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Research Article

How do Zoo Evening Events at ZSL London Zoo Affect Sumatran Tiger Behaviour and Enclosure

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Abstract

Globally, zoological collections may host public events after usual opening hours including festivals, special tours and evening events, in order to generate income. During the summer of 2014, The Zoological Society of London held a series of nine evening events during which zoos' opening hours were extended, with entertainment offerings such as tours and visitor events provided. This study investigated the effect of evening events on the behaviour and enclosure use of five Sumatran tigers (*Panthera tigris sumatrae)* at ZSL London Zoo. Instantaneous focal sampling was utilised to collect behavioural data and enclosure zone occupancy. Measures of visitor density, crowd noise volume and flash photography data were collected to identify their effect on behaviour and enclosure use. Overall, there was a significant decrease in feeding, locomotion and playing, and a significant increase in resting during event evenings. The event behaviours stretching, spraying, rubbing, flehmen and glass banging also occurred significantly more often during events than on control evenings. There was a significant difference in enclosure use between evening event and control nights, with tigers using distant zones more frequently during events. These data suggest that overall, event nights could influence the behaviour of zoo-housed tigers. In addition to altering their behaviour, tigers appear to exercise choice in space use to reduce the impact of visitor presence during evenings. Future studies should explore these potential impacts across a wider range of felids and investigate the effects of the different stimuli produced by visitors. This information can therefore be used to inform planning of effective mitigation strategies.

Keywords: Animal Welfare; Zoos; Event Evening, Visitor Effect; Flash Photography; *Panthera Tigris Sumatrae*

Introduction

Zoo animal welfare

The maintenance of good animal welfare is a priority for zoos and aquaria. Zoological collections face many challenges in the provision of good welfare, as they house many exotic species, whose husbandry requirements often differ considerably from domesticated animals [1,2]. Despite these challenges, several welfare measures have been developed in order to best understand the condition of zoo-housed animals [3,4]. For example, these welfare assessments now include behavioural (courtship, repetitive behaviour) [3], physiological (glucocorticoids in faeces [5,6] or hair [7]) biological (hair condition, body condition) [1] measures and enclosure use assessments [8-12].

The assessment of animal welfare presents unique challenges however, not only in finding appropriate metrics that can be measured but also as species and individuals vary considerably in their responses to stress [13] and all methods are vulnerable to limitations. Glucocorticoid assessment is often considered to be the gold standard in welfare assessments, yet it should be noted that glucocorticoid concentrations do fluctuate naturally on daily and seasonal basis [13] so data need to be collected over a long period of time. Also, ideally the results need to be interpreted alongside behavioural data, to contextualise as it can be difficult to conclude if an animal's physiological response to a stressor is "positive" or "negative" [13]. Additionally, not all stressors result in increased glucocorticoid concentrations [4]; whereas some increased glucocorticoid concentrations may happen as a response to some situations normally not considered stressful, e.g., mating or playing [14].

Ideally, welfare scientists should investigate individual animal welfare using a multi-disciplinary approach to achieve an objective assessment.

Visitor impact on welfare

The 'visitor effect' on captive animal behaviour and welfare has been well studied: visitors may be perceived by animals as an enriching, neutral or undesirable stimulus [15-17]. Williams., *et al*. [18] monitored the impacts of COVID-19 zoo closures on the behaviour and enclosure use of slender-tailed meerkats (*Suricata suricatta*). The meerkats studied used more of their enclosures during periods of closure; then upon reopening, spent longer than expected in zones furthest from visitor viewing areas [18]. A key aspect of visitor presence that may affect animal behaviour and welfare is visitor noise [19-22]. Quadros., *et al*. [2] identified that zoo visitors had a negative impact on welfare of twelve different species of zoo-housed mammals, especially when noise levels were recorded outside the recommended limits for humans (> 70dB). This research suggests that both visitor education and acoustic modification to enclosure should take place to prevent negative welfare impacts via noise pollution [22].

The visitor effect has been well studied in large felids [23-25]. Zoos South Australia compared felid behavior before, during and after "Behind-the-Scenes" zoo tours, and determined that between the conditions, feeding, pacing and inactivity levels changed [26]. However, these changes were not necessarily implying negative welfare but additional research using other methods to cross-examine these results is needed [27]. Mallapur and Chellam [27] studied Indian leopard (*Panthera pardus*) activity budgets across four zoos in India. Their findings suggested that enclosure size, shape and structure were better predictors of pacing behaviour than visitor presence [27]. On the other hand, visitor density and intensity were significant predictors of behaviour change for two captive jaguars (*Panthera onca*) [24]. In particular, visitor intensity significantly increased female pacing behaviour, whilst the male showed increased aggression with an increase in visitor density and intensity [27]. Given that animal visibility, particularly with big cats, may enhance visitor stay time, [28] there is a need to consider crowd placement, noise and its impact.

Out of hours zoo events

Evening zoo events may pose challenges to zoo-housed animals [29]. While limited studies have been published that have investigated the behaviour of animals during evening zoological events, Meade., *et al.* [29] reported the behaviour of zoo-housed dogs *(Canis lupus familiaris)* at Taronga Zoo, Sydney, during concerts. The study found no significant difference between concerts and control nights on the proportion of time the dogs spent inside their kennels. Furthermore, no significant differences were identified in behavioural welfare indicators, such as panting and whining. However, as this study looked at domestic animals, it would be beneficial to examine behaviour changes in other species kept at the zoo. A study was conducted at Tayto Park, Ireland by Harley., *et al.* [19] to identify behavioural responses to a music event in a range of species. Sound pressure levels (SPLs) were recorded at the observation locations at the same time as behavioural observations. They found that behavioural responses varied amongst the species, where some did not respond with any change in behaviour to the increased SPLs or the music event itself [19]. Studies like the above showcase the need for further research to provide an evidence-based assessment of how events may affect animal welfare and behaviour.

Felids

The Sumatran tiger *(Panthera tigris sumatrae)* is a Critically Endangered sub species with a declining population due to habitat destruction, fragmentation, persecution, and human-animal conflicts

[30]. Given their conservation importance and broad distribution throughout zoos globally, the Sumatran tiger is a good candidate species for research into the effects of evening events. The Zoological Society of London (ZSL) began regularly hosting evening summer events open to the public in 2011. On Friday evenings during June and July, ZSL London Zoo offered ticketed admission between 18:00 - 22:00 hours to allow guests to explore the zoo, additionally providing musical entertainment and group tours [31]. The aim of this study was to explore potential impacts of evening events of tigers in ZSL London Zoo. This study examined the effect of evening events on the behaviour and enclosure use of a family group of Sumatran tigers at ZSL London Zoo.

Methods

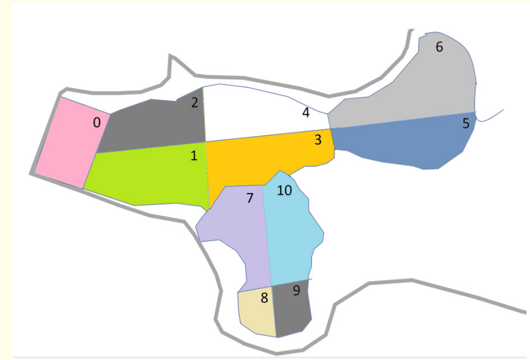
Observations took place on evening events (Evening) and control nights to investigate the effect of visitors during extended zoo open hours. Prior to observations taking place, the project was approved by the ZSL Ethics Committee.

Study animals and enclosure

An adult pair of Sumatran tigers both aged six years at the time of study and their three offspring (2.1) aged four months housed at ZSL London Zoo's Tiger Territory, were the subject of this study. The enclosure measuring approximately 1,624 m^2 in total, was divided into 10 zones of unequal size based on their biological relevance to the animals and the animals had access to all zones during the study (Table 1). Some of the enclosure zones included heated rocks, ponds, dens and elevated platforms (Figure 1). Enclosure zones were then divided into "near" and "far", with far zones categorized as those separated from public viewing from all sides by a minimum of one zone.

Zone	Name of Zone	Size of Zones (m^2)	Near/Far
0	House	110.78	Far
1	Grass near tapir exhibit	251.62	Near
2	Elevated platform	149.11	Near
3	Grass by viewing platform	175.79	Far
4	Glass viewing zone	167.04	Near
5	Distant grass and pond	150.69	Far
6	Front grass by glass wall	250.36	Near
7	Long grass viewing area	252.13	Near
8	Front of cave	116.6	Near
9	Back of cave	89.02	Near
10	Planted zone	253.39	Far

Table 1: Tiger Territory enclosure zones. Near is described as being separated from the public by a fence or boundary; far is described as zones that have no direct contact with the public.



A

B

Figure 1: A: Enclosure zones separation for Tiger Territory. Visitor pathways around the exhibit are shown in grey. B: Artist impression of bird's eye view of the enclosure.

Data collection

Observations took place between the 6th of June and 1st August, 2014, from 18:00-21:30. Control observations took place on Tuesdays, where, during this period, the average people present (keepers and researcher) were less than 5, and the husbandry and weather conditions were similar to the event evenings. "Evening" events took place during the Friday evenings. Observations were carried out on nine evening and nine control evenings.

Data collection was divided into four sessions: 18:00h-18:50h, 18:50h- 19:40h, 19:40h-20:30h, and 20:30h - 21:20h. During each session, all individuals were observed using instantaneous focal sampling at one-minute intervals over nine-minute periods. After a one-minute break a different animal was selected, selected using a random number generator. The order in which each animal was observed was randomised. Five focal sampling sessions took place over a 50-minute observation period. Continuous focal sampling for event behaviours was also conducted for the study individual, as per Quintavalle Pastorino [11]. A standardised ethogram for Felidae was adapted for behavioural observations: see Stanton, Sullivan and Fazio's [32] study for the full ethogram. State behaviours were then condensed into six generic states: see Table 2 for the condensed ethogram.

Behaviour type	Behaviour	Description
State	Feeding	The felid chews and swallows food items in its exhibit.
	Grooming	The tiger licks its fur.
	Locomotion	The felid moves around its enclosure (e.g. walking, running).
	Playing	The felid engages with objects or conspecifics in its environment, and may scratch, chase, or paw objects, or chase other individuals.
	Resting	The felid is stationary or performing minimal movements (e.g., laying, sitting, standing alone).
	Standing	The felid is in an upright position and immobile, with all four paws on the ground.
Event	Sneeze	The felid exhales rapidly with its eyes closed.
	Scratching self	The felid swipes its body using the claws of its hind feet.
	Scratching object	The felid swipes at objects using either its fore or hind paws.
	Knead	The felid pushes its forepaws into the ground in a rhythmic motion.
	Spray	The felid lifts its tail and ejects a small amount of liquid on objects in its enclosure.
	Rub	The felid approaches a conspecific and comes into physical contact, pushing its head or body against another individual.
	Rubbed	The felid allows another individual to engage it in rubbing behaviour.
	Flehmen	The felid makes a grimacing expression where the mouth is open and upper lip is elevated.
	Glass bang	The felid uses its front? paws to strike against glass visitor viewing areas.
	Yawn	The felid opens its mouth widely while inhaling, then closes its mouth whilst exhaling.
	Pacing	Repetitive locomotion in a fixed pattern, such as back and forth along the same route. Can include walking, trotting and running. Movement seems to have no apparent goal or function.

Table 2: Condensed ethogram, adapted from Stanton., *et al.* [32].

Subject Name	Sex	Origin
Jae Jae	1.0	Perth Zoo
Melati	0.1	San Francisco Zoo
Cub (1,2,3)	2.1	ZSL London Zoo

Table 3: Study subjects.

The state behaviours collected from the study were converted into activity budgets, whilst event behaviours were calculated as an average rate per animal per hour.

The maximum and minimum decibel reading was taken at the end of each 9-minute data collection session using Mini Sound Level Meters (Everbest CEM DT-85A). Noise levels were determined as the average maximum decibel reading per minute. This was carried out during both event and baseline nights.

Crowd size (number of visitors within 5 meters of the exhibit) was recorded every minute during each sampling session and recorded in the following categories: low (0-20), medium (21-50) and high (over 51) visitors. These values were used in order to transform visitor numbers into a categorical variable.

The total number of camera flashes occurring during each data collection session was also recorded.

Enclosure usage

The zone location of each animal was recorded at one-minute intervals during each observation session. Zone use data were used in the calculation of an Electivity Index per animal per condition. An Electivity index measures the use of each zone in consideration of its size (Brereton, 2020). Electivity values vary from -1 (where the animal did not use the zone) to 1 (where the animal overutilised the zone). The formula for Electivity Index is

$$\frac{\mathrm{Wi}-(1/\mathrm{n})}{\mathrm{Wi}+(1/\mathrm{n})} \quad \mathrm{Wi}=\frac{ri/pi}{\Sigma ri/pi}$$

Where *ri* and *pi* represent the observed and expected values for each zone respectively, and n represents the number of zones available to the animal. An Electivity Index was generated for each zone per animal per condition (event versus control).

Statistical analysis

Data were recorded using Microsoft Excel 2016, and analysis was conducted using R and Minitab version 21. Tiger behaviours were tested for effects using Poisson regressions, with individual tiger, treatment (event versus control), and interaction of treatment and individual used as the predictors. Pairwise individual comparisons were conducted using the Tukey post-hoc test. The alpha value was set to 0.05, and post-hoc pairwise comparisons were corrected according to the Bonferroni method.

The probability of a subject changing a zone of in the 9-minute period of observation was calculated by a logistic regression model (Freedman, 2009). The logistic regression is generally defined as a binary logistic model used to estimate the probability of a binary response based on one or more predictor (or independent) variables (Walker and Duncan, 1967). The four independent variables taken into account for each 9-minute session were the total camera flashes, the maximum and minimum decibel reading, and the difference between the maximum and minimum dB value in the same period (delta dB). Two qualitative variables were included in the model: the animal and the crowd size (classified as low, medium, and high). The "risk" of changing a zone for each variable was quantified by the unit odds ratio, which indicates the average "risk" of moving, given the variation of a unit of the independent variable (e.g., moving after nine flashes respect to eight flashes in 9-minute observation.

Results

State behaviours

An activity budget was developed to demonstrate differences between individual tigers and condition (event versus control night) (Figure 2). Cubs were grouped as they were not always individually identifiable. Poisson regressions were run on all six behaviours to identify potential impacts of the condition (event versus control) and individual (Table 4).

Behaviour	Treatment	Individual	Post hoc differences
Feeding	$X^2 = 15.760$, $P < 0.001$ *	$X^2 = 15.027$, $P = 0.005$ *	Cub 2 and Cub 1 (P = 0.019) Jae Jae and Cub 2 (P = 0.03) Melati and Cub2 (P = 0.095)
Grooming	$X^2 = 0.264$, $P = 0.607$	X2 = 11.092, P = 0.026 *	Cub2 and Cub1 (P = 0.025)
Locomotion	$X^2 = 19.723$, $P < 0.001$ *	$X^2 = 12.684$, $P < 0.05$ *	Jae Jae and Cub1 (P = 0.022) Jae Jae and Cub3 (P = 0.012) Jae Jae and Melati (P = 0.009).
Playing	$X^2 = 30.004$, $P < 0.001$ *	$X^2 = 30.146$, $P < 0.001$ *	Jae Jae and Cub1 (P < 0.001) Jae Jae and Cub2 (P < 0.001) Jae Jae and Cub3 (P < 0.001) Melati and Cub2 (P = 0.04) Melati and Cub3 (P = 0.04).
Resting	$X^2 = 39.488$, $P < 0.001$ *	$X^2 = 123.712$, $P < 0.001$ *	Melati and Cub1 (P = 0.046) Melati and Cub2 (P < 0.001) Melati and Cub3 (P < 0.001) Melati and Jaejae (P = 0.0011) Jae Jae and Cub1 (P < 0.001) Jae Jae and Cub2 (P < 0.001) Jae Jae and Cub3 (P < 0.001) Cub1 and Cub3 (P = 0.069).
Standing	$X^2 = 1.266$, $P = 0.261$	$X^2 = 16.518$, $P = 0.002$ *	Melati and Cub1 (P = 0.06) Melati and Cub3 (P = 0.074) Melati and Jae Jae (P = 0.074).

Table 4: Output of Poisson regressions on state behaviours.
*indicates significant values.

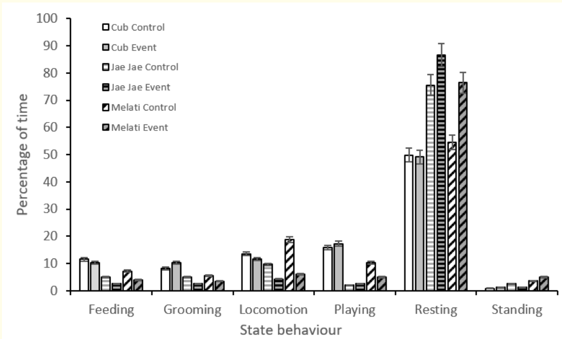


Figure 2: Activity budget for Sumatran tigers during control nights and evening events (+/- standard error).

Event behaviours

A bar chart was developed to demonstrate differences between event nights and control nights, as broken down by individual tiger (Figure 3). Poisson regressions were also run, to determine whether the condition (control versus event) and individual tiger influenced behaviour (Table 5).

Enclosure usage

Electivity indices were calculated for the two adult tigers and the cubs (pooled data) for control and event nights (Figure 4). The majority of zones were underutilised for all observations, whereas zones 6, 7 and 8 were often overutilised.

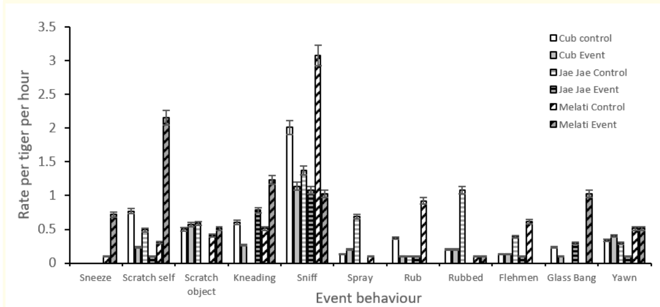


Figure 3: Occurrence of event behaviours in Sumatran tigers during control nights and evening events (+/- standard error).

Behaviour	Treatment	Individual	Post hoc differences
Sneeze	X^2 = 3.844, P = 0.05	X^2 = 3.844, P = 0.428	
Scratch self	X^2 = 15.096, P = 0.0001 *	X^2 = 24.717, P < 0.001 *	Melati and Cub1 (P = 0.011) Melati and Cub2 (P = 0.006) Melati and Cub3 (P = 0.083) Melati and Jae Jae (P = 0.019).
Scratch object	X^2 = 6.779, P < 0.01 *	X^2 = 3.729, P = 0.444	
Kneading	X^2 = 7.87, P = 0.005 *	X^2 = 17.34, P < 0.002 *	Melati and Cub2 (p = 0.04) Melati and Cub3 (p = 0.04)
Sniff	X^2 = 0.441, P = 0.507	X^2 = 11.944, P = 0.018 *	Melati and Cub3 (P = 0.022).
Spray	X^2 = 4.820, P = 0.028 *	X2 = 2.355, P = 0.671	
Rub	X^2 = 10.095, P = 0.001	X^2 = 9.405, P = 0.052	
Rubbed	X^2 = 6.779, P = 0.009 *	X^2 = 11.827, P = 0.019 *	
Flehmen	X^2 = 7.40, P < 0.007 *	X^2 = 0.89, P = 0.935	
Glass bang	X^2 = 8.195, P = 0.004 *	X^2 = 10.88, P = 0.028	
Yawn	X^2 = 2.563, P = 0.109	X^2 = 3.981, P = 0.409	

Table 4: Output of Poisson regressions on event behaviours.

* indicates significant values.

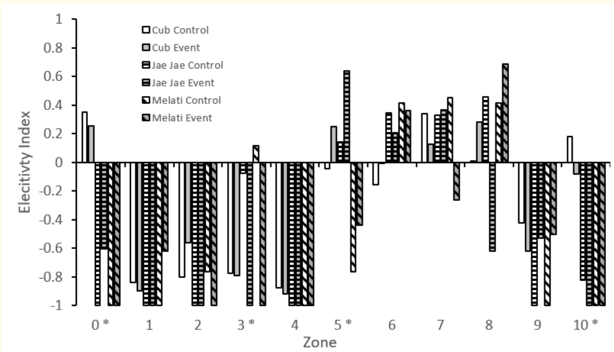


Figure 4: Electivity Index output for control and event nights for Sumatran tigers. Data for the cubs were pooled due to challenges associated with identification. Asterisks denote a zone that was separated from public viewing by at least one other zone.

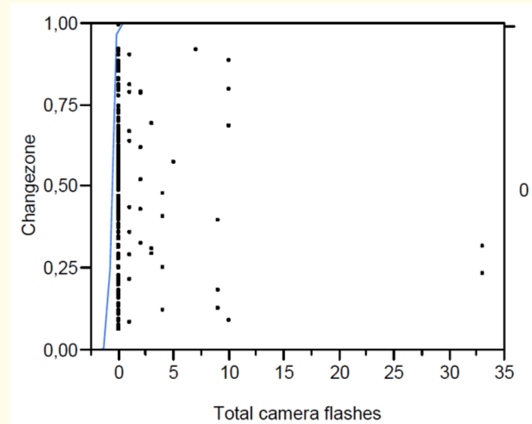


Figure 5: Relationship between the number of camera flashes per observation and the risk of a tiger changing zone.

Visitor impacts and zone change

Friedman's ANOVA was conducted to determine whether the visitor number (categories low, medium and high) influenced the chance of a tiger moving zones. No significant effect was found between conditions ($X^2(2) = 7.8$, p = 0.952).

Wilcoxon's signed rank tests were conducted to determine whether the number of camera flashes, minimum decibel or maximum decibel levels, and delta decibel value were predictors of the movement of a tiger from their occupied zone. Zone change events were not significantly associated with increased camera flashes (Z = -1.324, p = 0.714) (Figure 5), minimum decibel levels (Z = -2.31, p = 0.182), maximum decibel levels (Z = -1.451, p = 0.006), and delta decibel readings (Z = -2.232, p = 0.697).

Discussion

Overall, evening events altered both the behaviour and enclosure use of this group of tigers. Significant reductions were seen in feeding, locomotion and play behaviour. The tigers tended to use sections of their enclosures that were more distant to the public during Zoo Late evenings compared to control evenings.

Behavioural effects

Considerable research has been conducted with regards to the behaviour of captive felids, and welfare indicators are already well described [33]. Under stressful conditions, felids may exhibit stereotypic route tracing behaviours [26,34]. Mallapur and Chellam's [27] study indicated that active behaviours may be associated with enhanced welfare for felids. Conversely, inactivity may be observed in felids that are well settled in their exhibits [35]. Given the discrepancy between earlier studies, there is no clear consensus as to whether a change in active behaviour is indicative of welfare status. Rather, it is the diversity and individual merits of active behaviours that may be more predictive of positive welfare states [36].

The state behaviours, feeding, locomotion and play were reduced during evening events, whereas resting was observed significantly more frequently. This suggests that during the event nights, tigers are much less likely to engage in active behaviours. Reductions in feeding and locomotion were relatively small, but nonetheless significant.

The impacts on event behaviours are complex. Several event behaviours (scratching self and objects, kneading, and glass banging) were significantly increased during the evening events. Self -scratching and other self-injuring behaviours may be indicative of anxiety, as seen in clouded leopards (*Neofelis nebulosa*) hair-plucking [37]. Wielebnowski., *et al*. [6] found that captive clouded leopards that performed self-injuring behaviours had elevated faecal corticoids. In gorillas, Wells [38] found glass banging behaviour happened almost seven times more during conditions of higher visitor density.

It should be noted that not all individuals were equally affected; The adult female, Melati, appeared to increase self-scratching and kneading during the evening nights. Effects on the adult male, Jae Jae, were comparatively less. This suggests that tiger temperament may affect how well they respond to events [10,11,39,40].

For all tigers, rubbing against other individuals significantly decreased. This social affiliative behaviour is often considered a positive welfare indicator [41]. Rubbing is believed to be an affiliative behaviour in felids [32], so this suggests that tigers may be less willing to engage in affiliative activities during time periods when visitors are present. Spraying behaviour decreased. Spraying is generally categorised as a territorial behaviour to warn other tigers that a particular area is occupied. It is somewhat surprising that this behaviour was less likely to occur when visitors were present during the evening. This may be because tigers were trying to avoid visitors, rather than spray their territories.

Overall, the behavioural changes observed may suggest that higher visitor presence during evenings could be perceived as a novel stimulus to the tigers, as it was uncommon for visitors to be present at these times. The increased behaviours were indicative either of stress or of vigilance, with an unwillingness to approach the public. Visitor presence did not, however, result in increased levels of pacing behaviour (as is sometimes indicative of poor welfare [41]). Instead, the change in behaviour suggests an increase in alertness and avoidance of visitors, but overall, a limited effect on evening events on tiger affective state.

Enclosure use

Enclosure use studies have become increasingly popular in zoo literature, and Maple and Finlay [42] suggest that enclosure evaluations are invaluable to develop evidence-based best practice exhibits. Exhibits must be relevant from an educational viewpoint [43] but should also be tailored to the needs of the specific inhabitants. Enclosure use assessments such as Spread of Participation Index [44] and Electivity index [45] have become well cited throughout zoo literature [46-48]. This study found the use of zones 5 (distant to the public) and 8 (close to the public) were significantly affected by evening events, with tigers using areas far from the public more during the event nights.

The movement between zones may be considered of greater importance for the study, as movement may indicate that the tigers have been disrupted by external factors, such as visitor disturbance [49]. It has been hypothesised that flash photography may have a negative influence on the tigers. While it is common to request flash photography to be off in nocturnal exhibits, there is limited research on the impact of flash on the behaviour of captive animals. Because of the nature of an evening event, flash photography can be common during these hours. The number of flashes per observation session was higher in the later periods (20:30h- 21:20h), most likely due to the lack of natural light. Despite the potential of light flashes to disrupt behaviour, no changes were seen in terms of tiger zone use. This may suggest that tigers were not disturbed by visitors' flashes, or that the animals had already reduced the impact of this stimulus by adjusting their zone use. Despite having ambassadors present, some flashing of cameras was noted. Zoos planning to implement evening events should consider using staff to prevent flashes taking place around exhibits until investigations have taken place for their species.

Our findings that the tigers used zones farther from visitors during both evening events and control nights suggest that tigers may choose to use areas that they consider to be out of sight or at increased distance from visitors. The findings of this study correlate with Mallapur and Chellam's [27] findings that in the presence of visitors, leopards primarily used centre and back areas of their enclosure, suggesting visitor avoidance. Breton and Barrot's [35] comparative tiger study identified that when tigers were kept in small enclosures, they spent considerable periods of time engaged in stereotypic pacing. If not provided with the ability to access areas far from the public, it is theorised that tigers may exhibit a stress response, such as pacing.

Conclusion

This research suggests that the Evening event at ZSL London Zoo had a significant behavioural impact on the inhabitants of Tiger Territory. Enclosure use changes suggested a tendency to avoid areas close to the public during the evening events. This suggests that tigers make use of zones distant to the public during the public ~~to~~ reduce the impact of this stimulus on their behaviour. We hypothesise that these zones may act as a buffer, providing tigers with sufficient control over their environment to overcome some of the challenges associated with evening events, and possibly public viewing in general. The impact of events appears to affect individual animals differently, with the female adult tiger showing the greatest change in behaviour. It would be valuable for further studies to focus on the different stimuli during events (such as noise, camera flashes and visual visitor presence) to determine their impact so effective mitigation strategies can be implemented.

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Conflict of Interest Statement

There are no conflicts of interest in the production of this paper.

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