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Visitor effects on the behavior of drills (*Mandrillus leucophaeus*) and petting zoo animals at Parken Zoo

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As visitors play a fundamental part of the zoo setting, it is important to understand how zoo animals perceive these visitors. Even though this topic has been studied since the 1960's, visitor effects on zoo animals are not yet fully understood. However, most studies agree that visitors in many cases seem to be stressful to the animals which could have a negative impact on animal welfare. This study investigated how drills (Mandrillus leucophaeus) and free roaming petting zoo animals, alpacas, goats and sheep, at Parken Zoo, Eskilstuna, were affected by zoo visitors. Frequencies of behavior during different visitor intensity levels were compared to see if visitor intensity had an effect on the behavior of the animals. In drills, inactive, affiliative, agonistic, stereotypic/abnormal behaviors and visitor interactions were affected by visitor intensity. In petting zoo animals, desirable behaviors were mainly seen during low intensity levels, and undesirable behaviors seen more during medium and high intensity levels. However, there were differences in visitor effect among the three species used in this study. The results indicate that drills find visitors stressful and that their welfare might be impacted by high visitor intensity. The results from the petting zoo suggest that goats and sheep are relatively well adapted to their environment, while alpacas need further habituation to visitors to ensure their welfare is not compromised. To reduce visitor effects several measures could be taken, such as adding visual barriers in the drill enclosure, redesigning the retreat spaces in the petting zoo and increasing the information to visitors on how to act when visiting the zoo.

Nyckelord/Keyword:
Animal behavior, animal welfare, zoo animals, visitor effect, Mandrillus leucophaeus, petting zoo, zoo visitors

Content

1 Abstract

As visitors play a fundamental part of the zoo setting, it is important to understand how zoo animals perceive these visitors. Even though this topic has been studied since the 1960's, visitor effects on zoo animals are not yet fully understood. However, most studies agree that visitors in many cases seem to be stressful to the animals which could have a negative impact on animal welfare. This study investigated how drills (*Mandrillus leucophaeus*) and free roaming petting zoo animals: alpacas, goats and sheep, at Parken Zoo, Eskilstuna, were affected by zoo visitors. Frequencies of behavior during different visitor intensity levels were compared to see if visitor intensity had an effect on the behavior of the animals. In drills, inactive, affiliative, agonistic, stereotypic/abnormal behaviors and visitor interactions were affected by visitor intensity. In petting zoo animals, desirable behaviors were mainly seen during low intensity levels, and undesirable behaviors seen more during medium and high intensity levels. However, there were differences in visitor effect among the three species used in this study. The results indicate that drills find visitors stressful and that their welfare might be impacted by high visitor intensity. The results from the petting zoo suggest that goats and sheep are relatively well adapted to their environment, while alpacas need further habituation to visitors to ensure their welfare is not compromised. To reduce visitor effects several measures could be taken, such as adding visual barriers in the drill enclosure, redesigning the retreat spaces in the petting zoo and increasing the information to visitors on how to act when visiting the zoo.

2 Introduction

2.1 Visitor effects on zoo animals

Today, most zoos agree their primary goals are conservation, education and research. However, recreational aspects of zoos are a large part of their work and financially, zoos still rely on visitors for their survival. Also, the educational efforts of zoos rely on large numbers of visitors. Furthermore, most zoo visitors claim their primary reasons for visiting zoos are related to recreation (Reade & Waran, 1996). As the visitors play a fundamental part of the zoo setting, it is important to understand how the animals perceive these visitors. Hosey (2000) states that the behaviors of zoo animals must in some way be affected by the presence of human visitors. Even though opening hours and visitor density may vary, many zoo animals experience groups of visitors daily (Hosey, 2000). And while these visitors might watch the animals passively they might also try to interact with animals which could include a range of actions that could be more or less stressful for the animals, such as pointing, staring, shouting, knocking on glass etc. (Hosey, 2000; Davey, 2007). Hosey (2000) further argues if

disturbance levels are high, for instance on crowded days, and clear to us humans, it must affect the animals even more. Morgan and Tromborg (2007) and Fernandez et al. (2009) argue that there is often a conflict present in zoos; providing opportunities for paying visitors to see exotic animals up close, and providing the animals with environments that ensure their well-being, which might not always coincide.

Although visitor effects on animals have been discussed since the 1960's, the topic has not been thoroughly investigated until more recent years. Since then, there have been three different views on how visitors affect zoo animals: zoo visitors are of no consequence, enriching, or stressful for the animals (Hosey, 2000; Davey, 2007). However, as Hosey (2000) points out, it is likely visitor effects in general cannot be placed into just one of these categories as it might be expected the effects vary in different situations, species, individuals or be influenced by other factors such as weather, enclosure design, time of year, etc. Furthermore, it is difficult to prove causality even though associations between zoo visitors and animal behavior have been established; therefore it is problematic to interpret the nature of visitor effects (Davey, 2007). Nonetheless, the same authors that point out the difficulties are also in agreement that a visitor effect exists and at least in some cases it affects the animals negatively (Hosey, 2000; Davey, 2007).

According to authors such as Hosey (2000), Davey (2007) and Fernandez et al. (2009), many studies in this field infer that presence of human visitors leads to stress in the animals. In these studies increased stereotypies and other abnormal behaviors, increased both intraspecific and interspecific aggression as well as decreased affiliative behaviors, etc. are used as behavioral indicators of stress (e.g. Chamove et al. 1988; Sellinger & Ha, 2005; Wells, 2005). Short term stress may not be harmful to animals, however if the stress is prolonged, severe, frequent or chronic (sometimes referred to as distress), it may have several negative impacts on the health and well-being of the animals (Broom, 1991; Moberg, 2000; Tilbrook et al. 2002; Wielebnowski, 2003). These include immunosuppression, disease, inhibited reproduction and deleterious behaviors (Broom, 1991; Carlstead & Shepherdson, 1994; Moberg, 2000; Tilbrook et al. 2002; Wielebnowski, 2003). As visitors are often present for much of the zoo animals' life, their presence could lead to prolonged stress (or distress) if perceived as stressful and therefore lead to welfare or health implications. Even though there are many studies that show zoo animals are stressed by zoo visitors, there is also inconsistency and variability when comparing studies (Hosey, 2000; Fernandez et al., 2009). These differences in behavioral responses are probably due to the fact that several variables affect how animals respond to stressors (Hosey, 2000; Davey, 2007).

Several authors (Hosey, 2000; Davey, 2007; Fernandez et al. 2009) state knowing if a visitor effect exists and what that effect may be is important for several reasons. As previously mentioned, the most important is if the zoo visitors affect the welfare of the animals adversely (Hosey, 2000). However, it can also be important when creating a positive experience for zoo visitors, and finally if there is a visitor effect it could in turn affect results from research conducted in zoos (Hosey, 2000).

Davey (2007) further argues that even though it is evident visitors and how they act when visiting zoos, do affect zoo animals both behaviorally and physiologically, confident conclusions on how animal welfare is affected by visitors cannot be made without further investigation on the nature of these effects. However, physiological measures may be confounding as well, as both negative and positive stress lead to the same physiological changes in the body (Wielebnowski, 2003; Dawkins, 2004). Another issue with assessing stress is that stress is usually measured through physical or behavioral changes when exposed to a stimulus, when that change might be nothing more than an adaptation to the situation (Barnett & Hemsworth, 1990). According to Broom (1988) and Dawkins (2004) using behavior as a welfare indicator is very useful as there are several behavioral signs of both good and poor welfare. Even though there is some ambiguity on the validity of using behavior as a stress or welfare indicator, measuring behavior and behavioral changes when exposed to stimuli is an important tool when assessing animal welfare as it gives an indication if there is need for concern and further investigation (Dawkins, 2004).

One reason why visitor effect and its causality are difficult to determine and assess is the difficulties surrounding how to measure and interpret stress in animals (Hosey, 2000; Davey, 2007). Today we often rely on certain types of abnormal behaviors as stress indicators in animals (Davey, 2007). Furthermore, normal behaviors and changes within these behaviors are used as welfare indicators, for example affiliative behaviors are seen as indicators for good welfare and aggressive behaviors as poor welfare (Davey, 2007). According to Davey (2007), these interpretations might not be accurate as animals' behavioral responses to stress may be complex and changes might not be consistent.

Hosey (2000) also discusses if the visitor effect is actually due to visitor attraction; active animals attract more visitors meaning that the change in animal behavior leads to more visitors and not the other way around. Hosey (2000) has divided the two theories into the visitor effect hypothesis and the visitor attraction hypothesis. It is probable that the two theories have mutual effects which are not independent of each other (Hosey, 2000; Margulis et al. 2003). However, in the literature, the visitor effect hypothesis is favored and deemed more plausible, which might be due to the visitor attraction hypothesis not being

able to explain several of the observed behavioral changes in zoo animals (Farrand, 2007).

Regardless of the concerns about using behavior to measure welfare and the causality of behavioral and physiological changes related to visitors, previous research supports that there is a visitor effect. Even though some studies have found a positive general impact on the animals, most studies in the field found that the effect is in fact negative from the perspective of the zoo animals (Fernandez et al. 2009). Studies which found a negative impact on the well-being of zoo animals from zoo visitors include several primate species such as mandrills (*Mandrillus sphinx*), cotton-top tamarins (*Saquinus oedipus*) (Chamove et al. 1988), orangutans (*Pongo* spp.) (Birke, 2002; Choo et al. 2011), gorillas (*Gorilla gorilla gorilla*) (Wells, 2005; Kuhar, 2008), spider monkeys (*Ateles geoffroyi rufiventris*) (Davis et al. 2005) and baboons (*Papio hamadryas*) (Bortolini & Bicca-Marques, 2011) as well as several non-primate mammals, such as jaguars (*Panthera onca*) (Sellinger & Ha 2005), Indian gaur (*Bos gaurus gaurus*) (Sekar et al. 2008), sika deer (*Cervus nippon*) (Shen-Jin et al. 2010), Mexican wolf (*Canis lupus baileyi*) (Pifarré et al. 2012) and pumas (*Puma concolor*) (Maia et al. 2012).

The findings of these studies show some consistency over species in which behaviors were affected by visitors. Inactivity or resting behaviors decreased when visitor density or intensity was high in mandrills and cotton-top tamarins (Chamove et al. 1988), gorillas (Wells, 2005), Indian gaurs (Sekar et al. 2008), sika deer (Shen-Jin et al. 2010) and Mexican wolves (Pifarré et al. 2012). However, the opposite effect on activity was found in orangutans (Birke, 2002) and pumas (Maia et al. 2012), which were less active when visitor density or intensity was high. A decrease was also found in affiliative behaviors; mandrills and cotton-top tamarins showed less affiliative behaviors when visitors were present (Chamove et al. 1988). In contrast, in the presence of visitors or when visitor density or intensity increased, agonistic behaviors and intragroup aggression increased in several species: cotton-top tamarins (Chamove et al. 1988), gorillas (Wells, 2005; Kuhar, 2008), jaguars (Sellinger & Ha, 2005) and Indian gaurs (Sekar et al. 2008). Time spent non-visible to the visitors was also affected in several species: gorillas (Kuhar, 2008), jaguars (Sellinger & Ha, 2005), sika deer (Shen-Jin et al. 2010) and pumas (Maia et al. 2012), in which high visitor density or intensity led to the animals spending more time non-visible. Orangutans had a different solution to being non-visible, adult individuals in the study by Birke (2002), used paper sacks to cover their heads, which was observed more when visitor density was high. Furthermore, visitor presence, high visitor density or high visitor intensity led to increases in abnormal and stereotypic behaviors in mandrills (Chamove et al. 1988), gorillas (Wells, 2005) and jaguars (Sellinger & Ha, 2005). Finally, an increase in urinary

cortisol levels was found in spider monkeys (Davis et al. 2005) as well as an increase in fecal cortisol levels in Mexican wolves (Pifarré et al. 2012) was found when visitor numbers were high. Increases in urinary and fecal cortisol levels are commonly used as indicators of stress (Möstl & Palme, 2002).

Other noteworthy results in these studies which do not span over several species are: direct gazing, which pumas engaged in more often when visitor density and noise levels were high (Maia et al. 2012), throwing feces, which in the study on baboons by Bortolini and Bicca-Marques (2011) increased when visitor density was high and reduced play behavior in orangutans when visitors were in close proximity to the animals (Choo et al. 2011).

When summarizing these findings, several studies emphasize that not only the presence of visitors has an impact on the animals, but that visitor intensity and/or noise level of visitors in many cases is of equal or greater importance (e.g. Chamove et al., 1988; Birke, 2002; Sellinger & Ha, 2005; Davey, 2007; Maia et al. 2012). Further, some studies showed that altering the visitors behaviors could lead to a decrease in the visitor effect (Chamove et al., 1988; Birke, 2002), meaning that visitor behavior is of importance as well.

2.2 Visitor effects on petting zoo animals

The occurrence of visitor effects in petting zoos is perhaps even more obvious as the purpose of petting zoos is to provide close interactions between visitors and animals. This kind of hands-on interaction with animals plays an important educational role in many zoos (Anderson et al., 2002). To ensure positive experiences for both visitors and animals in petting zoos, the animals housed there must tolerate interaction attempts from visitors (Anderson et al. 2002; Anderson et al. 2004). However, this is not always the case, and zoo animals might respond with undesirable behaviors such as moving away from, avoiding or even charging at visitors (Anderson et al. 2002; Anderson et al. 2004). Further, Anderson et al. (2002) point out the importance of noting that such undesirable behaviors in petting zoo animals will impede positive human-animal interactions but may only be undesirable in the specific petting zoo setting. Because of the significant role of petting zoos, it is imperative that visitors do not affect the animals negatively (Anderson et al., 2002).

There are very few studies on how visitors affect petting zoo animals. Lacey and Pankhurst (2001) studied goats, sheep and pot-bellied pigs in a petting zoo in the UK. They found that visitor density led to an increase in aggression toward both animals and visitors in goats, but not in sheep or pigs (Lacey & Pankhurst, 2001). Further, avoidance behavior increased in goats and sheep as visitor

density increased while pigs did not seem to be much affected by visitors in this study (Lacey & Pankhurst, 2001).

Anderson et al. (2002) studied visitor effects in goats and sheep, with regards to three different conditions of retreat spaces. They found that avoidance, escape and aggressive behaviors, deemed undesirable behaviors, increased with increased visitor density in both species. However, when comparing the different retreat space conditions; no retreat space, semi retreat space and full retreat space, they found that undesirable behaviors where most frequent during the semi retreat condition (Anderson et al. 2002). This was thought to be due to the design of the retreat conditions; in the semi retreat condition visitors could reach into the retreat spaces and try to pet the animals from outside the retreat space, which could lead to further display of undesirable behaviors if the animal entered the retreat space to get away from visitors. In the full retreat condition this was prevented by the addition of chicken wire on the fence (Anderson et al. 2002). The increase of control over the environment provided by the full retreat condition vs. the frustration which might occur with the lack of control in the semi condition was considered to be a probable cause of these results (Anderson et al. 2002).

Anderson et al. (2004) conducted a study in which it was investigated if nearby presence of a zookeeper decreased undesirable behaviors in petting zoo goats and sheep. However, the results found were the opposite, undesirable behaviors increased when zookeepers were nearby, leading to the conclusion that ensuring nearby presence of zookeepers might not be a suitable method to decrease undesirable behaviors of animals in petting zoos (Anderson et al. 2004).

From these studies we can conclude that visitors seem to have an effect on petting zoo animals and that further studies in this field are needed.

2.3 Visitor effect and controllability

Several studies claim one major factor on how and to what extent visitors affect animals is the animals' control over their environment (Anderson et al. 2002; Wells, 2005; Kuhar, 2008). Zoo visitors are one factor which constantly varies and is unpredictable to zoo animals (Davey, 2007). Wells (2005) states that the lack of control over their environment experienced by many zoo animals through disruption by zoo visitors and inability to escape the attention of zoo visitors could lead to diminished welfare. In the study by Anderson et al. (2002) they found the design of retreat spaces for petting zoo animals has an impact on how visitor density affects the animals; retreat spaces which provided the animals with full control led to fewer undesirable behaviors. Anderson et al. (2002) emphasized the importance of providing zoo animals with control over

their environments through well-designed retreat spaces. Further, Kuhar (2008) claims that having the option to move out of sight is of great importance to zoo animals as this gives them some control over the visitors. This is supported by the results mentioned previously, in which several species spent more time non-visible when visitor density or intensity were high (Sellinger & Ha, 2005; Kuhar, 2008; Shen-Jin et al. 2010; Maia et al. 2012). Further support of the benefits of controllability is given by Choo et al. (2011) who conclude that enclosure design can impact how zoo animals are affected by visitors. In their study, the visitor effects on orangutans seemed relatively small, which was thought to be due to the naturalistic enclosure design which might have offered the animals more control over their environment.

Visual barriers of different types can offer opportunities to escape the attention of zoo visitors and provide some degree of control and therefore reduce the negative effects of visitors (Chamove et al. 1988; Birke, 2002; Kuhar, 2008). Additionally, visual barriers can contribute to providing zoo animals with more complex environments, which in turn can have several benefits, such as increased activity, reduction in abnormal behaviors, coping with stress etc. (Carlstead & Shepherdson, 1994) all of which lead to improved animal welfare as well as promoting positive zoo experiences for visitors (Reade & Waran, 1996).

2.4 Purpose and aim

The studies in this paper were conducted at Parken Zoo, a tourist facility with an amusement park, water park, camping and an animal park, located in Eskilstuna, Sweden. In this project, there are two separate studies within the field of visitor effects as Parken Zoo wanted studies conducted on two different parts of the zoo. The first study involves the zoo's drills (*Mandrillus leucophaeus*) and the second study the free roaming animals in the park's petting zoo: alpacas (*Vicugna pacos*), sheep (*Ovis aries*) and goats (*Capra hircus*).

One of the female drills, called F2 in this study, was hand reared and has a history of showing abnormal and stereotypic behaviors which were established before being moved to Parken Zoo, probably due to maternal deprivation. As she is genetically valuable it is important that she is incorporated into the breeding program of the species and reproduces successfully. The drills have been monitored and observed since their introduction into the animal collection at Parken Zoo; however, the park wanted further studies to be conducted with the focus on how the visitors might affect the behavior of the drills and what consequences this might have for the animals, especially the above mentioned female. Furthermore, the group composition has recently changed and therefore it was important to investigate and evaluate if the situation had improved and/or

if further improvements were needed to ensure welfare and provide good conditions for reproductive success and contribution to the conservation program of the species. This study will be used in the long term documentation and records being kept on the drills at Parken Zoo as well.

At Parken Zoo, the petting zoo, called "Lilla Zoo", is considered to help people get involved in conservation creating emotional engagement in animals by allowing the visitors close, "hands on" interactions with the animals in the exhibit. The philosophy is that this could help bridge the gap between generally positive attitudes to conservation to actively help conservation efforts. Parken Zoo wanted to ensure a continued positive experience for both visitors and animals in their petting zoo. Therefore, the free ranging animals in Lilla Zoo (alpacas, goats and sheep) were studied to investigate which behaviors the animals show toward and around the visitors that come into the petting zoo.

The aim of this study is to investigate how zoo visitors affect the behavior of the drills and petting zoo animals and if these visitor effects have any welfare implications for the animals.

3 Method

3.1. Drill

3.1.1 Subjects

The drill is a semi terrestrial primate which is classified as endangered by IUCN (Oates & Butynski, 2008). Sexual dimorphism is extreme in drills; males can weigh up to 45kg while females can weigh up to 20kg (Marty et al., 2009). Also, in contrast to females, adult males have bony paranasal swellings, long canines and secondary sexual coloration; a red stripe along their lower lip, red coloration above the groin as well as blue, pink and violet coloration on their rump and genitals (Marty et al. 2009). Drills form harem groups, typically of up to 25 individuals, however as their social organization is flexible they can occasionally form larger bands of up to 200 animals (Oates & Butynski, 2008). Drills are found in the lowland Atlantic rainforests of southeast Nigeria and northwestern Cameroon, as well as Bioko Island of Equatorial Guinea (Astaras & Waltert, 2010).

There are three adult drills, one male and two females, at Parken Zoo and all were included in this study. The male and one female were 14 years old, the other female 12 years old. All drills were housed together in an enclosure, consisting of an indoor enclosure which could be divided into three separate

areas, as well as a large naturalistic outdoor enclosure (Fig. 1). Glass walls separated the visitors from the drills in both indoor and outdoor enclosures. The drills had access to both inside areas and outdoor area of their enclosure except for shorter periods of time when they could be locked either inside or outside due to husbandry reasons, in which case this was noted. During the time of the study, the drills shared their entire enclosure with two l'Hoest's monkeys (*Cercopithecus lhoesti*).

Figure 1. Map of the drill enclosure and surrounding areas.

3.1.2 Procedure

Focal animal sampling was used. Each animal was observed in 5-minute intervals, each session was 30 minutes meaning that each animal was observed twice per session. Up to 8 sessions were conducted each observation day, alternating between mornings and afternoons. To ensure feeding did not confound the results the 5 minutes before and 15 minutes after feeding were excluded from the study. The ethogram used in this study was based on previous studies of the drills at Parken Zoo with some modifications (Table 1).

Table 1. Ethogram drill, behaviors and definitions

Inactive	Resting or sleeping
Sit/stand	Sitting or standing when not engaged in other behaviors
Locomotion	Moving in situations not considered social behaviors, foraging, or interactions with l'Hoest's monkeys or visitors
Forage	Searching for or eating food
Social affiliative	Affiliative social behaviors within species
Social agonistic	Agonistic social behaviors within species
Stereotypic/abnormal	Abnormal repetitive behaviors
L'Hoest's	Interactions with l'Hoest's monkeys
Visitor Interaction	Distinct and active interaction with visitors, specific behavior noted and described
Other	Other relevant behaviors, noted and described

Instantaneous sampling was used to record exhibit usage of the animals, and to record the density of the zoo visitors. All other animal behaviors and visitor intensity were recorded using continuous behavior sampling. The assessment of visitor intensity was based on the definitions found in the study by Sellinger and Ha (2005) but modified to fit the present study (Table 2). The focal animal was observed in the part of the enclosure (inside or outside) it chose to be in.

Table 2. Visitor intensity levels and definitions. A bout of noise is defined as lasting up to 5 seconds.

Level	Rating	Definition
Quiet	1	Quiet whispers, no loud talking
Low	2	Quiet talking, two or fewer bouts normal talking
Moderate	3	Normal talking, no shouting
High	4	Normal talking, two or fewer bouts shouting and/or knocking on glass
Extreme	5	Loud talking and/or more than two bouts shouting and/or knocking on glass

The drill enclosure was next to enclosures housing African wild dogs (*Lycaon pictus)* and meerkats (*Suricata suricatta)*. Visitors that were in the area of the outdoor drill enclosure were counted even if their attention was toward these other species. Furthermore, if the focal animal was indoors, only visitors within the indoor viewing area were counted.

3.2 Lilla Zoo

3.2.1 Subjects

"Lilla Zoo" is comprised of a larger area with several enclosures where visitors can interact with different species of pets and domesticated animals. Sheep (*Ovis aries*), goats (*Capra aegagrus hircus*) and alpacas (*Vicugna pacos*) roamed

freely throughout the petting zoo area with access to three retreat spaces (Fig. 2). Each retreat space was comprised of one shed and an enclosed area in front of the shed, and visitors could stand around the fences of the retreat spaces and reach in to touch animals that were close to the fence but were not allowed into the retreat spaces (Fig. 3). At the beginning of the season there were ten goats, four sheep, and four alpacas in Lilla Zoo, all of varying ages. Five goats were randomly chosen and used for the rest of the study; three adult females, one adult neutered male and one juvenile female. All sheep were initially included; however one had to be euthanized due to complications while giving birth during the pilot study; the remaining three sheep were used in the study. During the course of the study three sheep and six goats were born which were not included in the observations. All alpacas were used in the study but as one of the alpacas was pregnant, all alpacas were moved to a different enclosure before the birth of the foal, leading to a temporary disruption of the observations. The three alpacas without foals were moved back to Lilla Zoo before the end of the season and observations of them were continued.

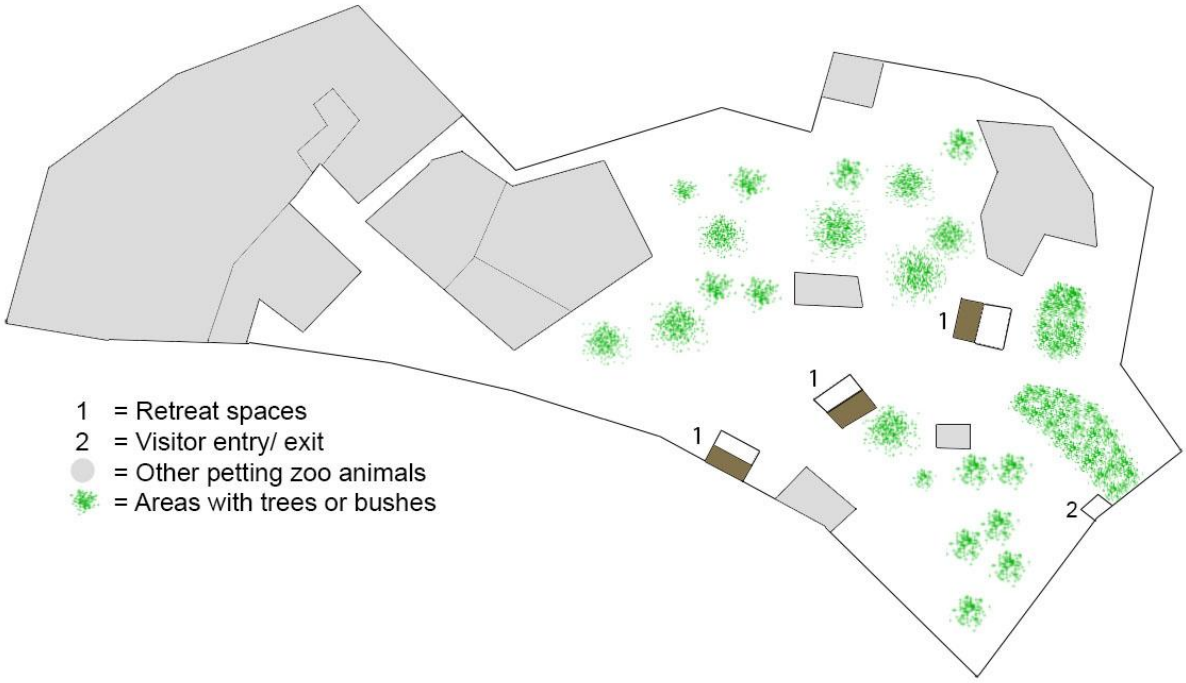

Figure 2. Map of Lilla Zoo and the area the free roaming animals (alpacas, goats and sheep) had access to.

Figure 3. Image of one of the retreat spaces in Lilla Zoo. All three retreat spaces had similar design.

3.2.2 Procedure

Focal animal sampling was used in the Lilla Zoo study. Each focal animal was observed for 10 minutes, meaning that alpacas were observed for 40 minutes, goats 50 minutes and sheep for 30 minutes per session. During each observation period, all focal animals of one species were observed before moving on to the next species. The order in which the species were observed was randomized, as well as the order of focal animals. One session per species was conducted each observation day, alternating between mornings and afternoons. As the alpacas were not observed while moved out of Lilla Zoo, one of the other two species was observed in their place. If there was heavy rain, observations were discontinued as the animals tended to stay in their shelters in the retreat spaces provided for them and visitors tended to not spend time in Lilla Zoo.

The ethogram used was based on previous studies performed by Anderson et al. (2002) as well as own pilot studies (Table 3). Even though the behavior “enjoy” can be considered arbitrary, it was included due to the importance of not only including undesirable behaviors in the study, but desirable behaviors as well. Each time the focal animal performed a relevant behavior, the number of visitors within a three meter radius of the animal was recorded, as well as the intensity of these visitors (Table 4). Bouts of touches the animal received within the observation interval were also recorded.

Table 3. Ethogram of behaviors recorded in Lilla Zoo

Head Toss	Animal tossing its head, using its horns to "stab" at visitors
Avoid	Moving away from visitors without contact with visitors
Leave	Moving away from visitors after contact with visitors
Alert	Looking at visitors, all other behaviors stopped, ready to move away, only for alpacas
Other	Other behaviors considered undesirable (e.g. head butting, kicking, spitting etc.)
Approach	Moving toward visitors
Enjoy	Distinctly enjoying petting or scratching from visitors, only number of visitors at the start of this behavior was recorded

Table 4. Intensity levels in Lilla Zoo

Level	Rating	Definition
Low	1	Speaking quietly, approaching animals slowly, crouching down
Medium	2	Normal talking, no shouting or running up to animals
High	3	Shouting, running up to animals or chasing after animals

3.3 Statistical analysis

SPSS 20.0 was used for statistical analysis. Visitor intensity levels in the drill study were grouped into three categories: Quiet and Low into Low, Moderate into Medium, and High and Extreme into High. The Lilla Zoo intensity levels were kept as they were.

Some behaviors from the drill study were not analyzed as there was not enough data; these were "l'Hoest's" and "Other". As the male and one female did not perform a sufficient amount of abnormal or stereotypic behaviors, only data from the female with a history of abnormal and stereotypic behaviors, called F2 in the study, was used in the analysis of this behavior. Furthermore, all visitor interactions observed were considered negative as they were aggressive: threatening visitors, charging at and attacking the glass.

Behaviors in the Lilla Zoo study were grouped into desirable (approach, enjoy and coming out from retreat space) and undesirable (all other behaviors including going into retreat space). In both studies Mann-Whitney U tests were performed to see if frequencies of behaviors differed between the three respective intensity levels. Further, time spent in retreat space by Lilla Zoo species was tested for differences between species. To correct for Type I errors, the significance level was set at 0.01.

4. Results

4.1 Drill

Data from a total of 7485 minutes of observation were included in the study, with intensity distribution as follows: low= 26%, medium= 52% and high= 22% of the time. Results of the Mann-Whitney U tests show that all analyzed behaviors were affected by visitor intensity.

As all analyzed behaviors were affected by visitor intensity, the behaviors that were assumed to be the most important for the welfare of the animals, considering previous research, were chosen for further analysis and discussion. These behaviors were inactive, social affiliative, social agonistic, stereotypic/abnormal (only F2) and visitor interactions. Mean frequencies of behaviors (±SE) per minute in the three intensity levels are shown in Fig. 4-8. Intensity level 1 = low, 2 = medium and 3 = high.

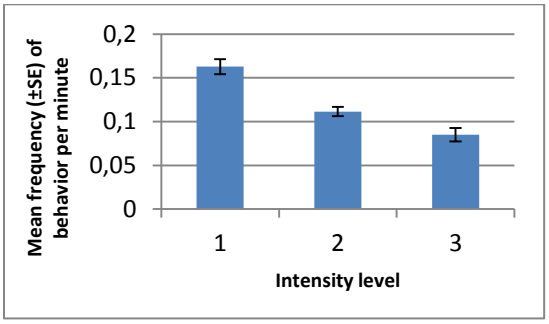

Figure 4. Mean frequency (±SE) of inactive behavior per minute in visitor intensity levels 1-3.

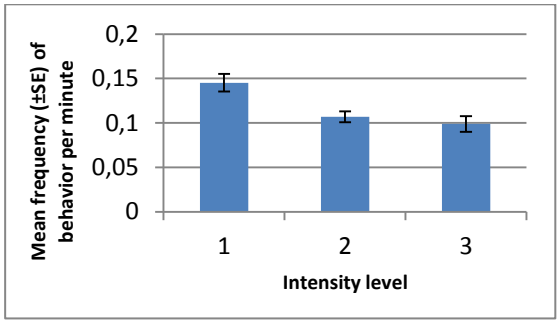

Figure 5. Mean frequency (±SE) of affiliative behavior per minute in visitor intensity levels 1-3.

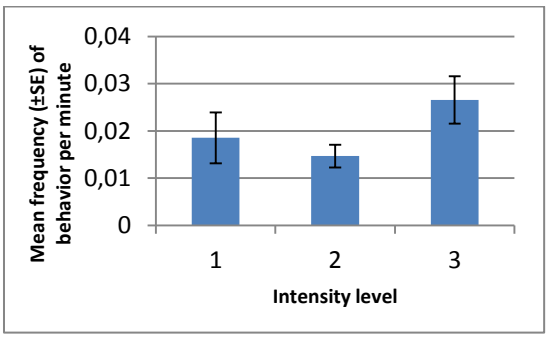

Figure 6. Mean frequency (±SE) of agonistic behavior per minute in visitor intensity levels 1-3.

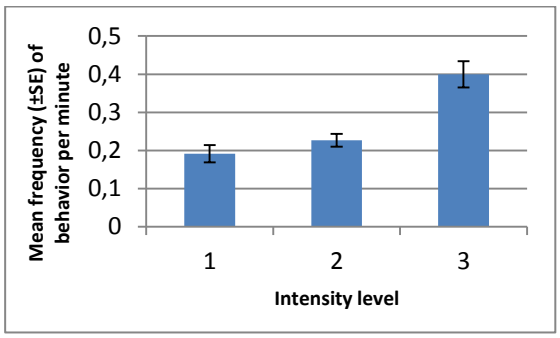

Figure 7. Mean frequency (±SE) of stereotypic/abnormal behavior (only individual F2) per minute in visitor intensity levels 1-3.

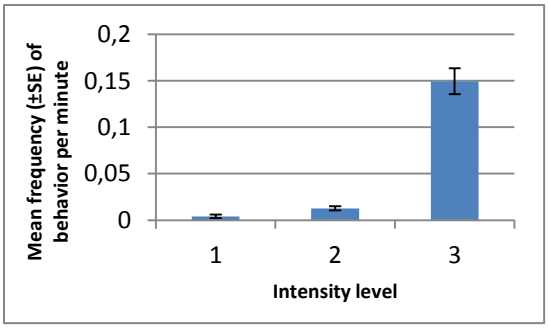

Figure 8. Mean frequency (±SE) of visitor interactions per minute in visitor intensity levels 1-3.

Inactive behavior differed significantly between all intensity levels ($p<0.000$). Social affiliative differed significantly between low and medium intensity levels, and between low and high ($p<0.000$) but not between medium and high intensity levels ($p=0.466$). Social agonistic did not differ significantly between intensity levels low and medium ($p=0.737$) however, a clear trend was found between low and high ($p=0.013$). There was a significant difference between medium and high levels ($p=0.008$). Visitor interactions differed significantly between all intensity levels; between low and medium $p=0.005$, between low and high levels, as well as between medium and high intensity levels $p<0.000$. Stereotypic/abnormal behaviors had a trend between low and medium intensity levels ($p=0.025$), and significant differences between all other intensity levels ($p<0.000$).

4.2 Lilla Zoo

Alpacas were observed for 1570 minutes, goats for 3150 minutes and sheep for 1920 minutes. Significant differences were found in all three species in all analyzed behaviors. No species showed any desirable behaviors at high intensity level and very few at medium intensity level. Even though visitors were not allowed to feed the animals in Lilla Zoo, all alpaca desirable behaviors were "approach" when visitors were feeding or attempting to feed them, which was also the case for all desirable behaviors in sheep and most desirable behaviors in goats at medium intensity level. Alpacas performed on average 0.22, goats 0.34 and sheep 0.24 desirable behaviors per session. Alpacas performed on average 0.89, goats 0.66 and sheep 0.3 undesirable behaviors per session. Mean frequency of behaviors (±SE) in the three intensity levels for each species is shown in Fig. 9 and 10. Intensity level 1 = low, 2 = medium and 3 = high.

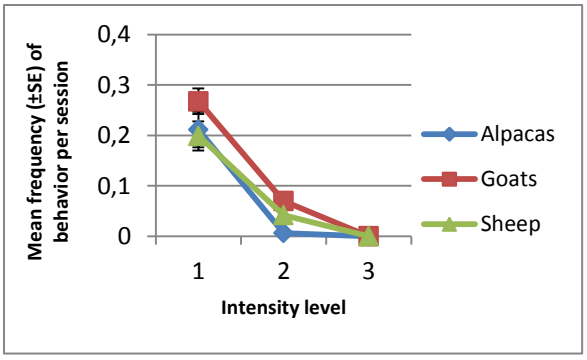

Figure 9. Mean frequency (±SE) of desirable behaviors per session in visitor intensity levels 1-3.

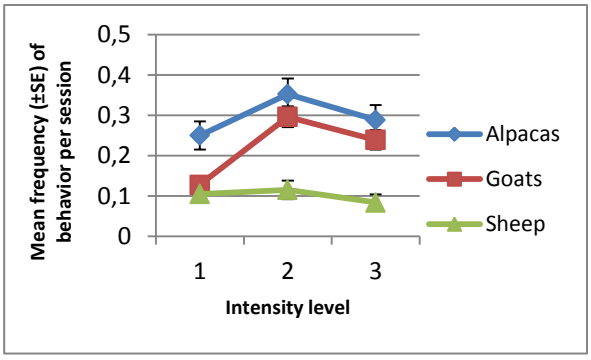

Figure 10. Mean frequency (±SE) of undesirable behaviors per session in visitor intensity levels 1-3.

Frequencies of desirable behaviors in alpacas and sheep were too low for statistical analysis in low and medium intensity levels; no statistical analysis was performed on desirable behaviors in these species. Frequencies of goats' desirable behaviors differed significantly between intensity levels low and medium ($p<0.000$). As no desirable behaviors were observed at high intensity level, no statistical analysis was performed.

Frequencies of alpacas' undesirable behaviors differed between low and medium intensity levels, and levels low and high ($p<0.000$), but not between levels medium and high ($p>0.01$). Frequencies of goats' undesirable behaviors differed between all intensity levels ($p<0.000$). Frequencies of undesirable behaviors in sheep differed between low and medium intensity levels, with a slight trend between levels low and high ($p=0.025$), but no significant difference was found between medium and high levels ($p>0.01$).

Time spent in retreat space (R.S.) also differed ($p<0.000$) between all three species. Alpacas spent on average 35.7 seconds/minute in retreat space, goats 10 s/min and sheep 20.6 s/min (Fig. 11). Further, alpacas attracted more visitors when in retreat space; 1.45 visitors per minute spent in retreat space, while goats and sheep both had just under 1 visitor per minute spent in retreat space (Fig. 12).

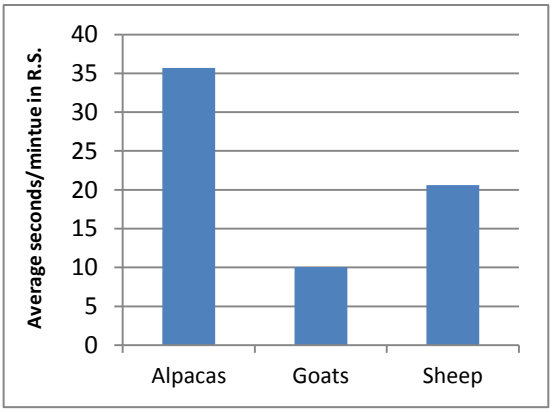

Figure 11. Average time spent in retreat space, in seconds per minute, for all three species.

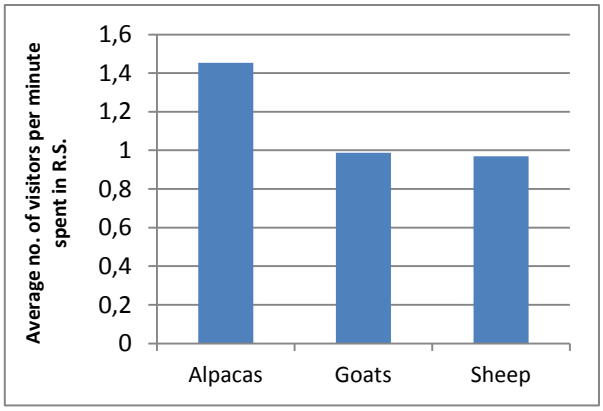

Figure 12. Average number of visitors at retreat space per minute spent in retreat space by each species.

5 Discussion

5.1 Drill

The behaviors chosen for further discussion were inactive, social affiliative, social agonistic, stereotypic/abnormal (only F2) and visitor interactions as these are behaviors typically shown to be affected by visitors in several species (e.g. Chamove et al. 1988; Sellinger & Ha, 2005; Wells, 2005; Kuhar, 2008). Frequency of inactive behaviors were higher when intensity levels were low, and lower when intensity levels were high, meaning that drills were more active with higher visitor intensity levels. Per the definition of inactive in this study, the animals were sleeping or resting when inactive, however, they could also passively be watching their surroundings, including visitors, as it was impossible for the observer to distinguish between resting and passively watching.

Here we must also consider the "visitor attraction hypothesis" proposed by Hosey (2000), in which he claims active animals attract more visitors which might lead to higher intensity levels, or simply that inactive animals do not excite visitors enough to provoke a higher intensity level from them. However, this was not the observer's experience during this study; many visitors would try to elicit animal activity through knocking or banging on glass, shouting etc. In this case it is more probable that the animals rested when the zoo was quiet, and chose not to rest when intensity levels were higher. It is difficult to determine if this has an impact on the animals without knowing their baseline behavior patterns and compare proportions of inactive behaviors to see if there is significantly less inactive behavior when visitors are present. As long as the animals get sufficient amounts of rest and sleep, the fact that they are more inactive when visitor intensity levels are low might not be a welfare indicator. Nevertheless, it is important to recognize the difference in inactivity between

different intensity levels and investigate if there is an impact on animal welfare. Furthermore, studies (Bitgood et al. 1988; Reade & Waran, 1996) have shown that active animals attract more zoo visitors and that zoo visitors want to see active animals. Therefore, from a zoo perspective, it could be considered positive that the drills are more active when the zoo is busier. However, inactivity is not the only behavior affected by visitor intensity and all affected behaviors should be weighed together when assessing visitor effects.

Social behaviors are often used as welfare indicators in animals, as well as widely used in studies of visitor effects (Chamove et al. 1988; Mendoza et al. 2000; Wells, 2005; Sellinger & Ha, 2005; Kuhar, 2008; Sekar et al. 2008), the postulation being that affiliative behaviors will decrease and agonistic behaviors increase if visitors have a negative effect on animals. This is what was found in this study. In the affiliative behaviors, the differences were between low intensity and both medium and high intensities, suggesting that the threshold of intensity for affiliative behaviors lies somewhere between low and medium. Fewer affiliative behaviors might not have a negative impact on the welfare of the animals, but as the purpose of keeping drills is conservation of the species it is imperative that groups function well, to facilitate successful breeding. Furthermore, facilitating affiliative behaviors can increase the overall well-being of the animals, as well as improve visitor experience at the zoo. Agonistic behaviors however can have a direct negative effect on animal welfare, for example if the animals harm each other. In this study, agonistic behaviors did increase at high intensity levels; however, the frequency of agonistic behaviors was at its lowest at medium intensity. The only significant difference was between intensity levels medium and high, with a strong trend between levels low and high ($p=0.013$). One factor that might affect the distribution of agonistic behaviors is that they were rather uncommon ($n=137$, compared to affiliative behaviors $n=861$). Additionally, the low frequency of agonistic behaviors could also be due to the group being socially well functioning. Nevertheless, it is still clear that agonistic behaviors are most common when intensity levels are high. Furthermore, studies show (Woods, 2002; Fernandez et al. 2009) that seeing aggressive behaviors among animals impacts the visitors negatively, leaving them with a more negative image of the zoo and its animals. Therefore, if decreasing high intensity levels leads to a decrease in agonistic behaviors, this would benefit both animals and visitors.

Some of the most commonly used animal welfare indicators are the presence of stereotypic and abnormal behaviors (Broom, 1991; Morgan & Tromborg, 2007; Hill & Broom, 2009). Studies have shown that stereotypic and other abnormal repetitive behaviors can be used as a coping mechanism for stressors other than those present when the behaviors developed (Pomerantz et al. 2012). These types of behaviors are often considered an indicator of stress (Broom, 1991; Hill

& Broom, 2009). One of the females has a repertoire of stereotypic and abnormal behaviors which she performs quite frequently, probably due to maternal deprivation. According to Latham and Mason (2008), maternal deprivation increases both severity and prevalence of abnormal and stereotypic behaviors in both human and non-human animals. Since moving to Parken Zoo these behaviors have decreased in both prevalence and severity, but are still quite severe. As she is genetically important it would greatly benefit the drill conservation program if she bred successfully. To facilitate breeding it is important that measures needed to decrease abnormal and stereotypic behaviors, and increase normal behaviors, are taken. Investigating if she is negatively affected by visitors was a part of the zoo's ongoing work with this female.

The results found in this study suggest this female is affected by visitors as stereotypic and abnormal behaviors increase with increase in visitor intensity. Significant differences were found between low and high intensity levels, as well as medium and high. A trend was found between levels low and medium ($p=0.025$). The increase in these behaviors suggests that this female experiences stress from higher visitor intensity levels. Even though this female most likely developed her abnormal and stereotypic behaviors as a juvenile, due to maternal deprivation, the results suggest she finds visitors stressful and uses these behaviors to cope with this stress. This finding is in concordance with previous research, which also found increases in stereotypic and/or abnormal behaviors in mandrills, gorillas and jaguars due to visitor effects (Chamove et al. 1988; Wells, 2005; Sellinger & Ha, 2005). Additionally, seeing abnormal and stereotypic behaviors can lead to visitors perceiving the zoo in a negative manner, which can contribute to a negative experience at the zoo for the visitors (Altman, 1998; Miller, 2012), which further infers the need to reduce visitor effects.

In this study, all visitor interactions observed included aggression toward visitors and were therefore considered to be negative. This is perhaps the most apparent evidence that the drills at Parken Zoo are affected by visitors and their intensity levels. Significant differences were found between all intensity levels with 248 out of 305 incidences occurring during high intensity level. Interactions included threatening visitors, charging at and/or attacking the glass, sometimes several times at the same visitors. It is clear that the drills get agitated when intensity levels are high, and as they often directed their aggression toward visitors which had a high intensity level it seemed the drills were aware of which visitors were agitating them. Often the response of the visitors were jumping away from the glass (startled), screaming, shouting, crying etc., and many times visitors "attacked back" through mimicking threats or charges at the glass, meaning that the intensity level often increased even more, or was prolonged, by an interaction. Many visitors were startled or frightened by the interactions, and

it was the observer's belief that many visitors were taken aback by the "attacks". However, it is important to note that even though these behaviors are considered signs of the drills finding visitors stressful, these visitor interactions might not lead to prolonged or chronic stress. Nevertheless, visitor interactions are an important contribution when investigating how visitors affect the drills at Parken Zoo, and a possible effect on prolonged stress cannot be ruled out. Therefore, as these types of visitor interactions can affect both animals and visitors negatively, it is essential that efforts be made to minimize the triggers of these behaviors.

If all behaviors are considered together, it is clear the drills at Parken Zoo are affected by visitors. As the behavioral changes seen as an effect of visitor intensity are commonly used as welfare indicators, the results also suggest that some welfare concerns are present. There is little research on captive drills, however the results of this study are similar to the ones previously found in a visitor effect study of mandrills (*Mandrillus sphinx*) by Chamove et al. (1988), as well as several other studies on various species (e.g. Sellinger & Ha, 2005; Wells, 2005; Sekar et al. 2008). The behavioral evidence of visitors being stressful to zoo animals is further supported by studies which have used physiological measures such as fecal and urinary cortisol levels (Davis et al. 2005; Pifarré et al. 2012). Additionally, according to several authors prolonged stress can inhibit reproduction (Broom, 1991; Moberg, 2000; Tilbrook et al. 2002; Wielebnowski, 2003). Sellinger and Ha (2005) argue that stress induced by the effects of visitors could have a negative effect on the success of breeding programs in zoos. Therefore, if the presence of visitors does affect the animals negatively and subjects the animals to prolonged stress, this could influence the conservation efforts in zoos as reproductive success rates might be affected.

To minimize the negative impact of visitors, and ensure good animal welfare, measures should be taken, such as providing additional visual barriers through having plants by the glass or covering the glass with camouflage netting, putting up sound insulation and providing more and clearer information to the visitors on how to act when watching the drills (Chamove et al. 1988; Birke, 2002; Wells, 2005; Kuhar, 2008; Bortolini & Bicca-Marques, 2011). Further, studies have shown that increasing the distance between the visitors and animal enclosures can decrease the visitor effects (Hosey, 2000; Bortolini & Bicca-Marques, 2011). This could be done for the drills through digging a flowerbed around the outside enclosure, which in addition to increasing the distance to the visitors would provide additional visual barriers, prevent visitors from pressing up against the glass and inhibit knocking and banging on the glass. In addition to having a direct decrease of visitor effect, these modifications could increase the drills' sense of control over their environment, which is considered beneficial to zoo animals (Anderson et al. 2002; Wells, 2005; Kuhar, 2008).

It could be beneficial to have information about the baseline behaviors of the drills, however baseline data is difficult to acquire as this data would have to be obtained during fall, winter and spring when weather and seasons might interfere with the results. Comparing visitor density and intensity levels is commonly used in research regarding visitor effects (e.g. Chamove et al. 1988; Birke, 2002; Wells, 2005), and if the aim of the study is to compare different visitor density or intensity levels, baseline data is not needed. Comparing visitor intensity levels was considered the most suited method for this study. In future studies, the impact of visitors after implementing suggested changes should be investigated.

To conclude, the behavior of the drills at Parken Zoo is affected by visitor intensity. The results in this study suggest that these drills at least to some degree find visitors stressful, which is in concordance with previous research. Adding visual barriers, improved information and increasing the distance between visitors and the enclosure are measures which could decrease the visitor effect and should be considered by Parken Zoo to ensure good animal welfare.

5.2 Lilla Zoo

In Lilla Zoo behaviors considered desirable and undesirable in the petting zoo setting in relation to visitor intensity were investigated. Again, it is important to note that behaviors which are undesirable in this setting might not be so under other circumstances (Anderson et al. 2002). The alpacas, goats and sheep roam freely within the whole petting zoo area, with access to three retreat spaces, and as staff cannot keep the entire area under observation at all times it is important the interactions between animals and visitors function well. If not, measures would need to be taken and changes made to ensure a positive environment for both animals and visitors.

Desirable behaviors were never seen when intensity level was high and rarely when intensity level was medium. This leads to the conclusion that to ensure visitors have a positive and hands on experience with the animals, which is the common goal of petting zoos, visitors should act in a manner in which intensity level is kept low.

As the animals in Lilla Zoo seem to mainly approach visitors who are feeding or attempting to feed the animals, even though they are not supposed to, one conclusion that could be drawn would be to incorporate feeding of the free roaming animals into the Lilla Zoo program. However, this could prove problematic as feeding can induce aggression between animals and not all of the animals are very polite when trying to obtain food; such as goats and sheep climbing on visitors or head-butting each other with the risk of children getting

in the way. Therefore, feeding might not be a suitable method to increase desirable behaviors as it might also lead to an increase in undesirable, or unpleasant, behaviors of the animals.

The frequency of desirable behaviors was low for all species; on average 0.22, 0.34 and 0.24 respectively for alpacas, goats and sheep per session. This could be interpreted as there being room for improvement in Lilla Zoo. This could be done by using the staff even more to inform and educate visitors on how to act and behave around the animals to promote more desirable behaviors from the animals. As the positive interactions between visitors and petting zoo animals are the purpose of Lilla Zoo, it is important to facilitate the occurrence of these interactions. However, Anderson et al. (2004) found that nearby presence of keepers could induce an increase in undesirable behaviors in goats and sheep, which is the opposite of the sought effect and therefore staff needs to be aware of this risk.

Like desirable behaviors, undesirable behaviors were overall not very frequent; alpacas performed on average 0.89, goats 0.66 and sheep 0.3 undesirable behaviors per session. Further, the highest frequencies of undesirable behaviors were found during medium intensity levels for all three species. Alpacas and goats did however have their lowest frequencies at low intensity levels, but for sheep, the lowest frequency was at high intensity level. One reason for this distribution could be the overall low frequencies of undesirable behaviors. Another explanation could be other influencing factors, not taken into consideration in this study. Further, as sheep had very low frequencies of undesirable behaviors it could be that they are well adapted to the petting zoo setting. Contrary to this study, Anderson et al. (2002) found that sheep performed more undesirable behaviors than goats, however, this was predicted as the breed of sheep used in that study were known to be more fearful of humans.

For both alpacas and goats, results show significantly less undesirable behaviors when intensity levels are low compared to other intensity levels. This could be an indicator of both medium and high intensity levels being stressful to these animals. This is central as it indicates the importance of visitors maintaining a low intensity level to avoid unpleasant and ensure positive interactions for both themselves and the animals.

Due to the results in this study, alpacas seem to be the least habituated to visitors and if there are any welfare concerns it would be with the alpacas. They perform the most undesirable behaviors, perform no desirable behaviors except approaching visitors with food and spend the most amount of time in the retreat spaces, all while seeming to be the most popular animals by looking at how

many visitors stood around the retreat spaces while the animals were in them. When Lilla Zoo was crowded, the retreat space the alpacas were currently in could be surrounded by visitors that wanted to get a closer look at them, which at times could lead to the alpacas having to press through visitors if they wanted to leave the retreat space. Considering the results indicate that alpacas do not want to be in close proximity to visitors, it is not probable they would attempt to leave the retreat space at these times, meaning they are in a sense trapped in the retreat space by the visitors. Furthermore, it should be noted that almost all of the alpacas' 34 observed desirable behaviors were performed by one individual. Additionally, it should be considered if it is suitable for alpacas to be one of the free roaming species in Lilla Zoo, perhaps it would be more beneficial for the animals, visitors and therefore also the zoo, if the interactions with alpacas were controlled and under direct supervision of staff.

It is important to note that the alpacas were not sheared until before moving back into Lilla Zoo after their relocation for foaling. The alpacas might therefore simply have used the cool shade provided by the retreat spaces to avoid over heating in the sun. The alpacas did spend less time in the retreat spaces after being sheared (27s/min) compared to before being sheared (37s/min), however Lilla Zoo was also less busy during the last part of the study, which could also have an effect on the behavior of the alpacas, making them more likely to spend more time outside of the retreat spaces. It is plausible shearing had an impact on the behavior of the alpacas, however when examining all data collected from the alpacas, it is likely visitors had an effect as well.

Goats and sheep seem to be well adapted to the Lilla Zoo environment. Goats perform more desirable behaviors than sheep, but also more undesirable behaviors, perhaps due to being more active as a species. Sheep spend a rather large proportion of their time in the retreat spaces (about 21 s/min), which could be interpreted in several ways. One interpretation is that they are well adapted and that their overall low frequency of behaviors is due to them using the retreat spaces the way they are intended; when Lilla Zoo is busy or they simply want to escape visitors. A harsher, but less probable, interpretation is the opposite, that they use the retreat spaces as they are not habituated to the Lilla Zoo environment and spend a lot of time in the retreat spaces to avoid visitors. As with the alpacas, it is important to note that the sheep were not sheared until later in the season, therefore, frequent usage of the retreat spaces could be because they were hot and needed the shade that the retreat spaces provided for them. Additionally, to ensure reliable results, some of the events that occurred during this study should be avoided, such as the move of the alpacas to a different enclosure for part of the study.

In conclusion, the results suggest that visitors do affect the alpacas, goats and sheep in Lilla Zoo; however the only welfare concern would be the alpacas in that they might need more habituation to visitors before being suitable as free roaming animals in Lilla Zoo. The results of Anderson et al. (2002) address the importance of well-designed retreat spaces as the undesirable behaviors in their study were most frequent during the semi-retreat space condition. The retreat spaces in Lilla Zoo can be compared to the semi-retreat spaces in that study as visitors can reach into the retreat spaces and try to pet animals that are in the retreat space. Further, visitors did not always see or respect signs stating they were not allowed in the retreat spaces. Therefore, undesirable behaviors in Lilla Zoo might be reduced by redesigning the retreat spaces, ensuring visitors cannot reach or go into them, which would increase the controllability for the animals. Furthermore, as desirable behaviors mainly occurred when visitor intensity was low, measures should be taken to ensure visitors are aware of how to act when in Lilla Zoo to enable positive interactions with the animals.

5.3 General discussion

According to Wielebnowski (2003) it is crucial to the well-being of animals to identify stressors which lead to long term stress responses in animals. Ensuring animal welfare is kept at a high level is an essential part of the work of zoos, which not only benefits the well-being of the animals but also the experience of zoo visitors. Further, factors which have a negative effect on animal welfare can impact conservation efforts as it can affect the health and reproduction of the animals negatively. Research has shown that zoo visitors in some cases are a stressor to zoo animals (e.g. Hosey, 2000; Davey, 2007). Even though the primary goals of zoos today are conservation, education and research, recreational aspects are still a large part of their work. As zoos greatly rely on the support visitors provide them with, it is vital to thoroughly understand and clarify the effect zoo visitors might have on zoo animals. By doing this, zoos will facilitate their work on improving animal welfare as well as conservation efforts.

6 Conclusion

Visitor intensity affects the behavior of drills as well as free roaming petting zoo animals at Parken Zoo. Inactive and affiliative behaviors in drills decreased when visitor intensity was high compared to low visitor intensity. The opposite was found for agonistic, stereotypic/abnormal behaviors and visitor interactions which increased when visitor intensity was high compared to low. These results are in concordance with previous research and are indicators of drills finding visitors stressful at least to some degree, which can impact the welfare of the drills. Measures to decrease the effects of visitors should be implemented by

Parken Zoo to ensure good animal welfare, such as adding visual barriers and increasing the distance between visitors and the enclosure.

Visitor intensity affects the alpacas, goats and sheep in Lilla Zoo as well. Desirable behaviors were not seen at high intensity levels and only sufficient amount of times for statistical testing at medium intensity levels in goats. In alpacas and goats undesirable behaviors were least frequent when intensity levels were low. Goats and sheep seem to be well adapted to the petting zoo setting. Alpacas appear to be the most affected by visitors; they only perform desirable behaviors when visitors attempt to feed the animals, perform the most undesirable behaviors and spend the most time in retreat spaces. If they are to be kept free roaming in Lilla Zoo further habituation to visitors is needed. Redesigning the retreat spaces could lead to a decrease in undesirable behaviors as it offers the animals more control over their environment. Finally, keeping visitor intensity level low is important to facilitate positive interactions between visitors and animals, which is the purpose of Lilla Zoo.

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