3-3-2017

Determining the Effect of Visitor Group Size and Other Variables on the Behavior of Orangutans at the Oregon Zoo as a Measure of Welfare

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By

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An undergraduate honors thesis submitted in partial fulfillment of the

requirements for the degree of

Bachelor of Science

in

University Honors

and

Biology: Organismal

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Portland State University

2017

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Abstract

The Oregon Zoo is home to many exotic animals, including Bornean and Sumatran orangutans. They live in a relatively new naturalistic exhibit and are subject to large volumes of visitor traffic throughout the day. This is a pilot study to determine the variables and details necessary to conduct a more in depth analysis of orangutan welfare in the future. Eleven behaviors were observed to create an activity budget for the orangutans to be used to analyze the effect of different variables on their behavior. The independent variables examined were crowd size, temperature, weather, test day, and individual (in regards to the orangutan). The behaviors focused on with relevance as potential welfare indicators were time spent looking at visitors, covering head, and time not visible. Behavior data in rainy and sunny weather were subsequently compared to determine if certain behaviors were responding to weather or other variables. Large crowd size was found to be correlated with decreased time spent not visible and increased time spent covering head when weather was sunny. Additionally, large crowd size was correlated with decreased time spent not visible and covering head in times of rainy weather. However, crowd size did not have a significant effect on these variables. A larger sample size needed to detect significance in the effect of independent variables on the dependent variables with the given amount of variance. Additional methods such as hormone testing, and including other variables such as exhibit design, social system, and other visitor variables would be helpful in creating a more thorough analysis of the welfare of the animals.

Introduction

Zoos are popular destinations for the public due to the access to exotic and exciting animals. Researching how the animals behave in response to this is essential in understanding the behavior of captive animals. In many cases, this type of research is also useful in assessing the welfare of captive animals. Extensive research has been conducted regarding captive

primates (Amrein 2014, Birke 2002, Choo 2011). The presence of researchers and other people such as zoo patrons or individuals that an animal is not used to being exposed to, has been shown to have a negative effect on the animals being observed – or in some cases, manipulated (Birke, 2002). To be able to accurately assess data collected in behavioral research, it is important to know if the mere presence of a human or groups of humans will impact the behavior of the animals being studied. Zoo animals are subject to large visitor traffic for much of the day and therefore their welfare may be affected if the presence of the visitors stresses them out. In general, a zoo's goal includes preserving the welfare of their animals as well as helping with the conservation of the species. However, there is conflict because if zoos are to continue to receive funding they need to have as many visitors as possible and keep them entertained and/or educated. In situations where visitors have a negative effect on the animals in the form of stress, this research will be important for considering how to improve the welfare of the animals.

The Oregon Zoo opened the renovated primate exhibit named "Red Ape Reserve" in September of 2010. The previous building was built in 1959 and was one of the oldest buildings at the zoo. The orangutans are housed together with the two white-cheeked gibbons in the enclosure that is a total of 5,400 square feet. The gibbons do have their own separate indoor area as well. The updates include a new indoor area, and a larger more naturalistic outdoor exhibit with plenty of climbing structures. The outdoor area is enclosed in mesh, and features climbing poles, vines, trees, a stream and pond, and a faux tree that can be used by keepers to hide treats for enrichment. A log tunnel with porthole windows runs through the exhibit to the interior exhibit and acts as the entrance for visitors. Many of the new features in the exhibit may help limit stress on the orangutans, however, it is important to identify what kind of effect visitors

have on these animals. The results may give insight into the effect of housing orangutans in more naturalistic enclosures.

To study the visitor effect on these primates, I observed their behavior and then used subsequent analyses to identify the variation and effects that different variables have on them. This is a pilot study to see if there are differences in behavior in response to visitor group size, as well as to analyze what other variables (temperature, weather, test-day, individual) affect their behavior. Studying animal behavior and being able to accurately make a judgement about that animal's welfare is a complex process and involves multiple variables to be considered. The goal of my research is to identify what would be necessary to design a comprehensive study of orangutan welfare at the Oregon zoo using original behavior data, and to analyze what other variables need to be included by considering related literature.

The visitor effect is the phenomenon in which the presence of human visitors induces behavioral changes in the animal being observed that would not necessarily occur without a visitor (Hosey 2000, Davey 2007, and Fernandez 2009). There has not been extensive research done on orangutans regarding the visitor effect. Instead, much of it has been done on chimpanzees and mangabeys (Maki et al. 1987, Mitchell et al. 1992). Hosey (2000) discusses three hypotheses for the visitor effect on animals in zoos: visitors are either stress-inducing, enriching (often when animals receive food or positive excitement), or of no consequence. He reviewed multiple studies including primates, non-primates, and multi-species studies. In conclusion, he claims that in the case of lab primates, passive humans (described as not actively trying to interact with the animals or being very noisy) were unsettling for the animals and is shown in the form of increased stress or stress-induced behavior. In zoo animals, there was no significant behavioral

difference (Hosey, 2000). It is possible that some species may become habituated to the presence of visitors after time, and may result in no behavioral differences in these studies (Hosey, 2000). In the case of aggressive humans in zoos, primates showed increased rates of returned aggression, avoidance, and intra-group interactions. Aggressive humans were visitors/patrons that were described as exhibiting behaviors such as teasing or banging on the enclosure. It is suggested that Zoos may need to reassess the visitor experience without necessarily reducing interactions (because interactions are important for maintaining visitor interest).

In the zoo environment, animals are subjected to a lot of visitor traffic throughout the day which may likely come with a lot of noise as well. In one part of a study conducted by biologist Lynda Birke (2002), the effect of human visitors on captive orangutans is observed including the element of noise as a variable. In the visitor focused experiment, visitor behavior was controlled for group size and relative loudness (either loud or quiet). Birke concludes that the orangutans exhibited a significant variation in their behavior with differences in visitor group size, but that there is indication that the animals respond more strongly to loud noise (Birke, 2002). The response seen in the orangutans was increased instances where the animals would look directly at visitors during noisy times. In other studies, looking at visitor frequency and crowd size, non-primate species often appear to be enriched by visitors to a certain point, while more often primates seem to be particularly negatively affected (Fernandez et al. 2009). In general, it is suggested that zoos should consider this and take visitor group size and noise volume into account when thinking about ways to maintain the health and welfare of their animals.

While many studies have focused mainly on visitor variables such as crowd size noise and type of behavior, Fernandez et. al. (2009) looked at a different side of the visitor effect with

exhibit design. They studied various exhibit designs and locations, and claim that different architectures can elicit different visitor behaviors, which in turn may affect the behavior of the animals. Exhibit design is something that is not often looked at extensively as a variable, and is important to keep in mind when designing a behavioral study. Choo et al. (2011) observed variables such as sound volume and visitor activity on captive orangutans in two exhibits at the Singapore Zoo. They broke visitor activity down into three subcategories; visitor number, proximity to animals, and activity. Visitor number had little effect on the behavior of the orangutans, however, proximity did have an effect. This resulted in decreased play in the juveniles (not in the adults, as they do not play very often), and increased instances of the animals looking at the visitors.

Housing may also have an impact on how orangutans behave in captivity. Typically, orangutans in zoos are housed in a social structure similar to that of gorillas (several females with one male). There is debate over whether this may be a source of stress for them because orangutans in the wild usually live semi-solitarily (Amrein et al. 2014). There is also a difference in social structure between the two species of orangutans. Bornean orangutans have shown evidence of being more susceptible to stress in response to living in larger groups, as in the wild they generally have less frequent close interactions, and live at lower densities than Sumatran orangutans (Amrein et al. 2014). There are conflicting views on this topic; although orangutans are thought to be the “least social of primates”, in some cases they have been hypothesized to be capable of more frequent social interactions than seen in the wild (Edwards & Snowdon, n. d.). Findings in Edwards et. al. study on two groups of orangutans resulted in both groups showing equivalent amounts of social activity.

In a study on the effect of fission-fusion housing on Bornean orangutans, Amrein et al. (2014) measured fecal glucocorticoid (fGCM) concentrations as an indicator of stress. Fission fusion housing is an arrangement in which group composition throughout the day can be dynamic and controlled. The result was that the fGCM concentrations were in the same range for orangutans living in the test zoo and orangutans in other zoos. The effect of visitor group sizes on the stress levels of the orangutans was reported as approaching significance, but wasn't quite there. In this example, fission-fusion housing did not seem to improve the stress levels in comparison to orangutans in more traditional zoos.

It is common in research to compare the behavior of captive animals to the behavior of their wild counterparts as a measure of welfare. Veasey et al. (1996) discuss the implications of this method and claim that it is not an accurate measure of welfare. Wild animal behavior was thought to be a good indication of welfare, because it was assumed that a healthy wild animal would have adequate welfare (Hughes & Duncan 1988). However, recent scientific studies have argued that the absence of some wild behaviors may not actually compromise the welfare of the captive animals (Veasey, 1996). In Rowell's (1972) study comparing baboons in captivity to the wild, their behavior patterns differed quantitatively, but contained the same patterns in both groups. There are some behaviors that may need to be expressed regardless of the physiological needs of the animal, such as how the tongue-playing behavior of giraffes is seemingly tied to the 'need' to express normal appetitive feeding behavior rather than with a physiological need to feed (Veasey, 1996). Measuring the physiological states of animals would give more insight into the welfare of animals as well. However, it is generally invasive and not easily suitable for a zoo environment. Observing behavior is non-invasive and does not require specialized equipment,

and therefore is a common way of assessing welfare in captive animals. In regards to primates specifically, studies have shown that the presence of wild-type behaviors are not required to have increased welfare (Markowitz et al 1978; Chamove 1989).

Based on the previous work done in this field on zoo animals, I hypothesized that crowd size would affect certain behaviors that might reflect stress or dissatisfaction in the orangutans at the Oregon zoo. These behaviors include head covering, and being not visible.

Methods

My research was directed towards the orangutans at the Oregon Zoo. At the time of my observations, there were four orangutans. These included two species; one male and one female of each. There were two Sumatran orangutans (*Pongo abelii*) named Inji and Kumar. Inji is the oldest orangutan in North America at 56 years old. After the observation period, Kumar was transferred to another zoo because he was matched with a female for breeding purposes, and therefore is no longer available for my observations. The two Bornean orangutans (*Pongo pygmaeus),* Kitra and Bob are 15 and 10 years old respectively.

Pictured above from left to right: Inji (female) and Kumar (male), the zoo's two Sumatran orangutans (*Pongo abelii*).

Pictured from left to right: Kitra (female) and Bob (male), the Oregon Zoo's two Bornean orangutans (*Pongo pygmaeus*).

The diet the orangutans receive at the Oregon Zoo is generally the same throughout the year with the exception of seasonally available fruits and vegetables (Walz, 2016, Oregon Zoo primate keeper, personal communication). Some of these included: berries, pears, pomegranates, pineapples, corn, green-beans, zucchini and more. Feeding times are consistent every day, with multiple feedings throughout the day typically at 8 and 11 AM, and then 1 and 3 PM. In the summer, they also may receive an additional feeding in the evening at about 8 PM. The keepers also do enrichment about two times a day, as well as at least one training session. Enrichment might include things such as hiding treats or activities throughout the enclosure for the orangutans to find, or providing blankets and other objects they like to use.

The method chosen for observations was instantaneous scan sampling. I chose to place myself in the inside of the building where I had access to the windows showing the inside exhibit as well as most of the outside part of the exhibit. I did 15-minute continuous observation periods with observations recorded each minute. There are multiple variables to consider including weather, temperature and time of day. I have included equal amounts of days on which

observations were conducted for both rainy and sunny weather. Due to scheduling restrictions, the timeframe presented in my research occurred between 9 AM to noon.

An ethogram was constructed of the behaviors that were observed and marked for each animal on each minute interval. One minute intervals were chosen because the Orangutans tend to change their behaviors frequently, and any interval smaller than that would not allow accurate and complete recording for all the animals. The actual ethogram used can be found in appendix A. The categories included are located and defined in table 1.

Table 1: Behaviors and their definitions in the context of this research that were included in the ethogram.

Behavior	**Defined as:**	**Abbreviation**
Looking	Any time one of the animals is looking towards the public or directly at visitors for more than just a moment.	LK
Covering head	When an animal is physically hiding its face, or covering its head with itself or an object.	CH
Interacting with public	Anytime an animal does something such as coming up to the glass and responding to visitors.	IP
Interacting with others	When animals come near one another, or make physical contact with another orangutan.	IO
Sleeping	Sleeping will be marked if the animal has been laying down for an extended period (more than 5 minutes), or appears to be sleeping/closing its eyes (as it will be hard to know for sure).	SL
Walking	When the animal is moving at any pace other than just standing in one place.	WK
Climbing	When an animal is either climbing a structure, a fence, or anything else, swinging or hanging is included.	CL
Stationary	Anytime an animal is sitting or standing at one spot for more than a few seconds.	ST
Eating	Anytime an animal is seen holding and/or ingesting food, as well as actively foraging for food.	EA

Not visible	When an animal has moved out of sight in the exhibit or if they are not currently in the exhibit.	NV
Other	Behaviors that are not listed in another category (example: chewing on a felt mat or playing with a stick).	O

Results

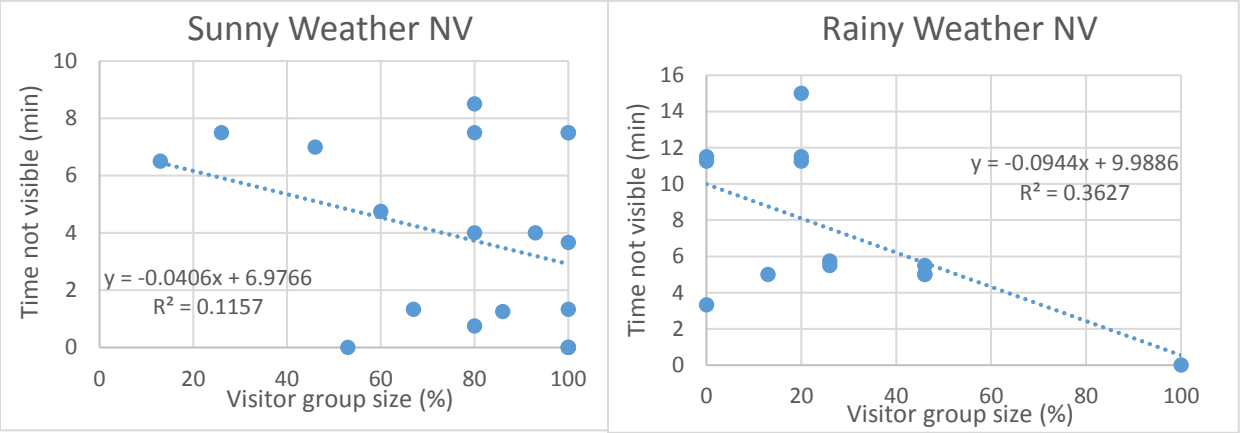

Figure 1: Scatter plot of average time across all orangutans during observation period spent not visible vs. percent of observation period with large visitor numbers.

The time the orangutans spent not visible to the public (or at least not visible to me as the observer) was plotted and correlated in a least squares regression to the percent of time during the observation period that there were large visitor group sizes present. As the amount of time increases that large visitor group sizes are present, time spent not visible decreases in both rainy and sunny weather.

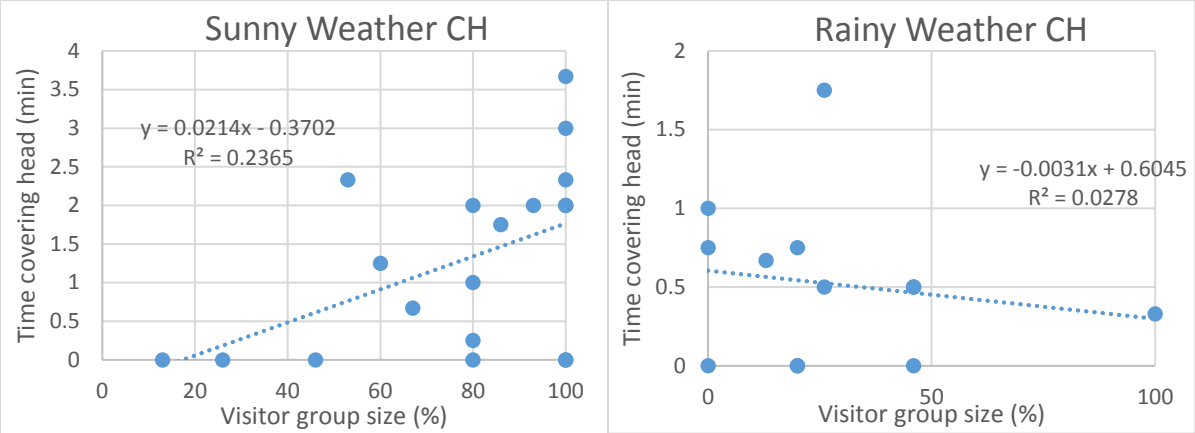

Figure 2: Scatter plot of average time for all orangutans during observation period spent covering head vs. percent of observation period with large visitor numbers.

The time the orangutans spent covering their heads was also correlated in a least squares regression to the percent of time during the observation periods that had large visitor group sizes present. In this case, the two types of weather had conflicting results. On days with sunny weather, the amount of time the orangutans spent covering their heads increased as visitor group size increased. In contrast, during rainy weather, the amount of time the orangutans spent covering their heads decreased as time large visitor groups were present increased.

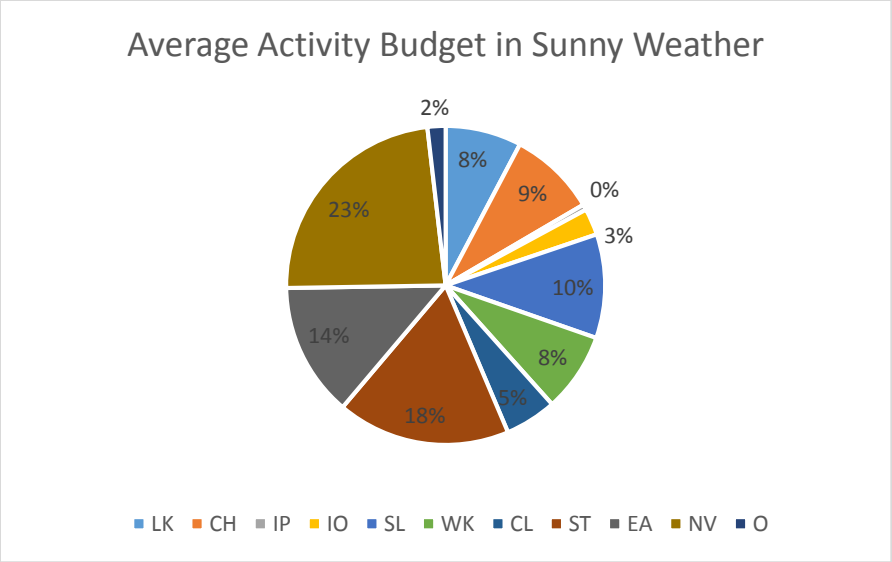

Figure 3: The percent of time that the orangutans spent doing each behavior averaged for all of the days on which the weather was sunny.

The observations for all orangutans on test days with sunny weather were averaged. Each behavior performed was mutually exclusive and was calculated as a percentage of a 15-minute observation period. This creates an activity budget portraying how much time on average the orangutans spent performing each behavior that was observed. The categories are relatively uniform with a few of the behaviors making up a smaller percentage including interacting with the public, other, interacting with each other, and climbing at 0, 2, 3 and 5% respectively. The largest categories were walking, stationary, and not visible at 14, 18, and 23 % respectively.

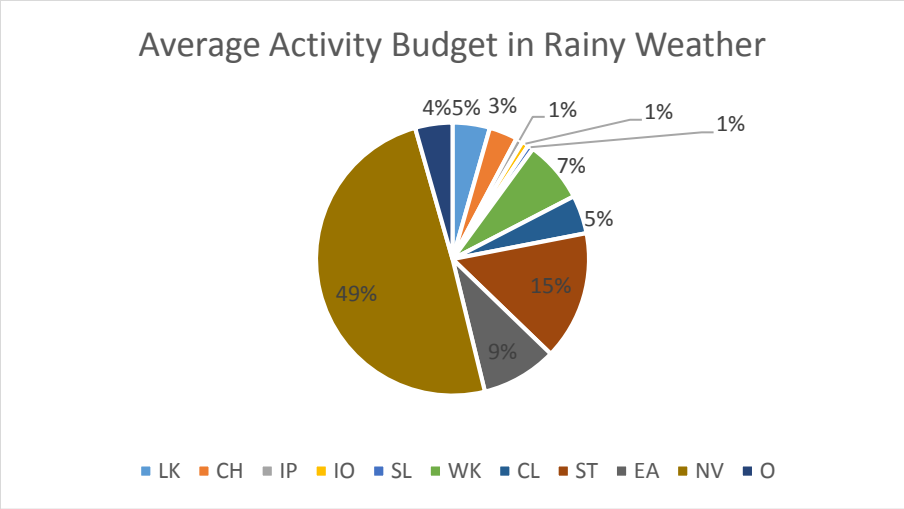

Figure 4: The percent of time that the orangutans spent performing each behavior averaged for all of the days that the weather was rainy.

Additionally, the times spent performing each behavior were averaged for all orangutans on days on which the weather was rainy. This creates an activity budget that portrays the percent of a 15-minute observation period that the animals would spend on each behavior on average. The distribution is uneven between the categories with not visible taking up almost half of the time at 49%, and the rest of the categories making up the other 51%.

Table 2: Descriptive statistics of the behavior data including mean, standard deviation, and variance of the averages for each behavior observations.

Behavior	Mean	Std. Deviation	Variance
Looking	0.7976	1.01098	1.022
Cover head	0.8878	1.75126	3.067
Interact public	0.109	0.22636	0.051
Interact other	0.2713	0.41286	0.17
Sleeping	0.7594	2.15852	4.659
Walking	1.1073	1.13021	1.277
Climbing	0.7241	1.09298	1.195
Stationary	2.3121	1.94655	3.789
Eating	1.6144	1.54658	2.392
Nonvisible	5.7941	5.78589	33.477
Other	0.238	0.45591	0.208

The mean times for each behavior ranged from 0.1 to 5.7 minutes. Most of the means were about one minute or lower. The variance and standard deviations of each behavior are listed as well, and are generally close to the value of the mean with the exception of the variance for nonvisible which is an outlier at 33.47.

Table 3: Significance results of multivariate test of between-subjects effects for independent vs dependent variables.

Dependent Variable	Independent variable				
Behavior	Test day	Individual	Crowd size	Temp.	Weather
Looking	**0.013**	0.129	0.202	0.216	0.167
Cover head	0.748	0.343	0.344	0.918	0.052
Interact public	0.209	0.261	**0.04**	**0.029**	0.585
Interact other	**0.035**	0.179	0.227	0.457	0.578
Sleeping	**0.001**	0.535	0.053	0.601	**0.033**
Walking	0.391	0.126	0.191	0.07	0.901
Climbing	0.904	**0.019**	0.232	0.456	0.701
Stationary	0.495	0.111	0.085	0.536	0.336
Eating	**0.047**	0.459	0.114	0.733	0.534
Nonvisible	0.115	0.19	**0.015**	0.874	0.107
Other	0.417	0.359	0.671	0.858	0.262

The independent variables: test day, individual, crowd size, temperature, and weather were compared to the dependent behavior variables in a multivariate test of between-subjects effects. The results give p-values for each interaction and determine whether each independent variable had a significant effect on each dependent variable for the data given. The significant results are highlighted in bold. Which individual was being observed did not have a significant effect on any of the behaviors. Which test day it was that was being observed did have a

significant effect on multiple behaviors, and the other independent variables only affected a few.

Table 4: Number of observations needed to measure differences in behavior by a factor of 2 with the measured variances of each variable.

Behavior Variable	Sample Size needed
Looking	55
Cover head	122
Interact public	4
Interact other	72
Sleeping	252
Walking	33
Climbing	72
Stationary	23
Eating	30
Nonvisible	32
Other	116

Power analysis was done to determine the number of observations necessary to get significant results with the variance observed in the data. There is a wide range with only four observations necessary to observe a significant difference in behavior for interacting with the public versus 116 observations necessary to observe a difference in “other” behavior and 252 observations necessary in sleeping behavior.

Analysis

The observation periods were each 15-minutes long, with animal behavior and visitor group size recorded each minute. While recording observations, group size was recorded as either large or small; large being 5 or more individuals, and small being less than 5 individuals. For the "group size" variable, the percent of the time during each observation period that there were large numbers of visitors present was calculated. For example, if for 7 out of 15 minutes of the observation period there were large visitor group sizes, the percent would be 46%. This method was chosen because I was unable record exact numbers of visitors going in and out of the exhibit for each minute I was recording observations. While running analyses, days that had "large visitor group" percentages of between 0-33% were marked as "S" for small, those that were between 34-66% were marked as "M" for medium, and those between 67-100% were marked as "L" for large. For the behavior variables, I calculated the average amount of time spent doing the behavior for all the animals in each observation period.

When focusing on specific behaviors during analysis, I chose to focus mainly on when the orangutans were not visible, and when they covered their heads. The analyses were designed to determine which variable accounts for most of the variation in each behavior, i.e. whether it is crowd size that effects the changes in behaviors, or if it is a different variable such as weather. Certain behaviors can be assumed to be affected by weather. For example, it would be safe to assume that an animal would spend more time out of sight/hiding, or covering its head with a sack in response to rain. The orangutans always had some type of sack available to them while observations were being made. If it is found that the variation in the amount of time the animals spend covering their heads is equal for both types of weather, then one could assume that

weather is not in fact the main factor influencing this behavior. In many of the analyses performed, rainy and sunny weather are compared for this reason.

If one wanted to consider a behavior change of an increase by a factor of 2 as significant, the sample sizes necessary for testing with the measured variances are included in table 4. If smaller differences in the data were to be measured, the sample sizes would need to be much larger still. The means for all of the behaviors ranged from as little time as 0.1 minutes to as high as 5.7 minutes. The standard deviation was about 1 for most of the behaviors, with sleeping and not visible the highest at 2.15 and 5.78 respectively. The variances differed greatly across each variable with not visible having an extreme variance of 33.

The independent variables: test day, individual, crowd size, temperature, and weather were tested for their main effects on the dependent variables in a multivariate test of between-subjects effects. In table 4, variables with significant p-values had a significant effect on the respective dependent variable, and these are in bold. Test day effected multiple behaviors including looking, interacting with each other, sleeping, and not visible. Which individual it was effected how much time was spent climbing. This means that not all of the orangutans spent the same amount of time climbing. Crowd size effected the amount of time the animals spent interacting with the public as well as how often they were not visible. Temperature only had an effect on how much time was spent interacting with the public, and weather only had an effect on time spent sleeping and covering head.

A two-tailed t-test with unequal variance the times the animals were not visible for both types of weather, and resulted in a p-value of 0.095. This suggests that the time the animals spent

not visible to the public was not significantly different from each other for the two types of weather. The result of the t-test comparing the times the animals spent covering their heads for both types of weather was a p-value of 0.047. This suggests that the times the animals spent covering their heads was statistically different from each other for each type of weather.

A correlation analysis on the data collected was done and the data was grouped together for each type of weather to minimize the effect of multiple variables on the results. Figure 1 showing time not visible versus the percent of time that there were large visitor group sizes present during sunny and rainy weather shows a negative correlation in each case. This indicates that for these observation periods the time the animals spent out of view of visitors decreased as visitor group sizes increased, meaning that they spent more time in view of visitors when there were more visitors present. This is counterintuitive to what one would assume would happen if large visitor groups had a negative effect on the animals' welfare. Figure 2 shows the percent of time (in minutes) that the animals spent covering their heads versus the percent of time that there were large visitor groups present during rainy and sunny weather. There is a slight negative correlation between covering head behavior and increased group size during rainy weather, whereas there is a positive correlation during sunny weather. This is opposite of what one might expect to see if covering head behavior was due to weather. If that were the case, the orangutans would cover their heads more when it was raining and less when it was sunny.

Looking at the activity budget pie charts in Figures 5 and 6, the amount of time the orangutans spent performing each behavior is averaged for rainy and sunny weather. The average amount of time that the orangutans spent walking is relatively consistent in both cases at about 7-8%. Covering head behavior has a higher percentage during sunny weather at 8.8%,

compared to only 3.5% in rainy weather. Time spent not visible, while large in both cases, is much larger in cases of rainy weather at 51%.

Conclusion

I conducted observations at the zoo for 5 days with sunny weather and 5 days with rainy weather. There were a total of 36 observations made, with the average of each individual orangutan on each day as a distinct observation. With this considered, the sample size needed to make a claim about the effect that the independent variables have on the dependent behavior variables is much greater than was possible in this study. Future research would need to include larger sample sizes/more observations to make a determination about their significance. In Figure 1, there is not much correlation between time visible and visitor group size. This may be due to the animals not having control over when they are allowed inside. The orangutans have access to travel between the indoor and outdoor exhibit as they choose throughout the day while visitors are present (as far as is known). However, they do not get to choose when they are brought into the "behind the scenes" area of the exhibit such as when the keepers are cleaning or perhaps performing checkups or enrichment activities with the animals. Accessing more information about when these types of activities take place would be beneficial in designing a future study.

I predicted that there would be increased covering head behavior in times of large visitor numbers, and that the amount of time the orangutans were not visible to the public would increase as visitor numbers increased due to avoidance behavior. In Figure 2 there is a positive correlation between large visitor group sizes and the time the orangutans spent covering their

heads during sunny weather. Due to this, it is likely that this behavior may be a result of wanting to escape visitors rather than a result of escaping rain or cold weather. This is reinforced in the activity budget data for each day shown in the pie charts in the appendix.

There was equal variability in the times the orangutans spent covering their heads in rainy weather and sunny weather. There were many times where an individual would have a blanket or a sack of some kind with which they would cover their heads. On one occasion, Bob walked around outside with a felt mat covering his head and shoulders. It is unknown whether this behavior is due to stress and is a mechanism to try to escape the public, or if it is just a behavior done for fun. If this distinction is to be made, there is additional research needed, and a more in depth study would be beneficial. Measuring hormone levels indicative of stress is more accurate than just observing behavior alone, but wasn't available for this study. Future studies may consider implementing the use of hormone testing as a measure of stress to further understand the behavior differences observed here.

Additionally, it is difficult to determine if the animals' behaviors are indeed in response to visitor presence, or if it is actually visitor behavior responding to the animals' behaviors. For example, a larger crowd might form at the exhibit if the orangutans are performing an interesting behavior (Hosey, 2000). Large crowd size is seen to correlate with decreased time spent not visible and increased time spent performing covering head behavior in sunny weather. Large crowd size is also correlated with decreased time spent not visible, and decreased time spent performing covering head behavior during rainy weather. However, with the current sample size, the results of the multivariate test show that crowd size did not have a significant effect on the

majority of the behaviors. Rather, it was a combination of the other independent variables that made up the effects on the orangutans' behavior.

It is also unknown whether the results of this study are representative of the population of captive orangutans or if it is an isolated situation. A study that includes observations on animals in multiple zoos would give a better look at the population. Each variable had a different variance, and therefore would require a different sample size to show significant changes in behavior. The variation in sleeping behavior was huge due to an outlier in the data, and I would recommend throwing out that data point and using the next highest variable for designing a future study. The sample size that would be necessary for seeing significance in the variables studied here would need to be as large as 122 data points.

There are many strategies than can be used in efforts to improve captive orangutan welfare in cases where it is not optimal. The social structure that orangutans are housed in can greatly improve stress levels if zoos try to resemble the natural social condition of the species (Amrein et al. 2014). Limiting the amount of noise that visitors emit around the orangutans, and the size of groups that pass by the exhibit may decrease their stress as well, although controlling visitor behavior would be very difficult to manage (Birke, 2002). Proximity was shown to affect the behavior of some orangutans, and exhibit design can be modified to control proximity of visitors to the animals (Choo et al. 2011). The placement of exhibits within the zoo is important, and stress prone animals should be located in sections of the zoo that are not prone to large amounts of visitor traffic such as near the entrance.

There has been very little research on captive orangutans in a social setting. Research on other primates is more abundant, such as on chimpanzees, mangabeys and baboons (Rowell, 1972). Visitor research is conducted in locations other than zoo as well, such as: museums, gardens, science centers and more. The topic of animal welfare is relevant in multiple disciplines including: education, psychology, biology, conservation biology, ecology, sociology, etc. Currently, there is a lack of interdisciplinary cooperation in research on this topic even though it is relevant in multiple fields of study (Davey, 2007). Collaborations between disciplines may provide greater insight into the issue of assessing and maintaining animal welfare.

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Appendices

Appendix A

Table 1: Behaviors and their definitions in the context of this research that were included in the ethogram.

Behavior	**Defined as:**	**Abbreviation**
Looking	Any time one of the animals is looking towards the public or directly at visitors for more than just a moment.	LK
Covering head	When an animal is physically hiding its face, or covering its head with itself or an object.	CH
Interacting with public	Anytime an animal does something such as coming up to the glass and responding to visitors.	IP
Interacting with others	When animals come near one another, or make physical contact with another orangutan.	IO
Sleeping	Sleeping will be marked if the animal has been laying down for an extended period (more than 5 minutes), or appears to be sleeping/closing its eyes (as it will be hard to know for sure).	SL
Walking	When the animal is moving at any pace other than just standing in one place.	WK
Climbing	When an animal is either climbing a structure, a fence, or anything else, swinging or hanging is included.	CL
Stationary	Anytime an animal is sitting or standing at one spot for more than a few seconds.	ST
Eating	Anytime an animal is seen holding and/or ingesting food, as well as actively foraging for food.	EA
Not visible	When an animal has moved out of sight in the exhibit or if they are not currently in the exhibit.	NV
Other	Behaviors that are not listed in another category (example: chewing on a felt mat or playing with a stick).	O

Table 2: Descriptive statistics of the behavior data including mean, standard deviation, and variance of the averages for each behavior observations.

Behavior	Mean	Std. Deviation	Variance
Looking	0.7976	1.01098	1.022
Cover head	0.8878	1.75126	3.067
Interact public	0.109	0.22636	0.051
Interact other	0.2713	0.41286	0.17
Sleeping	0.7594	2.15852	4.659
Walking	1.1073	1.13021	1.277
Climbing	0.7241	1.09298	1.195
Stationary	2.3121	1.94655	3.789
Eating	1.6144	1.54658	2.392
Nonvisible	5.7941	5.78589	33.477
Other	0.238	0.45591	0.208

Table 3: Significance results of multivariate test of between-subjects effects for independent vs dependent variables.

Dependent Variable	Independent variable				
Behavior	Test day	Individual	Crowd size	Temp.	Weather
Looking	**0.013**	0.129	0.202	0.216	0.167
Cover head	0.748	0.343	0.344	0.918	0.052
Interact public	0.209	0.261	**0.04**	**0.029**	0.585
Interact other	**0.035**	0.179	0.227	0.457	0.578
Sleeping	**0.001**	0.535	0.053	0.601	**0.033**
Walking	0.391	0.126	0.191	0.07	0.901
Climbing	0.904	**0.019**	0.232	0.456	0.701
Stationary	0.495	0.111	0.085	0.536	0.336
Eating	**0.047**	0.459	0.114	0.733	0.534
Nonvisible	0.115	0.19	**0.015**	0.874	0.107
Other	0.417	0.359	0.671	0.858	0.262

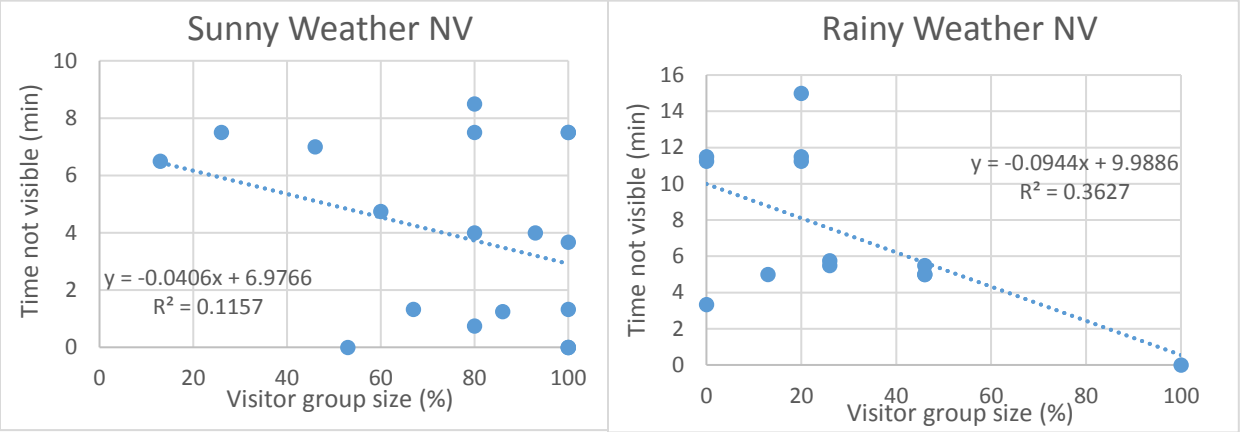


Figure 1: Scatter plot of average time during observation period spent not visible vs. percent of observation period with large visitor numbers for both types of weather

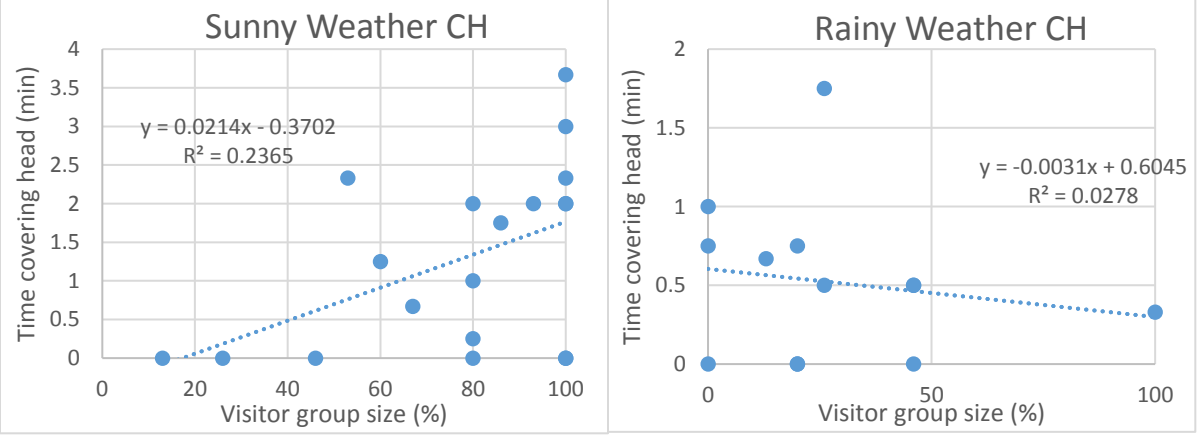


Figure 2: Scatter plot of average time during observation period spent covering head vs. percent of observation period with large visitor numbers for both types of weather.

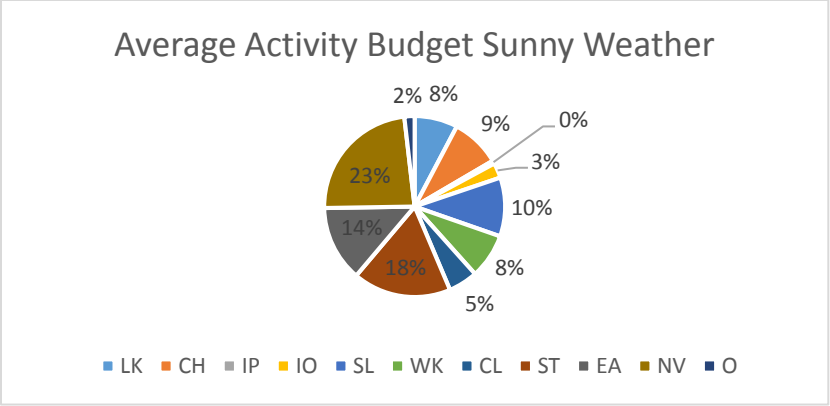


Figure 3: The percent of time that the orangutans spent doing each behavior averaged for all of the days on which the weather was sunny.

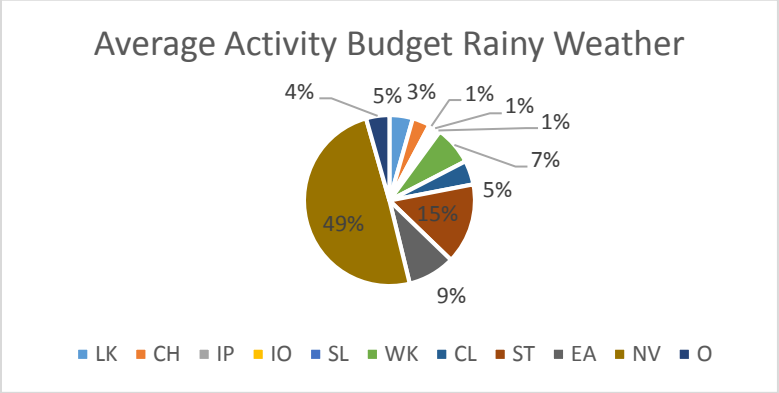


Figure 4: The percent of time that the orangutans spent performing each behavior averaged for all of the days that the weather was rainy.

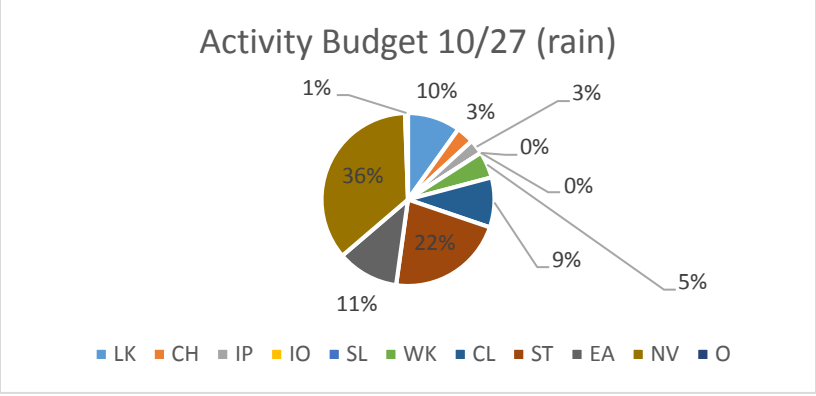


Figure 5: Percent of time spent performing each behavior on Oct. 27th during rainy weather, averaged for all animals.

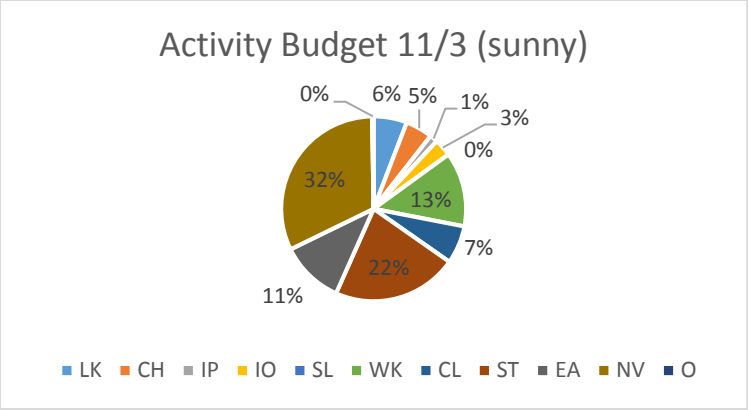


Figure 6: Percent of time spent performing each behavior on Nov. 3rd during sunny weather, averaged for all animals.

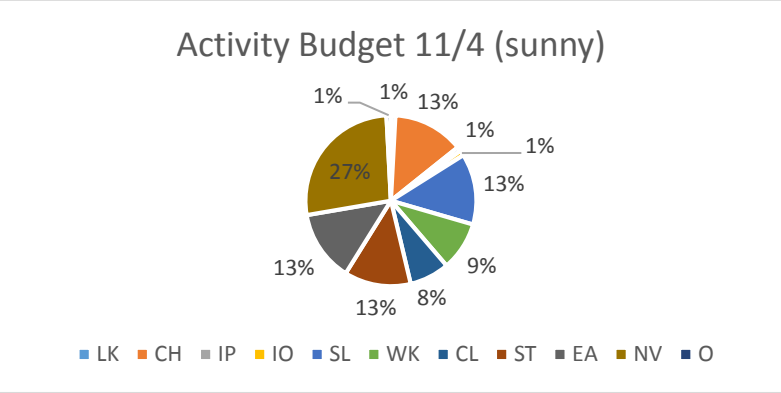


Figure 7: Percent of time spent performing each behavior on Nov. 4th during sunny weather, averaged for all animals.

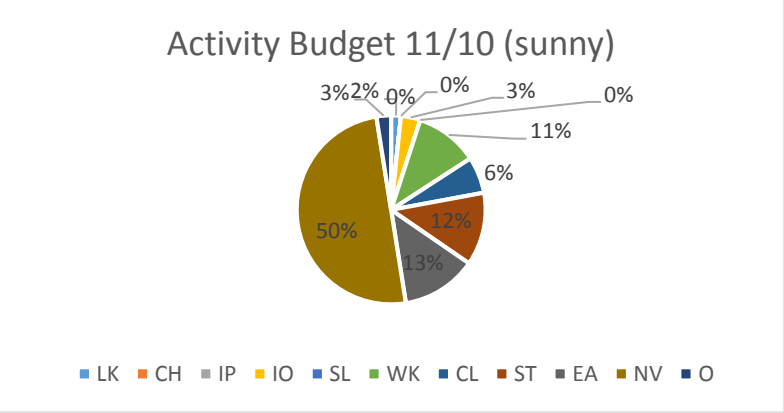


Figure 8: Percent of time spent performing each behavior on Nov. 10th during sunny weather, averaged for all animals.

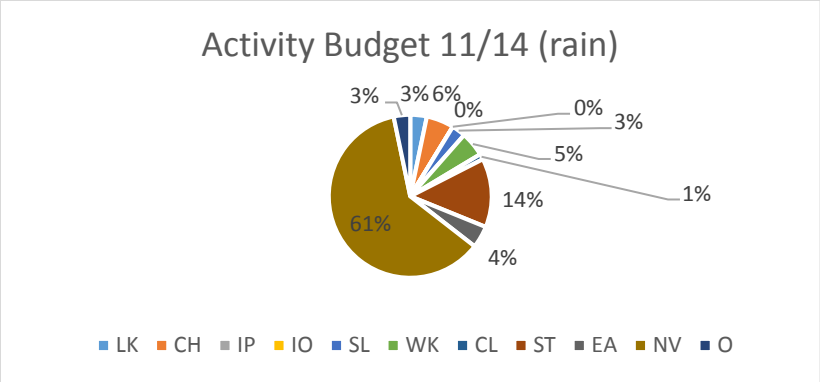


Figure 9: Percent of time spent performing each behavior on Nov. 14th during rainy weather, averaged for all animals.

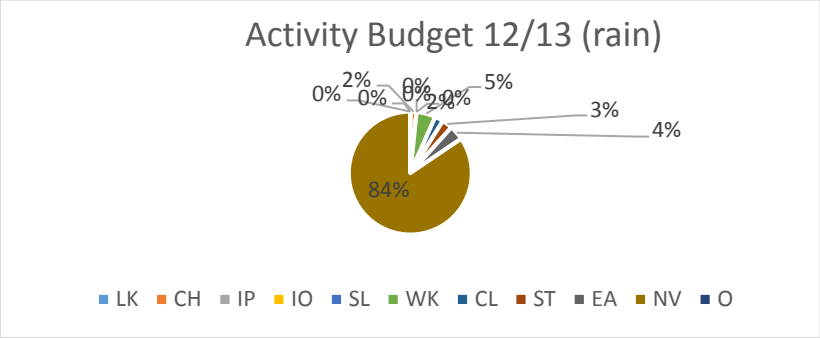


Figure 10: Percent of time spent performing each behavior on Dec. 13th during rainy weather, averaged for all animals.

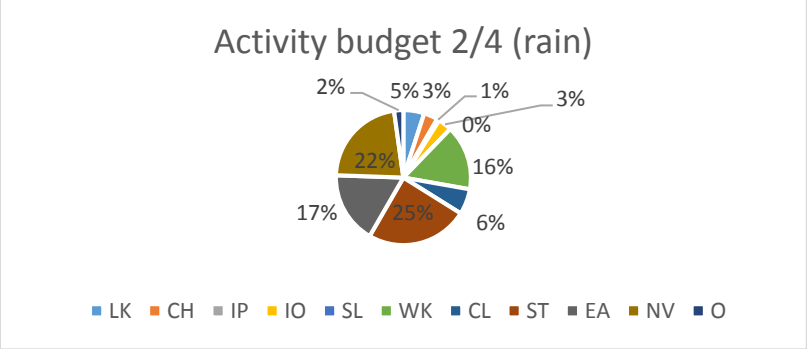


Figure 11: Percent of time spent performing each behavior on Feb. 4th during rainy weather, averaged for all animals.

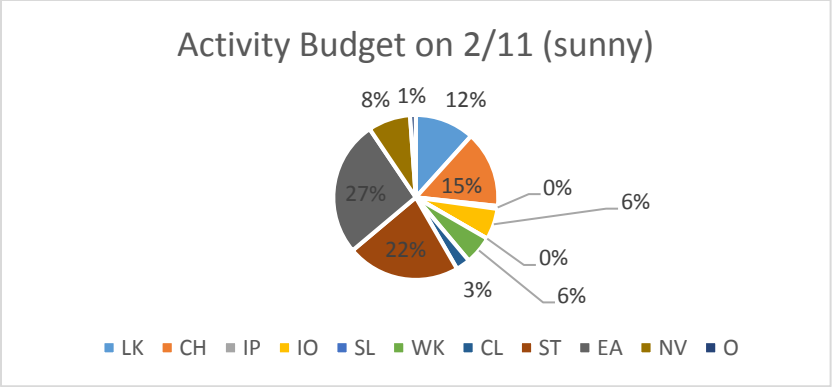


Figure 12: Percent of time spent performing each behavior on Feb. 11th during rainy weather, averaged for all animals.

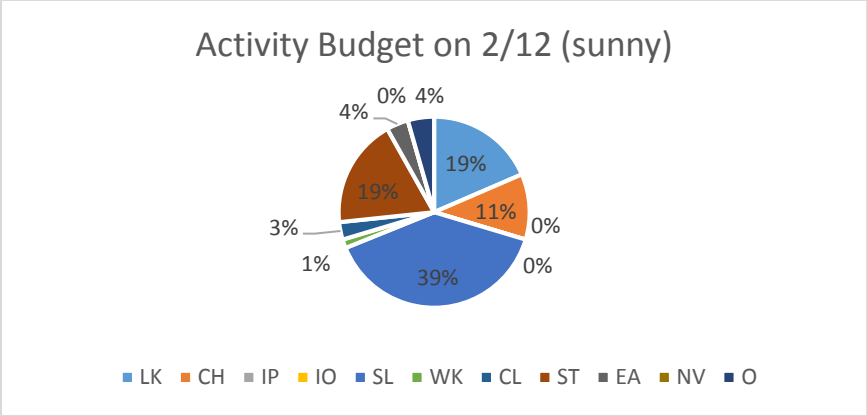


Figure 13: Percent of time spent performing each behavior on Feb. 12th during rainy weather, averaged for all animals.

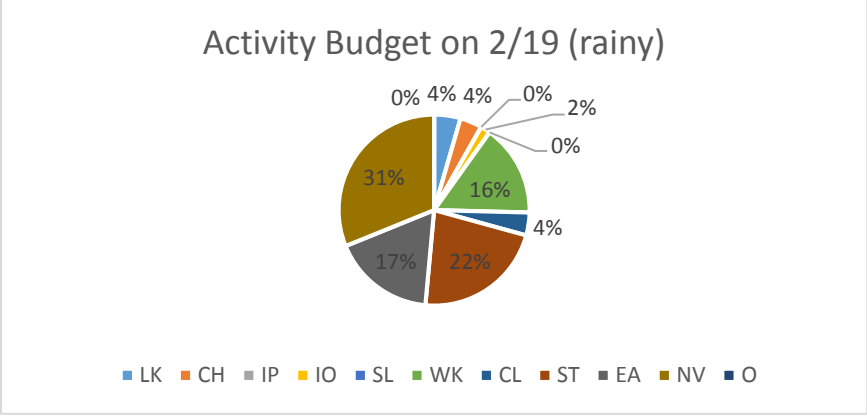


Figure 14: Percent of time spent performing each behavior on Feb. 19th during rainy weather, averaged for all animals.

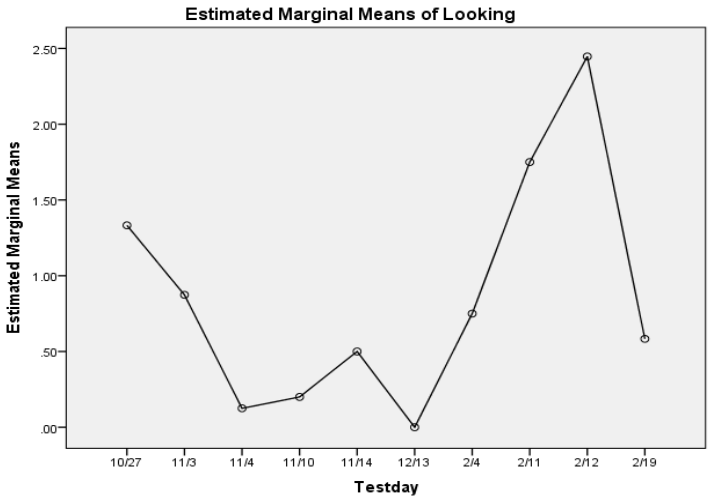


Figure 15: Average time an individual spent looking at the public plotted over each test day.

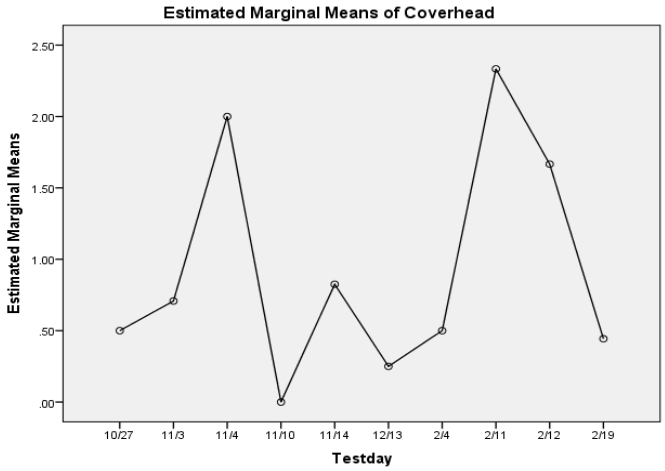


Figure 16: Average time an individual spent covering their head plotted over each test day.

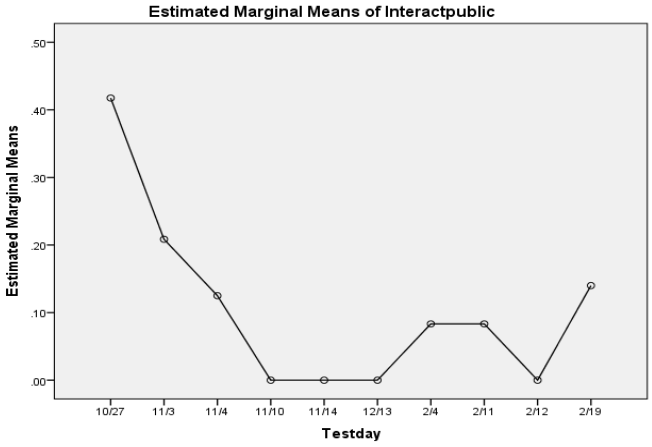


Figure 17: Average time spent interacting with the public plotted over each test day.

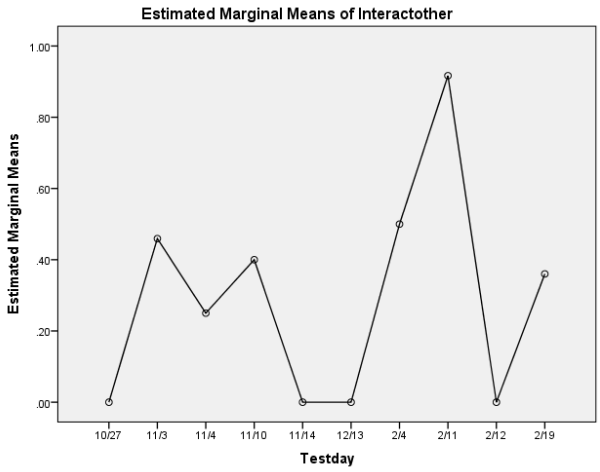


Figure 18: Average time spent interacting with another orangutan plotted over each test day.

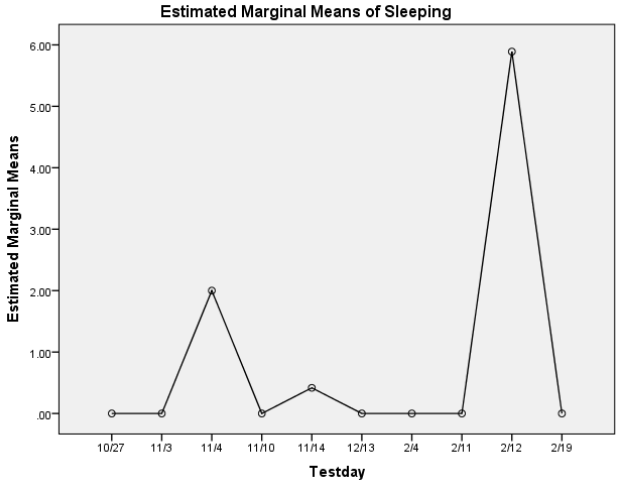


Figure 19: Average time spent sleeping plotted over each test day.

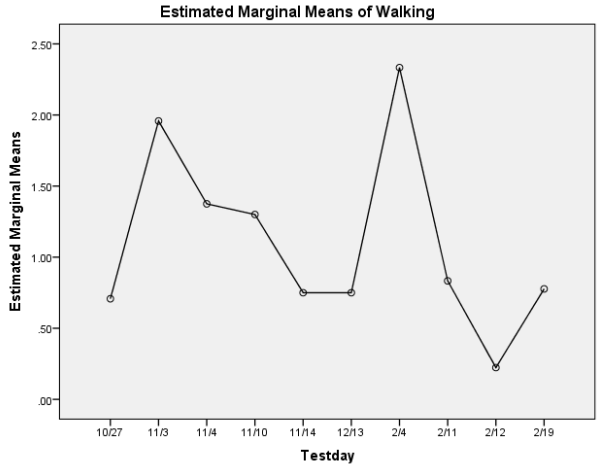


Figure 20: Average time spent walking plotted over each test day.

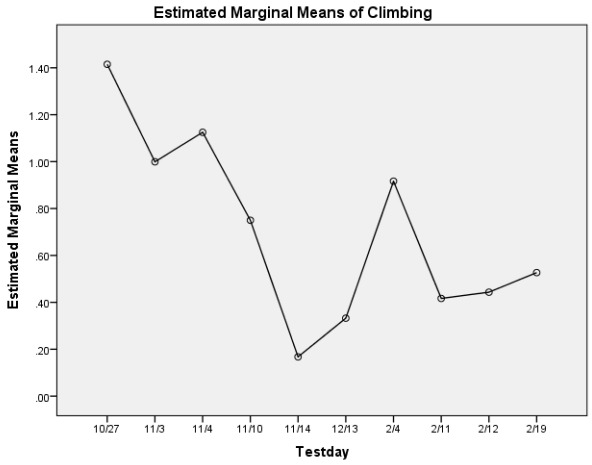


Figure 21: Average time spent climbing plotted over each test day.

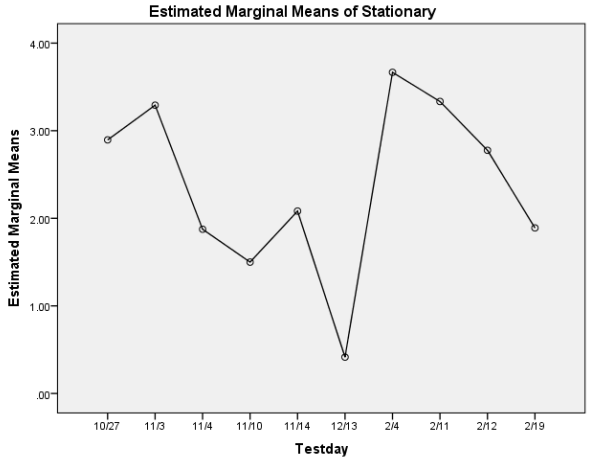


Figure 22: Average time spent stationary plotted over each test day.

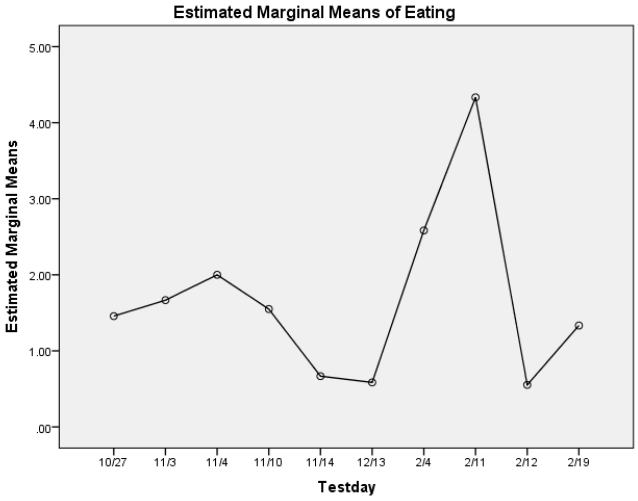


Figure 23: Average time spent eating plotted over each test day.

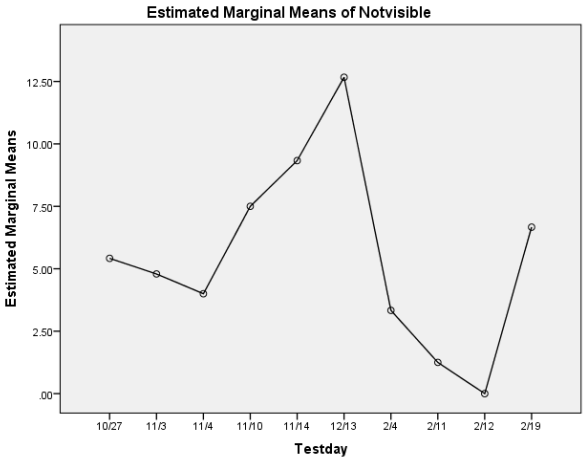


Figure 24: Average time spent “not visible” behaviors plotted over each test day throughout the study.

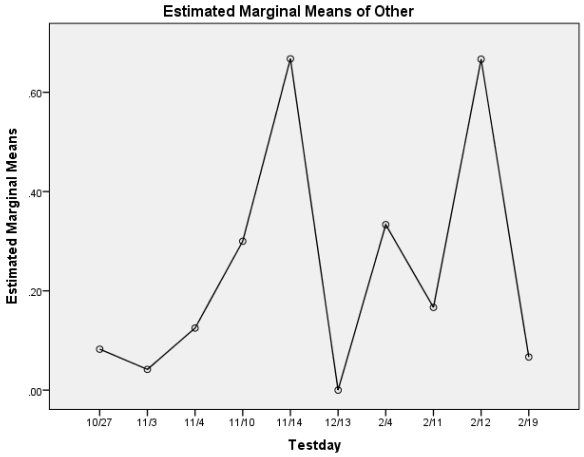
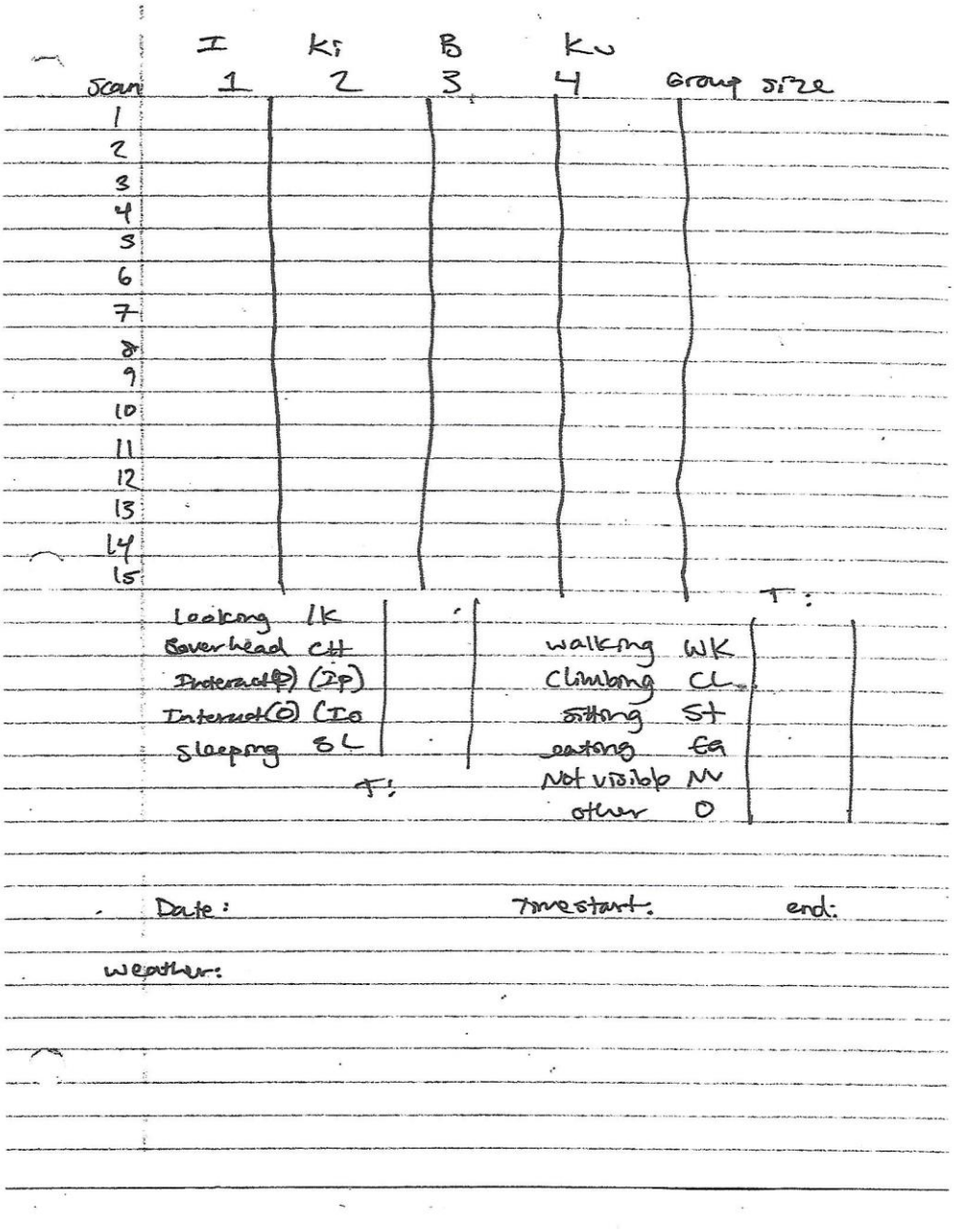


Figure 25: Average time spent performing “other” behaviors plotted over each test day.

Image: Ethogram created and used to record observations on orangutans in this study.

Image: Ethogram created to record observations on orangutans.



Annotated Bibliography

Amrein, M., Heistermann, M., & Weingrill, T. (2014). The effect of fission–fusion zoo housing on hormonal and behavioral indicators of stress in Bornean orangutans (Pongo pygmaeus). *International Journal of Primatology*, *35*(2), 509-528.

Fecal glucocorticoid concentrations can be measured as a good indicator of stress in primates. Amrein et al. discuss the social structures of orangutans housed in zoos vs. the natural structure of those in the wild. This might be stressful for them because orangutans naturally live semi-solitarily. Females generally stay with their offspring, and males are usually alone except during consortships. There is a primate park in the Netherlands that uses a fission-fusion social housing system for their orangutans. This is where the authors did their study looking at behavior and fGCM concentrations to measure stress with visitor group sizes. They compared fGCM values of orangutans living in the fission-fusion housing system and of those living in other traditional zoos. The levels were not significant, but the effect of adult group size was.

Birke, L. (2002). Effects of Browse, Human Visitors and Noise on the Behavior of Captive Orangutans. *Animal Welfare, 11*, 189-202. Retrieved October 5, 2016, from https://www.researchgate.net/publication/233488424_Effects_of_Browse_Human_Visitors_and_Noise_on_the_Behaviour_of_Captive_Orang_Utans.

Lynda Birke is a Biologist in the field of animal communication in the UK, as well as a Social Scientist in the field of Qualitative Social Research and Social Theory. In this paper Birke addresses two questions: How does fresh Browse affect the behavior of the captive orangutans? And what kind of affect does the presence of visitors have on them? Some of the larger implications of this research involve the topic of animal welfare. It is important for animals in zoos to be healthy. One problem with zoos is that there is often a lack of variability and stimulation. It is also a concern that human visitors may be stressful on the animals. In this paper Birke discusses a couple experiments that were done in order to investigate the questions she had. There was an experiment done with presenting fresh browse to the orangutans, and their time budgets were analyzed for changes in behavior. Visitor group size was also noted. In a second part of the experiment, the visitor's behavior was manipulated to either be loud or quiet, as well as either large or small groups. The conclusions that were made were that the presence of fresh browse led to decreased amounts of time sitting inactive (therefore there was more activity). There were significant differences in behavior between when large and small groups of visitors were present on the same day. There was also indication that the animals responded most strongly to noise, and would look at visitors more often when groups were noisy.

Choo, Yuanting, Peter Alan Todd, and Daiqin Li. 2011. "Visitor Effects on Zoo Orangutans in Two Novel, Naturalistic Enclosures." *Applied Animal Behaviour Science* 133 (1–2): 78–86. doi:10.1016/j.applanim.2011.05.007.

These authors are all from the department of biological sciences in Singapore. The question the authors wanted to look at in this paper was the effect of variables such as sound volume and visitor activity on captive orangutans in two exhibits at the Singapore Zoo. This was a new

approach to studying the visitor effect on top of just examining visitor number or presences. They also broke visitor activity down into sub categories to make a more complete picture for analysis. These included: visitor number, proximity to animals, and activity. The orangutans they studied were rotated daily between two enclosures allowing them to study the effects of exhibit design at the same time. The methods used were instantaneous scan sampling with 10 minute intervals. They stopped observations for an interval of 15 minutes before and after feeding times. They discovered that when it came to visitor number, there was little effect on behavior of the orangutans, however, visitor proximity did seem to have an effect. Some of the resultant behaviors included decreases in play and increases in animals looking at the visitors. The researchers suggest that looking at wider varieties of variables can give more meaningful conclusions when it comes to analyzing the visitor effect.

Davey, G. (2007, May 17). Visitors' Effects on the Welfare of Animals in the Zoo: A Review. *Journal of Applied Animal Welfare Science, 10*(2), 169-183. doi:10.1080/10888700701313595.

This is a review on studies that have been done on the topic of the visitor effect and animal welfare. There are a few tables consolidating results of multiple studies done on various animal species. This may be a useful reference. Davey brings up many important ideas relating to this topic. There have been studies arguing that rather than animals responding to humans, it may be that visitor density may be caused in response to the animals. Currently it is most common for "abnormal" behaviors to be used as stress indicators in the animals, however this may not be an accurate indicator. There hasn't been enough research done on the possibility that there are individual differences in the animals that may influence the visitor effect as well. More attention needs to be paid to visitor activities, size and proximity in addition to their presence and density. There is also a lack in interdisciplinary cooperation in research on this topic even though it is present in multiple fields of study.

Edwards, S. D., & Snowdon, C. T. (n.d.). Social behavior of captive, group-living Orangutans. *International Journal of Primatology, 1*(1), 39-62. doi:10.1007/BF02692257 .

It was thought that orangutans were the "least social of primates", and primarily solitary in the wild due to having small overlapping (or non-overlapping) ranges. Generally, adult males avoid one another and only associate with females every so often. It has been observed that consortships with several positive interaction days resulted in pregnancy more often than brief mating attempts. There has been very little research on captive orangutans in a social setting. Edwards and Snowdon hypothesized that orangutans are capable of more frequent social interactions than seen in the wild, and they tested that hypothesis at a Zoo. They observed two groups: adults and juveniles and observed categories of behavior. Each group had equivalent amounts of social activity. The juvenile group contained more active behaviors while the adult groups were more relaxed involving things such as allogrooming. The findings suggest that orangutans are capable of changing their social behavior depending on their environment, and are not restricted to primarily solitary behavior that is seen in the wild.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R., & Timberlake, W. (2009, August). Animal-visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science, 120*(1-2), 1-8. doi:10.1016/j.applanim.2009.06.002

These four authors are all psychologists, from Indiana University and University of Oklahoma. There were two questions that were looked at in this paper: the effects of exhibit design on the behavior of animals in zoos, and the effects of visitors on the behavior of the animals. The authors address the issue of zoos trying to balance different factors including animal welfare, education, research, conservation and entertainment. It is important for zoo visitors to keep entertained and interested in the animals for the zoo to continue to be funded and get support for conservation of their species. However, too much interaction or presence of visitors can be harmful on certain animal's welfare. The authors discussed exhibit design, and studied animals in various locations and styles. This section of their study isn't very relevant to my research, but it is noteworthy, especially because they claim that different exhibit designs can elicit different visitor behaviors. In the second section of their paper, they discuss visitor effects on animals. They mentioned other studies that had been done on non-primates and on primates. Looking at visitor frequency and crowd size, they claimed that non-primate species often appeared to be enriched by visitors to a certain point, while more often primates seem to be particularly negatively affected. They suggest that zoos keep in mind different exhibit designs and ways to educate the public in to minimize these visitor effects on their animals.

Hosey, G. R. (2004, November 18). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science, 90,* 107-129. Retrieved October 16, 2016, from http://www.sciencedirect.com.proxy.lib.pdx.edu/science/article/pii/S0168159104001893 .

In this paper Geoff is attempting to make comparisons between effects of a zoo environment and effects of other environments that animals might be found in. He claims that it is necessary to understand the differences in these scenarios to effectively analyze animal welfare. The "non-performance by captive primates of certain behaviors typically shown by wild-living animals does not necessarily indicate reduced welfare". The way animals behave in different environments are not equivalent to each other. There are three variables that Hosey claims need to be present to define an environment as a zoo. These are: the chronic presence of human visitors, restricted space, and being managed. It is important to think about what the human visitors are doing while they are present, and not only paying attention to how many people are there at one time. There are other situations besides zoos that animals may be exposed to many people as well. It is not necessarily accurate to compare zoo animals to animals in the wild because some groups of wild animals are also exposed to large groups of humans regularly. There is variability in ability to adapt to visitor presence in different species. It is also important to consider cage complexity because that can have an effect on animal behavior also.

Hosey, G. R. (2000, February 9). Zoo Animals and Their Human Audiences: What is the Visitor Effect? *Animal Welfare, 9,* 343-357. Retrieved October 5, 2016, from https://www.researchgate.net/publication/233716003_Zoo_Animals_and_Their_Human_Audiences_What_is_the_Visitor_Effect.

Geoff R. Hosey is a Biologist in the field of Zoology. Hosey discusses three different hypotheses for how the visitor effect plays a role with animals in zoos. The first is that human visitors had a stressful influence on animals, the second being that it is an enriching experience, and the third

being that there is no consequence at all on the animals. The paper reviews multiple studies done by other researchers on the topic of the visitor effect and evaluates how well they support these three hypotheses. Some of the larger concerns at stake in this field include the general welfare of the animals being studied. If visitors have a stressful effect on the animals, it will not be healthy for them in the long run. However, if it turns out that visitors have an enriching effect, then zoos can move forward to more interactive exhibits rather than just 'viewing animals in a cage'. Lastly, this research is important because it is necessary to understand how human presence effects animal behavior in order to be able to understand and interpret future behavioral and scientific studies. The categories of studies that Hosey reviewed included: non-primate studies, primate studies, multi-species studies, single species studies, and chimpanzees. In conclusion, in general it was found that when humans are passive viewers there was no significant behavioral differences in zoo animals (not the case for laboratory animals). However, there were signs of stress in the animals when human viewers were more active in forms of aggression or teasing, and this resulted in promoting returned aggression or avoidance in the animals. Hosey suggested that zoos should try to reduce stress in animals but not necessarily reduce animal-human interactions.

Jones, R., & Wehnelt, S. (2003, July). Two approaches to measure the effect of visitor numbers on orang-utan welfare. Paper presented at the Fifth Annual Symposium on Zoo Research, Marwell Zoological Park, Winchester, Hampshire, United Kingdom.

This paper analyzes three studies done by Birke (2002), Birke (2002), and Jones (2003) on three visitor variables. Two methods of measuring the visitor effect are discussed: the experimental and non-experimental approach. In reviewing the experimental approach where the researcher manipulates the conditions of the experiment by controlling the group sizes or other variables for example, Jones claims that using pre-determined groups can be beneficial in a study because it reduces variation in visitor characteristics. However, this could possibly present unrealistic conditions for the animals and skew the results. In non-experimental studies, visitor numbers can be controlled by choosing days when there is expected to be high visitor numbers or small visitor numbers on which to take observations. It is often very hard to control confounding variables with this approach, and usually requires significantly more time to collect data with this method. An important note that was made is that veterinary indicators such as disease history, weight gain/loss, reproductive health, etc. have not been discussed as welfare indicators in most studies and should be considered.

Veasey, J. S. Waran, N. K. and Young, R. J. (1996) On comparing the behavior of zoo housed animals with wild conspecifics as a welfare indicator. *Animal Welfare.* 5: 13-24.

The behavior of captive animals is often compared to the behavior of their counterparts in the wild. The absence of behaviors seen in the wild is commonly assumed to indicate negative welfare of the animals, however Veasey et al. claim that this is not necessarily the case. They claim that it is possible that wild-type behaviors may only correlate with enhanced welfare, but might not be the cause of it. They also claim that there are some behaviors that animals may have a need to perform regardless of their physiological needs.