the orangutan feeder condition.

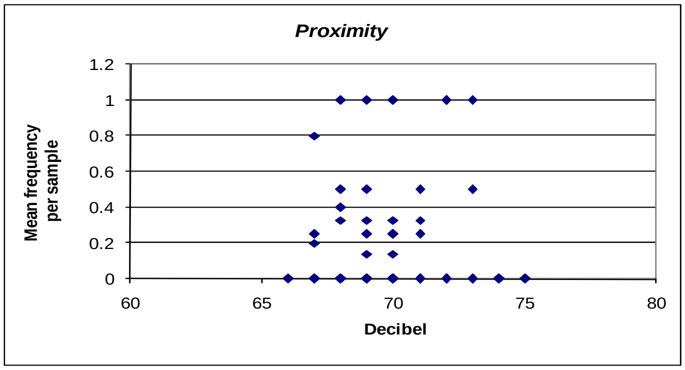

Figure 4.10 The negative relationship between visitor noise and the frequency of *proximity* in the orangutan feeder condition.

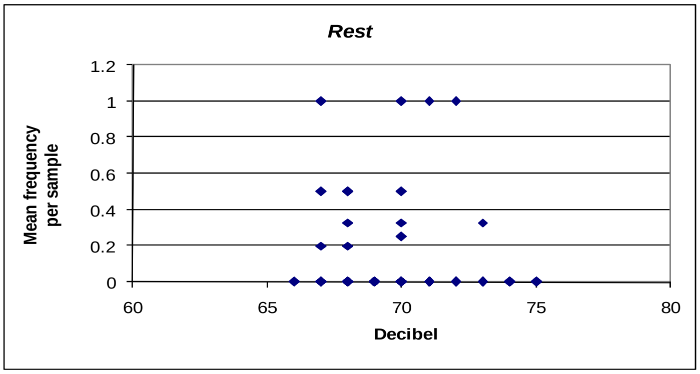

Figure 4.11 The negative relationship between visitor noise and the frequency of *rest* in the orangutan feeder condition.

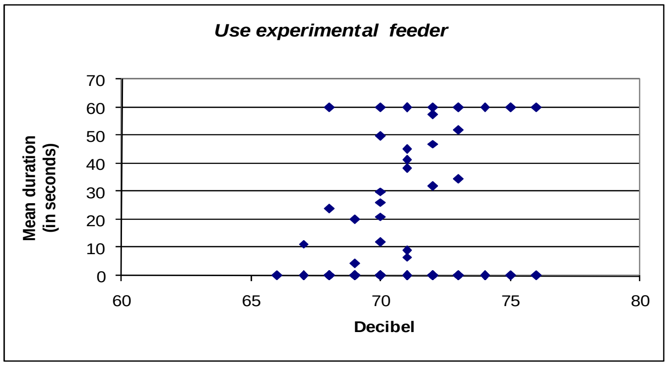

Figure 4.12 The positive relationship between visitor noise and the duration of *use experimental feeder* in the orangutan feeder condition.

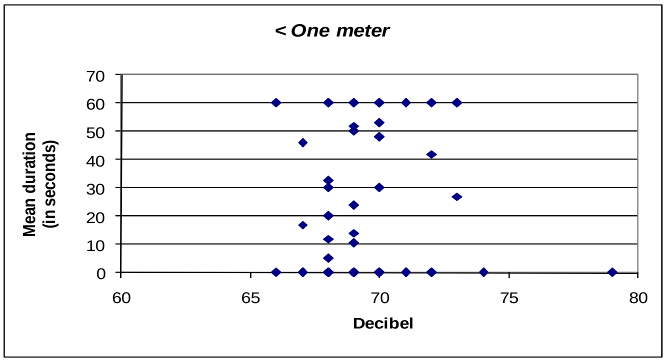

Figure 4.13 The positive relationship between visitor noise and the duration of *< one meter* in the orangutan-visitor feeders condition.

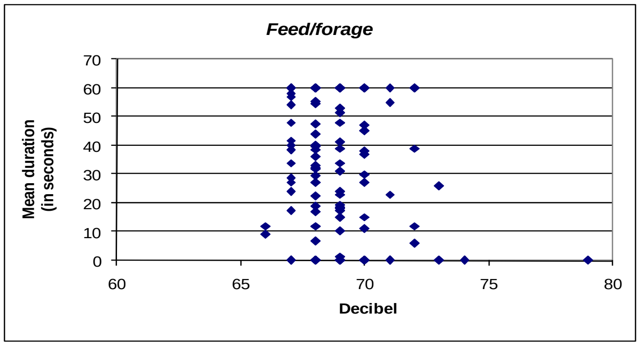

Figure 4.14 The negative relationship between visitor noise and the duration of *feed/forage* in the orangutan-visitor feeders condition.

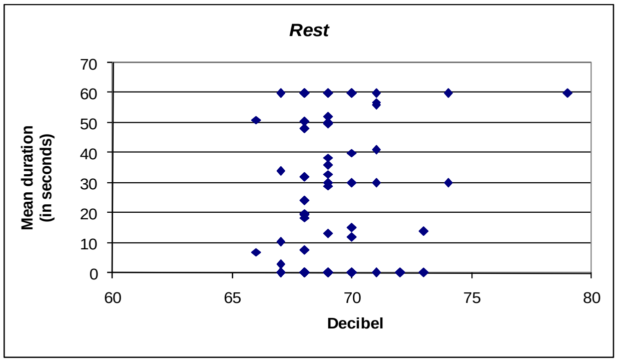

Figure 4.15 The positive relationship between visitor noise and the duration of *rest* in the orangutan-visitor feeders condition.

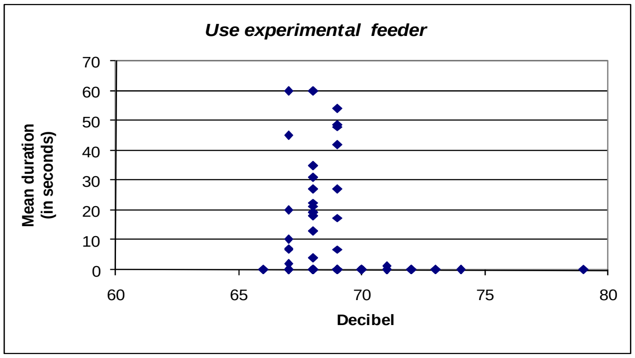

Figure 4.16 The negative relationship between visitor noise and the duration of *use experimental feeder* in the orangutan-visitor feeders condition.

4.6.6 Visitor Behaviour

To determine if the installation of the visitor puzzle feeder affected visitor behaviour, randomisation tests were computed for several behaviours such as hitting or banging on viewing windows and mimicking animal noises. The rate of the visitor behaviours measured, hitting viewing windows and mimicking animal vocalisations, did not change between experimental conditions (Table 4.5).

Visitor Behaviour	Test Statistic	*p*	n
Visitors hit window (f)	-.467	.220	7
Visitors mimic vocalisation (f)	-.600	.315	9

Table 4.5 The results of randomisation tests comparing visitor behaviour between the baseline and orangutan-visitor feeders conditions.

4.7 Discussion

4.7.1 Confounding Variables

The consistency of visitor density and visitor noise between the baseline and the orangutan feeder conditions suggests the change identified in orangutan behaviour following the installation of the orangutan feeder in the enclosure was not due to these visitor-related variables. The trends for density and noise to decrease between the orangutan feeder condition and the orangutan-visitor feeders condition, however, may have contributed to the observed behavioural changes in the study group. The decrease in visitor noise is not necessarily related to the decrease in visitor density because, as reported in Chapter 2, the two variables are not correlated at this exhibit. Because the changes in visitor density and noise were not statistically significant, it is reasonable to assume that the behavioural changes observed were not wholly due to the decrease in density and noise levels at the exhibit.

4.7.2 Behavioural Change in the Orangutan Feeder Condition

The installation of the experimental puzzle feeder had a limited effect on the behaviour of the Sumatran orangutans and none of the behaviours collected were significantly altered by the presence of the feeder. Social play was the only behaviour that showed an appreciable change, and the decrease in the duration of this behaviour was not predicted. While this result is not a desirable outcome for a device that was hypothesised to enrich the environment of the study group, an examination of individual data indicate that this unexpected outcome can be attributed to the age of the study animal that used the device most frequently. Jahe, a seven-year old female and the youngest member of the group, used the puzzle feeder more frequently and was also the group member who spent the most time playing socially. Therefore, it appears that some of the time Jahe spent playing with others in the baseline condition was redirected towards manipulating the puzzle feeder in the orangutan feeder condition.

4.7.3 The Orangutan-visitor Feeders Condition

The trend toward decreased time spent manipulating the experimental device with a tool-like object in the orangutan-visitor feeders condition may be attributed to their increased skill at achieving a reward with their hands or mouths alone over the course of the experiment. It is unlikely that this is a sign of habituation to the device, as one would also expect to see a decrease in overall use of the feeder between conditions.

The prediction that the orangutans would show interest in watching visitors use the visitor puzzle feeder was not supported by the data and the orangutans did not watch the visitors manipulate the visitor puzzle feeder. The lack of extensive behavioural change in the orangutans following the installation of the visitor puzzle feeder suggests the prediction that orangutan feeding and foraging behaviour and use of the puzzle feeder device would increase was also incorrect. Several factors may have contributed to the visitor puzzle feeder not stimulating the orangutans to use their puzzle feeder more frequently or for longer periods of time. The proximity of the orangutan puzzle feeder to the visitor puzzle feeder may not have been close enough for the orangutans to properly observe zoo visitors manipulate the device. The qualitative difference in the feeder rewards (the edible reward for the orangutans versus the inedible reward given to visitors) may also have affected the outcome of this experiment.

The selection of the puzzle feeder device may have also played a role in the lack of an effect. Although the visitors used the puzzle feeder (n= 9), the total time spent using the device was substantially less than the orangutans, suggesting the visitors did not find the puzzle feeder stimulating. One of the challenges of this experiment was to select an experimental device suitable for both nonhuman and human primates. The inability of the device to provide enrichment for the study orangutans and zoo visitors suggests the mechanism through which a positive visitor effect is investigated probably needs to be more stimulating for both visitors and the study animals so that they are motivated to participate in the experiment.

4.7.4 Visitor Density Effects in the Experimental Conditions

Given the trend toward decreased in visitor density between the orangutan feeder condition and the orangutan-visitor feeders conditions (but not between baseline and orangutan feeder conditions), the interpretation of the effect of the puzzle feeder on the association between visitor density and orangutan behaviour across the experimental conditions should be conservative. The orangutan group's minimal behavioural response to visitor density reported in Chapter 2 continued in the puzzle feeder experiment. Although the puzzle feeders may have played a role in removing the trend to associate *monitor visitor area* and density, it is likely that decreased visitor density required less vigilance or fewer people was less stimulating visually to the apes.

4.7.5 Visitor Noise in the Experimental Conditions

The reduced level of visitor noise between the experimental conditions would predict less of a visitor noise effect, but this was not the case. Higher levels of visitor noise continued to affect the study group in both feeder conditions, although there was a qualitative shift from a positive visitor noise association to one that was overall less positive for the group and their welfare. The trend toward increased time spent covering their heads when noisy visitors were present suggests the puzzle feeder was associated with increased sensitivity to visitor noise. Captive orangutans have been observed to cover their heads, presumably to block out zoo visitor stimuli (Birke 2002). Contrary to her prediction, Birke observed that her study group did not use sacks to cover their heads significantly more in the presence of noisy crowds; in fact, Birke identified a slight, non-significant decline in sack use in the presence of noisy visitors. The data from this experiment are not consistent with Birke's results and suggest there may be environmental or group composition factors which affect the response of zoo orangutans to visitor noise.

The orangutans spent significantly more time using the puzzle feeder when visitors were noisy, but following the installation of the visitor puzzle feeder, the orangutans spent significantly less time using the device in noisy conditions. The reason for the shift in the quality of the association is not clear, but it may be related to the decrease in the median decibel per sample in the orangutan-visitor feeders condition. Given the enriching association between visitor noise and orangutan behaviour in the baseline condition and the more extensive behavioural association between noise and behaviour in the two feeder conditions, it appears that higher levels of visitor noise had less of a negative impact on welfare than did the presence of the puzzle feeders.

4.7.6 Visitor Behaviour in the Experimental Conditions

Visitor behaviour was predicted to change between the baseline and orangutan-visitor feeders condition but this prediction was not supported by the data. The median decibel per sample did change between the orangutan feeder condition and the orangutan-visitor feeders condition, although not significantly, indicating that the presence of the visitor puzzle feeder may have contributed to quieter visitors. Although there was also a decrease in the median density level per sample between these conditions, it is not likely that this change was wholly responsible for the reduced levels of noise because, as demonstrated in Chapter 2, noise and density were not correlated for the Sumatran orangutan enclosure. Anecdotal claims of reduced visitor noise following the installation of camouflage nets over visitor viewing windows in a study of zoo-housed gorillas have been made (Blaney and Wells 2004), which suggests that it may be possible to affect visitor behaviour with enclosure modifications or enrichment devices.

The presence of the visitor puzzle feeder was also ineffective in reducing the rate of visitors hitting or kicking the viewing windows and mimicking primate vocalisations. Although the behaviours did not occur frequently at the orangutan enclosure, previous research has documented the negative effect of overt visitor behaviour on primates (Hosey and Druck 1986, Chamove et al 1988, Mitchell et al 1992b, Cook and Hosey 1995).

4.8 Conclusion

Providing the puzzle feeders to orangutans and zoo visitors did not result in a positive visitor effect on the study animals. The lack of behavioural change in the orangutan feeder condition suggests the puzzle feeder foraging device was not enriching to the orangutans and the introduction of the visitor puzzle feeder did not facilitate increased use of the orangutan feeder nor did the orangutans watch the visitors use the visitor puzzle feeder. The two experimental conditions in which the puzzle feeders were present changed the relationship between visitor noise and orangutan behaviour, but none of these changes supported a conclusion of an extensive positive visitor effect; the relationship between visitor density and orangutan behaviour remained essentially neutral across the three experimental conditions, while visitor noise effects were mixed. The predicted decrease in negative visitor behaviours, such as hitting the viewing windows and mimicking primate vocalisations, were not supported by the data.

There are several factors that may explain why a positive visitor effect was not achieved. The most obvious explanation is the positive visitor hypothesis is false and visitors only have a neutral or negative effect on the behaviour and welfare of zoo animals. The visitor effect literature generally supports this conclusion, but the work of Markowitz (1982) suggests that there are zoo conditions in which a positive visitor effect can be achieved. It is also possible that the lack of a positive visitor effect was due to the inability of the puzzle feeder devices to provide enrichment to the Sumatran orangutans or the zoo visitors. It is possible that a more stimulating or interactive device, such as the game used by Markowitz, would have been more successful in achieving a positive visitor effect. Although the feeders were used by the orangutans and visitors, the devices failed to have a more generalised effect on orangutan and visitor behaviour and therefore cannot be considered enrichment devices. The third hypothesis for the failure to achieve a positive visitor effect may be related to a failure to provide experimental conditions in which stimulus enhancement could be achieved. The results of the puzzle feeder experiment suggest that achieving a positive visitor effect is unlikely to be achieved by providing puzzle feeders to Sumatran orangutans and zoo visitors.

CHAPTER 5: The Role of Olfaction in the Visitor Effect

5.1 Introduction

Visitor effect studies have ignored the olfactory stimuli associated with zoo visitors and the experiment presented in this chapter explores the possibility of an olfactory visitor effect on the behaviour of three mammalian species. As discussed in Chapter 2, visitor effect research has focused primarily on the number of visitors present, and to a lesser extent visitor behaviour and noise, as the visitor-related variables that most affect captive animal behaviour. This focus has identified a visual and/or auditory visitor effect in many of the species studied and contributed significantly to our understanding of the visitor effect. However, a third sense modality with the potential to contribute to the visitor effect in zoo-housed mammals, olfaction, has yet to be investigated. The study animals in this experiment, chimpanzees (*Pan troglodytes*), hamadryas baboons (*Papio hamadryas*), and Bengal tigers (*Panthera tigris tigris*), were presented with olfactory stimuli in their enclosure, followed by an experimental condition in which the visitors in the viewing areas were holding olfactory stimuli. The behavioural responses of the three species in baseline and two experimental conditions are compared statistically to explore the olfactory visitor effect hypothesis.

The lack of data on the influence of visitor-related olfactory stimuli may partially be explained by the visitor effect research bias towards primates as study species. The scientific literature on visitor effects overwhelmingly favours primate species (Hosey 2000) and thus concentrates on their primary sense modes.

Although many primates rely on their olfactory system to provide information on their environment and conspecifics, primates are also heavily dependent on visual and auditory cues to gather information about their surroundings, justifiably leading visitor effect researchers to investigate the visual and auditory influence of zoo visitors first.

Despite the primate bias in visitor effect research prior to the year 2000, more recent research has been conducted on non-primate mammals that included visitor-related variables, including studies on felids (Sellinger and Ha 2005, Cunningham 2004, Margulis et al 2003, Mallapur and Chellam 2002, O'Donovan 1993), giant pandas (Owen et al 2004), and ungulates (Anderson et al 2004, Anderson et al 2002, Thompson 1989), and yet the olfactory impact of zoo visitors remains unknown. Although several of these studies were not devoted solely to investigating a visitor effect, the influence of visitors was a factor deemed worthy of measurement, and yet a potential olfactory component of the visitor effect was apparently not considered. Although it may be unreasonable to expect researchers to delve into the subtleties of the visitor effect in studies with a broader focus, the effect of visitor-related olfactory stimuli is certainly a hypothesis worthy of investigation.

In addition to the primate bias in visitor effect research, methodological concerns may have prevented experimental exploration of an olfactory visitor effect. The difficulty in experimentally manipulating visitor-related olfactory stimuli, as well as correctly measuring the intensity of olfactory stimuli, are likely to contribute to the paucity of data on an olfactory visitor effect in zoo animals.

Zoo visitors bring a multitude of odours into the captive environment, such as perfume, cosmetics, food, and beverages, and it is not possible for the researcher to control visitors’ use of these products or get an accurate report from visitors about the products they recently used or are carrying with them into the zoo. Given these methodological hurdles, determining the collective influence of the odours visitors bring into the zoo on animal behaviour is difficult to accomplish. The research methods used in this experiment are not an attempt to approximate “visitor odour” but rather an exploration of whether visitors are potentially a significant source of olfactory interest to zoo-housed animals or if they appear to be habituated to scent carried by or associated with zoo visitors.

5.1.1 Rationale for Selection of Study Species

Three species of mammal were selected for this experiment based on several selection criteria: 1) the visitor effect literature 2) hypothesised or documented response to olfactory environmental enrichment. The two primate species, chimpanzees and hamadryas baboons, were selected because primates have been shown in previous research to be influenced by the presence and behaviour of zoo visitors (Hosey 2000) and chimpanzees have been identified as motivated to interact with zoo visitors (Cook and Hosey 1995). A felid species, Bengal tigers, was included because there are data on captive felids suggesting the impact of visitors may not be significant (Margulis et al 2003, McPhee 2002, O’Donovan et al 1993), although the response of this species to zoo visitors is not known.

The three study species were also selected because of their differing reliance on olfaction to understand their environment. While many kinds of primates, such as prosimians and New World monkeys, use olfactory communication to disseminate and receive information, Old World monkeys and great apes are generally thought to be more visually and auditorally oriented to their environment (Cachel 2006). The vomeronasal organ, present in lemurs, lorises, tarsiers, and some New World monkeys, has been identified as the part of the olfactory system which processes chemicals produced by other conspecifics to convey socio-sexual information, but the function of this organ appears to be reduced in Old World monkeys and great apes (Fleagle 1999). The distinction between strepsirhine and haplorhine primates, based on the anatomy of the external nostril, also suggests that the function of the vomeronasal organ is moderated in the higher primates.

Olfactory environmental enrichment experiments using non-conspecific stimuli on Old World monkeys or apes are not common in the literature. Ostrower and Brent (1997) presented eight odours (vanilla, orange, peach, garlic, smoked oyster juice, limburger cheese, moth balls, and cigar smoke) on cloths to 21 laboratory chimpanzees and the study animals did not show significantly more interest in the scented cloths than unscented cloths. Hepper et al (2005) observed that zoo-housed western lowland gorillas (*Gorilla gorilla gorilla*) responded to food odours on scented cloths with more interest than they showed in the unscented cloths.

Contrastingly, felids appear to be highly responsive to olfactory stimulation introduced into their zoo enclosures (Mellen 1998) and may be more likely to be affected by visitor odours. The impact of non-conspecific odours on behaviour has been tested on several felid species. Wells and Egli (2004) tested the effect of nutmeg, catnip, and quail on the behaviour of a small cat, the black-footed cat (*Felis nigripes*), and recorded increased active behaviours such as exploration and a decrease in sedentary behaviour such as sitting, standing, and resting. Powell (1995) observed that the presentation of musk cologne, peppermint, allspice, and almond extracts elicited increased sniffing and flehmen responses from four zoo-housed lions (*Panthera leo*). Others have qualitatively described the enriching impact of scents on large cats. Ziegler and Roletto (2000) provides anecdotal evidence of the effect of the perfume Angelfire™ on a Bengal tiger and a jaguar (*Panthera onca*), noting the cats responded to the presentation of the stimuli by drooling, showing flehmen, and rolling in, scratching on, or playing with objects that had been sprayed with the perfume. Schuett and Frase (2001) supplied their lion study group with cinnamon, chilli powder, ginger, and zebra dung and observed that the lions exhibited a broader range of social behaviours and performed them more frequently, as well as increased olfactory exploratory behaviours.

5.1.2 Rationale for Selection of Study Scents

The selection of the odours for this experiment was based on methodological concerns about being able to ensure a reliable presentation of the olfactory stimuli. Perfumes and cosmetics are likely to be partially responsible for the hypothetical olfactory visitor effect, but they were deemed inappropriate for this experiment because the observer would be unable to separate the effect of the experimental stimuli from the products used by visitors attending the zoo but not participating in the experiment. The smell of food is probably of interest to zoo animals and there is evidence that the act of zoo visitors eating bananas while standing in front of monkey enclosures influenced primate behaviour. Buchanan-Smith (2004) found that six species of primate, black lemurs (*Eulemur macaco flavifrons*), black howlers (*Alouatta caraya*), titi monkeys (*Callicebus cupreus*), L'hoest monkeys (*Cercopithecus l'hoesti*), and gelada baboons (*Theropithecus gelada*) increased the amount of time they spent looking at visitors when visitors were eating bananas.

Despite the interest zoo primates show in visitors and human food, using the odours of foods humans might be consuming at the zoo is problematic for the same reason that cosmetics and perfume were: the overlap of non-experimental stimuli with experimental stimuli. However, despite this concern, it was decided that because food items were likely to be a source of interest to zoo animals, it was important to test at least one food-related olfactory stimulus for each species. Therefore, almond and banana were chosen as two of the experimental scents for the primates.

The overlap of experimental and non-experimental food scents are less of an issue for the tiger study group because it was improbable that zoo visitors would be eating food that would interest them, although meat products such as hot dogs and hamburgers were for sale at the concessions stands[1]. Because of the airborne nature of odours, and the frequency of its occurrence during the summer months when this experiment was conducted, it was not considered useful or feasible to record the eating habits of visitors during observations. Several scents resembling the type of animal that might fall prey to hunting felids were selected as experimental stimuli for the tiger group; these prey odours are analogous to the food smells chosen for the primates. The chosen scents, rabbit and quail, are unlikely prey for tigers in the wild but were hypothesised to simulate more suitable larger prey; deer scented products would have been a more obvious choice, but due to the proximity of many ungulate species to the tiger enclosure, the risk of olfactory stimuli overlap might have compromised the experiment.

Potentially enriching but biologically irrelevant scents were also selected for inclusion in the experiment. Quail scent was hypothesised to be innocuous to the two primate study species and was selected for experimentation with the monkeys and apes. A more common olfactory enrichment scent, catnip, was used experimentally for the tigers because of its pleasing scent for visitors as well as the documented effects on cat behaviour (Wells and Egli 2004).

Potentially threatening odours were also tested to determine if odour from visitor areas was a potential welfare concern for zoo animals. The scent of a large predator was selected to test the influence of the odour on the primates, although the chosen species, bobcat, was not one that the chimpanzees or hamadryas baboons would encounter in the wild. Because tigers do not have any predators

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[1] The concessions stands were approximately 200 meters from the tiger enclosure and were not visible to the tigers.

except humans, bobcat and bear scents were chosen to represent other large carnivores. For this experiment, commercially available urines and tracking scents were purchased for use for all the animal scents because their supply was plentiful and reliable.

Faeces and scent gland secretions, not urine, are the more common modes of introducing scent for environmental enrichment or research purposes into a zoo enclosure. Urine, however, has the advantage over faeces in that it is sterile and does not pose a health risk to the study animals. For this reason, urine was chosen as one of the experimental stimuli. The author is unaware of any zoos using urine for environmental enrichment or research purposes and the results of this study may be helpful in determining whether urine is useful for such programmes.

In addition to determining the interest zoo animals have in the scents and the role olfaction might play in the visitor effect, testing the experimental animal odours might also be useful in understanding whether the olfactory presence of other animals at a zoo influence animal behaviour. Buchanan-Smith et al (1993) found that introducing the scent of predators into cotton-top tamarin (*Saguinus oedipus*) enclosures in a primate laboratory unit increased anxious behaviour and suggested caution when housing predator and prey species where they might have olfactory contact. McCusker and Smith (2004) tested the influence of the scent of a natural predator, the fossa (*Cryptoprocta ferox*), and a closely related primate, the black and white ruffed lemur (*Varecia variegata variegata*), on the behaviour of six ring-tailed lemurs (*Lemur catta*) and these scents were associated with decreased social behaviour between the study animals.

5.1.3 Animal Welfare Issues

The introduction of potentially stressful scents into zoo animal enclosures was not undertaken without concern for animal welfare. The animals were monitored daily for behavioural signs of decreased physical and psychological health by the researcher and by the zoo staff as part of their normal husbandry routines. Explicit within the research proposal was the proviso that if any study animal showed any serious negative responses to the olfactory stimuli, the research project would be immediately discontinued.

5.1.4 The Study and Its Objectives

Following a baseline data collection period, individual scents were introduced into the enclosure on test days in the same manner as is often done in olfactory enrichment programmes. This step was important in ascertaining if the study animals responded to the experimental stimuli when the odours were not associated with visitors. The second experimental condition pairs the olfactory stimuli with the visitors in an effort to determine if visitors are likely to be a source of olfactory stimulation. Although this experiment cannot determine if the olfactory stimuli associated with visitors under everyday, non-experimental conditions influence the study animals' behaviour directly, it is possible to explore whether an olfactory visitor-related impact is probable and whether it could influence zoo animal welfare.

5.2 Research Objectives

1. Identify the effect of potential confounding variables, such as visitor density, temperature, and wind speed, which might contribute to changes in animal behaviour between the baseline and experimental conditions.
2. Identify changes in chimpanzee, hamadryas baboon, and Bengal tiger behaviour following the introduction of the olfactory stimuli in their enclosure.
3. Determine if changes in study group behaviour on the day of introduction of the olfactory stimuli remain on the following day when no fresh stimulus is introduced.
4. Identify changes in animal behaviour in the presence of visitors carrying olfactory stimuli.
5. Determine if the presence of olfactory stimuli within the enclosure or visitors carrying the olfactory stimuli moderates or exacerbates the visitor effect identified in the study groups in Chapter 2.

5.3 Methods

The olfactory experiment was performed at the Oakland Zoo in California (USA). Three species groups were used in the experiment; the composition of the Bengal tiger, hamadryas baboon, and chimpanzee groups are detailed in Appendix A. The barriers nearest the visitor viewing areas of the animal enclosures were all some form of chain-link metal fence, although the chimpanzee enclosure had several small viewing windows at either end of the enclosure (see Appendix C for enclosure descriptions). Instantaneous scan samples (Martin and Bateson 1986), each ten minutes long, were used to collect the behavioural data; there was a one minute interval between sample points in each scan. Appendix B lists the behaviours collected and their definitions for this experiment. The speed of the wind (kilometers per hour) and the temperature (Celsius) were collected at the beginning of each ten-minute instantaneous scan sample using a Skymate SM-18 (Speedtech Instruments) wind meter.

Data were collected on a Psion Workabout using the behavioural software program *The Observer* (Noldus). The occurrence of behaviours at sample points was calculated using The Observer's Elementary Statistics feature and then exported to SPSS for further statistical analyses.

5.4 Procedures

Six hours of baseline data were collected on each of the three study groups in March and April 2004. The enclosure olfactory stimuli were then tested over four weeks in June 2004, and will be referred to as the enclosure olfactory condition. The Oakland Zoo keepers placed olfactory stimulus in the enclosure in the morning during regular feeding and cleaning routines. Keepers placed the stimulus in the same two locations in the enclosures each time so that the researcher could differentiate between study animals' reactions to the experimental stimuli and non-test stimuli. In each of the three enclosures, one of the olfactory stimulus locations was located within one meter of the enclosure barrier near a visitor viewing area and the other was visible to visitors, but not near the perimeter of the exhibit. Four olfactory stimuli were tested for each species. The primates groups were exposed to the same four scents: banana (*Musa* spp.), almond (*Prunus amygdalus*), quail (*Callipepla* spp.), and bobcat (*Lynx rufus*). The Bengal tiger group was exposed to black bear (*Ursus americanus*), catnip (*Nepeta cataria*), rabbit (*Sylvilagus* spp.), and bobcat scents.

The olfactory stimuli were purchased from companies who provide hunting lures and lure ingredients. The bobcat, bear, and rabbit olfactory stimuli were urines; 30 ml of urine were placed in each location in the enclosures. The quail stimulus was a commercially available hunting dog training scent (Cabela's™); 30 ml of the quail liquid was placed in each location in the enclosures. The catnip, banana, and almond scent stimuli were essential oils; ten drops of essential oil were placed in each location. Data were collected on the day the olfactory enrichment was presented to the study groups as well as on the following day to gauge the short term effects of this method of olfactory enrichment. In this condition, the scents were randomly assigned to observation days, rather than individual scans, because alternating scents while the study groups were on display was impractical. Table 5.1 shows the amount of data collected on each study group.

Study Group	Day 1 Olfactory Enrichment Introduced	Day 2 Olfactory Enrichment 24 hours Old
Hamadryas baboons	14	8
Chimpanzees	15	11
Bengal tigers	15	10

Table 5.1 Number of hours of data collected on each study group during the enclosure olfactory condition.

The olfactory stimuli incorporating zoo visitors were tested during July 2004, and will be called the smelly visitor condition. The olfactory mechanism used in this condition was sponges soaked with the olfactory stimuli; the sponges were then attached to wooden handles, about 10 centimeters in length, for ease of visitor use. The stimuli and amount were the same as in the previous condition except for the essential oils; 30 drops of the almond, catnip, and banana essential oils were used to compensate for the distance between visitors and study animals.

Visitors were approached and asked if they would like to participate in the research project. The visitors were debriefed and then given instructions. Visitors were asked to remain within the visitor viewing areas and not to use the olfactory stimulus tool to try to draw the attention of the study groups. The visitors were then given the olfactory stimulus and the ten minute scan was collected. During some scans, no visitors were interested in taking part in the experiment; in these cases, the researcher held the olfactory stimuli for the duration of the scan. Six hours of data for each of the three species groups were collected during the smelly visitor condition. Scents were randomly assigned to blocks of two scans in this condition.

5.5 Statistical Analysis

The statistical analyses performed for this experiment were similar to those in previous chapters. Once again, non-parametric tests were chosen because of the single-case experimental design and data which were not normally distributed. Randomisation tests were calculated to determine the changes in behaviour between conditions, using Design 1 in Todman and Dugard (2001). The test statistic for Design 1 is the difference in condition means. Medians were the measure of central tendency used and box plots, showing the interquartile range, were the method of graphic presentation of the data. All boxplots use circles to represent outlying data points (1.5 box-lengths from the edge of the box) and asterisks to represent extreme outlying data points (3 box-lengths from the edge of the box). The effect of the three confounding variables, visitor density, wind speed, and temperature, were also investigated using this design. The median visitor density was calculated for each scan, to avoid the pitfalls of autocorrelation (BIAZA 2006) while the raw figures of wind speed and temperature were used because they were collected only once per scan.

The subsequent analyses comparing the effects of the individual olfactory scents on study groups' behaviour required the use of an alternating randomisation test, Design 5, because the scents were randomly assigned to treatment days for the enclosure olfactory condition and randomly assigned to observation periods in the smelly visitor condition. Only the behaviours identified statistically as significantly affected by the introduction of the olfactory stimuli were investigated further to understand if their expression was dependent on the type of olfactory stimulus presented. The test statistic for Design 5 is the residual sum of squares.

Randomisation tests were not suitable for several of the follow-up analyses of the data. Determining whether the effect of the olfactory stimuli remained on the day following its introduction required an analysis that was not suitable for the randomisation test designs provided by Todman and Dugard. These data were explored using descriptive statistics. Once again, the behaviours analysed were only the behaviours previously identified as having changed significantly from the baseline condition. Medians and interquartile ranges did not always convey enough information to properly evaluate the data because they were often equal to zero; therefore, mean and standard error of the mean were used to further aid in analysis when medians were equal to zero. Changes in the proportion of behaviour of at least five percent from the median (or the mean when the median is zero) were considered to be worthy of discussion and are, therefore, presented in bold text in the tables for easy reference.

The visitor density correlations were calculated in the same manner as in Chapter 2. A density category legend is provided in the first graph for each set of significant results. Visitor density was collected on the minute for every sample point and each density category was aggregated for each scan because they were not independent. The distribution of the data was analysed and found not to be normal, recommending the use of the non-parametric form of correlation, Spearman rank order correlation.

In conditions in which there was a significant change in the time the study groups spent *out of sight*, proportions were calculated using the number of sample points the animals were visible, not the total number of sample points. In conditions in which *out of sight* did not change significantly, the proportion of total sample time is used for the sake of consistency with the other data chapters.

5.6 Results

5.6.1 Baseline Activity Budgets

The baseline activity budgets of the three study groups were calculated and behaviours that comprised at least one percent of the total time sampled are presented in Figures 5.1-5.3. Resting behaviour represented the greatest percentage of each study species time budgets, suggesting that increased stimulation, such as the test enrichment, might contribute to increased physical and mental health of the animals.

The only stereotypies observed in the three study groups were performed by the Bengal tiger group. The behaviour, pacing (3%), was performed mostly by only one of the tigers and appeared to occur most often when a member of the zoo staff was present near the enclosure. Because the researcher had an obstructed view of staff activity surrounding the tiger enclosure, quantitative data were not collected on the effect of zoo employee presence or activity on tiger behaviour.

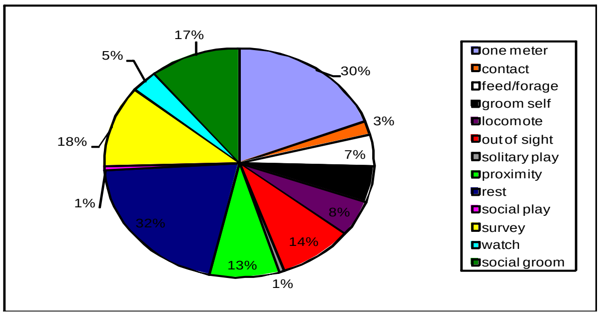

Figure 5.1 The percentage of total sample time the chimpanzee group engaged in the behaviours collected.

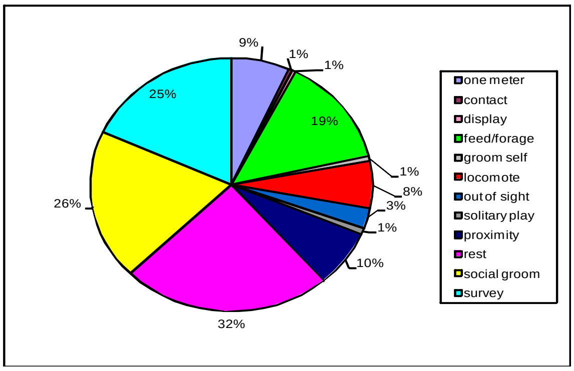

Figure 5.2 The percentage of total sample time the hamadryas baboon group engaged in the behaviour collected.

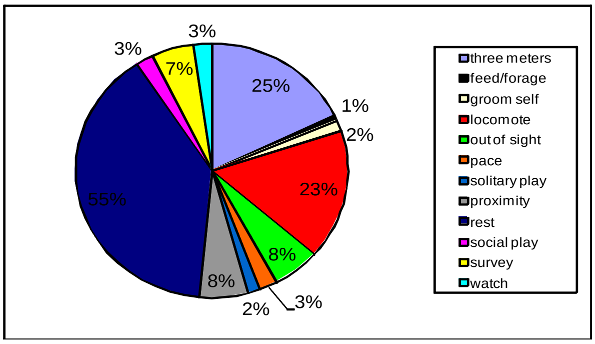

Figure 5.3 The percentage of total sample time the Bengal tiger group engaged in the behaviours collected.

5.6.2 The Effect of Potential Confounding Variables Between Conditions: Visitor Density, Temperature, and Wind Speed

The influence of several potential confounding variables was tested in an attempt to determine their effect on the behaviour of the study groups during the baseline and experimental conditions. Randomisation tests were used to investigate if there was a change in the median visitor density per sample between the baseline condition and the two experimental conditions. The median visitor density category per sample for the baseline condition was compared to the median visitor density category per sample for the enclosure olfactory condition and no changes were identified for any of the three study groups. The consistency in visitor density held true for comparisons of the median visitor density category per sample between the baseline and the smelly visitor condition for all three study groups. Table 5.2 lists the results of the randomisation tests comparing visitor density between the experimental conditions.

CONDITION	SPECIES GROUP	Test Statistic	*p* (two-tailed)	n
Baseline-Enclosure Olfactory	Chimpanzee	-.001	1.000	123
	Hamadryas baboon	-.664	.230	117
	Bengal tiger	.148	1.000	125
Baseline-Smelly Visitor	Chimpanzee	-.024	.899	71
	Hamadryas baboon	-.194	.571	72
	Bengal tiger	.472	.285	72

Table 5.2 The results of randomisation tests comparing the median visitor density category per sample between the baseline and experimental conditions for each of the study groups.

Temperature was also hypothesised to be a confounding variable in this experiment. A randomisation test comparing the temperature in the baseline to the experimental conditions, respectively, was carried out. The temperature (Celsius) per sample increased significantly between the baseline and enclosure olfactory conditions for the baboon (Figure 5.4) and tiger (Figure 5.5) groups, but not for the chimpanzee group. The temperature between the baseline and the smelly visitor condition was also compared using randomisation tests for each study group and there was no significant change in degrees between these conditions. Table 5.3 lists the results of the randomisation tests comparing the temperature in the baseline condition to each of the experimental conditions.

CONDITION	SPECIES GROUP	Test Statistic	*p* (two-tailed)	n
Base-Enclosure Olfactory	Chimpanzee	6.822	.546	123
	Hamadryas baboon	**5.068**	**.001**	**117**
	Bengal tiger	**2.725**	**.001**	**125**
Base-Smelly Visitor	Chimpanzee	6.382	.183	71
	Hamadryas baboon	3.444	.529	72
	Bengal tiger	1.777	.079	72

Table 5.3 The results of randomisation tests comparing the temperature (Celsius) between the baseline and experimental conditions. Significant results are in bold text.

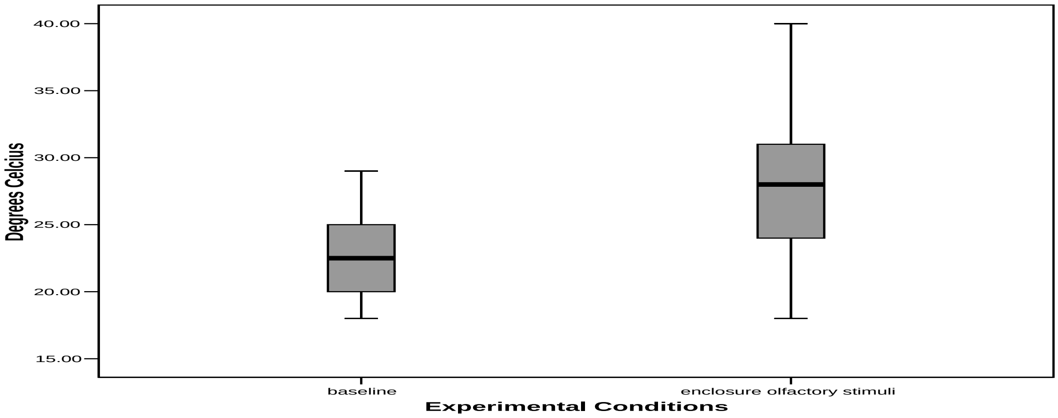

Figure 5.4 The increase in median temperature between the baseline and enclosure olfactory conditions in the hamadryas baboon group.

Figure 5.5 The increase in median temperature between the baseline and enclosure olfactory conditions in the Bengal tiger group.

Difference in wind speed (kilometer per hour) between the enclosure olfactory condition and the smelly visitor condition was posited to increase the distribution of the olfactory stimuli and potentially influence the effect of the olfactory stimuli on behaviour. A randomisation test comparing wind speed measurements in the enclosure olfactory stimuli condition to the smelly visitor condition was computed for each study group, and there were no significant differences in the force of winds between the two experimental conditions. Table 5.4 lists the results of these randomisation tests.

SPECIES GROUP	Test Statistic	*p* (two-tailed)	n
Chimpanzee	-.072	1.000	124
Hamadryas baboon	.046	.685	117
Bengal tigers	-.706	1.000	125

Table 5.4 The results of the randomisation test comparing the wind speed in enclosure olfactory and the smelly visitor conditions.

5.6.3 Changes in Animal Behaviour in the Enclosure Olfactory Condition

According to the results of randomisation tests, the three study groups showed significant behavioural change following the introduction of the olfactory stimuli into the enclosures. The chimpanzee behaviour *out of sight* was performed significantly more frequently in the enclosure olfactory condition than it had been in the baseline condition, necessitating the behavioural analysis to be calculated using the proportion of sample points when the apes were visible. Eight chimpanzee behaviours significantly affected by the introduction of olfactory stimuli into the enclosure decreased between the baseline and the experimental condition. Behaviours related to social cohesion and affiliation were affected by the olfactory stimuli, as evidenced by the significantly decreased performance of the behaviours *contact*, *proximity,* and *watch*. The behaviour *social groom* also decreased in the enclosure olfactory condition but did not achieve statistical significance. Interestingly, a significant decrease in the proportion of behaviours performed during aggressive interactions or other times of stress, such as *display*, *fight*, and *scratch self* were also identified.

The general activity level of the chimpanzee group also showed a decrease in the presence of the olfactory stimuli in the enclosure, as supported by the significant decrease in the behaviour *locomote* and the increase in *rest*. Behaviours directly related to olfaction such as sniffing did not occur frequently and, therefore, could not be analysed statistically; feeding and foraging, a suite of behaviours that can be directly connected to olfaction biologically, occurred frequently enough to allow for statistical analysis and remained unaffected in the presence of the olfactory stimuli in the enclosure.

A further randomisation confirmed that the proportion of the behaviours affected by the change in olfactory conditions did not differ significantly depending on which olfactory stimulus was present in the chimpanzee enclosure.

The behaviours affected by the presence of the olfactory stimuli on the day the scents were introduced were never more than five percent different on the following day, suggesting that the behavioural effect of the olfactory stimuli continued for at least one day subsequent to their introduction.

Table 5.5 lists the results of the randomisation tests comparing the behaviour of the chimpanzee group in the baseline and enclosure olfactory conditions. Figure 5.6 shows the results of the enclosure olfactory stimuli on chimpanzee behaviour. Table 5.6 presents the results of the randomisation test comparing the effects of the olfactory stimuli on the chimpanzee group. Table 5.7 lists the descriptive statistics used to compare the day of scent introduction to the day after scent introduction.

Chimpanzee BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
< one meter	.093	1.000	.288
contact	**-.023**	**.001**	**.010**
display	**-.023**	**.001**	**.010**
feed/forage	.014	.396	.062
fight	**-.008**	**.001**	**.002**
follow	.001	1.000	.002
groom self	-.002	1.000	.070
locomote	**-.006**	**.010**	**.065**
out of sight	**.167**	**.001**	**.261**
pant hoot	-.001	.873	.003
proximity	**-.085**	**.001**	**.071**
rest	**.075**	**.001**	**.309**
scratch self	**-.006**	**.001**	**.006**
social groom	-.101	.047	.098
social play	.013	.642	.013
solitary play	.017	.133	.020
Survey	.032	.279	.169
watch	**-.043**	**.001**	**.020**

Table 5.5 The results of the randomisation tests comparing chimpanzee behaviour between the baseline and enclosure olfactory conditions. Significant results are in bold text; trends are shaded. n= 123.

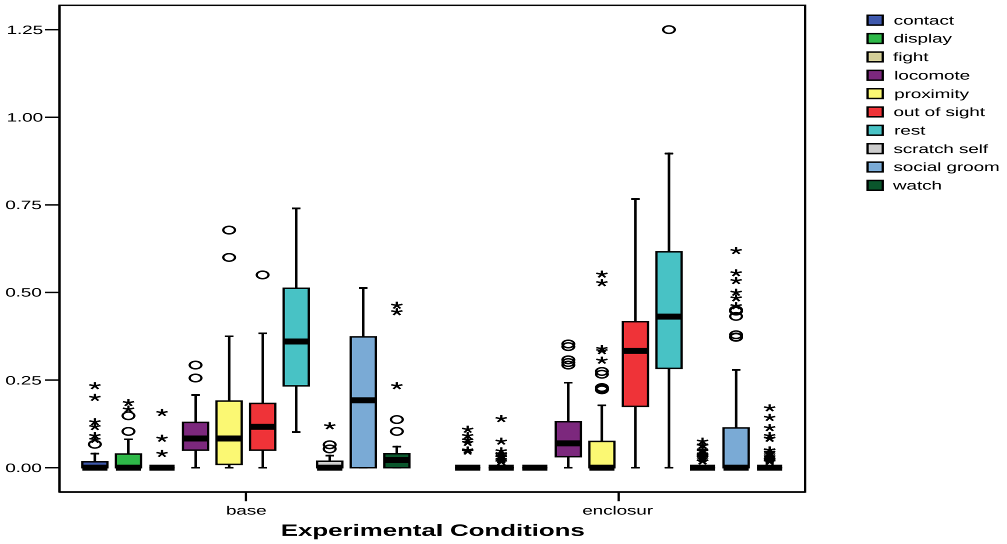

Figure 5.6 The change in the median proportion of sample points between the baseline (base) and the enclosure olfactory condition (enclosur) in the chimpanzee group. Baseline mean proportion= *contact*: .028, *display*: .029, *fight*: .008, *locomote*: .097, *out of sight*: .142, *proximity*: .146, *scratch self*: .012, *watch*: .055. Enclosure olfactory mean proportion= *contact*: .005, *display*: .006, *fight*: .000, *locomote*: .092, *out of sight*: .309, *proximity*: .061, *scratch self*: .007, *watch*: .012.

Chimpanzee BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
contact	.023	.099	.004
display	.019	.909	.005
fight	NA	NA	.000
locomote	.275	.883	.059
out of sight	2.411	.067	.310
proximity	.633	.265	.046
scratch self	.011	.082	.005
social groom	1.133	.063	.069
watch	.043	.233	.009

Table 5.6 The results of the randomisation test comparing the effect of the four experimental scents (almond, banana, bobcat, and quail) on the chimpanzee behaviours affected in the enclosure olfactory condition. n= 88. NA= not enough data for statistical analysis.

Behaviour	Median Proportion	Interquartile Range	Mean Proportion	SE	Proportion of Sample Points
contact	.000/.000	.000/.000	.004/.007	.002/.003	.005
display	.000/.000	.000/.000	.005/.006	.002/.003	.005
fight	NA	NA	NA	NA	.000
locomote	.050/.050	.070/.060	.060/.061	.006/.006	.060

Behaviour	Median Proportion	Interquartile Range	Mean Proportion	SE	Proportion of Sample Points
out of sight	.333/.369	.250/.230	.309/.384	.019/.023	.339
proximity	.000/.000	.050/.030	.045/.030	.009/.009	.040
scratch self	.000/.000	.000/.000	.005/.001	.001/.001	.003
social groom	.000/.000	.100/.090	.068/.065	.013/.015	.067
watch	.000/.000	.000/.000	.009/.009	.002/.003	.009

Table 5.7 Descriptive statistics comparing the proportion of chimpanzee behaviour on days when the enclosure olfactory stimulus was introduced to the following day when no olfactory stimulus was provided. The day of introduction statistics are separated from the following day statistics by a backslash (/). $\geq$ 5% difference in medians/means is in bold text. n= 146.

The hamadryas baboon group was significantly affected by an olfactory stimulus in their enclosure. The behaviours < *one meter* and *yawn threat* decreased significantly in the presence of the olfactory stimulus in the enclosure. The behaviour *chase*, categorised as intra-group agonism, also decreased, although there was no change in aggression with physical contact (*fight*). One indicator of group cohesion, the behaviour *follow*, decreased significantly in the presence of the enclosure olfactory stimuli, but other cohesion behaviours such as *contact* and *proximity* were unaffected.

The activity level of the baboons also dropped following the commencement of the enclosure olfactory condition, a change suggested by the significantly decreased levels of *locomote*. *Solitary play* was also performed significantly less frequently in the enclosure olfactory condition. Monitoring of the environment within and outwith the baboon enclosure was also performed less frequently in the presence of the enclosure olfactory stimuli, as indicated by the significantly decreased levels of *survey* and *vigilance patrol*. As in the chimpanzee group, behaviour directly related to olfaction did not occur frequently and were not analysed statistically.

A follow-up randomisation test suggested that, like the chimpanzee group, the baboon behaviours altered by the experimental olfactory stimuli were not dependent on the presence of a particular experimental scent. The behaviours affected by the presence of the olfactory stimuli in the enclosure on the day of introduction remained consistent on the following day.

Table 5.8 shows the behavioural changes identified in the hamadryas baboon group following the introduction of the olfactory stimuli into the enclosure. Figure 5.7 shows the results of the enclosure olfactory stimuli on baboon behaviour. Table 5.9 presents the results of the randomisation test investigating the potential differential effects of the olfactory stimuli on the hamadryas baboon group. Table 5.10 shows the descriptive statistics comparing baboon behaviour on the first day of introduction to the day following introduction in the enclosure olfactory condition.

Hamadryas baboon BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
< *one meter*	**-.041**	**.001**	**.065**
bark	-.006	.187	.004
bob	-.006	.194	.005
chase	**-.001**	**.001**	**.001**
contact	.003	.628	.008
copulate	-.001	1.000	.001
display	-.004	.186	.003
feed/forage	.021	.955	.199
fight	-.001	1.000	.001
follow	**-.003**	**.001**	**.002**
groom self	.006	1.000	.013
locomote	**-.018**	**.010**	**.068**
out of sight	.033	1.000	.056
proximity	-.013	.126	.088
rest	.044	.436	.354
scratch self	.003	.624	.008
social groom	-.017	1.000	.247

Hamadryas baboon BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
solitary play	**-.010**	**.001**	**.006**
survey	**-.052**	**.001**	**.210**
vigilance patrol	**-.030**	**.001**	**.017**
watch	-.015	.771	.012
yawn threat	**-.004**	**.001**	**.007**

Table 5.8 The results of the randomisation tests comparing baboon behaviour between the baseline and enclosure olfactory conditions. Significant results are in bold text. n= 117.

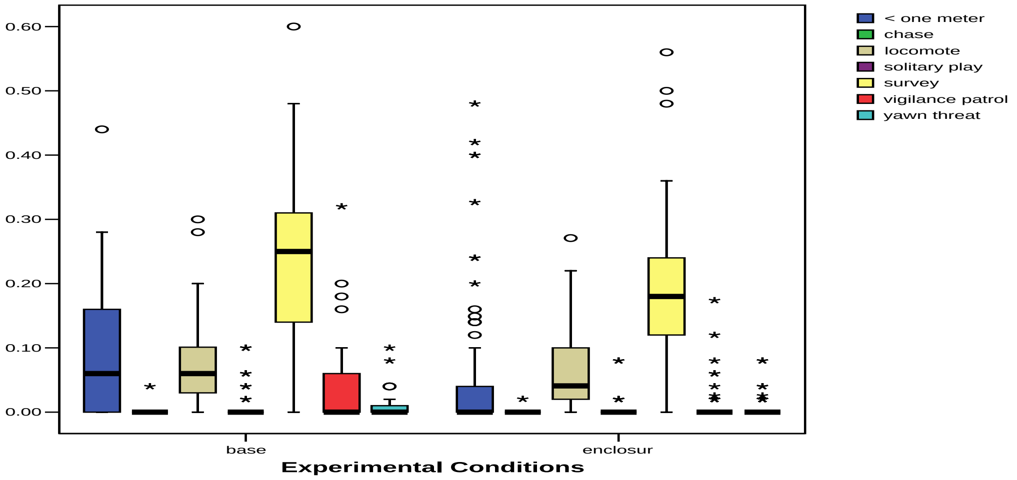

Figure 5.7 The change in the median proportion of behaviour between the baseline (base) and the enclosure olfactory condition (enclosur) in the baboon group. Baseline mean proportion= *< one meter*: .094, *chase*: .001, *follow*: .004, *locomote*: .081, *solitary play*: .012, *survey*: .246, *vigilance patrol*: .038, *yawn threat*: .010. Enclosure olfactory mean proportion: *< one meter*: .053, *chase*: .000, *follow*: .001, *locomote*: .063, *solitary play*: .003, *survey*: .194, *vigilance patrol*: .008, *yawn threat*: .006.

Hamadryas baboon BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
< one meter	.848	.089	.053
chase	NA	NA	.001
follow	.002	.117	.001
locomote	.238	.110	.063
solitary play	.013	.279	.003
survey	.837	.116	.194
vigilance patrol	.053	.121	.008
yawn threat	.017	.463	.006

Table 5.9 The results of the randomisation test comparing the effect of the four experimental scents (almond, banana, bobcat, and quail) on the hamadryas baboon behaviours affected by the enclosure olfactory condition. n= 81. NA= not enough data for statistical analysis.

Behaviour	Median Proportion	Interquartile Range	Mean Proportion	SE	Proportion of Sample Points
< one meter	.000/.000	.040/.080	.053/.053	.012/.019	.053
follow	.000/.000	.000/.000	.001/.001	.001/.001	.001
locomote	.041/.040	.080/.080	.063/065	.006/.014	.063
solitary play	.000/.000	.000/.000	.003/.001	.001/.001	.002
survey	.180/.180	.130/.180	.194/.172	.012/.020	.188
vigilance patrol	.000/.000	.000/.000	.008/.012	.003/.005	.010
yawn threat	.000/.000	.000/.000	.006/.002	.002/.001	.005

Table 5.10 Descriptive statistics comparing the proportion of hamadryas baboon behaviour on days when the enclosure olfactory stimulus was introduced to the following day when no olfactory stimulus was provided. The day of introduction statistics are separated from the following day statistics by a backslash (/). ≥ 5% difference in medians/means is in bold text. n= 108.

The Bengal tiger group, like the primates, was significantly affected by the introduction of the olfactory stimuli into their enclosure. The visitor-related behaviour *out of sight* was influenced by the experimental manipulation and the tigers were less visible to visitors in the enclosure olfactory condition. The significant decrease in *out of sight* between conditions necessitated the behavioural analysis to be calculated using the proportion of sample points when the tigers were visible.

Social cohesion between the two tigers was influenced by the presence of the olfactory stimuli in the enclosure, as indicated by the significantly decreased proportion of scans in which the behaviours *proximity* and *watch* were performed; however, the behaviour *contact*, also indicative of social cohesion, remained unaffected by the experimental manipulation. Two affiliative behaviours were affected by the presence of the olfactory stimuli within the enclosure, although the direction of the change differed. The tigers engaged in significantly increased levels of *social rub* following the introduction of the olfactory stimuli into the enclosure, while the level of *social play* decreased significantly in the enclosure olfactory condition.

The activity level of the tigers was also affected by the experimental manipulation and decreased significantly from baseline levels, as suggested by the decrease in the performance of the behaviour *locomote* and an increase in *rest*. *Solitary play* was also performed less frequently by the two tigers during the phase in which the olfactory stimuli were present within the enclosure. Behaviours related to olfaction, such as *lick, sniff,* and *sniff air,* were not affected by the olfactory stimuli within the enclosure but the proportion of *feed/forage* bouts decreased significantly from baseline levels.

Like the primates, tiger behaviour was not dependent on which olfactory scent was present in the enclosure, although the proportion of *proximity* approached the level of significance. The performance of this behaviour was at its lowest in the presence of the bear urine and highest on days when the rabbit urine was introduced. The tigers were the only study group whose behaviour did not appear, based on descriptive statistics, to remain consistent from the day of stimuli introduction to the following day. Two of the behaviours changed more than five percent from the first to second day of observations. The median proportion of *locomote* increased from 0% of sample points on the first day when the olfactory stimuli were introduced to 5% of sample points on the day following the introduction of the stimuli. The median proportion of *rest* bouts decreased from 100% of sample points on the first day to 80% on the second day. These changes suggest tiger behaviour was likely returning to baseline levels on the day following the introduction of the olfactory stimuli.

Table 5.11 lists the statistical results of the effect of the enclosure olfactory stimuli on the behaviour of the Bengal tiger group. Figure 5.8 shows the results of the enclosure olfactory stimuli on Bengal tiger behaviour. Table 5.12 details the results of the randomisation test exploring the potential influence of the particular olfactory stimuli on the Bengal tiger group. Figure 5.9 shows the differential effect of the scents on tiger behaviour. Table 5.13 shows the descriptive statistics comparing the day of olfactory stimuli introduction and the subsequent day of observations when no fresh scent was placed in the enclosure. Figures 5.10 and 5.11 show the difference in behaviour between the day of olfactory presentation and one-day old stimulus.

Bengal tiger BEHAVIOURS	Test Statistic	*P* (two-tailed)	Proportion of Sample Points
< three meters	.219	.820	.413
claw object	-.001	1.000	.001
contact	.020	1.000	.013
feed/forage	**-.012**	**.001**	**.004**
fight	.002	.324	.002
flehmen	.001	.819	.001
follow	.001	.608	.002
groom self	-.001	.947	.015
lick	.003	.727	.002
locomote	**-.173**	**.001**	**.126**
out of sight	**-.062**	**.001**	**.033**
pace	-.026	.548	.018
proximity	**-.051**	**.001**	**.042**
rest	**.254**	**.001**	**.742**
roll-in	.001	.178	.001
rub-on	-.001	.241	.001
sniff	-.010	.182	.005
sniff air	-.005	1.000	.005
social play	**-.027**	**.001**	**.010**

Bengal tiger BEHAVIOURS	Test Statistic	*P* (two-tailed)	Proportion of Sample Points
solitary play	**-.022**	**.001**	**.009**
social rub	**.004**	**.001**	**.003**
survey	.044	.908	.108
urine mark	-.001	1.000	.001
vigilance patrol	.011	.164	.008
watch	**-.029**	**.001**	**.012**

Table 5.11 The results of the randomization tests comparing tiger behaviour between the baseline and enclosure olfactory conditions. Significant results are in bold text. n= 125.

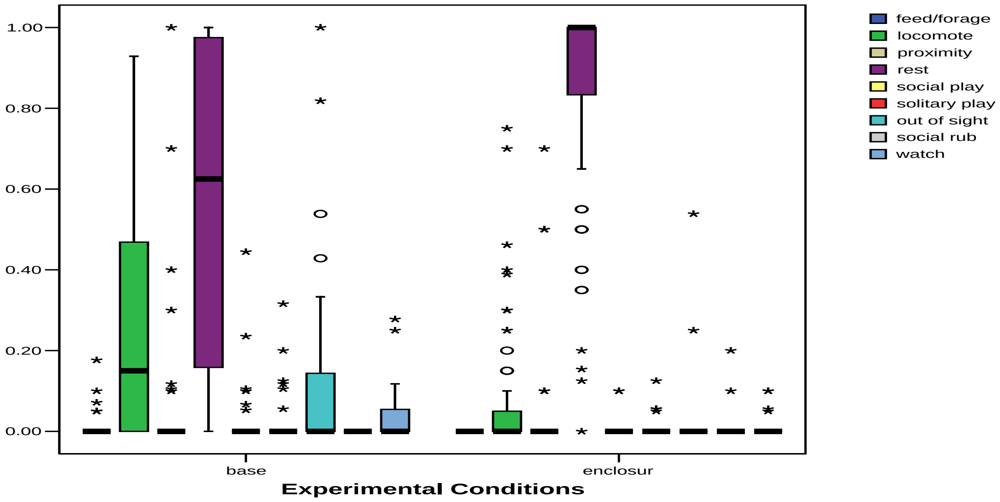

Figure 5.8 The median proportion of sample points in which the affected behaviours were performed by the tigers in the baseline (base) and the enclosure olfactory condition (enclosur). Baseline mean proportion= *feed/forage*: .012, *locomote*: .264, *out of sight*: .076, *proximity*: .078, *rest*: .571, *social play*: .031, *solitary play*: .026, *social rub*: .000, *watch*: .034. Enclosure olfactory mean proportion: *feed/forage*: .001, *locomote*: .091, *out of sight*: .015, *proximity*: .028, *rest*: .824, *social play*: .003, *solitary play*: .004, *social rub*: .005, *watch*: .005.

Bengal tiger BEHAVIOURS	Test Statistic	*P* (two-tailed)	Proportion of Sample Points
feed/forage	NA	NA	.001
locomote	1.873	.054	.085
out of sight	.252	.072	.015
proximity	.961	.029	.027
rest	6.314	.082	.819
social play	.028	.141	.003
solitary play	.018	.814	.003
social rub	.056	.363	.005
watch	.028	.503	.005

Table 5.12 The results of randomisation test comparing the effect of the four experimental scents on the Bengal tiger behaviours affected by the enclosure olfactory condition. Trends are shaded. n= 89. NA= not enough data for statistical analysis.

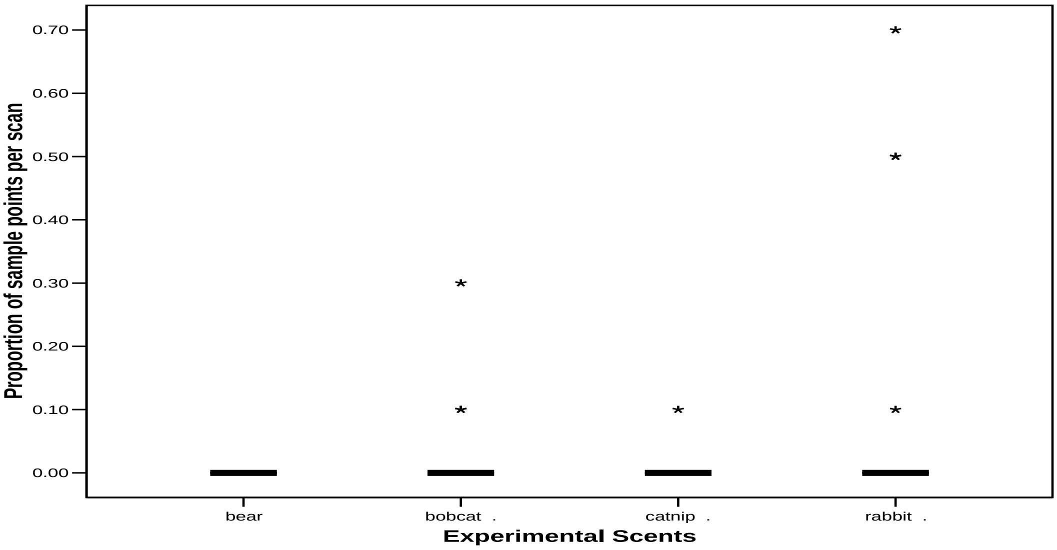

Figure 5.9 The median proportion of sample points in which the behaviour *proximity* was performed on the day of experimental scent introduction in the enclosure olfactory condition. Bear mean proportion= .000; bobcat mean proportion= .023; catnip mean proportion= .004; rabbit mean proportion= .082.

Behaviour	Median Proportion	Interquartile Range	Mean Proportion	SE	Proportion of Sample Points
feed/forage	.000/.000	.000/.000	.001/.000	.001/.000	.001
locomote	**.000/.050**	**.100/.200**	**.085/.138**	**.016/.022**	**.779**
out of sight	.000/.000	.000/.000	.015/.000	.006/.000	.009
proximity	.000/.000	.000/.000	.027/.023	.012/.010	.026
rest	**1.000/.800**	**.300/.480**	**.820/.719**	**.030/.037**	**.779**
social play	.000/.000	.000/.000	.003/.002	.002/.002	.003
social rub	.000/.000	.000/.000	.005/.005	.003/.003	.005
solitary play	.000/.000	.000/.000	.003/.005	.002/.003	.004
watch	.000/.000	.000/.000	.005/.018	.002/.005	.009

Table 5.13 Descriptive statistics comparing the proportion of Bengal tiger behaviour on days when the enclosure olfactory stimulus was introduced to the following day when no olfactory stimulus was provided. The day of introduction statistics are separated from the following day statistics by a backslash (/). $\geq$ 5% difference in medians/means is in bold text. n= 146.

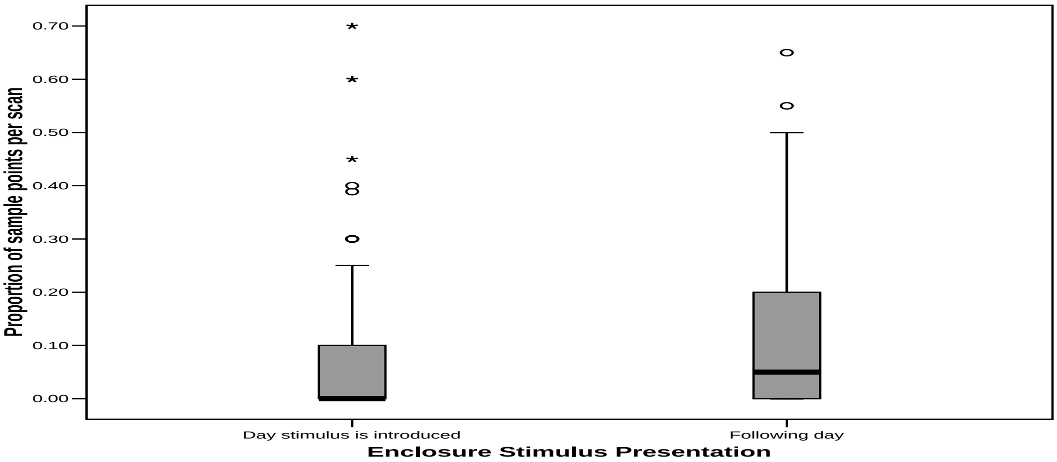

Figure 5.10 The median proportion of sample points per enclosure olfactory condition scans in which the behaviour *locomote* was performed by the tiger group on the day of stimulus introduction and the following day when no stimulus was provided.

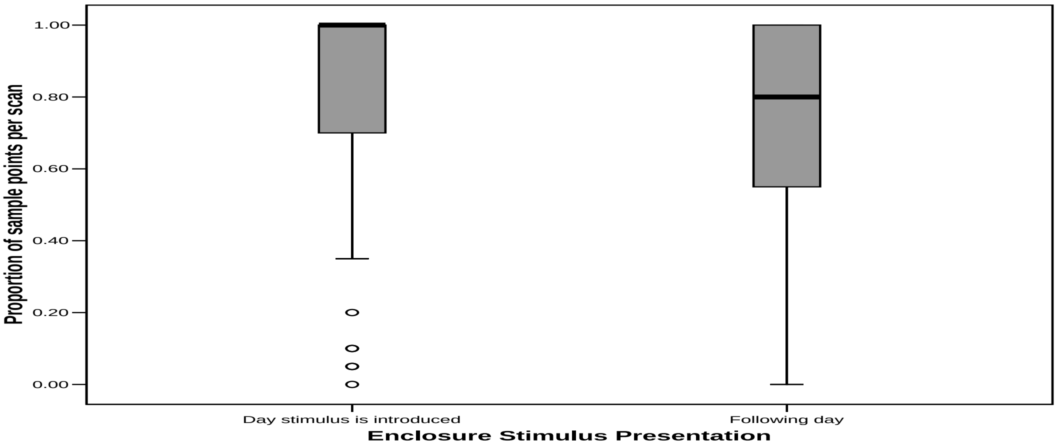

Figure 5.11 The median proportion of sample points per enclosure olfactory condition scans in which the behaviour *rest* was performed by the tiger group on the day of stimulus introduction and the following day when no stimulus was provided.

5.6.4 Changes in Animal Behaviour in the Smelly Visitor Condition

Randomisation tests were used to determine if scenting the zoo visitors had an effect on animal behaviour. Further randomisation tests were then computed for behaviours identified as having increased or decreased to determine whether these changes were dependent upon a particular scent. There were no statistically significant changes between the baseline and smelly visitor condition for the chimpanzee, baboon, or tiger groups. Two chimpanzee behaviours, < *one meter* and *solitary play*, showed trends toward increased performance in the presence of smelly visitors. Neither of these behaviours was dependent on whether the visitors smelled like almond, banana, bobcat, or quail. Table 5.14 lists the results of the randomisation tests comparing the behaviour of the chimpanzees in the baseline and smelly visitor conditions. Figure 5.12 show the behaviours affected by the presence of smelly visitors. Table 5.15 presents the results of the randomisation test investigating potential differential effects of the olfactory stimuli on the chimpanzee group.

Chimpanzee BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
< one meter	.091	.040	.342
bark	.001	.559	.001
contact	-.020	.492	.016
display	-.020	.303	.016
feed/forage	-.049	.476	.043
fight	-.006	.491	.004
follow	.003	.593	.004
groom self	-.034	.298	.066
grunt	-.006	.505	.003
locomote	.028	.959	.080
out of sight	.175	.502	.230
pant hoot	.003	.145	.005
proximity	-.054	.490	.106
rest	.070	.267	.357
scratch self	-.009	.127	.028
scream	.005	.555	.004
social groom	-.094	.141	.122
social play	-.008	.490	.004
solitary play	.007	.040	.017
survey	.076	.507	.216
watch	-.042	.313	.028

Table 5.14 The results of the randomisation tests comparing chimpanzee behaviour between the baseline and smelly visitor conditions. Trends are shaded. n= 71.

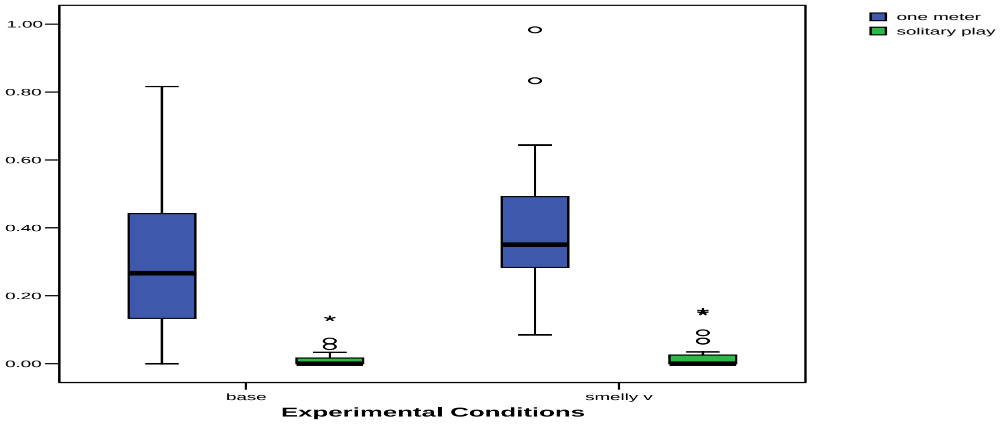

Figure 5.12 The median proportion of sample points in which the affected behaviours were performed by the chimpanzees in the baseline (base) and the smelly visitors condition (smelly v). Baseline mean proportion= < *one meter*: .296, *solitary play*: .014. Smelly visitors mean proportion= < *one meter*: .387, *solitary play*: .020.

Chimpanzee BEHAVIOURS	RSS	*p* (two-tailed)
< *one meter*	1.105	.395
solitary play	.049	.304

Table 5.15 The results of randomisation test comparing the effect of the four experimental scents on the chimpanzee behaviours affected by the presence of smelly visitors. n= 36.

Like the behaviour of the chimpanzee group, the behaviour of hamadryas baboons was not significantly influenced by the presence of smelly visitors. However, the proportion of two baboon behaviours, *chatter* and *out of sight*, increased in the presence of smelly visitors and showed a trend toward statistical significance; the increase in *out of sight* necessitated the behavioural analysis to be calculated using the proportion of sample points when the monkeys were visible. The infrequent occurrence of the chatter vocalisation did not allow for a statistical comparison of the effect of the different scents on the expression of the behaviour. The proportion of performance of *out of sight* bouts was not dependent on whether the visitors smelled like almond, banana, bobcat, or quail. Table 5.16 presents the hamadryas baboon behaviours affected by the presence of smelly visitors. Figure 5.13 shows the change in baboon behaviour between the baseline and the smelly visitor condition. Table 5.17 lists the results of the randomisation test that did not identify differential effects of the olfactory stimuli on the baboon group.

Hamadryas baboons BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
one meter	-.055	.689	.067
bark	-.005	.558	.006
bob	-.012	.461	.006
chatter	.001	.049	.001
contact	.026	.095	.016
display	.003	.819	.006
feed/forage	.007	.829	.187
follow	-.001	.529	.003
groom self	.008	.742	.012
grunt	-.020	.736	.025
lick	.011	.080	.006
locomote	-.006	.368	.071
out of sight	.043	.048	.056
proximity	.015	.423	.102
rest	.087	.796	.354
scratch self	-.006	.331	.006
scream	.001	.868	.004
social groom	-.032	.498	.239
solitary play	-.008	.519	.008
survey	.019	.510	.249
vigilance patrol	-.034	.522	.021
watch	-.009	.630	.017
yawn threat	-.003	.529	.008

Table 5.16 The results of the randomisation tests comparing baboon behaviour between the baseline and smelly visitor conditions. Trends are shaded. n= 72.

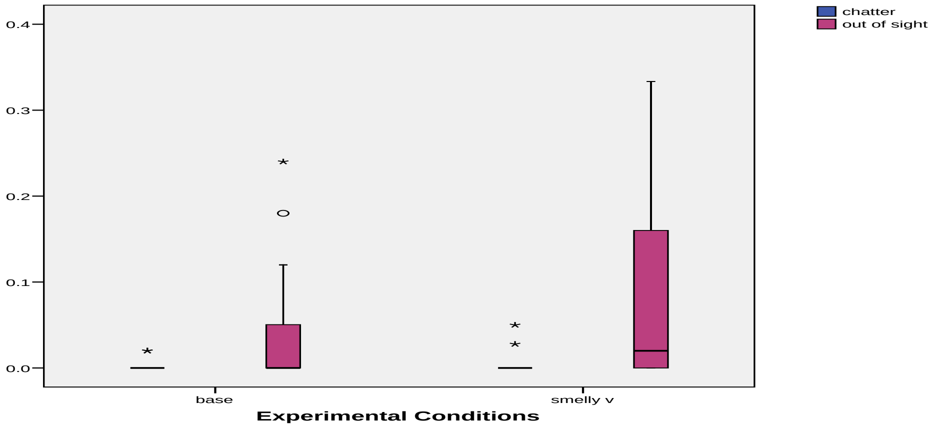

Figure 5.13 The median proportion of sample points in which the affected behaviours were performed by the baboons in the baseline (base) and the smelly visitors condition (smelly v). Baseline mean proportion= *chatter*: .001, *out of sight*: .034. Smelly visitors mean proportion= *chatter*: .002, *out of sight*: .077.

Hamadryas baboon BEHAVIOURS	RSS	*p* (two-tailed)
chatter	NA	NA
out of sight	.349	.721

Table 5.17 The results of the randomisation test comparing the effect of the four experimental scents on the hamadryas baboon behaviours affected by the presence of smelly visitors. n= 36. NA= not enough data for statistical analysis.

According to the results of the randomisation tests, the behaviour of the Bengal tiger group was not significantly influenced by the presence of smelly visitors. Table 5.18 lists the results of the randomisation tests comparing Bengal tiger behaviour in the baseline condition with that observed in the smelly visitor condition.

Bengal tiger BEHAVIOURS	Test Statistic	*p* (two-tailed)	Proportion of Sample Points
< three meters	.129	.515	.311
claw object	.000	1.000	.001
dig	.004	.521	.002
feed/forage	-.011	.515	.006
flehmen	-.010	.144	.005
follow	.004	.541	.003
groom self	.022	.281	.026
locomote	-.091	.524	.179
out of sight	-.076	.532	.038
pace	.074	.395	.068
proximity	.000	1.000	.078
rest	.040	.599	.575
sniff	-.028	.591	.009
sniff air	.025	.457	.021
social play	-.016	.468	.020
solitary play	-.014	.536	.017
survey	.146	.103	.141
urine mark	.003	.530	.003
vigilance patrol	.061	.527	.031
watch	-.022	.551	.020

Table 5.18 The results of the randomisation tests comparing tiger behaviour between the baseline and smelly visitor conditions. n= 72.

5.6.5 The Relationship Between Visitor Density and Animal Behaviour in the Experimental Conditions

The effect of visitor density on study animal behaviour was influenced by the presentation of olfactory stimuli in the experimental conditions. A significant positive correlation between *feed/forage* and visitor density was identified when the olfactory stimuli was presented within the chimpanzee enclosure, while a positive correlation between *social play* and density approached but did not achieve significance. Negative trends toward statistical significance were also identified between *groom self*, *proximity*, and *scratch self* in the enclosure olfactory condition. There were no significant associations between ape behaviour and visitor density in the smelly visitor condition, but the proportion of *locomote* and *solitary play* showed a trend toward statistical significance in its relationship to visitor density. Table 5.19 lists the results of the Spearman correlations investigating the relationship between visitor density and chimpanzee behaviour in the experimental conditions. Figures 5.14-5.20 show the associations between visitor density and chimpanzee behaviour in the experimental conditions.

Chimpanzee BEHAVIOUR	Experimental Conditions					
	Enclosure Olfactory		Smelly Visitors		Baseline	
	r	*p* (two-tailed)	r	*p* (two-tailed)	r	*p* (two-tailed)
< *one meter*	-.131	.187	-.077	.579	**.385**	**.019**
contact	-.109	.271	NA	NA	NA	NA
display	.081	.414	NA	NA	-.055	.748
feed/forage	**.257**	**.009**	-.049	.725	.229	.174
follow	-.010	.924	NA	NA	NA	NA
groom self	-.217	.027	-.258	.059	.083	.624
locomote	-.075	.454	.290	.033	.139	.412
out of sight	.123	.214	.176	.203	-.003	.984
pant hoot	-.079	.427	NA	NA	NA	NA
proximity	-.196	.047	.054	.699	.155	.359
rest	-.145	.143	.038	.787	.020	.907

Chimpanzee BEHAVIOUR	Experimental Conditions					
	Enclosure Olfactory		Smelly Visitors		Baseline	
	r	*p* (two-tailed)	r	*p* (two-tailed)	r	*p* (two-tailed)
scratch self	-.232	.019	NA	NA	-.029	.866
social groom	-.051	.608	-.208	.132	-007	.966
social play	.250	.011	NA	NA	NA	NA
solitary play	.035	.726	-.295	.030	.063	.712
survey	-.019	.846	.167	.226	-035	.838
watch	.045	.653	NA	NA	.078	.648

Table 5.19 The relationship between visitor density and chimpanzee behaviour across the baseline and experimental conditions. Significant results are in bold; trends are shaded. Baseline n= 37; enclosure olfactory n= 103: smelly visitors: n= 54.

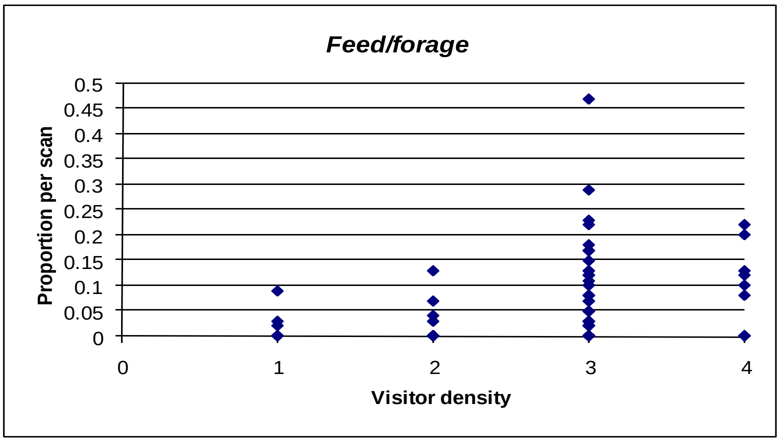

Figure 5.14 The relationship between visitor density and the *feed/forage* in the enclosure olfactory condition in the chimpanzee group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 50 or more visitors.

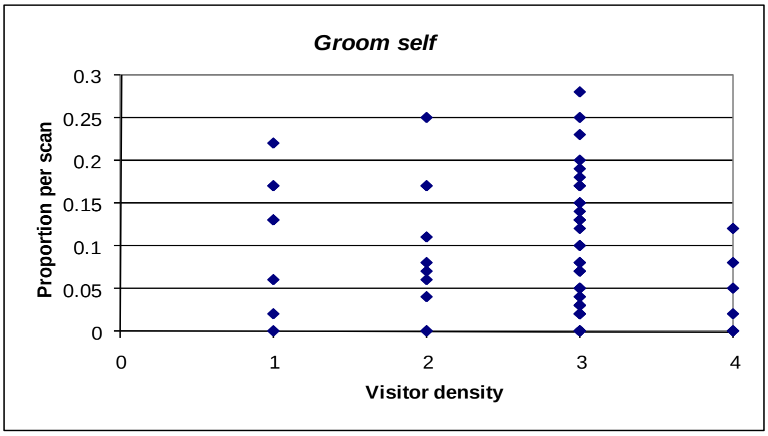

Figure 5.15 The relationship between visitor density and *groom self* in the enclosure olfactory condition in the chimpanzee group.

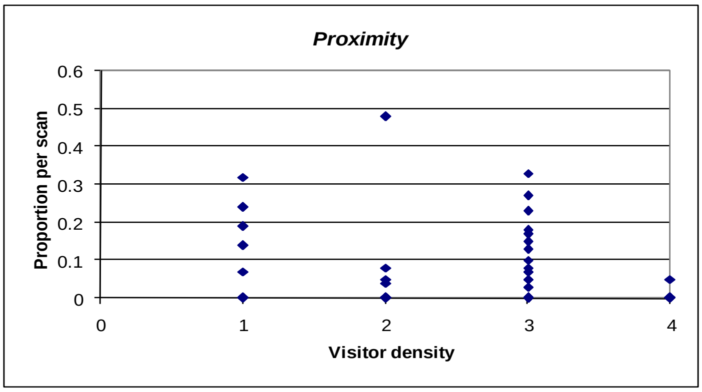

Figure 5.16 The relationship between visitor density and *proximity* in the enclosure olfactory condition in the chimpanzee group.

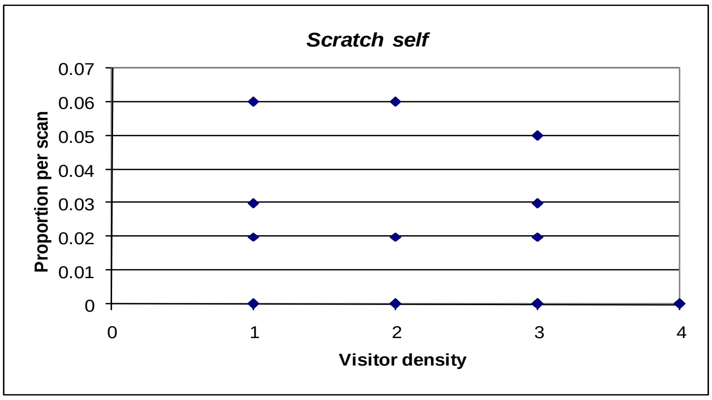

Figure 5.17 The relationship between visitor density and *scratch self* in the enclosure olfactory condition in the chimpanzee group.

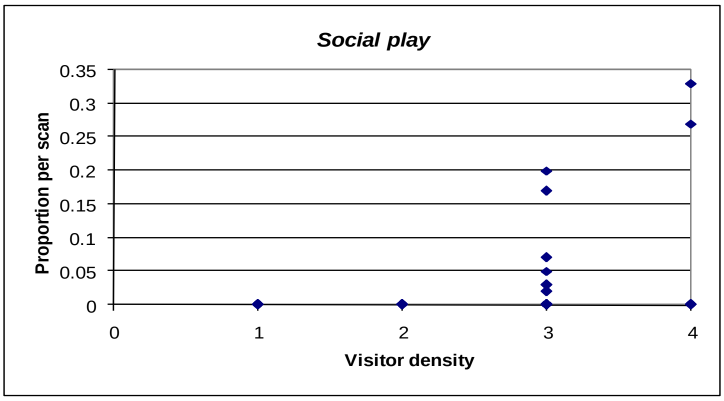

Figure 5.18 The relationship between visitor density and *social play* in the enclosure olfactory condition in the chimpanzee group.

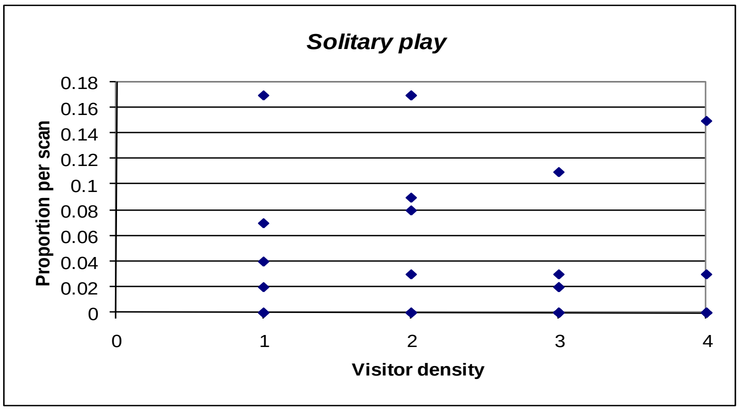

Figure 5.19 The relationship between visitor density and *solitary play* in the smelly visitor condition in the chimpanzee group.

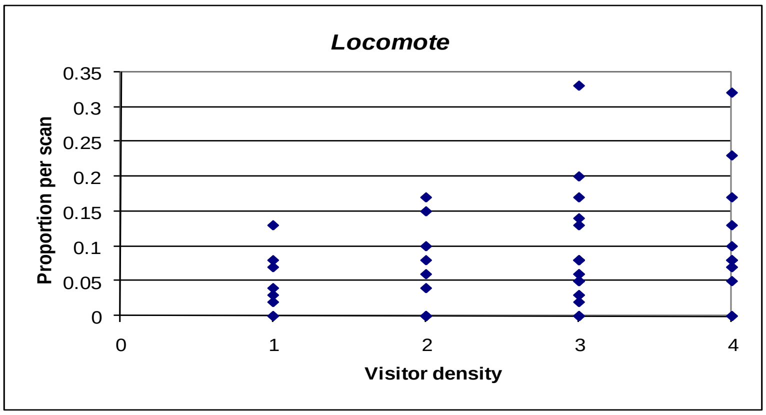

Figure 5.20 The relationship between visitor density and *locomote* in the smelly visitor condition in the chimpanzee group.

The relationship between visitor density and the behaviour of the hamadryas baboon group, like the chimpanzee group, was also affected by the introduction of the olfactory stimuli within the enclosure, but there was no significant association between visitor numbers and baboon behaviour in the smelly visitor condition. The baboons were more often in the < *one meter* zone near visitor viewing areas when there were olfactory stimuli within the enclosure. Table 5.20 lists the results of the Spearman correlations investigating the relationship between visitor density and hamadryas baboon behaviour in the experimental conditions. Figure 5.21 shows the associations between visitor density and baboon behaviour in the experimental conditions.

Hamadryas baboon BEHAVIOUR	Experimental Conditions					
	Enclosure Olfactory		Smelly Visitors		Baseline	
	r	*p* (two-tailed)	r	*p* (two-tailed)	r	*p* (two-tailed)
< ***one meter***	**.241**	**.005**	.188	.134	.209	.150
bark	-.058	.505	NA	NA	NA	NA
bob	NA	NA	NA	NA	-.216	.137
contact	-.067	.444	.191	.127	NA	NA
display	NA	NA	-.132	.295	NA	NA
feed/forage	-.042	.632	.087	.490	**.417**	**.003**
groom self	.020	.820	.205	.101	-.152	.298
grunt	-.041	.638	-.153	.222	.198	.172
locomote	-.016	.852	-.187	.135	.149	.308
out of sight	-.124	.158	.156	.215	.340	.017
proximity	-.022	.804	-.096	.445	.095	.516
rest	-.110	.211	-.153	.225	-.119	.416
scratch self	-.137	.118	NA	NA	.156	.285
social groom	.050	.572	.086	.498	**-.416**	**.003**
solitary play	.070	.427	NA	NA	.138	.346
survey	-.035	.688	-.121	.337	.018	.901
vigilance patrol	-.124	.157	NA	NA	-.083	.571
watch	.029	.743	-.025	.843	.023	.874
yawn threat	-.096	.272	-.092	.467	NA	NA

Table 5.20 The relationship between visitor density and baboon behaviour across the baseline and experimental conditions. Significant results are in bold; trends are shaded. Baseline n= 49; enclosure olfactory n= 132; smelly visitors: n= 65.

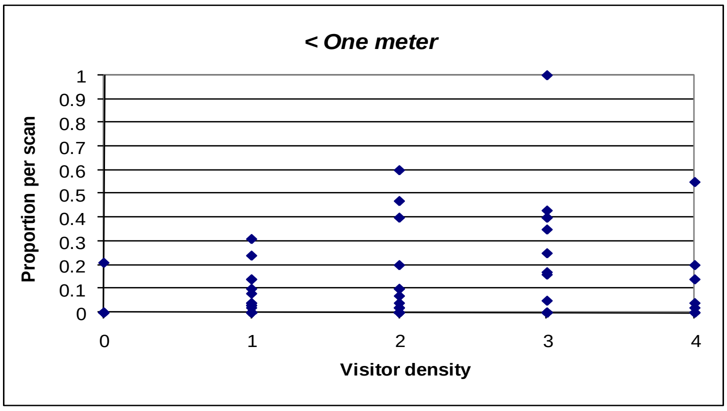

Figure 5.21 The relationship between visitor density and < *one meter* in the enclosure olfactory condition in the hamadryas baboon group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 50 or more visitors.

While there was no statistical correlation between visitor density and Bengal tiger behaviour in the baseline condition, a relationship between these variables was established following the introduction of olfactory stimuli. The proportion of sample points in which the tigers were in the < *three meter* zone or engaged in *rest* increased significantly as visitor density increased when the olfactory stimuli was present within the enclosure. The proportion of sample points in which the tigers performed the behaviours *groom self, locomote*, and *out of sight* decreased significantly as visitor density increased in the enclosure olfactory condition, while there was a trend toward a negative association between *pace* and density which did not achieve significance. The introduction of smelly visitors had less of an effect on the relationship between the behaviour of the Bengal tigers and visitor numbers, but there was a significant association between density and *pace* in this condition. Table 5.21 lists the results of the Spearman correlations investigating the relationship between visitor density and Bengal tiger behaviour in the experimental conditions. Figures 5.22-5.28 show the associations between visitor density and tiger behaviour in the experimental conditions.

Bengal tiger BEHAVIOUR	Experimental Conditions					
	Enclosure Olfactory		Smelly Visitors		Baseline	
	r	*p* (two-tailed)	r	*p* (two-tailed)	r	*p* (two-tailed)
< *three meters*	**.375**	**.001**	-.122	.323	-.045	.709
groom self	**-.205**	**.004**	.102	.410	NA	NA
locomote	**-.409**	**.001**	.064	.609	-.108	.369
out of sight	**-.243**	**.001**	NA	NA	.228	.056
pace	-.154	.033	**.357**	**.003**	NA	NA
proximity	-.018	.804	-.159	.200	-.009	.940
rest	**.464**	**.001**	-.024	.849	.034	.781

Bengal tiger BEHAVIOUR	Experimental Conditions					
	Enclosure Olfactory		Smelly Visitors		Baseline	
	r	*p* (two-tailed)	r	*p* (two-tailed)	r	*p* (two-tailed)
sniff air	NA	NA	.175	.156	NA	NA
survey	-.059	.418	.052	.675	-.039	.746
watch	NA	NA	NA	NA	-.090	.456

Table 5.21 The relationship between visitor density and tiger behaviour across the baseline and experimental conditions. Significant results are in bold; trends are shaded. Baseline n= 71; enclosure olfactory n= 192; smelly visitors n= 67.

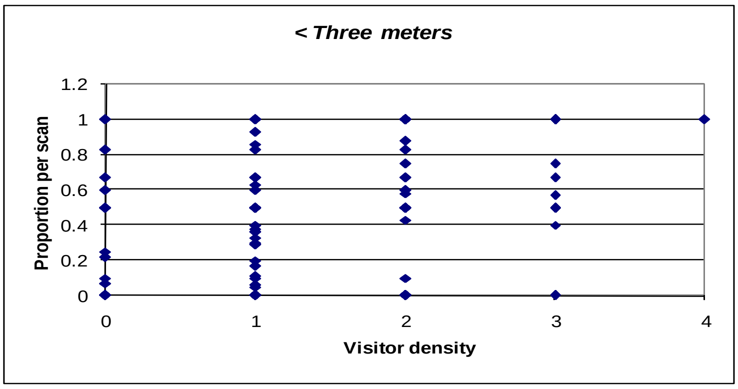

Figure 5.22 The relationship between visitor density and < *three meters* in the enclosure olfactory condition in the Bengal tiger group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 50 or more visitors.

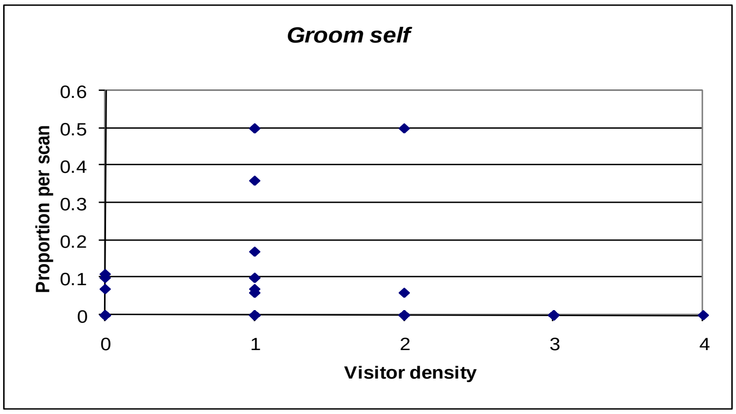

Figure 5.23 The relationship between visitor density and *groom self* in the enclosure olfactory condition in the Bengal tiger group.

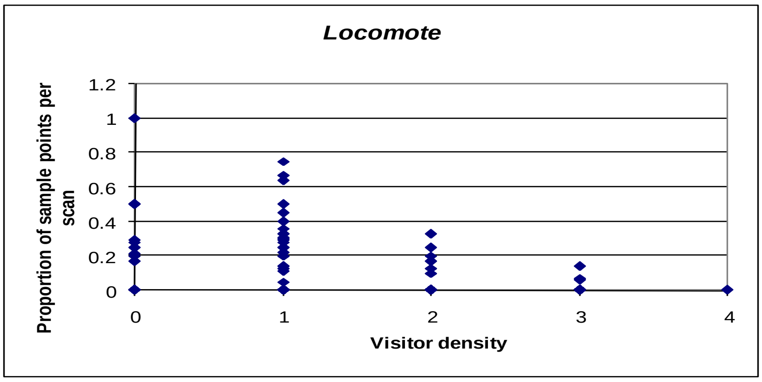

Figure 5.24 The relationship between visitor density and *locomote* in the enclosure olfactory condition in the Bengal tiger group.

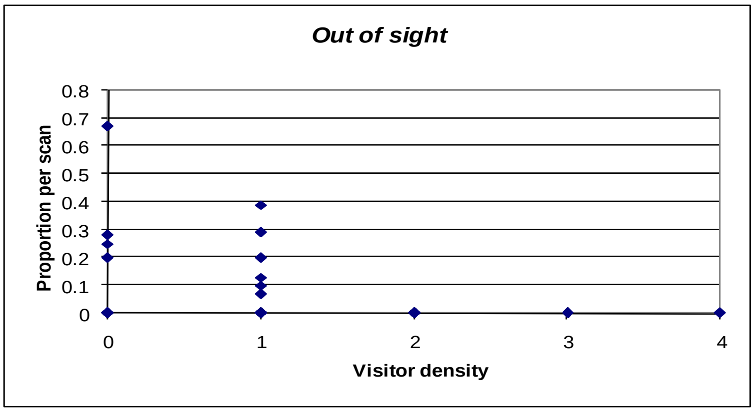

Figure 5.25 The relationship between visitor density and *out of sight* in the enclosure olfactory condition in the Bengal tiger group.

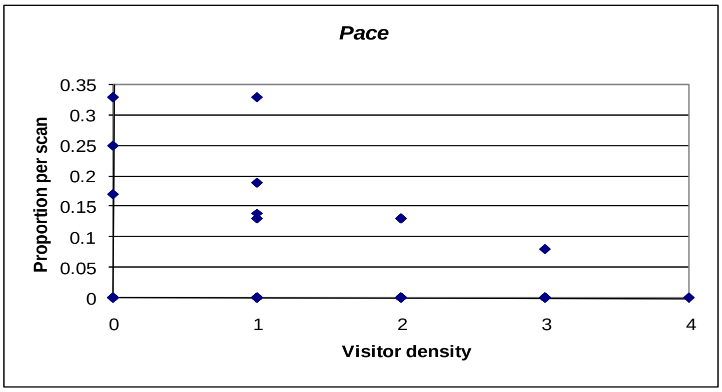

Figure 5.26 The relationship between visitor density and *pace* in the enclosure olfactory condition in the Bengal tiger group.

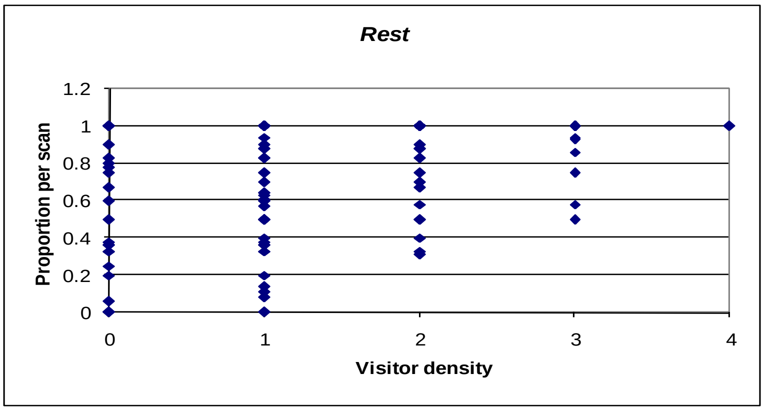

Figure 5.27 The relationship between visitor density and *rest* in the enclosure olfactory condition in the Bengal tiger group.

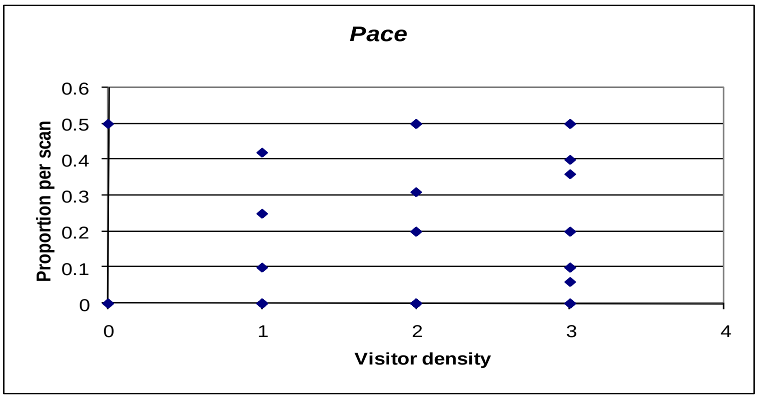

Figure 5.28 The relationship between visitor density and *pace* in the Bengal tiger group in the smelly visitor condition.

5.7 Discussion

5.7.1 Confounding Variables

It is essential to address the effects of potential confounding variables before interpreting the results of the statistical analyses. As shown in previous studies (Hosey 2000) and in the data presented in Chapter 2, zoo animal behaviour is affected by the number of visitors present. Therefore, it was important to determine if a change in visitor density across the baseline and experimental conditions occurred during the experiment. The randomisation tests identified that visitor density remained consistent between conditions and was not likely to be a factor in behavioural change between the baseline and experimental conditions.

Significant temperature increases across the five month experimental period were expected and are a possible factor in behavioural change in the study groups. The statistics identified a significant increase in temperature between the baseline and enclosure olfactory condition for the baboon and tiger groups. Despite a consistent temperature for the chimpanzee group, there was a significant change in behaviour for this group, indicating temperature was probably not the only cause for the change in baboon and tiger behaviour. Statistics showed temperature changes were not significant between the baseline and smelly visitor condition.

Wind speed was hypothesised to affect how much scent was perceptible to the animals and thereby influence the response of the study groups. Statistical analysis did not identify a significant change in wind speed between the two experimental conditions, suggesting wind speed did not affect the presentation of the olfactory stimuli and is not likely to have influenced the results of this experiment. Following the analysis of the three potentially confounding variables, it appears likely that the behavioural changes recorded during this experiment are the result of the presentation of the olfactory stimuli, although the increase in temperature between the baseline and enclosure olfactory condition in the hamadryas baboon group and the Bengal tiger group cannot be ruled out as a source of behavioural change.

5.7.2 Behavioural Responses to Enclosure Olfactory Stimuli

The extensive behavioural change observed between the baseline and enclosure olfactory conditions in the Bengal tiger group are unremarkable, given the previous literature on introducing olfactory stimuli into felid enclosures (Wells and Egli 2004, Schuett and Frase 2001, Ziegler and Roletto 2000, Mellen 1998, Powell 1995). However, the number of behavioural changes observed in the two primate groups is surprising considering the lack of behavioural change following presentation of the odours in the experiment conducted by Ostrower and Brent (1997) on laboratory chimpanzees.

Although these wide-sweeping changes are interesting from a behavioural perspective, the interpretation of these data from an enrichment and welfare perspective are mixed. Three behaviours indicative of stress and intragroup aggression within the chimpanzee group, *display*, *fight*, and *scratch self*, all decreased between the baseline and enclosure olfactory condition and show a positive influence of the olfactory stimuli on the psychological health of the chimpanzees. Unfortunately, there were also behavioural changes associated with the olfactory stimuli in the chimpanzee group which are not desirable. Significantly decreased affiliative behaviours, such as *watch*, *contact*, and *proximity*, in a highly social primate should not be fostered in long-term enrichment programmes; the trend toward decreased social grooming also supports this conclusion. Some of the behavioural changes observed in the chimpanzee group are not advantageous from an institutional perspective either. Increased periods when the chimpanzees are out of sight, not moving about the enclosure, or resting do not contribute to the educational or entertainment value of the chimpanzee display, and, therefore, do not further the mission statements of zoos.

Like the chimpanzees, the hamadryas baboon group had both positive and negative responses to the olfactory stimuli placed in their enclosure. Behaviours related to visitor stress for this group, *< one meter*, *survey*, *yawn threat*, and *vigilance patrol*, all decreased significantly from the baseline condition. Vigilance patrols were performed mainly by the two males of the group, as were yawn threats. The majority of vigilance patrols took place within the one meter zone of their enclosure nearest the visitor viewing area, suggesting this behaviour was a reaction to visitor pressure. The significant decrease in visual monitoring of their surroundings should be considered a positive result of this experiment because the group was spending one quarter of its time observing visitors during the baseline condition, and in conjunction with the other visitor-related behaviours, suggests an overall reduction in visitor-focused behaviour. The significant decrease in the incidence of *chase* between group members in the enclosure olfactory condition may also be interpreted as a decrease in agonism between group members, although the proportion of scans in which this behaviour was performed was negligible. Although decreasing visitor stress is a positive result, the decrease in activity such as *locomote*, *follow*, and *solitary play* is not beneficial to the animals.

Like the primate groups, the behavioural changes observed in the Bengal tiger group in the enclosure olfactory condition were extensive. Following the introduction of the scents into the enclosure, there was a significant decrease in performance of the behaviour *out of sight*, which is beneficial for visitors because zoo-housed felids are often difficult to find in their enclosures. There was also a significant increase in social rubbing between the two tigers, although this behaviour occurred infrequently. Increased social rubbing has been identified in lions following the presentation of scent or dung into their enclosures (Schuett and Frase 2001, Baker et al 1997). Significantly decreased feeding and foraging behaviour in the tigers was observed, but as this was an infrequent event and, given that most large cats are fed when they are off display, the decrease does not represent a cause for concern.

The results of the tiger group contradict some previous findings on olfactory enrichment in zoo felids. The decrease in tiger activity in the enclosure olfactory condition, as evidenced by significantly decreased *locomote* and increased *rest* behaviour, is not supported by the olfactory enrichment reports; reports which include quantitative data find an increase in activity and a decrease in sedentary behaviour (Wells and Egli 2004) or no change in active or sedentary behaviours (Powell 1995). None of the anecdotal or quantitative studies on olfactory enrichment in felids show an increase in inactive behaviours as identified in this experiment.

The significant decrease in social behaviour, such as *watch*, *social play*, and *proximity*, between the tigers is also not supported by the literature. A decrease in social play has not been documented in lion olfactory enrichment studies, and there are several reports of increased affiliative behaviour due to olfactory enrichment (Schuett and Frase 2001, Baker et al 1997). However, given that tigers are not naturally social cats, this difference in social behaviour following the introduction of olfactory stimuli may be reflective of species differences and the social housing of tigers rather than a sign of ineffective enrichment. Olfactory enrichment experiments in singly-housed tigers are needed for accurate interpretation of these data. Significantly decreased solitary play was also not a result that could be predicted by the literature. Although there are no quantitative studies on olfactory enrichment in tigers[2], anecdotal reports show increased solitary play behaviour in Bengal tigers and jaguars (Ziegler and Roletto 2000), and lions (Shuett and Frase 2001).

Curiously, none of the behaviours significantly affected by the enclosure olfactory stimuli included exploratory behaviours or those which might be considered directly related to olfaction. This holds true for all three study groups and is puzzling given the results of felid olfactory enrichment presented by previous researchers (Wells and Egli 2004, Schuett and Frase 2001, Ziegler and Roletto 2000, Powell 1995), who recorded increased exploratory behaviours, sniffing, and flehmen. This lack of increased olfactory behaviours such as sniffing are particularly odd when one considers Hepper et al's observation of increased sniffing of food odours by gorillas (2005), a species that is not considered to be oriented towards olfactory exploration of their environment.

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[2] Without the addition of other stimuli, such as feeding poles, "tug of war" contraptions, artificial prey, and boomer balls.

5.7.3 Responses to Scents

Despite a general trend in the literature for felids to respond differentially to smells used in olfactory enrichment programmes, the behaviour of the tiger group in this experiment was not statistically dependent on which scent was introduced into the enclosures. The tigers were most frequently in proximity to other group members when the scent of rabbit was introduced in the enclosure and least often in each other's proximity when the odour of bear was present in the enclosure, but this finding was not statistically significant. The lack of behavioural dependency on particular scents was not predicted by the olfactory enrichment literature. Wells and Egli (2004) report that captive black-footed cats are most active in the presence of catnip or quail scents, while the odour of nutmeg is less effective. Schuett and Frase (2001) document at least a twofold increase in activity in captive lions following the introduction of zebra dung compared to cinnamon, chilli powder, ginger, and human scent. Baker et al (1997) identified a strong preference for the dung of Dorcas gazelles (*Gazella dorcas*) and nyala antelope (*Tragelaphus angasi*) over that of other ungulates.

Behavioural independence of particular scents in the primate study groups was also not predicted by previous research. Ring-tailed lemurs (McCusker and Smith 2004) and cotton-top tamarins (Buchanan-Smith et al 1993) have been shown to respond differently to the scents of natural predators and other sympatric species. It appears that biologically relevant scents are necessary to elicit the strong reactions to particular scents documented by previous researchers, but the data from this experiment suggest that scents of non-sympatric animals can influence behaviour.

5.7.4 Habituation to Olfactory Stimuli

Although olfactory stimuli are often effective in altering behaviour in some mammals, few researchers provide data on the rate of habituation to olfactory stimuli. The behaviour of the primate study groups in this experiment did not return to baseline levels on the day following scent presentation within the enclosure, which suggests that changes due to olfactory stimuli may extend in time beyond which the olfactory stimuli is at its full potency. Although the habituation period for this experiment was short, lasting only 30 hours, the data suggest that the influence of olfactory stimuli can persist over days rather than hours for chimpanzees and hamadryas baboons.

Unlike the primate groups, the Bengal tiger group began to show signs of habituating to the experimental scents on the observation day following the introduction of odours into the enclosure. With a 5% increase in *locomote* behaviour and a 20% decrease in *rest* behaviour, tiger behaviour appeared to be returning to pre-stimulus levels. This result is concordant with the data on felids provided by Wells and Egli (2004) who observed habituation by black-footed cat to olfactory enrichment over a five day period. Baker et al (1997) saw continued exploratory and social activity in a pride of lions over a 48 hour period following the introduction of ungulate dung, but once the dung was removed, observed diminishing proportions of social activity. These studies, in conjunction with the data from this experiment, suggest that felids may habituate to olfactory stimuli more rapidly than do chimpanzees and hamadryas baboons.

5.7.5 Behavioural Responses to Smelly Zoo Visitors

Smelly zoo visitors did not significantly affect the behaviour of any of the three study groups, although the primates showed changes in behaviour which approached significance. While the behavioural changes following the introduction of visitors carrying olfactory stimuli in the chimpanzee and hamadryas baboon group did not achieve statistical significance, they suggest that smelly visitors were perceived by the primates. A trend toward increased solitary play within the chimpanzee group implies a positive olfactory visitor effect on the group and indicates the chimpanzees did not find smelly visitors stressful. The trend toward an increase in the proportion of time the chimpanzees spent within one meter of the perimeter of their enclosure near a visitor viewing area indicates that they may have found smelly visitors more interesting and attractive. This interpretation of the data is supported by Hosey's review (2000) of the visitor effect literature on chimpanzees which suggests that chimpanzees may have a "mild interest" in zoo visitors. From a visitor perspective, the amount of time the chimpanzees spent near the perimeter of the enclosure most likely increased the visibility of the chimpanzees to visitors. Increased visibility may reduce unwanted visitor behaviour because there is no longer the need to coax animals into coming closer to the enclosure perimeter so that people can get a better view of display animals. Data on a possible link between animal visibility and visitor behaviour should be collected to better understand visitor behaviour.

The effect of smelly visitors on the hamadryas baboons appeared to be the opposite of that observed in the chimpanzee group. Rather than spending more time closer to visitors, as the chimpanzees did, the baboons responded to smelly visitors by spending a greater proportion of time out of sight of the visitors. This change, although not statistically significant, suggests that the baboons did not find smelly visitors interesting, but may have been indifferent to the smelly visitors or even found them repellent. The static nature of the data for visitor-related behaviour such as vigilance patrols and displays, however, suggests the baboons did not find the smelly zoo visitors stressful.

As in the enclosure olfactory condition, the proportion of behaviours affected by the presence of smelly visitors was independent of the scent for all three groups. As previously stated, the lack of response to specific odours in this experiment contradicts previous research suggesting that particular odours elicit differential responses in the few primates and felids that have been tested.

The lack of response to smelly visitors in the Bengal tiger group is more difficult to interpret than the limited response observed in the two primate groups. It may be that felids are habituated to the stimuli provided by visitors, as implied by Margulis et al (2003), McPhee (2002), and O'Donovan et al (1993). Cats may disregard any odours associated with zoo visitors, even if they had previously reacted to the scents when they were inside their enclosures. It is possible that the olfactory stimuli were not perceived by the tiger group, but this seems unlikely given their keen sense of smell and the two to three meter distance between the wire mesh perimeter of the tiger enclosure and the visitor viewing area where the smelly visitors were standing. Given that the primates' appeared responsive--although minimally--to the experimental method, it seems unlikely that this is the best interpretation of the data.

5.7.6 Visitor Density in the Experimental Conditions

Comparing changes in the relationship between visitor density and study animal behaviour in the baseline and experimental conditions should be evaluated only after determining if there has been a significant change in visitor density for those periods of time. As there was no significant change in the number of visitors attending the primate or felid enclosures in this experiment, it is reasonable to conclude that the documented shifts in the way visitor density affected the study groups during the experimental conditions cannot be attributed to either an increase or decrease in visitor density.

The olfactory stimuli influenced the visitor density effect to varying degrees in the two primates groups. In the baseline condition, the chimpanzee group was minimally affected by the presence of large numbers of visitors but following the introduction of the olfactory stimuli into the enclosure, the chimpanzees' behaviour was more influenced by visitor crowds. The influence of crowds had a generally positive impact on the chimpanzee group following the introduction of scent into the enclosure. The apes fed and foraged significantly more, while there were trends toward increased social play and fewer bouts of self-directed behaviours such as scratching and grooming their own bodies. The trend toward decreased proximity bouts between the apes following the introduction of the odours into the chimpanzee enclosure, given the other positive behavioural changes, are likely to be just a function of increased activity and not a sign of decreased social cohesion. Contrastingly, the presence of smelly visitors did not have a positive welfare impact on the visitor density effect in the chimpanzees. The trend toward decreased solitary play in the presence of crowds suggests that the smelly visitors did not foster a positive visitor density effect in the chimpanzees.

The visitor density effect in the hamadryas baboon group in the baseline condition was generally negative in terms of animal welfare. The baboons groomed each other at a significantly lower proportion when there were large crowds present, and a trend for increased out of sight was also identified in the baseline condition. However, the introduction of olfactory stimuli appears to have moderated the visitor density effect in this group. Following the introduction of scent into their enclosure, the baboons were significantly more frequently within one meter of the perimeter of their enclosure near the visitor viewing area and this indicates the baboons may have been less stressed by the presence of crowds. The lack of a visitor density effect in the smelly visitor condition supports the conclusion that olfactory stimuli, in particular visitors carrying olfactory stimuli, may moderate the visitor density effect in hamadryas baboons.

The olfactory stimuli in the experimental conditions had a more mixed effect on the influence of visitor density in the tiger group. When the olfactory stimuli were introduced into their enclosure, the tigers were significantly more likely to be within three meters of the perimeter of their enclosure and were less frequently out of sight of the visitors as visitor density increased, most likely benefiting the visitor experience at this enclosure. Although the tigers were more visible to the public, they moved around the enclosure significantly less, groomed themselves significantly less and spent significantly more time resting in the presence of higher visitor density in the enclosure olfactory condition. The most noteworthy result of the enclosure olfactory stimuli's affect on the visitor density effect in the tiger group is the trend toward a negative relationship between visitor crowds and stereotypic pacing. The moderation of a stereotypy by increased visitor density has not been previously documented in the literature. Unfortunately, the positive effect of visitors did not continue into the smelly visitors condition and, following the introduction of smelly visitors, the relationship between visitor density and pacing in the group was reversed and increased visitors elicited significantly more frequent pacing.

Little research into the interaction between environmental enrichment and visitor density has been carried out, making it difficult to interpret the results of this experiment within a wider context. Wood (1998) investigated the interaction between the size of visitor crowds and the newness of environmental enrichment in zoo chimpanzees and identified that smaller crowds and new enrichment resulted in increased foraging and object use while higher crowds resulted in lower proportions of foraging, object use, grooming, and play with both new and one-day old enrichment. The overall positive visitor density effect in the chimpanzee group during the enclosure olfactory condition does not appear to support Wood's data that high crowds decrease the effectiveness of enrichment.

5.8 Conclusion

The results of the experiment suggest olfactory stimuli within an enclosure are an effective way to alter both primate and felid behaviour, although these changes are not solely positive and may not result in improved animal welfare. Many of the behavioural changes were not predicted by the literature and suggest there may be individual and species differences in responses to olfactory stimuli.

The overall presence of the olfactory stimuli within enclosures affected study group behaviour while particular scents had no effect. Although the animal scents tested were not biologically relevant, the stimuli were still effective in influencing animal behaviour. This suggests that while testing the scent of species that are sympatric in the wild is useful for understanding how these smells affect animal behaviour and impact animal welfare, they are not necessary to achieve behavioural change in zoo primates and felids. In fact, scents of biologically irrelevant species appear not to be acutely stressful to chimpanzees, hamadryas baboons, and Bengal tigers. The lack of acute stress responses to the odours of biologically irrelevant species in this experiment suggest that housing species that are not sympatric in the wild in close proximity is less likely to impact animal welfare. They can also broaden the range of olfactory enrichment stimuli available for use in zoos. A wider arsenal of scents for use in olfactory enrichment programmes, including biologically irrelevant animal odours, may also slow down the rate of habituation to olfactory stimuli.

Smelly visitors did not result in significant behavioural change in the chimpanzees or baboons, although there were species differences in the trends identified. The chimpanzees appeared to exhibit mild interest in smelly visitors while the baboons were either disinterested or repelled by them, and more research into an olfactory visitor effect in a wider range of species, with a larger sample size, is warranted. The lack of behavioural response to smelly visitors suggests that felids may be habituated to the odours associated with visitors. The overall inability to demonstrate an olfactory visitor effect in primates or felids is positive in animal welfare terms and indicates that zoo animals may not be stressed by the olfactory presence of zoo visitors.

The data indicate that the interaction between environmental enrichment and the effect of visitor density can be complex and may be dependent on species as well as the type of enrichment. The enclosure olfactory stimuli moderated the visitor density effect in the baboon group while, in the chimpanzees, the olfactory stimuli within the enclosure resulted in trends toward a positive visitor density effect and improved welfare in the presence of higher visitor density. The enclosure olfactory stimuli had an overall mixed influence, in welfare terms, on the visitor density effect in the tiger group, but the finding that the tigers showed a trend toward less stereotypic pacing as visitor density increased during this condition is promising and suggests stereotypic pacing in Bengal tigers may be moderated through environmental enrichment and increased visitor stimulation.

While the smelly visitors moderated the visitor density effect in the baboon troop, the interaction between the smelly visitors and number of visitors showed trends that are negative for both the chimpanzees and the tigers. The tigers were particularly negatively affected and showed a trend toward increased pacing in the presence of larger numbers of visitors, some of whom were holding experimental olfactory stimuli. The data regarding the combined effect of smelly visitors and visitor density highlights the need for further investigation into the interaction of factors such as the presence and type of environmental enrichment, visitor density, and species that contribute to a neutral, negative, or positive visitor effect in zoo animals.

Chapter 6: The Visitor Effect in Petting Zoo Animals

6.1 Introduction

The scientific literature on the behaviour and welfare of animals housed in petting zoos is limited. Despite the breadth of research conducted in zoological parks, petting zoo animals are rarely the focus of behavioural or welfare projects. The lack of data on petting zoos is surprising given the numerous welfare issues this kind of animal display creates. Petting zoo exhibits can be characterised by conditions such as physical contact with visitors, mixed species exhibits, and sanctioned feeding of animals by visitors—all conditions which pose obvious welfare concerns. One of the more pressing welfare issues for petting zoo animals is the effect of visitors on their behaviour. The two experiments in this chapter explore the visitor effect on petting zoo animals. The first experiment presents data on the influence of the presence and number of petting zoo visitors on the behaviour and welfare of mixed-breed goats, llama, and Vietnamese pot-bellied pigs housed in the same contact yard. The second experiment explores the potential of visitors to dispense effective non-food enrichment to the same group of goats, llama, and pigs used in the first experiment.

6.1.1 Previous Petting Zoo Research Findings

The three studies of petting zoo animal behaviour in the literature are relevant to a discussion of the visitor effect. Lacey and Pankhurst (2001) investigated the role visitor density played in inter- and intra-specific aggression exhibited by goat, sheep, and pigs housed in a petting zoo at Marwell Zoo (UK). Noticeable levels of aggression directed towards other animals and visitors were reported by the keepers and the researchers hypothesised that visitor density was associated with the unwanted behaviour. Four pygmy goats, three Wiltshire lambs, one Southdown lamb, one Wiltshire horn cross breed sheep, and four Vietnamese pot-bellied pigs were the study animals. Lacey and Pankhurst identified a significant positive correlation between visitor density and the level of aggression in the goats, but no relationship between these variables in the sheep or the pigs. The goats and sheep also avoided visitors more as visitor density increased and spent more time in the retreat areas of the enclosure, but again, visitor density did not affect pig behaviour significantly. However, non-aggressive pig behaviour was associated with visitor density. The study pigs spent significantly more time moving around the enclosure and sleeping decreased as visitor density increased. Visitor behaviour was also affected by visitor density in Lacey and Pankhurst's study. Visitors chased the study goats more when visitor density was higher, but this association was not identified in the sheep or pigs.

The other two petting zoo studies were carried out by researchers at Zoo Atlanta (USA). Anderson et al (2002) tested the effect of providing different retreat spaces on the behaviour of five African pygmy goats and two Romanov sheep. The experiment was carried out as part of an effort to moderate undesirable behaviour directed towards visitors by the study animals. They labelled behaviour as undesirable if it prevented visitors from having physical contact with the goats and sheep. The behaviour was deemed undesirable, not because it was inherently maladaptive, but because it was contrary to the institutional goal of promoting “positive attitudes” towards animals through “one-on-one contact with an animal.” Undesirable behaviours exhibited by the Romanov sheep and pygmy goats included aggressive and escape behaviours such as rearing, charging, foot stamping, head butting, head tossing, threat jumps, rigid alarm posture, nose-blowing, and moving away from visitors.

Modifications to the Zoo Atlanta petting zoo enclosure provided increasing levels of retreat space for the animals. A semi-retreat space, formed by installing wooden boards .9m off the ground of the enclosure’s permanent shade structure, was provided for the first experimental condition. Visitors were allowed to reach over the wooden boards to make contact with the animal, but were not allowed to crawl over or under the boards and enter the semi-retreat space. The second experimental condition involved returning to the normal layout of the enclosure, which provided no retreat space for the sheep and goats. The third experimental condition tested a full retreat space, constructed of chicken wire-style fencing, which did not permit any contact between the visitors and the animals utilising the space.

Using linear regression, Anderson et al calculated the rate of undesirable behaviour from the predictor variables, namely species, visitor density level, visitors’ touches of animals per hour, and the level of the retreat conditions. The authors identified a species difference in the frequency of undesirable behaviours, with the Romanov sheep exhibiting a higher rate than the pygmy goats. There was also a positive correlation between visitor density and the rate of undesirable behaviours, which the authors suggested may be the result of the decrease in distance between visitors and the animals. The rate of undesirable behaviour exhibited by the sheep and pygmy goats was not predicted by the rate of visitor touches the animals received. These results suggest that species and visitor density are significant predictors of the rate of undesirable behaviours performed by the study animals, while visitor touches are not.

The level of retreat space was also not a reliable predictor of the rate of undesirable behaviour. In the full retreat space condition, the rate of undesirable behaviour was lower than in the no retreat space condition, but the semi-retreat space condition recorded the highest rate of undesirable behaviours in both species. The investigators posited that the design and function of the semi-retreat space may have encouraged undesirable behaviour by allowing the visitors to further provoke undesirable behaviour even after the animals had attempted to re-establish a suitable distance between themselves and the visitors. With this experiment, Anderson et al provided data that suggested exhibit design can be an important factor in the frequency of aggressive and escape behaviours directed towards visitors.

Anderson et al (2004) attempted to reduce undesirable behaviour in Romanov sheep and African pygmy goats housed in the Zoo Atlanta petting Zoo by examining the influence of keeper-animal distance on behaviour. Anderson et al hypothesised that the presence of keepers with whom the study animals had generally positive relationships, developed through primarily neutral and positive interactions while carrying out husbandry tasks and training, might contribute to a less fearful or aggressive response from the goats and sheep when interacting with petting zoo visitors. Thus, seven pygmy goats and four Romanov sheep were used to test the hypothesis that keeper-animal distance would be a factor in the rate of undesirable behaviour performed by the study animals. Keeper-animal distance was evaluated on two levels, close and distant. Close keeper-animal distance was defined as being within two focal animal body lengths, while a distant keeper-animal distance was defined as within two to four focal animal body lengths.

Anderson et al used linear regression analysis and the predictor variables animal species, visitor density, keeper-animal distance, and the rate of visitor touches to predict the frequency of undesirable behaviour exhibited by the goats and sheep. The investigators reported a negative relationship between keeper-animal distance and the rate of undesirable behaviour, suggesting that a close keeper-animal distance was associated with a higher rate of undesirable behaviour in the study animals. Anderson et al also identified a positive relationship between the frequency of visitor touches and the frequency of undesirable behaviour exhibited by the goats and sheep, indicating that frequent contact with visitors is associated with undesirable behaviour in the study animals. Visitor density, however, was not significantly related to the rate of undesirable behaviour of the study animals. Species differences in the rate of undesirable behaviour were presented, supporting their hypothesis that pygmy goats as a breed are less fearful of humans than the Romanov sheep.

Anderson et al’s hypothesis that a close keeper-animal distance would reduce the rate of undesirable behaviour in the goats and sheep was not supported by their data. The researchers had several ideas as to why a close keeper-animal distance did not moderate undesirable behaviour in their study animals. There is no direct evidence to suggest that African pygmy goats can distinguish between individual humans and the inability to distinguish between keepers and petting zoo visitors might result in the animals perceiving the keepers as another visitor who has violated their sense of critical distance, triggering a fearful or aggressive response. Anderson et al discuss reports that claim sheep have the ability to distinguish between individual humans, suggesting that this explanation of their results may not be applicable to the sheep.

Another possible explanation for their results is that there is a negative bias against keepers. Although the majority of interactions between keepers and the study animals were reported to be positive, the keepers were also involved in isolation and restraint procedures, which may have lead to a negative perception of keepers. The authors suggest a negative keeper bias by the study animals may be related to the length of time keepers remain in close proximity to the animals. It is possible, they posit, that the study animals interpret the extended close keeper-animal distance as a precursor to unpleasant husbandry or veterinary procedures.

The experiments in Anderson et al (2002, 2004) suggest many avenues for further research on the behaviour and welfare of petting zoo animals. Their work demonstrated that exhibit design, species, and visitor behaviour can influence the behaviour of petting zoo animals and that these factors need to be better understood to improve the welfare of petting zoo animals. Two of the factors that affected the study animals in Anderson et al's experiments, species and visitor density, are explored in the experiments presented in this chapter.

6.2 **Part I.** The Visitor Presence and Density Study

As discussed in Chapter 2, visitor density is the most often studied visitor-related variable. However, the results from visitor density studies of exhibits housing exotic species are not directly comparable to visitor density findings in petting zoos for several reasons. The most striking difference between petting zoo displays and exotic animal displays is the level of contact permitted between visitors and the animals. Exotics on display are generally classified as captive wild animals and, therefore, cannot be habituated to physical contact with inexperienced handlers such as zoo visitors. The domestic species commonly displayed in petting zoos are more suitable for contact yards because they have been bred, in part, for physical and temperamental characteristics which facilitate management by humans. Selective breeding for particular traits desirable to humans is, in itself, a sufficient reason to consider the effect of visitor density on petting zoo animals a distinct subcategory of the visitor effect literature.

The results of an experiment testing the hypothesis that the presence and density of visitors has an effect on the behaviour of mixed-breed goats, llama, and Vietnamese pot-bellied pigs are presented in Part I of this chapter. The effect of a winter break from the presence of visitors, achieved when the safari park in which the petting zoo is located closes for winter, is also hypothesized to have an effect on the influence of visitor presence and density on petting zoo animals. It is predicted that a winter break from visitors will temporarily increase the visitor effect in the petting zoo study animals once the safari park is re-opened to visitors. Removal and reintroduction of visitor stimuli is hypothesised to necessitate habituation of the study species once again to the presence of visitors. Based upon the results of the two petting zoo experiments in the visitor effect literature (Anderson et al 2002, 2004), the spring habituation process is expected to be characterised by increased avoidance of or aggression directed towards visitors. Neither Anderson et al (2002) or Anderson et al (2004) indicate how animal behaviour in general changed in relation to keeper distance, visitor density, or the presence of retreat areas, making a prediction regarding the qualitative or quantitative change in solitary or social behaviour difficult.

6.3 Research Objectives

1. Determine whether the two potential confounding variables, visitor density and weather, changed between the experimental conditions.
2. Determine if the behaviour of the three study species changed significantly in the presence of visitors.
3. Determine if the winter break from visitors significantly affected the on-display behaviour of the three study species.
4. Determine if there are quantitative and/or qualitative differences in the interactions between the study animals and visitors.
5. Determine the relationship between visitor density and the behaviour of the three study species.

6.4 Methods

The study animals consisted of 15 mixed Angora, pygmy, and mixed-breed goats (*Capra hircus* spp.), 16 llama (*Llama glama*), and six Vietnamese pot-bellied pigs (*Sus scrofa*) at the Pets Farm exhibit at Blair Drummond Safari and Adventure Park in Stirling, Scotland. Five of the llama were born during the winter break, halfway through the study. The Pets Farm paddock also housed five greater rhea (*Rhea americana*) but the birds did not regularly interact with the study animals and were not part of the study. Appendix C provides a description of the Pets Farm enclosure. Observations in all conditions were made between the hours of 10:00 and 16:00 to ensure the data were not influenced by the time of day. Instantaneous scan samples (Martin and Bateson 1986) on five individuals per species were collected every ten minutes. Data were collected on a Psion Workabout using the behavioural software program *The Observer* (Noldus).

None of the observations for this study was collected when a Blair Drummond Safari park keeper was in the paddock. Keepers occasionally entered the paddock to replenish browse, but observations were always suspended when keepers approached the paddock gate and were not resumed until the keeper had left the enclosure and the animals had stopped being alert to the keeper's withdrawl.

The methodological distinctions regarding the definitions of visitor presence and density made in Chapter 2 are applicable for the petting zoo visitor density experiment as well. The scale of measure of visitor density was exhibit scale, meaning that only visitors within the paddock were included in the visitor density calculations. The latency of effect was immediate in order to ascertain the effect of visitor density at the moment the scan was recorded. The natural fluctuations in visitor density were exploited. The *no visitors present* condition was achieved by collecting data when the safari park was closed to visitors. The visitor density categories were as follows: no visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51-99 visitors, 100 or more visitors. A density category legend is provided in the first graph for each set of significant results.

To obtain visitor presence and density data across seasons, two data collection periods were established (Table 6.1). Observations were made with both visitors present and visitors absent for both data collection periods. Observations for the initial *visitors present* condition were made over 19 days in September-October, 2004; the condition will henceforth be referred to as **Autumn Visitors Present** or **AVP**. Observations for the *no visitors present* condition were made over 11 observation days in October, 2004; the condition will be referred to as **Autumn No Visitors Present** or **ANVP**. The observations for the second *no visitors present* condition, following the winter closure of the safari park, took place over 11 days in March, 2005; the condition will be known as the **Spring No Visitors Present** or **SNVP**. The observations for the second *visitors present* condition were conducted over 11 days in March-April, 2005; the condition will be referred to as **Spring Visitors Present** or **SVP**.

Autumn Visitors Present (**AVP**) 128 scans	Autumn No Visitors Present (**ANVP**) 122 scans	*Winter* NO VISITORS SAFARI PARK CLOSED	Spring No Visitors Present (**SNVP**) 125 scans	Spring Visitors Present (**SVP**) 126 scans

Table 6.1 The data collection periods for the visitor density study conducted on the Pets Farm study animals.

Behavioural definitions are provided in Appendix B. Following the AVP and ANVP data collection periods, several additional behavioural categories were added because of the birth of the five llama infants. These behaviours were not included in statistical comparisons between conditions, with the exception of the SNVP-SVP comparison, but were included in analyses of individual conditions where relevant. Although all the behaviours listed in the Appendix B were collected, several of them did not occur or were not performed frequently enough to warrant statistical analysis; behaviours that did not occur at least twice were not used in statistical analyses and are not listed in the Results tables.

6.5 Procedures

The presence of the researcher during the ANVP and SNVP conditions essentially constitutes an audience of one; although the effect of the presence of the researcher could not be eliminated, measures were taken to attempt to lessen the potential effect of observation. Upon arrival at Pets Farm for a sampling session, the researcher sat quietly in the middle of the field and waited to begin sampling until the animals habituated to her presence; habituation was considered to have taken place when the animals no longer visually monitored her or startled at her movements, usually about five minutes.

The species subgroups for each scan were selected systematically. The behaviour of the first five individuals of each of the study species observed were recorded, totalling 15 focal animals per scan; the beginning location of scans alternated from left to right, right to left, middle to left, and middle to right. This routine ensured that animals in all areas of the paddock were equally represented in the samples and active animals were not over-represented.

6.6 Statistical Analysis

Proportions were calculated using *The Observer*'s Elementary Statistics feature and then exported to SPSS for further statistical analysis. The proportion of study animals per sample engaged in the behavioural categories collected were calculated and used in statistical testing as the unit of analysis. For the reasons previously discussed in Chapter 1, randomisation tests as described by Todman and Dugard (2001) were the statistical technique chosen to compare the behaviour of the study animals and to compare visitor density levels between conditions. Design 1, a phase design, was suitable for analysing data for a single case experiment. The test statistic for Design 1 was the difference between condition means. Each species was treated as a single participant because individuals were not identified and because the behaviour of socially-housed animals is not independent. The proportion of study animals per sample engaged in the behavioural categories was used to calculate the randomisation test statistic.

Descriptive statistics were used to compare the level of interaction with visitors across species because there is no randomisation test design in Todman and Dugard suitable for this type of analysis and the sample size is not large enough for other more common statistical tests. Both median and mean are reported because of the tendency of the median to equal zero.

To determine if there was any relationship between the proportion of behaviours and the number of people in the Pets Farm paddock, correlation was used. The distribution of proportions was not normally distributed and could not be satisfactorily transformed, therefore a non-parametric statistic, Spearman rank order correlation, was employed.

6.7 Results

6.7.1 <u>Activity Budgets</u>

The activity budgets of the three study species were calculated for the AVP and ANVP conditions to provide the groups' behavioural and welfare baseline. Behaviours comprising at least .5 percent of scans were included in the bar graphs. Figures 6.1-6.3 show the activity budgets of the three study groups.

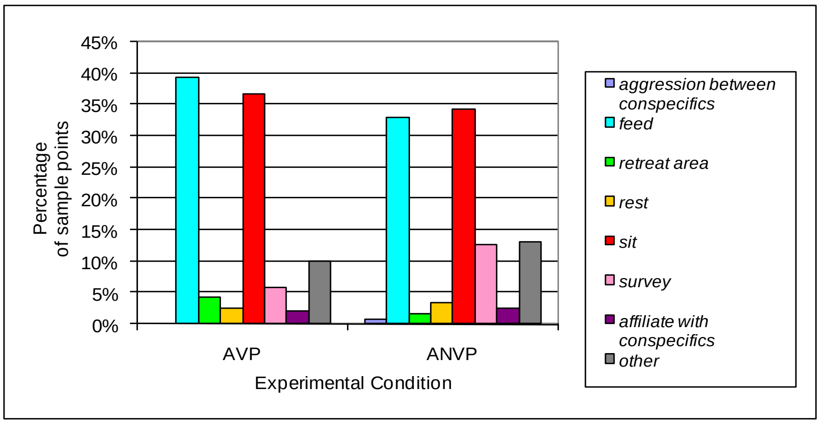

Figure 6.1 The activity budget of the goat group in the AVP and ANVP conditions.

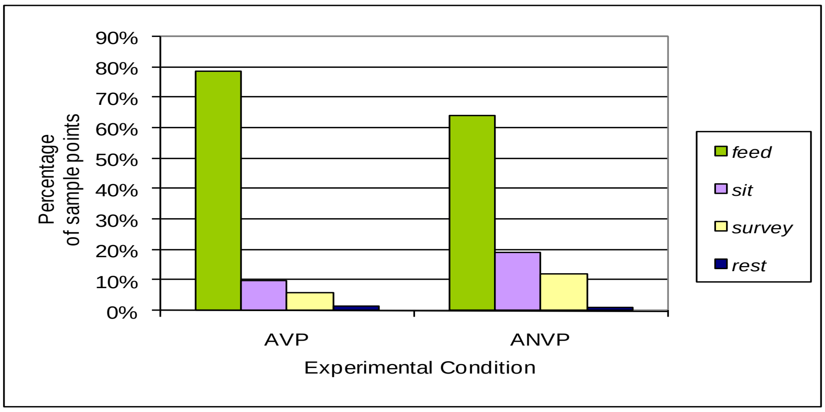

Figure 6.2 The activity budget of the llama group in the AVP and ANVP conditions.

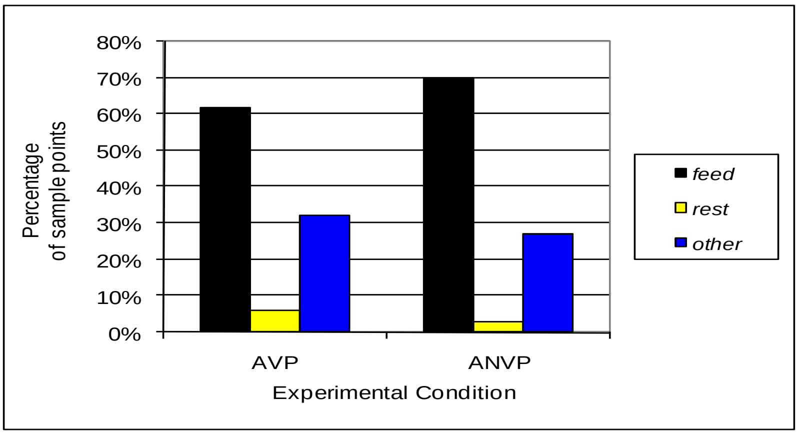

Figure 6.3 The activity budget of the pig group in the AVP and ANVP conditions.

6.7.2 Potential Confounding Variables: Visitor Density and Weather

Visitor density between the two *visitors present* conditions, AVP and SVP, was compared using a randomisation tests. There was no significant difference in visitor density between the two experimental conditions in which visitors were present (test statistic= .991, n= 251, *p*= .548).

It was hypothesised that weather might differ enough between experimental conditions to affect the behaviour of the study animals. Table 6.2 shows the mean, maximum, and minimum temperature (Celsius), the number of hours of sunshine, and the level of rainfall (in millimeters) for Scotland[1].

Condition	Mean Temp	Max Temp	Min Temp	Sunshine (hrs)	Rainfall (mm)
AVP & ANVP	8.5	11.4	5.5	222.8	499.5
SNVP & SVP	7.3	11.1	3.7	398.8	282.7

Table 6.2 The weather in Scotland during the experiment at Pets Farm.

6.7.3 The Effect of the Presence of Visitors on Pets Farm Behaviour

Randomisation tests were used to determine if there was a change in species behaviour, regardless of season, between the *no visitors present*

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[1] Met Office statistics.

(ANVP+SNVP) condition and *visitors present* (AVP+SVP) condition. The behaviour of the goat group did not change significantly between the two conditions. Table 6.3 lists the results of the randomisation tests comparing goat behaviour in the *no visitors present* to the *visitors present* condition.

Goat BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
affiliate with conspecifics	-.014	.395	.020
aggression between conspecifics	-.003	.435	.006
feed	-.034	.618	.360
rest	-.025	.568	.031
retreat area	.013	.306	.015
sit	-.035	.279	.359
survey	.003	.576	.084

Table 6.3 The results of the randomisation tests comparing the *no visitors present* condition to the *visitors present* condition in the goat group.

Figure 6.4 Two of the mixed-breed goats play in the *no visitors present* condition. Pets Farm, Blair Drummond Safari Park (Stirling, Scotland). Photo by author.

The behaviour of the llama group was not significantly affected by the presence of visitors to Pets Farm, although the proportion of *sit* showed a trend toward decreased levels in the conditions in which visitors were present. Table 6.4 lists the results of the randomisation tests comparing llama behaviour in the *no* *visitors present* to the *visitors present* condition. Figure 6.5 shows decrease in *sit* in the llama group.

Llama BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
affiliate with conspecifics	-.003	.399	.012
aggression between conspecifics	-.002	.399	.003
feed	.062	.081	.645
rest	-.015	.399	.016
sit	-.090	.040	.135
survey	.008	.911	.117

Table 6.4 The results of the randomisation tests comparing the *no visitors present* condition to the *visitors present* condition in the llama group. Trends are shaded.

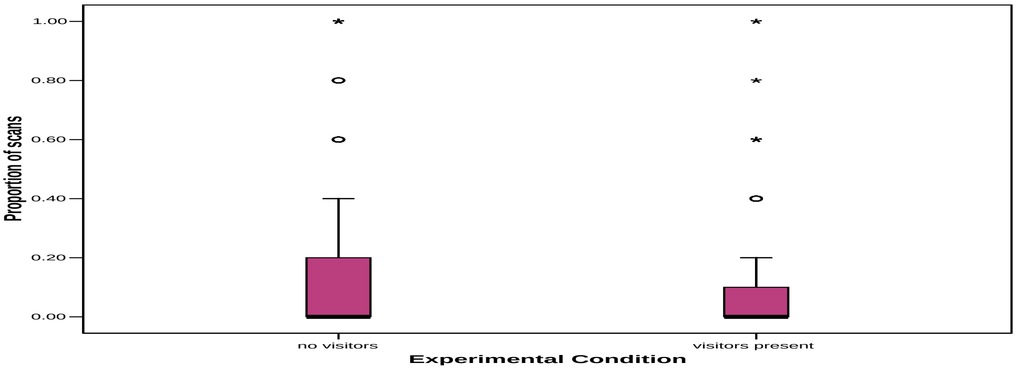

Figure 6.5 The decrease in the median proportion of *sit* in the *visitors present* condition in the llama group.

The pig group's behaviour changed significantly in the presence of visitors. The proportion of *affiliate with conspecifics, aggression between conspecifics*, and *sit* all decreased in the *visitors present* condition. Table 6.5 lists the results of the randomisation tests comparing pig behaviour in the *no visitors present* condition to the *visitors present* condition. Figure 6.6 shows the change in pig behaviour in the presence of visitors.

Pig BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
affiliate with conspecifics	**-.002**	**.001**	**.001**
aggression between conspecifics	**-.004**	**.001**	**.002**
feed	-.122	.363	.613
rest	.031	.188	.048
sit	**-.006**	**.001**	**.005**
survey	.009	1.000	.015

Table 6.5 The results of the randomisation tests comparing *no visitors present* condition to the *visitors present* condition in the pig group. Significant results are in bold text.

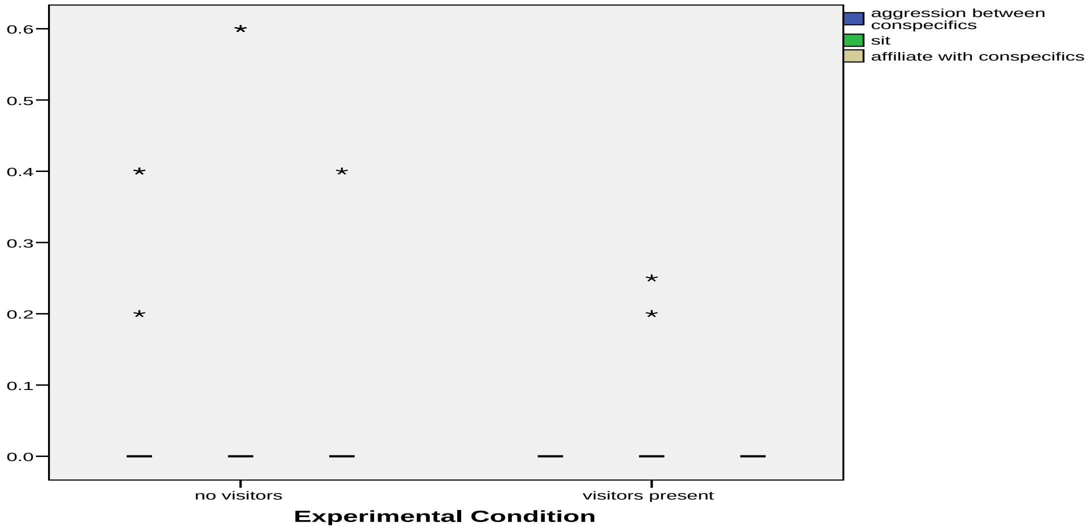

Figure 6.6 The decrease in the median proportion of *aggression between conspecifics*, *sit*, and *affiliate with conspecifics* in the *visitors present* condition in the pig group. *No visitors present* mean proportion: *aggression between conspecifics*= .005, *sit*= .008, *affiliate with conspecifics*= .002. *Visitors present* mean proportion: *aggression between conspecifics*: 0, *sit*= .002, *affiliate with conspecifics*= 0.

6.7.4 Seasonal Effects on On-display Behaviour

The two *visitors present* seasons, AVP and SVP, were hypothesised to have different effects on the behaviour of the three study species housed at Pets Farm. To test the hypothesis, randomisation tests were computed for each species to identify an effect of visitor season on goat, llama, or pig behaviour. The behaviour of the goat, llama, and pig groups did not differ significantly between the two *visitors present* conditions, but the goat behaviour *aggression between conspecifics* showed a trend toward increase in the SVP condition that did not achieve statistical significance. Tables 6.6-6.8 list the results of randomisation tests comparing AVP and SVP conditions in the goat, llama, and pig groups. Figure 6.7 shows the increase in the goat behaviour *aggression with conspecifics* in the SVP condition.

Goat BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
affiliate with conspecifics	-.016	.774	.013
aggression between conspecifics	.008	.040	.004
avoid visitors	-.001	1.000	.005
contact with visitors	.061	.511	.116
feed	-.100	.084	.343
rest	-.010	.548	.019
retreat area	-.040	.492	.022
sit	-.043	.643	.342
survey	.055	.507	.085

Table 6.6 The results of the randomisation tests comparing behaviour in the AVP condition to the SVP condition in the goat group. Trends are shaded.

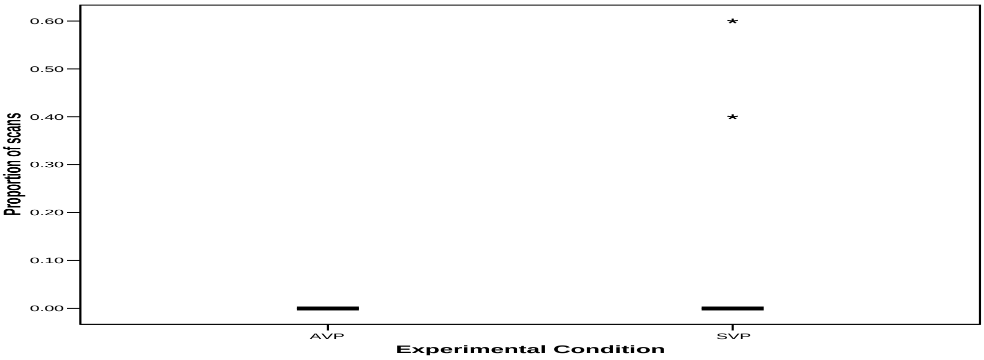

Figure 6.7 The increase in the median proportion of *aggression with conspecifics* in the SVP condition in the goat group. AVP mean proportion= .000, SVP mean proportion= .008.

Llama BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
affiliate with conspecifics	.022	.460	.011
aggression between conspecifics	.003	.548	.002
avoid visitors	.025	.548	.014
contact with visitors	.006	.959	.041
feed	-.241	.090	.672
rest	-.008	.636	.009
sit	-.010	.492	.091
survey	.128	.126	.122

Table 6.7 The results of the randomisation tests comparing behaviour in the AVP condition to the SVP condition in the llama group.

Pig BEHAVIOUR	Test Statistic	*p* (two-tailed)	Proportion of Total Sample Points
avoid visitors	.003	.548	.003
contact with visitors	.097	.349	.086
feed	-.085	.414	.551
rest	.014	.084	.060
sit	.004	.497	.002
survey	.034	.548	.020

Table 6.8 The results of the randomisation tests comparing behaviour in the AVP condition to the SVP condition in the pig group.

6.7.5 Comparison of Species Interactions with Visitors

All three study species interacted with visitors (AVP + SVP). The mean percentage of scans was calculated to determine which species engaged in more visitor-directed behaviour. The goats interacted with visitors in a non-aggressive context in 12% of the scans, the pigs slightly less at 9%, and the llama in 4% of scans. The llama and goats avoided visitors in 1% of scans, while the pigs avoided visitors in less than 1% of scans. Neither the goats nor the pigs directed aggression towards visitors, but the llama spent .1% of scans in visitor-directed aggression. Table 6.9 lists the median and mean percentage of three visitor-directed behaviours for the goats, llama, and pigs.

	BEHAVIOUR	Mean %	Median %
Goat	*contact with visitors*	12	0
	aggression towards visitors	0	0
	avoid visitors	1	0
Llama	*contact with visitors*	4	0
	aggression towards visitors	.1	0
	avoid visitors	1	0
Pig	*contact with visitors*	9	0
	aggression towards visitors	0	0
	avoid visitors	.3	0

Table 6.9 The median and mean proportion of scans in which the study species exhibited visitor-directed behaviour in the two *visitors present* conditions (AVP + SVP).

6.7.6 The Relationship Between Visitor Density and Behaviour

The relationship between visitor density and behaviour in the AVP and SVP conditions were analysed for all three species using Spearman rank order correlations. Three goat behaviours were significantly correlated with visitor density. The proportion of *contact with visitors* increased as the numbers of visitors increased in the AVP and SVP conditions. Both *proximity with non-conspecifics* and *contact with conspecifics* decreased as visitor density increased in the SVP condition in the goat group. Table 6.10 lists the results of the Spearman correlations between visitor density and goat behaviour. Figures 6.8-6.11 show the relationship between visitor density and goat behaviour.

Goat	AVP		SVP	
BEHAVIOUR	r	*p*	r	*P*
affiliate with conspecifics	-.139	.122	NA	NA
contact with visitors	**.327**	**.001**	**.427**	**.001**
contact with conspecifics	---	---	**-.231**	**.009**
feed	-.067	.456	.005	.960
proximity to non-conspecifics	---	---	**-.257**	**.004**
proximity to conspecifics	---	---	-.073	.419
rest	-.068	.453	NA	NA
retreat area	-.134	.136	NA	NA
sit	.009	.924	.012	.898
survey	.113	.212	.093	.302

Table 6.10 The results of the Spearman correlations between visitor density and the proportion of goat behaviour. AVP n= 125, SVP n= 126. (---)= behaviour not collected in this condition. Significant results are in bold.

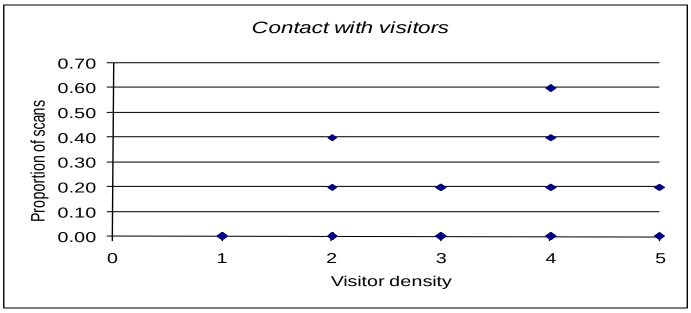

Figure 6.8 The relationship between visitor density and *contact with visitors* in the AVP condition in the goat group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51-99 visitors, 5= 100 or more visitors.

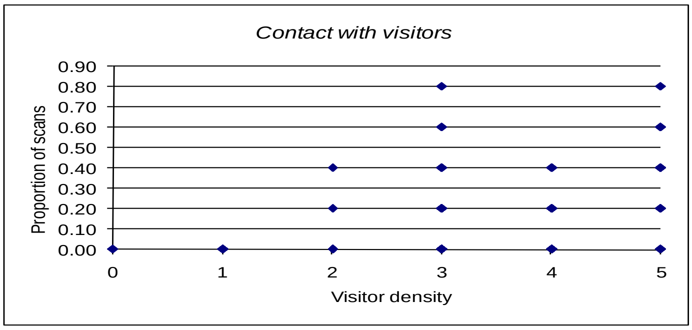

Figure 6.9 The relationship between visitor density and *contact with visitors* in the SVP condition in the goat group.

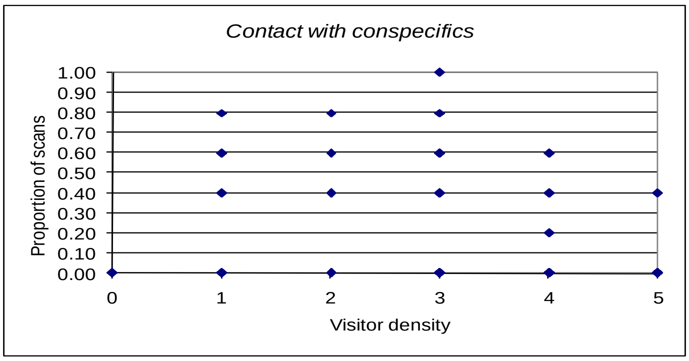

Figure 6.10 The relationship between visitor density and *contact with conspecifics* in the SVP condition in the goat group.

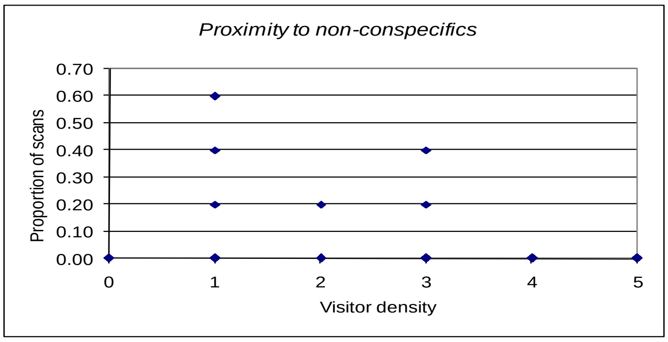

Figure 6.11 The relationship between visitor density and *proximity to non-conspecifics* in the SVP condition in the goat group.

Only one llama behaviour was dependent on the level of visitor density. The proportion of *contact with visitors* increased significantly as visitor numbers increased in both the AVP and SVP conditions. Table 6.11 lists the result of the

Spearman correlations between visitor density and llama behaviour. Figures 6.12 and 6.13 show the relationship between visitor density and llama behaviour.

Llama BEHAVIOUR	AVP		SVP	
	r	*p*	r	*p*
affiliate with conspecifics	NA	NA	.082	.360
avoid visitors	NA	NA	.157	.078
contact with conspecifics	---	---	.016	.860
contact with visitors	**.364**	**.001**	**.283**	**.001**
feed	-.014	.876	-.045	.620
maternal contact	---	---	.012	.895
proximity to conspecifics	---	---	.011	.899
sit	-.072	.423	-.062	.492
survey	.069	.441	.101	.261

Table 6.11 The results of the Spearman correlations between visitor density and the proportion of llama behaviour. AVP n= 126, SVP n= 126. (---)= behaviour not collected in this condition. Significant results are in bold.

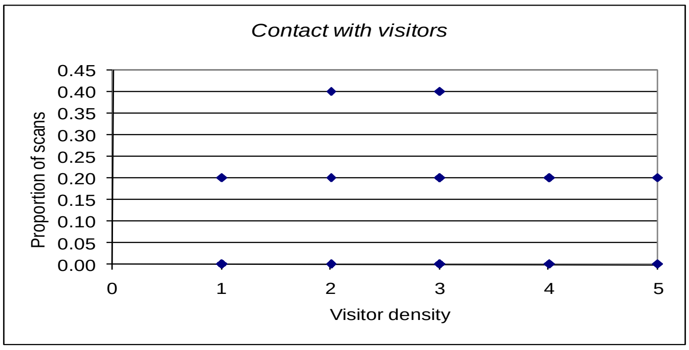

Figure 6.12 The relationship between visitor density and *contact with visitors* in the AVP condition in the llama group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51-99 visitors, 5= 100 or more visitors.

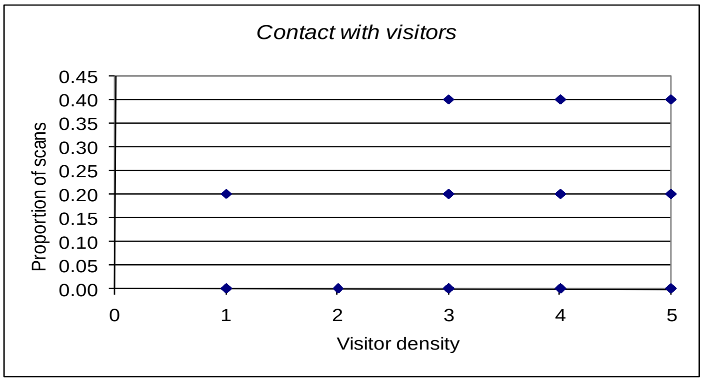

Figure 6.13 The relationship between visitor density and *contact with visitors* in the SVP condition in the llama group.

Two pig behaviours were correlated with visitor density. The proportion of *contact with visitors* increased significantly as visitor density increased in both the AVP and SVP conditions. The proportion of *feed* was also significantly negatively correlated with visitor density in the AVP condition, but showed only a trend toward association in the SVP condition. Table 6.12 lists the result of the Spearman correlations between visitor density and pig behaviour. Figures 6.14-6.17 show the relationship between visitor density and pig behaviour.

Pig BEHAVIOUR	AVP		SVP	
	r	*p*	r	*p*
contact with visitors	**.486**	**.001**	**.344**	**.001**
feed	**-.361**	**.001**	-.176	.048
rest	-.029	.749	.081	.370

Table 6.12 The results of the Spearman correlations between visitor density and the proportion of pig behaviour. AVP n= 125, SVP n= 126. (---)= behaviour not collected in this condition. Significant results are in bold; trends are shaded.

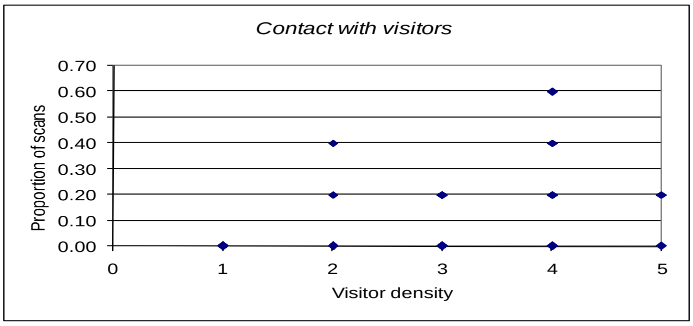

Figure 6.14 The relationship between visitor density and *contact with visitors* in the AVP condition in the pig group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51-99 visitors, 5= 100 or more visitors.

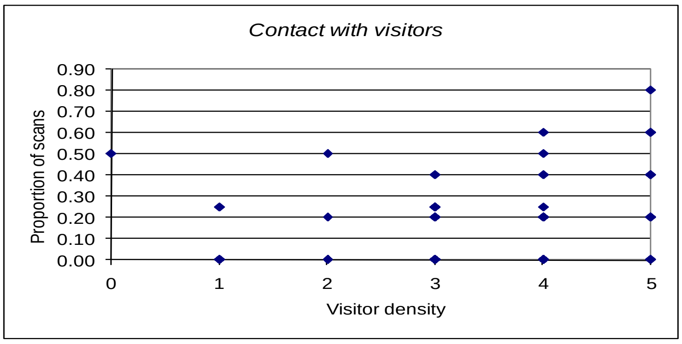

Figure 6.15 The relationship between visitor density and *contact with visitors* in the SVP condition in the pig group.

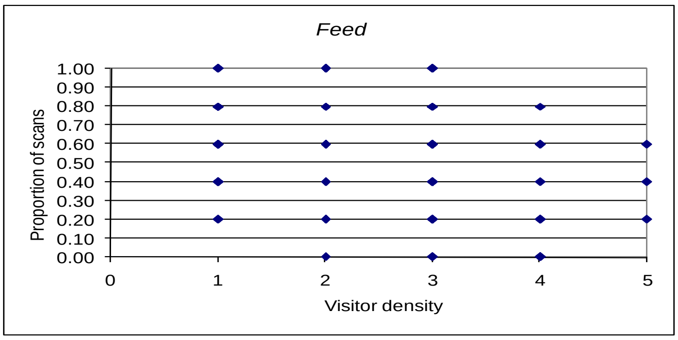

Figure 6.16 The relationship between visitor density and *feed* in the AVP condition in the pig group.

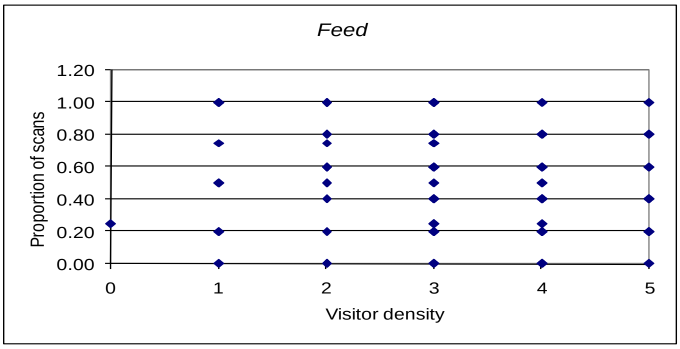

Figure 6.17 The relationship between visitor density and *feed* in the SVP condition in the pig group.

Figure 6.18 A Vietnamese pot-bellied pig interacts with visitors in Pets Farm, Blair Drummond Safari Park (Stirling, Scotland). Photo by author.

6.8 Discussion

6.8.1 Visitor Density and Weather Unlikely Confounding Variables

The comparison of visitor density between the two visitor conditions demonstrates a consistent level of visitors to the petting zoo in the pre- and post winter break conditions, suggesting different levels of visitor density were not affecting the results of the experiment. The descriptive comparison of weather suggests the mean, minimum, and maximum degrees Celsius did not vary much between the autumn and spring data collection periods and was unlikely to affect animal behaviour. Although there were a greater number of hours of sunshine and less rain in the spring conditions than in the autumn, these changes were unlikely to impact animal behaviour negatively and, therefore, contribute to a negative response to visitors that was predicted in the autumn visitor condition.

6.8.2 The Presence of Visitors Affects Llama and Vietnamese Pot-bellied Pig Behaviour

The hypothesis that the behaviour of the three study species would differ depending on the presence or absence of visitors was supported by the data on one of the three species. Goat behaviour was unaffected by the presence of visitors, a finding which suggests that goats do not experience a visitor effect. This result is in keeping with Anderson et al (2002, 2004) who reported that African pygmy goats exhibited less undesirable visitor-directed behaviour than Romanov sheep. Although there wasn’t a statistically significant change in llama behaviour when visitors were present in the petting zoo, the proportion of sitting showed a trend toward decreased levels which suggests the presence of zoo visitors may have minimal influence on their behaviour.

The lack of extensive visitor pressure reported for the goats and llama appears not to extend to pigs. The decrease in the proportion of three behavioural categories between the *no visitors present* and *visitors present* conditions indicates they experienced more visitor pressure. The significant decrease in both affiliative and aggressive behaviour towards conspecifics suggests that the visitor effect in Vietnamese pot-bellied pigs results in decreased social behaviour. While the study has demonstrated a negative visitor effect in the study pigs, the level of expression of both these behaviours was low and was likely to have a negligible effect on their welfare. The common visitor effect in ungulates housed in petting zoos, based on this small sample of llama and pigs, appears to be a decrease in inactivity, which has been reported in primates (Chamove et al 1988, Todd et al 2006) and in other petting zoo-housed pot-bellied pigs (Lacey and Pankhurst 2001). The observed behavioural changes related to visitor pressure in the pigs are surprising given that Vietnamese pot-bellied pigs are a breed frequently kept as household pets and, therefore, might be assumed to be less susceptible to the influence of the presence of visitors than non-companion animal species such as llama and goats.

6.8.3 Seasonal Visitor Effect in Goats

The hypothesis that a winter break from visitors would affect the on-display behaviour of the study animals was not supported by the data. The behaviour of the three study species did not change significantly between seasons, but a trend toward increased levels of aggression within the goat group between the AVP and SVP conditions was identified. This behavioural change was statistically non-significant, and the proportion of scans in which this behaviour was observed was minimal and probably does not impact in goat welfare. The lack of behavioural change in the three study groups does not support the hypothesis that a sustained period without the presence of visitors results in an increased visitor effect, and demonstrates that the removal and reintroduction of visitor-related stimuli does not impact goat, llama, or pig behaviour.

6.8.4 Species Differences in Interactions with Visitors

All three study species interacted with visitors, and the goats spent the greatest proportion of scans interacting with visitors, followed by the pigs and then the llama. This result is not unexpected given the previous reports of Anderson et al 2002 and Anderson et al 2004 which indicate that African pygmy goats are less fearful of zoo visitors than sheep. Only the llama group directed aggressive behaviour towards visitors, but this represented a small mean percentage of scans and only indicates that llama may be slightly less tolerant of visitors than goats and pigs when housed in petting zoos.

6.8.5 Visitor Density Effects

The hypothesised association between visitor density and behaviour was supported by the data for all three species groups, but not in the direction predicted. *Contact with visitors* was significantly correlated with density for the goats and llama in both visitor conditions, while the pig data showed only a trend toward increased levels in the SVP condition; these findings suggest that increased numbers of visitors within the paddock increased rather than decreased contact between humans and display animals. Interestingly, the strength of the association was greater in the spring visitor condition for the goats and less strong in the spring for the llama. While the introduction of the llama young in the spring might explain the reticence of the llama to interact with visitors, it is also possible that the winter break contributed to the decline in the willingness to interact with humans in the presence of a larger number of zoo visitors. The association between *contact with visitors* and visitor density in this study contradicts Anderson et al (2002) in which the authors found increased rates of undesirable visitor-directed goat and sheep behaviour as the number of people increased. The results of the Pets Farm study also contradict Lacey and Pankhurst (2001), who identified increased goat aggression towards animals and visitors as visitor density increased.

Proximity to non-conspecifics and *contact between conspecifics* decreased as visitor density increased in the spring condition in the goat group. The change in group cohesion in association with visitor density suggests that visitor density can have an effect on the instinct to herd in ungulates. This result appears to contradict the herding instinct that causes prey animals to form groups when threatened, and indicates that further visitor density studies on domesticated animals housed in zoos should be carried out. Goat feeding behaviour, which represents a large proportion of their activity budget (49% for feral goats: Stronge et al 1997), was not affected by visitor density and suggests that visitor density may not have an intense effect on goats housed in petting zoos.

Pig feeding behaviour decreased significantly as visitor numbers increased for the pre-winter break visitor condition, but did not achieve significance in the post-break visitor condition. The visitor effect in Vietnamese pot-bellied pigs housed in petting zoo is supported by previous findings of increased locomotory behaviour and decreased sleeping behaviour (Lacey and Pankhurst 2001).

Part II. The Grooming Experiment

6.9 Introduction

The human-animal relationship (HAR) has been investigated in domesticated species that are commonly held on farms, and methodologies to evaluate the phenomenon have been tested and refined (Waiblinger et al 2006). The application of the HAR concept has recently been adapted to examine the interactions between zoo animals and the humans they encounter (Hosey 2007). Although the HAR methodologies have yet to be explicitly utilised in experiments in the zoo environment, the application of the concept and accompanying literature is particularly well-suited to petting zoo research because petting zoos have several environmental conditions in common with both of these captive situations. Petting zoos are similar to farms in that they house domesticated species such as pigs, goats, and sheep; the animals in petting zoos are also handled by familiar humans (keepers) as is the case on farms, where stockpersons manage the animals. The typical petting zoo enclosure may be more similar in size to farm paddocks than they are to traditional exotic animal enclosures at zoos; petting zoos are also like farms in that humans enter the animals' living space to handle the animals. In addition to the similarities to farms, petting zoos also have several of the characteristics of zoos that house exotic species. The animals in petting zoos are exposed to large numbers of unfamiliar humans (zoo visitors) on a daily basis, as is the case in non-contact zoos housing exotics. The presence, density, and behaviour of humans visiting zoos are known to have an effect on the behaviour and welfare of zoo animals (Hosey 2000) and there is evidence to suggest that petting zoo inhabitants also experience a visitor effect.

The primary objective of the Pets Farm grooming experiment was to test a potential enrichment technique that was stimulating to both the visitors and the animals and had the potential to improve petting zoo animal welfare. One of the most common forms of environmental enrichment provided for captive animals housed in zoos or laboratories is foraging enrichment. The feeding of petting zoo animals by visitors can be classified as foraging “enrichment” since the animals are required to search for their food in visitors’ hands and where it has fallen on the ground. However, this kind of feeding probably provides pleasure to the visitors at the expense of the physical health of the animals, although there are no published data on the impact of visitor feedings on petting zoo animal behaviour or welfare.

It is likely that allowing visitors to feed domestic animals housed in petting zoos enhances the visitor experience, but the practice may introduce welfare concerns. It is hypothesised that the feeding of zoo animals is generally prohibited in North America and Europe because it is thought to 1) encourage excessive animal orientation towards visitors which leads to reduced behavioural diversity and species specific behaviour, 2) cause nutritional or dietary imbalances, 3) promote behavioural problems in the animals such as frequent aggression towards other animals or visitors, 4) reduce the educational value of display animals. Therefore, although visitor feeding may be considered to be a form of enrichment for visitors, it is unlikely the practice would hold up under empirical scrutiny in an animal welfare study. For these reasons, visitor feeding of petting zoo animals was deemed an unsuitable potential enrichment programme. It is unclear how widespread the practice of visitor feeding in petting zoos is currently, although it seems probable that in these days of heightened interest and concern for animal welfare, it is relegated to zoos operating without accreditation or recognition by zoological associations such as the British and Irish Association of Zoos and Aquariums and the American Zoo and Aquarium Association.

Visitor grooming of petting zoo animals, the technique tested here, was selected as a potential method of visitor and animal enrichment based on the desire of humans to interact with animals in a zoo setting. The visitor effect literature provides empirical evidence of visitor motivation to interact with zoo animals, unfortunately using primarily negative modes of interacting. For instance, Fa (1989) reported that visitors fed green monkeys (*Cercopithecus aethiops sabaeus*) at the Mexico City Zoo; visitor feeding was also reported in chimpanzees at Chester Zoo by Cook and Hosey (1995). Mitchell et al (1992a) observed visitors threaten and harass golden-bellied mangabeys (*Cercocebus galeritus chrysogaster*) housed at the Sacramento Zoo. Siamang-visitor interactions have also been reported by Nimon and Dalziel (1992). Given visitors' desire to interact with display animals, the appeal of petting zoos is assumed to be the high degree of contact with animals visitors are able to achieve. From a visitor perspective, being allowed to groom the animals is potentially a pleasurable experience and is hypothesised to satisfy the visitor enrichment criterion.

Everyday petting and stroking by visitors, without a grooming tool, could be enriching to petting zoo animals. The data on gentling in farm animals suggests that humans stroking or petting domestic animals can positively affect animal behaviour and their response to humans. For example, Grandin et al (1987) reported "mingling[2]," alone or in conjunction with other types of enrichment, reduced excitability and improved handling in chute in pigs. Norwegian dairy kids who were talked to and stroked by a seated human approached and interacted more with a human than study kids who did not receive the handling (Boivin and Braastad 1996). Gentle handling in association with food reward resulted in increased approaches to a human in ewe lambs (Boivin et al 2000).

Visitor stroking of petting zoo animals using their hands may provide some tactile enrichment for the animals, although if this were the case, one would have expected to see a negative relationship between visitor touches and the rate of undesirable behaviour exhibited by the goats and sheep studied by Anderson et al[3] (2002). While the data presented in Part I of this chapter did not show high levels of negative interactions between visitors and the Blair Drummond study

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[2] Defined as a human entering a pen and petting the pigs in either an assertive or a gentle manner. This definition appears to be equivalent to the more commonly used term "gentling."

[3] This assumes that visitor touches were generally affiliative in nature; Anderson et al did not distinguish between affiliative and aggressive visitor touches.

animals, there was a significant negative change in animal behaviour due to the presence and density of humans in the paddock. These changes indicate that techniques such as grooming, which may increase rewarding visitor-animal interactions for both participants, should be tested to determine if they moderate the visitor effect.

As evidenced by the available petting zoo data, normal zoo visitor contact may not be enriching to petting zoo animals. There are several explanations for why this may be the case. The number of zoo visitors petting zoo animals are exposed to could affect their response to visitor petting. Anderson et al (2002) observed a positive relationship between visitor density and undesirable goat and sheep behaviour directed at visitors. Although the results of Anderson et al's experiments on petting zoo behaviour suggests visitor density can be a factor in undesirable petting zoo animal behaviour, the density study in Part I of this chapter showed increased levels of non-aggressive interactions between study animals and visitors as visitor density increased, suggesting visitor density is only one factor in a constellation of variables that contribute to the visitor effect in petting zoos.

Another possible explanation for why everyday petting zoo visitor touching and stroking may not be enriching is that visitor petting is simply not tactilely stimulating for petting zoo animals, although Hemsworth (1997) reports commercial pigs are sensitive to tactile interactions with humans, such as pats, strokes, and hands resting on pigs' backs. The thick coats of hair of many domesticated animals, such as the llama and goats in this experiment, may prevent the animals from receiving much sensation from even forceful petting or stroking. The lack of stimulation, combined with the number of interactions with unfamiliar visitors, may simply outweigh any positive sensation they experience from visitor petting. If this hypothesis explains the apparent lack of animal reward provided by everyday visitor petting, the grooming tool provided to visitors in the experimental condition should increase the sensory reward for the study animals and make interactions more positive for the animals.

There is evidence to suggest that positive interactions between domesticated animals and humans can alter the way animals perceive other unfamiliar humans. Data on the relationship between pigs, handlers, and unfamiliar humans that suggest pigs generalise positive experiences with handlers to other humans, but aversive experiences are not generalised. Hemsworth et al (1996) reported that pigs associated rewarding experiences (being fed) with the handler, demonstrated by their less fearful approach of a handler in a standard human approach test. Using the same approach test, Hemsworth et al also found that pigs receiving frequent positive handling did not associate negative experiences (an oestrus detection procedure) with the handler. The familiarity of the handlers did not appear to influence the approach behaviour of the pigs as there was no significant difference between the approach behaviour of the pigs to familiar or unfamiliar handlers. The results of Hemsworth et al's experiment have implications for the Petting Farm grooming experiment because they indicate that by creating positive interactions between pigs and humans, animal perception of humans in general is improved. Although it is not clear whether goats generalise positive experiences with humans to all humans as pigs do, increasing positive visitor- animal interactions through grooming has the potential to moderate the visitor effect in the inhabitants of Pets Farm.

6.10 Research Objectives

1. Determine if there were significant changes in visitor density between the experimental conditions which could contribute to observed behavioural changes.
2. Determine the effect of visitor grooming on animal behaviour.
3. Determine the animal response to visitor grooming and assess whether the manipulation is rewarding to petting zoo animals.
4. Determine the effect of visitor density on animal response to visitor grooming.
5. Determine the effect of visitor grooming on visitor behaviour.

6.11 Methods

The study animals used in Part I of this chapter were also used in the grooming experiment, although visitors only groomed the llama twice and, therefore, they were excluded from statistical analysis. Observations for both the *no visitor grooming* and *visitor grooming* conditions were made simultaneously over a 19 day period in September and October of 2004. Continuous focal animal samples (Martin and Bateson 1986) were used to collect the data. Table 6.13 lists the number of samples per condition for both species in the grooming experiment.

SPECIES	No Visitor Grooming	Visitor Grooming
Goat	46	38
Pig	84	12

Table 6.13 The number of samples per condition in the grooming experiment for the goats and the pigs.

Data were collected on a Psion Workabout using the behavioural software program *The Observer* (Noldus). The grooming tool was a solid rubber scrubbing block with long flexible teeth designed to groom domestic animals (Mikki™ 6275-185).

6.12 Procedures

No visitor grooming samples began when a visitor approached a study animal to within contact range (about 1m); *no visitor grooming* samples ended when either the animal or the visitor walked away, signalling an end to the interaction. *Visitor grooming* samples began when visitors, wielding the grooming tool provided by the researcher, approached the study animals to within contact range; *visitor grooming* samples ended when either the visitor or animal walked away, indicating the interaction had come to an end. In some cases, during both the *no visitor grooming* and *visitor grooming* samples, the study animal walked or ran away from the approaching visitor before contact had taken place and either one of the following scenarios was recorded for the interaction: 1) The behaviour *avoid visitor* was recorded and then the sample was ended if the visitor did not pursue the animal OR 2) The behaviour *avoid visitor* was recorded and the sample continued if the visitor pursued the animal. As in Part I, none of the observations for this study was collected when a Blair Drummond Safari Park keeper was in the paddock.

6.13 Statistical Analysis

Frequencies and durations of bouts were calculated using *The Observer*'s Elementary Statistics feature and then exported to SPSS for further statistical analyses. Because the focal samples varied in length, depending on how the long the focal interacted with visitors, frequencies were converted to frequency per hour before statistical analysis to achieve standardisation. The grooming experiment was consistent with an alternating design with random assignment of observation periods to treatment conditions, making Design 5a as described in Todman and Dugard (2001) a suitable randomisation test for the data. The test statistic for Design 5a is the residual sum of squares.

6.14 Results

6.14.1 Potential Confounding Variable: Visitor Density

Visitor density levels between experimental conditions were compared using randomisation tests. There was no statistical difference in visitor density between the *no visitor grooming* and the *visitor grooming* conditions in the goat group (test statistic= .423, n= 119, *p*= .033), but the data suggest there was a trend toward increase. There was no difference in visitor density between the conditions in the pig group (test statistic= .571, n= 47, *p*= .189). Figure 6.19 shows the increase in visitor density in the *visitor grooming* condition in the goat samples.

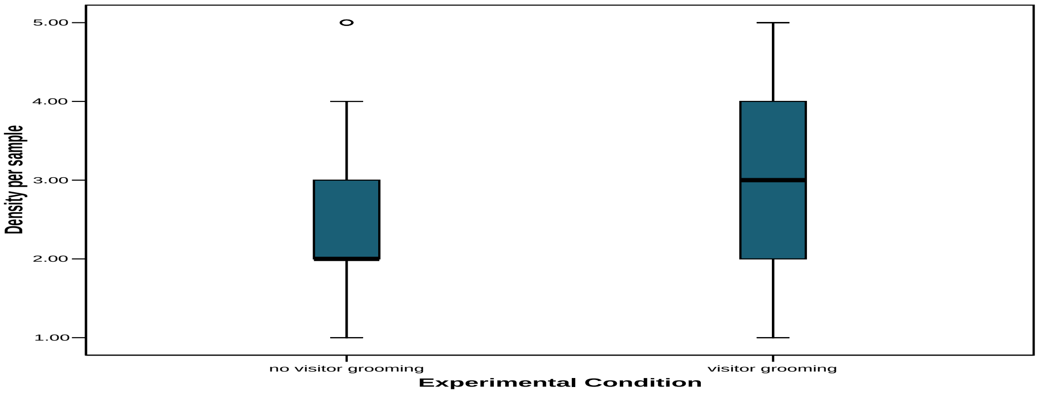

Figure 6.19 The increase in median visitor density per sample between the *no visitor grooming* and *visitor grooming* conditions in the goat group.

6.14.2 The Effect of Visitor Grooming on Animal Behaviour

Randomisation tests were used to compare study animal behaviour between the *no visitor grooming* condition and the *visitor grooming* condition. There was no significant difference between animal behaviour between the two conditions in either the goat or the pig group. Tables 6.14 and 6.15 list the results of the randomisation tests comparing goat and pig behaviour in the *no visitor grooming* and *visitor grooming* conditions.

Goat BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
aggression towards visitors (fph)	.001	.292	5
avoid visitors (fph)	.001	.752	22
feed (d)	-1.075	.620	19
feed (fph)	.001	.961	19
rest (d)	1.036	.383	3
rest (fph)	.001	.383	3
sit (d)	6.378	.318	60
sit (fph)	.002	.307	60

Table 6.14 The results of the randomisation tests comparing goat behaviour in the no grooming and grooming conditions. (d)= duration, (fph)= frequency per hour.

Pig BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
avoid visitors (fph)	.001	.119	16
feed (d)	-.351	.985	38
feed (fph)	.005	.236	28
rest (d)	9.807	.495	8
rest (fph)	.003	.365	8

Table 6.15 The results of the randomisation tests comparing pig behaviour in the no grooming and grooming conditions. (d)= duration, (fph)= frequency per hour.

6.14.3 Response to Visitor Grooming

Randomisation tests were used to compare the level of animal response to visitor grooming. The levels of *respond to grooming* were significantly different than the levels of *tolerate grooming* in both the goat and pig groups, with the duration of *tolerate grooming* being significantly longer than the duration of *respond to grooming* in both species. However, the frequency per hour of *respond to grooming* did not differ statistically from *tolerate grooming* in the pigs. Table 6.16 lists the results of randomisation tests comparing levels of *respond to grooming* to *tolerate grooming* in the goat and pig groups. Figures 6.20-6.23 show the differences in animal response to visitor grooming.

	BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
Goat	***respond to grooming* vs. *tolerate grooming* (d)**	**25.440**	**.001**	**110**
	***respond to grooming* vs. *tolerate grooming* (fph)**	**1.278**	**.005**	**110**
Pig	***respond to grooming* vs. *tolerate grooming* (d)**	**28.250**	**.001**	**15**
	respond to grooming vs. *tolerate grooming* (fph)	.018	.016	15

Table 6.16 The results of randomisation tests comparing *respond to groom* vs. *tolerate groom* in the goat and pig groups. (d)= duration, (fph)= frequency per hour. Significant results are in bold text; trends are shaded.

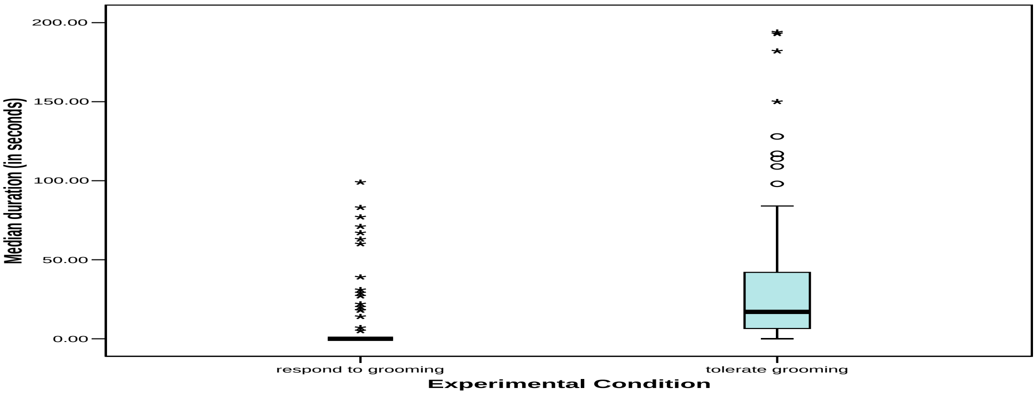

Figure 6.20 The difference in the median duration of *respond to grooming* and the median duration of *tolerate grooming* in the visitor grooming condition in the goat group.

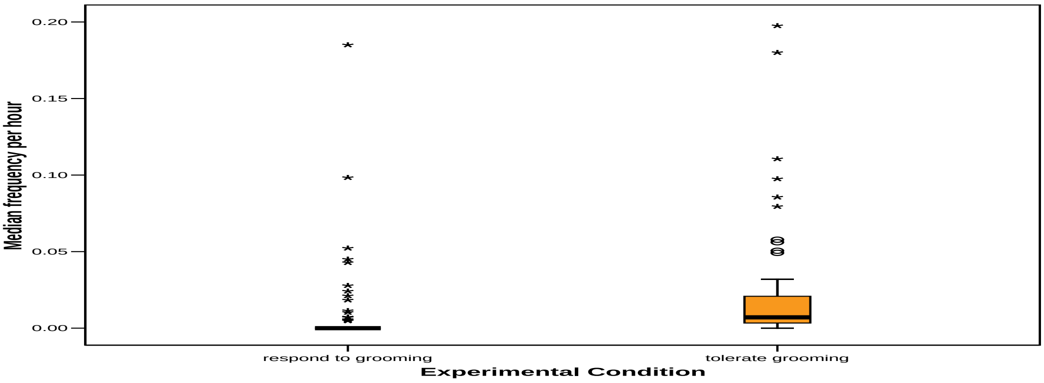

Figure 6.21 The difference in the median frequency per hour of *respond to grooming* and the median frequency per hour of *tolerate grooming* in the visitor grooming condition in the goat group.

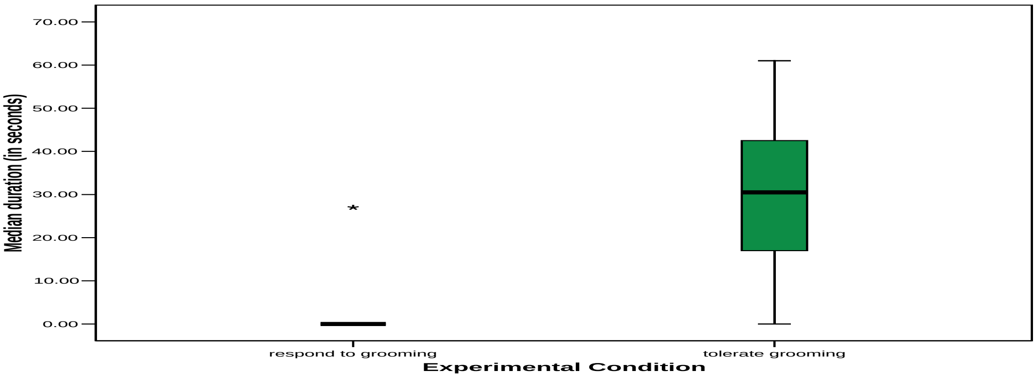

Figure 6.22 The difference between the median duration of *respond to grooming* and the median duration of *tolerate grooming* in the visitor grooming condition in the pig group.

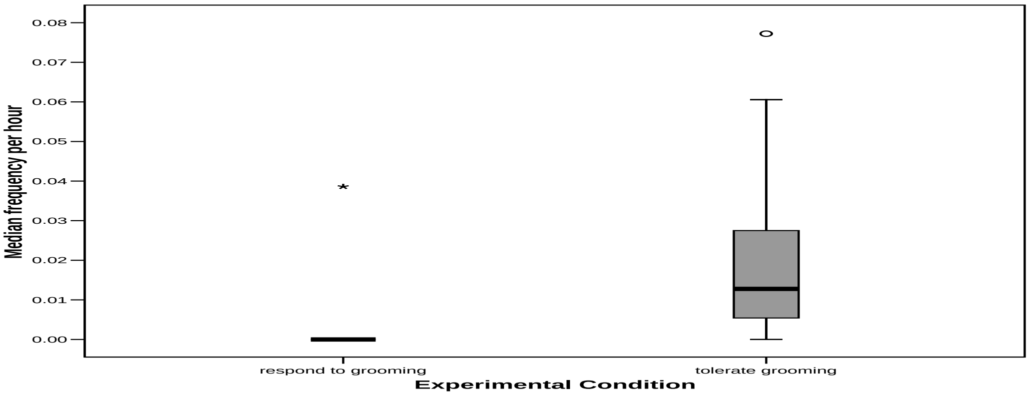

Figure 6.23 The difference between the median frequency per hour of *respond to grooming* and the median frequency per hour of *tolerate grooming* in the visitor grooming condition in the pig group.

Spearman correlations were computed to determine whether visitor density had an effect on the response of goats and pigs to visitor grooming. The frequency per hour and duration of *respond to grooming* were significantly negatively correlated with visitor density in the goats, but there was no association between *respond to grooming* and visitor density in the pig group. Table 6.17 lists the results of the Spearman correlation in the goat and pig groups. Figures 6.24 and 6.25 show the relationship between visitor density and *respond to grooming* in the goat group.

	BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
Goat	***respond to grooming* (d)**	**-.319**	**.004**	**78**
	***respond to grooming* (fph)**	**-.315**	**.005**	**78**
Pig	*respond to grooming* (d)	-.462	.130	12
	respond to grooming (fph)	-.462	.130	12

Table 6.17 The results of Spearman correlations between visitor density and the frequency per hour and duration of *respond to grooming* in the goat and pig groups. (d)= duration, (fph)= frequency per hour.

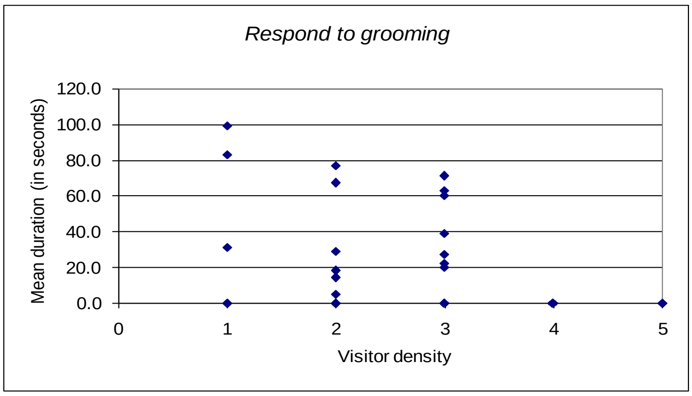

Figure 6.24 The relationship between visitor density and the duration of *respond to grooming* in the goat group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51-99 visitors, 5= 100 or more visitors.

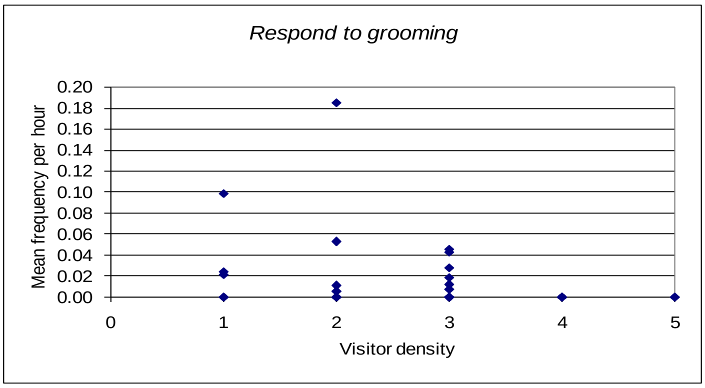

Figure 6.25 The relationship between visitor density and the frequency per hour of *respond to grooming* in the goat group. Visitor density categories: 0= no visitors, 1= 1-10 visitors, 2= 11-20 visitors, 3= 21-50 visitors, 4= 51-99 visitors, 5= 100 or more visitors.

6.14.4 The Effect of Grooming on Visitor Behaviour

Randomisation tests were used to determine whether allowing visitors to groom the goat and pigs affected visitor behaviour. Visitors groomed goats significantly more frequently than interacted with them without grooming, as shown by the increased frequency per hour of *groom animal* in the *visitor grooming* condition as compared to the frequency per hour of *affiliate with animal* in the *no visitor grooming* condition. Visitors spent more time interacting with goats in the *visitor grooming* condition, as evidenced by the significantly longer duration of *groom animal* in the *visitor grooming* condition compared to the duration of *contact with visitors* in the *no visitor grooming* condition.

Visitor behaviour directed toward the pigs did not change significantly between the *no visitor grooming* and *visitor grooming* condition. Table 6.18 lists the results of randomisation tests comparing visitor behaviour directed towards the study goats and pigs. Figures 6.26 and 6.27 show the difference in the frequency per hour and duration of *affiliate with animal* compared to the frequency per hour and duration of *groom animal* in the goat group.

	BEHAVIOUR	Test Statistic	*p* (two-tailed)	n
Goat	***affiliate with animal* vs. *groom animal* (d)**	**24.385**	**.001**	**155**
	***affiliate with animal* vs. *groom animal* (f)**	**.018**	**.006**	**155**
	pursue animal (f)	.001	.944	8
Pig	*affiliate with animal* vs. *groom animal* (d)	1.487	.920	66
	affiliate with animal vs. *groom animal* (f)	.003	.768	66
	pursue animal (f)	NA	NA	NA

Table 6.18 The results of randomisation tests comparing visitor behaviour directed towards the goat and pig groups. (d)= duration, (f)= frequency. Significant results are in bold text. NA= behaviour did not occur frequently enough for statistical analysis.

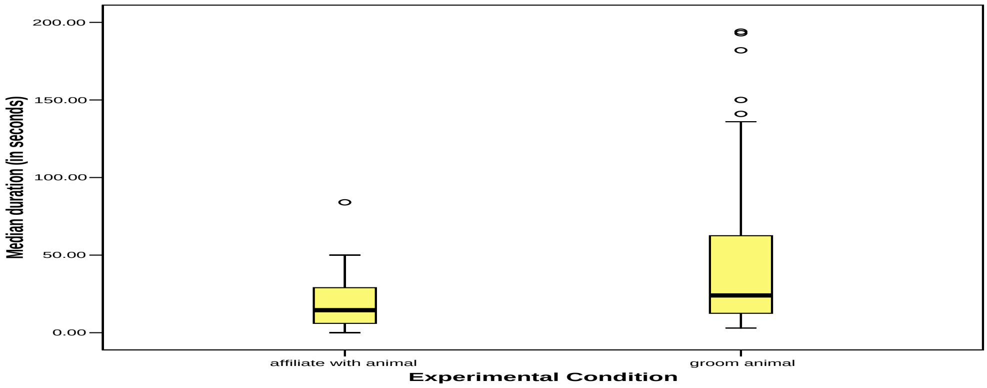

Figure 6.26 The difference in the median duration of *affiliate with animal* in the *no visitor grooming* condition compared to the median duration of *groom animal* in the *visitor grooming* condition directed toward the goat group.

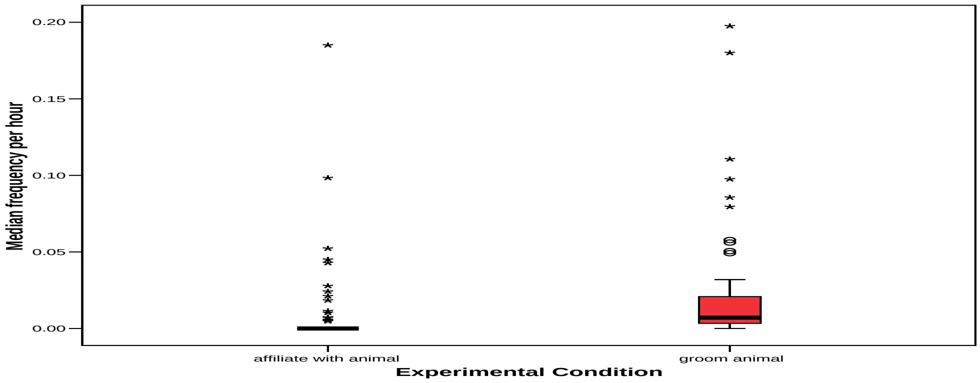

Figure 6.27 The difference in the median frequency per hour of *affiliate with animal* in the *no visitor grooming* condition compared to the median frequency per hour of *groom animal* in the *visitor grooming* condition directed toward the goat group.

6.15 Discussion

Visitor density levels were not significantly increased in the visitor grooming condition compared to the no visitor grooming condition, although there was a trend toward increase in the goat samples which may have impacted the effectiveness of visitor grooming on the goats. The visitor density data in Part I of this chapter indicate that the behaviour of the study goat and pigs is dependent on visitor density. Anderson et al (2002) also reported a positive correlation between visitor density and the rate of undesirable behaviour exhibited by petting zoo African pygmy goats and Romanov sheep.

The introduction of visitor grooming did not affect the behaviour of the goats or the Vietnamese pot-bellied pigs, indicating that the technique was not enriching to the study animals. The lack of change in avoidance of visitors suggests that grooming visitors were not perceived as more threatening by the petting zoo inhabitants than visitors who did not groom them.

The lack of a significant response to grooming has several explanations. It could be that goats and pigs simply did not enjoy being groomed. This explanation seems unlikely because during a pilot test in which the researcher and her thesis supervisor groomed the goats and pigs, they elicited responses to grooming that indicated sensory enrichment was taking place. It is also possible that the grooming tool was not ideal for this task, although this explanation seems unlikely as it was a commercially available product designed for use on domestic animals and was the same tool used in the pilot test.

The most plausible explanation for the ineffectiveness of the visitor grooming enrichment is the incorporation of visitors in dispensing the enrichment. The large number of unfamiliar visitors participating in the experiment adversely affected the goats' response to grooming and this was evidenced by the significant negative correlation between *respond to groom* and visitor density. The pigs' response to grooming was not dependent on visitor density, and indicates that grooming may not be an effective method of improving HARs in petting zoo pigs.

It also seems likely that visitor inexperience in grooming domestic animals was, in part, responsible for the ineffectiveness of the grooming. Given the anecdotal results of the pilot test in which experienced yet unfamiliar animal behaviour researchers were able to elicit positive responses to grooming, it appears that visitors might have dispensed more effective grooming enrichment if they were educated on proper grooming techniques. During the experimental trials, visitors were given general instructions by the researcher on how to groom the animals, but were not directed further. A few visitors asked the researcher for more direction in proper grooming methods and received instruction. The data on gentling in farm animals, in which stockpersons handle the animals, also suggests that experienced animal handlers may be more effective in creating a positive HAR.

The lack of visitor grooming experience was anticipated to be a potential factor in the effectiveness of the grooming experiment, but it was decided to test the enrichment on the essentially uneducated public because the visitor-friendly grooming method was developed in part to provide some relief for keepers, who provide the majority of the enrichment captive animals receive. The role visitor skill plays in this enrichment technique could be moderated by providing instruction signs, although this might not be the best solution in the petting zoo environment where many of the visitors grooming will be children who are unable or unwilling to read the instructions before they make contact with the animals. A better, but more labour-intensive solution may be to have daily keeper grooming sessions which would give visitors hands on instruction in proper grooming techniques.

The failure of visitor grooming to provide enrichment for the petting zoo animals did not prevent grooming from positively affecting visitor behaviour. The frequency per hour and the duration of visitor interactions with the petting zoo goats increased significantly in the grooming condition, suggesting that visitor interest in non-aggressive contact with the goats increased during the enrichment condition. Surprisingly, the increased frequency and duration of contact with goats in the grooming condition did not extend to the pigs, suggesting visitors found the pigs less rewarding to groom. Despite the increased interest in interacting with the petting zoo goats, visitors did not pursue or chase the goats or pigs any more frequently in the grooming condition, which was anticipated to be a potential negative consequence of encouraging visitors to take part in increased contact with the animals. The general lack of visitor ill-treatment of the animals in both experiments bodes well for further attempts to incorporate visitors into animal enrichment programmes.

6.16 Conclusion

Three of the factors influencing petting zoo animal behaviour appear to be the exhibit environment, visitor pressure, and species. The results of the visitor presence and density experiment suggest domestic animal species exhibit a visitor effect in varying degrees, but the quantitative and qualitative nature of the behavioural changes indicate that the three study species were relatively unaffected by the presence of visitors. Overall, this study provides evidence that visitors do not have an extensive impact on petting zoo goat, llama, and pig welfare. The goats were unaffected by the presence of visitors in this study but previous research on petting zoo goats indicate that goats do direct aggressive and avoidance behaviour towards visitors as visitor density increases. The llama study group exhibited statistically non-significant behavioural change in the presence of visitors, but they were the only study species who engaged in visitor-directed aggression. The low level of aggression toward and avoidance of visitors is notable in all three species studied at Blair Drummond’s Pets Farm, and indicates that other variables as yet unidentified may play a role in the aggression in petting zoo animals reported by other researchers. The visitor pressure experienced by the pigs, manifested by decreased social behaviour, suggests that Vietnamese pot-bellied pigs may be more sensitive to the presence of visitors than other domesticated ungulates; previous research on this breed reported decreased inactivity in relation to visitors and these qualitative differences highlight the needs for larger sample sizes and a broader range of study breeds in future petting zoo research.

The prediction that the winter break from visitors would result in behavioural changes with adverse welfare implications was not supported by the data. Although there was a trend toward increased aggression between goats once the petting zoo was re-opened to visitors in the spring, this behaviour was rarely exhibited and this finding suggests that the removal and re-introduction of visitor stimuli may not have an adverse impact on petting zoo animals.

. The behaviour of all three study species was dependent on the number of visitors. The reduced tendency to herd in goats and decreased levels of feeding in the Vietnamese pot-bellied pigs were identified as potentially negative visitor density effects, however the increased interactions with visitors when visitor numbers increased suggests that an increased human presence did not elicit fearful or aggressive responses in the petting zoo animals which would indicate a welfare concern.

Although the grooming enrichment appeared to be enriching for the visitors, the enrichment technique might have been effective for the animals had visitor education been incorporated in the research design. However, before a modified version of the visitor grooming technique is tested, more studies of the visitor effect on commonly held petting zoo species should be carried out to determine species which might be more responsive to grooming interactions with visitors. The lack of desire of visitors to groom the llama and pigs indicates more effective visitor enrichment might be attained by testing the technique on species that are more appealing to visitors.

Little is known about how petting zoo conditions affect behaviour independently or synergistically, but research into the interaction between environment, visitor pressures, and species increases the understanding of the behaviour of domestic animals across different conditions. Implementation of HAR methodologies in visitor effect research should result in a better working knowledge of domestic species behaviour in the unique environment of petting zoos, eventually leading to improved animal welfare and better educated and entertained zoo visitors.

Chapter 7: Conclusion

This thesis outlined the reasons for studying the effect of zoo visitors on captive mammals, as well as the difficulties in identifying reliable welfare measures in the zoo environment. A series of studies and experiments examined the effect of zoo visitors on the behaviour of zoo mammals, with particular attention to species-specific behaviour. In addition to documenting the negative, neutral, and positive influences of the visiting public on the behaviour of nonhuman primates, large carnivores, and domesticated ungulates, the welfare implications of the identified changes were also discussed.

This thesis investigated a range of potential factors which may contribute to the visitor effect in zoo mammals. The results of the experiments were not consistent within this thesis and also contradicted the existing visitor effect literature. There are several possible reasons for this inconsistency. Firstly, the behavioural changes identified here as trends may be significant both statistically and behaviourally and, because of the use of a conservative alpha, important behavioural change has not been identified (i.e. Type II error). This explanation, however, does not adequately address the qualitative inconsistencies between the visitor-related changes in inactivity, aggression, and abnormal/stereotypic behaviour reported by other researchers and the idiosyncratic visitor effect trends in the Toronto Zoo, Oakland, Zoo, and Blair Drummond Safari Park study groups.

Secondly, extraneous uncontrolled variables may have affected the results of the studies and experiments presented in this thesis. Unfortunately, the zoo environment does not allow for the strict control of conditions often achieved within a laboratory, and one must consider the possibility that uncontrolled variables may explain, at least in part, the reason for inconsistent results between experiments on the same study groups. While every effort was made to record data on likely confounding variables, such as weather, keeper presence, visitor density, visitor noise, and light levels, and assess their impact on the behaviour of the study animals, it was not possible to statistically control for these variables and their potential impact on behaviour cannot be ignored.

7.1 Recommendations for Zoos

Despite the inconsistencies in the results of the studies and experiments presented here, it is possible to draw some conclusions about the visitor effect in the study species which may be useful to zoos in managing their primate, ursid, ungulate, and felid collections. Although the use of randomisation tests limits the ability to generalise to other collections, the following section has been written with the objective of providing a concise, take-away message for zoo professionals and researchers about the visitor effect in each of the study groups:

> *Sumatran orangutan*. This species was not affected by visitor density in the baseline condition, but the presence of enclosure modifications such as camouflage nets created an association between visitor density and monitoring of visitor areas. Visitor noise increased social grooming and time spent farthest away from viewing windows in baseline conditions, but the apes were less often near viewing windows when the nets were in place. Attempts to facilitate a positive visitor effect using puzzle feeder devices for both orangutans and visitors did not result in behavioural changes signifying enrichment. Groups including infants appear to be more likely to experience a visitor effect (Birke 2002) and the lack of infants in the Toronto Zoo study group mostly likely contributed to the lack of a negative visitor effect.
>
> *Western lowland gorilla.* This species was not affected by visitor density in the baseline condition, and the installation of camouflage nets created a relationship between density and decreased locomotory activity and

decreased proximity to viewing windows; levels of regurgitation and reingestion should be monitored if nets are installed, as there was a trend toward increase as visitor density increased. Visitor noise was associated with decreased social play in young gorillas in baseline conditions, which was moderated by the presence of nets; however, new associations between density and decreased locomotion and increased distance from viewing windows were identified. Like the orangutans, there was less of a negative visitor effect in this group than the literature (Blaney and Wells 2004, Wells 2005) would predict, but infants and juveniles are likely to be most affected by visitor-related variables.

Chimpanzee. Visitor density had little effect on the behaviour of these apes, but increased visitor numbers were associated with increased proximity to the perimeter of the enclosure; this finding suggests, like the literature, that chimpanzees find visitors mildly interesting. Olfactory enrichment within their enclosure resulted in a surprising degree of behavioural change, while the presence of smelly visitors had no significant effect. This suggests that olfactory stimuli from visitors did not affect their welfare. These data suggest that the visitors may have little effect on zoo chimpanzee behaviour and welfare when in similar housing conditions.

Hamadryas baboon. Visitor density increases were associated with decreased social grooming and a trend toward increased out of sight behaviour, suggesting that baboons experience a degree of negative visitor effect. Like the chimpanzees, the baboons also experienced a surprising degree of significant behavioural change in response to the olfactory enrichment in their enclosure, but this did not extend to the smelly visitor condition and they are unlikely to be a source stress to baboons. Additionally, the olfactory stimuli conditions appeared to moderate the negative visitor density effects identified in the baseline condition. Overall, the baboons appeared to be more sensitive to visitor pressure and the tendency to be out of sight and reduced social grooming may be indicators of visitor stress in these monkeys. Adequate cover from visitors should be provided to help them cope with increased visitor numbers.

Golden lion tamarin. Visitor density was associated with decreased solitary grooming in this group in the baseline condition, suggesting self-directed grooming was not a coping mechanism in times of higher visitor density for the Toronto Zoo group; changes in visitor noise were not associated with changes in tamarin behaviour. Installation of camouflage nets had little effect on their behaviour, even in times of increased density or noise. Providing an internal screen from visitors did not alter behaviour significantly either, and there were no significant relationships between density and noise and behaviour. Despite the hypothesis in the literature that small arboreal monkeys experience a greater visitor effect (Chamove et al 1988), this group did not show signs of visitor-related stress.

Squirrel monkey. The group showed changes indicative of visitor-related influence, such as increased locomotory behaviour and visual monitoring when density was higher; however, they also spent less time out of sight when visitor density was high. It is possible that rather than take cover from visitors as terrestrial species like baboons do, arboreal species such as squirrel monkeys prefer to remain vigilant to potential threats. It is possible that providing adequate high canopy perches, as was done for this group, helps these monkeys cope with visitor stress. Despite these significant changes, behaviour indicative of poor welfare was not present and there was no evidence that this group's welfare was compromised by the presence of visitors.

Amur tiger. This felid species showed the most behavioural consistency across the studies, spending less time near viewing windows in times of higher visitor density and noise. The installation of nets did not moderate these associations, nor did it affect the absolute rate or duration of behaviour. These data suggest that density and noise tend to only significantly affect tiger enclosure positioning and there is little visitor effect in this species.

Bengal tiger. Visitor density had no effect on this species' behaviour in the baseline condition, but the presence of olfactory stimuli (in the enclosure and associated with visitors) resulted in an extensive relationship between this variable and tiger behaviour. Of particular welfare concern was the trend toward correlation between stereotypic pacing and increased density in the smelly visitor condition. Although there was no change in the absolute rate or duration of behaviour in the presence of smelly visitors, these data suggest that the interaction between environmental variables may have unexpected effects on felid behaviour which could impact their welfare. These findings also suggest that the collection of data on visitor-related variables in future studies of abnormal behaviour and stereotypy in captive felids is warranted.

African lion. Visitor density affected the two lion groups slightly differently. While the Oakland Zoo group showed decreased levels of contact at higher visitor density, the Toronto Zoo group was not affected by density levels. Visitor noise was significantly associated only with increased monitoring of the visitor area. The installation of camouflage nets had no effect on behaviour either, nor were there correlations between density or noise and behaviour. Overall, these felids showed little sign of being impacted by visitor-related variables but environmental enrichment which encourages affiliative social contact may help moderate the visitor density effect in zoo lions.

> *Polar bear*. Visitor density had no significant effect on behaviour in baseline conditions, but visitor noise was correlated with decreased exploratory behaviour. The installation of nets did not influence the absolute rate or duration of behaviour, but there was a trend toward decreased resting and increased swimming behaviour. Reducing the visual impact of visitors may increase activity levels in captive polar bears, and this hypothesis should be considered in future behaviour research on this species. Although there was no profound negative visitor effect in this group, given the poor welfare of many captive polar bear groups, a connection between visitor-related stress and the performance of abnormal behaviour, stereotypies, and inactivity should be investigated.
>
> *Petting zoo goats, llama, and Vietnamese pot-bellied pigs.* The presence of visitors had little influence on the behaviour of the three groups. While there were significant changes in social behaviour and inactivity in the pigs, these behaviours represented such a small proportion of their activity budgets that they are unlikely to be meaningful in terms of animal welfare. The removal and reintroduction of visitors had no effect on animal behaviour, and visitor density was correlated with increased contact between visitors and animals; this increased contact was affiliative, not aggressive or avoidance-related. Overall, the welfare of these petting zoo species was sufficient to keep levels of aggression or avoidance of visitors low; visitors were rarely observed to mishandle the animals and did not tend to pursue animals that chose to move away from them. Attempts to groom the goats and pigs did not result in increased aggression or avoidance either, although the practice did not appear to provide any enrichment to the animals. Allowing visitors to groom, however, did increase the level of contact between animals and visitors, which indicates that the visitor experience was enriched.

As stated in the introduction to this thesis, it is hoped that the data presented here and the methodology used to collect and analyse it can contribute to the science of visitor effect research and animal welfare in general. To that end, several recommendations are presented in this conclusion which may be useful to others beginning visitor effect projects and it is intended to serve as a supplementary reference to the BIAZA visitor effect guidelines.

7.2 Visitor Density/Noise And Other Audience-Related Variables

The studies on visitor density in Chapter 2 made methodological distinctions in measuring visitor density which are helpful in defining the term and in interpreting the current visitor effect literature. Considering the perspective of the study animal when choosing the scale of density used in one's research may be helpful when investigating short-term effects. As is obvious in both the visitor effect literature and the BIAZA guidelines, researchers habitually conflate different scales of visitor density and the data suggest that this is not appropriate. The studies in Chapter 2 also determined that visitor density and visitor noise are more often than not discrete variables, indicating that methodologies that assume large crowds are noisier or smaller crowds are less so are not reliable. The BIAZA guidelines suggest using a "decibel recorder" (i.e. sound level meter) but provide no instructions on proper use of the equipment or how to interpret the results. The guidelines would best serve its readers if a warning about the importance of understanding the technical aspects of the device was included. For instance, selecting the proper weighting of a sound level meter for the species being studied is critical and must be considered. Also, sound level meters are sensitive machines and environmental influences such as wind or construction noise could interfere with accurate measurement of anthropogenic noise.

The sensitivity of young apes to visitor noise, as seen in the gorilla group in this study and Birke's (2002) orangutan group, highlight the need for consideration of group composition in visitor effect research. The BIAZA guidelines do not mention the potential importance of age-class differences in response to visitors, but particular attention to recording the behaviour of infants and juveniles may be necessary. Additionally, using statistical techniques that allow one to tease out individual or subgroup responses to visitors is important if this type of analysis is warranted by the size of one's sample.

7.3 Moderating the Negative Visitor Effect

Visual barriers were tested to determine their effectiveness in moderating a negative visitor effect. Little mention of techniques to reduce the visitor effect is made in the BIAZA guidelines, and testing of techniques that have the potential to moderate the negative visitor effect in zoo-housed animals has been minimal (Anderson et al 2004, Blaney and Wells 2004, Cunningham 2004, Anderson et al 2002). While the experiments presented here suggest that nets and screens may have a limited benefit for animals whose behaviour is not extensively affected by visitors, more research into methods that reduce the visitor effect is needed. Reducing the visual impact of visitors has received some scientific attention, but there has been little effort to reduce other modes of visitor influence on animal behaviour and welfare. For instance, there are no published data on efforts to reduce anthropogenic noise on zoo-housed mammals.

It is possible that reducing the negative visitor effect may be achieved through enriching the environment, rather than attempting to block out visitor stimuli, and it would be advantageous for the BIAZA guidelines to encourage study of the interaction between animal behaviour, environmental enrichment, and visitor-related variables. As was shown in the puzzle feeder and olfactory stimuli experiments, the introduction of environmental enrichment may have unintended consequences and create or exacerbate a negative visitor effect, highlighting the importance of recording visitor-related variables when evaluating environmental enrichment.

Understanding the role keepers, husbandry routines, and hand-rearing may play in the visitor effect may also suggest ways of moderating the visitor effect in zoo animals. While the presence of keepers has been shown to alter the reaction of animals to visitors (Anderson et al 2004, Thompson 1989), there are no quantitative data on whether hand-reared animals are more or less reactive to visitors. One would predict that hand-rearing will negatively affect animals' ability to cope with visitor-related variables, but there is evidence to suggest that adult chimpanzees (*Pan troglodytes*) reared by their mothers do not differ extensively in social play and grooming behaviour from those separated from their mother but reared with other conspecifics or those reared without other conspecifics. Although rearing style does not affect these social behaviours in chimpanzees, early extensive contact with humans may affect an animal's susceptibility to visitor influence, and this aspect of zoo management should be studied in a wider range of species.

7.4 Facilitating a Positive Visitor Effect

The data presented here and the visitor effect literature in general suggests that a positive visitor effect is rare and that fostering that type of visitor influence may be extremely difficult. Some studies that show "positive" results of visitor-related variables to the animals are ones in which visitors fed the study animals. While the animals may perceive this to be beneficial, unregulated feeding of zoo animals is ultimately detrimental to their welfare and should not be considered a positive visitor effect. The most promising data on a positive visitor effect was the behavioural engineering work of Markowitz (1982), which suggests that giving animals control and choice in interacting with visitors may be helpful in fostering a positive visitor effect. Interactive elements also appear to be helpful in making successful enrichment for both animals and visitors, although the interactive elements in the grooming experiments did not facilitate a positive effect in the llama, goats, and pigs housed in Pets Farm. Several zoos in the United States have attempted to give animals control in interacting with visitors by allowing chimpanzees to blast visitors with air (Lincoln Park Zoo) or ring bells and spray water on visitors (Los Angeles Zoo); unfortunately, neither of these zoos have published empirical assessments of how these modifications affect animal or visitor behaviour. The BIAZA guidelines do not provide any potential positive visitor effect research ideas, but it does provide a list of behaviours that are indicators of good welfare and are likely to change if there is a positive visitor effect; understanding the behaviours that are likely to change with a positive visitor effect is an important first step in developing techniques that encourage the phenomenon.

Given the level of contact possible in petting zoos, it seems probable that this type of exhibit would have high levels of a negative visitor effect but also have more potential for a positive visitor effect than displays where contact is not possible. Animal-human contact has been shown to have beneficial effects on farm animals (Waiblinger et al 2006, Boivin et al 2000, Boivin and Braastad

1996, Hemsworth and Gonyou 1996, Hemsworth et al 1996, Grandin et al 1987), suggesting that a positive visitor effect may be possible with domesticated species. Future researchers should be encouraged to study both the negative and positive visitor effect in contact yards, with particular attention to implementing the HAR methodologies suggested by Hosey (2007).

7.5 Primate Bias in Literature and BIAZA Guidelines

Although the BIAZA visitor effect guidelines state that there is a need for more data on the influence of visitors on non-primate animals, the recommendations provide a number of techniques for evaluating the visual impact visitors have on display animals. As the primary sense modality for most primates is vision, the guidelines may be less suitable for other animals, such as felids or bats, which are reliant on olfactory or auditory cues to gather information about their environment. Given the likely differences between primates and other mammals in how they experience visitor stimuli, research could be more inclusive of the methods that might be useful for studying non-primate species. As shown in Chapter 5, associating visitors with olfactory stimuli had little effect on the behaviour of the primates and none on the tiger group, but case studies on only three species do not rule out an olfactory visitor effect in other animals. Measuring visitor-related olfactory stimuli and determining their effect on zoo animals has methodological challenges, but interdisciplinary research projects may lead to the development of more innovative techniques to assess the non-visual impact of zoo visitors on animals.

7.6 Short-term (Immediate) versus Long-term Studies

The BIAZA visitor effect guidelines advocate recording of various visitor-related characteristics such as “colour of clothing” or “frequency of camera flashes.” While there may indeed be an association between these variables and zoo animal behaviour, the collection of this kind of data raises issues about whether this information can be used to improve animal welfare in the long-term. Given that zoos are unlikely to restrict the colour of clothes visitors wear or the use of flash photography, and that so little is known about the visitor effect factors that probably have a more profound impact on the lifespan of zoo animals, perhaps it would be more useful to focus on visitor characteristics that are less likely to have a short-term and minor impact on animal behaviour and welfare. An argument can be made for at least a temporary pulling-back from studying the minutiae of visitor effects research and moving towards investigating how visitors affect life history indicators of welfare and physical health such as reproductive success and infant mortality; this type of information is critical for species that are involved in captive breeding programs due to their endangered status in the wild, such as the giant panda (*Ailuropoda melanoleuca*), western lowland gorilla (*Gorilla gorilla gorilla*), and the white rhinoceros (*Ceratotherium simum*). An additional supporting fact which may convince future researchers to widen the scope of their investigations is, although BIAZA suggests several audience characteristics that may impact zoo animal behaviour, there are only limited data to support the notion that animals are affected by visitor details, with the exception of visitor sex (Mitchell et al 1991a) and activity level (Mitchell et al 1992b, Hosey and Druck 1987).

7.7 Non-behavioural Measures of the Visitor Effect

Although the BIAZA guidelines are expressly for the collection of behavioural data in relation to the visitor effect, encouraging researchers to gather non-behavioural supporting data would greatly advance the science of visitor effect research. For instance, there are no data in the literature on how visitors affect animals, such as dolphins and bats, who use echolocation to learn about their environment. Physiological measures, such as heart rate, blood pressure, and body temperature might be associated with visitor-related stress in some animals and are regularly collected by zoo biologists. There is only one study of the influence of visitors on the urinary cortisol levels of primates (*Ateles geoffroyii rufiventris*: Davis et al 2005) and only one on the visitor effect on faecal cortisol levels in the black rhinoceros (*Diceros bicornis*: Carlstead 2005). As captive animals can be easily trained using positive reinforcement techniques to provide salivary samples for cortisol analyses (Cross et al 2004), there may be an increase in the number of hormonal visitor effect studies to support the behavioural in the current literature.

7.8 Baseline Welfare Level Determines the Extent of the Visitor Effect?

Many of the identified negative visitor effects in the literature have been found in groups with poor baseline welfare. High baseline levels of intragroup aggression, stereotypic masturbation, stereotypic locomotion, and vigilance patrols in a group of mandrills (*Mandrillus sphinx* and *Mandrillus leucohpaeus*) increased with visitor density, indicating that visitors exacerbated undesirable behaviour in an already disturbed group of primates (Chamove et al 1988). Camouflage nets were shown to be effective in reducing the visitor effect in a group of western lowland gorillas (*Gorilla gorilla gorilla*) that exhibited aggression and stereotypical behaviour in the baseline condition (Blaney and Wells 2004). Chronic self-injurious behaviour, developed in infancy, was correlated with visitor density in a zoo-housed male pileated gibbon (*Hylobates pileatus*) that was formerly kept as a pet (Skyner et al 2004). Singly-housed lion-tailed macaques (*Macaca silenus*) exhibited increased baseline levels of abnormal behaviour and aggression when on display to the public (Mallapur et al 2005). In contrast to the literature, the overall level of animal welfare was high in the groups studied here. Although the western lowland gorilla and the Bengal tiger groups exhibited abnormal or stereotypic behaviour, the majority of incidents of regurgitation/reingestion and pacing were performed by a single gorilla or tiger. Levels of aggression and self-directed behaviour were also low in the study groups. Given the minimal display of behaviours considered to be indicative of poor animal welfare, it is not altogether surprising that a more intense visitor effect was not observed in the study groups.

Although the inconsistency between the results presented here and the visitor effect literature may initially suggest there are concerns of a lack of external validity with this research, the contradictions may in fact be indicative of an overall improvement in zoo animal welfare in the United Kingdom and North America. One could argue that advancements in zoo management in North

America and the United Kingdom, such as increased use of positive reinforcement training, social housing, and environmental enrichment, have given rise to a zoo mammal population which has sufficient physical and psychological welfare to cope with visitor pressure. While there are still alarming welfare concerns for certain species commonly held in zoos, and zoo management best practice may vary widely across the globe, the results presented here suggest that the welfare of zoo mammals is often adequate to allow them to handle the stress of zoo visitors without increasing levels of aggression, self-directed behaviour, or stereotypies.

Although controlled comparisons of visitor impact between animals with poor welfare and those with adequate welfare must be made, it appears that baseline levels of aggression, self-directed behaviour, and stereotypies may be predictive of the degree of visitor pressure animals are likely to experience. The BIAZA visitor effect guidelines do not explore this hypothesis, but it could be useful to consider when designing a visitor effect study. Choosing study groups with adequate welfare when investigating factors such as visitor presence or density may not serve much point once this hypothesised connection has been studied with a reasonable sample size, while investigating these factors in groups with poor welfare may be more likely to yield significant negative results which inform our understanding of zoo animal well-being.

7.9 Prevention Rather Than Cure

Ideally, visitor effect research will progress to the point where we can predict which zoo-housed animals are more likely to be susceptible to visitor influence and attempt to prevent the formation of an association between behaviour and visitor-related variables. The visitor effect, like stereotypies, may be difficult behaviour to eradicate once a behavioural pattern has formed. Therefore, it is essential that researchers focus on the environmental conditions that may give rise to animals who exhibit a neutral visitor effect. At this time, there are no studies which identify the elements that are most predictive of healthy animals who are not influenced by visitor-related variables, but factors which are likely to contribute to the phenomenon include: 1) a less excitable species temperament 2) environmental enrichment 3) positive reinforcement training, 4) species typical group size and composition and 5) enclosure designs which allow animals choice and control over a complex environment. Although the science of visitor effects is still in a formative stage, it is conceivable that if the factors which contribute to the phenomenon are identified by researchers and implemented by zoo management, it will become an historic sub-discipline of zoo animal welfare.

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APPENDIX A: Group Composition

SPECIES	HOUSE NAME	SEX	ORIGIN	SIRE/DAM (in group)	DATE OF BIRTH	REARING STYLE
Leontopithecus rosalia	Righty	♀	captive	No/No	17/04/83	parent
	NA	♂	captive	No/Righty	02/10/97	parent
Ursus maritimus	Kunik	♂ (neut.)	wild	NA	27/12/80 (est.)	NA
	Sanikiluaq	♀	wild	NA	10/01/80 (est.)	NA
	Bisitek	♀	wild	NA	10/01/80 (est.)	NA
Panthera tigris altaica	Tonghua	♂	captive	No/No	22/04/93	parent
Pongo pygmaeus abelii	Puppe	♀	wild	NA	07/09/67 (est.)	NA
	Dinding	♂ (neut.)	wild	NA	11/09/58 (est.)	NA
	Dinar	♂	captive	Dinding/No	06/03/87	parent
	Ramai	♀	captive	Dinding/No	04/10/85	parent
	Sekali	♀	captive	Dinding/No	18/08/92	hand
	Jahe	♀	captive	No/Puppe	28/11/97	parent
Gorilla gorilla gorilla	Josephine	♀	wild	NA	08/12/71 (est.)	NA
	Charles	♂	wild	NA	23/09/72 (est.)	NA
	Samantha	♀	wild	NA	23/09/72 (est.)	NA
	Shalia	♀	captive	Charles/Samantha	09/02/02	Parent
	Johari	♀	captive	Charles/Josephine	12/05/01	Hand
Panthera leo	Lyndy	♂	captive	Rowdy/Nokanda	14/07/00	Parent
	Jerroh	♂ (neut.)	captive	Rowdy/Nokanda	14/07/00	Parent
	Rowdy	♂ (neut.)	captive	No/No	27/03/91	Hand
	Nokanda	♀	NA	NA	NA	NA

Table A.1 The study groups housed at the Toronto Zoo. NA= not available.

SPECIES	HOUSE NAME	SEX	ORIGIN	SIRE/DAM (in group)	DATE OF BIRTH	REARING STYLE
Panthera tigris	Suma	♀	captive	No/No	1989 (est.)	NA
	Torako	♀	captive	No/No	1997 (est.)	NA
Panther leo	Victor	♂	captive	No/No	19/02/91	NA
	Marika	♀	captive	No/No	19/02/91	NA
	Maddie	♀	captive	No/No	1/03/91	NA
	Sophie	♀	captive	No/No	1/03/91	NA
Papio hamdryas	Gordon	♂	captive	No/No	12/04/80	NA
	Jennifer	♀	captive	No/No	30/08/80	NA
	Dink	♀	captive	Gordon/Jennifer	3/06/87	NA
	Violet	♀	captive	No/Jennifer	16/01/90	NA
	Rafi	♂ (neut.)	captive	No/No	28/02/90	NA
Pan troglodytes	Larry	♂	NA	No/No	1963	NA
	Moses	♂	NA	No/No	18/04/93	NA
	Amira	♀	captive	Larry/Abigail	4/11/95	hand
	Caramia	♀	captive	No/No	02/09/95	NA
	Abigail	♀	captive	No/No	14/04/83	NA
	Andi	♀	captive	No/No	09/11/92	NA
Saimiri sciureus	Poppy	♀	captive	No/No	02/08/91	NA
	Pod	♂	captive	No/No	07/10/94	parent
	Pablo	♂	captive	No/Poppy	15/07/97	parent
	Peru	♂	captive	No/Poppy	006/06/99	parent
	Phil	♂	captive	NA/Poppy	07/09/02	parent

Table A.2 The study groups housed at the Oakland Zoo. NA= not available.

Appendix B: Behavioural Categories and Definitions

BASELINE: TORONTO ZOO

Visitors
Visitor density: 0 visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51 or more visitors
Feed animal: Visitor feeds study animals
Mimic animal vocalisation: Visitor mimics vocalisations typical of the species
Visitor distress: Young visitors crying
Throw object: Visitor throws an inedible object into the enclosure
Visitor hit/kick window: Visitor hits or kicks the viewing window
Noise level: Ambient noise measured in decibels

Panthera leo
< *One meter:* Within one meter of a visitor viewing area
< *Three meters:* Within three meters of a visitor viewing area
> *Three meters:* More than three meters away from a visitor viewing area
Charge window: Focal charges viewing window
Chuff: Quickly expel air from the mouth; often used in greeting
Contact: Physical contact with another group member
Crouch/cower: Submissive bow gesture to another lion
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Flehmen: Facial expression typified by a wrinkled nose, tongue out, and canines exposed; expressed when lions smell a particularly pungent or exciting scent
Growl: Low vocalisation coming from the back of the throat
Hiss: Slow release of air through an open mouth; usually accompanied by flattened ears
Hit/kick window: Focal uses paws to hit viewing window
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Out of sight: Focal is not visible from viewing areas
Pace: Stereotypical pattern of locomotion
Proximity: Within one meter of a group member
Rest: Sitting or lying down
Roar: Loud: low vocalisation
Rub: Rub any part of the body (except the cheek) on an object
Scent mark: Focal rubs cheek on an object
Scratch object: Focal uses claws to scratch object
Scratch self: Focal uses a paw to scratch a part of the body
Sniff air: Raises head and inhales
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another lion groom each other
Social play: Engaged in play with another group member
Social rub: Focal and another lion rub cheeks: tails: or flanks on each other

Social sniff: Lion sniffs any part of another lion's body
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Threat: Raise paw aggressively or lunge at conspecific; may include open mouth and vocalisations
Urine mark: Spray urine

Figure B.1 African lions at the Toronto Zoo. Photo by author.

Panthera tigris altaica
< One meter: Within one meter of a visitor viewing area
< Three meters: Within three meters of a visitor viewing area
> Three meters: More than three meters away from a visitor viewing area
Charge window: Focal charges window
Chuff: Quickly expel air from the mouth; often used in greeting
Feed/forage: Engaged in searching for or consuming food
Flehmen: Facial expression typified by a wrinkled nose, tongue out, and canines exposed; expressed when smelling a particularly pungent or exciting scent
Growl: Low vocalisation coming from the back of the throat
Hit/kick window: Focal animal hits viewing window with paws
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Moan: Low vocalisation similar to a wail or cry
Out of sight: Focal is not visible from viewing areas
Pace: Stereotypical pattern of locomotion
Rest: Sitting or lying down

Roar: Loud, low vocalisation
Rub: Focal rubs any part of its body but cheeks on an object or part of the enclosure substrate
Scent mark: Focal rubs cheek on object
Scratch object: Focal uses claws to scratch object
Scratch self: Focal uses a paw to scratch a part of his body
Sniff air: Raises head and inhales
Sniff object: Puts nose to an object and inhales
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Vigilance patrol: Locomoting and surveying, usually oriented outwith the enclosure
Urine mark: Spray urine

Leontopithecus rosalia
Beg: Beg for food from visitors
Contact: Touching another group member
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Nestbox: Focal is in nestbox
On floor: Focal is on the floor of the enclosure
Out of sight: Focal is not visible from viewing areas
Proximity: Within arms reach of another group member
Rest: Sitting or lying down
Scent mark: Focal rubs suprapubic or sternal scent glands on an object
Scratch self: Focal uses a paw to scratch a part of the body
Sniff object: Put nose to an object and inhale
Social contact: Touching another group member in an affiliative context
Social groom: Focal and another monkey groom each other
Social play: Engaged in play with another group member
Social sniff: Sniff another group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus

Ursus maritimus
Beg: Beg for food from visitors
Bite self: Repeatedly bite or bite and hold a limb or paw
Contact: Physical contact with another group member
Crouch/cower: Submissive bow gesture to another bear
Feed/forage: Engage in searching for or consuming food

Fight: Aggressive contact which may include wrestling, biting, or scratching
Growl: Low sound coming from the back of the throat
Head swing: Sweeping the head back and forth repeatedly
Huff: Quickly expel air from the nose and mouth
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Pace: Stereotypical pattern of locomotion
Proximity: Within one meter of a group member
Rest: Sitting or lying down
Rub: Focal rubs any part of its body on an object or part of the enclosure
Scratch self: Bear uses a paw to scratch a part of the body
Scratch object: Bear uses paw to scratch an object
Sniff object: Puts nose to an object and inhales
Sniff air: Raises head and inhales
Snort: Quickly expel air from nose only
Social contact: Touching another group member in an affiliative context
Social play: Engaged in play with another group member
Social sniff: Sniff another group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include object manipulation, such as playing with a barrel
Startle: Focal jumps or appears surprised by some stimulus
Swim: Immerses part of the body in water
Threat: Raise paw aggressively or lunge at conspecific; may include open mouth and vocalisations

Pongo pygmaeus abelii
< One meter: Within one meter of a visitor viewing area
< Three meters: Within three meters of a visitor viewing area
> Three meters: More than three meters away from a visitor viewing area
Beg: Focal animal stretches hand out asking for food from visitors
Bite self: Repeatedly bite or bite and hold a limb or paw
Charge window: Focal charges window
Contact: Physical contact with a group member
Crouch/cower: Submissive bow gesture to another group member
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Ground threat: Focal hits ground with hand
Hair pluck: Pull out hairs
Head cover: Place an object, such as a bucket or burlap sack, over head and eyes
Hit/kick window: Focal hits or kicks the viewing window
Infant care: Transporting, grooming, nursing offspring
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Nest building: Focal gathers or rearranges materials to make a nest
Out of sight: Focal is not visible from viewing areas

Proximity: Within one meter of a group member
Rest: Sitting or lying down
Scratch self: Focal uses a paw to scratch a part of the body
Social groom: Focal and another ape groom each other
Social play: Engaged in play with another group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Tool use: Focal uses an object to accomplish a task

Gorilla gorilla gorilla
< *One meter:* Within one meter of a visitor viewing area
< *Three meters:* Within three meters of a visitor viewing area
> *Three meters:* More than three meters away from a visitor viewing area
Beg: Focal animal stretches hand out asking for food from visitors
Charge: Run towards a group member
Charge window: Focal charges viewing window
Chest beat: Focal slaps chest with hands
Contact: Physical contact with another group member
Crouch/cower: Submissive bow gesture to another ape
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Ground threat: Focal hits ground with hand
Grunt: Short guttural vocalisations
Hair pluck: Pull out hairs
Hit/kick window: Focal hits or kicks the viewing window
Hoot: High pitched long vocalisation similar to that of an owl
Infant care: Transporting, grooming, nursing offspring
Locomote: Moving from one location to another
Monitor visitor area: Focal directs his gaze towards the visitor area
Nest building: Focal gathers or rearranges materials to build a nest
Out of sight: Focal is not visible from viewing areas
Proximity: Within one meter of a group member
Regurgitation/reingestion: Focal vomits and then consumes the disgorged food
Rest: Sitting or lying down
Scratch self: Focal uses a paw to scratch a part of the body
Sniff: Put nose to an object and inhale
Social groom: Focal and another ape groom each other
Social play: Engaged in play with another group member
Social proximity: Within half a body length of a group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Stiff stance: Focal displays with elbows and knees locked

Strut display: Focal swagger walks
Tight lip: Lips are stretched tautly
Tool use: Focal uses an object to accomplish a task

Figure B.2 A female gorilla and her offspring. Toronto Zoo. Photo by author.

BASELINE: OAKLAND ZOO

Visitors
Visitor density: 0 visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51 or more visitors
Feed animal: Visitor feeds the lions
Mimic animal vocalisation: Visitor mimics the vocalisation typical of the species
Visitor distress: Young visitors crying
Throw object: Visitor throws an inedible object into the enclosure
Visitor hit/kick window: Visitor hits or kicks the viewing window

Panthera leo
< *Three meter:* Within three meters of a visitor viewing area
Bite self: Repeatedly bite or bite and hold a limb or paw
Chew object: Bite or chew and inedible object
Chuff: Quickly expel air from the mouth; often used in greeting
Contact: Physical contact with a group member
Copulate: Male mounts female and copulates
Crouch/cower: Submissive bow gesture to another lion
Dig: Use paws to move substrate

Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Flehmen: Facial expression typified by a wrinkled nose, tongue out, and canines exposed; expressed when lions smell a particularly pungent or exciting scent
Growl: Low vocalisation coming from the back of the throat
Lick object: Place tongue to object
Locomote: Moving from one location to another
Lunge threat: Lunge but without contact; may include open mouth and vocalisations
Out of sight: Focal is not visible from viewing areas
Pace: Stereotypical pattern of locomotion
Proximity: Within one meter of a group member
Rest: Sitting or lying down
Roar: Loud, low vocalisation
Roll: Writhe on ground
Rub: Rub any part of the body except the cheek on an object
Scent mark: Rubs cheek on an object or part of the enclosure
Scratch object: Focal uses claws to scratch object
Scratch Self: Focal uses a paw to scratch a part of the body
Sniff air: Raises head and inhales
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another lion groom each other
Social play: Engaged in play with another group member
Social rub: Focal and another lion rub cheeks, tails, or flanks on each other
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Stalk: Attempt to hunt prey item (within or outside the enclosure)
Startle: Focal jumps or appears surprised by some stimulus
Survey: Look around enclosure or visitor area
Urine mark: Sprays urine
Vigilance patrol: Repeated surveying while walking or running, orientation can be within or outwith the enclosure
Watch: Look at a group member for at least five seconds

Panthera tigris
< Three meters: Within three meters of a visitor viewing area
Bite self: Repeatedly bite or bite and hold a limb or paw
Chuff: Quickly expel air from the mouth; often used in greeting
Contact: Physical contact with a group member
Crouch/cower: Submissive bow gesture to another lion
Dig: Use paws to move substrate
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or scratching
Flehmen: Wide-mouthed inhalation of scent

Flehmen: Facial expression typified by a wrinkled nose, tongue out, and canines exposed; expressed when smelling a particularly pungent scent
Lick object: Place tongue to object
Locomote: Change location by walking or running
Moan: Vocalisation similar to a wail or cry
Out of sight: Focal is not visible from viewing areas
Pace: Stereotypical pattern of locomotion
Proximity: Within one meter of a group member
Rest: Sitting or lying down
Roar: Loud, low vocalisation
Roll: Writhe on ground
Rub: Rub any part of the body except the cheek on an object
Scent mark: Rubs cheek on an object or part of the enclosure
Scratch object: Focal uses claws to scratch object
Scratch self: Focal uses a paw to scratch a part of the body
Sniff air: Raises head and inhales
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another tiger groom each other
Social play: Engaged in play with another group member
Social rub: Focal and another tiger rub cheeks, tails, or flanks on each other
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Stalk: Attempt to hunt prey item (within or outside the enclosure)
Startle: Focal jumps or appears surprised by some stimulus
Survey: Look around enclosure or visitor area
Threat: Raise paw aggressively or lunge at conspecific; may include open mouth and vocalisations
Urine mark: Sprays urine
Vigilance patrol: Repeated surveying while walking or running, orientation can be within or outwith the enclosure
Watch: Look at another group member for at least five seconds

Pan troglodytes
< One meter: Within one meter of a visitor viewing area
Bite self: Repeatedly bite or bite and hold a body part
Body rock: Stereotypically move torso in a swaying or rocking motion
Contact: Physical contact with another group member
Coprophagy: Ingest faeces
Copulate: Male mounts female and copulates
Crouch/cower: Submissive bow gesture to another group member
Display: Piloerection, dragging/throwing objects, swagger walking, and strutting; usually accompanied by vocalisations
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or pushing
Lick object: Place tongue to object

Locomote: Change location by walking or running
Out of sight: Focal is not visible from viewing areas
Pant hoot: A *pant* vocalisation followed by an owl-like hoot
Proximity: Within arm's reach of a group member
Rest: Sitting or lying down
Scratch self: Focal uses a hand to scratch a part of his/her body
Scream: A piercing cry-like vocalisation
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another ape groom each other
Social play: Engaged in play with another group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Survey: Look around enclosure or visitor area
Watch: Look at another group member for at least three seconds

Papio hamadryas
< One meter: Within one meter of a visitor viewing area
Bark: Short, loud dog-like vocalisation
Bite self: Repeatedly bite or bite and hold a body part
Bob: A display characterised by repeated lowering and uprighting of the torso
Body rock: Stereotypically move torso in a swaying or rocking motion
Chase: Follow another group member in an agonistic context
Chatter: Repeated squirrel-like vocalisations
Chew object: Bite or chew and inedible object
Contact: Physical contact with another group member
Copulate: Male mounts female and copulates
Crouch/cower: Submissive bow gesture to another group member
Display: Dragging/throwing objects, swagger walking, and strutting; often accompanied by vocalisations
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or pushing
Follow: Walk or run behind another group member in a non-agonistic context
Grunt: A pig-like guttural vocalisation
Lick object: Place tongue to object
Locomote: Change location by walking or running
Out of sight: Focal is not visible from viewing areas
Pace: Stereotypical pattern of locomotion
Proximity: Within arm's reach of a group member
Rest: Sitting or lying down
Scratch self: Focal uses a hand to scratch a part of his/her body
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another baboon groom each other
Social play: Engaged in play with another group member
Solitary groom: Autogroom

Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Survey: Look around enclosure or visitor area
Vigilance patrol: Repeated surveying while walking or running, orientation can be within or outwith the enclosure
Watch: Look at another group member for at least three seconds

Saimiri sciureus
One meter: Within one meter of a visitor viewing area
Bite self: Repeatedly bite or bite and hold a body part
Chirp: High, bird-like vocalisation
Contact: Physical contact with another group member
Copulate: Male mounts female and copulates
Crouch/cower: Submissive bow gesture to another group member
Feed/forage: Engaged in searching for or consuming food
Fight: Aggressive contact which may include wrestling, biting, or pushing
Lick object: Place tongue to object
Locomote: Change location by walking or running
Out of sight: Focal is not visible from viewing areas
Proximity: Within arm’s reach of a group member
Rest: Sitting or lying down
Scratch self: Focal uses a hand to scratch a part of his/her body
Sniff object: Puts nose to an object and inhales
Social groom: Focal and another monkey groom each other
Social play: Engaged in play with another group member
Solitary groom: Autogroom
Solitary play: Engaged in play; may include manipulating an enrichment device in a playful manner
Startle: Focal jumps or appears surprised by some stimulus
Survey: Look around enclosure or visitor area
Watch: Look at another group member for at least five seconds

VISUAL BARRIERS

Camouflage Net Condition: Same as baseline for all groups

Privacy Screen Condition: Baseline +
behind screen: focal is behind the privacy screen

PUZZLE FEEDER

Baseline +

Orangutan Feeder Condition: Baseline +
Pongo pygmaeus abelii

Use puzzle feeder: Ape manipulates the puzzle feeder
Use puzzle feeder with a tool-like object: Ape manipulates the puzzle feeder with an object
Use non-experimental feeder: Visitor manipulates another foraging device in the enclosure

Orangutan-Visitor Feeder Condition: Orangutan Feeder Condition +
Pongo pygmaeus abelii
Watch visitors: Watch visitors use puzzle feeder

Visitors
Use puzzle feeder: Visitor manipulates the puzzle feeder
Use puzzle feeder with tool-like object: Visitor manipulates the puzzle feeder with an object

OLFACTORY STIMULI: OAKLAND ZOO

Same as baseline for all groups

PETS FARM: BLAIR DRUMMOND SAFARI PARK

No Visitors Present Conditions

Affiliate with conspecifics: Playing, grooming, etc. involving contact
Aggression between conspecifics: Charging, spitting, biting, kicking, rearing, foot stamping, head butting, head tossing, nose blowing
Feed: Eating an edible object or chewing cud
Rest: Animal is lying on the ground with head down
Retreat area: Animal is in retreat area
Sit: Animal has haunches on the ground but head is erect
Survey: Animal is visually scanning its surroundings

Visitors Present Conditions

Visitors
Visitor density: no visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51-99 visitors, 100 or more visitors
Visitor aggression: Visitor hits, kicks, or yells at animal
Pursue: Visitor chases or follows an animal

Capra hircus spp., *Llama glama, Sus scrofa*
Affiliate with conspecifics: Playing, grooming, etc. involving contact
Contact with visitors: Playing with, being petted, or social physical contact with a visitor
Aggression between conspecifics: Charging, spitting, biting, kicking, rearing, foot stamping, head butting, head tossing, nose blowing

Aggression towards visitor: Charging, spitting, biting, kicking, rearing, foot stamping, head butting, head tossing, nose blowing
Avoid visitors: Running or walking away from visitor
Contact with conspecifics:* Physical contact with another member of the same species
Contact with non-conspecifics:* Physical contact with another species housed in Pets Farm (excluding rhea)
Feed: Eating an edible object or chewing cud
Proximity to conspecifics:*Within one meter of another member of the same species
Proximity to non-conspecifics:*Within one meter of a member of another species housed in Pets Farm (excluding rhea)
Rest: Animal is lying on the ground with head down
Retreat area: Animal is in retreat area
Sit: Animal has haunches on the ground but head is erect
Survey: Animal is visually scanning its surroundings

* SVP only

Visitor Grooming Condition

Visitors
Visitor density: no visitors, 1-10 visitors, 11-20 visitors, 21-50 visitors, 51-99 visitors, 100 or more visitors
Visitor aggression: Visitor hits, kicks, or yells at animal
Visitor grooming: Visitor uses tool to groom animals
Pursue animal: Visitor chases or follows an animal
Affiliate with animals: Visitor pets or plays with animal

Capra hircus spp., *Llama glama, Sus scrofa*
Affiliate with conspecifics: Playing, grooming, etc. involving contact
Aggression between conspecifics: Charging, spitting, biting, kicking, rearing, foot stamping, head butting, head tossing, nose blowing
Aggression towards visitor: Charging, spitting, biting, kicking, rearing, foot stamping, head butting, head tossing, nose blowing
Avoid Visitor: Running or walking away from visitor
Feed: Eating an edible object or chewing cud
Respond to Grooming: Animal performs behaviour indicative of pleasure including vocalising, leaning into or rubbing against the brush/visitor, licks brush/visitor, presents part of its body to visitor
Rest: Animal is lying on the ground with head down
Retreat Area: Animal is in retreat area
Sit: Animal has haunches on the ground but head is erect
Survey: Animal is visually scanning its surroundings
Tolerate Grooming: Animal remains in the same location, but appears to be neutral to grooming

Appendix C: Enclosure Descriptions

TORONTO ZOO

Gorilla gorilla gorilla

The Western lowland gorilla enclosure was located in the African Rainforest Pavilion. This indoor exhibit, which simulated a rainforest ecosystem in both temperature and naturalistic sound effects, was approximately one-half acre. Natural light was let in through the large skylights above the gorilla portion of the pavilion. Although the Pavilion housed many different species, the gorillas had limited visual contact with other animals while on exhibit. Tanks of West African dwarf crocodiles (*Osteolaemus tetraspis*) and another group of gorillas were visible. The exhibit was naturalistic in design and furnished with many shrubs and plants, bark substrate, fallen logs, and a climbing frame with a net and ropes. Other forms of enrichment included basket feeders, toys, and a wading pool. Visitors could view the gorillas across a planted moat or through the exhibit's four viewing windows.

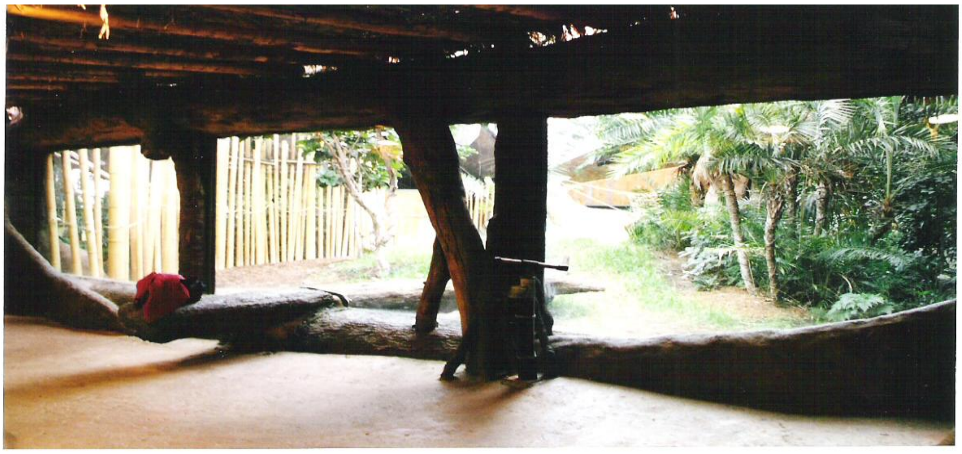

Figure C.1 The western lowland gorilla enclosure windows. Toronto Zoo. Photo by author.

Figure C.2 The western lowland gorilla enclosure. Toronto Zoo. Photo by author.

Pongo pygmaeus abelii

Like the gorilla exhibit, the Sumatran orangutan exhibit was located in a large pavilion with controlled climate, naturalistic sound effects, and many species found within the Indo-Malayan rainforest ecosystem. The orangutan enclosure, although smaller than the gorilla enclosure, was spacious vertically. The climbing frame was extensive and multi-layered, with numerous aerial pathways constructed of various materials such as rope, metal, wood, and netting. Various feeding/resting platforms and basket/puzzle feeders were also installed at different levels of this structure and were spread throughout the exhibit at visitor eye level. Visual contact with other species consisted mainly of birds, although there was a pair of white handed gibbons (*Hylobates lar*) within sight. The visitors could view the orangutans from several vantage points: across a moat and through two walls of viewing windows.

Figure C.3 The Sumatran orangutan enclosure. Toronto Zoo. Photo by author.

Panthera leo

The African lion enclosure was approximately one half acre of undulating turf and rock, surrounded by other savannah animal enclosures which allowed for visual contact with other species such as ostriches (*Struthio camelus australis*), caracal lynx (*Felis caracal*), assorted ungulates, and olive baboons (*Papio cynocephalus anubis*). Enclosure furnishings included two heated concrete slabs and scratching posts. Visitors could view the lions across a moat as well as through a series of ground level windows which were located in a simulated rocky cavern.

Figure C.4 The African lion enclosure. Toronto Zoo. Photo by the author.

Leontopithecus rosalia

The golden lion tamarins were housed in an indoor mixed-species enclosure in the Americas Pavilion, which presents Central and South American species within a simulated American tropical forest ecosystem that included controlled temperature; forest sound effects were not played during the time this research was conducted, but the vocalizations of the many birds housed in the pavilion were a constant natural soundtrack. Visitors could view the tamarins through a viewing window which comprised the entire front of the enclosure, measuring 3 meters wide and 2 meters in length. The monkeys share their enclosure with one male golden agouti (*Dasyprocta agouti*) and had visual contact with common marmosets (*Callithrix jacchus*), Hoffman's sloths (*Choloepus hoffmanni*), common two-toed sloths (*Choloepus didactylus*), golden agouti (*Dasyprocta agouti*), double-striped thicknees (*Burhinus bistriatus*), and white-faced sakis (*Pithecia pithecia*). The tamarin cage had painted concrete walls, a nest box, and bark substrate. The cage was furnished with a collection of tree branches that allowed the monkeys to access all parts of their enclosure except for the space within approximately .5 meter of the glass front.

Panthera tigris altaica

The Amur tiger was housed in a sparsely wooded outdoor exhibit which covered approximately a quarter of an acre. A portion of the enclosure was sheltered, with a concrete floor and furnished with logs and other materials suitable for using as scratching and rubbing posts. The back side of the exhibit looked onto a main service road, so the tiger had a view of the comings and goings of many zoo employees. Visual contact with other nonhuman animals during visitor hours was limited to black-faced kangaroos (*Macropus fuliginosus melanopus*.)

Ursus maritimus

The polar bear exhibit was an outdoor enclosure of approximately one-half acre. About one-third of the enclosure was made up of a swimming pool, the remaining substrate composed of concrete and large boulder formations. A waist-high concrete wall surrounded the entire exhibit, except for a small area reserved for the keepers to stand while giving presentations, and was topped by a series of glass panels forming a transparent wall almost two meters high. Six viewing windows, which allowed visitors to watch the bears while they swam underwater, were located in a grotto-like underground viewing area which was infrequently used by visitors. The bears were given large plastic barrels as part of their enrichment program. The polar bears did not have visual contact with any non-human animals while on exhibit.

OAKLAND ZOO

Panthera tigris

The four study groups were all housed in outdoor enclosures during the research period. The Bengal tiger enclosure was approximately three quarters of an acre. The enclosure substrate was grass and many large shrubs and small trees provided cover for the tigers. The exhibit had two water features: a small wading pool and a waterfall with a pool at the bottom; the tigers used both of these features for play, swimming or wading, and drinking. The enclosure was furnished with enrichment items such large logs and tree stumps for scratching and large rubber balls. The public could view the tigers from several vantage points, one about 10 feet above the animals and other only a few feet off the ground. The Zoo's sky ride also ran over the enclosure, so visitors could also view the tigers from the air on weekends and during the week in the summer months. The tigers did not have visual contact with any other species.

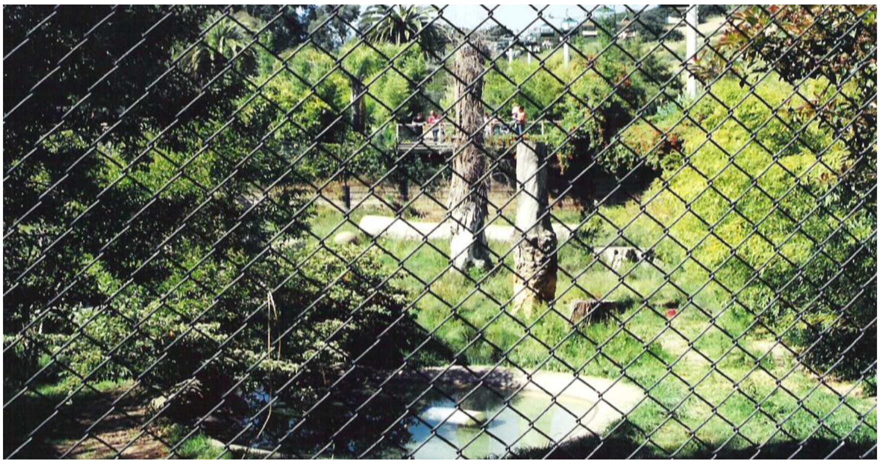

Figure C.5 The Bengal tiger enclosure. Oakland Zoo. Photo by author.

Pan troglodytes

The chimpanzee exhibit was approximately one quarter acre enclosed with steel mesh and two viewing windows which the animals could touch but the visitors could not. The substrate was patchy grass and dirt and had large boulder formations that provided nooks where the animals could be out of view of the public; the chimpanzees also had access to an indoor room which is also out of view of the zoo visitors. The enclosure was well-equipped with climbing frames and nets that allowed the chimpanzees to engage in natural locomotory patterns off the ground; the high vertical beams at the top of the enclosure also provided the animals with a good view of the surrounding area. The keepers provided many different enrichment items for the chimpanzees and also engaged in daily grooming and play sessions with the apes. The chimpanzees has visual contact with the hamadryas baboons, squirrel monkeys, white-handed gibbons (*Hylobates lar entelloides*), and siamangs (*Hylobates syndactylus*); mid-way through the experiment a colony of Malayan fruit bats (*Cynopterus brachyotis*) was installed across the path from the chimpanzees.

Figure C.6 The chimpanzee enclosure. Oakland Zoo. Photo by author.

Saimiri sciureus

The squirrel monkey enclosure was approximately five metres wide by four metres long by four metres high. The enclosure had dense foliage, climbing ropes, and a grass substrate. The monkeys had access to their indoor holding areas, which was out of the sight of zoo visitors, during this experiment. The exhibit was enclosed with wire mesh which provided an additional climbing surface for the monkeys. The squirrel monkeys had visual contact with the hamadryas baboons, chimpanzees, and a colony of Malayan fruit bats.

Figure C.7 The squirrel monkey enclosure. Oakland Zoo. Photo by author.

Papio hamadryas

The hamadryas baboon exhibit was approximately six metres wide by six metres long by 10 metres high. The enclosure simulated a natural rocky outcropping and was furnished with a wooden climbing frame and other enrichment such as plastic balls. The baboons had access to their indoor holding areas, which was not visible to the zoo visitors. The baboons had visual contact with chimpanzees, squirrel monkeys, and a colony of Malayan fruit bats.

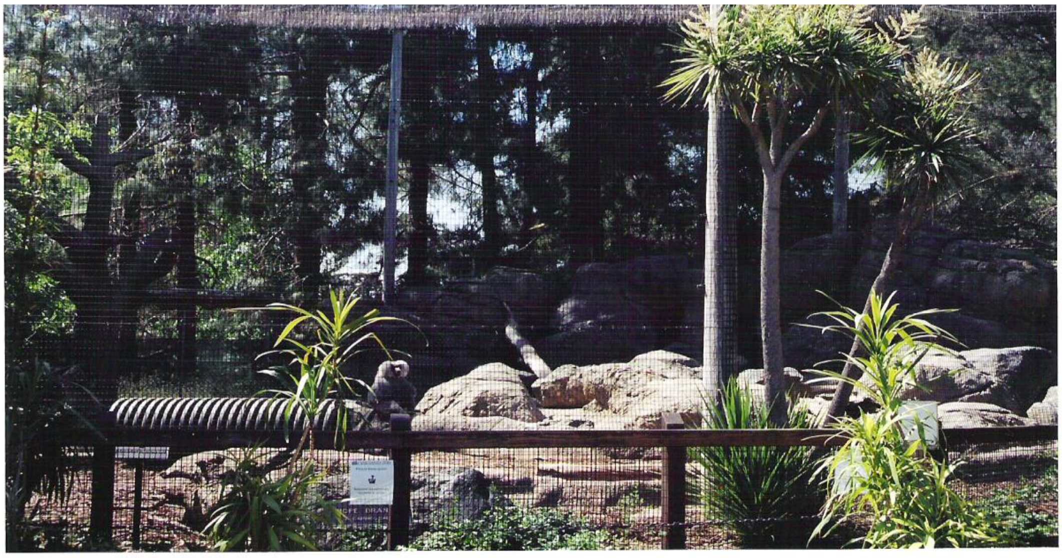

Figure C.8 The hamadryas baboon enclosure. Oakland Zoo. Photo by author.

PETS FARM, BLAIR DRUMMOND SAFARI PARK

The Pets Farm exhibit is a large grassy paddock, approximately an acre in size, and is sparsely dotted with large trees. A concrete path for visitors winds through the exhibit. The keepers provided the study animals with feeding troughs filled with hay as well as browse during the day. A small area underneath one of the trees was fenced off to form a retreat area which visitors are prohibited from entering, but still allows visitors to touch the animals. The Pets Farm abutted several other animal enclosures, including Amur tiger, Bennett’s wallaby (*Diprotodonta marsupialia*), and European brown bear (*Ursus arctos*) exhibits.

Figure C.9 The Pets Farm paddock. Blair Drummond Safari Park. Photo by author.