The effects of enrichment on the physical and psychological health of two related species at the Toronto Zoo

by

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Foreword

As an animal advocate and true believer in animal welfare policy and regulation, this topic was thought of from a place of disbelief in the conditions that some animals are still housed in today. In many cases, non-human animals are still considered objects that we can control and dominate instead of equals, with whom we share this planet. The abuse begins with environmental destruction, ultimately forcing animals out of their natural habitats, to which we then subject them to the dismal conditions of some captive animal facilities. When will the cycle of exploitation end? Choosing to investigate the impact that enrichment programs have on the physical and psychological health of zoo animals was one way to shed some light on a dark and uncomfortable topic. This is potentially an important step in alleviating some of the negative implications of captivity. Although this will not fix the greater problem of environmental disregard and complete disrespect for species, it could be a step in the right direction. Any move forward is better than standing still. This paper was designed as a broad discussion that integrates all three components of my plan of study - environmental destruction, animal captivity, and human-animal relations. It begins with a discussion on environmental destruction and how this has created a situation where keeping animals in captive animal institutions is necessary. From here, I discussed enrichment as a possible means to alleviate some of the negative implications of captivity, and the extent to which enrichment should and could be used for all captive animals. Not only do I directly discuss environmental destruction and captivity, but intertwined in these discussions is a conversation about human-animal relations, and how we as a society continue to exploit animals – both wild and captive. This major paper seeks to tie in my area of concentration and what I have learned over the last two years. I have managed to integrate a number of my independent studies, as well as knowledge I have acquired from course work, into this final major paper. The drive to investigate such a topic came from passion and love for all animals, and the hope that positive change for vulnerable species is possible.

Abstract

The cumulative effects of environmental destruction have resulted in the unavoidable need for captive animal institutions that house captive animals for a multitude of reasons. Regardless of the reason for placing these species in captivity, the physical and psychological health implications of captive animals should be considered. An observational study investigating the effects of enrichment on the display of abnormal/stereotypic behaviour for both the western lowland gorilla and the ring-tailed lemur at the Toronto Zoo, was conducted. Both species had varying amounts of enrichment, which allowed for the comparison between the amount of abnormal/stereotypic behaviour being displayed and the amount of enrichment provided. In terms of psychological health, results indicated that more enrichment was beneficial for reducing the amount of abnormal/stereotypic behaviour displayed. In terms of their physical health, it seems that the amount of enrichment had very little bearing on the amount of physical illnesses displayed over a one-year period. Results indicated that although there is no optimal enrichment program, as each animal has individual needs, providing captive animals with any form of enrichment is beneficial – particularly for their psychological well-being. The extent to which all captive animals should be given enrichment needs further investigation, but it seems likely to assume that all captive animals should be given this consideration.

Introduction

Environmental destruction affects all species – both human and non-human animals - alike. The accumulated effects of habitat loss, pollution, and the resulting climate change has pushed many species to the brink of extinction, and with a limited number of possible solutions to this ongoing problem, the future of the environment and the species within it seems grave. As more and more animals are being pushed out of their natural habitats, the need to place animals in captivity is growing, and the need for captive animal institutions to house these animals is increasing. The conditions of these facilities - from research facilities to zoological parks – vary, and the quality of care that these animals receive should be considered. One common method used in many zoological facilities is to implement an enrichment program with hopes of enhancing the quality of life for captive animals (Hosey et al., 2009). Investigating the effects of enrichment on the physical and psychological health of captive species is a good way to understand the benefits and limitations of such a program, and to gain a more depth understanding of the welfare issues in these facilities. Often observational studies are used to assess behavioural changes associated with a particular stimulus, and positive behavioural changes may indicate positive environmental interactions (Carlson & Morrison, 2009). Conversely, abnormal or stereotypic behaviour displayed in the presence of a stimulus often indicates negative environmental interactions, and poor psychological health (Hosey et al., 2009). The importance of maintaining excellent psychological health in captivity is undoubtedly high, but the physical health of the animal is also important. This paper discusses the contemporary reasons for placing animals in captivity, captivity itself, and captive animal institutions. The ultimate goal is to understand and assess the use of enrichment programs in zoological facilities, as well as the degree to which enrichment programs should be used for all captive species. This paper has been designed to investigate each of these areas separately, but as one topic directly relates and leads into the next, it allows these separate topics to be considered and analyzed together. The remainder of this paper will go as follows, the first section will include a discussion on environmental destruction and how it ultimately forces wild animals into captivity. The second section will discuss animal captivity and its pros and cons, followed by a discussion on captive animal institutions (with a focus on zoological facilities) in section three. Section four will include a discussion on the different types of enrichment, as well as a discussion on the neurobehavioural evidence behind the implementation of these programs in zoos. Section five will discuss the types of observational studies, and their relevance in assessing animal behaviour in a captive setting. Finally, section six will consist of an observational study investigating the effects of enrichment on the physical and psychological health of two related species at the Toronto Zoo. Following these sections, a conclusion will tie these topics together, ultimately assessing the importance of deploying enrichment programs in zoos, and contributing to a larger body of literature on how to effectively assess and improve the welfare of captive animals.

Section 1 - Environmental Destruction

Over the last few decades, humans have become more and more destructive. The "negative effects on the environment as a result of human-mediated environmental change, has put enormous stress on ecosystems and the species that live within them" (Nichols & Williams, 2006, p. 668). Not only have we as a society altered and exploited many plant species, but we have done the same thing to many animal populations as well. Everything from climate change and pollution, to habitat destruction and fragmentation, human's effect on the environment has been overwhelmingly negative to say the least. Although each of these methods could cause irreversible environmental destruction, for the purposes of this paper, I will focus solely on habitat loss and fragmentation.

As it currently stands, habitat loss or fragmentation is one of the leading causes of the loss of biodiversity and species extinctions (International Union for Conservation of Nature [IUCN], 2010). In fact, habitat loss and degradation affects "86% of all threatened birds, 86% of threatened mammals and 88% of threatened amphibians" (IUCN, 2010, np). What makes this situation even more grave is the fact that habitat loss and fragmentation has been listed as a main threat to 85% of species categorized as threatened or endangered under the IUCN's red list of threatened species (World Wildlife Fund [WWF], 2013). The loss of roughly half of the world's original forests is detrimental to species survival, and "forests are still being removed at a rate 10x higher than any possible level of regrowth" (WWF, 2013, np). Forests are particularly important as many of them, specifically the Amazon rainforest, are biodiversity hotspots and not only contain the majority of species on earth, but are also home to a disproportionate number of endemic species in comparison to other ecosystems (Pimm & Brooks, 2013). Although animals are often the focus when discussing the consequences of habitat destruction and fragmentation, plants are just as important. Plant species play a crucial role in the environment and if a particular habitat does not support a healthy balance of abiotic and biotic features, the entire dynamic of an ecosystem will be in danger. Furthermore, animals cannot effectively survive and reproduce in an ecosystem that fails to provide these crucial elements.

A common misconception amongst environmental industries is that if they keep a forest intact by fragmenting the forest as opposed to completely removing all of the vegetation, that this will be effective in maintaining viable populations of animals (Ferraz et al., 2003). This is contentious, and in fact, researchers have found that fragments of 100 hectares lose one half of their species in roughly 15 years (Ferraz et al., 2003). Ferraz et al. (2003) conducted the longest fragment experiment in the Amazon rainforest. The researchers first created patches of forest of areas of 1, 10, or 100 hectares. They then counted the number of species in each of these patches, and recounted the number of species years to decades later. They determined that small fragments lost most of their species in a relatively short period of time, and large fragments lost fewer, but still a significant number of species over a longer period of time. They determined that a 10-fold decrease in the rate of species loss would require a 1,000-fold increase in forest area. The researchers argued that there would not be a sufficient amount of time for the execution of conservation measures of this magnitude. Fragmented habitats and the limited connectivity that it creates also reduces gene flow, exacerbating inbreeding among genetically related individuals and ultimately contributes to a decrease in genetic diversity among species (Li et al., 2013). This also impacts the reproductive potential of individuals and can lead to deformities and other health related issues. For endangered or threatened species, this could be the beginning of an extinction phase that has the potential to wipe out the species indefinitely. Additionally, habitat loss and fragmentation also have the potential to increase disease transmission among species. Although this phenomena is relatively under-studied and disease transmission is highly variable, fragmented landscapes can alter disease prevalence and transmission, and can increase mortality while reducing fecundity (Brearley et al., 2013). These small fragmented areas of forest, also known as forest islands, are driving extinction, and if the issues of habitat loss and fragmentation are not addressed with the real objective for environmental change, species will undoubtedly pay the ultimate price (Ferraz et al., 2003). The obvious solution is to eliminate practices that lead to habitat loss or extinction. However a more realistic solution is to limit the negative consequences that these practices could have, while trying to repair damage that has already been created. One approach might be to reconnect the fragmented forest by creating corridors for animals to travel along. Many researchers argue that although corridors come with their own set of risks such as: easier access for poachers; increased human-animal conflict; and psychological stress for the animals, corridors are still a viable option for helping animals reconnect with their habitat and other species (Klar et al., 2012, Rodríguez-Soto et al., 2013). This method aids conservation efforts by attempting to keep at risk species in their natural ranges and by attempting to minimize any disturbances that could have a negative effect on species. Despite the benefits of corridors, this conservation strategy should not be considered a permanent solution to the issues surrounding habitat fragmentation.

Another commonly deployed tactic in the conservation battle is the use of GIS technology. This relatively new technology is allowing researchers to assess habitat availability and quality at the landscape level, and can help determine lost or fragmented habitats (Kaminski et al., 2013). GIS technology also allows researchers to detect land cover disturbances, including shifts in vegetation and proximity to man-made infrastructure (Tumar et al., 2013, Kivinen & Kumpula, 2014). This has the potential to identify appropriate locations for species habitats, or could identify regions in which the environmental integrity of the land should be maintained. Therefore, GIS technology can also be used to identify land that should be designated as conservation or protected areas (Walker & Wendte, 2005). GIS software has enabled detailed mapping of the environment, including crucial habitats for animals, particularly at risk or endangered species. Mapping multiple layers at different spatial scales has created a comprehensive and inclusive look into a particular region, and has provided crucial information in a time-efficient manner. Assessing habitats using GIS software and data has not only created a platform for tackling conservation issues, but it has also reduced uncertainty with tracking and mapping species and their habitats, and has motivated society to participate in ongoing conservation initiatives. Aside from the development of corridors and the use of GIS technology, there are a number of other areas that could be useful in aiding conservation issues, such as the role of local communities, but for the purposes of this paper, I chose to focus on these two initiatives rather than other social initiatives. Despite these potential methods of alleviating some of the negative consequences of habitat loss and fragmentation, this global crisis continues to put an increasingly large number of species at risk, despite efforts made from governing bodies around the world.

When looking at Canada specifically, it is easy to see that the impact of habitat loss and fragmentation is having a large negative effect on species on a national scale. There are 345 at risk species in Canada, and the list continues to grow each year (Environment Canada, 2013). Deforestation and the resulting habitat loss and fragmentation provides one explanation for the large number of at risk species identified. In 2010, an estimated 45 000 hectares were deforested in Canada, however these numbers are questionable as logging practices are often not counted as deforestation, despite its large negative influence on species (Natural Resource Canada, 2014). Although this number seems low when compared to the global rate of deforestation that amounts to 13 million hectares per year, it is still contributing to species decline. When analyzing the reasons for deforestation, namely resource and transportation development, urban expansion, forestry, and hydroelectricity, it seems challenging to reduce deforestation and the resulting habitat loss and fragmentation (Natural Resource Canada, 2014). It seems as though a paradigm shift in which society prioritizes conservation initiatives over economic growth and development is needed, but how can society successfully engage in conservation programs if other goals always take precedence? Increased awareness and education, along with government action are a few of the ways to get society involved in reducing environmental destruction and contribute to the ongoing conservation battle. Specifically, the Government of Canada, on both the federal and provincial level, has developed a number of programs aimed at protecting the environment by reducing environmental damage associated with habitat loss and fragmentation and protecting at risk species.

One of the largest governmental action plans approved by parliament is the federal sustainable development strategy that was approved in 2008 and has the goal of reducing environmental damage through a number of different objectives by 2016 (Environment Canada, 2013a). This sustainable development strategy outlines a number of different goals that the government would like to achieve, followed by a list of specific targets within each of those goals. Two different sections stand out, namely the "preserve nature" and "reduce ecological footprint" categories (Environment Canada, 2013b). Within the preserving nature section, a few of the main goals include: conserving wildlife through the recovery of species at risk; conserving lands and waters by conserving priority habitats; and to sustainably use biological resources through effective forest management (Environment Canada, 2013b). The reducing ecological footprint category also had a number of different targets including: managing waste and reducing paper consumption (Environment Canada, 2013b). Both of these categories went into great detail into how they planned on achieving such goals, and each of them set out a number of targets that were to be achieved by a specific date. For the purposes of this paper, those details will not be discussed, even though each one of them plays a crucial role in minimizing environmental damage while conserving the land and the species within it. Another governmental program that aims to help conserve and protect species is the Habitat Stewardship

Program for Species at Risk. This program allocates funds “to projects that conserve and protect species at risk and their habitats and help preserve biodiversity” (Environment Canada, 2012, np). This program encourages the participation of local communities and landowners to help with “the recovery of species at risk and prevent other species from becoming a conservation concern” (Environment Canada, 2012, np). Although this program is administered by Environment Canada, it is managed by Fisheries and Oceans Canada and the Parks Canada Agency and it focuses priorities on protecting habitats of at risk species, mitigating threats to species at risk, and supporting the implementation of other conservation strategies (Environment Canada, 2012). Many non-governmental organizations, aboriginal groups, community groups, and educational groups can apply for funding from this program, which actively engages other interests groups in conservation initiatives and encourages a reduction in environmental destruction (Environment Canada, 2012).

Despite the effort made to implement conservation programs, more needs to be done. Although the Canadian government is taking steps to create and implement strategies that aid conservation issues, there is too much onus on the public to take these initiatives into their own hands to ensure that goals are met. The Canadian government at both the federal and provincial level should take more responsibility to ensure goals are met. Despite the fact that it would be beneficial if a greater focus was placed on conservation initiatives in Canada, the issue of habitat destruction and its corresponding habitat loss and fragmentation is not an issue solely affecting North America. This issue spans international boarders, creating one of the most challenging environment situations to tackle on a global scale. Regardless of the progress made in Canada, without the cooperation and determination of the international community, environmental destruction, particularly habitat loss and fragmentation will continue exponentially. This pattern of environmental destruction is one of the main driving forces for the need for captive animal institutions. Many species will fall victim to irreversible environmental damage in which placing these species in captivity will be the only viable solution to avoid a steep population decline and a possible extinction event. Furthermore, one could argue that the patterns and causes of environmental destruction correspond to how society views nature and species. Their perception of nature and animals provides an interesting view on human-nature relations and may play an important role in how animals are viewed in captivity. This may in turn influence the conditions in which animals are housed and cared for in a captive setting. Other questions worth asking are how will these species fair in captive conditions? Will species maintain their wildness qualities in a captive setting? What exactly are the advantages and disadvantages of placing animals in captivity? The following section seeks to answer these questions and will provide an in-depth analysis on the overall effect captivity can have on a species.

Section 2 - Captivity

As the current extinction rate continues to increase, species are lost at an alarming rate. Scientists are currently estimating a loss of species at 1000 to 10000 times the background extinction rate of 1 to 5 species per year (Chivian & Bernstein, 2008). This amounts to the loss of dozens of species per day, with as many as "30% to 50% of all species heading towards extinction by mid-century" (Chivian & Bernstein, 2008). Scientists estimate that roughly 6300 known amphibians are listed as at risk and 12% of the 9865 known bird species are at risk, with an additional 2% of bird species listed as at extreme risk for extinction (Wake & Vredenburg, 2008). Similarly, 21% of the 1851 known fish species are at risk, 30% of the 9526 known invertebrates are at risk, and 20% of the 5491 known mammals are at risk of extinction (Jelks et al., 2008; Center for Biological Diversity, 2008). Although there are many reasons for the accelerated extinction rate, habitat destruction is one of the most devastating environmental crises that is contributing to this phenomena. As a result, species have been taken from their natural habitats and placed in captive animal institutions in hopes of introducing conservation measures that may increase population numbers and save the species from extinction. To say that captivity is ideal for species recovery is short-sighted, but with increasing habitat loss and fragmentation, captivity seems like an inevitable fate for many species. When discussing captivity and its influence on the physical and psychological health of species, many important questions come to light, many of which will be addressed in the remainder of this section.

Over the last few decades, there has been an ongoing debate over the institution of captivity and whether or not animals, particularly mammals, display awareness or consciousness. Far too often is the human perception on captivity given priority, while the animal's perception is deemed invalid or non-existent. Animal consciousness has often been ignored as it stretches the limits of our knowledge and scientific inquiry, and if "proven" would present an ethical and moral dilemma for those exploiting animals. The word consciousness is an ambiguous term and can be interpreted in many different ways. It can be defined as "a waking state, a sensory experience, or possessing any mental state (i.e. having beliefs, fears, intensions, desires etc.)" (Cottee, 2012, p. 3). Although science has demonstrated positive accounts of animal consciousness, skeptics continue to dispute such claims. Many researchers have demonstrated that animals, especially primates, dogs and cats, have the ability to show emotion (Carmichael et al., 2003). Because many of the brain structures of animals are similar to humans, they suspect and have actively documented that animals show fear, grief, jealousy and love emotions (Carmichael et al., 2003). This is not to say that because the brains of some animals are similar to the human brain that they experience consciousness in the same way that humans do. If fact, researchers have documented the existence of complex cognitive processes in animals that are phylogenetically distinct from humans. Some examples of this include: the presence of working memory; planning; problem solving; and social learning in birds (Pepperberg, 2006; Salwiczek et al., 2010). There are often correlations made between complex cognitive processes and a higher level of consciousness, however some would argue that one does not predict the other and you can display evidence of complex cognitive processes without displaying conscious awareness. In many cases this is correct, however you also have to consider the fact that if an animal displays the presence of a more complex brain, this is usually indicative of more hierarchical connectivity of brain structures, which can lead to complex cognitive processes and a higher level of consciousness (Boly et al., 2013). Furthermore, some researchers have discussed the ability to measure animal consciousness. Specifically, Damasio (1999), discusses the ways in which human consciousness is measured, which can be extrapolated and used to measure animal consciousness as well. He discusses that you can measure consciousness in three ways: by observing external signs like wakefulness, attention, or observable behaviour; through internal signs that we can report on; and through internal signs that we can verify in ourselves when we are in situations similar to those of the observed individual (Damasio, 1999). The latter is very similar to the ways in which animal consciousness can be measured. One common method is to compare the similarity of the observed responses of animals to those of humans or other higher functioning species who are generally believed to have consciousness (Cottee, 2012). Although subjective, this could demonstrate the ability of a species to feel emotions like love, fear or pain. If animals do in fact have the ability to feel emotions and are consciously aware of their surroundings, how does captivity affect their livelihood? Are animals in captivity still considered wild and do they continue to maintain their wildness qualities?

The question of whether or not a wild animal is still considered wild in a captive setting has been debated for many decades. Essentially, this question is asking whether or not an animal has been domesticated in a captive setting, and in turn, if their wildness qualities have disappeared. When assessing whether or not an animal has become domesticated, it is important to assess and compare the animal's genetic make-up, physiological alterations, and behavioural changes to a wild counterpart. If an animal's genome remains the same as its wild counterpart, but its physiology and behaviour has changed, is it safe to assume this animal has undergone some form of domestication? A conservative approach could assume that any major physiological or behavioural deviations from a wild counterpart is indicative of a loss of "wildness" qualities. Although are changes in the genome, physiology, or behaviour occurring in wild-born captive animals? Kunzl et al. (2003) intended to shed some light on this topic when they analyzed whether the rearing of wild mammals in captivity affects their behavior and physiological stress responses. They used three separate populations of guinea pigs *(Cavia aperea)*, one population that was domesticated, and two that were wild. The domesticated guinea pigs were descendants from 40 animals from a breeder in 1975, and were given the designation "DGP". One population of wild guinea pigs were descendants from a feral population that were trapped in Argentina in 1974. These descendants have therefore been living under human-made conditions for 30 generations, and were given the designation "WGP-30". Finally, the last population of wild guinea pigs were designated as "WGP-1" and consisted of a population that were wild trapped in Argentina that consist of first generation offspring. The researchers then assessed the behaviour of the guinea pigs in each group, and analyzed their exploratory behaviour in an exploration apparatus. Subsequently, blood samples were taken from the males to analyze cortisol, epinephrine and norepinephrine concentrations. Results indicated that the domesticated animals showed significantly less aggression and significantly more sociopositive behaviour then their wild ancestors. Results also indicated that the domesticated guinea pigs were much less attentive to their surroundings then their wild ancestors and that both groups of the wild guinea pigs displayed more exploratory behaviour then the domesticated group. Finally, catecholamine and values of cortisol were significantly reduced in the domesticated group in comparison with their wild counterparts. The researchers concluded that although there was a distinct difference in behaviour and blood concentrations of challenge value cortisol levels, the rearing of wild guinea pigs in captivity does not produce a significant difference in overall behaviour and stress response. They suggest that bringing about domesticated characteristics in wild-born captive animals may take much longer periods of time than what the experiment permitted. The fact that modifications to the behaviour and stress response of the domesticated guinea pigs were observed, albeit not to the extent that the researchers wanted, still illustrates that captivity can exert an influence on behaviour and physiological processes over an extended period of time and can effectively reduce “wildness” characteristics in captive/domesticated species. Captivity has the potential to alter other aspects of the physical, psychological, and physiological repertoire of a species, a few of which will be discussed in the following section.

The effects of captivity on animal species is often debated. Animal activists argue that animals undergo needless suffering in captivity, whereas many researchers would argue that although captivity does have its negative points, captivity and the potential benefits that may arise should not be overlooked. Generally speaking, the arguments on both sides of the spectrum are valid, and it is important to be aware of the major points for each side. First, captivity has the potential to prolong the age of a species. Many animals in captivity are free from predators, are given ample food, and receive adequate health care, creating a situation where captive animals can live a longer, and healthier life than wild conspecifics (Mason, 2010). This is not to say that all species live longer, or healthier lives, but some species, such as the Kestrel (*Falco tinnunculus*) have a longer lifespan and lower mortality rate than their wild conspecifics (Mason, 2010). Placing animals in captivity also creates an opportunity to protect biodiversity by enabling captive breeding programs (Hosey et al, 2009). Although these programs have their own set of problems (which will be discussed in more detail in a later section), having the ability to engage in this type of program does in fact aid conservation efforts for threatened and endangered species. Despite these few advantages of captivity, there are also a number of negative implications that could affect the animals overall health and well-being. First, the increased risk and spread of diseases in captivity is of concern. There are a number of infectious, degenerative, genetic, and nutritional diseases that affect captive animals. When just considering infectious diseases, captive animals have to contend with at least 28 different bacterial, viral, fungal or parasitic infections (Hosey et al., 2009). These diseases, such as salmonellosis, rabies, ringworm or scabies, can significantly reduce the overall health of captive animals, and in some cases can lead to death (Hosey et al., 2009). The fact that captive animals are kept in close proximity to other conspecifics, as well as other enclosures housing entirely different species accelerates the spread of disease. Degenerative diseases, such as arthritis or diabetes, are also commonly observed in captive animals (Hosey et al., 2009). Because animals have an increased lifespan in captivity, these diseases are often not found in wild conspecifics. Genetic diseases are also of concern. The relatively small population size of each species may lead to inbreeding and a reduction in genetic diversity (Hosey et al., 2009). Although captive animal facilities often try to avoid this, sometimes they cannot, and genetic repercussions are seen. For example, congenital abnormalities, such as scoliosis and skull deformities have been recorded in black-and-white ruffed lemurs as a result of inbreeding (Benirschke et al., 1981). Finally, nutritional diseases, such as metabolic bone disease, iron storage disease, tooth decay, malnutrition, or obesity are also prevalent in captive animals (Hosey et al., 2009). Although malnutrition in captive animals can happen, obesity is more common, especially in zoological facilities. For example, Schwitzer and Kaumanns (2001), examined forty-three ruffed lemurs from thirteen European zoos and determined that 46% of those individuals were clinically obese. The lack of physical activity that takes place in some zoological facilities significantly contributes to this predicament. Another issue with captivity is the decreased reproductive potential observed in a number of species. As many captive animal facilities rely on the ability to maintain successful captive breeding programs for possible reintroductions, this poses a significant threat to the viability of a species. Atsalis and Videan (2009) investigated this by looking at the fertility patterns of both captive and wild female chimpanzees. They found that wild chimpanzees tend to reproduce well into their 40's, but captive chimpanzees tend to go into menopause at that time. They discussed the relative inefficiency of captive conditions that tend to prolong the life of chimpanzees, but shorten their reproductive lifespan. This seems counterproductive, and demonstrates the notion that the pros and cons of captivity should be weighed carefully. Captive animals also undergo physiological changes as a result of captivity. Aside from the physical changes to the body, skull, and internal organs as mentioned above, the chemical physiology of an animal can also be altered. For example, Fanson et al. (2012) wanted to compare the concentrations of glucocorticoids in captive and wild Canadian lynx (*Lynx Canadensis*). Glucocorticoids are a product of the hypothalamic-pituitary-adrenal axis (influencing both the brain and kidneys), and are often linked to the level of stress an animal is experiencing. The researchers monitored fecal glucocorticoid metabolites (FGM) over several contexts, and found that captive lynx had a higher concentration of FGM than wild lynx. They concluded that this could be a result of differences in stress levels, metabolic rate, diet, or body condition (Fanson et al., 2012). Captive animals also suffer from a number of psychological inflictions as well. Most captive animals will suffer from stress, depression, anxiety, boredom or social deprivation at some point throughout their captive lives. These psychological inflictions often lead to some sort of abnormal or self-mutilating behaviour that can be detrimental to the health of the animal. Displays of abnormal behaviour could include, but are not limited to: abnormal escape reactions; refusal of food; abnormal displays of aggression; stereotyped motor reactions; apathy; or lack of appetite (Hosey et al., 2009). One example was the stereotypic swaying observed in elephants, as a result of prolonged exposure to captive conditions (Wilson et al., 2004). The extent to which animals succumb to the physical, physiological, and psychological health afflictions is often dependent on the captive animal institution housing the animal. A lot can be said for accredited, as opposed to non-accredited zoological facilities, and the level of commitment to animal welfare practices often correlates with the quality of life for captive species. However, what do these facilities do, and how do the rules and regulations at these facilities address and influence conservation and animal welfare issues? The following section will examine these questions, with a focus on one of the largest categories and most influential captive animal facilities – zoos.

Section 3 - Captive Animal Institutions

The need for placing species in captivity has become seemingly unavoidable as we as society continue to damage their habitats to the point where habitat restoration is nearly impossible. However, how do you determine which species should be placed in captivity? Surely not every species will benefit from captivity, however the current trend shows more and more species in captive animal institutions, and not just at risk species who are suffering from habitat destruction and loss. Nevertheless, animals are living in captive conditions in aquariums, zoos, and research facilities, and whatever their reason for being there, their overall physical and psychological welfare should be considered. It has become clear that despite obvious objections to some captive animal institutions, the need for some of these institutions has become necessary. With that being said, these institutions have the responsibility to ensure that the welfare of the animal is in no way compromised, and all measures to ensure the upmost quality of life for the animals within their care should be taken. As mentioned above, animals live in captivity in a number of different facilities, some of which promote better welfare practices then others, but for the purposes of this paper, I will focus solely on zoological facilities in Ontario, Canada.

There are many accredited and non-accredited zoos in Ontario, mounting to a total of 60 zoological facilities in Ontario alone – many of which are unregulated roadside zoos (World Society for the Protection of Animals [WSPA], 2010). The objective of these roadside zoos is strictly profit as they aim to attract individuals long enough to get them into a shop or store. Despite the good intentions that some of the owners of these roadside zoos may have, the animals often live in “poorly designed cages and tiny spaces containing improper floor surfaces” (WSPA, 2010, p. 6). They also lack appropriate shelter and privacy, and they are subjected to “poor quality feed, filthy water containers, and excessive buildup of feces or food items” (WSPA, 2010, p. 6). Even if these roadside zoos effectively eliminate these concerns, there is still no guarantee that they are able to prevent the psychological suffering that captive animals face. What worsens this situation is that Ontario remains the only province in Canada that does not have any provincial policies in place to prevent the average citizen from opening up a roadside zoo, and importing and breeding exotic animals (WSPA, 2010). There are no provincial regulated licensing requirements or permits, and there are no regulated comprehensive standards for keeping captive exotic animals in captivity (ZooCheck, 2013). The few municipalities that have bylaws in place regarding the keeping and trade of exotic animals are not enough to stop this epidemic (WSPA, 2010). If an individual happens to live in a municipality that doesn't allow roadside zoos, that individual can simply move to a different municipality a short distance away. The lack of cohesion between the Ontario municipalities worsens the plight for captive exotic animals and enhances the number of roadside zoos. In terms of keeping native animals in captivity, licenses are required, however these regulations are never enforced and are often undermined (ZooCheck, 2013). Furthermore, the Ontario SPCA Act Regulation 60/09 contains "general standards of care for animals and for wildlife in captivity, but they are minimal, non-specific or vague, and are subject to a high degree of interpretation" (ZooCheck, 2013, np). With this lack of regulation and monitoring, it seems as though animals will continue to suffer in captive conditions in roadside zoos. Many have argued that the new power and funding given to the Ontario Society for the Prevention of Cruelty to Animals (OSPCA) will greatly aid in the regulation and monitoring of Ontario's 60 zoological facilities (Toronto Star, 2013). Although how effective will this new funding be, as the OSPCA is a charity organization that receives a lot of its funding from the same facilities that they are supposed to be investigating? One piece of recent legislation, Bill 125, the Exotic Wildlife in Captivity Act, was proposed in 2010 as an amendment to the Fish and Wildlife Conservation Act, 1997 (Exotic Wildlife in Captivity Act, Bill 125, 2010). If passed, "the Bill will give the Minister of Natural Resources the ability to regulate the ownership, breeding and acquisition of exotic wildlife by private citizens" (ZooCheck, 2013a, np). This Bill will require that any individual who wishes to own an exotic animal must apply for a licence, must provide the animals with proper housing and care, must keep the public safe, and must surrender the animal if the minister finds that the individual is not complying with the new requirements (Zoocheck, 2013).

Aside from roadside zoos, Ontario is also home to a few accredited zoological facilities. In order to receive accreditation from Canada's Accredited Zoos and Aquariums (CAZA-AZAC), zoos must fulfill the requirements of the standardized numerical assessment that the inspection team, including one veterinarian and one senior zoological professional, carry out (CAZA-AZAC, 2013). This assessment looks at a number of different zoological operations, including: animal care; enrichment; nutrition; conservation; research; education; security; public safety; financial stability; and administration (CAZA-AZAC, 2013). Under the category of animal care, the zoological facility in question should also follow and achieve the five freedoms of animal welfare originally developed by the UK government, but what is now internationally recognized by the World Organization for Animal Health (Hosey et al., 2009). These five freedoms have been adopted by the Canadian Association of Zoos and Aquariums (CAZA) and are as follows: freedom from hunger or thirst; freedom from discomfort; freedom from pain, injury or disease; freedom to express most normal behaviour; and freedom from fear and distress (Hosey et al, 2009). Specific requirements within the areas of: animal care; human and animal contact; animal acquisition and deposition; animal transport; elephant and large animal care; and veterinary care are also investigated before designating an accreditation status (CAZA-AZAC, 2013a). Although these address most, if not all areas of animal health in captivity, the guidelines for accreditation are murky and the words "mandatory", and "recommended" are often blurred. The objective of most accredited zoological facilities is definitely one of profit and entertainment, however this is not their only objective. Many of these facilities, particularly the Toronto Zoo, actively participate in education, conservation, and research efforts (CAZA-AZAC, 2013b). For example, the Toronto Zoo actively promotes ongoing educational programs, including school programs and camps (Toronto Zoo, 2014). This helps bring awareness to the general public about which species are in danger, the reasons why they are at risk, and things that we can do to help. Educating the general public, especially the younger generation, has the potential to create a foundation for promoting conservation and welfare initiatives as the child ages. Many accredited zoos, particularly the Toronto Zoo, also engage in both *ex situ* and *in situ* conservation initiatives. For example, the Toronto Zoo has a captive breeding program that removes a species from the wild with the hope of increasing their population numbers in captivity, in which they will then attempt to reintroduce that species back into their natural ranges in the wild. The hope being that they can re-establish a viable population size in the wild that will help promote species recovery (Toronto Zoo, 2014a). Despite the many limitations of captive breeding and reintroduction programs, the Toronto Zoo has had a few successful cases, particularly the black footed ferret and the Vancouver Island marmot. Zoological facilities, like the Toronto Zoo, may also engage in *in situ* conservation, in which conservation initiatives are directed towards improving the wild environment and species habitats. One example is the removal of invasive species from the surrounding environment. These could include invasive plants such as garlic mustard and dog strangler vine that is prominent in the local and surrounding communities of Rough Park (Toronto Zoo, 2014b). Finally, many accredited zoological facilities engage in research initiatives as well. The Toronto Zoo engages in behavioural research, focusing on behavioural assessments, husbandry techniques, and enrichment methods, to name a few (Toronto Zoo, 2014c). They also conduct nutritional research and perform diet profiles on the captive animals (Toronto Zoo, 2014d). In doing so, they aim to promote optimal health and well-being for the animals within their care. Finally, the Toronto Zoo also engages in research on reproduction, particularly gamete and endocrinology research to aid their captive breeding and reintroduction program (Toronto Zoo, 2014e). Each of these areas of research may also aid in compiling a better understanding of the physical and behavioural requirements of each species. Zoological facilities have the potential to improve the conditions in which captive animals are forced to live, but at the same time, these same facilities don't always, whether intentional or not, provide the most desirable conditions for their animals. What exactly are the pros and cons of zoological facilities, and how do their practices affect the animals within their care?

Zoological facilitates can have both a positive and a negative effect on the health and welfare of an animal within their care. The ways in which zoos operate, manage, and provide care to their animals can have dramatic effects on their overall physical and psychological well-being. There is an ongoing debate within the scientific community that suggests zoos cause more harm to the animal than good, but many conservationists could argue that in many cases, placing animals in captivity is a necessary step in order to save the species from extinction (Hosey et al., 2009). Both sides of the debate raise good points, but the truth of the matter is, animals are in fact living in captivity, and they deserve to live in a happy, relatively stress free environment that allows them to display normal behaviour. There are many areas of zoo care that can be analyzed, but some of the most important areas to focus on include; animal identification methods, housing and husbandry, captive breeding programs, feeding and nutrition, and human-animal interaction. Enrichment, as a source for alleviating some of the physical and psychological health implications associated with captivity, is also a very important area to analyze and as a result will be discussed in greater detail in its own section following this discussion. Each of these areas have the potential to affect the quality of life for the animal, and so each area will be discussed individually. The following section has been previously researched, however the most recent research associated with each area of zoo care has been added to provide a better understanding of life in captivity.

Animal Identification Methods

There are two different types of identification methods that can be used on animals within zoos – temporary or permanent. Temporary methods can include: using naturally occurring characteristics of the animal (ex. colour of their coat); colouring or clipping hair; and adding adornments to the animal, such as, tags or necklaces (Hosey et al., 2009, p. 139). Permanent methods can include: cuts; branding and tattooing; and removal of a part of the animal (ex. removal of a digit) (Hosey et al., 2009, p. 139). It is clear that the permanent identification methods are more invasive and can cause substantial pain for the animal, however the temporary methods can also be detrimental to the health of the animal. A temporary method will have to be applied numerous times, as hair grows out or ornaments fall off, subjecting the animal to the repeated stress of handling and procedures (Hosey et al., 2009). Choosing between the two methods can be extremely difficult for zoo personnel, and it often requires the careful consideration of a number of different factors. First, zoo personnel must consider the amount of handling that is necessary to apply the identification method, followed by an investigation into how much pain the application of the identifier might cause (Hosey et al., 2009). Finally, they must consider the length of time an identifier might last, as well as any long-term impacts that the particular identifier might have on the animal, such as negative affects to the health, mating, and reproductive processes of the animal (Hosey et al., 2009). When considering these factors, it is also important to avoid assuming that an identifier is more or less invasive or intrusive based on the way it is deployed. For example, removing a digit or toe clipping sounds painful and sounds like it would cause a great deal of stress, but this may not be the case for all species. Fisher et al. (2013) found after investigating plasma corticosterone levels in cane toads, that toe-clipping doesn't cause any more stress than handling does. It would be easy to assume that it would, which makes conducting research and having the appropriate knowledge of the species that you are working with, that much more important. After everything is considered, the right type of identification method will be applied, and zoo personnel will be able to identify each animal individually. It is extremely important to be able to identify each animal individually, because it not only helps ensure optimal health for the animal, but it also aids in conservation efforts (Hosey et al., 2009). If you are able to identify individual animals, you can keep accurate records of their health and behaviour. This will give you a reference from which you can compare current behaviour. This in turn allows for the identification of abnormal behaviour that may indicate poor health or disease. In fact, Watters et al. (2009) believe that knowing each individual animal's life history traits and being able to identify them accurately is very important. They argue that being able to effectively analyze each animal's behaviour, in order to monitor the changes that occur with their behavioural repertoire can be one of the first ways to detect the presence of illness, whether physical or psychological. This ability is often underutilized in zoological facilities and can lead to inefficient monitoring of behaviour that may represent poor health. Having records of an animal also gives you crucial information regarding their genetics and demographics, which can be very beneficial in terms of captive breeding programs (Hosey et al., 2009). It allows zoo personnel to match individuals that are reproductively compatible, while reducing the likelihood of inbreeding. When all of this is taken into consideration, it has been shown that the methods used for identification can have negative health implications for the animal, and the upmost care should be taken when faced with this dilemma. Zoos should strive to reduce the amount of pain associated with the application of an identifier, while at the same time, trying to minimize the amount of handling that is required. The identifier should also be chosen on the basis of which one will last the longest in order to avoid unnecessary stress or pain. As technology advances, and new methods of animal identification arise, the use of an identifier to keep records of an individual animal will hopefully become a pain free practice, and will lose the reputation as being a negative aspect of captivity.

Housing and Husbandry

When focusing on enclosure design and husbandry, there are three principal groups that should be considered – the animals, the keepers, and zoo visitors (Hosey et al., 2009, p. 168). Although the functioning of an appropriate enclosure requires the careful consideration of all three groups, for the purposes of this paper, I will be focusing solely on the needs of the animals. At the very least, housing and husbandry practices should aim to ensure that the “five freedoms” of animal rights are fulfilled. As mentioned above, this includes: the freedom from hunger or thirst; the freedom from pain, injury or disease; the freedom from discomfort; the freedom to express most normal behaviour; and the freedom from fear and distress (Canadian Federation of Humane Societies, 2014). When trying to fulfill these five freedoms, it is important to consider the animal specifically, and to consider things such as age, size, previous lifetime experience, and external environmental factors (Canadian Federation of Humane Societies, 2014). In terms of age, older and younger animals have different needs, and their physiological systems can differ dramatically (Hosey et al., 2009). Older animals may experience senescence and may no longer be able to cope as well as they previously could. Older animals may also have difficulty regulating their body temperatures, which can cause a wide array of additional health issues (Hosey et al., 2009). Colman et al. (2005) also determined that older animals may also suffer from an ailment known as sarcopenia. Through their research on the muscle mass loss of Rhesus monkeys, they determined that older individuals in captivity can suffer from a decline in muscle mass that can leave them frail and weak. This contributes to an overall decrease in physical well-being and an increase in disability. Younger animals may also have difficulty coping, but simply because of the fact that they are unaware and unsure of their surroundings. They have yet to build trust with the keepers, and as a result, may require additional places to hide or places to escape from view. The size of the animal will also need to be considered. Besides the obvious fact that larger animals require larger enclosures, you also have to consider the fact that larger birds and mammals live longer and require more exercise than smaller animals (Hosey et al., 2009). This must be taken into account when designing an enclosure, because you need to know how long each animal will occupy the enclosure, and what enrichment activities you will include to keep these animals occupied for a longer period of time. Correspondingly, Hunter et al. (2014) investigated the extent to which an animal uses the enclosure and how that could help indicate enclosure appropriateness. He found that the ways in which the animal used their enclosure not only indicated the animal's preference for some enrichment devices over others, but it also helped determine the appropriateness of the enclosure, in terms of both size and associated structures, for that individual animal. These are crucial elements in the animal's environment that can truly affect their quality of life. An animal's previous experiences must also be considered. An animal that is coming from the wild or from another zoological facility may have difficulty coping with a new environment, and so making the enclosure as similar as possible to their previous housing situation may help avoid unnecessary stress (Hosey et al., 2009). Knowing the animal's previous experiences can also aid in the application of the right kind and the right amount of environmental enrichment. Finally, the external environment must also be considered when designing an enclosure. Climate variations, as well as variations in day length can affect the animal's biological processes, and can dramatically influence their life in captivity (Hosey et al., 2009). Likewise, Young et al. (2013), also found that an animal's microclimate is also very important for their overall well-being. They studied two difference species of African lions (*Panthera Leo* and *Panthera tigris altaica*), and took a number of different microclimate measurements, including: air temperature; relative humidity; solar radiation; and wind. They determined that where the animal's spent more of their time was influenced by the microclimate, and an enclosure needs to be effectively designed so that each individual animal can adapt to the microclimatic conditions. Ensuring that the animal is exposed to the right kind of environmental factors can, at times, be difficult, but it is necessary to ensure optimal health of the animal. With this being said, the evolution of enclosure design has significantly improved over the last few decades. There are three main types of enclosure design today - realistic, modified, and naturalistic (Hosey et al., 2009). Realistic enclosures reproduce the animals' wild habitat, including land formation and plant life; modified enclosures simulate the animals' wild habitat by using available resources that the zoo can get a hold of; and naturalistic enclosures make no attempt to duplicate the animals' wild habitat, and instead, natural materials are used in the design (Hosey et al., 2009). More and more zoos are adopting an enclosure design that not only provides privacy areas for the animal, but creates a safe environment that meets all of the needs of the animal. If zoo personnel are not careful, it is very easy to cause anxiety for an animal by creating an inadequate enclosure, ultimately contributing to the negative effects that captivity can have on the psychological health of the animal.

Captive Breeding Programs

Three of the most common assisted reproductive technologies (ART) used in zoological facilities are; artificial insemination, in vitro fertilization, and embryo transfer (Hosey et al., 2009, p. 316). Durrant (1990) states that although all three are valid methods, in zoological facilities, artificial insemination and in vitro fertilization are much easier to deploy than embryo transfer, and zoo personnel should focus more on the former than the latter. Although there are many advantages of using one of these techniques to aid in conservation efforts - by enhancing the breeding potential of endangered species - there could also be negative side effects associated with their implementation. When speaking in terms of artificial insemination, some of the direct advantages to the individual animal include: it reduces the risk of fighting or injury that could occur when an animal is introduced to their mating partner in a novel environment; the genetic material can be exchanged between *in situ* and *ex situ* populations without the need to transport wild animals; the risk of disease transmission from parent to offspring can be reduced via the screening of semen or embryos for pathogens; and the transfer of sperm or embryo between zoos is much cheaper, easier, and safer than moving the animals between zoos (Hosey et al., 2009, p. 318). With that being said, the use of assisted reproductive technologies can also have detrimental effects on the overall welfare of the animal. These effects could include: the procedure is extremely variable in terms of success; there is an increased risk of chromosomal abnormalities and spontaneous abortions as a result of tampering with their genetics; the animal could experience an adverse reaction to anesthetic or post-op medications; and the animal is subjected to increased levels of stress and pain as a result of the procedure (Loskutoff, 2003; Hosey et al., 2009). Many would argue that the pros and cons must be weighed in this circumstance, because although the animal may experience some temporary distress, it could prevent the species as a whole from going extinct if the procedures are successful. Before an ART can be used, animal keepers and veterinarians have to effectively monitor the animal's reproductive hormones in order to see when the animal is ready to mate (Pickard, 2003). One common way of doing this, particularly in primates, is to subject their urine to a pregnancy test, a method that dates back to the 1940's (Pickard, 2003). This is just one of the many ways hormones can be monitored. Other areas for future research surrounding assisted reproductive technologies that could potentially increase its effectiveness in developing healthy offspring include: research into ovarian stimulation protocols; sperm and embryo cryopreservation methods; embryo culture systems; and fetal and neonatal viability testing following the use of assisted reproductive technology (Swanson, 2006). If zoos do engage in captive breeding and assisted reproductive programs, they should ensure that the upmost care for the animal is taking place, and the effects on the animal are kept to a minimum.

Food and Nutrition

How an animal is fed, and the quantity and quality of food they are given can have implications on the animal's immediate and long-term health (Hosey et al., 2009). Most accredited zoos provide great quality food to their animals that meet all of their daily nutritional requirements, however in some instances this is not case, and nutritional diseases and disorders are seen in captive zoo animals (Hosey et al., 2009). It is important to note that preparing a diet for zoo animals in not based solely on nutritional requirements, but also takes into account the health status of the animal and any management constraints (Crissy, 2005). This can be very challenging as many zoos do not have sufficient information to make these decisions. As mentioned above, both malnutrition and obesity are seen in zoo animals (Hosey et al., 2009, p. 469). It is common for animals to be underfed, leading to lethargy, exhaustion and muscle wasting (Hosey et al., 2009). Obesity is also common as many animals are receiving their required daily calories, however because of inactivity, they are not burning any of it off, leading to large fat stores and other associated diseases, such as cardiovascular issues (Hosey et al., 2009, p. 470). As mentioned earlier, one example of how prevalent obesity can be in captivity was demonstrated by Schwitzer and Kaumanns (2001) when they found that within a sample of forty-three ruffed lemurs in thirteen European zoos, that 46% of them were obese. With that being said, many cases of obesity in zoological facilities occur not because of purposeful overfeeding, but rather a lack of information and knowledge about the species (Goodchild & Schwitzer, 2008). Another common nutritional disease is rickets, a bone disorder that is characterized by a lack of calcium or phosphorus in the animal's diet, ultimately resulting in either bowing of the larger bones, or breakage of a bone (Hosey et al., 2009, p. 467). Metabolic bone disease is another issue that affects bones. This can be caused by a calcium deficiency, and like most bone disorders, can be irreversible and sometimes fatal due to the inability to treat them (Fidgett and Dierenfeld, 2007). Vitamin and mineral disorders are also common in captive populations. Vitamin C deficiency is a particular problem for primates, as well as vitamin A deficiency, which can lead to decreased immune function (Hosey et al., 2009, p. 469). Pica, a common consequence of a mineral disorder, is also very detrimental, and results in the consumption of items not typically found within the animals' normal diet (Hosey et al., 2009, p. 470). Zinc toxicity is another common mineral disorder that primarily affects birds, and has damaging effects on growth and egg production in these species (Hosey et al., 2009, p. 470). Arthritis and diabetes are also seen as a result of an imbalanced diet (Hosey et al., 2009). Although most zoological facilities aim to provide a balanced diet consisting of all the vitamins and minerals an animal needs, some would argue that they can't entirely replicate the diet an animal would receive in the wild. This demonstrates why nutritional disorders often occur, and why in some instances, they are expected.

Human-Animal Interaction

Human-animal interactions in a zoological setting could come in the form of handling from a keeper, medical check-ups and procedures by veterinarians, as well as observations and contact with zoo visitors (Hosey et al., 2009). The animals could react to these interactions in one of three ways. First, they could view it as an exciting, pleasant experience, such as in the case of a keeper bringing food or a new enrichment toy for the animal (Hosey et al., 2009). The animal could also view the interaction as negative and fearful, such as an unpleasant medical procedure where the animal may experience pain or discomfort (Hosey et al., 2009). Finally, an animal may have no view or opinion of the interaction at all (Hosey et al., 2009). They may be completely neutral and not look at the interaction as positive or negative. Fernandez et al. (2009) also looked into animal-visitor interactions and found similar results – the animal may view the interaction as positive or negative. They suggested that zoo personnel pay careful attention to exhibit design, species characteristics, and visitor education in hopes of increasing positive animal-visitor interactions. Of course zoological facilities try to promote positive human-animal interactions, but negative interactions are inevitable, and many zoos will take the approach of simply reducing the number, and intensity of the negative interactions, while trying to promote more positive or neutral interactions. It is often difficult to accurately perceive the animals' response to a given situation, but it is the job of the keepers – the individuals closest to the animal – to assess whether or not the animal is in distress or showing abnormal behaviour. When aversive behaviour is known, zoo personnel can apply methods for trying to mitigate the problem, however if the animal's behaviour is misread, the animal may undergo chronic stress, which can have long-lasting, detrimental effects on their overall health (Hosey et al., 2009). Specifically, Larsen et al. (2014) found that visitor number and visitor noise can have a negative effect on captive species, in particular captive Kola, however it was determined that more research is needed to figure out just what that effect is, and how it affects the animals' physical and psychological health. Zoo personnel, along with zoo visitors and researchers, need to consciously assess their own behaviour to make sure that they are not contributing in any way to a negative interaction. This is easy to say, but in reality, the implementation of such a task can be very difficult, if at all possible.

With the exploration of each of these areas of animal care, it is easy to see how an animal's overall health can be negatively affected, but it is also important to note that most zoos within the Association of Zoos and Aquariums try to engage in a beneficial program referred to as the species survival plan (SSP's). They aim to "cooperatively manage specific, and typically threatened or endangered species populations within AZA-accredited Zoos and Aquariums, certified related facilities, and approved non-member participants" (Association of Zoos and Aquariums, 2009, np). They engage in many activities, but one of the most important ones that has a direct effect on the health of their animals is the process of overseeing the development of a Studbook, which "identifies population management goals and recommendations to ensure the sustainability of a healthy, genetically diverse, and demographically varied AZA population of animals" (Association of Zoos and Aquariums, 2009, np). Other functions include: increasing public awareness of wildlife conservation issues; developing a breeding and transfer program; and developing non-breeding programs through the use of contraceptives (Association of Zoos and Aquariums, 2009). Whatever objective these zoological facilities have, or whatever program they are trying to implement or promote, they should strive to maintain an excellent quality of life for the species within their care. If it's necessary to place animals in captivity, and we know that these animal suffer physical and psychological afflictions in captivity, what can be done to avoid such an unnecessary cycle of suffering? A relatively recent idea has emerged that proposes the use of environmental enrichment as a method to stimulate captive animals, ultimately positively contributing to their overall health and well-being (Markowitz, 1982). Research is still being conducted to determine the overall effectiveness of enrichment techniques on captive animals, however if it does in fact have any positive affect on the welfare of captive animals, than this would be a huge step forward in addressing animal welfare issues in these institutions.

Section 4 – Enrichment

Enrichment is one idea that many accredited zoological facilities are attempting to incorporate into their enclosures to enhance animal welfare. The idea of enhancing the lives of captive animals can be dated as far back as the 1920's when the idea of installing apparatuses into the enclosures of primates was suggested by Robert Yerkes in order to induce play behaviour (Adams, 2007). This idea was then expanded upon by a number of different psychology researchers in the 40's and 50's (Adams, 2007). Around this time, Hebb (1949), a Canadian psychologist, decided to conduct an experiment on rats, in which he brought a group of rat's home to be raised as pets, and left another group in an empty box in the laboratory. During the testing phase of his experiment, he discovered that the rats that had been raised as pets outperformed the control group of rats in problem-solving tasks. He concluded that the richer experiences received by the pet rats enhanced their development. Other researchers expanded on his work throughout the 50's and 60's, which eventually lead to the use of the term "enriched" to describe a complex environment (Adams, 2007). Up until this point, the idea of enriched environments was only considered for laboratory animals. It wasn't until Hediger (1964) proposed that quality space was more important than quantity of space, for the idea of environmental enrichment to seep its way into the zoological community. Shortly after, traditional zoological enrichment programs were revolutionized in the 70's and 80's when Hal Markowitz emphasized the role of choice in an animal's environment, subsequently introducing the term behavioural enrichment (Markowitz, 1982). The efforts of these researchers has changed the way we view captivity, and has initiated a moral obligation for ensuring an excellent quality of life for captive zoo animals.

Much of the information described in this section has been previously researched, but through the use of Hosey et al. (2009) and a number of other researchers, a comprehensive description of enrichment is described. Not only is a description of enrichment and the different forms of enrichment described, but the goal of enrichment programs and the neurobehavioural evidence surrounding the use of enrichment has been added to enhance the previous research conducted and show the potential benefits and limitations for deploying enrichment programs. Enrichment is a broad term used to describe "any change to an animal's environment or lifestyle that is implemented to improve the animal's physical fitness and mental well-being" (Hosey et al., 2009, p. 259). However in most zoos, there is a tendency to call every change to the housing and husbandry of an animal that improves their health and well-being 'enriching' (Hosey et al., 2009). There has been a lot of controversy over whether or not this is a suitable way to view enrichment, because as it stands, some practices (such as giving a vaccine for example) alters the animals' lifestyle, and may improve the animal's physical fitness and overall health, but still induces pain, and under this view is still considered "enrichment". Arguments have been made to permanently change the definition to "any changes in an animal's life or environment that confers benefits without any negative ramifications" (Hosey et al., 2009, p. 261). Many of the commonwealth countries state that enrichment can be defined as "an animal husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being" (Shepherdson, 1998, p. 2). Likewise, the Association of Zoos and Aquariums has a similar definition and argue that enrichment should be defined as a "dynamic process for enhancing animal environments within the context of the animal's behavioral biology and natural history" (Association of Zoos and Aquariums [AZA], 2009a, np). Despite which definition is used as a frame of reference, enrichment should aim to positively influence the lives of animals in captivity.

In particular, the goal of many enrichment programs is to generate some behavioural changes in the animals (Hosey et al., 2009). Specifically, this could include the stimulation of positive behaviours or prevention of aversive behaviours that could contribute to improved fitness (Hosey et al., 2009). Enrichment therefore aims to enhance "natural behaviour expression by increasing activity and preventing stereotypies" (Hosey et al., 2009, p. 263). Observing stereotypic behaviour – which can be defined as "repetitive, unvarying behaviour with no obvious goal or function" – can help determine the extent to which the animals' psychological well-being has been compromised in captivity, and can determine the level of need of multiple forms of enrichment (Mason & Rushan, 2006, p.1). The behavioural objectives of enrichment can be placed in three separate categories. The first is to promote wild-type behaviour, ultimately bringing wild and captive animal behaviours more in line with each other (Hosey et al., 2009). The second is to promote the development of desirable behaviours and to avoid undesirable behaviours such as stereotypies or self-injurious behaviours (Hosey et al., 2009). Although this seems optimal, it has been suggested that completely reducing these behaviours may not be as beneficial as anticipated as many animals will use the display of these types of behaviours as coping mechanisms for living in captivity (Hosey et al., 2009). On the other hand, if conditions in captivity were improved, it is reasonable to assume that the animal would not need to deploy these coping mechanisms as often. The final objective of enrichment is to promote active behaviours (Hosey et al., 2009). The thought being that active behaviours ensure an adequate level of exercise and stimulation and helps enhance the fitness of the animal. Clark and Melfi (2012) argue that the main objective of environmental enrichment is to promote a target species-typical behaviors and behavioral diversity, while increasing the use of enriched exhibit zones. Enrichment programs in zoological facilities can meet their objectives by acquiring knowledge of a species' natural behaviours and physiology before implementing one of the forms of enrichment and their associated enrichment devices (Hosey et al., 2009). It is important to note that there is no optimum method for providing enrichment for all species, particularly primates, however there are some "best practices" that can be explored (Marriner & Drickamer, 1994). It is important to understand the needs of the animal in question, and to treat the development of an enrichment program in a species-specific manner. This requires trial and error, and the combination of a number of different enrichment methods at once. Re-evaluations and re-configuring enrichment programs should also occur frequently in order to ensure the upmost quality of care for the animals. The remainder of this section will outline the major forms of enrichment devices, and will discuss some of the neurobehavioral evidence supporting the implementation of these devices.

There are five general categories of enrichment. The first category of enrichment is food-based enrichment. This type of enrichment includes providing different types of food or a mixture of food, as well as presenting food in novel ways (AZA, 2009). Enrichment devices - defined as objects that can be manipulated by the animal - can be used to accomplish this form of enrichment (AZA, 2009). There are two main types of enrichment devices, natural and man-made, and this form of enrichment incorporates both types (AZA, 2009). Accomplishing this form of enrichment involves manipulating food in the following ways: food may be presented as fresh, frozen, soft, hard, smooth, rough, heavy, light, or cold; and may be incorporated into puzzle boxes, hidden in or scattered about the habitat, or buried in the substrate (AZA, 2009). Many studies surrounding food-based enrichment demonstrates that captive animals spend much less time engaging in food-related behaviours than their wild counterparts, and so making captive animals active in the search for their food enhances hunting and foraging behaviors, problem-solving strategies, and facilitates behavioral conditioning (Hosey et al., 2009). Other studies show that when an animals' food is hidden, or lower calories are given at one time, the animal will be much more motivated to engage in foraging activities, making food-based enrichment one of the easiest and most commonly deployed enrichment techniques (Hosey et al., 2009). Food-based enrichment can also aid in promoting species-specific behaviour. For example, at the Paignton Zoo in the United Kingdom, zookeepers provided their elephants with straw that had been placed in a wire rack. The only way to gain the food was for the elephants to use their dexterous trunks to twist around the bars reaching the food (Hosey et al., 2009). This species-specific behaviour is often loss or underutilized in captivity, and using food-based enrichment is a good method for re-establishing diminishing positive behaviours. Furthermore, Clark and Melfi (2012) found that presenting two food-based enrichment devices together significantly increased species-typical behaviors and the behavioral diversity of armadillos and bush babies. Changing the number of feedings, or altering the feeding schedule in another commonly used technique (Swaisgood & Shepherdson, 2005). This introduces unpredictability and simulates more of a wild environment.

The second type of enrichment is physical enrichment. This form of enrichment is defined as "any change to the animals' structural environment, whether permanent or temporary, or the provision of objects that can be manipulated" (Hosey et al., 2009, p. 267). The most important aspect of an enclosure is its design, and it's important to include the appropriate species-specific beams, platforms, ponds, perches, nesting/denning areas, feeding/water dispensers and barriers (Hosey et al., 2009). Barriers in particular are an important aspect of enclosure design as they provide privacy areas for the animals to hide and to get out of visitor's view. A properly designed enclosure promotes active behaviours and physical exercise, and has the potential to enhance their behavioural repertoire. Space should also be a top priority when designing an enclosure (Hosey et al., 2009). Animals who do not have adequate space may not receive adequate exercise, which could result in wasting disease and other physical ailments (Hosey et al., 2009). Physical enrichment techniques aim to enhance both physical and psychological well-being. In terms of psychological health, physical enrichment in the form of toys has the potential to stimulate social and cognitive development, on top of physical development.

The third type of enrichment is sensory enrichment. Sensory enrichment is defined as anything that stimulates the animals' senses, including their sense of smell, touch, hearing, vision, and taste (AZA, 2009). This type of enrichment is particularly important because animals rely on their senses for survival and communication. Examples of olfactory stimuli may include: pheromones; prey scents; or novel scents such as spices or perfumes (AZA, 2009). Tactile stimuli may encompass different textures and different building materials incorporated into the enclosure design (AZA, 2009). Auditory stimuli could include natural sounds or animal vocalizations (AZA, 2009). Visual stimuli could include: other animals in close proximity;

different colours; objects that move in response to the wind or water; mirrors; or video presentations (AZA, 2009). Finally, gustatory stimuli could include flavoured food or drinks. One good example of the use of this enrichment technique is incorporating bird sounds into the leopard enclosure (Hosey et al., 2009). This stimulates the animal's foraging behaviours as the bird sounds signifies possible food. Sensory enrichment has the least amount of scientific research to demonstrate its efficacy, but it remains an active area for future research.

The fourth form of enrichment is social enrichment, which can be defined as "interactions with other animals or people" (Hosey et al., 2009, p. 267). One common way of facilitating this type of enrichment is through social groupings. These groups should resemble those observed in the wild, in order to facilitate feeding, grooming, social, territorial, and courtship behaviors (Hosey et al., 2009). "Mixed species exhibits may also provide symbiotic or complementary activities between species" (AZA, 2009, np). One good example of this is the study conducted by De Rouck et al. (2005) on the appropriate housing conditions for captive tigers (*Panthera tigris).* They found that housing tigers in pairs promoted a greater diversity of performed behaviour in comparison to tigers housed alone. Interactions with human-beings on the other hand, despite being a part of the formal definition of social enrichment, can have negative effects on captive animals, and can not only create stress, but can also make it nearly impossible to successfully reintroduce the small percentage of species that will ever be reintroduced into their natural ranges (Hosey et al., 2009). As a result, it has been argued that the formal definition of social interaction should be limited to social interactions with non-human animals only.

The fifth and final form of enrichment is cognitive enrichment. This can be defined as "additions to the environment that requires problem solving of differing degrees of complexity to stimulate the animals mentally" (Hosey et al., 2009, p. 269). These problem-solving skills would require the use of navigational, tool-making, or cooperative skills and can aid in challenging the animals' cognitive skills (Meehan & Mench, 2007). Cognitive enrichment is often used in association with food enrichment, and leads to a concept referred to as contrafreeloading (Hosey et al., 2009). This concept demonstrates that captive animals want to work through cognitive enrichment devices for food rewards, even if food is freely available (Hosey et al., 2009). For example, Coulton et al. (1997), demonstrated that captive parrots (*Rhynchopsitta pachyrhyncha*), macaws (*Ara chloroptera*), and lorys (*Lotius garrulous*) preferentially ate from a wooden log with food hidden in it, even though food was available in a bowl. The enrichment device mimicked these animals' natural environment, and stimulated them to the point where they would rather work for their food then receive it freely. Hosey et al. (2009) argues that using food based cognitive enrichment devices not only increases the likelihood of the device being used, but it evokes species-specific behaviour and prolongs the amount of time the animal is engaging with the device and receiving stimulation. Many of these studies suggest that environmental enrichment is beneficial for improving the lives of captive zoo animals, if this is true, how exactly does enrichment work?

The goal of any enrichment program is to provide opportunities for motivation and species-specific behaviour, while reducing undesirable and abnormal behaviours (Martin, 1999). But what are these abnormal behaviours? As mentioned above, some abnormal behaviours commonly associated with captivity are: abnormal escape response; refusal of food; abnormal aggressiveness; stereotyped motor reactions; self-mutilation; abnormal sexual behaviour; perversion of appetite; and apathy (Hosey et al., 2009). The ways in which enrichment can help reduce the display of these behaviours is well explained by Curtis and Nelson (2003), in their review on how enrichment affects the brain of captive laboratory animals. The experiment they discuss was conducted on captive laboratory mice, however the neurochemical and neurobiological alterations exhibited in the brains of these animals can be expected in any captive animal, including those living in zoological facilities. They determined that enrichment has the ability to affect 4 general areas of the brain and its associated structures. First, enrichment devices could influence and alter neurochemicals in the brain. In particular, the mice that were exposed to enriched environments had a higher amount of acetylcholine production in the cortex of their brain, in comparison to mice who did not receive any enrichment (Curtis and Nelson, 2003). Acetylcholine is an active neurotransmitter that reduces heart rate (anti-anxiety affects), and activates muscles (reduces apathy and motivates the animal to be active), demonstrating its importance for mitigating some of the abnormal behaviours mentioned above (Curtis and Nelson, 2003). Second, enrichment devices can alter physiological mechanisms in the brain (Curtis and Nelson, 2003). Specifically, the mice that were exposed to enriched environments spent a greater amount of time in REM (rapid eye movement) sleep, in comparison to mice who did not receive any enrichment. REM sleep plays a critical role in the consolidation of memories, and is important for learning and keeping focused and attentive during the day (Harvard Medical School, 2013). Without an appropriate amount of REM sleep, the subject can experience fatigue, apathy, and impaired coordination. They can also suffer from an inability to learn new things, and can exhibit signs of impaired judgment and behaviour (self-mutilation) (Harvard Medical School, 2013). Third, enrichment devices can cause neuroanatomical changes (Curtis and Nelson, 2003). In particular, mice that were exposed to enriched environments showed a greater cortical weight in the occipital cortex, ventral cortex, and somatosensory cortex than mice who were not in enriched conditions (Curtis and Nelson, 2003). An increase in cortical weight is indicative of enhanced stimulation and use of each of these brain regions. Each region plays an important role in the lives of captive animals, and influences different aspects of their sensory repertoire. Environmental enrichment has therefore been shown to stimulate and enhance brain regions responsible for visual processing mechanisms, memory consolidation, spatial navigation, touch, temperature, proprioception, and nociception (Curtis and Nelson, 2003). Finally, enrichment devices can also cause behavioural changes. The most significant finding from this study was the fact that mice reared in enriched conditions were less fearful, and exhibited lower levels of anxiety than mice who did not receive any enrichment (Curtis and Nelson, 2003). This is an important finding that suggests that enrichment not only alters the neurophysiology of captive animals, but also has the potential to influence and change their behaviour as well.

In discussing the neurobehavioural evidence for enrichment, it is important to consider each form of enrichment individually, and a review of the research demonstrating its effectiveness should be discussed. The first form of enrichment that will be discussed is food-based enrichment. As mentioned above, food-based enrichment involves providing different types of food or a mixture of food, as well as presenting food in novel ways. Baker (1997), demonstrated in his research on the influences of foraging material on abnormal behaviour in captive chimpanzees that foraging behaviour can be stimulated by hiding food in flooring substrate, and that this behaviour increases overall activity and enclosure use, while decreasing incidences of aggression. Other researchers have found similar findings with other primate species, including rhesus macaques *(Macaca mulatta)* and white-faced capuchin monkeys *(Cebus capucinus)*, suggesting that this behaviour was not an isolated incidence but rather can be observed in different species (Lutz and Novak, 1995, Ludes-Fraulob and Anderson, 1999). O'Conner (2000) found similar results but in a completely unrelated species. He found that when captive fruit bats *(Pteropus rodricensis)* were given food unpredictably through a mealworm feeder, it lead to a significant increase in activity level and a significant decrease in acts of aggression. Additionally, Roberts et al. (1999) demonstrated that the use of gum feeders (a long cylindrical feeding apparatus with small holes) in captive laboratory-reared marmosets *(Callithrix jacchus)* significantly reduced the time spent in stereotypic pacing and sitting behaviours. Although this study is based on captive laboratory animals, the same results can be expected in captive zoo animals. These are just a few of the many research studies demonstrating the effectiveness of food-based enrichment in reducing the abnormal behaviours mentioned above.

Physical enrichment, as described above, is "any change to the animals' structural environment, whether permanent or temporary, or the provision of objects that can be manipulated" (Hosey et al., 2009, p. 267). Renner and Lussier (2002) found that providing climbing structures in the bear *(Tremarctos ornatus)* enclosure increased the bears' behavioural repertoire and increased their activity level. Unlike Renner and Lussier, Carlstead et al. (1993) demonstrated a physiological change in response to physical enrichment as opposed to a behavioural change. They found that leopard cats (*Felis bengalensis)* would seek out privacy/hiding places when they were stressed, as indicated by an increase in the steroid hormone cortisol. They also determined that when hiding places and perches were provided, the cats showed an increase in exploratory behaviour and a decrease in stereotypical behaviours relative to those seen in their previously unenriched enclosures. Shepherdson (1994) found similar results that indicated that clouded leopards *(Neofelis nebulosa)* had lower fecal cortisol levels when hiding places were provided, in comparison with leopards that did not have anywhere to hide. These physiological changes demonstrate that enrichment has the ability to not only alter behaviour, but the actual chemical and physical makeup of the brain as well.

Sensory enrichment is defined as anything that stimulates the animals' senses, including their sense of smell, touch, hearing, vision, and taste (AZA, 2009). Despite the lack of research on this particular form of enrichment, there are a few studies that discuss the effectiveness of sensory enrichment. One example was the study conducted by Wells and Egli (2004) on the influence of olfactory enrichment on the behaviour of black-footed cats *(Felis nigripes)*. They found that the activity level of these animals significantly increased when they were provided with cloths soaked in nutmeg or the natural odour of quail, a prey species. The implementation of sensory enrichment can be extremely difficult as human error is a possibility that may lead to a misunderstanding regarding the data and information that you are trying to replicate. The information that you are communicating should be precise and should accurately portray what you intend (Hosey et al., 2009). If precautions are not taken, many captive animals may experience adverse reactions to the sensory stimuli, making sensory enrichment one of the most difficult forms to apply (Hosey et al., 2009).

The next type of enrichment that will be discussed is social enrichment, defined above as "interactions with other animals or people" (Hosey et al., 2009, p. 267). Much of this research has been done on laboratory animals as nowadays, animals in zoological facilities are often housed in social groups, but there are a few studies that analyzed social enrichment in the context of captive zoo animals. For instance, Reinhardt and Reinhardt (2000) argue that social enrichment is essential for captive primate welfare, and having a cage-mate can be very beneficial. Furthermore, Spring et al. (1997) have demonstrated that social enrichment can actually reduce stereotypies in a number of species, even when other environmental changes have not worked. Like sensory enrichment, social enrichment can be difficult to manage, and there are limitations with its implementation that should be considered.

Finally, cognitive enrichment, defined as "additions to the environment that require problem solving of differing degrees of complexity to stimulate the animals mentally" will be discussed (Hosey et al., 2009, p. 269). This type of enrichment often works hand-in-hand with other forms of enrichment, such as physical or food-based enrichment. One good example of the effectiveness of this type of enrichment is the study conducted by Visalberghi and Vitale (1990). They provided nuts to capuchin monkeys *(Cebus paella),* however they coated them in non-toxic glue to make it more difficult for the monkeys to open them. The monkeys were found to spend much more time opening the nuts, and had to find creative ways to open them, such as finding items in the enclosure that they could use as tools. This mental stimulation keeps their minds sharp and encourages species-specific behaviour. Despite the fact that cognitive enrichment is often coupled with other forms of enrichment, it is an ongoing active area of future research.

The above-mentioned research studies endorse the use of enrichment for improving the lives and well-being of captive zoological animals. These studies showed that enrichment affects multiple aspects of the brain and body, and can have profound effects on behaviour. The influence of enrichment devices is without a doubt positive, and there are a number of things that can aid in making enrichment effective. First, the enrichment device should not compromise the health and safety of the animals (Hosey et al., 2009). Second, assessments should be done before the transfer of enrichment devices from one animal to another animal (Hosey et al., 2009). Finally, every enrichment device should be checked to ensure that the animal will not be physically harmed in anyway (Hosey et al., 2009). If zoological facilities take into account these easy considerations, enrichment has the potential to positively influence life in captivity. Another useful frame to consider when thinking about the potential positive effects of enrichment is the extended-self theory. Although this frame is often used to help explain the self-identity of humans, the same concept can be extrapolated and use to understand how non-human animals perceive their surroundings and themselves. This theory explains that ones' self-identity is attributed not only to the way they think and feel, but also to our surroundings (Sivadas & Venkatesh, 1995). The way one feels both emotionally and physically can be directly related to ones surroundings/possessions, better known as their extended-self. Enrichment therefore could enhance the animal's self-identity and in turn their physical and psychological health. With that being said however, the implementation of enrichment devices does not come without its flaws, and there are a few limitations associated with its' application that are worth mentioning.

Despite the overwhelming evidence supporting the use of enrichment in zoos, enrichment can also have its limitations. First and foremost, it is important to note that enrichment methods are extremely variable and generalization between species, and sometimes even between individuals of the same species is difficult. Enrichment that seems to have positive effects on one species many have negative effects on other species, and enrichment methods may not be successful at all. Another limitation of the implementation of enrichment devices is the limited time and ability to test its efficacy (Hosey et al., 2009). Conducting studies to determine the effectiveness of a particular kind of enrichment can be time consuming and inefficient (Hosey et al., 2009). It may take months to years to determine an accurate result, and in the case that you do see a change in behaviour, it is hard to determine the extent to which enrichment was the only influence on that behaviour. One of the common ways to determine whether or not enrichment has had an effect is through observing the animals' behaviour and comparing that behaviour to normal behaviour displayed by wild animals of the same species. This presents a number of concerns. First, if there isn't already a behavioural profile for a particular wild species, then acquiring that information in order to properly compare the behaviour of both groups would be very time consuming and expensive (Hosey et al., 2009). It is a lack of data that makes it extremely challenging to conduct appropriate behavioural studies. Observational studies in general are subjective and often errors and biases occur (Altmann, 1974). Behaviours exhibited by the animals may also be misinterpreted and a behaviour that an observer considered optimal might in fact diminish the animals' health and well-being. Similarly, particular forms of enrichment may promote certain behaviours, but at the same time, some enrichment techniques may prevent the expression of other behaviours that may be an essential part of the animals' behavioural repertoire, thus making reintroductions or breeding programs a challenge. Other more specific limitations involve analyzing each form of enrichment specifically. With regards to food-based enrichment, one recognized limitation is the fact that the provision of food-based enrichment may lead to increased calories (Hosey et al., 2009). If the amount of calories exceeds the animal's daily nutritional requirements, and if the animal is not active, this could lead to a number of health problems, including obesity. Physical enrichment also has its limitations. The most obvious limitation with this form of enrichment is the danger it poses to the animal (Hosey et al., 2009). In many instances, beams and platforms will be designed, and if the appropriate behaviour required to effectively utilize this form of enrichment is dormant, then the animal can suffer injuries and falls. Also, some forms of enrichment, such as physical barriers, may reduce aggression in some members of a species, as they are able to escape the visitors' view, however may cause more aggression in other members of the species (Hosey et al., 2009). For example, the provision of barriers reduces aggression in female pig-tailed macaques *(Macaca nemestrina)*, but because these females can also hide from the males of the group, this increased aggression in the males (Erwin, 1979). Another limitation of physical enrichment (as well as other forms of enrichment) is its limited novelty. The enrichment device may provide stimulation for a brief amount of time, and then the novelty might diminish overtime. The constant provision of new enrichment devices could be expensive and unattainable. Sensory enrichment is probably one of the most difficult enrichment devices to implement, as it requires extreme care and knowledge regarding the information that you are portraying. Some olfactory and auditory stimuli intended to stimulate and arouse specific species, may in fact do the opposite and cause stress and anxiety (Hosey et al., 2009). Similarly, visual stimuli, such as the proximity of an enclosure to other animals (whether it is a prey or predator species) can cause extreme stress and may result in avoidance behaviour (Hosey et al., 2009). Social enrichment, such as proximity to humans, multiple-individual exhibits, and mixed-species exhibits can lead to social pressure and competition for resources. This can lead to acts of aggression, such as fighting, as well as the display of stereotypic behaviour (Hosey et al., 2009). In terms of cognitive enrichment, one common limitation is the display of frustration in response to challenging stimuli (Hosey et al., 2009). Although the benefits outweigh the limitations, frustration can lead to aggression and stress, which can have negative effects on both physiological and behavioural systems. Many of these limitations could be managed and the risks associated with implementing enrichment devices can be reduced. The amount of research on the efficacy of enrichment is limited, and a more thorough investigation into the potential benefits and limitations of its implementation should be conducted.

As mentioned above, one method for analyzing the effectiveness of enrichment devices is to compare the captive animals' behaviour with the behaviour of wild individuals of the same species. This relies heavily on observational studies and analysis, and depends on the observers' accurate interpretation of behaviour. In many cases, this is the only method used for analyzing the extent to which the behaviour being displayed is less than optimal, despite the fact that observational studies are often highly subjective and have a multitude of limitations. Conducting observational studies can be tricky, and an understanding of the methods, processes, advantages, and limitations involved in this type of study should be discussed before an accurate picture of the effectiveness of enrichment devices can be drawn.

Section 5 - Observational Studies

Observational studies are one of the most common qualitative research methods. Observation can be defined as, the action or process of perceiving/observing someone or something, in order to gain information for a particular purpose (Oxford Dictionary, 2014). In terms of assessing an animal's behaviour in captivity or in the wild, observational studies are the research method used most frequently. Observational studies can be used to assess the type of displayed behaviour, such as displays of aggression, foraging, or social or mating behaviours, and can also be used to determine the frequency with which the animal displays a particular behaviour. If data are collected accurately, it can tell the researcher a lot about the physical and psychological state of the animal, which can be used in a number of different research areas. Despite these benefits, observational studies also have a number of limitations, many of which will be discussed later. Within the broad category of observational studies, a number of different research designs and methods are often deployed. Choosing the right research design and method can be challenging, and researchers often find themselves questioning which research design and method are the most appropriate for their behavioural research problem, while attempting to limit the options that could potentially restrict their research (Altmann, 1974). Even after choosing an appropriate research design, choosing the method of data collection can raise its own questions. Should every occurrence of behaviour be recorded? Should one member of a group be the focus, or should each individual in a group be assessed? These questions, and many more, can make observational studies all that more difficult. The remainder of this section will first discuss the different types of observational research designs, followed by a discussion on the most common observational research methods and the associated benefits and limitations of each. This section will conclude with a discussion on the benefits and limitations of observational studies in general.

Observational Research Designs

There are three different types of observational studies – cross-sectional, cohort, and case-control (Carlson & Morrison, 2009). Although these research designs are often used to observe human participants, any research design that aims to assess behaviour to a particular stimulus can also be used to observe animal participants as well (Toris, 2010). A cross-sectional observational research design, like cohort and case-control, can involve the use of a diverse population in a range of possible settings (Carlson & Morrison, 2009). Exposure to something (whether it be a disease, or a particular stimuli), and the outcome of that exposure are discovered simultaneously (Carlson & Morrison, 2009). The main use of this type of observational design is too screen hypotheses and determine the prevalence of something (such as a disease or a particular behaviour) (Carlson & Morrison, 2009). A cohort observational research design also involves a diverse population in a range of settings, but exposure to something is usually identified before the outcome can be determined (Carlson & Morrison, 2009). The main use of a cohort research design is to “assess associations between multiple exposures and outcomes over an extended period of time” (Carlson & Morrison, 2009, p. 2). Finally, a case-control observational research design also involves a diverse population in a range of settings, but the outcome of an exposure is determined before the exposure itself can be ascertained (Carlson & Morrison, 2009). The main use of this type of research design is to assess the associations between the exposure to something, and rare outcomes (Carlson & Morrison, 2009). Each of these research designs play their own role in aiding the complexities of observational studies, and the correct design to use will be based on the particular research question being investigated.

Observational Research Sampling Methods

In terms of observational sampling methods that aim to collect behavioural data, there are a number of different options to choose from. Specifically, you could choose any one of the following: *Ad libitum* sampling; sociometric matrix completion; focal-animal sampling; all occurrences sampling; sequence sampling; one-zero sampling; and instantaneous and scan sampling (Altmann, 1974). These methods can be used individually, or multiple methods can be used in the same study, depending on the research question (Altmann, 1974). Although each of these sampling methods has its own benefits and limitations that should be discussed, for the purposes of this paper, I will focus on focal-animal sampling, all occurrence sampling, and one-zero sampling. These three sampling methods are commonly deployed when conducting research on animal behaviour, and each will be discussed individually.

Focal-animal sampling refers to "any sampling method in which (i) all occurrences of specific actions of an individual, or specified group of individuals, are recorded during each sample period, and (ii) a record is made of the length of each sample period and, for each focal individual, the amount of time during the sample that it is actually in view" (Altmann, 1974, p. 242). This type of sampling follows the selected focal individual to whatever extent possible in each sampling period (Altmann, 1974). One limitation of this sampling method is that it is only possible if you can keep every selected focal individual under continuous observation until that sampling period is completed. This may be problematic if the animal you are observing has a large home range with multiple places to hide. This is often a common problem when observing animals in the wild, but is less challenging when animals are in a captive enclosure. However, one benefit of this type of sampling method is that when an observer is following one focal individual continuously, they may observe behaviours in situations that they would not ordinarily be able to observe (Altmann, 1974). Although this may provide the observer with crucial information, the amount of time that would need to be invested in observing an animal in order to get this type of information might be out of reach. When observer's use this type of sampling method, the length of a sample session needs to be addressed, for fear that a prolonged session may lead to inaccurate data collection due to observer fatigue (Altmann, 1974). Altmann (1974) argues that this type of sampling is usually the technique chosen by animal behaviourists, because it can provide relatively unbiased data, however because the observer is collecting data on one individual, it is not a good method if your behaviour question seeks to understand the behavioural synchrony of the focal species.

All occurrence sampling method involves "recording all occurrences of certain classes of behaviours in all members of the group during each observation period" (Altmann, 1974, p. 247). In order for this type of sampling method to work, observational conditions must be excellent, the behaviours must be attention-attracting, and the behavioural events cannot occur too frequently (Altmann, 1974). This specific type of sampling method is excellent for providing information about rate of occurrence of a particular behaviour in the group (Altmann, 1974). If each member of the group can be identified at the same time as the occurrence of the behaviour under study occurs, then this type of sampling method is equivalent to focal-animal sampling, and the data collected can represent an unbiased sample of the distributions of behaviours among individuals of that particular species (Altmann, 1974). This type of sampling method is also appropriate for studies involving behavioural synchrony, but only as long as the observational and recording conditions allow the behaviour to be recorded, even if that behaviour is occurring in more than one individual simultaneously (Altmann, 1974). This type of sampling method is typically not the method of choice if your research involves sequential analysis, as it records all behaviour of all members of a group, and doesn't necessarily focus on a target behaviour that directly follows a specific behaviour (Altmann, 1974).

One-zero sampling method is another commonly deployed observational research method that can be defined as " the observation of everyday behaviour of an individual or group of individuals for definite short periods of time and the recording of the occurrence or non-occurrence of certain specified and objectively defined forms of behaviour during each of these periods" (Altmann, 1974, p. 251). This type of sampling method focuses on whether or not a behaviour occurred, rather than the frequency at which a specific behaviour, or class of behaviours occur. The interactions of individuals or pairs of individuals are recorded in each sample period, in which the sample periods are often short (15-30 seconds) (Altmann, 1974). This method is often used when observing caged animals and it provides an accurate picture of the frequency of intervals that included the animal spending any amount of time in a specified behaviour (Altmann, 1974). With that said, this method tends to record the animal in a particular behavioural state (a behaviour that is already in progress), rather than recording a specific behavioural event. This type of sampling methods does not provide any information on the frequency or duration of the behaviour in question, and despite the fact that it may be easier to deploy and has a greater observer agreement, this type of method does not provided very much information about the behaviour in question, and should be used with caution (Altmann, 1974).

Observational studies are a "necessary link between laboratory research and real world behaviour" (Altmann, 1974, p. 4). They have the ability, when used carefully, to help enhance our knowledge of animal behaviour and behavioural interactions among wild and captive species. Topics such as, but not limited to: mating; hunting; social interaction; hierarchies; and coping are not fully understood for every species, and observing these animals is the only way to acquire more information on these important topics. Other areas of research, such as the effects of captivity on these behavioural processes and the resulting implications on the animals' physical and psychological health, also require more accurate records. Despite the growing need, observational studies have a number of limitations as well. First and foremost, observational studies in general are subjective, and the observed behaviour indicated by the observer may be their interpretation of the actual behaviour displayed (Altmann, 1974). The reported behaviour may be inaccurate, which may be problematic when using this data for example, to assess the physical and psychological health of a captive animal. This observer bias can inhibit the collection of accurate data, ultimately skewing the results of the study (Altmann, 1974). Furthermore, just the observers' presence may be enough to disturb or alter the normal behaviour patterns of the animal (Altmann, 1974). This can also negatively impact the results of any observational study. If the subject is aware of the observer's presence, the animal may display aggressive or maladaptive behaviour because they are not pleased with the intrusion. This behaviour may be observed and concluded to be the result of another stimulus, and may not reflect the true cause. It is assumed that each observer will take precautions to avoid inserting biases into the study, and take a number of precautions to prevent their presence from altering the behaviour of the subjects, but sometimes these things could occur regardless of how diligent the observer is. To limit the impact the observer may have on the study, Ary et al. (2009), have developed a few preliminary steps that should be taken before engaging in direct observational studies. First, they argue that the specific behaviour that you will be observing should be addressed. It is unrealistic to assume that an observer can record all instances of behaviour, especially when they are observing more than one subject, and so selecting the behaviour beforehand limits errors that could occur when trying to record every behaviour (Ary et al., 2009). Second, the researcher needs to clearly define which behaviours fall under the category of behaviour you will be assessing. This limits observer interpretation, therefore limiting observer bias (Ary et al., 2009). Third, a method for quantifying and recording the desired behaviours must be determined (Ary et al., 2009). For example, having observation segments, or specific times from which the behaviour will be recorded reduces observer fatigue, again, limiting potential observer bias. Fourth, the researcher should develop a method for recording the behaviour in question (Ary et al., 2009). For example, if the behaviour is occurring too rapidly, it may be beneficial to create a coding system that can be jotted down quickly and accurately interpreted later. This will avoid having to rely on the observer's memory which could also lead to observer bias. Finally, they argue that it is extremely important to ensure that the observers know the objectives of the study and what is expected of them (Ary et al., 2009). Making sure that everyone is on the same page and fully aware of their duties reduces the chances of careless errors. Other limitations with observational studies are the issues surrounding its precision and validity. Generally speaking, precision refers to "a lack of random error or random variation in a study's estimates", and can be assessed by considering the sample size and efficiency of the study (Carlson & Morrison, 2009, p. 80). Specifically, a larger study with a more balanced group of subjects allows for greater precision. With that being said however, a smaller, well-balanced group, may be easier to observe, yielding more accurate data, and thus contributing to a high study precision as well (Carlson & Morrison, 2009). Next, the issues surrounding the validity of a study are also important to consider. Specifically speaking, observational studies tend to have high external validity and low internal validity. Internal validity refers to “the strength of the inferences from the study” (the evidence for casualty), whereas external validity refers to the “degree to which the conclusions in a study would hold for other subjects in other places and at other times” (Carlson & Morrison, 2009, p. 81). As mentioned above, the behaviour observed could be the result of a number of different stimuli, and differentiating the cause of a particular behaviour may be challenging. Furthermore, being able to generalize results across different groups may be more attainable, however the sample group should be large, and subjects should be assessed from different facilities and at different times. This ensures a well-rounded sample that is more likely to yield comprehensive, inclusive results.

It is well known that with any type of observational study, observer bias has the potential to influence the results of the study. However like any limitation, this type of pitfall can be addressed and the impact that it may have on the study can be reduced. As long as the researchers are aware of the shortcomings of the study design and/or sampling method, and they take the necessary precautions to address and train other members of the research team to be aware of these shortcomings, they can keep the potential negative effects to a minimum. Observational studies are very important in animal research, and can provide us with important information that wouldn’t be otherwise known. The next section uses observational studies to assess the effect enrichment devices have on the physical and psychological health of two members of the primate family at the Toronto Zoo. This study will hopefully shed some light on the extent to which enrichment should be deployed for all animals in a captive zoological setting.

Research Study - Investigating the effects of enrichment on the physical and psychological health of two related species at the Toronto Zoo

Introduction

Captivity, and the negative health implications that go along with it, have the potential to negatively affect the physical and psychological welfare of zoo animals (Hosey et al., 2009). As captivity becomes more and more necessary to prevent species extinctions, the role of zoological facilities, and the ways in which they abide by animal welfare practices and philosophies, are called into question. Despite the improvements in the ways in which accredited zoological facilities care for their animals, there are always ways to improve the quality of life for these animals. Animal welfare issues in zoological facilities are well known and well researched, and it is not unheard of to have many animals succumb to both physical and psychological health problems as a direct result of captivity (Hosey et al., 2009). One method for mitigating such a common problem among zoological facilities is the relatively new idea of enrichment (Markowitz, 1982). There are many different types of enrichment, everything from environmental enrichment to cognitive and food-related enrichment, and a general consensus among academic literature is that enrichment does in fact positively contribute to the animal's overall physical and psychological well-being (Hosey et al., 2009, Clark, 2011, Mason et al., 2007). In terms of the care for primates specifically, this wasn't revolutionized until the late 20th century when the Ontario Society for the Prevention of Cruelty to Animals Act was amended in 2009 to include a separate section for the regulation of primate care in captivity (Ontario Society for the Prevention of Cruelty to Animals Act, 2009). This regulation assures that primate species will be given physical, social, and cognitive enrichment, on top of the regular standards of care that apply to all captive species. Enrichment has become a new method of hope for captive species, and although there are many articles within the literature that explore this topic, there is a gap in the literature in assessing two related species, each with differing levels of enrichment, and exploring both physical and psychological health instead of one over the other. This study will aim to compare the effect of differing amounts of enrichment on the physical and psychological health of two primate species – the western lowland gorilla (*Gorilla gorilla gorilla*) and the ring-tailed lemur (*Lemur catta*) – at the Toronto Zoo. This will not only provide important information on the effectiveness of enrichment devices specifically for these two species, but will also help determine the extent to which enrichment could and should be used for all zoo animals.

Study Species/Study Area

These species have roughly the same number of visitors, and whose nutritional requirements are met each day. Their enclosures are very close together within the same pavilion, and they both live in the same tropical climate that has artificially been created at the Toronto Zoo. Having two primates that have this much in common will help control for other elements that could be influencing the display of abnormal behaviour, and can help eliminate possibilities as to why one species might be displaying more abnormal behaviour than the other.

The western lowland gorilla is the smaller of the two subspecies of gorilla, and despite its critically endangered status, it still remains an important member of the great ape family – a group that consists of some of the most powerful jungle species in the world (Kubesh et al., 2007) (Fig 1). Gorillas are the largest of the great ape family and they reside in Africa (Kubesh et al., 2007). They have broad chests and shoulders, human-like hands, small eyes, can reach a height of 4-6 feet and can reach a weight of 440 pounds (Kubesh et al., 2007). They live in small social groups called troops that typically consist of five to ten members, and can live up to 50 years of age in the wild and even longer in captivity (Kubesh et al., 2007). This species is listed a critically endangered with a population of 100 000-200 000 (Kubesh et al., 2007). The survival of the gorilla is in jeopardy for a number of reasons, including: habitat loss; hunting; trading; and disease (Kubesh et al., 2007). It is because of these reasons that the need to place gorillas in captivity has never been more necessary. In captivity, particularly at the Toronto Zoo (located in East Scarborough, near the Scarborough/Pickering border), the western lowland gorilla receives a vegetarian diet, consisting of, but not limited to: tofu; sweet potato; squash; carrot; lettuce; corn on the cob; cauliflower; broccoli; green beans; browse; silage (fermented apple); and oranges. The gorillas also receive vitamins, antibiotics if they are sick, and the females receive birth control to reduce the chances of inbreeding. The gorillas at the Toronto Zoo are housed in a social group of 7 gorillas, including one 3-month old baby girl. The two elders (Josephine and Charles) are wild-born gorillas, and the remaining 5 are captive-born. The group consists of 3 females, and 4 males – with only one dominant silverback male. They are fed 3-4 times daily, and have a regular feeding schedule. They also alternate between the inside and outside enclosure, depending on temperature and weather conditions. Without knowing the dimensions of these enclosures, they look visibly larger than the size of other primate enclosures at the Toronto Zoo, including the ring-tailed lemur enclosure.

The ring-tailed lemur is an endangered primate species that occupies a small, isolated island off of the coast of Africa known as Madagascar (Jurmain et al., 2012) (Fig 2.). They use their hands and feet to move through the trees, however they can’t use their long, stripped tails for gripping. They are about 45 centimetres tall, and weigh anywhere from 5 to 7.5lbs (Jurmain et al., 2012). These lemurs can live up to the age of 25 years in the wild and potentially longer in captivity, and live in social groups called troops of up to 10 to 25 individuals. They use scent glands and the corresponding odor as a dominant method for communication and mating (Jurmain et al., 2012). This species is quickly declining in the wild because of habitat loss, and a lack of suitable habitat elsewhere. As a result, ring-tailed lemurs are often placed in zoological facilities for conservation purposes. At the Toronto Zoo, this species lives in a social group of 11 adults and 2 babies. The troop consists of both males and females, most of which are captive born, with one dominate female leading the group. They are also fed a vegetarian diet roughly 3-4 times a day on a regular feeding schedule. They receive a number of food items, including but not limited to: lettuce; sweet potato; green pepper; zucchini; apples; and oranges. They are kept in one enclosure, however the enclosure design has allowed for natural light and warmth. The enclosure is about three-quarters the size of the gorilla enclosure and although smaller, houses this troop efficiently.

The evolutionary care of these species has dramatically changed over the past few decades and a comparison study on how enrichment affects two primate species was needed (Fig 3). In this study, both primate species received enrichment, but the amount of enrichment provided to both species differed, ultimately allowing for a comparison between the amount of enrichment and the amount of abnormal behaviour displayed. The goal is to assess the influence enrichment has on both the physical and psychological health of both species and to see if enrichment can help reduce the amount of abnormal behaviour displayed. For the purposes of this observational study, stereotypic behaviour is characterized as "excessive repetition of or lack of variation in vocalizations, movements, postures, or patterns of travel" (Gorilla Species Survival Plan, 2008, p. 15). The display of abnormal/stereotypic behaviour often indicates that the animal "is in some way suffering [either mentally or physically] or that its welfare has been compromised" (Hosey et al., 2009, p. 116). Marriner and Drickamer (1994) even go as far to say that stereotypic behaviour indicates “that an animal's psychological welfare is at a suboptimal level” (p. 267).

Methods

Before the behaviour of both species could be assessed, the types and amounts of enrichment in each enclosure needed to be evaluated. All visible enrichment devices were noted and additional enrichment devices that may not have been visible to the public were identified by the animal keeper, and subsequently recorded. The only enrichment device that was added to the enclosure during each observational period was food-based enrichment devices. The animals within the enclosure were then identified with the help of the keeper. This was relatively easy with the gorillas, as the size of each gorilla was distinct and easily recognizable. This was not the case with the lemurs, as there were a larger number of individuals, who all looked very similar. In this case, the dominant female was the only one who could be identified and recognized. This information was not used for any specific reason, as all individuals were observed for abnormal behaviour, instead, this information was used to obtain a general familiarity with the subjects being observed. This was followed by observations of abnormal behaviour of these two species. An observational research design was adopted for this study where the associations between the exposure to enrichment devices in captivity and the expression of abnormal behaviour were assessed over a period of time (Carlson & Morrison, 2009). All occurrence sampling method was used to record all occurrences of abnormal behaviour during the specific observational periods (Altmann, 1974). Abnormal behaviour was recognized using previously researched ethograms of each species that had distinguished between normal and abnormal behaviour (Fig. 4 & 5). Observational data was collected on different days of the week, at different times, with hopes of collecting a well-rounded and representative data set of any abnormal/stereotypic behaviour. Each observational period was 2 hours long, and 5 observational sessions occurred from April 28th, 2014 to May 15th, 2014, amounting to 10 hours of observation for each species. The weather conditions and number of visitors were also documented during each observational period. Microsoft Excel was used to analyze any data obtained. Finally, one gorilla animal keeper, and one ring-tailed lemur animal keeper were asked a number of questions to obtain data on the physical health of the animals over a one-year period. The purpose of obtaining these data was to see if the amount of enrichment had any correlation with the amount of abnormal behaviour displayed by each species, or the number of physical illnesses that occurred over a one-year period.

Results

The different types and amounts of enrichment were identified (Table 1). It was found that both species were given a mixture of all 5 categories of enrichment, but that the gorillas were given a greater quantity of enrichment in comparison with the ring-tailed lemurs. The gorillas were given a greater amount of each type of enrichment, aside from social enrichment, as their enclosure is only a single-species space. The greatest differences in the amount of enrichment were seen in the amount of food-related and physical enrichment. The gorillas were given more enrichment devices in these two categories, with a total of 73 devices, in comparison to the ring-tailed lemurs who were given a total of 23 devices. The gorillas received four times the amount of food-related and physical enrichment combined, than the ring-tailed lemurs. Overall, the gorillas were given over three times as many enrichment devices as the ring-tailed lemurs.

Observational studies of both species were then conducted. All occurrences of abnormal/stereotypic behaviour were documented in (Table 2). It was documented that regardless of the weather conditions or number of visitors, the ring-tailed lemurs consistently showed more abnormal behaviour than the western lowland gorillas during the 10 hours of observation for each species. They not only showed more abnormal/stereotypic behaviour overall, but the ring-tailed lemurs also showed more stereotypic behaviour in comparison with the gorillas in each observational period. The ring-tailed lemurs showed 37 instances of abnormal/stereotypic behaviour, whereas the gorillas only showed 4. On average, the ring-tailed lemurs displayed 7.4 abnormal behaviours over the 10 hours of observation (s^2=6.64, s=2.58), whereas the gorillas displayed 0.8 abnormal behaviours over the 10 hours of observation (s^2=0.16, s=0.4). It was noted that as the temperature got warmer (May 7th to May 15th, 2014), the number of visitors increased, however this had no effect on the number of displays of abnormal behaviour for either species. The gorillas did not perform the same abnormal behaviour more than once during each 2 hour observational period, which amounted to 4 distinct types of stereotypic behaviour. This differs from the ring-tailed lemurs who not only displayed the same stereotypic behaviour more than once during the same 2 hour observational period, but also displayed a number of different types of abnormal/stereotypic behaviour in the same observational period. The gorillas displayed stereotypic rocking and pacing (on April 24th and May 6th), as well as two different types of stereotypic object use, including rope pulling and stick shaking (on April 28th and May 7th). The ring-tailed lemur displayed multiple instances of stereotypic self-grooming and grooming-other, as well as, stereotypic pacing and self-injurious behaviour (April 24th to May 15th). It should be noted that the large difference in the amount of abnormal/stereotypic behaviours displayed by each species could be, in part, because there are more individuals to observe in the ring-tailed lemur troop in comparison with the gorillas, therefore increasing the probability that a larger number of abnormal/stereotypic behaviours will be observed. With that being said, the ring-tailed lemurs have more than double the number of individuals than the gorillas, however the amount of abnormal behaviour displayed from the lemur's is not double that of the gorillas, but is just over 9 times that of the gorillas. The larger amount of stereotypic/abnormal behaviour displayed by the ring-tailed lemurs therefore cannot be solely the result of more individuals, but rather the result of some external influence. Although this is not included in Table 2, it should also be noted that the amount of abnormal/stereotypic behaviour displayed by the ring-tailed lemurs far exceeds that of the gorillas, in terms of both duration and frequency. Not only did members of the ring-tailed lemur troop perform abnormal/stereotypic behaviour at a higher frequency than the gorillas, but they engaged in that behaviour for a much longer time than the gorillas. Each individual gorilla who displayed abnormal behaviour only displayed it for roughly 30 seconds, whereas each individual ring-tailed lemur who displayed abnormal behaviour displayed it for a few minutes each time. Although some of these behaviours, such as self-groom or grooming-other, are considered "normal" behaviours, what makes them abnormal and stereotypic is the frequency with which they are performed. To sum-up, the ring-tailed lemurs showed a greater number of abnormal/stereotypic behaviours, and these behaviours were more frequent and lasted longer than the gorillas.

Two animal keeper's (1 gorilla keeper and 1 ring-tailed lemur keeper) were then asked a number of questions in order to get an idea of the physical health of both species, and to discuss the kinds of illnesses that these captive animals can succumb too. The results of these interviews are illustrated in Fig 6 & 7. The keeper's wanted to remain anonymous for this study, however they provided a lot of interesting information on the physical health of these species. In particular, it was interesting to note that the gorillas had more incidences of physical illness than the ring-tailed lemurs. On average, one gorilla (or multiple individuals at once), acquire 2-3 physical illnesses in a one-year period, as opposed to the ring-tailed lemurs who have had reportedly zero incidences of physical illnesses over the last year. The types of illnesses that each group could acquire was also different, and while the gorillas were more prone to genetic ailments or bacterial infections, the ring-tailed lemurs were more prone to nutritional issues. It is interesting to note that despite the gorillas having more enrichment devices, they still had more incidences of physical illness in a one-year period when compared to the ring-tailed lemurs.

Discussion/Conclusion

Some of the findings were expected, while others were surprising. In terms of the amount of enrichment both the gorillas and the ring-tailed lemurs received, it was expected that the former would be given more enrichment devices than the latter. Results indicated that this was the case, and can more than likely be contributed to the fact that gorillas are more popular, and attract a larger number of visitors than the ring-tail lemurs. To gain public support, it may be essential to use charismatic species or species at risk to spark interest and motivate society to help conserve this species (Toronto Zoo, 2007). Although both the ring-tailed lemur and western lowland gorilla are considered “charismatic” species, the gorilla is more globally recognized, and is an important flagstone species – a charismatic species that acts as a symbol and helps stimulate conservation awareness and actions (Heywood, 1995). The fact that the gorilla shares 98.3% of their DNA with humans (their genome only differs by roughly 1.6%) may also spark an inherent obligation for public participation in their survival and well-being (Goidts et al., 2006). For these reasons, it makes sense to provide the species that is deemed more important and more publically valuable with more enrichment, ultimately enhancing their welfare more so than the ring-tailed lemurs.

The findings on the amount of stereotypic behaviour displayed by both the gorillas and ring-tailed lemur seemed to correspond with the amount of enrichment provided. As mentioned above, the gorillas received much more enrichment than the ring-tailed lemurs, and expectedly displayed much less stereotypic behaviour. Many studies have found that the amount of enrichment is related to the amount of positive, wild-type behaviour displayed (Hosey et al., 2009; Ryan et al., 2012; Zaragoza et al., 2011). In particular, Ryan et al. (2012) found that providing feeding enrichment by hand-scattering it around the enclosure promoted more foraging behaviour and less inactivity. These are positive behaviours that can help reduce the amount of stereotypies displayed. Zaragoza et al. (2011) found similar results in their study on the influence of environmental enrichment on chimpanzees (*Pan troglodytes*) and western lowland gorillas (*Gorilla gorilla*). They assessed the behaviour of these captive animals in two different phases – an enriched phase and a non-enriched phase. Results showed that the frequency of inactivity and anomalous behaviors in both groups were reduced during the enriched phase, in comparison to the non-enriched phase. In this study however, the frequency of locomotors and feeding behaviours were reduced in the gorillas and not in the chimpanzee. This behaviour seems surprising as the researchers provided the gorillas with food-based enrichment, and they were still disinterested. This was not the case with the gorillas at the Toronto Zoo, as they all exhibited ongoing foraging behaviour. These differences just go to show that although associations can be made between enrichment and behaviour, each individual within a group is different and not every gorilla has the same daily requirements and will not respond the same way to a particular enrichment device. On the other hand, the amount of abnormal behaviour displayed by the ring-tailed lemurs were surprising. Given the fact that the ring-tailed lemurs were given less enrichment than the gorillas, it was hypothesized that they would show more abnormal behaviour, however the amount displayed was very high. The frequency in which the ring-tailed lemurs displayed stereotypic behaviour – particularly the self-grooming and grooming other behaviours – lead to visible bald spots. This is fascinating as other researchers have found that certain groups of lemurs may reduce the amount of grooming in captivity as a result of the stress cause by the presence of visitors (Hosey, 2008). It is possible that the ring-tailed lemurs (as a sub-species of lemur) fall outside of this general category in this particular case, and do in fact show an opposite behaviour than expected in response to the stress of captivity. The amount of abnormal behaviour displayed by the ring-tailed lemurs overall was unanticipated. Clubb and Mason (2003) actually found opposite results that indicated ring-tailed lemurs thrive in captivity, and the amount of stereotypic behaviour displayed is often kept to a minimum. Of course there are always exceptions to this, and other factors could be contributing to the displays of abnormal behaviour, such as differences in: location where the data was collected; troop size; social hierarchy; diet; and level of enrichment. Maybe the ring-tailed lemurs at the Toronto Zoo would benefit from more enrichment, despite the amount they are already receiving. It is possible that by providing more enrichment, or a different combination of enrichment, the amount of abnormal/stereotypic behaviour being displayed could be reduced. This requires further investigation and a larger amount of resources would be necessary.

Finally, the interviews with the animal keeper's revealed a number of interesting things (Fig. 6 & Fig. 7). It was postulated that the animal's that were given more enrichment would have less physical illnesses than the animal's that had more enrichment. After reviewing the data, the opposite was found. The gorillas, who were given more daily enrichment had more physical illnesses over a one-year period, than the ring-tailed lemurs who were given less enrichment. With other potential factors controlled for, it makes sense to infer that the level of enrichment may help mitigate some of the potential for physical illness. Given that both species are fed vegetarian diets, both species' daily nutritional requirements are met, and both species are exposed to roughly the same number of visitors, it is logical to assume that the level of enrichment – the only variable that differs – is what influences physical illness. This was not the case. A number of reasons could explain these results. First, physical illnesses in the ring-tailed lemurs are easier to control for than in the gorillas. The ring-tailed lemur enclosure is fully enclosed as these animals are avid climbers, and by doing so, it significantly reduces the risk of disease transmission from visitors. What was a main threat to the gorillas (sick visitors throwing food into the enclosure and infecting the animals) has been effectively eliminated for the ring-tailed lemurs. Furthermore, the keepers of the ring-tailed lemurs can actually enter the enclosure to conduct physical examinations or give medication if the beginning of an illness is suspected. This allows closer monitoring of disease/illness processes and they can be identified and corrected much quicker than in the case of the gorilla. These results could also just be the result of the ways in which each species adapts and copes to the stresses of captivity and their environment. As mentioned above, some groups of ring-tailed lemurs thrive in captivity, and although this wasn't the case when investigating the amount of stereotypic behaviour displayed in this study, the positive effects of enrichment might act more on their physical health than their psychological health. Conversely, maybe these results occurred as no reasonable conclusion can be drawn that links the level of enrichment with the physical health of the species. More research would be required to investigate these sorts of questions. Despite the fact that some of the results were not expected, each and every study conducted on the effects of enrichment on the physical and psychological health of captive zoo animals aids in the improvement of captive conditions and enhances the overall welfare of the animals. For those facilities that are unsure of how to begin the process of deploying an enrichment program, figure 8 demonstrates a possible sequence of events that could make the beginning stages easier. Every animal deserves to live in a stress free, enriching environment, and deploying enrichment devices creates an opportunity that allows humanity to move one step further in the right direction to ultimately achieve this goal.

Conclusion

Whatever the motivation is, animals are increasingly being put into captivity and many (if not all) are succumbing to physical and psychological inflictions. Enrichment in the forms of food-based, sensory, social, physical, or cognitive, is one up-and-coming method aimed at reducing these inflictions, while promoting animal welfare and well-being. The research that has investigated the potential influences of enrichment has determined that the overall net effect of enrichment has been positive, despite the few limitations. Taking into consideration the limitations and challenges associated with enrichment and its implementation, it is still in the animal's best interest for zoological facilities to execute an enrichment program. The benefits far outweigh the limitations, and this is revealed by the observed reduction in maladaptive and stereotypic behaviour that is so commonly displayed by captive animals. Enrichment programs are nowhere near perfect, and much more research needs to be conducted to determine its potential, however it is my belief that all zoological facilities, and any other facility that houses captive animals should implement an enrichment program for the animals within their care. Until the day when animals are no longer placed in captivity and can successfully survive in their natural environments, and until the human population learns to operate sustainably, enrichment is one of the only progressive methods for improving their quality of life and well-being. Enrichment devices and techniques are the future of animal welfare in captivity. Furthermore, promoting enrichment for all captive animals not only improves their physical and psychological health directly, but it also has the potential to influence the way society perceives animals and nature. If facilities that house captive animals consistently provide their animals with enrichment devices, society may see the animal in a new light, potentially as a living, breathing being that deserves better than a concrete enclosure, rather than an animal on display, or used as a research subject. This in turn may be enough to convince an individual to help keep nature as safe and clean as they can, preserving a natural place for these animals in the wild. This could have positive ramifications for these animals, but could also aid conservation battles. The opportunities for improving the environment, and for improving animal welfare concerns in captivity are increasing, and enrichment is at the forefront of this exciting era.

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Appendix

Figure 1. Two western-lowland gorillas (Ngozi [mother] and Nneka [infant]) at the Toronto Zoo (Google Images, 2014).

Figure 2. Troop of ring-tailed lemurs at the Toronto Zoo (Google Images, 2014).

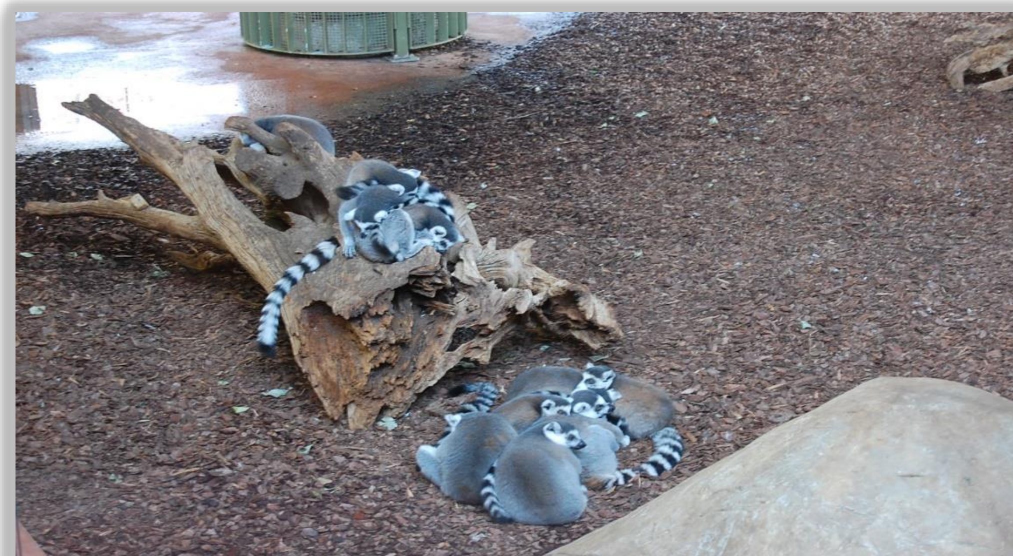

Figure 3. An evolutionary timeline illustrating the improvement of captive conditions from 1920 (top left), to 1940 (top right), to 1960 (bottom left), to the 21st century (bottom right) (Google Images, 2014).

Figure 4. Western lowland gorilla ethogram (Gorilla Behaviour Advisory Group, 1991).

- Gorilla

Headshake - From a sitting or squatting position the gorilla moves its head to one side and slightly upwards in a somewhat circular motion or quickly up and down. The mouth might open and then close quickly. The movement can be so slight that it may seem as if the gorilla is moving its head in order to relieve a crick in the neck. It may be mistaken for a comfort movement. The gorilla appears to regurgitate into the mouth; cheek bulging and chewing movement can be seen. Vomitus is usually retained in the mouth.

Methods of reingestion:
Reingest with the hand - An animal will dip or run its fingers and whole hand into vomitus and then lick the material off. Usually, the material has a liquid consistency. An animal sometimes uses its hand to scoop and maintain vomitus in small puddle. If the vomitus is thick or chunky, the fingers and thumb, in a pincer motion, are used to pick up matter and transfer it to the mouth.
Reingest with the mouth - Use mouth, lips and tongue to suck, lick, or pick up vomitus.

Positions for reingestion:
Squat on elbows - Feet are flat on the ground, the body is bent forward at the hips so that the ventrum is on the ground. The gorilla is resting on the forearm(s). Hand or mouth will be used to reingest from this position.
Sit/squat - Animal assumes a sit or squat posture (described elsewhere) after the quadrupedal, quick tilt, or head shake regurgitation.
Lie ventral - Similar to the squat on elbows position but the feet are not flat on the ground but extend out from the body. The animal usually rests on the forearms.
Tilt position - This is the same posture as used during the regurgitation phase.

Stereotypic, unusual, aberrant behavior:

Stereotypic: Stereotypic behavior is characterized by excessive repetition of or lack of variation in vocalizations, movements, postures, or patterns of travel.

Stereotypic posture: Prolonged maintenance of an unusual or bizarre stance, placement of extremities, or attitude. Specify act.

Stereotypic movement: Involves body or limb movements but not travel.

Head circle: A series of 2-12 unidirectional head rotations which occur most frequently while in a quadrupedal stance with the head, neck, and shoulders oriented towards a corner of an enclosure. The head is only 1/3 to 1/2 m from the wall. This behavior has been observed only in the younger silverbacked male.

Head swing: This motion is similar to head circles but the head hangs down and swings back and forth. The head does not make full rotations. It occurs mainly while sideways walking and occasionally while facing the wall or into a corner. This behavior has been observed only in the younger silverbacked male.

Rock: Legs are bent and the knees are near chest, arms are on knees or folded across chest. From this position, the animal sways from side to side (movements are no more than 5-10 cm to each side). This is usually done while the animal's back or side is against a vertical structure but has occurred while it is gripping the cage bars with its hands or while perched on a horizontal bar. Rocking occurs in association with finger sucking. This behavior has been observed only in the younger adult female.

Hand clap: Hands, with fingers curled in, are brought together rapidly several times. This behavior has been observed only in the younger adult female.

Stereotypic locomotion: Repetitive, unvarying, and seemingly meaningless pattern of travel.

Pace: Repetitious, patterned and usually unidirectional movement around the exhibit/habitat. The animal seldom makes more than two complete circles about an enclosure. Pacing speed is faster than the usual walking speed. This behavior is seen in the younger silverbacked male and in both adult females.

Stereotypic self-oriented: Excessive repetition of an unvarying form of self manipulation or self grooming.

Finger sucking: Animal will insert forefinger and/or middle finger of either hand completely into mouth. Seen frequently in association with rocking. Occurs while the animal is in a sitting, squatting, or perched position. Legs are bent up near chest, arms are on knees, or folded across chest. This behavior has been observed only in the younger adult female.

Belly scratching: Belly scratching consists of a rhythmic flexion of fingers or up and down movement of wrists so that the fingers are rubbed gently across the stomach region. Hands may alternate scratching, scratch in unison, or scratch singly. The animal will belly scratch while holding straw in the scratching hand.

The scratching posture is sitting with knees acutely bent and rotated outwards so the soles of feet are flat against each other or legs may be slightly extended with feet gripping cage bars. Seen only in the older adult female.

Stereotypic object use: Repetitive, unvarying, and seemingly useless manipulation of an object.

Stereotypic noises (Auditory): Repetitive, unvarying, and seemingly useless production of sound. This does not include the occasional production of unusual sounds or noise.

Motor boat sounds: Forcing air through tight lips makes a sound similar to a high pitched motor boat. Emissions are of short duration (≤ 1 sec), but occur in series (one bout had 35). Occurs primarily while the animal is in a resting/idle posture. This behavior has only been observed in the younger silverback male.

Unusual/idiosyncratic:

Lip hang: The lower lip droops loosely down exposing gums and inner lips. This behavior occurs in a variety of contexts, such as after aggressive encounters, during resting periods, during foraging bouts, while locomoting, while manipulating objects, and when head circling or head swinging. This behavior has been observed only in the younger silverbacked male who displays it frequently and incorporates it into many behavior patterns.

Affiliative:

Reproductive/Sexual:

Precopulatory: Sexual behavior which occurs prior to copulatory mounting.

Penile erection: There is no mounting. This is *very* difficult to observe.

Inspect genitalia: Close visual, tactile, or olfactory scrutiny of the genitalia or genital region of another.

Touch: An animal briefly touches, holds, fondles, or mouths the genitalia of another.

Olfactory/sniff: An animal leans over and presumably sniffs the genital region of another. Touching another's genitalia and then sniffing the fingers/hand is included in this category.

Solicit: One animal engages in a variety of postures, gestures, or movements which have a high probability of eliciting sexual behavior from another.

Stare: Female stands motionless while intensely watching the male.

Extended arm invitation: Female reaches toward male with arm stretched and palm facing the male.

Figure 5. Ring tailed lemur ethogram (Shire, 2012).

APPENDIX: ETHOGRAM – Ring tailed lemur

Behavior	Category	Abbreviation	Description
Foraging	Active	FR	When the focal animal searches for food in the enclosure either by actively moving through the enclosure or by visually searching for food items. Manipulation of food items without placing them in the mouth.
Sunning	Inactive	SN	The focal animal moves into the sunlight, torso vertical, forelimbs extended and allows solar rays to warm the body. In rare cases, this may be exhibited in the absence of sunlight.
Groom-Self	Inactive	GS	The animal uses the grooming claw or tooth comb to clean itself
Groom-Other	Inactive	GO	The animal uses the grooming claw or tooth comb to clean another individual or is cleaned by another individual
Climb	Active	CL	The animal moves about on a vertical structure, including but not limited to walking on trees, branches, locomotion on the cage itself, or leaping between substrates
Walk/Run	Active	WK	The animal locomotes terrestrially using all four limbs.
Sit	Inactive	ST	When the animal sits with head up and eyes open
Rest/Sleep	Inactive	RS	When the animal puts their head down. Eyes may be closed.
Cuff	Active	CU	The animal hits another individual using their hand in an aggressive manner. Does not include play behavior.

Behavior	Category	Abbreviation	Description
Bite	Active	BI	The animal attacks another individual using their teeth in an aggressive manner.
Vocalization Meow	---	VM	The animal opens mouth and emits a noise that sounds like "mew" or "me-ow" used as a contact call during traveling in the wild
Vocalization Bark	---	VB	The animal opens mouth and emits a yapping sound. May occur in response to a predator or neighboring troop.
Vocalization Spat	---	VS	The animal opens mouth and emits a squeak, twitter, yip, or squeal. Often occurs during aggressive encounters.
Vocalization General	---	VG	The animal emits a click, purring, or grunting sound. Occurs in a variety of contexts, such as while grooming, staring at a new object, or mobbing a predator.
Scentmark	Active	SC	The animal uses glands (such as those located under the tail, arms, wrist) to mark surfaces
Stereotypical Pace	Active	SP	The animal travels the same path repeatedly (back and forth) in succession
Stereotypical Somersault	Active	SS	The animal repeatedly turns itself head over heels. Does not occur during play or agonistic interactions
Stereotypical Overgroom	Active	SO	The animal cleans itself or another individual excessively. May result in bald patches of fur
Stereotypical Self Injurious	Active	SI	The animal uses teeth, claws, or nails to cause harm to itself, such as self-biting or chewing.
Other		OT	Other behaviors

Figure 6. A questionnaire for the keeper of the western lowland gorilla, discussing enrichment and the physical health of this species.

Keeper of the Gorilla **Questionnaire**

Name of Keeper: *Confidential*
Date: *May 14th, 2014*
Time: *2:30pm*

Question 1 – Are there any enrichment devices that are not visible to the public?
- *Bottles (provides cognitive enrichment, as well as food-related enrichment).*
- *Puzzles (provides cognitive enrichment).*

Question 2 – How many individuals are in this enclosure?
- *7 gorillas.*
- *Josephine and Ngozi are mature females.*
- *Charles is the only silverback male.*
- *Nassir is the young male.*
- *Sadiki and Johari are the middle aged males.*
- *Nneka is the newborn female.*

Question 3 – How do you identify them?
- *Each gorilla is a different size and are easily recognizable.*
- *Each gorilla also has its own distinct personality, making them easy to distinguish.*

Question 4 – What do they eat?
- *They are fed a vegetarian diet consisting of: tofu; sweet potato; squash; carrots; lettuce; corn on the cob; cauliflower; broccoli; green beans; browse; silage (fermented apple); and oranges.*

Question 5 – Is their feeding pattern regular?
- *They have a regular feeding pattern and are fed 3-4 times daily*.

Question 6 – How often do these individuals get sick in a one-year period?
- *Not often – roughly 2 -3 times a year max.*
- *Typically one individual gets sick at one time.*
- *A big problem arises if the illness is contagious and all members of the group get it.*

Question 7 - What illnesses does this species/these individuals usually get and how are they treated?
- *Typically, the gorillas at the Toronto Zoo are relatively healthy, and will become sick from something they catch from a visitor. For example, one of the gorilla's caught a bacterial infection from a visitor who threw a slice of apple into their enclosure. Two other gorillas*

- *caught this as well from the infected gorilla. Antibiotics are prescribed and placed in the animal's food for effective treatment.*
- *Another common health related issue with captive gorillas is congestive heart failure. This was typically an issue seen in male gorillas, but it is becoming more common in female gorillas. They have been restricted to a vegetarian diet and are given a lot of opportunities for exercise with hopes of slowing the progress of any heart conditions.*
- *Other than these main illnesses, these gorillas are pretty healthy.*

Question 8 – How do you recognize when they are sick?

- *It is usually the job of the animal keeper to recognize any changes in behaviour, such as not eating, drinking, or playing, which are typically good indicators that something is wrong. It is only when the change in behaviour has become so severe that they will begin testing. The gorillas at the Toronto Zoo are trained to allow veterinarians and technicians to do required testing, whether it be bloodwork, a urine test, or an echocardiogram. From there treatment is prescribe, often consisting of medication that is added to their food. Only in the most severe cases will a veterinarian decide to tranquilize a gorilla in order to do a procedure. Gorillas don't do well under anesthetic and will often die on the table.*

Figure 7. A questionnaire for the keeper of the ring-tailed lemur, discussing enrichment and the physical health of this species.

Keeper of the Ring-tailed lemur **Questionnaire**

Name of Keeper: *Confidential*
Date: *May 14th, 2014*
Time: *1:30pm*

Question 1 – What are some of the enrichment devices that are not visible to the public?

- *The devices visible to the public are the ones that this troop gets*.

Question 2 – How many individuals are in this enclosure?

- *11 adults, and 2 babies.*

Question 3 – How do you identify them?

- *The dominant female has an ear tag, and the babies are much smaller, but it is challenging to recognize who is who without spending a lot of time with them, and getting to know each of their individual personalities. As a keeper you have to be able to identify all of the animals under your care, however this takes time and patience.*

Question 4 – What do they eat?

- *This troop gets a vegetarian diet consisting of: lettuce; sweet potato; green pepper; zucchini; apples; and oranges.*

Question 5 – Is their feeding pattern regular?

- *They are fed 3-4 times a day, and have a regular feeding schedule. They do receive special treats (tree branches) sporadically.*

Question 6 – How often do these individuals get sick in a one-year period?

- *The lemurs at the Toronto Zoo rarely get sick, and they haven't been any reported illnesses over the last year.*

Question 7 - What illnesses does this species/these individuals usually get and how are they treated?

- *Typically, a major concern with this species in captivity is obesity, or other nutritional disorders. The Toronto Zoo has a very specialized diet that aims to prevent any nutritional deficiencies, while maintaining a healthy body weight.*

Question 8 – How do you recognize when they are sick?

- *Like most captive animals, it is easy to recognize when they aren't feeling well. Changes in behaviour, if they are lethargic, or if they are not eating or drinking are good indicators that something is wrong. Unlike most primate species, keepers can actually enter into the enclosure of these animals and can assess their health more closely, as well as treatment is much easier.*

Figure 8. Enrichment planning checklist that can be used as a frame of reference when deploying an enrichment program (The shape of enrichment Inc., 2011).

Enrichment Planning Checklist

1. Investigate current research
2. Determine what goals you are trying to meet
3. Brainstorm possible ideas
4. Based on your ideas, look at the criteria you need to meet – if they meet the criteria finalize a plan, if they do not, come up with alternative ideas until a finalized plan can be established.
5. Once a plan has been developed and approved, build a prototype environment. These ideas and prototypes should be the based on the input of all staff/individuals involved.
6. Test the prototype – Observe and record all instances of changes in behaviour of your species.
7. Evaluate if the prototype achieved the intended goals. If not, revise prototype and try again until goals are met.
8. **Once a successful prototype is developed, continue to evaluate the effectiveness of that prototype environment, and make improvements. An environment call always be improved upon.**

****This should be done for each individual species, and should be continually monitored and altered based on the changing needs of the animal.****

Table 1. The type and amount of enrichment in the enclosure of each species.

Species/Type of Enrichment	**Western Lowland Gorilla (*Gorilla gorilla gorilla*)** *Inside and Outside Enclosure*	**Ring-tailed Lemur *(Lemur catta)***	**Total Individual Enrichment Devices for Gorilla**	**Total Individual Enrichment Devices for Ring-tailed lemur**
Food Enrichment	-8 closed baskets of food -14 closed tubes of food -Food scattered throughout enclosure for foraging -Bottles	-Food scattered throughout enclosure for foraging	24	1
Physical Enrichment	-9 rope swings -8 balls -6 hammocks - 1 real tree to climb -15 wooden platforms to climb too -1 artifical cave-type structure to hide/sleep	-5 wooden logs to jump on -7 rope swings -1 hammock -2 large artificial tree structures to climb	40	15
Sensory Enrichment	-Inside and outside enclosure -Woodchip/dirt/grass enclosure bottom -Forest painted background on enclosure with real trees/plants -2 ponds	-Woodchip/dirt enclosure floor -Forest painted background on one enclosure wall -Pond -1 heating lamp	5	4
Social Enrichment	-Shares enclosure with conspecifics	-Shares enclosure with conspecifics -Shares enclosure with 2 Grey-necked crowned cranes	1	2
Cognitive Enrichment	-Sticks to get food out of closed food baskets -Puzzles in order to get food	-Tied big branch with leaves on rope	2	1
Total Enrichment Overall	-	-	73	23

Table 2. Documented abnormal/stereotypic behaviour of the western lowland gorilla and the ring-tailed lemur at the Toronto Zoo.

Date/Time of Observation	**Weather Conditions**	**Number of Visitors (Low, Medium, High)**	**Western Lowland Gorilla *(Gorilla gorilla gorilla*)**	**Ring-tailed Lemur *(Lemur catta)***
April 24th, 2014 12:30pm - 2:30pm	Sunny and warm	Low <50 visitors	N/A	- 8 instances of stereotypic grooming-other - 2 instances of stereotypic self-grooming - 1 instance of stereotypic pacing
April 24th, 2014 2:30pm – 4:30pm	Sunny and warm	Low <50 visitors	- 1 instance of stereotypic rocking	N/A
April 28th, 2014 1pm – 3pm	Partially cloudy and warm	Low <50 visitors	-1 instance of stereotypic object use (rope pulling)	N/A
April 28th, 2014 3pm – 5pm	Partially cloudy and warm	Low <50 visitors	N/A	- 4 instances of stereotypic grooming-other - 1 instance of stereotypic self-injurious (biting metal cage)
May 6th, 2014 3pm – 5pm	Sunny and warm	Medium <100, but >50 visitors	N/A	- 1 instance of stereotypic grooming-other - 2 instances of stereotypic self-injurious (biting metal cage - 1 instance of stereotypic pacing
May 6th, 2014 5pm – 7pm *Outside Enclosure*	Sunny and warm	Medium <100, but >50 visitors	- 1 instance of stereotypic pacing	N/A

May 7th, 2014 3pm – 5pm	Partially cloudy and warm	Medium <100, but >50 visitors	N/A	- 4 instances of stereotypic self-grooming - 5 instances of stereotypic grooming-other
May 7th, 2014 5pm – 7pm	Partially cloudy and warm	Medium <100, but >50 visitors	- 1 instance of stereotypic object use (shaking stick vigorously and repetitively)	N/A
May 15th, 2014 1:30pm – 3:30pm	Cloudy, rainy, and warm/hot	High >100 visitors	N/A	- 7 instances of stereotypic grooming-other - 1 instance of stereotypic self-grooming
May 15th, 2014 3:30pm – 5:30pm	Cloudy, rainy, and warm/hot	High >100 visitors	- No instances of abnormal/stereotypic behaviour	N/A
Total number of hours of observation	-	-	10 hours	10 hours
Total instances of abnormal/stereotypic behaviour	-	-	4	37