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Quadros, S, Goulart, VDL, Figueiredo Passos, L, Vecci, MAM and Young, RJ (2014) Zoo visitor effect on mammal behaviour: Does noise matter? Applied Animal Behaviour Science, 156. pp. 78-84. ISSN 0168-1591

Zoo visitor effect on mammal behaviour: does noise matter?

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ABSTRACT

The zoo visitor effect is the change in animal behaviour and physiology in response to the presence of a viewing public. It is thought to result from, amongst other things, visitor generated sound (i.e., noise), but this hypothesis has never been explicitly tested. We tested this hypothesis through observations on the behaviour and enclosure use of 12 mammal species held in 12 separate enclosures at the Belo Horizonte Zoo when exposed to different sound pressure levels (i.e., noise) from the visiting public. The results show that increasing sound pressure levels without the public being present significantly reduced resting behaviour. Whereas increasing sound levels with the public present significantly reduced resting, other behaviour and significantly increased vigilance and social negative behaviours. In terms of enclosure use in the presence of visitors, the majority of species spent significantly more time in the 50% of their enclosure furthest away from the public (when public were present). These results show that zoo visitors have a negative welfare impact on zoo-housed mammals, especially groups of noisy visitors where levels were recorded outside of the recommended limits for human well-being (>70 dB(A)). Thus, zoos need to address this issue, probably, through a combination of visitor education campaigns and acoustic modification to enclosures.

Keywords: animal behaviour; animal welfare; mammals; noise; zoo visitor effect.

1 Introduction

The zoo visitor effect is the change in behaviour and/or physiological responses of animals in the presence of zoo visitors (Davey, 2006). Such changes are often indicators of poor animal welfare, but, for certain species, human audiences are an enriching interaction (Hosey, 2000; Davey 2006). Scientific investigations into the zoo visitor effect have been ongoing since the 1980s and have generally considered how the viewing public's behaviour affects the well-being of the animals they are watching (Davey, 2006, 2007). In many of these studies, it is assumed that more people means greater levels of noise (i.e., Noise pollution) at animal enclosures.

A positive correlation of noise levels and the audience is a common assumption, but it was not empirically tested. In fact, the link between the visitor effect and sound pollution remains untested.

Modern zoos, first and foremost need to ensure the well-being of the animals in their care. It is from this core activity that the stated goals of the modern zoo in conservation, research, education and entertainment can be achieved (Young, 2003). Besides the common effort to improve the animal welfare, zoos can negatively impact the well-being of the animals they house due to inherent aspects as unvarying husbandry routines (Lyons et al., 1997) and exposing the animals to the public (Young, 2003; Davey, 2006, 2007).

The zoo-going public is a potential source of both positive and aversive stimuli for the animals. Previous studies into the zoo visitor effect have largely reported a negative impact on animal behaviour (Mallapur et al., 2005; Sellinger and Ha, 2005) and animal physiology (Hosey, 2000; Davis et al., 2005; Davey, 2006, 2007). For example, some species show less affilitative behaviour (Glatson et al., 1984; Hosey, 2008) in the presence of the public and in some species stress hormone levels are higher during visitor presence (Davis et al., 2005). Typically, such studies have measured the zoo visitor effect in a poorly quantified manner or using qualitative measurements such as the presence or absence of visitors (Mitchell et al., 1991, 1992), while other studies subjectively categorised visitor behaviour as 'agitated' or not (Wells, 2005) for primate species. These studies provide some insights into the zoo visitor effect; however, a better quantification of zoo visitor impacts would provide greater insights. Sound pressure level meters are now relatively low cost and the principles of measuring and assessing noise pollution have been well established by acoustic engineers (Ross, 2007) and are now used by biologists (e.g., Duarte et al., 2011).

Zoo visitors are the source of three potential types of stimuli to animals: visual, olfactory and auditory (Young, 2003). Visual and olfactory stimuli are difficult to quantify and measure, not least because there are the emitted stimuli (e.g., colours, movement, smell) and there are the perceived stimuli (i.e., what the animal was observing or smelling). Auditory stimuli are easier to quantify, as they are perceived if the animal is paying attention or not, and their effects, at least on human well-being, are understood (WHO, 1999). Furthermore, there are some studies of noise pollution of the viewing public in zoos, which show negative effects on animal welfare (Owen et al., 2004; Powell et al., 2006). Despite this, we found no zoo studies on sound pollution, which have quantitatively measured noise as a direct consequence of the public's behaviour. Therefore, the aim of this study was to directly measure how sound pollution from the zoo-going public affected behaviour and enclosure use by zoo housed mammals.

2 Methods

2.1 Study area and experimental subjects

This study was conducted at the Belo Horizonte Zoo, Minas Gerais, Brazil (S 19° 51', W 44° 01') from June 2009 to March 2010. Subjects were 12 different mammal species housed in 12 different enclosures (see Table 1). We chose species known to be popular with visitors such as Chimpanzee (*Pan troglodytes*), and matched with less popular species such as deer (*Cervus elaphus*) (Ward et al., 1998; Whitworth, 2012). Matching was done across all families and its function was to ensure that we had species, which received large and small zoo visitor numbers.

2.2 General data collection

The Belo Horizonte Zoo is closed to the public every Monday (i.e., this creates the experimental condition: background noise but no public) and receives intense visitation on Tuesdays (free entrance day) and the weekend (i.e., this creates the experimental condition: noise and public). Unfortunately, it was not possible for us to create a condition of background sound level and public (i.e., visitor present but control sound pressure level to be equal to background levels). Therefore, control data; that is, no public influence on sound pressure levels were collected on Mondays, and days with visitor influence on Tuesdays and weekends. On Mondays, background levels of noise observed were due to normal routine zoo maintenance activities (e.g., feeding of animals and cleaning of enclosures). To control for time of day effects, we observed, animals in different enclosures using a Latin square experimental design from 0900 h to 1700 h. Each group of animals in the 12 different enclosures was observed for 10 hours without (i.e., background sound condition) and 10 hours with the zoo visitors being present (i.e., sound and public condition). We used each enclosure as statistical units for noise pollution sampling (N=12).

2.3 Behavioural sampling visitor avoidance

We observed animals using scan sampling and behaviour was recorded once every two minutes during a 20-minute observation period (see Table 2). Animals in different enclosures were observed at least once or twice per day with the minimum interval of 4 hours between observation sessions (to increase statistical independence) (N=15).

The animal's positions within enclosures were recorded simultaneously with the behavioural sampling. All enclosures had an indoor area not in view of the public. When the animal was inside the shelter or hidden by any element inside the enclosure we recorded the behaviour Not visible. The frequency of Not visible was used to measure the visitor avoidance by comparing the expression of this behaviour while high levels of public's noise.

2.4 Sound pressure level measurements

All sound pressure level measurements were made simultaneously with behavioural and enclosure use measurements, thus permitting the direct comparison of data. Sound pressure levels were measured using a sound level meter (model 1325C Minipa, São Paulo, Brazil), mounted on a tripod 2 m above the ground and 2 m from the public (to avoid interference) outside the enclosure pointing towards the animals. All enclosures were open-air with no solid barrier between the animal and the public. The sound level meter had frequency weighting, a fast response, and could measure between 30 and 130 dB on the "A" curve (Rossing, 2007). Immediately before and after each measurement, the sound level meter was calibrated (MSL Calibrator, Minipa model 1326, São Paulo, Brazil). We used 'equivalent continuous sound level' (L_{eq}) as our measurement of noise, which is the energy mean of the noise level averaged over the measurement period. L_{eq} is the most widely used measurement of sound pollution (see Rossing, 2007; Duarte et al., 2011). We also calculated the percentage sound pressure level L_{50}, which represents an average sound pressure level during the sampling.

The non-constant source of sound in this study was from zoo visitors. The number of visitors varied throughout our sampling points during each 20 minutes observation session. As a L_{eq} value represents the energy levels as a constant noise during sampled period, we used categories ranging from one visitor (researcher excluded) to 49, because above this number we were not able to count the number of visitors precisely. . Each category of visitors is represented by a median of Leq from all samples with the same number of visitors.

2.5 Statistical analysis

We tested whether the data met the requirements for parametric statistics by an Anderson-Darling Normality test. Noise levels follow a parametric distribution

(P>0.05), but the behavioural data did not (P<0.05), even after attempting data transformations; therefore, parametric tests were used for noise levels analysis and non-parametric statistical tests were used for behavioural analysis.

For noise levels analysis, we performed a linear regression to verify the relation of visitors (independent) and L_{eq} (dependent). We also compared L_{eq} values between intense visitation days and Mondays (day closed for visitation) for each enclosure by a Paired T test. Noise levels for all enclosures were assessed by Kruskal-Wallis test and a cluster analysis (Nearest neighbour cluster method) was performed to identify groups were the noise levels are similar. Noise levels, L_{eq} for enclosures (Cage, Paddock, and Pit/Island) were also evaluated by Kruskal-Wallis tests. The correlation between rank of noise levels and rank popularity was also examined by Spearman rank correlation test. Ranks of species popularity were based on Whitworth (2012).

Behavioural data were converted into percentages for each session per species group (N=15). Behavioural and shelter use data were compared for days with and without the presence of visitors using Wilcoxon matched pair tests. This was performed for each species group as well as for enclosure type. As noise levels can be similar for days with and without visitors, we established a noise threshold for L_{eq}. When the equivalent noise levels were higher than the mean, we considered the noise higher than usual and expected a behavioural change. In other words, when the L_{eq} was higher than L_{50}, we predict a behavioural response. We compared the behaviours shown by each species group with higher L_{eq} and lower L_{eq} employing the Wilcoxon matched pair tests. The same procedure was used for comparing expressed behaviours in louder and quieter samples at each enclosure type. All statistical tests used a statistical significance level of $P<0.05$ and were carried out in the software Minitab version 16 and IBM SPSS 20.

3 **Results**

3.1 Noise levels

On days without public, the mean sound pressure level for all enclosures L_{eq} was 46.75 dB(A) ±1.18, which was significantly lower than the 60.42 dB(A) ±2.46 on days with the public (Paired T test=-20.00, $N_1=N_2=12$, $P<0.001$).

Noise levels are significantly predicted by visitor numbers by the following regression equation: L_{eq} = 55.5 + 0.18 x visitor number. Results from the linear regression shown a significant positive relationship between L_{eq} and visitors ($r^2 = 0.55$, F(1)= 55.31, $P<0.05$). The equivalent noise levels slightly increase with the number of visitors.

Overall, enclosures showed significantly different noise levels ($H(11) = 92.51$, $P<0.001$). The cluster analysis revealed three main groups. Howler monkeys (*Alouatta guariba*) enclosure only was the quietest with a median L_{eq} of 56 dB(A) and an interquartile range of 5.25. The second grouping was deer (*Cervus elaphus*) (58±4.5 dBA), bushdog (*Speothos venaticus*) (58±5.5 dBA), and ocelot (*Leopardus pardalis*) in the pit enclosure (58.5±6.5 dBA). The third grouping contains all remaining animals, including: ocelot (*L. pardalis*) in the cage enclosure (59.5±6 dBA), giraffe (*Giraffa camelopardalis*) and kob (*Kobus ellipsiprymnus*) at the same paddock (60.5±6 dBA), golden lion tamarin (*Leontopithecus chrysomelas*) (61±5.25 dBA), jaguar (*Panthera onca*) (61±6.25 dBA), elephant (*Loxodonta africana*) (62.5±5 dBA), gorilla (*Gorilla gorilla*) (63±5 dBA), capuchin (*Cebus xantosthernos*) (63.5±4.25), and chimpanzee (*Pan troglodytes*) (63.5±6.25).

Noise levels across enclosures also demonstrated significant differences while comparing enclosures with different shapes and public's proximity ($H(2) = 25.77$, $P<0.001$). Circular enclosures, such as islands and pits, had greater public access from almost the whole perimeter, and showed higher L_{eq} values of 62.00±6.0 dB(A) (Z=4.93), followed by the rectangular paddock with L_{eq} of 60.00±6 dB(A) (Z=-2.02) and the square cage with a L_{eq} of 59±5.25 dB(A) (Z=-3.41).

Visitors' preferences and attitudes, regarding noise levels, were evaluated correlating the rank of noise levels and the rank of popularity based on Whitworth (2012). We considered apes, monkeys, elephants, giraffe, big cats, canids and relatives, and deer species, as a descending order of popularity. Noise levels and popularity were positively correlated ($r_s(10) = 0.668$, $P<0.05$).

3.2 Behaviour

The mean of each behaviour expressed for every species group (N=9) between days with intense visitation and in days closed to visitation were not statistically different for all species observed ($P>0.05$). The use of shelter or any other structure at the enclosure to avoid the public was also not significant ($P>0.05$). The same occurred comparing behaviours per enclosure (N=3). Behaviours expressed on Pits and Islands, Cages, or Paddocks are not significantly different when comparing days with and without visitors (P>0.05). Besides the fact of different noise levels due to visitation, we were not able to find behavioural differences between days with or without zoo visitors.

As we observed enclosures with different noise levels and different attitudes towards animals, due to popularity, we set a threshold for L_{eq} at the midpoint of noise level during sampling, L_{50}. Each enclosure has a different L_{eq} and, consequently, a different L_{50} values. The bushdog's paddock (L_{50} = Median 61.5, Interquartile range ± 5 dBA), capuchin's island (L_{50} = 67±4.25 dBA), chimpanzee's pit (L_{50} = 66.5±4.75 dBA), deer's paddock (L_{50} = 61.5±4 dBA), elephants' paddock (L_{50} = 65±4.25 dBA), giraffe's and kob's paddock (L_{50} = 63±5.5 dBA), golden lion tamarin's cage (L_{50} = 65±6.25 dBA), gorilla's pit (L_{50} = 67±5 dBA), howler's cage (L_{50} = 61.5±5 dBA), jaguar's pit (L_{50} = 64±6 dBA), ocelot's cages (L_{50} = 62.5±5.25 dBA), and ocelot's pit (L_{50} = 61±7.5 dBA) presented these respective values for L_{50}. For these values, we used for behavioural analysis, only records where the L_{eq} were greater than or equal to the L_{50} limit.

We did not observed any behavioural change between higher and lower noise levels (P>0.05). No differences in shelter use or public avoidance were observed either (P>0.05). As before, no behavioural differences for animals in Pit or island, Paddock or Cage was verified (P>0,05).

4 Discussion

In this study, we did not assume that a higher visitor numbers implies greater noise levels. We approached the effects of visitor presence and the noise that they produce from their effects on the behaviour of the mammals.

As expected, noise levels were greater during visitation days. Despite the difference found, this does not necessarily imply non-visitor days were better for animal welfare. Belo Horizonte Zoo is located in an urban area, approximately 5.6 kilometres from an airport and 3.5 kilometres from football stadium. Thus, the zoo is not free from traffic noise from roads and air even on non-visitor days.

Visitors' presence slightly increased noise levels, although, individual enclosures presented different noise levels. We found three groupings based on L_{eq} values, the enclosure's location and animal activity level appear to explain these groupings. In the case of the group represented by Howler monkeys. Trees surround this cage and visitors have a naturalistic experience observing these animals. Naturalistic enclosures are more aesthetically pleasing and provide visitors with an immersive experience changing their perception of animals, their conservation and their welfare (Hancocks 2012, McPhee and Calstead 2012). Bushdog, ocelot in pit enclosure, and deer, composed the second group. These animals express low activity levels and responses towards the public. Big and charismatic animals form the last group. Indeed, we found that popularity was a good predictor for noise levels. This reinforces the result that an increase in visitor numbers does not always result in greater noise levels. The behaviour of animals and the visitor's preference strongly influenced the noise levels.

The enclosure type also influenced the noise from visitors. Circular enclosures, such as islands and pits, allow the public to follow the animal using the perimeter, increasing the interaction and the noise produced. At these enclosures, we observed the highest L_{eq} values. In the same manner, the rectangular shape of paddocks, allowed the public to move only along the front. Cages, besides being the smallest enclosures, permitted the animals to move in three-dimensional space escaping from the public view, consequently decreasing the interaction and noise levels.

The lack of significant behavioural changes in this study does not mean that visitors or noise pollution does not have impacts on the welfare of captive animals. Previous studies have reported increases in vigilance and social negative behaviours in response to visitor numbers (Glatson et al., 1984; Mallapur et al., 2005; Wells, 2005; Davey, 2006, 2007), but had not confirmed the link with sound levels. Increased vigilance behaviour is associated with animals perceiving that their environment may contain some kind of serious threat (e.g. a stressful situation such as predator presence; Chamove et al., 1988). Whereas, clearly, public induced aggressions towards each other is not good for animal welfare. Some studies of animal stress reported that increasing stress levels often leads to increased levels of aggressive interactions (Hosey and Druck, 1987). However, absence of behavioural changes may also reflect a deprived individual state. Behavioural responses in birds are strongly influenced by the environment and individual state and can be independent from the strength of the disturbance event (Beale and Monaghan, 2004). It might be the case that animals have habituated behaviourally to the noise from the public, but this does not mean they are not being stressed. Studies of humans have found that they can habituate to noisy environments, even learning to sleep in them, but physiological studies show stress levels are maintained high (Ross, 2007).

It is also important to take into account the management plan adopted to increase the animals´ welfare and avoid displays of acute and agonistic behaviours. Environmental enrichment, conditioning, enclosure design and other variables are relevant when discussing animal welfare and may have an important influence on our results. A number of studies have reported an increase in locomotor behaviour in the presence of zoo visitors. For example, in a study of several primate species the most common response was an increase in locomotion with increasing public numbers (Mitchell et al., 1992). It is interesting to note that zoo visitors prefer more active animals and the results of this study suggest that many zoo animals may respond to increases in noise with an increase in activity. Thus, it would appear that this interaction between animals and visitors is a positive feedback cycle. This phenomenon has been reported in sports stadiums where crowds shout to try and influence the referee and players (Unkelbach and Memmert, 2010; Barnard et al., 2011). In other words the more noise a crowd makes the more an animal becomes active and the more a crowd shouts in response. Clearly, this problem is something zoos could try to resolve using public education programmes.

Some studies show that animals may perceive human disturbance similarly to predation risk and, consequently, divert their time and energy into anti-predator responses (Frid and Dill, 2002). Visitor noise could change species' activity cycles making them more active after the zoo closes. This was not investigated in the present study.

We observed no increase of shelter use or Not Visible as predicted for public and noise avoidance. Acoustic stimuli are more difficult to avoid than visual stimuli (Wright et al. 2007). Escape from noise is almost impossible in enclosures where the animals have a limited space and shelters are not usually soundproof. Visual stimuli are generally reflective and indirect in which animals could mainly turn way to avoid.

Untangling precisely what is aversive about zoo visitors would be complicated as it would involve a reductionist approach to the great number of components that make-up the visual (e.g., crowd size, behaviour, clothes) and auditory (e.g., amplitude, frequencies) stimuli emitted by zoo visitors. In addition, to other possibly harder to quantify stimuli such as olfactory (Farrand, 2007).

Despite, physiological responses to noise being difficult to measure, noise pollution has well verified relationship with human health and well-being (Clark et al 2006, Dallman and Bhatnagar 2001). Although different from traumatic experiences (e.g. capture and containment), noise can be equally traumatic (Wright et al. 2007). The constant exposure to noise pollution can lead to negative health consequences, even for sub-threshold levels (Wright et al. 2007).

We also should bear in mind that different species have different sensitivities to noise based on their acoustic perception thresholds (Heffner and Heffner, 2007), thus the extrapolation of human standards for noise pollution to animals should be avoided and specific studies regarding healthy noise limits should be reinforced.

The sound pressure produced by visitors is characterised by loud peaks and not continuous in nature. Behavioural responding might be occurring only during such peaks. The L_{eq} itself is a measure used for the noise analysis represented by all noise events as a constant noise for the sampled period. Fright responses are related to peak values and are commonly reported events (Ross 2007). However, this study aimed to understand how the noise pollution influences the behaviour of captive mammals and its implications for animal welfare.

5 Conclusions

This study showed that the presence of the public increased the sound pressure levels in the areas of visitation at the enclosures of several species of mammals to levels above those recommended for human well-being (>70 dB(A); WHO, 1999); therefore, almost certainly having a negative impact on the welfare of these species. A species inherent activity level and the visitor's species preferences strongly influenced noise levels. The results of this study demonstrate the need for auditory barriers and opportunities for animals to escape from visitor-generated noise. Future research should consider the variation in the amplitude of the pressure levels, the noise frequency spectrum produced by visitors and other noise sources (e.g., vehicles). Furthermore, the sound propagation characteristics of enclosures should be investigated [Ross, 2007].

Acknowledgements

We thank the Belo Horizonte Zoo, Mammals and Environmental Enrichment Sections, for permission to work at the zoo and logistical support. SQ was supported by a postgraduate scholarship from CAPES during this research. VDLRG was in receipt of a CAPES postgraduate scholarship Proc. 1213-13-0. LFP was in receipt of a CAPES postgraduate scholarship Proc. 6060-13-7. RJY received financial support from FAPEMIG and CNPq.

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Table 1

Mammal species studied and their enclosures at the Belo Horizonte Zoo, Minas Gerais, Brazil.

Enclosure Style	Species	Enclosure size (m²)	Distance animal (m)	Visitation area (m)	Sex
Cage	*Alouatta guariba*	40	1	14	1♂, 3♀
Cage	*Leontopithecus chrysomelas*	29	1	7	4♀
Pit	*Pan troglodytes*	1256	15	100*	2♂, 2♀
Pit	*Gorilla gorilla*	2040	3	110*	1♂
Island	*Cebus xantosthernos*	2123	1	50*	1♂, 3♀
Pit	*Panthera onça*	1256	15	100*	2♂
Pit	*Leopardus pardalis*	1256	15	100*	3♂
Cage	*Leopardus pardalis*	70	1	7	1♂, 1♀
Paddock	*Speothos venaticus*	263	1	13	4♂
Paddock	*Loxodonta africana*	7407	1	74*	1♂, 3♀
Paddock	*Giraffa camelopardalis*	2100	1	105*	2♀
	Kobus ellipsiprymnus				1♂, 2♀
Paddock	*Cervus elaphus*	1027	1	26	2♂, 1♀

*Area of visitation: it is possible to have more than 200 people in front of the enclosure; Distance animal = minimum possible distance between animal and sound pressure meter (m).

Table 2

Ethogram of behaviours recorded in the present study on zoo visitor effects at the Belo Horizonte Zoo, Minas Gerais, Brazil.

Behaviour	**Description of behaviour**
Movement	Animal in any type of movement around its enclosure
Feeding	Animal eating or drinking
Resting	Animal in any posture with its eyes closed or not paying attention to its environment
Foraging	Animal exploring its enclosure and clearly searching for a resource
Vigilance	Animal stationary in any posture paying attention to its environment or actively scanning/checking its environment
Vocalisation	Any sound deliberately made by the animals
Affilitative behaviours	Animals from the same group interacting positively, including: contacts, copulas, grooming, social play, sniffing
Aggressive behaviours	Animals from the same group interacting negatively, including: fights, threats, and agonistic behaviours.
Abnormal behaviour	Behaviour that is qualitatively (e.g., stereotypic) abnormal
Other behaviours	All other behaviours expressed, which are not described above
Not visible	When the animal cannot be observed and/or inside the shelter.