Golden-headed lion tamarin (Leontopithecus chrysomelas) acclimation to a new zoo habitat: The effect of visitor presence on behavior

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Golden-headed lion tamarin (Leontopithecus chrysomelas) acclimation to a new zoo habitat: The effect of visitor presence on behavior

by

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A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Major: Anthropology

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Iowa State University
Ames, Iowa
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Abstract

Zoos play an increasingly important role in primate conservation due to the fact that primate species are increasingly endangered in the wild. Zoos now play a key role by preserving examples of genetic variation. The well-being of zoo animals is therefore of utmost concern. The goal of this study was to examine the effect of visitor presence on a newly transferred group of golden-headed lion tamarins (Leontopithecus chrysomelas) as they acclimated to a new zoo environment. Data were recorded on days when the zoo was open and on days it was closed to document any effects caused by visitor presence. Data were collected using visual scan sampling every five minutes to record the tamarins’ general activity and space use behavior. The results showed that as the amount of visitors increased, tamarin activity decreased. The findings also illustrated that tamarin visibility and activity rates did not differ on zoo open versus zoo closed days. The results of this study indicates that zoo visitors do have an effect on animal behavior, but future research is desired to determine how strong that relationship is as well as its effects on primate well-being on a broader scale.
Chapter One: Introduction & Literature Review

There are three key threats to primate survival in the wild: (1) habitat loss, (2) hunting, and (3) live capture of primates for biomedical research and pet trades [Feistner and Price, 2002]. Approximately 90% of the world’s primates live in tropical forests that are now being abused by humans. This had led to 50% of all primate species becoming a conservation concern, according to the World Conservation Union, with 20% considered endangered [Campbell et al., 2007]. Zoos, therefore, play an important role in the conservation of endangered species, specifically in terms of preserving examples of genetic variation. Further, zoos can also help animal reintroductions to the wild, especially in cases of critically endangered species.

One of the most successful examples of a captive breeding program involves the golden lion tamarin (Leontopithecus rosalia). In 1975 there were less than 200 golden lion tamarins in Brazil, by 2000, the tamarin population was estimated at 1,000 [Campbell et al., 2007]. Further, 40% of all golden lion tamarins in the wild were either born in captivity or are the offspring of captive-born tamarins [Campbell et al., 2007]. Therefore it is critical to study tamarins in captivity because of their reintroduction successes, and because they are a critically endangered primate species [Campbell et al., 2007; Mittermeier et al., 2007].

Lion tamarins belong to the subfamily Callitrichinae, which contains six other genera. Golden-headed lion tamarins are one of the four species of tamarins in the Genus Leontopithecus [Rowe, 1996]. The Callitrichinae include some of the world’s most critically endangered primates [Campbell et al., 2007]. Leontopithecus, as a group, faces the most serious threat. Two species (L. caissara and L. chrysopygus) are listed as critically
endangered, while the other two (L. rosalia and L. chrysomelas) are listed as endangered [Rylands and Chiarello, 2003]. Generally Callitrichines are known for unusual reproductive and behavioral characteristics. Social suppression of reproduction, twinning, and cooperative care of young are some examples [Campbell et al., 2007].

The goal of this study was to observe a newly transferred group of golden-headed tamarins as they acclimated to a new zoo environment. This was done not only to gather results on visitor presence, but also to ensure that the tamarins habituate to their new environment. The tamarins’ health and well-being were of utmost importance due to the fact that tamarins are critically endangered in the wild; therefore it is imperative to preserve their genetic makeup. Scan data on the tamarins’ behavior and location were taken on days when the zoo was open to the public and when it was closed to document the influence of visitor presence. These recordings were taken to illustrate specifically how the tamarins dealt with environmental variables such as visitors after being released into a new habitat. This is an important issue, as the degree to which zoo visitors influence animal behavior is of great interest to zoological parks because of the implications for animals’ well-being [Margulis et al., 2003].

1.1 Objectives & Hypotheses

The present study made three predictions regarding how golden-headed lion tamarins would react to their novel environment after being transferred from the Toledo zoo to the Blank Park zoo. First, it was predicted that the amount of time spent in the hidden part of the enclosure would decrease as the tamarins became acclimated to their new environment and to the visitors. Second, it was expected that following their introduction to the new enclosure,
the tamarins’ activity would decrease as the number of visitors increased. This prediction was made based on previous studies, such as Glatson et al. [1984], which found that tamarin behavior was affected by human audiences, resulting in less time participating in social interactions, and less friendly behavior towards other tamarins, including kin. Further, Mallapur et al. [2005] found that visitor presence increased both abnormal and aggressive behaviors in lion-tailed macaques (Macaca silenus) in a zoo setting. Therefore, I predicted that as the amount of visitors increase the tamarins’ activity levels would decrease in response to stresses in their environment. Lastly, it was predicted that the tamarins would be more active on days the zoo was closed than when it was open. That predication was made based on studies that found that visitors were stressful to the zoo primates [Hosey, 2000].

1.2 The Captive Environment

Feistner and Price [2002] note that the number of primate species housed in research facilities is limited, while zoos have a large variety of species. Zoos can provide access to their animals to universities, which in turn can lead to research collaborations. However, working in zoos comes with perceived disadvantages, such as the potential negative influence of routine maintenance, cage design, and presence of visitors on animals’ behavior [Feistner and Price, 2002]. Nevertheless these disadvantages can be overcome as zoos recognize the importance of research, which in turn promotes animal welfare and public education [Feistner and Price, 2002]. Assessing animal welfare can now be measured scientifically by how animals cope with their environment [Hill and Broom, 2009]. Further, animal welfare should be considered when designing future enclosures [Hill and Broom, 2009].
By and large a zoo’s principal goal is to care for both the physical and psychological well-being of the animals living there [Hosey, 2005]. It is thus a zoos’ ethical and scientific responsibility to minimize harm and maximize well-being in zoo animals [Rennie and Buchanan-Smith, 2006]. The question, then, becomes how zoo environments affect animal behavior. Hosey [2005] gives three reasons why one should examine primates’ behaviors in zoos: (1) to ensure their welfare, (2) to ensure a positive zoo experience for all visitors, and (3) to ensure that results of research done at a zoo can be evaluated properly. In addition to accounting for the psychological well being of animals, an important aspect of a zoo environment is promoting conservation efforts, especially for endangered species. Zoo staffs are often specialists in certain taxonomic groups and thus can be a crucial source of information for university researchers [Feistner and Price, 2002]. They are also aware of the broader conservation concerns surrounding a particular species, which is helpful for creating ideas for research projects that benefit both the zoo and the researcher [Feistner and Price, 2002]. Together zoos and universities have the unique ability to combine their resources and produce research that can be critical to primate conservation, as well as train individuals who will carry on this work in the future [Feistner and Price, 2002]. Furthermore, collaboration between zoos and academic institutions can further our understanding of animal behavior, raise awareness for conservation and propagation of species, and educate students and the public about the importance of conservation [Fernandez and Timberlake, 2008].

Hosey [2005] states that it is generally assumed that zoo environments are more extreme than other environments where primates live (with the exception of the laboratory setting). However this hypothesis remains to be tested in regard to what specific aspects of
zoo life are extreme. Hosey [2005] notes that at the most extreme level zoo animals can develop abnormal behaviors such as regurgitation and re-ingestion in gorillas (*Gorilla gorilla*) [Lukas, 1999]. However, the author states that in some cases, it is not captivity itself that produces these abnormal behaviors but particular aspects of captive environments. It is thus a priority to better understand how variables in the zoo environment can be manipulated to improve primate well-being [Hosey, 2005].

Hosey [2005] states that a zoo can be characterized by three components: the regular presence of unfamiliar humans, restricted space, and being managed. Generally, one of the most pessimistically perceived features of the zoo environment is the restricted space that is allotted to the animals [Hosey, 2005]. However, physical space remains a complex issue because captive primates can live in an assortment of environments, not all of which require unrestricted space [Hosey, 2005]. Researchers have become progressively more aware of the role that captive environments play in the development of primate behavior [Wilson, 1982]. It is therefore of great importance to quantify and examine aspects of captive environments that influence primates’ daily behaviors, which in turn can provide answers to which features of zoo life are enriching and which features are not [Wilson, 1982].

### 1.3 The Effect of Novel Environments

Over the past decades, design of captive animal enclosures has shifted towards incorporating features that are similar to animals’ natural habitats [White et al., 2003]. Activity-based exhibits, having several animals occupying the same exhibit within a certain time period, are an example of this new movement. By moving to different exhibits, animals
come across multiple types of environmental stimuli, which include both physical variation and the stimuli of being in contact with different individuals [White et al., 2003].

Clarke et al. [1982] evaluated the behavioral effectiveness of a move from a captive cage environment to a more multifaceted and naturalistic island in a group of captive chimpanzees (*Pan troglodytes*). A total of 40 behaviors were recorded during a six-month period while observing four individuals. The chimpanzees’ first enclosure consisted of an indoor-outdoor compartment that measured eight by 20 feet. Their second habitat, the island “Kingdom’s Three Animal Park”, contained concrete culverts with heaters, a cage, structures for shade, and foliage surrounding the island [Clarke et al., 1982]. Clarke et al. [1982] found that the move to the new habitat controlled the output of stereotyped and self-directed behaviors. However, social behavior was not affected during the course of this study. The authors attribute this finding to the fact that two of the chimpanzees had lived in restricted settings for over 20 years, the third had been socially deprived for nine years, and the fourth had been raised in a human household [Clarke et al., 1982]. Therefore, the reduction in self-directed and stereotyped behavior was interpreted as a positive effect of changing the chimpanzees’ environment, and perhaps as a first step towards species-typical or normal social behavior [Clarke et al., 1982].

Ogden et al. [1990] assessed the acclimation of lowland gorillas to new enclosures by studying their exploration of the new habitats. Eleven gorillas housed in three harem groups were examined, all of who had previous, but limited, outdoor access. Observations were taken during the first year each group lived in their new enclosure. Continuous behavioral sampling was used to collect information on behaviors, substrate, environmental variables
used, and location of the gorillas. A focal animal within each group was observed for 15-minute intervals. Furthermore, instantaneous scans were taken every 15 minutes to provide more information on location and behavior of all the gorillas [Ogden et al., 1990]. Ogden et al. [1990] hypothesized that the gorillas would display a high level of exploration that would gradually decline as they became habituated to the new environment. However, the results did not support that prediction. The gorillas had a slow onset of exploratory behavior, a lengthier period of stabilization of exploration than was expected, and then significant declines in exploratory behavior [Ogden et al., 1990]. The slow onset of exploratory behavior was defined by low levels of object manipulation, while the stabilization of exploratory behavior was defined by the fact that once object manipulation began it did not decrease until six months into the study [Ogden et al., 1990]. The authors state that these results show a period of initial caution, which was followed by limited exploration of the enclosure for the first six months of habituation. After the first six months, exploration declined radically. Ogden et al. [1990] discussed multiple explanations for these results, with the first being that the decline in object manipulation was due to preferred objects becoming less available. Additionally, low levels of object manipulation and slow dispersal rates of behavior could indicate species-typical temperamental characteristics. Further, the declines in exploration could be due to habituation of the gorillas [Ogden et al., 1990].

White et al. [2003] evaluated the behavioral effects of activity-based animal management on a number of mammalian species at the Louisville Zoo’s “Islands” exhibit. They hypothesized that differences between the exhibits would affect individuals’ behaviors. They also predicted a lower frequency of stereotypic behaviors in the new system compared
to a traditional exhibit. Lastly they predicted that contact with other animals would draw out species-typical behaviors that are not generally seen in a traditional zoo setting [White et al., 2003]. The subjects in the study were four orangutans (*Pongo*), two Malayan tapirs (*Tapirus indicus*), two siamangs (*Symphalangus syndactylus*), two babirusa (*Babyrousa*), and a Sumatran tiger (*Panthera tigris sumatrae*). Every day in the Islands habitat the animals were moved to their exhibits before ten o’clock and were then rotated in the early afternoon. Focal animal sampling every ten minutes was conducted during the summers of 1996-1998. For recording purposes the horizontal plane of each exhibit was divided into thirds, from left to right, and from front to back. This amounted to six segments of horizontal space. Vertical space was divided into three categories: terrestrial, middle, and upper [White et al., 2003]. Sampling orders for observing the animals were randomly chosen, with observations between all individuals being evenly distributed [White et al., 2003].

For purposes of this study only the orangutan results will be discussed. White et al. [2003] observed that “orangutan 1” showed a significant decline over the years in terms of object manipulation and in time resting, with no significant differences in these behaviors between the two exhibits. Further data revealed that she manipulated objects more during the first summer than those following. The authors also noted significant changes in her use of horizontal and vertical space during the three summers that data was taken [White et al. 2003]. The influence of the exhibits were more pronounced during the first year and then declined. Results from “orangutan 2” also demonstrated that the strongest differences in behavior between the exhibits occurred during the first summer. Across the exhibits White et al. [2003] observed differences in object manipulation and use of vertical space. The authors
concluded that the activity-based management of animals did add variety and activity to the everyday life of orangutans. Thus, their hypothesis was supported as variation in exhibits produced variation in behaviors. However this variation in behavior declined across the three summers that data was taken; therefore habituation was an issue. The authors suggest adding novel items on a continuing basis to maintain variation in animal behavior. It was shown that activity-based exhibits increased the variability in the animals’ behavior and encouraged species-typical behavior. The authors end by stating that there was no evidence that showed any detrimental effects of having multiple animals in the exhibits [White et al., 2003].

Little and Sommer [2002] measured activity budgets and social interactions of a captive group of hanuman langurs (*Presbytis entellus*) in two different zoo enclosures. The first enclosure was a smaller, older-styled pavilion that was furnished with beams, wooden platforms, ledges, and ropes. There was also a slide in the wall that led to an outdoor enclosure containing wooden platforms and grass and other vegetation on the ground. The second, newer, enclosure contained both natural and artificial features. One area contained a variety of trees and shrubs along with telegraph poles that were joined by thick ropes. The newer facility also contained different species: sloth bears (*Melursus ursinus*), a muntjac (*Muntiacus reevesi reevesi*), peafowl (*Pavo cristatus*), and waterfowl shellducks (*Tadorna ferruginea*) [Little and Sommer, 2002]. The authors collected 53 hours of observational data in the old enclosure, and 53 hours of data in the new enclosure. The data collection was conducted via scans (every 15 minutes) and ad libitum sampling along with focal animal sampling. Observations indicated that in the old enclosure the langurs spent most of their day sitting together inside, resting or dozing. When they were outside they appeared to be
limited by space. Upon gaining access to their new enclosure the langurs destroyed most of
the new shrubs, with only the elder trees surviving. On the first day of their transfer the
langurs interacted with the other species; however they seemed to identify the sloth bears as a
threat. The sloth bears elicited a predator-avoidance behavior in the langurs, which the
authors point out could produce a level of “eustress” that counteracts boredom [Little and
Sommer, 2002]. Little and Sommer [2002] concluded that the langurs’ activity budgets
changed significantly regarding the category of “less stationary” behavior in the new
enclosure. The rates of affinitive and aggressive behaviors were reduced in the enclosure,
which the authors note could be due to a reduction in stress that had been caused by
crowding in the old enclosure. Lastly, they note that the new multi-species exhibit may raise
public awareness on issues such as conservation of species and their habitats [Little and
Sommer, 2002].

To determine the effects of novelty on captive gorilla behavior, Lukas et al. [2003]
alternated gorilla groups between two zoo exhibits on a regular basis, making theirs the first
study to systematically alternate gorilla groups between naturalistic, outdoor exhibits. The
authors hypothesized that by systematically alternating the gorilla groups; species-typical
behavior, activity levels, enclosure use, and visibility to the public would increase [Lukas et
al., 2003]. The two groups consisted of a total of 13 gorillas that occupied their enclosures
from ten o’clock in the morning until five o’clock at night. After five they were held in
indoor holding areas. Half of the subjects were wild-caught as infants, while half were born
in captivity. During the study the daily routines remained unchanged. The ethogram used
included five categories of behavior: posture, solitary, social, social proximity, and location.
A continuous, behavioral change sampling method was used where both focal and scan data were recorded. The subjects were observed for 10 minute periods, while an instantaneous group scan was also taken every 10 minutes to document the location of each individual in the group. A total of 227 hours of data was taken, with approximately 17.5 hours per subject [Lukas et al., 2003]. Lukas et al. [2003] observed that during the novel phase of each exhibit exchange, exhibit use, generalized activity, and social approaches all increased. The gorillas’ use of grass areas and the amount of time spent visible to the general zoo public also increased, which indicated that the gorillas were increasing their use of the exhibit space during that period of time. The authors also noted that the gorillas spent more time exploring an alternative exhibit within the first several days of residing in that space than during the ensuing days. An interesting finding was that object examination, which the authors note is usually an indicator of exploration, did not increase during the novel phase of each habitat exchange. Lukas et al. [2003] point out that the two exhibits were characterized by the same environmental furnishings, so that this finding is not necessarily unexpected. In terms of the novel phase, the authors found that there was a generalized increase in activity [Lukas et al., 2003]. They also noted that social approaches during the first four days in an alternate exhibit increased. Lucas et al. [2003] also discuss that exposing the gorillas to the novel environments did not increase any stress-related behaviors. This suggests that the novel phases of the exhibit exchange were not stressful for the gorillas. Lukas et al. [2003] concluded that regular alternations of gorillas between zoo habitats promoted the use of more exhibit space. Therefore exhibit rotation, on a regular basis, can be used as a form of environmental enrichment for captive gorillas [Lukas et al., 2003].
Burrell and Altman [2006] compared the behavior of cotton-top tamarins (*Saguinus oedipus oedipus*) across three exhibit types at a zoo: a rainforest exhibit, a caged outdoor exhibit, and a caged enclosure with access to both indoor and outdoor areas. They hypothesized that the captive environment would differentially affect the activity levels of the tamarins. The four cotton-top tamarins were initially in the rainforest enclosure, which was a large domed building with windows and tropical plants. A circular path for visitors was present. The tamarins had a nest box in the back area of the rainforest that was not visible to visitors. The rainforest represented a mixture of vegetation, free-ranging species, and visitors [Burrell and Altman, 2006]. After two months of observations, the tamarins were moved to an outdoor exhibit where visitors could view them from all sides. This enclosure had no live plants but contained severed tree limbs, a nest box, and hollowed-out logs. This second enclosure had little variation from day to day [Burrell and Altman, 2006]. The last exhibit was an indoor-outdoor exhibit that allowed shelter for the tamarins during the cold weather. The indoor enclosure contained potted plants, a man-made waterfall, a cement tree, a nest box, severed tree limbs, and artificial lighting. The outdoor enclosure contained live trees, a nest box, a tire swing, and tree limbs. This exhibit also had little variation, except for the choice to be indoors or outdoors [Burrell and Altman, 2006]. Burrell and Altman [2006] observed the tamarins with focal animal scan sampling. They were scored on 12 different behaviors and behavior-related characteristics. The authors supported their initial hypothesis, that a complex and dynamic exhibit (the rainforest) would produce the greatest amount of activity. The tamarins were the most active in the rainforest exhibit and the most inactive in the outdoor exhibit. These results thus signify the importance of the
habitats primates are placed in, and that the environment is a key player in what skill set New World monkeys develop [Burrell and Altman, 2006].

Due to the fact that the design of captive animal enclosures has shifted towards incorporating features that are similar to animals’ natural habitats [White et al., 2003], activity-based exhibits are becoming more popular. By moving animals to different exhibits, animals come across multiple types of environmental stimuli, which includes coming into contact with other species and physical variation [White et al., 2003]. Incorporating activity-based exhibits has been found to increase variation in behaviors [White et al., 2003], and to promote the use of more exhibit space [Lukas et al., 2003]. It has also been suggested that exhibit rotation can be seen as a form of environmental enrichment [Lukas et al., 2003]. This points towards the importance of the habitats primates are placed in [Burrell and Altman, 2006], and leads us to discuss how other factors affect primates, specifically visitors.

1.4 The Effect of Visitors on Zoo Animals

One of the most prominent aspects of a zoo environment is the daily presence of human visitors, which can elicit both positive and negative behaviors from the animals living there. Research on the effect of visitor presence on primates has produced conflicting results. Some have reported an enriching effect where chimpanzees were motivated to interact with visitors if food rewards could be obtained [Cook and Hosey, 1995]. However, the majority of studies have suggested that visitors are detrimental to some primates [Davis et al., 2005; Glatson et al., 1984; Hosey, 2005; Lambeth et al., 1997; Mallapur et al., 2005; Wells, 2005]. Generally, studies have assumed a “visitor effect” paradigm that decrees that visitors influence animal behaviors [Margulis et al., 2003]. However, another model, the “visitor
attraction” model, has also been used. The “visitor attraction” model states that visitors are more attracted to active animals [Margulis et al., 2003]. Before visitor effects on primates are discussed it is also important to briefly review visitor impacts on another species, the felids.

Margulis et al. [2003] examined the effects of the visitor attraction model and a nonprimate group, the felids. They noted that there was no significant difference in felid activity whether or not visitors were present. Therefore visitor presence did not seem to influence felid activity. The authors also concluded by stating that the literature concerning visitor influence on primate behavior is not always the best model for visitor activity-animal activity relationships in all taxa [Margulis et al., 2003]. Margulis et al. [2003] state that in the case of animals with low levels of activity (who also respond little to visitors), a visitor attraction model is more appropriate.

Sellinger and Ha [2005] looked at the influence of visitor density and intensity for two jaguars (*Panthera onca*). The jaguars were observed for a total of 230 hours with continuous frequency sampling. It was found that visitor intensity had a larger effect on jaguar behavior than visitor density because it affected two behaviors in the female (pacing, non-visible behavior), and one in the male (non-visible behavior). While visitor density levels only affected one behavior in the male and female (non-visible behavior for both). The authors noted that because both visitor intensity and density caused levels of stress for the jaguars further research is needed to determine if this was a confined finding or if similar effects exist in other captive populations [Sellinger and Ha, 2005].
Cunningham [2005] sought to identify the effect of visitors and noise levels on the behavior of five felid species at the Edinburgh Zoo. Two Persian leopards (*Panthera pardus saxicolor*), two snow leopards (*Uncia uncia*), and a jaguar were observed. The author concluded that the behavior of the felids was altered with increased levels of visitor presence and noise levels. Four out of the five felids changed their positions in response to visitors/noise levels. However, the visitors/noise levels did not affect stereotypical behaviors of the felids [Cunningham, 2005]. The author also notes that, although the visitors did affect the behavior of the five felids, the study could not determine whether the visitors had a positive or negative effect on the animals [Cunningham, 2005]. It appears that felids are affected by visitor presence in a different manner than primates. Hosey [2008] states that if the earliest studies had been done on felids versus primates the literature would have concluded that zoo animals were not affected by visitors. It is therefore very important to consider what species are more affected by visitor presence and help alleviate the stresses that come along with that.

Glatson et al. [1984] looked at the influence of the zoo environment on the social behavior of a group of cotton-topped tamarins. Four family groups were observed. The tamarins that lived in the off-display habitat were housed in one of two types of cages: (1) smaller cages used for pairs or small groups and (2) larger cages used for groups of more than four tamarins. All of the off-display cages were in one room, so all tamarins had visual, auditory, and olfactory communication with each other [Glatson et al., 1984]. The on-display group that could be seen by the viewing public was housed in a large wire cage but was then transferred during the first part of the study to a glass-fronted enclosure. The on-
display tamarins had no contact with other cotton-topped tamarins. All of the cages contained nestboxes and had branches [Glatson et al., 1984]. The observations were taken in one-hour intervals, where all interactions that involved one or both of the breeding pair were recorded. Three observation periods were evenly distributed throughout the day. The groups were observed individually in a varied order with the three different groups being observed every day. Observations were taken three to four days each week [Glatson et al., 1984]. The study itself was broken up into two parts (each six months): (1) one of the study groups was housed in the on-display enclosure, with the other three being held in the off-display enclosure, (2) the same group was kept on-display for the first 12 weeks; then they were exchanged with another group that came from the off-display room [Glatson et al., 1984].

Glatson et al. [1984] noted that there was more amicable behavior between the breeding pair of tamarins and less agonistic behavior between mother and young in the on-display group of tamarins during the first observation period of the day than in the subsequent observation periods. The first period was identified as having the least amount of visitors in the zoo. In regards to prolonged habituation to the public, Glatston et al. [1984] found that after being housed in front of the public for more than one year the group’s behavior still remained quite different from the off-display groups. The members of this group spent less time participating in social interactions and showed significantly less friendly behavior towards each other than the other breeding pairs. In terms of parent-offspring interactions, the on-display group had a lower number of interactions between parent and young than the off-display groups and also had more agonistic interactions between father and young in the on-display group [Glatson et al., 1984]. Thus the authors
concluded that there was a difference in the behavior of the groups of tamarins stemming from being on or off-display to the public. They suggested one way to elevate the stress of being on-display was to put the cages in quieter areas of the zoo [Glatson et al., 1984].

Wells [2005] investigated the effect of the human audience on the welfare of a group of captive gorillas. Six gorillas at the Belfast Zoological Gardens in Northern Ireland were observed in an exhibit that consisted of an outdoor arena and a large indoor den. A glass barrier separated the visitors from the gorillas in the indoor enclosure while a concrete wall separated them in the outdoor enclosure. Wells [2005] described ‘visitor density’ as the incidence of individuals that were admitted to the zoo. Surveys indicated that the gorilla exhibit was one of the most popular and frequently visited exhibits and attracted between 97-99% of individuals visiting the zoo [Wells, 2005]. Gorillas were observed for four hours a day, for 20 days of high visitor density and 20 days of low visitor density. High visitor density constituted weekends during July-August, and low visitor density constituted weekdays during November-January [Wells, 2005]. Data were collected at the same time every day. The gorillas’ behavior was recorded every five minutes using a scan-sampling data technique. Both the behavioral state and the position of the gorilla were recorded [Wells, 2005]. Wells [2005] concluded that the zoo-housed gorillas were significantly influenced by visitor density. Low visitor density was correlated with a greater proportion of time resting, while high visitor density encouraged behaviors that were indicative of stress. Examples were intragroup aggression, stereotypies, and autogrooming. Wells [2005] concluded that the visitors excited the gorillas. Thus, more work is needed to explore
different ways of reducing the arousing effect of the human audience while at the same time encouraging the zoo-visiting experience for the public.

Mallapur et al. [2005] studied the effects of short and long-term visitor presence on captive lion-tailed macaques in eight zoos across India. Short-term effects were determined by observing 30 individuals on both visitor presence and visitor absence days. Long-term effects were observed by recording the behavior of seven monkeys when on and off exhibit. To measure the long-term effects of visitor presence the individuals’ behaviors were recorded when they were in the on-exhibit enclosures and in the off-exhibit enclosures [Mallapur et al., 2005]. While recording the short-term effects Mallapur et al. [2005] spent two days per animal in each of the zoos (for a total of eight zoos). While recording the long-term effects the authors collected data at one zoo, viewing seven individuals. Behavioral sampling was undertaken, with instantaneous scans every 15 minutes followed by a 15-minute focal animal sample. The sampling periods were one hour in duration [Mallapur et al., 2005]. To study space utilization the enclosures were divided into four zones: (1) the edge zone, which was closest to the visitor area, (2) the back zone, which was farthest from the visitor area, (3) the enrich zone, which contained trees, logs, or sleeping platforms, and (4) the other zone, which was the area that did not fall into one of the above categories [Mallapur et al., 2005]. Therefore both the zone occupied and the behaviors of the monkeys were recorded during each scan [Mallapur et al., 2005]. Mallapur et al. [2005] concluded that the use of enclosure space was influenced by the viewing public, as the monkeys preferentially used the enrich zone when off-display. The authors also concluded that for the short-term effects the visitors influenced 20% more abnormal behaviors and 3% more social, mating, and aggressive
behaviors in the macaques. In terms of long-term effects visitors were associated with a 30% increase in abnormal behavior [Mallapur et al., 2005]. Therefore it was found that visitor presence was associated with both abnormal and aggressive behaviors in captive lion-tailed macaques. However, the authors noted that due to lack of animal welfare awareness programs in India levels of disturbance by zoo visitors are quite high. It was suggested that stress reduction methods such as the addition of ropes, vines, trees, and logs for more climbing and visitor barriers to hide from visitors be added to the exhibit [Mallapur et al., 2005].

Hosey and Druck [1987] sought to quantify the effects that zoo visitors have on primate behavior in zoos. Data were collected on 12 species of primate that included ring-tailed lemur (*Lemur catta*), mayotte lemur (*Lemur fulvus mayottensis*), black spider monkey (*Ateles paniscus*), white-fronted capuchin (*Cebus albifrons*), patas monkey (*Erythrocebus patas*), de Brazza monkey (*Cercopithecus neglectus*), Sykes monkey (*Cercopithecus mitis albogularis*), talapoin (*Miopithecus talapoin*), Barbary macaque (*Macaca sylvanus*), lion-tailed macaque (*Macaca silenus*), Celebes black macaque (*Macaca nigra*), and hamadryas baboon (*Papio hamadryas hamadryas*). To measure the effects of the public audience, two variables were considered: group size and group activity. In terms of group size, groups between one to five individuals were classified as small, and groups of over six were deemed large. Group activity was observed through five conditions: (1) no audience, (2) small active group, (3) small passive group, (4) large active group, and (5) large passive group [Hosey and Druck, 1987]. To measure the primates’ behavior levels four measures were taken: (1) frequency of behaviors towards audience, (2) frequency of behaviors directed towards other
members in a group, (3) locomotory activity levels, and (4) spatial dispersion of animals within the cage [Hosey and Druck, 1987]. Hosey and Druck [1987] observed some general trends in the data. Mainly it appeared that active audience groups had the largest influence on the animals. One solution the authors gave to alleviate this was to post a sign outside cages that asked the public to not interact with the animals. The results also indicated that most of the primate groups in this study did not alter their interactions between other group members when an audience was present. They concluded by stating that further studies are needed to determine whether specific behaviors are influenced by audiences and if there are clear species differences [Hosey and Druck, 1987].

Mitchell et al. [1992] replicated the work of Hosey and Druck [1987] but with different species of primate, different enclosures, and at another zoological park. Eleven different species of primates were observed. These species included: ring-tailed lemur, mongoose lemur (Lemur mongoz), red-ruffed lemur (Varecia variegata rubra), squirrel monkey (Saimiri sciureus), francois langur (Presbytis francoisi francoisi), spot-nosed monkey (Cercopithecus ascanius schmidti), De Brazza’s monkey, golden-bellied mangabey (Cercocebus galeritus chrysogaster), gibbon (Hylobates lar), orangutan (Pongo pygmaeus abelii), and chimpanzees. The same four behavioral measures and five audience conditions were taken following Hosey and Druck [1987]. These measures were taken to determine the relationships between the size and activity levels of audiences and the behavior of the primates in the zoo [Mitchell et al., 1992]. Mitchell et al. [1992] concluded that the results indicated that the primates directed some behaviors toward the visitors in all of the audience conditions, but more behaviors were directed at active rather than passive audiences. The
authors noted no relationship between size and activity of the audience and interactions with cage-mates. Lastly it was observed that the locomotory activity levels of the primates were higher when both large and small active audiences were present. It thus appeared that the size and activity levels of visitors and the behavior of zoo primates were related [Mitchell et al., 1992].

Wood [1998] looked at the interactions between environmental enrichment, viewing crowds, and 11 zoo chimpanzees. Specifically, the primary objective was to investigate whether a group of zoo chimpanzees would respond to environmental enrichment differently when faced with higher versus lower weekday crowds. The visitors were set apart from the chimpanzee exhibit by a dry moat that encircled the front and sides of the exhibit. No mesh or Plexiglas separated the visitors from the chimpanzees, so they were exposed to the auditory impact of the visitors along with those who threw items into their exhibit [Wood, 1998]. Videotaped data was collected over three months. Wood [1998] concluded that larger crowds corresponded with a lesser amount of foraging, object using, grooming, and play in these chimpanzees. Thus it appeared that crowd size plays a role not only in the everyday lives of the animals but that it also affects their behaviors [Wood, 1998]. It is therefore important to take into account visitor presence and how it affects individuals’ behavior.

Lambeth et al. [1997] looked at an archival database of chimpanzee wounding among 88 individuals in a captive colony at the Michael E. Keeling Center in Texas to determine whether human activity was linked to changes in chimpanzee wounding patterns. The chimpanzees lived in an outdoor/indoor enclosure where human activity was higher during
weekdays than weekends. This was due to the fact that most people worked during the week in activities such as veterinary procedures, twice daily sanitizing of enclosures, behavioral observations, and delivery of food. The authors note that multiple aspects of the colony management were consistent throughout both the weekdays and weekends, but fewer personnel conducted these activities on weekends [Lambeth et al., 1997]. In an examination of wounding incidents that occurred between April 1980 and March 1990, the authors found that only 10% of wounding episodes were recorded during the weekends [Lambeth et al. 1997]. Therefore, a greater number of wounding episodes took place during weekdays. The authors noted that the major factor distinguishing weekdays from weekends was the amount of human activity in the chimpanzee colony (with higher levels during weekdays). This study suggests that the routine presence and activities of caregiving, veterinary, research, and other personnel can have unwanted effects on primate wounding [Lambeth et al., 1997]. However, even though the day of the week affected the frequency of wounding, it did not affect the severity of the wounding. The authors give four ways in which individuals who manage chimpanzee colonies can use these results: (1) employ procedures to reduce aggression when human activities are at their highest, (2) reduce the level of human activity in certain situations, (3) use techniques to reduce the perceptible level of human activity around primates, and (4) implement techniques that can reduce distress that is associated with some of the human activity to which the primates are exposed to [Lambeth et al., 1997].

Davis et al. [2005] sought to understand the relationship between visitor numbers and activity in the hypothalamic-pituitary-adrenal (HPA) axis in spider monkeys (Ateles geoffroyi rufiventris). This was done to increase the understanding of visitor impact by using
physiological measures. Cortisol levels were measured in the urine, which provided information about the spider monkeys’ physiological responses to stressors [Davis et al., 2005]. By examining the cortisol levels it was shown that increasing visitor numbers were associated with increasing levels of cortisol in spider monkeys. However, one monkey (out of five) showed the opposite trend of not having raised cortisol levels. The authors note that one explanation for this could be that the visitors did not affect this individual as much of the others [Davis et al., 2005]. The conclusion drawn was that levels of urinary cortisol increased with higher visitor numbers, implying that visitors had a probable negative impact on the monkeys [Davis et al., 2005].

Due to the fact that human visitors are a daily occurrence in zoo environments, it is critical to determine what effect that has on the animals living there. Research on the effect of visitor presence on primates has produced conflicting results, but the majority of studies have suggested that visitors are detrimental to some primates [Davis et al., 2005; Glatson et al., 1984; Hosey, 2005; Lambeth et al., 1997; Mallapur et al., 2005; Wells, 2005]. Interestingly, visitors seem to have a different effect on felids. Margulis et al. [2003] reported that visitor presence did not influence felid activity. While Cunningham [2005] noted that visitors did affect the behavior of felids, although whether this affected them in a positive or negative way still needs to be investigated. However, it is clear that visitor presence does affect primates; therefore zoos must seek to understand and reduce stresses that come along with visitor presence [Davey and Henzi, 2004]. Zoos could do so by counterbalancing any direction tendencies that occur by housing species that are less responsive to visitors where the visitation rates are highest [Davey and Henzi, 2004].
Chapter Two: Methods

2.1 Objectives

The objectives of this study were as follows:

1. To study a newly transferred group of golden-headed lion tamarins as they acclimated to a new habitat

2. To record data on both zoo open, and zoo closed days to document any effects that occurred with visitor presence

3. To examine how the zoo environment affects tamarin behavior

2.2 Study subjects

Two golden-headed lion tamarin siblings living at the Blank Park Zoo in Des Moines, Iowa were included in this study. Jose, a 7-year old male, and Nut monkey, an 8-year old female were both born at the zoo in Gulf Breeze, Florida and were then transferred to the Toledo Zoo in 2003. They are currently on loan to the Blank Park Zoo from the Toledo Zoo. The tamarins were brought into the zoo due to the fact that the previous inhabitants of the discovery center exhibit, a group of Weids marmosets (*Callithrix kuhlii*), were catching and eating the free-flying birds in the exhibit. The female, Nut Monkey, was on birth control in the form of an implant that is changed every year following the species survival plan (SSP). Both subjects arrived at the zoo with mild diabetes; however the symptoms stopped after sugars were lowered and canned food (ZooPreem®) was increased.

2.3 Housing

The tamarins arrived, and were put in quarantine on September 10, 2009. They were in quarantine until their release into their new habitat on December 5, 2009. The tamarins were housed in the Discovery Center of the Blank Park Zoo that is set up as a rainforest type
environment with plants and trees [Figure 1]. The enclosure is somewhat circular with a path surrounding the enclosure on which visitors can walk. The exhibit is roughly 12 feet tall, and 15 by 18 feet wide. At the rear of the exhibit there is a rock wall with a small hole at the top that leads to a holding area, which is the one area where the tamarins are not visible. The enclosure contains one large tree, a metal stand, and multiple branches and ropes. Rocks surrounded the bottom half of the exhibit with a shallow pool of water on the floor. The exhibit was closed off by mesh so the tamarins have a view into another enclosure where turtles and free-flying birds are kept. Objects such as a swing, toys, and different types of food were put in the enclosure for enrichment purposes. Positive reinforcement training was also used to make medical procedures easier, if they were needed.
2.4 Procedure

The golden-lion tamarins were observed using visual scan sampling to record each individual’s behaviors [Altmann, 1974] every five minutes for a total period of 100 hours. Observational data were collected from 12/5/2008 to 1/23/2009 for a total of 27 observational days (when data was taken) and 49 elapsed days. The data were collected equally on days where the zoo was both open and closed, therefore 50 hours of data were collected on zoo open days, and 50 hours of data were taken on zoo closed days. The ethogram used was taken from Burrell and Altman [2006] and included moving, eating, grooming, self-grooming, hunting, investigating, social play, aggression, calling, other, sitting, and not visible [Table 1]. This ethogram was selected due to the fact that it incorporated different behaviors that could be associated with tamarins. Scans were taken every five minutes to record the tamarins’ location and behavior, and the estimated number of visitors around the exhibit. A five-minute scan interval was chosen after reviewing the literature to determine an appropriate scan time [Wells, 2005].

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving</td>
<td>Climbing, running, or jumping along trees or walls of enclosure</td>
</tr>
<tr>
<td>Eating</td>
<td>Pulling bark and fruit from trees or food pans</td>
</tr>
<tr>
<td>Grooming</td>
<td>In a group of two or more, picking through hair and cleaning each other</td>
</tr>
<tr>
<td>Self-Grooming</td>
<td>Picking through hair, cleaning, or scratching at self</td>
</tr>
<tr>
<td>Hunting</td>
<td>Watching for small vertebrates, capturing vertebrates</td>
</tr>
<tr>
<td>Investigating</td>
<td>Looking at people or animals in area (other than tamarins), coming close to them, sniffing, or peering into windows of enclosure</td>
</tr>
<tr>
<td>Social Play</td>
<td>Nonaggressive interaction with other tamarins, pushing or rolling over each other, lying calmly on one another, not grooming</td>
</tr>
<tr>
<td>Aggression</td>
<td>Scratching at another tamarins face, pushing or picking at another tamarin, making threatening or warning motions, and short call vocalizations</td>
</tr>
<tr>
<td>Calling</td>
<td>Long vocalizations that are directed towards other tamarins, or other animals</td>
</tr>
<tr>
<td>Other</td>
<td>Any behavior not included in ethogram</td>
</tr>
<tr>
<td>Sitting</td>
<td>Stationary position, usually on tree branches or other surfaces, possibly moving head about</td>
</tr>
<tr>
<td>Not visible</td>
<td>Animal is out of sight, in separate part of exhibit or in nest box, obscured by foliage</td>
</tr>
</tbody>
</table>
2.5 Data Analysis

Three hypotheses were tested during this study. The first predicted that the amount of time spent hidden would decrease as the tamarins became acclimated to their new environment. The second was that tamarin activity would decrease as the number of visitors increased following introduction to their new enclosure. Lastly, it was predicted that the tamarins would be more active on zoo open versus zoo closed days. The statistical program Minitab was used to test these hypotheses.

Minitab is a statistical program that offers a plethora of statistical tools to analyze data (http://www.minitab.com). To use the program I coded my data and imported it into Minitab. Coding was done by giving a numeric value to a certain characteristic. For example, the behavior “sitting” was given the number one. Once the data were in Minitab it was analyzed by independent two sample t-tests and/or simple linear regression. For example, I used a two-sample t-test to compare two variables, such as the amount of time spent visible for Nut Monkey versus the amount of time spent visible for Jose. I would use regression analyses when two continuous variables were being compared, for example, when comparing the proportion of time visible (for both animals combined) versus elapsed days.
Chapter Three: Results

Data were collected from 12/5/2008 to 1/23/2009. This amounted to a total of 27 observational days (when data were taken), and a total of 49 elapsed days. During the 27 observational days 100 hours of data were collected, 50 hours during which the zoo was open and 50 hours when the zoo was closed. Data were analyzed using both two-sample t-tests and simple linear regression. Frequency distributions were run to analyze what behaviors were predominantly observed (Table 3.1). Table 3.1 illustrates that the behaviors most common were “not visible” and “sitting”.

**Table 3.1** The number of times a certain behavior was exhibited and the proportion of that behavior (the frequency of the behavior divided by the total number of 1200 observations)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Jose</th>
<th>Nut Monkey</th>
<th>Proportion (Jose)</th>
<th>Proportion (NM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Visible</td>
<td>771</td>
<td>571</td>
<td>0.6425</td>
<td>0.475833</td>
</tr>
<tr>
<td>Sitting</td>
<td>310</td>
<td>445</td>
<td>0.258333</td>
<td>0.370833</td>
</tr>
<tr>
<td>Moving</td>
<td>59</td>
<td>90</td>
<td>0.049167</td>
<td>0.075</td>
</tr>
<tr>
<td>Self-groom</td>
<td>30</td>
<td>32</td>
<td>0.025</td>
<td>0.026667</td>
</tr>
<tr>
<td>Grooming</td>
<td>6</td>
<td>3</td>
<td>0.005</td>
<td>0.0025</td>
</tr>
<tr>
<td>Eating</td>
<td>12</td>
<td>21</td>
<td>0.01</td>
<td>0.0175</td>
</tr>
<tr>
<td>Investigating</td>
<td>12</td>
<td>38</td>
<td>0.01</td>
<td>0.031667</td>
</tr>
</tbody>
</table>

Since the animals spent the majority of their time not visible, I deleted that behavior in analysis of activity. Once “not visible” was taken out, sitting became the most frequent behavior (Table 3.2).
Table 3.2 The number of times a behavior was exhibited and the proportion of that behavior (the frequency of the behavior divided by the total frequency) excluding “not visible”

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Jose</th>
<th>Nut Monkey</th>
<th>Proportion (Jose)</th>
<th>Proportion (NM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>310</td>
<td>445</td>
<td>0.722611</td>
<td>0.707472</td>
</tr>
<tr>
<td>Moving</td>
<td>59</td>
<td>90</td>
<td>0.137529</td>
<td>0.143084</td>
</tr>
<tr>
<td>Self-groom</td>
<td>30</td>
<td>32</td>
<td>0.06993</td>
<td>0.050874</td>
</tr>
<tr>
<td>Grooming</td>
<td>6</td>
<td>3</td>
<td>0.013986</td>
<td>0.004769</td>
</tr>
<tr>
<td>Eating</td>
<td>12</td>
<td>21</td>
<td>0.027972</td>
<td>0.033386</td>
</tr>
<tr>
<td>Investigating</td>
<td>12</td>
<td>38</td>
<td>0.027972</td>
<td>0.060413</td>
</tr>
</tbody>
</table>

A frequency distribution analysis was run to determine in which locations the tamarins were spending the majority of their time (Figure 3.1). The histogram illustrates that the tamarins spent the majority of their time, when visible, on a branch (1). The other locations the tamarins used included a carrier (2), the rock wall (3), the mesh (4), the sloth stand (5), a rock (6), a rope (7), and the ground (8).
Figure 3.1 Histogram of tamarins’ location use and frequency rates where 1=branch, 2=carrier, 3=rock wall, 4=mesh, 5=sloth stand, 6=rock, 7=rope, 8=ground.

3.1 Hypothesis One: Visibility

My first hypothesis predicted that the amount of time spent in the one non-visible area of the enclosure would decrease as the animals became acclimated to their new environment. Therefore, it would be expected that the two individuals would initially spend most of their time not visible. The first question was whether or not the animals were spending more time visible in their enclosure as time elapsed. This would be regardless of whether or not the zoo was open or closed. A two-sample $t$-test was conducted to determine if the proportion of time spent visible was related to the time period (beginning versus end of study). There was a significant difference in visibility of the two animals together over time ($t=-5.23$, $p<0.001$, $n=42$). For the initial observations, the mean visibility was 0.213, while at the end of the study the mean visibility was 0.538. That means that, for initial observations, the animals were visible in 21% of the scans. At the end of the observation period the
animals were visible in 54% of the scans. Therefore, the animals were significantly more visible at the end of the study than at the beginning.

Another factor that should be considered is the amount of elapsed time during the study. Although data were collected on 27 days, a total of 49 days elapsed during the study period. A simple linear regression model was estimated to determine if the proportion of time spent visible was related to the elapsed day. The animals (considered together) did become more visible as the elapsed days increased ($b_1=0.0092$, $t=4.93$, $p<0.001$, $r^2=0.318$, $n=54$). Since we now know that the amount of time spent visible is related to the elapsed day it would be interesting to find out if there were any individual differences between the two tamarins. A regression model was estimated to determine if the proportion of time spent visible (for Nut Monkey, and Jose) was affected by the amount of elapsed time. It appears that the baseline level of activity for the two animals was different (NM=0.265, J=0.154), but both animals were significantly more visible as time went on (Figure 3.2).
Another point of interest would be whether or not there is a difference between Nut Monkey’s proportion of time spent visible versus Jose’s. A two-sample t-test revealed that Nut Monkey was, on average, more visible than Jose (Figure 3.3). Over the entire study Nut Monkey’s visibility for the average day was 51.6%, while Jose’s was 34.3%. This was a statistically significant difference of 17.3% \((t=2.76, p=0.008, n=54)\). Since the two animals had different amounts of visibility, a two-sample t-test was run to determine if their activity levels were different. Nut Monkey was not statistically more active than Jose. Nut Monkeys average activity level was 15%, while Jose’s activity was 9.7% \((t=1.99, p=0.052, n=54)\).
In summary, the first question addressed whether the animals spent more time visible as time went on. A two-sample $t$-test was conducted showed that the animals were, indeed, more visible at the end of the study than at the beginning. The next question was whether the proportion of time spent visible was related to the elapsed day. A regression indicated that the animals became more visible as the elapsed days increased. To investigate further, the data for the two animals were separated for analyses. The regression showed that both animals were significantly influenced by elapsed day as their visibility increased as time went on. A $t$-test was then conducted to determine if the two animals differed in their proportion of time spent visible. The $t$-test showed that NM was on average more visible than Jose. However it was found that NM was not statistically more active than Jose.
3.2 Hypothesis Two: Behavior

My second hypothesis predicted that following their release the tamarins’ activity levels would decrease as the amount of visitor presence increased. For this to be supported the tamarins’ initial activity level would have to have been at a moderate level, followed by a decrease as visitors entered the area around their enclosure. The first step to answering this question was to establish that the tamarins were exposed to a similar number of visitors at the beginning of the study versus the end of the study. A two-sample t-test was conducted comparing the mean visitor rate versus the amount of visitors from the beginning of the study (observational days 1, 2, 5, 6, and 7) versus the end of the study (observational days 19-21, 24-27). The test revealed that the number of visitors at the beginning and at the end of the study was similar ($t=0.93, p=0.377, n=12$).

To further address this hypothesis, the tamarins’ activity levels on days 1 and 2 were examined to see if their activity level was indeed at a “moderate” level. For both animals, on both day 1 and day 2, every observation showed them either sitting or not visible. The question is then whether their initial activity level was moderate, or, in other words, whether it could go down. A two-sample t-test was conducted for data collected on days the zoo was open to compare the proportion of time spent active (i.e., not sitting) over the course of the study (beginning versus end). It was shown that the tamarins were significantly less active at the beginning of the study than at the end of the study ($t=-5.64, p<0.001, n=24$). Figure 3.4 illustrates which behaviors the tamarins’ were engaging in the most.
Figure 3.4 Histogram of tamarins’ behaviors where 1=sitting, 2=moving, 3=self-groom, 4=grooming, 5=eating, 6=investigating

The next question was whether or not the proportion of time-spent active (not sitting) was related to the number of visitors present (range of visitors were between 0-7). A simple linear regression model comparing the proportion of time active relative to the total number of visitors was estimated to determine this. It was revealed that increasing the number of visitors had a negative influence on activity, as measured by proportion of time spent not sitting. For every additional visitor to the exhibit, the proportion of time spent active (measured by proportion of time spent not sitting) decreased by 0.00119 units. Thus, as the number of visitors to the exhibit increased, the activity levels of the animals decreased ($b_1=-0.00119, t=-2.65, r^2=0.118, n=54$). Additionally, a regression analysis was conducted on the proportion of time spent active versus the mean number of the visitors present for each scan within a particular day. Results showed that visitors negatively influenced activity levels of
the two animals ($b_1=-0.0649$, $t=-3.09$, $p=0.003$, $r^2=0.155$, $n=54$). Therefore, the influence of mean number of visitors (a scaling of how many individuals might be in the exhibit at any given time) had a larger influence than the total amount of visitors.

To summarize: three questions were examined that related to my first hypothesis. The first was whether there where more visitors at the beginning of the study or at the end. Analysis showed that there were not more visitors at the beginning of the study versus the end of the study. The second question addressed whether tamarin activity was higher in the beginning of the study or at the end of the study. Results showed that the tamarins’ activity levels were lower in the beginning of the study versus the end. Lastly, the question of whether the proportion of activity (not sitting) was related to the amount of visitors was addressed. A regression analysis showed that an increase in visitors had a negative influence on tamarin activity. Therefore, as the number of visitors increased, tamarin activity levels decreased.

3.3 Hypothesis Three: Visitors

My third hypothesis was that the tamarins would be more active when the zoo was closed (lower visitor presence) than when the zoo was open (higher visitor presence). The first question addressed whether or not the visitor rate differed on zoo open or zoo closed days. A two-sample $t$-test was conducted comparing the mean amount of visitors during the 2 conditions. The test showed that, in fact, the animals were exposed to more people on zoo open days than on zoo closed days, as expected ($t=-4.34$, $p<0.001$, $n=27$). The mean for the visitor rate on zoo closed days was 0.421 (which means that was the number of individuals...
that would be observed on average for each scan), while the mean was 1.228 for zoo open days.

The next question addressed was whether the proportion of time spent not sitting (active) differed on open versus closed days. A two-sample $t$-test was conducted comparing the proportion of time not sitting and whether the zoo was open or closed. This showed that the activity rate of both animals did not differ between zoo open and zoo closed days ($t=1.07$, $p=0.290$, $n=54$), even though zoo open days had more visitors to the enclosure than on zoo closed days. A two-sample $t$-test was then conducted to see how visible the animals were on zoo open/closed days. Similarly, there was no difference between zoo open and zoo closed days in the visibility rate of the two animals. On zoo closed days the animals’ visibility rate was 44.5% on average. In contrast, on zoo open days, they were visible 41.2%, a difference that was not statistically significant ($t=0.49$, $p=0.624$, $n=54$).

In summary, the first question addressed whether there was a difference in visitor rates when the zoo was open versus closed. A $t$-test showed that there were more people on zoo open than zoo closed days. The next question addressed whether or not the proportion of time spent not sitting (active) was different on zoo open versus closed days. A $t$-test was conducted that showed that the activity rate of both animals did not differ between zoo open versus closed days. There was also no difference between zoo open/closed days in the visibility of the two animals.
Chapter Four: Discussion

Zoo visitors are a prominent aspect of any zoo environment. Therefore, it is vital to determine what their influence is on zoo animals, as zoo audiences are now considered a noteworthy variable in behavioral research [Mitchell et al., 1992]. Considering that 50% of all primate species are now of conservation concern, and 20% are listed as endangered [Campbell et al., 2007], it is of utmost importance to preserve examples of genetic variation in zoos. Moreover, in addition to studying how visitor presence affects primates it is also important to study how primates’ environments affect their behaviors. Multiple studies are now supporting regular movement of animals between enclosures to increase activity levels and enclosure use [Hosey, 2005]. Lastly, it is imperative that animals’ welfare is of outmost concern when interpreting the results of such studies.

Due to the fact that one of the most successful examples of a captive breeding program involves the golden lion tamarin it is important to compare the behavioral development of reintroduced, captive-born animals and their wild-born offspring. Furthermore it is vital to compare the behavior of individuals who were captive-born and then reintroduced to conclude if their survival rates/differences were related to behavioral deficiencies [Stoinski et al., 2002]. To develop hypotheses on how the behavior of captive-born, reintroduced animals and their wild-born offspring would differ, Stoinski et al. [2002] compared natural histories and behaviors of golden lion tamarins in different populations. Wild tamarins, captive-born reintroduced tamarins, and wild-born descendents of reintroduced individuals were all part of the populations studied [Stoinski et al., 2002]. The authors concluded that captive-born tamarins relied more on human-made substrates, spent
more time on the ground, fell more, and rested less than first-generation individuals [Stoinski et al., 2002]. In terms of foraging, captive-born tamarins micromanipulated at higher rates than their offspring. Stoinski et al. [2002] noted that captive-born animals were lacking in foraging and locomotor skills when compared to their wild-born offspring. The authors recommended certain points for future reintroductions: (1) increased exposure to complex environments, (2) post-release support, (3) introduction of naïve animals with knowledgeable conspecifics, (4) comparisons of wild and reintroduced populations, (5) short and long-term management plans [Stoinski et al., 2002]. Due to the fact that reintroduction is a complicated process, it is also important to compare captive tamarin behavior with wild tamarin behavior to determine if there are any similarities.

Lopes and Ferrari [1994] reported that a group of tamarins (S. fuscicollis weddelli) spent approximately 20% of their day foraging, 10% feeding, 24% traveling, and 46% resting. Dietz et al. [1997] studied seven groups of golden lion tamarins and found that the groups had a range of travel between 21% to 43%. Further, Raboy and Dietz [2004] observed three groups of wild golden-headed lion tamarins living in the Una Biological Reserve, Bahia State, Brazil. They noted that foraging and feeding behaviors between the three groups did not differ very much (foraging/feeding behaviors accounted for 34%, 35%, and 24% of the groups) [Raboy and Dietz, 2004]. The authors also mention that the tamarins spent most of their day traveling (33%) [Raboy and Dietz, 2004]. Passamani [1998] studied a group of marmosets (C. geoffroyi) in southeastern Brazil and found that the group spent their time resting (29%), feeding (21%), moving (20%), and foraging (14%). The studies are summarized below in Table 4.1. The tamarins in this study spent the majority of their time
not visible, and when visible they spent the majority of their time sitting/resting. The fact that the tamarins in this study spent the majority of their time (when visible) resting/sitting does follow other studies, such as Lopes and Ferrari [1994], and Passamani [1998]. The biggest difference between the captive tamarins studied here and the wild tamarins and marmosets is the fact that the captive tamarins did not spend much time traveling or foraging/feeding. This could be due to many issues, the first being that they are in a restricted space. Further, the captive tamarins are given food daily so they have no need to forage. This does point to the importance of perhaps scattering the captive tamarins’ food so that not only do they have to “travel” more, but also forage for their food.

<table>
<thead>
<tr>
<th>Study</th>
<th>Species</th>
<th>Time spent traveling</th>
<th>Time spent foraging/feeding</th>
<th>Time spent resting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietz et al. [1997]</td>
<td><em>L. rosalia</em></td>
<td>Range between 21.3% to 42.9%</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Lopes and Ferrari [1994]</td>
<td><em>S. fuscioillis weddelli</em></td>
<td>24.2%</td>
<td>20.3%/9.8%</td>
<td>45.7%</td>
</tr>
<tr>
<td>Raboy and Dietz [2004]</td>
<td><em>L. chrysomelas</em></td>
<td>33%</td>
<td>34%, 35%, 24%</td>
<td>-----</td>
</tr>
<tr>
<td>Passamani [1998]</td>
<td><em>Callithrix geoffroyi</em></td>
<td>20%</td>
<td>14%/21%</td>
<td>29%</td>
</tr>
<tr>
<td>This study</td>
<td><em>L. chrysomelas</em></td>
<td>4.916% (Jose), 7.5%(NM)</td>
<td>1% (Jose), 1.75% (NM)</td>
<td>25.83% (Jose), 37.08% (NM)</td>
</tr>
</tbody>
</table>

This study’s first hypothesis predicted that the amount of time spent in the one non-visible area of the enclosure would decrease as the animals became acclimated to their new environment. Tests showed that the tamarins were more visible at the end of the study than at the beginning. Also, the tamarins became more visible as the elapsed days increased. The tamarins’ data were then analyzed separately to determine if there were any individual
differences in visibility. I found that Nut Monkey was, on average, more visible than Jose. This could be due to several reasons, one of which being that she was more dominant than Jose. However she was not statistically more active than Jose. Habituation has been studied by gauging primates’ behavior after they are introduced to a novel environment. Due to the fact that designs of captive animal enclosures are now integrating features that are similar to animals’ natural habitats [White et al., 2003], activity-based exhibits are currently the focus. Ogden et al. [1990] studied lowland gorillas as they explored their new habitat. They found that the gorillas had a slow onset of exploratory behaviors, and a longer than expected period of stabilization [Ogden et al., 1990]. Although the researchers did not expect this, it does correlate with my prediction that the tamarins would take some time to habituate to their new environment. Ogden et al. [1990] described their results as a “period of initial caution” which was then followed by enclosure exploration. Another reason that the tamarins became more visible over time could have been that they were acclimating to visitor presence as well.

This study’s second hypothesis predicted that following their release the tamarins’ activity levels would decrease as visitor presence increased. The results indicated the tamarins were more active (measured in time spent not sitting) at the end of the study than at the beginning. Analyses of visitor presence also showed that there were not more visitors at the beginning of the study than at the end (meaning visitor rate did not change enough to be statistically significant). Further, it was shown that any increase in visitor rate had a negative influence on tamarin activity (measured through time spent not sitting). This finding points to the issue that the visitors were providing some level of stress to the monkeys.
These results correlate with other studies that found that visitors can be detrimental to some primates [Wells, 2005]. Glatson et al. [1984] noted that their on-display groups of tamarins were more amicable during the first observation period of the day. That observation period was identified as having the least amount of visitors in the zoo. Further, Wells [2005] found that visitor density levels significantly influenced zoo-housed gorillas. Low visitor density was correlated with a greater amount of resting, while high visitor density encouraged behaviors that were associated with stress [Wells, 2005]. Birke [2002] noted that adult orangutans used paper sacks to cover their heads more when there were more visitors present. Further, infant orangutans approached and held onto adults more when there were loud visitor groups [Birke, 2002]. There has also been physiological evidence that zoo visitors affect primates. Davis et al. [2005] discovered that high amounts of zoo visitors were associated with increasing levels of cortisol in spider monkeys. Therefore the “visitor effect” paradigm seems to apply in this study because it was shown that the visitors influenced tamarin behavior [Margulis et al., 2003]. These results indicate that the relationship between zoo visitors and animal behavior is a significant one.

One interesting finding came through testing the third hypothesis. I predicted that the tamarins would be more active when the zoo was closed (lower visitor presence) than when the zoo was open (higher visitor presence). This prediction follows the literature that states that higher visitor density can be detrimental to primates [Wells, 2005]. Tests showed that the tamarins were exposed to more visitors on zoo open days than on zoo closed days. However the tamarins’ activity rate did not differ between zoo open and closed days even though zoo open days had more visitors to the enclosure than on zoo closed days. There was
also no difference between zoo open and closed days in the visibility rate of the two animals. This result seemingly contradicts my first hypothesis because it was shown that a higher visitor density had a negative impact on tamarin activity levels. One reason for this finding could be due to the fact that the study took place during the winter season. The winter season is characterized by extremely low levels of visitors; therefore, even though zoo open days were associated with a higher visitor density the actual amount of visitors could have been quite low compared to what a summer audience might have been. Because of these conflicting results, it is important to look at other studies concerning visitor presence and another species.

Margulis et al. [2003] studied a lion (Panthera leo), Amur leopard (Panthera pardus orientalis), Amur tiger (Panthera tigris altaica), two snow leopards, a clouded leopard (Neofelis nebulosa), and a fishing cat (Felis viverrinus) to examine the “visitor attraction” model (assumes that visitors are attracted to more active animals). Their results suggested that the felids’ activities were not influenced by visitor presence. The authors concluded that the visitor attraction model is more suitable for taxa such as felids that are more inactive and who do not respond to visitor disturbances [Margulis et al., 2003]. However, Cunningham [2005] studied five felids (two Persian leopards, two snow leopards, and a jaguar) and concluded that the behavior of the felids altered with increased amount of visitor presence/noise levels. Furthermore, Hosey [2008] notes that visitor presence affects different taxa in different ways. He maintains that if the earliest studies done were on felids rather than on primates the literature would have concluded that zoo animals were not affected by visitor presence.
This study and others indicate that zoo visitors can be stressful for captive animals. Therefore, zoos must seek to understand and reduce these stressful situations captive animals face [Davey and Henzi, 2004]. To improve animal welfare, Hill and Broom [2009] suggest giving animals choices in their environment. By “asking” animals what they want we can better understand their needs for access to certain resources, and give them chances to express behaviors that vital to them [Hill and Broom, 2009]. Due to the fact that animal welfare can be measured scientifically through how animals cope with their environments studying an animal’s behavior can be a helpful tool when evaluating an animal’s welfare [Hill and Broom, 2009].

Davey and Henzi [2004] suggest that the pattern of visitors’ circulation and orientation should be studied to better understand visitor effects. They found that the majority of visitors (84%) turned right when they entered the primate exhibit. Thus the animals on the right side received greater amounts of visitors than the left side [Davey and Henzi, 2004]. Further, Mitchell et al. [2005] found that cages nearest the entrance/exits had significantly more visitors than cages away from those areas. This highlights the importance of cage location and what species are housed in high visitor traffic areas. Zoos should take this into consideration and perhaps begin to counterbalance any direction tendencies that take place. One solution to this problem would be to house species that are generally less responsive to visitors where the visitation rates are the highest [Davey and Henzi, 2004]. Another step that could be taken would be to utilize technological advances in the field such as using urine or fecal samples to determine stress levels. This allows numerous hypotheses
to be tested and furthers attempts to meet the welfare needs of the zoo animals [Melfi, 2005]. Those steps and more could be taken to help primates acclimate to visitor presence.

Since one of the most successful examples of a captive breeding program involves the golden lion tamarin, it is critical that we study them in captivity. Given that animal welfare can be measured scientifically through observing behaviors we can assess how animals are coping with their environments. Further, by doing so we can help give them choices in their environment, which can increase our understanding of their needs, which will help improve their overall welfare [Hill and Broom, 2009]. Together zoos and universities have the unique ability to combine their resources and produce research that can be critical to primate conservation [Feistner and Price, 2002]. Furthermore, collaboration between zoos and academic institutions can further our understanding of animal behavior, raise awareness to conservation and propagation of species, and educate students and the public about the importance of conservation [Fernandez and Timberlake, 2008].

4.1 Conclusions

1. Tamarins were more active (determined by proportion of time spent not sitting) at the end of the study than at the beginning.

2. As the amount of visitors increased, tamarin activity levels decreased.

3. The tamarins were more visible at the end of the study, and more visible as the number of elapsed days increased.

4. There was a difference in individuals concerning visibility; Nut Monkey was more visible than Jose.

5. The tamarins were exposed to more people on zoo open days versus zoo closed days.

6. Visibility and activity rates did not differ on zoo open versus zoo closed days.
4.2 Future Directions

One future direction I would suggest to the Blank Park Zoo would be to recollect data at some point in time. One issue that needs to be addressed is the time period of this study. Data were collected from December 5, 2008 to January 23, 2009. This was done because the tamarins were released on December 5, 2008, thus the study needed to begin that day as well. However, because of the season there were not many visitors at the zoo. Therefore, the tamarins were not getting a high visitor presence due to the winter season. Hence the results are based on a low visitor density. Although not ideal conditions for a research study, a low level of visitors (winter season) appears to be a positive time to introduce animals to a new habitat. Another issue that could be addressed in the future was the definition of “visitor” and how that affected the study. I recorded every individual who was present at the time of the scan on both zoo open and zoo closed days. Therefore caretakers were recorded as visitors on zoo closed days. Because of the season it was possible for more visitors to be present on zoo closed days than on zoo open days. Due to the fact that results showed that visitors did affect the tamarins in a negative way it is extremely important to look into how a higher visitor presence (such as during the summer or peak season) affects the animals.
References


