2013

# Visitor effects on zoo animals

Sade, C.

Sade, C. (2013) 'Visitor effects on zoo animals', The Plymouth Student Scientist, 6(1), p. 423-433.
http://hdl.handle.net/10026.1/14027

The Plymouth Student Scientist
University of Plymouth

*The Plymouth Student Scientist, 2013, **6**, (1), 423-433*

# Visitor effects on zoo animals

Camille Sade

*Project Advisor: Stephen Burchett, School of Biomedical & Biological Sciences, Faculty of Science & Technology, Plymouth University, Drake Circus, Plymouth, PL4 8AA*

## Introduction

It is extremely useful to know if the presence of visitors has an effect on zoo animals and what that might be (Hosey, 2000). The three foremost reasons for this being, firstly, as an instrument to ensure welfare, secondly to apply the insight when providing a positive 'zoo experience' for guests and lastly, so that any research conducted within a zoo can be accurately assessed (Hosey, 2005). When confronted with the knowledge that approximately 26 billion animals, covering ten thousand species, are held in captivity (Mason, 2010) it becomes especially important. The first studies performed in order to appreciate this relationship were carried out in the 1970's and by the late 1980's a collection of studies had emerged which discovered that zoo visitors did have an influence on the activities of captive animals to greater degree than was once imagined (Davey, 2007).

Hosey (2000) identified three different possible consequences of a 'visitor effect', that a human audience can be stressful (negative), enriching (positive) or of no effect. Many different species have been observed to show an assortment of reactions to unknown people (Claxton, 2011), however, one study by Hosey (2008) suggests that an animal showing no signs of disturbance may just not be expressing it through changes in their actions so caution must be given when considering results. Discussed below are the differing types of effects caused by human visitors on zoo animals.

## Negative effects

The majority of studies carried out imply that zoo visitors induce stress (Hosey, 2000), (Hosey, 2008) and (Fernandez et al., 2009). Hosey et al., (2010) also states that the vast amount of research carried out generally points to a negative effect and that the way in which an individual animal reacts to people will be reliant upon its species or the individual. Many studies agree that visitors are of a harmful influence for some primates (Hosey, 2000), (Wells, 2005) and (Fernandez et al., 2009). Generally this confirmation shows itself in the appearance of variations in behaviour associated with human visitors (Carder and Semple, 2008). Hosey et al.,

(2010) describes behavioural indicators of stress including, increased abnormal behaviours, especially stereotypies, more intra-specific (between cage-mates) aggression and inter-specific (human directed) aggression. Increased activity is also mentioned (or sometimes decreased activity), along with lower instances of affiliative behaviours like grooming. Morgan and Tromborg (2007) highlight the detrimental effects of chronic stress responses on the long-term health of captive animals. They describe consequences such as, immunosuppression, poor reproduction and self-injurious behaviour.

A study on captive lion-tailed macaques (*Macaca silenus*) found a rise in visitor numbers caused rates of abnormal behaviours to intensify, such as, stereotypical behaviours, begging and self-biting all of which could have welfare implications (Mallupur et al., 2005). A paper on orang-utans (*Pongo pygmaeus*) found that, on occasion, the occurrence of zoo visitors was detrimental to them, with adults covering their heads with paper sacks and infants approaching and holding onto adults (Birke, 2002). Chimpanzees (*Pan troglodytes*) have shown less foraging, object-using, playing and grooming when larger weekend crowds are present (Wood, 1998). Chamove et al. (1988) carried out a succession of studies on 15 different primate species. When visitors were in attendance reductions in grooming, inactivity and affiliative behaviour were observed in the cotton-topped tamarins (*Saguinus oedipus*), diana monkeys (*Cercopithecus diana*) and ring-tailed lemurs (*Lemur catta*). Comparable changes in two mandrills, one (*Mandrillus sphinx*) and one mandrill/drill hybrid (*Mandrillus leucohpaeus*), were seen expressing a positive relationship involving number of visitors and the mandrill's attention, threat and abnormal behaviours. The changes were more prominent in the males. It is useful for the purposes of balance that there have been some studies on non-primates. Sekar et al. (2008) looked at visitor effects on Indian Gaur (*Bos gaurus gaurus*) and found that when people were present more intragroup aggression and moving behaviour was seen, when visitors were not present the bison rested more. Therefore, it was concluded that the presence of visitors considerably altered their behaviour and possibly affected their welfare. Sika deer (*Cervus nippon*) forage less, spend more time watching and resting and hiding in the presence of visitors according to Shen-Jin et al. (2010).

As Hosey (2008) mentions, some species or individuals may not choose to express stress through behavioural responses so some studies provide extremely useful results following research using other means. Assessing the levels of cortisol in urine or faeces is an effectual indicator for establishing physiological stress (Crocket et al., 2000). Spider monkeys (*Ateles geoffroyii rufiventris*) in one study showed that when tested four out of five subjects showed elevated cortisol levels with growing visitor numbers (Davis et al., 2005). However, as Chamove and Moodie (1990) point out heightened levels of cortisol alone do not necessarily point towards a harmful impact on an animal's welfare, the capacity for an individual to cope with short-term stressors could be seen as beneficial. It is perhaps useful then that similar studies on cortisol levels have been carried out and compared against behaviour also. Black rhinos (*Diceros bicornis*) were also found to have heightened levels of corticoid in zoos where they were kept in enclosures that

had a higher contact with people and this corresponded with higher instances of fighting between breeding partners and elevated rates of mortality (Carlstead and Brown, 2005). Indian blackbuck (*Antelope cervicapra L*.), when exposed to high visitor density, took part in more intergroup aggression and increased activity, this positively correlated with higher concentrations of fecal cortisol (Rajagopal et al., 2011).

However, some studies show conflicting results for some primate species (Hosey, 2005). Western lowland gorillas (*Gorilla gorilla gorilla)* were studied at two sites with only one group showing signs of underlying levels of anxiety, such as, self-scratching and visual monitoring of visitors (Carder and Semple, 2008). It must be taken into account however, as some studies have found, that enclosure design can influence behaviour in numerous ways (Hosey, 2008). For example, cotton-topped tamarins (*Saguinus Oedipus*) exhibit less within-group amicable behaviours when kept in small, glass-fronted enclosures than larger, wire meshed-fronted cages (Glaston et al., 1984). It seems the significance of enclosure design is the degree of control is gives the animal over the level it is exposed to visitors, therefore not lessening the fear felt but how the interaction is viewed (Hosey, 2008).

A paper by Hosey (2000) identifies two different rationalizations for the relationship between animals and visitors as 'visitor effect hypothesis' and 'visitor attraction hypothesis'. He infers the 'visitor attraction hypothesis' as being credible as increased activity and aggression are events likely to attract more people to watch, he also points out that not many other papers take this explanation into account.

**Positive effects**

There are a small amount of studies that seem to suggest that, for some species, visitors provide a form of enrichment (Davey, 2007) and (Hosey et al., 2010) and positive contact with humans can sometimes lead to an improvement in welfare (Morgan and Tromborg, 2007). The benefit comes in the form of visitors providing variability and therefore can be classed as environmental enrichment (Moodie and Chamove, 1990) and (Hosey, 2000). Chimpanzees (*Pan troglodytes*) housed indoors and in small social groups displayed changes in behaviour considered positive when exposed to positive human contact, such as, lower levels of abnormal behaviour, were less tense, increased levels of affiliative behaviour and less time being inactive (Baker, 2004). However, some concern was raised during this study at the behaviour of the chimpanzees during this exposure suggesting more research is needed (Baker, 2004). An earlier study by Cook and Hosey (1995) observed chimpanzees choosing to interact with visitors in exchange for food suggesting it was a positive experience for them. Nimon and Dalziel (1992) found in their study that a long-billed corella (*Cacatua tenuirostris*) spent an astonishing 93.8% of his time at the front of his enclosure and seemed to searching for visitors, due to humans being in front of his enclosure these interactions were thought to be enriching, however, when the zoo was very busy the corella occasionally retreated. Asian short-clawed otters (*Aonyx cinerea*) are another species which have shown positive signs towards visitors with increased play, feeding and foraging and begging directed towards the

visitors (Owen, 2004). The author of this study interpreted this as a positive consequence of an audience on the otters.

Unfortunately, however, the premise that visitors could be viewed as a source of enrichment has not been examined in the same way other forms of enrichment have and therefore convincing arguments cannot be made as the research is limited (Davey, 2007). Hosey (2005) also agrees with this when primates are concerned claiming that zoo visitors as a form of enrichment for them has not really been examined.

**Neutral effect**

Many studies on felids suggest they display much lower frequencies of behavioural change when exposed to zoo visitors especially when compared to primates (Hosey, 2008). Margulis et al. (2003) studied six species of felids, lion (*Panthera leo*), amur leopard (*Panthera pardus orientalis*), amur tiger (*Panthera tigris altaica*), snow leopard (*Panthera uncia*), clouded leopard (*Neofelis nebulosa*) and fishing cat (*Felis viverrinus*) none of which showed behavioural differences when in the presence of visitors and attributed this to species-specific variations, the animals level of experience with visitors and exhibit parameters. There is a small quantity of substantiation that suggests different species of animals in zoos are expected to differ in their fear of humans but this suggestion is a region where additional study is clearly needed (Hosey, 2008). Some possible reasons though have been put forward. Indications that smaller species, such as arboreal primates, might be especially liable as visitors may be viewed as possible predators and are therefore more likely to react with avoidance and defensive behaviours, conversely, bigger animals may be non-reactive (Chamove et al., 1988), (Hosey, 2000) and (Margulis et al., 2003). As has already been discussed, cotton-topped tamarins do show signs of stress when exposed to visitors (Glaston et al., 1984) and (Chamove et al., 1988) and more sizable species, such as felids, appear to be less distressed so there does appear to be some support for this hypothesis. Hosey et al., (2010) discusses how even within the same species, individual animals may react differently to humans, this being probably due to their behaviour being subjected to other variables, such as, cage space and complexity, species and visitor behaviour.

With this in mind however, other studies have emerged with conflicting results concerning felids. Mallapur and Chellam (2002) concluded Indian leopards (*Panthera pardus*) were behaviourally affected by visitors. On visitor days more resting behaviour was seen, interpreted as an effort to maintain distance, and on extremely busy days more stereotypic pacing was seen, it was intimated that this was in an effort to escape the visitors. Sellinger and Ha (2005) found jaguars (*Panthera onca*) also showed their activities changed when in contact with visitors as more pacing and periods of hiding were witnessed. They make note of the contrast of their results in comparison to Margulis et al. (2003) and attribute possible differences to the techniques and methods used and also the different social behaviours utilised by the species studied. It becomes clear that when looking at any type of visitor effect making assumptions can be extremely complex and difficult and with many variables to consider findings are not clear-cut.

**Crowd density, noise, activity and enclosure design**

Hosey (2005) stresses the need to understand that zoo visitors are a condition as opposed to a variable and it is essential to try and understand which variables cause which reactions. Davey (2007) also agrees that many studies have revealed that visitor variables such as, density, activity and position are coupled with behavioural and physiological changes. A few studies focus on these variables and help to provide a greater insight into the different aspects of a crowd. A study on orang-utans (*Pongo pygmaeus*) is one paper that looks at crowd size and noise levels and found that the subjects were affected by high volumes of noise such as, loud shouting and screaming (Birke, 2002). White handed gibbons (*Hylobates lar*) also show behavioural changes when exposed to high noise levels in the form of excessive and repetitive scratching, which is considered abnormal or stereotypical, and with increasing crowd size the female of the pair developed a preoccupation with a toy as if it were an infant (Cooke and Schillaci, 2007). Visitor activity has been shown in some species to be a factor that can induce behavioural changes. Siamangs (*Hylobates syndactylus*) were more aggressive when visitors imitated their behaviour, such as staring or yawning (Nimon and Dalziel, 1992). Birke (2002) also noted increased aggression in male orang-utans in reaction to human stares. Fernandez et al. (2009) believes that it appears the most destructive aspect of visitors is not always the number of visitors but it is the type of interaction combined with the powerlessness to escape and that primates seem to be especially bothered by highly interactive visitors. The proximity of a crowd can also sometimes be a problem. Coho et al. (2011) saw that in captive zoo orang-utans when their human audiences were in close proximity, play significantly decreased and the subjects looked more at the visitors.

In common with many other species of primate, western lowland gorillas (*Gorilla*) have been found to be considerably influenced by visitor density with small crowd numbers inducing behaviour associated with relaxation, such as resting, and high visitor numbers, in comparison, producing behaviours more telling of stress, such as intergroup aggression, stereotypies (e.g. teeth clenching, body rocking) and auto grooming (Wells, 2005). The evidence from this study suggesting that gorillas are affected by zoo visitors is given some weight by a later study carried out by Carder and Semple (2008) as previously discussed. A study by Kuhar (2008) on the same species, however, found no behavioural differences between large or small crowds, which contradicts Wells' (2005) findings, he suggests this may be due to methodological or individual animals differences and stresses the need for further research to explain these findings. A paper written by Ross et al. (2007) commenting on the study by Wells (2005) goes some way to explaining possible reasons for the differences in the findings on gorillas. Ross et al. (2007) points out that the study makes no mention of the fact that high visitor density data were collected during mid-summer and low visitor density data were collected during mid-winter. He goes onto suggest that due to this reason, amongst others, the conclusion Wells (2005) comes to is premature and possibly deceptive. When looking at the all of the studies mentioned, there is obvious confusion over the effects that crowd density has on the behaviour of captive gorillas, however, all of the papers agree that

some, if not all, of the individuals studied did display signs of disturbance when in contact with human audiences. As previously mentioned, many other papers on primates do seem to go along with this conclusion in that zoo visitors induce stress.

From many of the studies carried out on primates it seems that larger, louder and more aggressive audiences are detrimental to them (Fernandez et al., 2009). However, when considering visitor activity and proximity though Davey (2007) cites that the research is unbalanced with not enough known about these variables.

**Can visitor effects be reduced?**

There is some literature that looks into possible ways of moderating the effects of visitor presence. Hosey (2000) discusses how enclosures that are more naturalistic lead to more naturalistic behaviour that will be more resilient to disturbances from human audiences. Studies have found that a barrier placed in the middle of visitors and animals, concealment screens or camouflage nets, can lessen the impact from watching visitors (Mononen et al., 2001) and (Blaney and Wells, 2004). Blaney and Wells (2004) detected lower instances of stereotypical behaviours and reduced conspecific-directed aggression when a camouflage net barrier was introduced at the viewing area of a gorilla enclosure. Anderson et al. (2002) found higher rates of aggression when visitor numbers were larger in African pygmy goats (*Capra hircus*) and Romanov sheep (*Ovis aries*). One reason put forward for this was that the animals in the petting zoo found it harder to keep a critical distance from humans when the zoo was busy. Following the introduction of a retreat space that visitor were not able to enter, aggression was reduced. This is another example of small changes within an enclosure can lessen the effects of human audiences. A step up from this is Hosey's (2005) idea of allowing free ranging wherever possible to give the animals more power over their encounters with people. He suggests that this is likely to make the entire practice of habituating to, interacting with and coping with humans considerably easier for the animals but concedes there is no absolute proof to support this hypothesis.

The results of visitor density may also be diminished by accommodating species that are less reactive to visitors in exhibits with higher visitation rates (Davey and Henzi, 2004) and (Davey, 2007). This also applies in housing species more susceptible to visitors in enclosures that have lower visitation rates. Mitchell et al. (1991) looked at the results of moving golden-bellied mangabeys (Cercocebus chrysogaster) into different enclosures that were identical apart from different visitor numbers marked as low, medium or high. When mangabeys from medium visit cages were moved to low visit cages there was a dramatic drop in people-directed and within-group aggression whist grooming, play, sexual behaviour and aggressions displays towards non-human primates increased. When the subjects in the low visits cage were moved to the medium visits cage, people-directed, within-group aggression and within-group play increased and aggression towards non-human primates decreased. Fernandez et al. (2009) suggests that managing the visitor numbers outside an enclosure, repeating to crowds what not to do

and explaining what types of visitor behaviour is stressful for that species may result in a beneficial outcome.

Chamove et al. (1988) found that when visitors watching primates were asked to crouch so that only their heads could be seen, more activity, grooming and aggressive behaviour was recorded than when the visitors were asked to stand tall. These results could give provocation for a possible rethink of how walkways and paths are positioned outside the enclosures of some species.

**Conclusions**

When considering the possible effects of visitors on zoo animals there is a vast amount of literature to indicate that changes can occur behaviourally and physiologically, although these changes are not fully understood. Further research is required involving a more varied range of animal groupings, determinants of stress and animal-visitor variables (Davey, 2007) to help us further appreciate these changes and reach more convincing decisions. It has been suggested that more research is needed concerning individual differences involving gender and personality along with the visitor effect as knowledge on this is minimal (Thompson, 1989) and (Hosey, 2000). Birke (2002) and Chamove et al. (1988) both observed differences in male and female subjects which lends support for the need of these suggested further studies. Davey (2007) adds to this by expressing that other features like the effect of social groups and hierarchy, if the animal is captive born, length of captivity, time of day and seasonal differences have also not been investigated enough. Ross et al., (2007) agrees, as he refers to seasonal differences being a possible affective factor when considering results. Another variable to consider is previous human interactions, animals with a history of negative encounters with people display a higher fear of humans, especially unfamiliar ones (Hosey, 2008).

In conclusion, from the literature reviewed here, it is clear to see that are many possible effects that visitors can have on zoo animals with much yet to still be discovered and understood. What we do know can vary widely and be influenced by many variables. There has been a large amount of research carried out looking into areas such as, reactions in non-human primates and behavioural differences. Other areas such as, visitors as enrichment and reactions in non-primate species have received less attention and require further research. Human visitors are an integral part of the environment in which zoo animals live, therefore, their possible effects must be recognized as a way of moderating or removing any damaging consequences. Though it will never be possible to fully understand exactly what any animal is feeling this review considers some probable visitor outcomes ultimately promoting our comprehension of some species and from this we can try to understand them to the best of our ability. Overall, with the majority of data pointing towards the inference that zoo visitors cause a negative effect on zoo animals, especially primates (Hosey et al., 2010), which if prolonged, could lead to welfare issues it would be beneficial for additional studies to be carried out imminently.

**References**

Anderson, U.S., Benne, M., Bloomsmith, M.A. and Maple, T.L. (2002) Retreat space and human visitor density moderate undesirable behaviour in petting zoo animals. *Journal of Applied Animal Welfare Science*, **5**, pp. 125-137.

Baker, K.C. (2004) Benefits of positive human interaction for socially housed chimpanzees. *Animal Welfare*, **13**, pp. 239-245.

Birke, L. (2002) Effects of browse, human visitors and noise on the behaviour of captive orangutans. *Animal Welfare*, **11**, pp. 189-202.

Blaney, E. and Wells, D. (2004) The influence of a camouflage net barrier on the behaviour, welfare and public perceptions of zoo-housed gorillas. *Animal Welfare*, **13**, pp. 111-118.

Calstead, K. and Brown, J.L. (2005) Relationships between patterns of fecal corticoid excretion and behavior, reproduction, and environmental factors in captive black (Diceros bicornis) and white (Ceratotherium simum) rhinoceros. *Zoo Biology*, **24**, pp. 215-232.

Carder, G. and Semple, S. (2008) Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science*, **115**, pp. 211-220.

Chamove, A.S. and Moodie, E.M. (1990) Are alarming events good for captive monkeys?. *Applied Animal Behaviour Science*, **27**, pp. 169-176.

Chamove, A., Hosey, G. and Schaetzel, P. (1988) Visitors excite primates in zoos. *Zoo Biology*, **7**, pp. 359-369.

Choo, Y., Todd, P.A. and Li, D. (2011) Visitor effects on zoo orangutans in two novel, naturalistic enclosures. *Applied Animal Behaviour Science*, **133**, pp. 78-86.

Claxton, A.M. (2011) The potential of the human-animal relationship as an environmental enrichment for the welfare of zoo-housed animals. *Applied Animal Behaviour Science*, **133**, pp. 1-10.

Cook, S. and Hosey, G. (1995) Interaction sequences between chimpanzees and human visitors at the zoo. *Zoo Biology*, **14**, pp. 331-440.

Cooke, C.M. and Schillaci, M.A. ( 2007) Behavioural responses to the zoo environment by white handed gibbons. *Applied Animal Behaviour Science*, **106**, pp. 125-133.

Crocket, C.M. Shimoji, M. and Bowden, D.M. (2000) Behaviour, appetite and urinary cortisol responses by adult female pig tailed macaques (*Macaca nemestrina*) to cage size, cage level, room change and ketamine sedation. *American Journal of Primatology*, **52**, pp. 63-80.

Davey, G. (2007) Visitors' effects on the welfare of animals in the zoo: A review. *Journal of Applied Animal Welfare Science*, **10**, pp. 169-183.

Davey, G. and Henzi, P. (2004) Visitor circulation and nonhuman animal welfare: An overlooked variable?. *Journal of Applied Animal Welfare Science*, **7**, pp. 243-251.

Davis, N., Schaffner, C.M. and Smith, T.E. (2005) Evidence that zoo visitors influence HPA activity in spider monkeys (*Ateles geoffroyii rufiventris*). *Applied Animal Behaviour Science*, **90**, pp. 131-141.

Fernandez, E.J., Tamborski, M.A., Pickens, S.R. and Timberlake, W. (2009) Animal-visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science*, **120**, pp. 1-8.

Glaston, A.R., Geilvoet-Soeteman, E., Hora-Pecek, E. and van Hooff, J.A.R.A.M. (1984) The influence of the zoo environment on social behaviour in groups of cotton-topped tamarins *Saguinus oedipus Oedipus. Zoo Biology*, **3**, pp. 241-253.

Hosey, G.R. (2000) Zoo animals and their human audiences: What is the visitor effect?. *Animal Welfare*, **9**, pp. 343-357.

Hosey G.R. (2005) How does the zoo environment affect the behaviour of captive primates?. *Applied Animal Behaviour Science*, **90**, pp. 107-129.

Hosey, G. (2008) A preliminary model of human-animal relationships in the zoo. *Applied Animal Behaviour Science*, **109**, pp. 105-127.

Hosey, G., Melfi, V. and Pankhurst, S. (2010) *Zoo animals behaviour, management, and welfare*, Oxford University Press, New York, pp. 486-494.

Kuhar, C.W. (2008) Group differences in captive gorillas' reaction to large crowds. *Applied Animal Behaviour Science*, **110**, pp. 377-385.

Mallupur, A., Sinha, A. and Waran, N. (2005) Influence of visitor presence on the behaviour of captive lion-tailed macaques (*Macaca silenus*) housed in Indian zoos. *Applied Animal Behaviour Science*, **94**, pp. 341-352.

Mallapur, A. and Chellam, R. (2002) Environmental influences on stereotypy and the activity budget of Indian leopards (*Panthera pardus*) in four zoos in southern India. *Zoo Biology*, **21**, pp. 585-595.

Margulis, S.W., Hoyos, C. and Anderson, M. (2003) Effects of felid activity on zoo visitor interest. *Zoo Biology*, **22**, pp. 587-599.

Mason, G.J. (2010) Species differences in responses to captivity: Stress, welfare and the comparative method. *Trends in Ecology & Evolution*, **25**, pp. 713-721.

Mitchell, G., Obradovich, S., Herring, F.H., Dowd, B. and Tromborg, C. (1991) Threats to observers, keepers, visitors and others by zoo mangabeys (*Cercocebus galeritus chrysogaster*). *Primates*, **32**, pp. 515-522.

Mononen, J., Kasanen, S., Harri, M., Sepponem, J. and Rekila, T. (2001) The effects of elevated platforms and concealment screens on the welfare of blue foxes. *Animal Welfare*, **10**, pp. 273-385.

Moodie, E. and Chamove, A. (1990) Brief threatening events beneficial for captive tamarins?. *Zoo Biology*, **9**, pp. 275-286.

Morgan, K.N. and Tromborg, C.T. (2007) Sources of stress in captivity. *Applied Animal Behaviour Science*, **102**, pp. 262-302.

Nimon, A.J. and Dalziel, F.R. (1992) Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, **33**, pp. 261-272.

Owen, C. (2004) Do visitors affect the Asian short-clawed otter in a captive environment? *Proceedings of the sixth annual symposium on zoo research BIAZA*, London, pp. 202-211.

Rajagopal, T., Archunan, G. and Sekar, M. (2011) Impact of zoo visitors on the fecal cortisol levels and behavior of an endangered species: Indian blackbuck (*Antelope cervicapra L*.). *Journal of Applied Animal Welfare Science*, **14**, pp. 18-32.

Ross, S.R., Lonsdorf, E.V. and Stoinski, T. (2007) Assessing the welfare implications of visitors in a zoo setting: A comment on Wells (2005). *Applied Animal Behaviour Science*, **102**, pp. 130-133.

Sekar, M., Thangavel, T. and Archunan, G. (2008) Influence of zoo visitor presence on the behaviour of captive Indian gaur (*Bos gaurus gaurus*) in a zoological park. *Journal of Applied Animal Welfare Science*, **11**, pp. 352-357.

Sellinger, R.L. and Ha, J.C. (2005) The effects of visitor density and intensity on the behaviour of two captive jaguars (*Panthera onca*). *Journal of Applied Animal Welfare Science*, **8**, pp. 233-244.

Shen-Jin, L., Shen-Jin, L., Todd, P.A., Yan, Y., Lin, Y., Hongmei, F. and Wan-Hong, W. (2010) The effects of visitor density on sika deer (*Cervus nippon*) behaviour in Zhu-Yu-Wan park, China. *Animal Welfare*, **19**, pp. 61-65.

Thompson, V. (1989) Behavioural response of 12 ungulate species in the presence of humans. *Zoo Biology*, **8**, pp. 275-297.

Wells, D.L. (2005) A note on the influence of visitors on the behaviour and welfare of zoo-housed gorillas. *Applied Animal Behaviour Science*, **93**, pp. 13-17.

Wood, W. (1998) Interactions among environmental enrichment, viewing crowds and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*, **17**, pp. 211-230.