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Evidence-based practice

Effects of assembly and operation of an amusement ride on the behaviour of a pair of captive Amur tigers (*Panthera tigris altaica*)

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Abstract

The effects of construction, noise and visitors on behavioural and physiological responses in zoo animals have become increasingly well documented. However, scientific data are lacking on the impact of amusement rides on the welfare of captive animals. Capital developments in 2014 at Tayto Park, Ireland included expansion of their theme park. This project provided an opportunity to investigate the effects of visual and auditory stimuli of an amusement ride on the behaviour of two Amur tigers. Data on the behaviour and spatial location of the tigers in the enclosure, as well as visitor numbers and noise levels, were collected across four phases of the project: pre-assembly, assembly, operation and when the park closed in the off-season. Differences in the tigers' behaviour across phases were analysed with Kruskal-Wallis tests, and enclosure use was calculated using a modified SPI.

The time tigers spent off-show (in-house) was proportionately higher during Phase Two and findings were statistically significant for the male ($X^2(3)=7.935$, $P=0.047$). SPI values show that the female tiger had a strong bias when using her enclosure in Phase Two with an SPI of 0.87 and spent 87% of her time off-show (in-house). There was no significant difference between phases in the proportion of time tigers spent in observed behaviours. Further, there was no statistical difference in behaviours exhibited by the tigers in Phases with high and low decibel levels and visitor numbers. It was concluded that visual disturbance from the ride was more aversive to the tigers than either noise or visitor levels. Zoological collections should consider the potential negative impacts of novel visual stimuli and provide free access to off-show retreat, as well as ensuring visual barriers are sufficient to minimise environmental disturbance.

Introduction

High visitor numbers, construction and auditory disturbance are known to affect the physiology and behaviour of captive animals (Mallapur and Chellam 2002; Owen et al. 2004; Sellinger and Ha 2005; Powell et al. 2006; Maia et al. 2012; Chosy et al. 2014). Animals exposed to environmental stimuli, whether an actual or perceived threat, may elicit a stress response (Cockram 2012). In nature, when the stress response is prompted, an animal may escape confounding stimuli, but in captive environments, movement is restricted and opportunities to escape or hide from potential stressors may be limited. As a response, behavioural and physiological reactions associated with stress may occur, which include increased secretion of glucocorticoids, reduced fecundity, inactivity or stereotypic behaviours (Carlstead 1996, 1998; Shepherdson et al. 2004; Veasey 2006; Morgan and Tromborg 2007). When confronted with environmental stressors, captive felids have been reported to pace (Mallapur and Chellam 2002; Gusset 2005), increase levels of inactive behaviour (Sulser et al. 2008) and hide (Carlstead et al. 1993; Sulser et al. 2008; Chosy et al. 2014). These behaviours may be an indicator that an animal's welfare is compromised (Carlstead 1996).

When an expansion development for Tayto Park included the announcement of a mechanised amusement ride, the Rotator, it presented an opportunity to investigate the effects

Table 1. Four phases of data collection including pre-assembly (baseline), assembly, operation and when the park was closed to the public.

Phase	Description of Phase	Dates	Number of Weeks	Number of 30-minute observations
1	Pre-assembly (baseline)	June 9–27	3	24
2	Assembly of Ride	June 30–July 4	1	10
4	Operation of Ride	July 15–Aug 7	3	22
3	Park Closed to Public	Sept. 2–23	3	24

Table 2. Ethogram of tiger behaviours for data collection.

Behaviour	Definition
Inactive	Standing, sitting or lying down with eyes open and attentive or closed and sleeping
Explore	Foraging, feeding, manipulating food or objects, smelling scent trails
Locomotion	Walking, trotting, running (does not include pacing)
Affiliative	Play, lick, nuzzle, social rub/allorub
Self-Groom	Cat cleans itself by licking, scratching or biting
Pacing	Repetitive locomotion in a fixed pattern. Movement seems to have no apparent goal or function. Must be performed at least two times in succession before quantifying as stereotypic.
Off-show (house)	In interior enclosure, not visible to observer or public

of the assembly and operation of an amusement ride on the behaviour of the two Amur tigers (*Panthera tigris altaica*) housed in the proximity of the new development. Despite many zoological collections featuring amusement rides, the effects of assembly and operation of these rides have not been reported. Carnivores are susceptible to the development of stereotypic behaviour, and studies have shown that construction and noise can negatively affect behavoiur. Thus, it was hypothesised that tiger activity levels would decrease, and that abnormal behaviour would increase, during the assembly and operation of the amusement ride. The study anticipated a return to baseline values post-assembly and operation of the ride when the park was closed.

Materials and methods

Study subjects and housing

Two Amur tigers, a 14-year-old female, and a 10-year-old male, were the subjects of this study. Their housing consists of a large (2749m^2) open-air, outdoor space with access to an indoor off-show house (126m^2). The tigers have full access to the interior and exterior aspects of the enclosure at all times except during periods when keepers are carrying out husbandry practices (feeding/cleaning).

Visitor attraction

The location of the Rotator is 81m from the southeastern tip of the exterior enclosure and within the view of the tigers from the front of their enclosure. The base size of the ride is 21.5x16.4m with 24 vehicle seats. The ride rotates 360˚ at 13 revolutions/minute and reaches a height of 31m. It is powered by a sound insulated, diesel generator; supplying an electric motor with no significant operational noise. Sound levels at the southeastern tip of the enclosure during unoccupied operation range from 50–55 decibels (dB).

Timing of data collection

Data collection began three weeks before the assembly of the amusement ride (Phase One) and was collected over four Phases (Table 1). Phase Two was forecasted to take approximately three weeks to complete. However, assembly and testing were completed within one week. Phase Four took place in the off-season when the park is closed to the public Monday–Friday. Observations were conducted Monday–Friday, distributed similarly over the opening hours of the zoo (10:00 and 17:00 hours) for a total of eighty observations (Table 1).

Behavioural observations

Continuous focal sampling (Altmann 1974) was used to monitor behaviour for each subject, and each observation session was 30 minutes in duration. The observer was randomly assigned to one tiger and positioned in front of the enclosure and not hidden from view. Two observers were used to ensure all data points were recorded accurately. As such, the observers were included in the visitor numbers. Before commencement of the study, an ethogram was created incorporating data published in the literature (Rybak 2002; Margulis et al. 2003, Stanton et al. 2015) with the addition of those behaviours observed during ad lib sampling. Table 2 lists the ethogram of behaviours recorded during each observation. Observations did not take place one hour before or after feeding or during inclement weather.

Visitor numbers, decibel levels and enclosure use

Visitor numbers (manual count), decibel levels and location of the tigers in their enclosure were recorded at 3-minute intervals. Decibel levels were measured using a CEL decibel reader (model: 240; Casella/CEL Inc., Amherst, NH). Sound levels and visitor numbers were calculated and averaged for the 30-min observation period.

Calculation of enclosure use

The exterior enclosure was split into sections and numbered one to seven with the interior enclosure listed as House. A modified Spread of Participation Index (SPI) was calculated to study the extent which the tigers used all areas within their enclosure space by Phase (Plowman 2003). With this, a result of 0 is indicative that all zones are used equally, whereas a result of 1.0 shows bias in zone/enclosure usage.

Table 3. Mean (SD) proportion of time spent in behaviour, visitor and noise levels by phase and subject. Mean (SD) for behavioural and environmental variables recorded across the four phases of the assembly and operation of the amusement ride the 'Rotator.' Behaviours are the proportion of time observed. Single *indicates phase with the greatest proportion of time in behavior. Significant results are indicated as ** P<0.05.

	Phase 1 (baseline)		Phase 2 (assembly)		Phase 3 (operation)		Phase 4 (closed)	
Subject Behaviour	F	M	F	M	F	M	F	M
Affiliative	0.008 (O.O24)	0.008 (0.024)	0.000	0.000	0.04* (0.007)	0.02 (0.05)	0.03 (0.04)	0.03* (0.04)
Explore	0.004 (0.01)	0.007 (0.013)	0.02 (0.03)	0.03* (0.03)	0.11* (0.26)	0.02 (0.04)	0.01 (0.02)	0.02 (0.03)
Locomotion	0.09 (0.17)	0.14* (0.17)	0.04 (0.07)	0.08 (0.07)	0.07 (0.09)	0.13 (0.14)	0.12* (0.13)	0.10 (0.14)
Inactive	0.16 (0.20)	0.65* (0.34)	0.05 (0.10)	0.19 (0.20)	0.30 (0.34)	0.35 (0.35)	0.33* (0.29)	0.54 (0.39)
Pacing	0.00	0.00	0.00	0.00	0.00	0.00	0.02* (0.06)	0.00
Self-groom	0.00	0.02 (0.04)	0.003 (0.007)	0.00	0.009* (0.02)	0.02* (0.05)	0.002 (0.006)	0.01 (0.02)
Off-show (in-house)	0.72 (0.35)	0.15 (0.29)	0.87* (0.14)	0.61** (0.33)	0.45 (0.38)	0.40 (0.38)	0.49 (0.34)	0.28 (0.35)
Environmental Variables								
Noise (dB)	65.5 (3.3)	67.0 (5.6)	69.0 (3.0)	66.1 (5.3)	72.1** (3.0)	72.6** (2.5)	63.8 (2.0)	63.6 (2.0)
Visitor Numbers	10.7 (7.5)	10.6 (6.7)	6.7 (5.0)	6.4 (4.4)	13.3** (7.3)	13.6** (7.3)	2.0 (0)	2.0 (0)

Analysis

Observational data were collected and collated using Microsoft Excel. The R Statistical system was used for data analysis and plotting. Data were not normally distributed, so non-parametric tests were used. The differences in the proportion of time spent in each behaviour between different phases were tested using Kruskal-Wallis tests with post hoc pairwise comparisons to pinpoint differences. Differences in both sound level and visitor numbers between Phases were also tested using Kruskal-Wallis tests. Correlations were tested with Spearman's rank correlation coefficient. An alpha level of 5% was used for determining statistical significance.

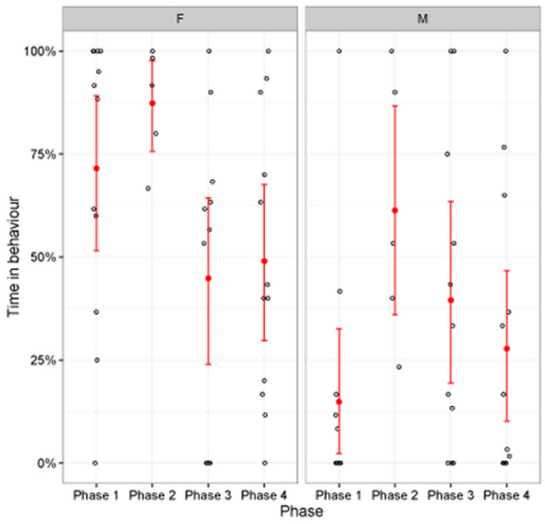

Figure 1. Proportion of time off-show by phase. Individual observations are shown as black points (horizontally jittered to reduce over-plotting). Mean and bootstrapped 95% confidence intervals for each phase/behaviour are in red.

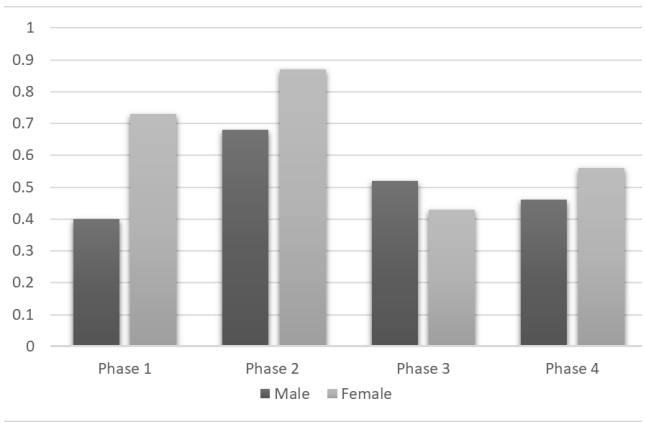

Figure 2. Spread of Participation Index (SPI) for enclosure use by Phase. SPI=1.0, indicates minimum utilisation of enclosure by tigers where SPI=0 indicates maximum use.

Results

Mean sound levels varied from 63.6 to 72.6dB, with the highest levels in Phase Three (Table 3). There was a significant difference in sound levels between Phases for both male ($X^2(3)=18.537$, P=0.0003) and female ($X^2(3)=24.245$, P=0.0001) observation sessions. However, there was no significant correlation between noise levels and the proportion of time each tiger spent in each behavior by Phase. Mean visitor numbers varied from 2.0 to 13.6, again with the highest numbers during Phase Three. A significant difference in visitor numbers across the four phases was noted for the male ($X^2(3)=26.892$, P=0.0001) and the female ($X^2(3)=26.650$, P=0.0001) observation sessions. However, there was no significant correlation between visitor levels and the proportion of time each tiger spent in behaviours by Phase.

The proportion of time that the tigers spent off-show (in-house), without any direct line of sight to the ride, was significantly higher during Phase Two for the male ($X^2(3)=7.935$, P=0.047), but just failed to reach statistical significance for the female $X^2(3)=7.284$, P=0.063), even though she spent 87% of her time off-show in Phase Two (Figure 1). Nevertheless, the female's SPI Index was 0.87 in phase Two, indicating minimum utilisation of areas in her enclosure (Figure 2). The females lowest SPI of 0.43 occurred in Phase Three, where she exhibited a more even use of interior and exterior aspects of her enclosure. The male's enclosure use bias was greatest in Phase Two, in which SPI=0.68, and maximum utilisation of the enclosure occurred in Phase One, where SPI=0.40 (Figure 2).

Discussion

The prediction that activity levels would decrease and abnormal behaviour increase, during assembly and operation of the amusement ride, was not supported. Conversely, the study found no statistical difference in the proportion of time spent in observed behaviours across the four phases. However, the usage of enclosure space by the tigers did show changes across the four phases, with greater use of the indoor (off-show) space in Phase Two, which was the period of assembly of the ride. Retreating behaviour has been documented in domestic cats and other felid species confronted with environmental stressors, including construction (Carlstead et al. 1993; Rochlitz 2000; Gusset 2005; Sulser et al. 2008, Chosy et al. 2014). Physiological responses have also been noted in felids. Six clouded leopards (*Neofelis nebulosa*) each showed a significant decline in faecal glucocorticoid concentrations when they were provided with additional hiding spaces (Shepherdson et al. 2004). The ability to hide or withdraw to remote parts of exhibits appears to be an important behavioral strategy for felids. It is, therefore, plausible that the tiger's time off-show and reduced use of the exterior enclosure were coping strategies for this environmental disturbance.

Sound and visitor levels fluctuated over the phases with highest dB recordings and visitor numbers in Phase Three. Despite higher levels of noise during operation of the amusement ride, there was no evidence of a statistically significant difference in the tiger's behaviour or time spent off-show in House. There are numerous studies investigating noise and its effect on behaviour with varied results (Kempf and Hueppop 1996; Owen et al. 2004; Powell et al. 2006, Quadros et al. 2014). In part, this may be due to species-specific sensitivity and tolerance as well as species ability to acclimate to high noise exposure (Kempf and Hueppop 1996). Visitor numbers were also highest in Phase Three, but again there was no statistically significant difference in behaviour of the tigers. A number of felid studies have shown inconsistent conclusions about the effect of visitors, elucidating changes in behaviour including increased inactivity (Mallapur and Chellam 2002), avoidance/less visible (Mallapur and Chellam 2002; Sellinger and Ha 2005), increased activity (Rybak 2002) increased pacing (Rybak 2002; Sellinger and Ha 2005) as well as no change in behaviour (O'Donovan et al. 1993; Margulis et al. 2003). Varying results may be indicative that the visitor effect is unpredictable both within and among species groups, and that other factors may have a role in how the animal will respond to visitors, such as exhibit design/ characteristics, the animals temperament, and what the visitors are doing (Hosey 2000, 2008).

Conclusion

The study has shown that Phase Two was associated with a significant change in enclosure use, and in particular increased usage of the indoor space. While not conclusive, retreating by the tigers during Phase Two suggests that they found the visual stimuli associated with the disturbance caused by construction of the ride more aversive than either higher ambient noise or visitor numbers around the enclosure. Despite the tigers' negative response in Phase Two, behaviour was unaltered in Phase Three. It is suggested that by providing access to the off-show area the tigers were able to modify their behaviour to mitigate the disturbance of the visual stimuli, by retreating to their off-show enclosure.

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